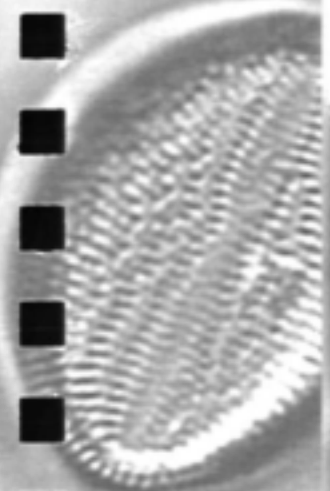
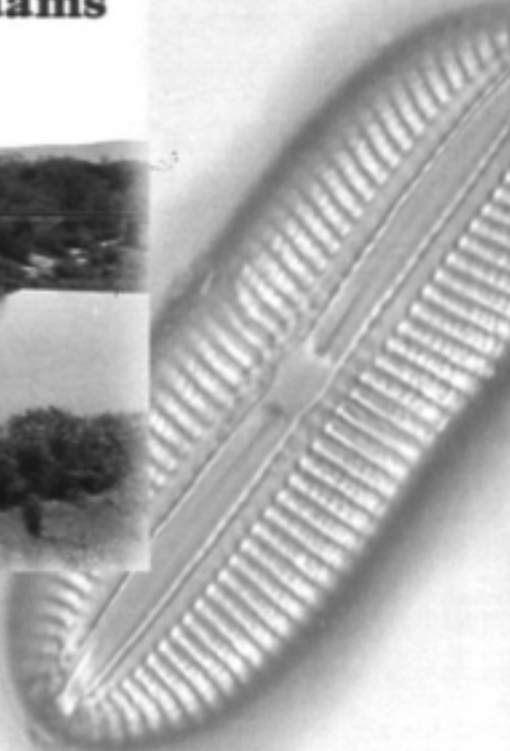
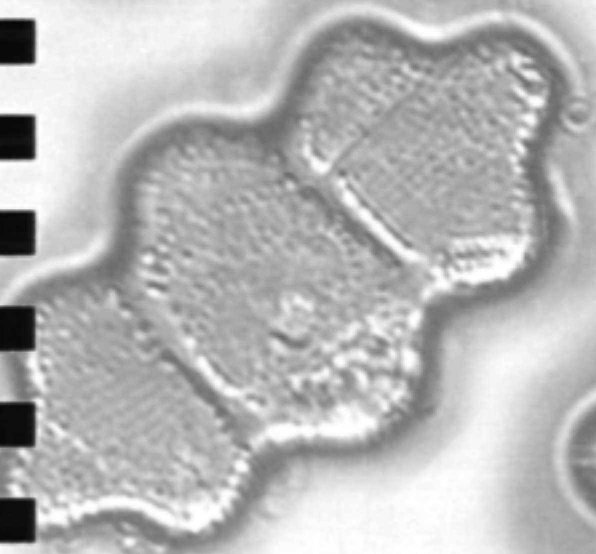
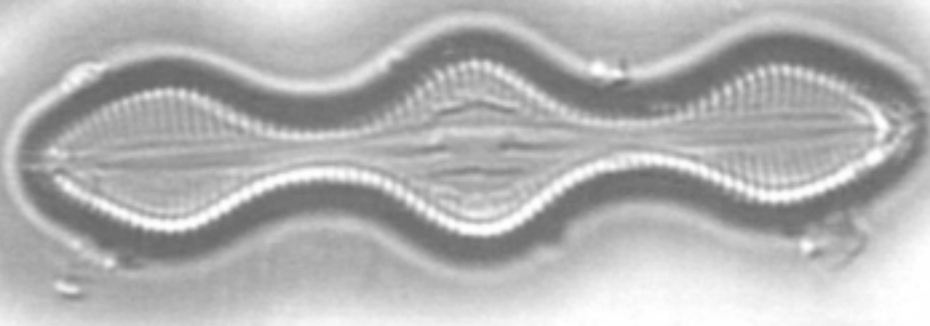
Benthic Diatoms in the Rivers and Estuaries of South Africa

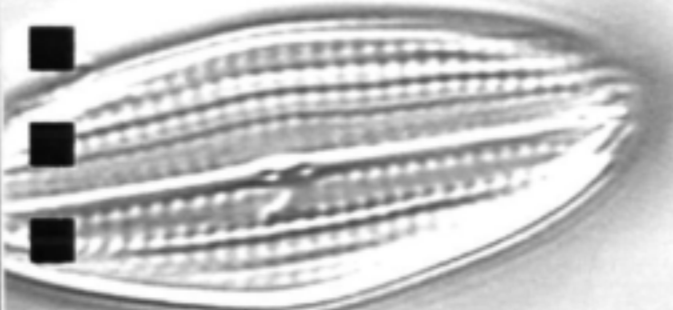
GC Bate, PA Smailes & JB Adams











TT 234/04

Water Research Commission

BENTHIC DIATOMS IN THE RIVERS AND ESTUARIES OF SOUTH AFRICA

Report to the Water Research Commission

GC Bate, PA Smailes, JB Adams

Department of Botany, University of Port Elizabeth

WRC Report No. TT 234/04

September 2004

Obtained from:

Water Research Commission

Private Bag X03

Gezina

0031

The publication of this report emanates from a project entitled: *Benthic diatoms in the rivers and estuaries of South Africa* (WRC Project No. K5/ 1107)

ISBN No. 1-77005-182-1

Printed in the Republic of South Africa

EXECUTIVE SUMMARY

- Three reports should be included when considering the full results of the diatom study on the rivers and estuaries of South Africa. These are, WRC K5/814/02/1, this report and the MSc report submitted by Ms C. Minnè.

- This report consists of three sections, Section 1: Data Analysis, Section 2: Estuary Diatoms and Section 3: River Diatoms.

- 68 diatom species were found to be dominant in the 212 river sites sampled from all phytogeographical regions of South Africa. The number of dominants and sub-dominants totalled 121. This implies that the taxonomic difficulties anticipated, when using diatoms as indicators of water quality, were much lower than expected. The early estimate was 350 taxa. The high number of sub-dominant taxa relative to the dominant taxa may imply that the number of river habitats sampled was low.

- 122 diatom species were found as dominants in the 289 estuary sites sampled from all around the South African coastline. The number of dominant and sub-dominant taxa was 168. The small number of extra taxa found as sub-dominants suggests that the sample coverage was adequate for the purpose intended. The greater number of estuarine taxa is likely a reflection of the far greater number of habitats sampled and present in estuaries compared to rivers. The greater number of habitats was due to daily tidal (saline) surge.

- All the sites sampled in both the rivers and estuaries had the diatom species assemblages resolved completely. It was not possible to identify some taxa but these were coded. The international experts consulted on taxonomy expressed the opinion that some new species will emerge from the study. These species will need to have their taxonomy resolved.

- Not all the river-water quality values were received from the analytical laboratories. In some cases, the data sets were incomplete, while in others the data/samples were misplaced/lost.

- A number of different analysis methods were applied to the results. An arbitrary water quality index was constructed from 13 months of river water data obtained from the

Swartkops River near Port Elizabeth. This index was applied to each of the dominant diatoms obtained during the study. The Water Quality Index (WQI) is an indication of the average water quality indicated by each dominant.

- The WQI of each species is an indicator of the total dissolved solids measured by the dominant taxon at each site. TDS has been shown to be the only significant parameter indicated by diatoms when using Canonical Correspondence Analysis methods. This also appears to be the experience of international workers.

- A problem identified during this study is that there are no data showing how quickly an individual taxon becomes sub- or non-dominant following a change in water quality of short duration, i.e. a spike. This phenomenon may result in short-term luxury consumption of some mineral nutrients, which may cause a species to be dominant at a site for longer than would be the case had the species not been able to store the mineral.

- Because the study concentrated more on countywide coverage than on site replication, a recommendation on the way forward is to select sites, where "spikes" are a feature, and collect data on changes in species dominance under those conditions.

- NAVIGREG occurred as the dominant on most occasions (36). In the Swartkops River NAVIGREG was dominant on 20 occasions over a period of 13 months. The variability of total dissolved solids (TDS) was the highest at those sites where NAVIGREG was dominant in the Swartkops River (Eastern Cape). This may mean that the condition being indicated is rapidly changing quality but with relatively low TDS water.

- The dominant species with the highest WQI (i.e. occurring in the poorest water quality) was NITZLITE. It was found in the Sundays River at site SR2, which is at Jansenville in the Eastern Cape. The EC was 590 $mS.m^{-1}$, which is equivalent to more than 3800 $mg.l^{-1}$. Its dominance frequency was 22%. The dominant species with the lowest WQI (1.00) were ACHNABUN (Keurbooms River, Eastern Cape, site KR3) and EUTIINCI (Bedeke River Western Cape, site KB1).

- The international literature refers to diatom species as being found in either marine, brak or freshwater. Although some species are known to occur across these three water types, i.e. NAVIGREG, the majority are moderately good indicators of salinity. In the estuary component of the study, the data indicated that many species are sensitive enough to be able to reflect high (24–35 $g.l^{-1}$), medium (13– 23 $g.l^{-1}$) or low salinity (1– 12 $g.l^{-1}$).

- In the estuary study, only salinity was considered. This is because DWAF does not routinely measure water quality in estuaries. However, salinity is the only available indicator of freshwater flow into estuaries. The only *post hoc* indicator of freshwater flow to an estuary is likely to be the benthic diatom flora. For this reason, the microphytobenthos is likely to be an important monitoring tool in the future.

- A recommendation is that estuarine microphytobenthos should be studied in relation to daily tidal surges. This will be important to show the extent of species dominance under changing salinity regimes related to tidal flow.

- The study has produced a number of images that will provide an important reference source in future studies on estuarine and riverine microphytobenthos.

- The microphytobenthos is likely the largest source of primary productivity in the rivers and estuaries of South Africa. For this reason, studies of a similar nature should have a high priority for future funding.

- Five projects have been recommended for further research. These include (1) the need for more data, (2) for repetitive data similar to that of the Swartkops study in K5/814, (3) the need to understand the causes of species dominance change, (4) the need to resolve what NAVIGREG is indicating and (5) the need to identify all the existing non-dominant taxa collected. The latter project is necessary to gather data towards the implementation of an "index" system.

ACKNOWLEDGEMENTS

During the course of this study (K5/814 and K5/1107) we received a great deal of assistance from organisations and persons too numerous to mention. However, we are especially grateful to the Water Research Commission, not only for funding this project, but also for their continued enthusiasm and support. This applies especially to Dr. S. Mitchell whose enthusiasm never appeared to flag. Funds were also supplied by way of a University of Port Elizabeth research grant to one of us (GCB). We are very grateful to the Department of Water Affairs and Forestry who assisted during the collection of the samples from most of the rivers. Their field assistants showed great interest in the project and they were never put out by having to transport us to different sites. The Department also undertook the bulk of the water analyses through the Institute for Water Quality Studies at Roodeplaat. We would like to thank those involved for sending the data as quickly as they did. Umgeni Water, Rand Water Board and Durban Metro were extremely helpful in providing information and transport to their various collection sites. We spent a most enjoyable and exciting trip to the Kruger National Park where we were shown to the DWAF sampling sites. We were also protected from the various inhabitants of the Park and for this we are especially grateful. We were generously supported by staff of the Botany Department at the University of Port Elizabeth, especially Mrs. J. Kritzinger, Dr. D. R. du Preez, Mr. A. Gouws and Mr. M. Brassil. We would like to acknowledge the important assistance of the staff of the Physics Department, UPE. These latter staff members were unbelievably patient in providing assistance and advice on the correct use of the scanning electron microscope. The members of the WRC Steering Committees provided considerable assistance in their very constructive criticism over a long period. Finally, this project was international in the sense that we received a considerable amount of assistance from Professor F.E. Round, Bristol University; Dr. D. Mann, Royal Botanic Gardens, Edinburgh and Dr. E. Cox, British Museum, London.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

This report is the culmination of a two-part endeavour that began as Water Research Commission Project K5/814 that lasted for three years (1997-1999) and was subsequently extended as WRC Project K5/1107. Project K5/814 only examined benthic river diatoms. Project K5/1107 extended the river component so that rivers from all the apparent phytogeographical regions of South Africa were sampled – at least where perennial rivers are normally present. In addition, K5/1107 examined benthic estuarine diatoms. The estuarine study included a selection of estuaries extending from northern KwaZulu Natal (Nhlabane and Mhlathuze) all along the Cape east coast, south coast and west coast as far north as the Olifants Estuary on the west coast. Hence, while there are many other rivers, river sites and estuaries that can still be sampled, the data collected and presented here is probably a good representation of the benthic diatom flora to be found, especially the dominant flora.

River water samples are collected routinely from a great many rivers across South Africa. They are preserved with mercuric chloride and the chemical constituents analysed centrally by the Department of Water Affairs and Forestry (DWAF) at Resource Quality Services (formerly IWQS, Institute for Water Quality Studies) situated at Roodeplaat in Gauteng. Samples are also collected and analysed by various water boards around the country, e.g. Rand Water, Mhlathuze Water and Umgeni Water. The result of these activities is that the samples are stored (during transport and awaiting analysis) prior to chemical analysis. Although the water samples are preserved with mercuric chloride, the treatment aims to halt biological changes in the water quality but cannot prevent purely chemical changes. Hence, the results of chemical analysis may not be truly representative of the water quality at the time of sampling. In addition, one must also realise that inter-laboratory calibrations sometimes show differences in the mineral element content of sub-samples. From this it emerges that sampling is time-consuming, expensive and different analytical laboratories do not always produce the same results. After analysis, the water samples cannot be retained indefinitely, hence unless an error is identified immediately, it is not possible to re-analyse a sample. If an alternative system were available for water quality monitoring, it should be considered in relation to the current system.

River water sampling is necessary in order to manage the resource. South Africa has water requirements that are beginning to exceed supply, especially in certain areas of the country. Quantity and quality are therefore an essential component of water management. The National Water Act of 1998 makes provision for securing the water resources of the country. The Act, inter alia, requires that not only river resources be protected, but that estuarine resources also must be protected. The interpretation with respect to estuaries is that sufficient freshwater must be discharged into estuaries in order to protect them to a level approved in terms of the Resource Directed Measures programme of the Department of Water Affairs and Forestry. The quality of estuary water in South Africa is not presently analysed by any authority, yet the supply of freshwater, in terms of the Act requires that estuary water should conform to prescribed quality minima. In areas where agricultural, industrial and municipal effluents reach estuaries, water quality might necessarily include the concentration of mineral and biological constituents. However, because estuaries, and especially permanently open estuaries, receive water from a river and the sea, one of the major factors that needs to be kept within natural limits is salinity. Estuaries naturally have a salinity gradient, becoming fresher inland and often fresher vertically. Diatoms are known to respond to salinity change; hence their possible use to integrate and record salinity fluctuations is part of the purpose of this research. Benthic diatoms also comprise the bulk of the primary productivity at the base of the food chain. Knowledge of their ecology is therefore as vital a part of estuarine management as is the knowledge of grasses in grassland management.

An international effort is currently underway to establish diatoms as indicators of water quality. Such a system has been implemented in Europe for some years. The United States is still working on a system, as is the United Kingdom. The methods being employed differ between countries (see literature review for details). France has implemented an index system that relates all the diatoms recovered from a site. Some workers in the United Kingdom (e.g. G. Underwood – University of Essex) are using the index system while others (e.g. F. Round – University of Bristol) are using dominants as the determinants. Van Dam *et al.* (1994) produced a list of taxa with the water quality values in which they were found. However, most workers have used Canonical Correspondence Analysis (CCA) in its various forms at some stage or another. This analytical technique was used in WRC project K5/814 and showed that diatoms indicated TDS significantly but the method could not be used for the components of TDS. Speakers at the International Diatom Symposium held in Ottawa in September 2002 also reported this.

One of the perceived problems with CCA is that the presence of a dominant diatom or suite of diatoms has to be related to the water quality at the time of sampling. This need not necessarily be the case because the quality at the time of sampling may not be that to which the diatom population has responded, i.e. there may have been a "spike" at the time of sampling. Alternatively, the diatoms may have responded to a high value of mineral element(s) present only for a short period, which may be stored within the cell. The chemical analytical method of determining water quality also suffers from these problems. Diatoms should integrate water quality over time whereas the latter method cannot.

Because the Index System introduced into France appears to work satisfactorily, a pertinent question is why a similar system was not used in this study. The main reason is that the information on South African diatoms is widely spread in the international literature. Much of that information is taxonomic and details of where collections were made usually only refer to a river and not a site. Much of the work is many years old and the quality of the water in the rivers has probably changed considerably as a result of population increases and industrialisation. At the same time there are, unfortunately, very few ecological diatomists working on the benthos. Over the period of this study, many diatom taxa have been revised. The opinion of Dr. D. Mann (Royal Botanic Gardens, Edinburgh) is that this study should reveal many new species. Hence, before an index system can be attempted, there is a need to gather information on South African dominant species, their locations and the water quality. When more data are available it might be possible to re-analyse these data into an index system.

2. AIMS AND PROJECT APPROACH

The project had three main objectives:

1. To gather more data on other South African rivers;
2. to include estuaries, and
3. to transfer the technology to others.

Because this project was a continuation of WRC K5/814, part of the aims were to continue the collection of diatoms from rivers in areas that had not been included before and to relate the species identified to the river water quality in which they were found. The river project, therefore, extended the collection to include Limpopo Province, KwaZulu Natal, Northern Cape, Eastern Free State and the Kruger National Park; a total of 80 sites from 43 rivers.

The realisation that benthic diatoms are probably the most productive organisms at the base of the food chain in estuaries identified the need to extend the investigation into estuaries. At the same time, because diatoms are known to fall into salinity tolerance categories, i.e. freshwater, brak and marine, among the aims of the estuarine component was to determine: (a) which diatoms were dominant in estuaries and (b) whether these might fall into groups that can be used to identify the salinity characteristics of South African estuaries. This aspect has been completed and is reported in Section 3.

In Project K5/814, an important component was the preparation of a "river water diatom genus identification database" for use by workers in South Africa. This database was completed and consists of all 238 genera described by Round *et al.* (1990). The database has been sent out on a compact disc to interested parties, thus fulfilling the technology transfer study objective. Ms P Hilaal and Mrs S Mundree from the CSIR, Durban also spent time at UPE learning the various techniques.

While the diatom identification database has been extensively used by one of us (GCB) to identify diatoms to genus level, continuous work at the identification level (PAS) has meant that the system is seldom used. When diatoms are worked with on a regular basis they are easily recognised; also there are not many involved when one considers only the dominants. Identification of more recently formed genera, i.e. *Seminavis* split off from *Amphora*, is difficult without SEM and this has not yet been included in the genus ID database. It is possible that such alterations are only necessary once in 10 years because there has to be general acceptance of such changes by the international diatom research community.

The specific aims of this project were:

1. To produce a manual of South African benthic diatoms containing images of all dominant and sub-dominant taxa found in South African rivers and estuaries.
2. To collate information on the relationship between benthic diatoms and water quality in South African rivers and estuaries.
3. The data were to be included in a manual to be produced in three sections:

   Section 1: South African benthic diatom taxa and their sites of collection.

   Section 2: Dominant benthic diatoms from the rivers of South Africa and the water quality associated with them.

   Section 3: Dominant benthic diatoms from the estuaries of South Africa and their habitat conditions.

A report has been produced containing images of all the diatom taxa identified in the rivers and estuaries that were sampled (i.e. Sections 2 and 3). Each diatom is presented on a page with the sites where it was located and the Water Quality Index for that particular taxon. These images will form the basis of an identification system for use by students and water researchers in the future. For this reason it is important that the images be presented at a good enough level of resolution that most, if not all, of the identifying features can be seen clearly. Furthermore, all of the diatoms found, in addition to the dominants and sub-dominants, have been included on a CD accompanying this written report, so that a complete list of diatoms can be included in any future index system that may be produced. Because of time constraints, these additional diatoms have not all been identified. This does not detract from the importance of their presence in the flora of each site.

A small part of this project was to assess the ability of diatoms to identify both levels of salinity and mineral nutrient concentration in estuarine water in order to extend the quality component to include all aspects of water quality. This was only a small component because, although important, it was undertaken as a student project in co-operation with RQS, Roodeplaat. It was not included in the original project aims because a student was not available at the time the project description was submitted. Subsequently, Ms Chantel Minne undertook the project, which included an assessment of estuary water quality compared to the analysis of the same samples by RQS.

A full review of the literature pertaining to diatoms in rivers is contained in WRC Report 814/1/02. The MSc dissertation by C. Minne contains a literature review on estuarine diatoms (Minne 2003). Readers are referred to these documents if additional references are required. This report consists of three sections, Section 1: Data analysis, Section 2: Estuary diatoms and Section 3: River diatoms.

3. MATERIALS AND METHODS

3.1 Sampling sites

Estuaries

The estuarine component of the project followed a very specific sampling protocol. The reason for this was that we wished to know whether intertidal sites had a different flora to subtidal sites and whether the higher average salinity near the mouth supported a different flora to the very low salinity sites near the head. Knowing that the tidal surge caused daily changes in salinity, three sites were sampled between the mouth and head and one each between mouth/middle and middle/head. This meant that 10 samples were taken from each estuary.

The head of the estuary was identified as the position where the surface water was either fresh (< 2 mg l^{-1}) or to a position where it was not possible to proceed further upstream because of shallow conditions. In a few cases where it was possible to gain access, river samples were taken and diatoms extracted for comparison.

The Knysna, Keurbooms, Breede, Mtata, Sundays and Nhlabane estuaries were sampled by boat in 2000 while the Great Brak, Goukamma, Mhlathuze and Swartkops estuaries could be sampled by road. If an estuary can be sampled by road, the process is normally much quicker than collecting by boat. However, collecting by boat usually allows the sites to be selected more equidistantly.

The Bushmans, Great Fish, Kowie, Mpekweni, Olifants, Breede and Swartkops estuaries were sampled in 2001. The Berg, Goukou and Gourits estuaries were sampled in 2002. The Nhlabane and Mhlathuze estuaries were sampled in 1998 as part of a DWAF freshwater requirement study.

Rivers

As far as possible, river samples were taken at a DWAF water quality monitoring site. Samples were collected in the Western Cape, Orange Free State, Northern Cape, KwaZulu-Natal, Northern Province, Eastern Cape, Kruger National Park, Durban Metro area and DWAF Rand Water area. Full details of the sampling sites, GPS co-ordinates and date of sampling are provided in Section 3.

3.2 Diatom collection and processing

The methods employed in this project are the same as those reported for WRC project K5/814 but with some modifications. They are reproduced here for the sake of completeness. The epipelon was sampled as described by Round (1981). Samples were taken using a length of glass tube that was drawn across the sediment and allowed to fill with a mixture of surface sediment and water. This was repeated up to five times in different positions in order to get a sample that was representative of the different micro-habitats. The mixture was stored in a plastic sample container (50 ml). In a field laboratory, the sample was placed in a petri dish. The sediment was allowed to settle overnight. The following morning most of the supernatant was drawn off and 5 clean degreased cover slips (covering ca. 40% of the sediment surface) were placed on top of the wet sediment. On the same day (ca. 2 hours later) the cover slips were carefully removed with as little sediment as possible. In this way only living cells that had attached to the cover slips were sampled. The five cover slips from each sample were placed in glass bottles and transported to the laboratory. There is no time limit at this stage to process the diatoms further. To each glass bottle containing the cover slips, 2 ml of $KMnO_4$ (saturated) and 2 ml of HCl (10 M) was added. This mixture was heated on a hot plate at ca. 60°C until the solution cleared (~20-40 mins) and became straw-coloured.

All acid cleaned samples were washed with distilled water using 5 consecutive spins (2000 rpm for 10 minutes). Stubs, to be viewed under a Scanning Electron Microscope (SEM), were made by placing a drop of the diatom 'digest' onto filter paper (HTTP Millipore, 0.4 mm). The filter paper was dried and fixed to a SEM stub using double-sided tape. The stub was subsequently sputter-coated with gold in an Edwards Sputter Coater S150B (2 minutes, 20 mA). Permanent light microscopy slides were made with 1-2 drops of diatom 'digest', placed onto an acid-washed cover slip (subsequently stored in ethanol) and allowed to dry in air. Cover slips treated and stored in this manner allow the drop of sample to spread more evenly. When completely dry, a small amount of Naphrax^{R} mounting medium (Northern Biological Supplies, U.K.) was dotted onto a glass microscopy slide and the cover slip placed over it. Air trapped under the slide and the Naphrax were dispersed by heating the slide on a hot plate (approx. 60°C). The Naphrax was allowed to dry for 2-3 days. Each slide was eventually sealed around the edge of the cover slip with Bioseal^{R} to prevent ageing of the Naphrax. The slides were logged and stored in a slide library, to form a permanent record.

3.3 Diatom identification and enumeration

Diatom frustules were examined under a Zeiss Axioplan light microscope with Differential Interference Contrast (DIC) optics. Using a television camera (JVC KY-F3), images of the dominant species were visualised using the AnalySIS image analysis programme (©1999, Soft Imaging System GmbH). If these images did not provide enough detail for species identification, a sample was prepared for viewing in a Scanning Electron Microscope (SEM, Philips XL 30). The light and SE microscope images were catalogued according to river/estuary and genus. Information regarding habitat, site of origin, taxonomic name, authority and source of reference was saved with each image.

Diatom valves were counted in each sample using 1000x magnification until an obvious dominant was established. At least one of each taxon was made into a digital image. All the images were then printed and used in the counting procedure. This achieves two important aspects, (1) a digital image of each taxon and (2) a count of the total number of taxa. The nomenclature of Krammer & Lange-Bertalot (1986-91 and 2000) was used with a few exceptions associated with some taxonomic revisions suggested by Round *et al.* (1990). Other taxonomic works consulted included Archibald (1983), Hustedt (1976), Lange-Bertalot & Krammer (1989), Simonsen (1987) and various articles by R.E.M. Archibald, B.J. Cholnoky and F.R. Schoeman (e.g. Cholnoky, 1960; Schoeman and Archibald, 1976).

Each species was assigned a code name (See Appendix). The decision to use code names was mainly because it is easier for the layman to use and recognise an 8-letter codename than the full scientific name. The decision was also based on the fact that we were sometimes uncertain of genus and species. The feeling was that a code name can remain or subsequently be altered if necessary. In the Appendix, the code names used in this report are associated with the identities as we identified them to the best of our ability.

The rules applied to the application of a code name are as follows:

1. Each code name shall comprise the first four letters of the genus followed by the first four letters of the species, i.e. *Navicula gregaria* = NAVIGREG.
2. Where the first four letters of a genus is the same as the first four letters of another genus, the genus further down the alphabetical order shall use the first two letters followed by the last two, i.e. *Petrodictyon* and *Petroneis*. In such cases, *Petrodiction* would produce PETRO- whereas *Petroneis* would produce PEIS-. Thus *Petrodictyon gemma* has the code name PETRGEMM, while *Petroneis humerosa* has the code name PEISHUME.
3. Where a species has a variety, the last four letters are reduced to the first two (in upper case) and the first two letters of the variety in lower case, i.e. *Amphora ovalis* var. *affinis* = AMPHOVaf.
4. Where a species cannot be correctly identified, cf (compare) is used. This implies that the closest match possible to a published species is that shown, i.e. EUTIcfSO = *Eunotia soleirolli*.
5. These names sometimes get more complicated and an example is *Navicula gregaria* Donkin var. 1. In this instance, the species clearly has not been fully resolved and a number of sub-varieties can be observed. Hence in this example, *Navicula gregaria* Donkin var. 1 = NAVIGRv1
6. Where it has not been possible for us to identify a species from the available literature, the genus name is just entered followed by "sp" and a number, i.e. SEMIsp01 = *Seminavis* sp01.

3.4 Water quality analysis

The water samples (250 ml) collected at each river site were taken by the DWAF representative present during the collection, preserved with $HgCl_2$ (8 mg.l^{-1}) and analysed at the laboratories of Resource Quality Services (RQS), Department of Water Affairs and Forestry, Pretoria, South Africa (National Laboratory Accreditation Service, Accredited Laboratory No. T0073). The samples were analysed for EC, NH_4, NO_2+NO_3, F, pH, alkalinity as $CaCO_3$, Na, Mg, Si, PO_4, SO_4, Cl, K, Ca and total dissolved solids (TDS). *In situ* dissolved oxygen (WTW, Oxi 330), electrical conductivity (YSI model 30 conductivity meter), pH (UniFet 100 pH meter) and temperature (read from the conductivity meter) were measured in situ at some sites. In those cases where the samples were taken by Rand Water, Durban Metro and Umgeni Water, the water samples were handled and treated in their own prescribed manner.

4. DATA ANALYSIS

4.1 Background

Diatoms respond to the environment of their habitat. While some species are just tolerant to high parameter levels, others require these high levels. Hence, some species are tolerant to high levels of, for instance, salinity while others are not. This adaptation to high salinity is the first level of discrimination between those species found in marine and brak environments and those found only in freshwater habitats.

The chemical constituents of water are only some of the factors that determine the presence and dominance of indicator species because diatoms also respond to other parameters, e.g. light intensity and water velocity. Presumably, if the determinant parameters influencing diatom dominance change, the frequency of occurrence of the species will change in favour of another species. The latter will then become dominant as long as the determinant parameters are present.

While the foregoing is the theory behind the use of diatoms as indicators of water quality, there is less understanding about the rate of change within diatom communities in response to environmental parameter change. Do all diatoms grow at the same rate? Do those in the most favourable environment outgrow the others? Do those in an unfavourable environment stop growing? Furthermore, do those diatoms growing in an environment with fluctuating parameter values adapt to the fluctuations, or does dominance change with every fluctuation? These are just a few of the questions we ask.

These unknown variables have influenced the analytical methods employed during the course of these investigations. A description follows as to why some methods have been reported while others, popular elsewhere, have not been used.

4.2 Canonical Correspondence Analysis (CCA)

CCA in its various forms is currently the most common form of interpretation used by the international scientific community involved in diatom analysis. In this project, however, data have shown that the only water quality variable of significance was total dissolved solids (TDS). For this reason, the use of CCA as an analytical method was not pursued.

While CCA is an excellent analytical tool for use with vegetation analyses in that it allows relationships to be established between vegetation types and the environmental variables that determine the presence, absence and dominance of species, in the case of diatom research there are problems not normally encountered with other vegetation analyses. A specific problem relates to the time-based rate of mineral element fluctuations in rivers. In some areas of the world where the source water has relatively constant mineral values, (e.g. countries with large lakes discharging fairly constant volumes into rivers), the rate of change of mineral element parameters is likely to be much slower than in semi-arid countries where rain often falls in one catchment area while another remains dry. In the former countries, the dominant diatom communities will change slowly, if at all, because water quality influences change more slowly than they do in the latter.

Even if diatom species dominance in rivers does not change in response to rapid changes in water quality, we will be unable to recognise this until we have a large number of analyses, i.e. n must be large. In the case of grassland, a single application of fertiliser (especially nitrogen) can increase the growth, palatability and yield of indigenous grasses, but will not cause the dominant species to change. If the fertilisation is continued for a long period (years) then clear changes in grass species dominance occur (Bate, 1959). This time frame is not likely in the diatom community.

Relating this to CCA analyses in the case of grassland, an increase in soil nitrogen will have no effect in the short-term. The outcome of the analysis will indicate that nitrogen has no effect on grassland species dominance. The long-term CCA analyses will show the opposite. In the case of diatoms, however, the species may respond to a pulse of high nitrogen but the analysis of the water will not indicate the pulse unless the sample was taken at the time the pulse was passing the site. Continuing the analogy of grassland, Bate and Heelas (1974) showed that the grass species that became dominant under high nitrogen had a biochemical ability to utilise high nitrogen, while the indigenous species did not. Does the same set of biological conditions exist in diatoms? Are they able to take up luxury quantities of minerals and then become dominant over a period of time, i.e. are they integrating high mineral level pulses rather than requiring a continuous high level?

After due consideration of the foregoing factors the conclusions arrived at resulted in our rejecting CCA as a method of analysis in this project. This conclusion is supported by data emerging from the early part of this project (WRC K5/814), where CCA in its various forms was only able to demonstrate a statistically significant response by diatoms to TDS.

4.3 Diatom Indices

The use of diatom indices has been described in the literature (Prygiel 2002).
A biological diatom index (IBD) has been developed in France as one means of managing water quality, and the system has been made applicable to the whole French hydrological network.

The system relies on epilithic diatom community relationships in water. To develop these relationships, information from 949 stations was assembled over a period of 17 years. The data comprise 1048 taxa from 1332 inventories. To reduce this large number, the first priority was to exclude those species considered as rare. The second was to arrange into groups the species that were difficult to identify using optical microscopy.

The French IBD system considers 14 chemical parameters (water temperature, pH, EC, TSS, BOD, COD, dissolved oxygen as O_2 and O_2% NTK, NH_4, NO_2, NO_3, PO_4 and chloride), some of which are not routinely reported in RSA.

The IBD system was not considered suitable as a method for use in this study because there are at present not nearly enough data in RSA to undertake a similar comparison. As yet we have insufficient data to determine which taxa are rare and which are not. Furthermore, we are working with the epipelon rather than epilithon, in order to unite data for both rivers and estuaries. Exposed stones are rare in South African estuaries because of the high silt content brought down by rivers during floods.

This project has analysed the ability of the dominant epipelic diatoms to reflect water quality, because these are relatively easy to determine and might therefore be implemented across the country. It is possible that when more manpower is available for diatom investigations, a national index system might be developed along the same lines as the European IBD.

4.4 Water Quality Index

The arbitrary water quality index, in the context of this report, is a set of numerical values to indicate the concentration of chemical constituents present in river water. The term "arbitrary" is used to indicate that the values contained have no biological or chemical reason for being used, but simply reflect a case for comparison.

The water quality index values chosen in this study were taken from the Swartkops River in the Eastern Cape, South Africa, because those data were the most comprehensive available. More particularly, they represent water quality data from a system that is almost pristine at the head to rather polluted at the lower extremity. Hence this Water Quality Index (WQI) is one of the data sets by which diatoms, identified as dominants in this project, were classified.

The water quality data taken from the Swartkops River are shown in Table 1 and illustrate that the ranges between minimum and maximum values for these data are narrower than for the "all South Africa" data. To construct an index from the wide ranging data set from all the RSA data results in lower sensitivity. On the other hand, some of the Swartkops River maximum values are higher than the Canadian Drinking Water Standards (Health Canada, 2002), which implies that an arbitrary set of standards, based on Swartkops River quality values, might be suitable as a comparative standard for use in this report. Importantly, the data in Table 1 show that the maximum values of the Swartkops River data cover 90 - 100% of all the values taken from 212 river sites in all the obvious phytogeographical regions of South Africa.

Table 1. Water quality (WQ) data from the Swartkops River showing the minimum and maximum values for each factor by comparison with the minimum and maximum values taken from all the sites in South Africa during this study and the percentile of the Swartkops maximum compared with the RSA maximum. (All units; $mg.l^{-1}$ except for pH and EC ($mS.m^{-1}$).

Component	Swartkops River minimum WQ value	Swartkops River maximum WQ value	All RSA minimum WQ value	All RSA maximum WQ value	Swartkops River maximum WQ as a %ile
Ca	2	90	1	504	94.9
Cl	40	1577	<10	6844	99.3
F	0	0.5	<10	0.7	96.4
K	0.6	34.2	0	242.6	94.3
Mg	3	129	1	690	98.8
Na	24	899	<0.02	3645	99.4
NH_4	0	3.8	<0.04	295	99.4
NO_3+NO_2	0	6.2	<0.04	340	96.8
pH	6.81	8.8	4.2	9.6	97.9
PO_4	0.01	7	<0.01	336	93.1
SiO_2	0	8.9	0.5	47	92.8
SO_4	0	514	2.1	2114	98.1
Alkalinity	7	851	6	851	100
TDS	95	3380	26.1	14139	99

The Water Quality Index is presented in Table 2. The determination of an index class is that Class 1 begins at the lowest value found from the Swartkops River data, while a Class 2 has the range (Class 2-Class1)/2. The same principle applies for the other classes. Anomalies occur where the water quality at a site is either below the minimum of the index range or above its maximum. This has been accommodated in cases where the number is higher than the maximum in the Swartkops series, by applying a suffix to the class value, where relevant. Hence, it is possible to have a Class 1- or a Class 5+.

To determine the water quality index for a species, the data for that species was copied to an MS Excel sheet where the data in Table 2 were situated. The calculation of the index was performed in Excel by reference to water quality boundaries. Hence, TDS Class 1 was calculated using nested conditional statements from 0 to 819.45 (922.45-103.00) (Table 2). Class 2 was calculated as (922.45-103.00) to (1741.50-922.25), and so on. If a class was calculated to be more than 3380 $mg.l^{-1}$ for TDS (Table 2) then it was classified as 5+. If it was more than an order of magnitude higher than the upper boundary for Class 5 then it was given the value of Class 5++, because of the exponential nature of all the RSA water quality data for all sites sampled (except for pH). In the calculations, pH was ignored in arriving at the average class for a species because pH is not relevant as an indicator of water quality in the same way as the other parameters. pH does not provide any mineral nutrient. It alters the solubility and chemical structure of mineral elements and in this way might influence the response of diatoms to a water body. However, as far as water quality is concerned, within the natural ranges of pH, it does not seem to be a factor. It certainly never seems to be significant in any statistical analysis, i.e. CCA. Also, it is not a component of TDS, which seems to be the major factor to which diatoms respond. The higher the TDS, the greater is the probability that the water quality has deteriorated due to pollution.

The use of an average Water Quality Index allows one to assess rapidly the overall water quality of the site where the species was found as the dominant. At the same time, the quality of the water for each of the components can also be quickly determined.

4.5 Location of Water Quality Component Spread using Percentiles

Using a Water Quality Index only does not allow one to see where the data for each WQ component fits into the greater picture of RSA water quality values. To overcome this, the percentile value for each WQ component was determined using MS Excel. The percentile value for each species/WQ component was then read off the "All-RSA" data sheet.

Table 2. Ranges of values from the Swartkops River used in the determination of the water quality classes. (All values in mg.l^{-1} except for pH and electrical conductivity (EC) mS.m^{-1}).

Component	Class 1 Range		Class 2 Range		Class 3 Range		Class 4 Range		Class 5 Range	
	Low	High	Low	High	Low	High	Low	High	Low	High
Ca	2.00	13.00	>13	35.00	>35.00	57.00	>57.00	79.00	>79.00	90.00
Cl	40.00	232.13	>232.13	616.38	>616.38	1000.63	>1000.63	1384.88	>1384.88	1577.00
EC	17.30	128.01	>128.01	349.44	>349.44	570.86	>570.86	792.29	>792.29	903.00
F	0.00	0.05	>0.05	0.15	>0.15	0.25	>0.25	0.35	>0.35	0.40
K	0.60	30.85	>30.85	91.35	>91.35	151.85	>151.85	212.35	>212.35	242.60
Mg	3.00	18.75	>18.75	50.25	>50.25	81.75	>81.75	113.25	>113.25	129.00
Na	24.00	133.38	>133.38	352.13	>352.13	570.88	>570.88	789.63	>789.63	899.00
NH_4	0.00	0.48	>0.48	1.43	>1.43	2.38	>2.38	3.33	>3.33	3.81
NO_3-NO_2	0.00	0.78	>0.78	2.33	>2.33	3.89	>3.89	5.44	>5.44	6.22
pH	6.81	7.07	>7.07	7.58	>7.58	8.10	>8.10	8.61	>8.61	8.87
PO_4	0.01	0.88	>0.88	2.62	>2.62	4.36	>4.36	6.10	>6.10	6.97
SiO_2	0.00	1.11	>1.11	3.34	>3.34	5.56	>5.56	7.79	>7.79	8.90
SO_4	0.00	64.25	>64.25	192.75	>192.75	321.25	>321.25	449.75	>449.75	514.00
Alkalinity	7.00	112.50	>112.50	323.50	>323.5	534.50	>534.5	745.50	>745.50	851.00
TDS	95.00	505.63	>505.63	1326.88	>1326.88	2148.13	>2148.13	2969.38	>2969.38	3380.00

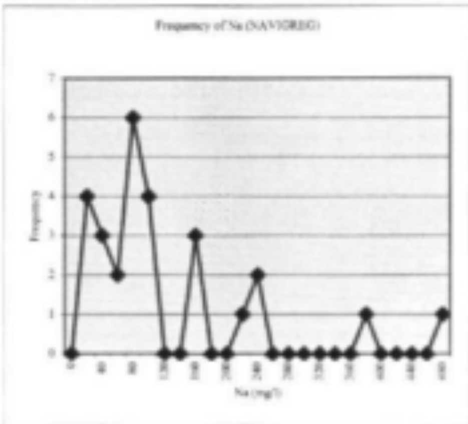
The value of percentiles is that, unlike the WQ Index, the percentile data illustrate where the species fits into the overall water quality for the sites sampled in South Africa. In the case of the ubiquitous NAVIGREG, found in both rivers and estuaries, the use of percentiles illustrated that in our samples it never occurred at any site unless the Na content was > 12th percentile and the Cl content > 13th percentile. These are equivalent to a Na content of 10 mg.l^{-1} and a Cl content of 15 mg. l^{-1}.

4.6 Identification of the maximum frequency of occurrence of WQ components

While the foregoing methods of calculating a value by which individual species can be assessed provide useful information, a means of positioning the species into a WQ category, and assessing the frequency of such positioning, was also deemed valuable.

To make these assessments, those species that had been dominant at a minimum of 5 different sites were used to test the value of this calculation. In the case of NAVIGREG, the data showed that although it was found in water with a wide range of Na and Cl, it occurred more frequently at the lower values for all rivers sampled (Figures 1a and b).

(a) (b)



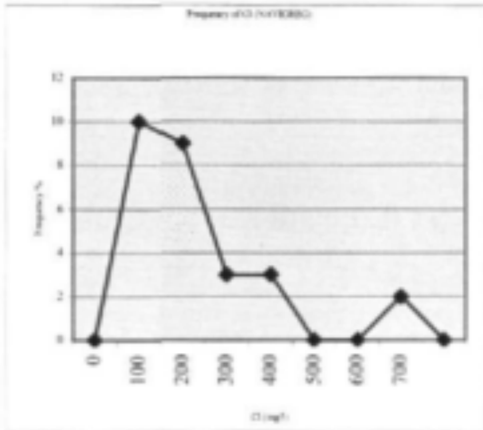


Figure 1. The frequency of occurrence of Na^+ and Cl^- for NAVIGREG at different concentrations in the rivers from where the species was dominant.

From the data set, it is not possible to determine whether the range of NaCl in which NAVIGREG is dominant is just distributed that way (in which case the species is not responding to the concentration) or whether the low frequency but higher concentrations in the rivers were spikes to which the diatom was not responding because the duration of the water quality level was too short. For these reasons, the Water Quality Index used is the only value provided in the pages illustrating the dominant species found in this project.

4.7 Comparison between the rating of Van Dam *et al.* (1994) and the rating provided by the Water Quality Index

A comparison was made between those species that were found in both the van Dam *et al.* (1994) data and the species found in this project. This was achieved by comparing an average van Dam value and our average Water Quality Class using regression analysis (Statistica). In the case of the Water Quality Class, the TDS value was omitted so as not to bias the results with what would effectively be a double TDS component.

4.8 Comparison of the Swartkops water quality classes (Project K5/814) and the Water Quality Class for species found in all South African rivers sampled in Project K5/1107

The purpose of this set of calculations was to gain an impression of whether the species classes changed as water quality changed. The comparison was undertaken using data for the 13 month sample series in the Swartkops River, to see whether the species changes over that period (September to October) were similar to actual water quality changes. To do this, each of 14 water quality parameters were graphed against the Swartkops Water Quality data for the 6 sites. This yielded too many graphs to present in the final report (i.e. 84). These data can be seen in the CD provided and in the Excel spreadsheet "SWQCvDa.xls". Although the WQC is calculated from the water quality values measured from the Swartkops River only, the species index is that value calculated for species from all the South African rivers and the corresponding water quality data.

5. RESULTS AND DISCUSSION

5.1 WATER QUALITY

The project was designed to identify which diatoms can be used to assess the water quality of rivers and estuaries. The hypothesis is that water quality forms an important component of the habitat in which the organisms are living. However, the water quality is not the only habitat component to which diatoms respond. For this reason, within a given water quality range, there may be many taxa. Hence, if a body of water has a given range of water quality, it will not necessarily be possible to specify which diatom taxon will be dominant. However, the hypothesis states that a dominant diatom flora should indicate the water quality within a certain range.

Van der Molen (2000) showed that "water quality taken from the Swartkops River is often very variable. River flow (measured at site D) was generally below 1 $m^3.s^{-1}$ (Figure 2). The physical conditions at the sampling sites were such that the flow velocity seldom exceeded an estimated 0.3 $m.s^{-1}$. Zero flow conditions were recorded on several occasions during the two years of the survey" (Figure 2). The fact that water flow varies to the extent shown in Figure 2 indicates that quality will also vary to some extent, but not necessarily to the same extent for each chemical constituent. At the same time, the sampling during the study took place at monthly intervals, hence variations in population densities may not be relatable directly to the available water quality values. The reason for this is that if a "spike" of ammonium were to flow down the river between the two sampling dates, the species might change in response to it if it was present for long enough. Similarly, the "spike" may be of very short duration and the diatom flora may not be affected by it, yet the water sample might have been taken while it was passing.

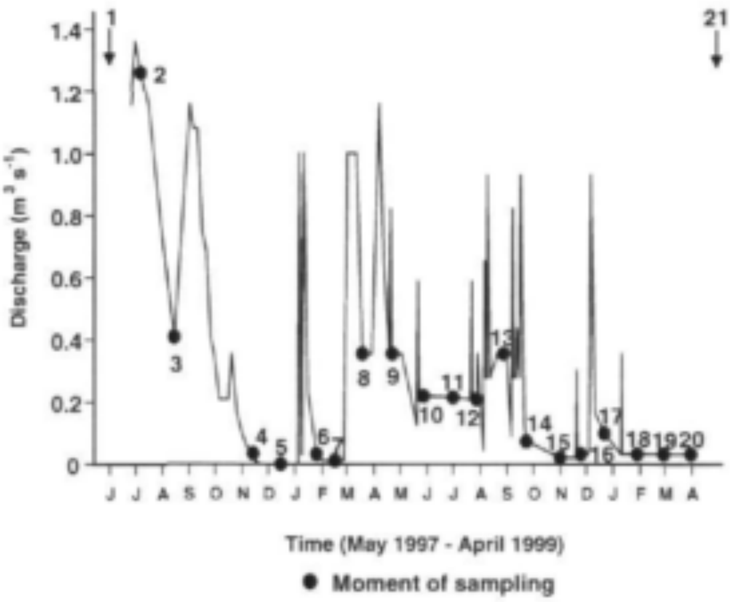


Figure 2. Discharge ($m^3\ s^{-1}$) at site D between June 1997 and April 1999. Numbers indicate consecutive sampling sessions. No flow data available for sessions 1 and 21.

The maximum and minimum water quality values analysed by the Department of Water Affairs and Forestry for samples from this project are given in Table 1. They show that certain South African river sites have concentrations of chloride, fluoride, sodium, nitrate, sulphate and TDS that would render them unsuitable as drinking water by, for example, Canadian standards. The presentation of diatom data as an indication of water quality can be done by simply showing the actual water quality values of the sites in which the diatom species were found. The problem with that approach is that the reader is left without any perspective of where the species lies in the context of all South African water quality values. If an index of water quality is constructed from all the water quality data collected in this project, the spread will be very great and, therefore, not useful. For this reason the choice was made to construct an arbitrary index using data from the Swartkops River. This choice was made because, as has been said, information was available from collections made from 6 sites over a period of 13 consecutive months. The analysis of water quality data was undertaken by DWAF (RQS) Pretoria and included samples from sites situated in the mountains west of Port Elizabeth down to contaminated sites near Despatch, a heavy industry area.

The data for the complete range of South African sites showed that the water quality values were not normally distributed except in the case of pH. This is because there are a few very high values and a great many lower values.

The water quality analyses for TDS were examined as individual values by comparison with the sum of the component salts. The results showed that the sum of all the constituent salts was 102% of the TDS value. The 2% discrepancy was likely due to rounding up of decimals. Where TDS was not reported in the data set, it was derived by multiplication of EC by 6.5. This constant was checked using data where TDS was reported. The average of all available data was 6.49 and the mean value of 6.5 was accepted.

A multiple regression analysis of the water quality data (only those data that were complete for a site) was undertaken, using Statistica 6.0. The results are shown in Table 3.

Table 3. Multiple regression analysis of the components of TDS against the TDS value.

n=94 units = ($mg.l^{-1}$)	Regression summary for dependent variable: TDS ($mg.l^{-1}$). R=0.999; R^2=0.999; Adjusted R^2=0.999; F(12,81)=1942e^2; p<0.000; Std Error of estimate: 5.668					
	Beta	Std.Err. of Beta	B	Std Err. of B	T (81)	p-level
Intercept			**2.428**	**1.672**	**1.452**	**0.150**
Ca	0.038	0.003	1.234	0.097	12.611	0.000
Cl	0.429	0.016	0.944	0.035	26.777	0.000
F	**-0.002**	**0.002**	**-0.133**	**0.108**	**-1.235**	**0.220**
K	0.028	0.001	0.934	0.051	18.014	0.000
Mg	0.045	0.005	1.060	0.122	8.670	0.000
Na	0.294	0.015	1.089	0.056	19.194	0.000
NH_4	**0.000**	**0.000**	**1.358**	**1.119**	**1.213**	**0.228**
NO_3	0.015	0.000	4.957	0.258	19.201	0.000
PO_4	**-0.000**	**0.001**	**-0.008**	**0.040**	**-0.206**	**0.836**
SiO_2	**-0.000**	**0.001**	**-0.275**	**0.578**	**-0.475**	**0.635**
SO_4	0.171	0.004	0.953	0.027	35.323	0.000
Alkalinity	0.153	0.004	1.209	0.031	38.314	0.000

The results of the analysis show that F, NH_4, PO_4 and SiO_2 were not significantly (closely) associated with the TDS values. The implication of this is that the standard errors (SE) of TDS and the non-correlated mineral elements are not similar. This prompted an investigation of the outliers in the relevant data. First investigated was fluoride. The highest data point had been entered as $mg.l^{-1}$ whereas the analysis was reported as $\mu g.l^{-1}$. Hence 119 $mg.l^{-1}$ altered to 0.119

mg.l^{-1}. The corrected distribution of the F-data representing sites from where a complete data set was available is shown in Figure 3.

After the fluoride data were corrected, a further multiple regression analysis of the TDS components and TDS itself showed that concentrations of fluoride and ammonia were still not significantly correlated, but that phosphate and silicon were (Table 4). An investigation of fluoride and ammonia data did not reveal any further errors that could be attributed to transcription. Hence, the conclusion must be that the reported analytical data are in error somewhere at the point of analysis. Ammonia is very difficult to analyse accurately because of absorption of gaseous NH_3 from the atmosphere. However, no such difficulty seems to exist for silicon.

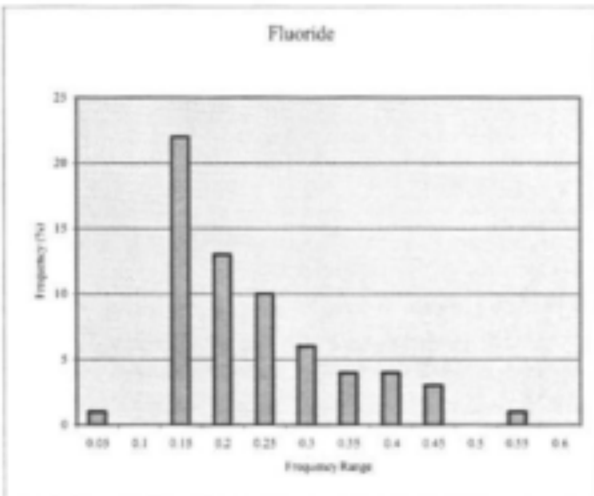


Figure 3. Frequency distribution of fluoride at the different stations where samples were taken during the study.

The relationship between the diatom WQI and the average value obtained by van Dam et al. (1994) for the same taxa was tested by regression analysis. A visual relationship is presented in Figure 4. The data show that there is a positive relationship between the average values derived from the van Dam et al. (1994) data and the WQC data from this project. Although the R^2 value was low, it is necessary to recall that the van Dam sources include historical non-quantitative data. While the data in this project are quantitative, they are mainly from single samples from a large number of sites, rather than a large number of samples from a small number of sites. Water quality variability in this context is an aspect discussed later.

Table 4. Multiple regression analysis of the corrected data for the components of TDS against the TDS value.

n=94 units = $mg.l^{-1}$	Variables in the equation; DV: TDS ($(mg.l^{-1})$; $R=0.999$; $R^2=0.999$; Adjusted $R^2=0.999$; $F(12,81)=1933e^2$; $p<0.000$; Std Error of estimate: 5.681					
	Beta	Std.Err. of Beta	B	Std Err. of B	T (81)	p-level
Intercept			2.820	1.566	1.800	0.075
Ca	0.034	0.003	1.115	0.127	8.751	0.000
Cl	0.436	0.016	0.961	0.036	26.562	0.000
F	**0.001**	**0.001**	**10.763**	**10.164**	**1.058**	**0.292**
K	0.029	0.001	0.951	0.057	16.429	0.000
Mg	0.044	0.005	1.047	0.121	8.654	0.000
Na	0.286	0.015	1.058	0.058	18.039	0.000
NH_4	**0.000**	**0.000**	**1.381**	**1.122**	**1.231**	**0.221**
NO_3	0.015	0.000	4.982	0.256	19.440	0.000
PO_4	-0.002	0.000	-0.051	0.018	-2.780	0.006
SiO_2	0.001	0.000	-0.756	0.376	-2.009	0.047
SO_4	0.174	0/004	0.968	0.027	35.695	0.000
Alkalinity	0.154	0.003	1.218	0.030	40.593	0.000

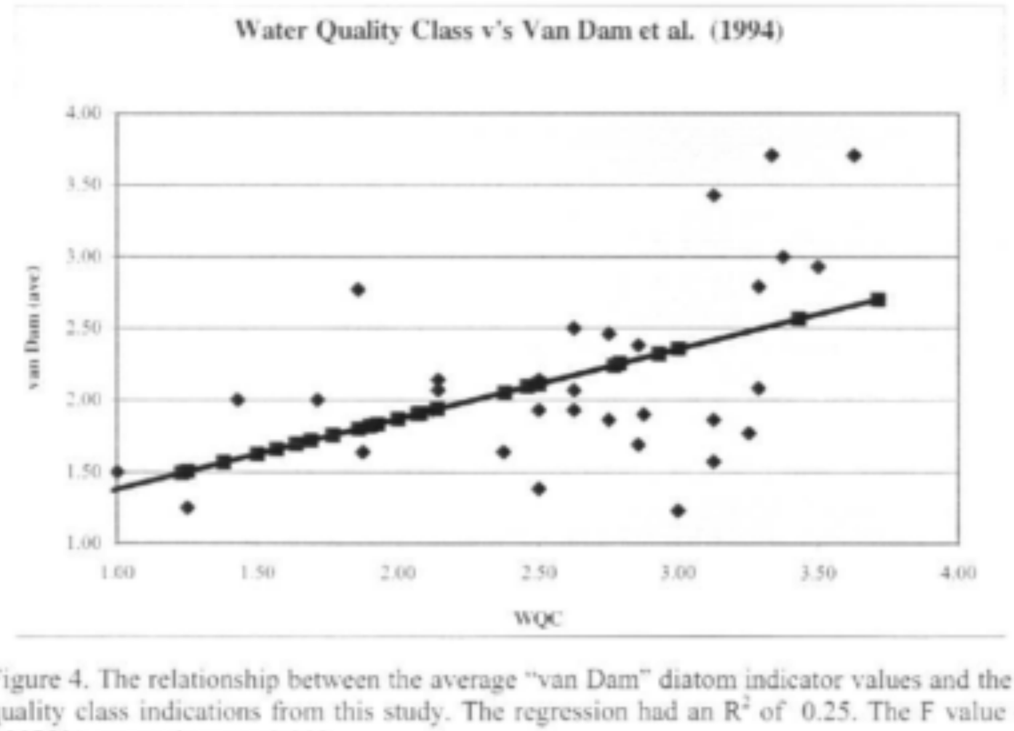


Figure 4. The relationship between the average "van Dam" diatom indicator values and the water quality class indications from this study. The regression had an R^2 of 0.25. The F value of the ANOVA regression was 0.003.

5.2 ESTUARY PELON

5.2.1 Dominants

The results showed that 168 taxa were either dominant or sub-dominant (>10%) in the 289 sites sampled. Of these 168, 122 taxa were found as dominants. Species with a frequency of < 10 % were ignored. The remaining 46 were found at a frequency of > 10% but were never dominant.

NAVIGREG (*Navicula gregaria* Donkin) was found 57 times, 36 times as the dominant and 21 as the sub-dominant (>10%). Of the 36 sites at which it was dominant, 19 were intertidal while 17 were subtidal, indicating no preference for either. The salinity in which the species was found ranged from 1 to 36 $g.l^{-1}$. This wide range of habitat has been reported in the literature (Sims *et al.* 1996; Lange-Bertalot 2000; Schoeman and Archibald 1976), which also showed that the species has a widely variable morphology. In order to examine whether the wide range of salinity tolerance might also be correlated to gross valve morphology, the original slides were re-examined. This was to see if there were different morphological characteristics within the taxon, upon which they might be separated. Using the descriptions from Barber and Haworth (1981) the following attributes were examined: valve ends (subcapitate to rostrate), striae (parallel throughout to slightly radiate at the centre), aerolae (rod-shaped to almost invisible), axial area (parallel and abruptly widening to a circular central area), raphe (straight on a ridge-like and quite wide axial area, or on a narrow axial area).

No morphological relationships could be associated with any salinity value or range. Sims (1996) showed that *N. gregaria* is considered to occur in fresh, brak or marine habitats. Sims (1996) also indicated that the taxon is quite variable; a point also made clearly by Round (2001). NAVIGREG occurred 7 times in the Breede Estuary. On 5 occasions, it was found on one sampling date viz., the 18 March 2000. Figure 5 shows that the distribution of salinity was unusual in that the upper three sites (3, 4 and 5) were fresh because of heavy rains. The data in Figure 5 illustrates the problem of salinity in estuaries, in that at any one site salinity changes depending on the tide and the discharge of freshwater from the river.

NAVIGREG was found in estuaries all around the coast of South Africa from the Olifants Estuary on the west coast to the Mngazana Estuary just south of Port St Johns on the east coast. It seems unlikely therefore, that it has a specific temperature preference. It seems to have been well named but is not a useful species as a specific estuarine habitat indicator because it is also very common in South African rivers.

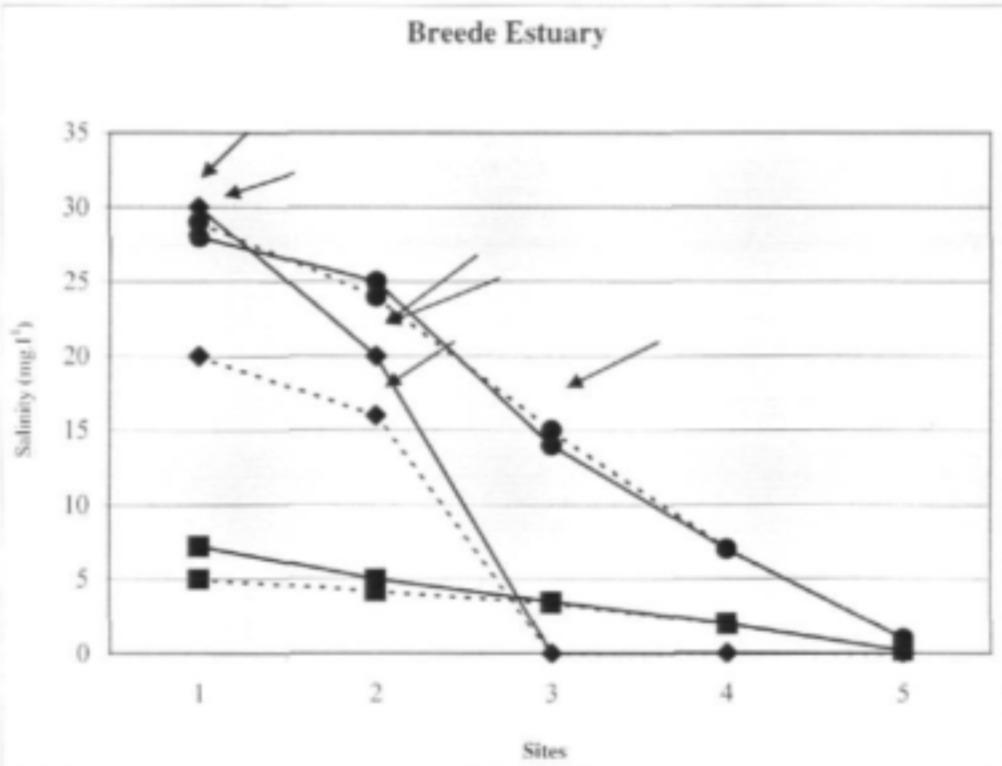


Figure 5. Salinity values in the Breede Estuary at the time that samples were collected for analysis. (▲- 18/03/2000; ■ - 11/08/2000; • – 3/04/2001. The different lines indicate the different sampling dates. Solid lines – subtidal sites; Broken lines = intertidal sites. The arrows indicate the positions where NAVIGREG was found).

The taxon found at the second highest frequency was PLANDELI (*Planothidium delicatula* (Kutzing) Round and Buktiyarova. This taxon occurred 20 times, 11 as the dominant and 9 as the sub-dominant. Of the 11 sites where it was dominant, 10 were subtidal where the salinity ranged from 10-39 $g.l^{-1}$. In 10 of the 11 cases the salinity ranged between 21-39 $g.l^{-1}$, placing it mostly in the high brak to marine category. Lange-Bertalot (2000) considered it a marine to brak taxon, while Hustedt (1976) described its habitats as coastal waters with low brak and only occasionally freshwater. Sims (1996) considered it a fresh to brak taxon. Round and Bukhtiyarova (1996) reclassified PLANDELI from *Achnathidium delicatulum* Kutzing and noted that it was a taxon recorded as marine or electrolyte-rich inland waters. Hence, the results from this study fit well with the literature except that it has appeared more commonly in high brak to marine habitats. PLANDELI has been reclassified quite frequently which suggests that it is difficult to identify. This is not the case however, because while its taxonomy might be difficult, it is easy to recognise.

The taxon found at the third highest frequency was NAVISALI (*Navicula salinicola* Hustedt) initially believed to be dominant at 13 sites. The salinity of the water with this taxon ranged from 0 to 30 $g.l^{-1}$. Except for three sites that had salinity values of 0, 5 and 6 $g.l^{-1}$, the salinity ranged from 27 to 33 $g.l^{-1}$, indicating that the taxon is mostly an indicator of a strong brak or marine habitat. Images of all 13 examples of this taxon were examined without prior reference to the salinity at the site where they were found. The results were that three images showed different characteristics to the others. All three of them fell into the low salinity ranges. Since NAVISALI is the code name for *Navicula salinicola* Hustedt, a marine to high brak taxon (Lange-Bertalot, 1996), the probability was that it had been mis-identified initially. Further examination of the three images indicated that they were more like NAVITENE (*Navicula tenelloides* Hustedt), a freshwater taxon (Sims, 1996). They were therefore transferred to NAVITENE. (For further comment on possible mistaken identity between NAVISALI and NAVITENE, reference is made to Archibald (1983, pg 200-201) and his discussion of the possible initial misidentification of the two taxa by Simonsen and Cholnoky).

The remaining 10 taxa of NAVISALI were all from habitats having salinity values ranging from 27 to 33 $g.l^{-1}$. In estuaries where freshwater has been flowing continuously for some days or weeks, the salinity gradients are frequently both vertical and longitudinal. This means that if a sample has been taken from a site below the low-water depth, it is still possible that the habitat will have experienced low salinity, or freshwater, for a long or short duration. Similarly, the further the inter- and subtidal samples have been taken up the estuary, the greater the likelihood that there will be a lower salinity than those near the mouth and therefore more influenced by tidal surge.

In addition to the 10 occasions where NAVISALI was dominant, it was also found as the sub-dominant on 6 occasions.

AMPHSUBL (*Amphora sublaevis* Hustedt) was found 14 times and dominant at 10 sites. All of the latter had salinity values of between 24 to 38 $g.l^{-1}$, placing it in the high salinity to marine indicator range. On closer examination, the data revealed that it was found only in sites that were strongly marine influenced. The one case that might be problematical was that where the salinity was 24 $g.l^{-1}$. This site was in the Olifants Estuary at the intertidal site at the mouth. Work done at this site (Bornman, *et al*. 2002) showed that the intertidal sites were adjacent to a salt marsh in an arid region. Our interpretation of this is, therefore, that the species is marine and when found in an estuary is an indicator of seawater penetration. The species was located on a single occasion half way up the Swartkops Estuary (site 3) at a salinity of 33 $g.l^{-1}$, which would imply that it could tolerate high brak conditions. In this case, the Swartkops Estuary was hypersaline with salinity values of 28-37 $g.l^{-1}$ with no vertical gradient.

AMPHSUBA (*Amphora subacutiuscula* Schoeman) occurred 21 times and was dominant at 9 sites where the salinity range was from 2.6 to 34 $g.l^{-1}$. At 7 of these sites, the salinity ranged from 26 to 34 $g.l^{-1}$. It was found in Durban Bay at site subtidal 4 at a time where the salinity was 20 $g.l^{-1}$. The low salinity at this time was unusual because although the site is deep into the harbour, the water was very clear and similar to the rest of the marine water in the bay. It is highly likely that the salinity of this site was temporarily low because it was on a sandbank where rainwater might have accumulated causing the temporarily low salinity.

It was found in the Mtata Estuary mid-way from the mouth to the head (site intertidal 3) when the salinity was 2.6 $g.l^{-1}$. Lange-Bertalot (2000) described the species as being from brak water without specifying a salinity value. The Mtata Estuary is one where fine muddy particles make the water extremely turbid. Since this is the only site where AMPHSUBL was found at such a low salinity, we prefer to consider the Mtata site as unacceptable and reject it from the data set. This would place AMPHSUBL as an indicator of high brak to marine.

AMPHCOFF (*Amphora coffeaeformis* Agardh) was found at 20 sites and at 8 sites where it was dominant the salinity ranged from freshwater to 31 $g.l^{-1}$ at both subtidal and intertidal sites. The images from each of the sites were compared without reference to the salinity values because Archibald (1983) stated that it was an "extremely complicated group with a number of similar taxa". He reported that it had been "recorded from a number of localities in South Africa but mainly from inland alkaline freshwaters". However, he refers to the fact that *Amphora veneta* var *capitata* had often been mistaken for *A. coffeaformis*. It seems therefore that *A. veneta* v. *capitata* is the freshwater species, while *A. coffeaformis* is the brak indicator. The brak indication is not, however, narrow with respect to salinity.

BACIPAXI (*Bacilllaria paxillifera* (O.F. Müeller) Hendy – Syn. *B. paradoxa* Gmelin) was found at 16 sites of which it was dominant at 8 and where the salinity ranged from freshwater to medium brak (~20-25 $g.l^{-1}$). Lange-Bertalot (2000) found this species in "brakish water" or as a "species commonly inhabiting marine coasts and very electrolyte-rich waters". Sims (1996) considered it a brak species while Hustedt (1976) quoted it as found in salt-water of different concentrations. Hence, the data from this study conform to the average salinity values from the literature.

FRAGELLI (*Fragillaria elliptica* Schumann) was found at 7 sites (never sub-dominant) in water with salinity ranging from fresh to 38 $g.l^{-1}$. In the Breede Estuary, it was found in freshwater and low salinity (7 $g.l^{-1}$). Where it was found in the Swartkops Estuary, the salinity data are not recorded, but it was at the head of the estuary at site 5 and therefore at low salinity. The site where the salinity was recorded as 38 $g.l^{-1}$ was in the Keurbooms Estuary at intertidal 2. This was an odd reading, because intertidal 1 had a salinity of 34 $g.l^{-1}$ while intertidal site 3 had a salinity of 19 $g.l^{-1}$. The salinity of 38 $g.l^{-1}$ was, therefore, the highest recorded from the estuary. Krammer and Lange-Bertalot (1991) noted that Archibald had found it in brak and in freshwater sediments. However, the aerolae were somewhat different to normal, which raised doubt as to whether it was a true example of the taxon. The genus is most commonly epipelic in freshwater but with a few taxa in the plankton (Round *et al.* 1990). The genus is colonial and, when it is digested, it commonly occurs in quite high numbers. The frequency where it was found in 38 $g.l^{-1}$ was the lowest of all the sites (12%). This may indicate that the species is more of a fresh to low salinity indicator and that the single sighting in high brak was abnormal.

NAVITENE (*Navicula tenelloides* Hustedt) was dominant at six sites (plus 3 sub-dominant). Of the dominants, 4 were found in low brak to freshwater, but two were found at > 30 $g.l^{-1}$. Sims (1996) considers the species to be found in freshwater. The only other reference to the species is Archibald (1983) who found it in the Sundays Estuary at high salinity. His comments are in accord with the data from this study. Archibald (1983) was of the opinion that NAVITENE may form a "continuum" with NAVISALI.

DIPLELLI (*Diploneis elliptica* (Kutzing) Cleve) was dominant at 5 sites (plus 7 sub-dominant). The dominants were found where the salinity was low to medium brak (9-28 ppt). Sims (1996) considered it an indicator of fresh to brak water, without being more specific. The data from this study appear to confirm a low to medium brak status.

HANTDIST (*Hantschia distinctpunctata* (Hustedt) Hustedt) was also dominant at 5 (plus 3 as sub-dominant) sites with salinity values of 0 to 17 $g.l^{-1}$. Sims (1996) considered it to be a freshwater taxon while Lange-Bertalot (2000) stated it to be a marine species but found in freshwater but with a high ion content, i.e. low brak. The data in this study indicate low to medium brak.

NAVIcfIN (*Navicula* cf. *incerta* Grunow) was found at medium brak to marine salinity values. This species has been named this way but it may not even be a *Navicula*. Cox (2002) declared that she had not seen anything like it before which means that it may be new to science and more work needs to be done on it. NAVIPERM (*Navicula perminuta* Grunow) was found in medium brak sites. Lange-Bertalot (2000) considered it a brakish species. NAVIPHYL (*Navicula phyllepta* Kutzing) was found in low brak. Lange-Bertalot (2000) reported, "it is probably cosmopolitan, inaccurately known due to frequent misidentification. Found only in brakish or very electrolyte-rich waters with very variable salt content or actually marine". Sims (1996) classified it as a freshwater species. This species also occurred 4 times as a sub-dominant.

NITZANva (*Nitzschia angularis* var (?) W. Smith) was found as a dominant in medium brak to marine conditions. Lange-Bertalot (2000) has an illustration but no description. It was also found on 3 occasions as the subdominant.

HASLOSTR (*Hastlea ostrearia* (Gaillon) Simonsen) was also found 4 times as the dominant at medium brak to marine sites (5 times as the sub-dominant). Lange-Bertalot (2000) considered it a marine species, as do Round *et al.* (1990). On the occasions that it was found at medium brak salinity, it was bordering on high brak according to our definition (21-35 $g.l^{-1}$). Hence, from all the data, we conclude that species described as "marine" are capable of surviving in high brak conditions in estuaries.

AMPHcfst (*Amphora* compare with *A. strigosa* Hustedt) was found as the dominant at salinity values between 0 and 33 $g.l^{-1}$. Our original identification as *Seminavis* sp03 was corrected by Cox (2001) to *Amphora sp.* The occasion where the species was found in freshwater should be discarded because the site was in the Mlalazi Estuary where the subtidal salinity values from mouth (closed) to head were 34, 34, 33, 33, 0 $g.l^{-1}$. Since the estuary was closed at the time, it is possible that our sampling site was not accurately positioned relative to the salinity sample. The single freshwater value is therefore suspicious. *A. strigosa* was described as a marine species by Lange-Bertalot (2000).

AMPHCAST (*Amphora castellata* Giffen) was the dominant on four occasions at salinity values between 9-32 $g.l^{-1}$. It was never sub-dominant. The taxon was discussed by Archibald (1983) from the Sundays Estuary but no mention was made of the salinity or the site where it was collected. The conclusion is that it can be found in a wide range of salinity.

AMPHACUT (*Amphora acutiuscula* Kutzing) was dominant at 4 sites with salinity values between 5 and 23 $g.l^{-1}$. Lange-Bertalot (2000) described the species as "brakish" which conforms to the findings from this study.

Nine taxa were each found on only 3 occasions as dominants. Their names and the salinity values in which they were found are shown in Table 5.

The data shown in Table 5 illustrate that species reportedly occurring in marine habitats can also be found in estuaries at medium salinity ranges (12-21 $g.l^{-1}$). Whether these data also indicate that the median salinity being experienced by the species is high brak or marine must remain an open question. There were 20 taxa that were each found on only 2 occasions as dominants. Their names and the salinity values at which they were found are shown in Table 6.

There were 71 taxa that only occurred on a single occasion as the dominant. These are listed in Table 7.

5.2.2 Sub-dominants

The results showed that 46 diatom taxa were found as sub-dominants (count > 10% of the total counts but not the dominant taxon). Where relevant, data about them have been included in the section on dominants. Images and codename descriptions can be found in Section 2 : Estuary Diatoms.

Table 5. The epipelic diatoms found as dominants on 3 occasions. The salinity values of the water are provided as $g.l^{-1}$ (* = number of occasions found as sub-dominant).

Code name	Salinity values for 3 site occurrences			Sub-D*	Comments
AMPHCOv2	34	34	35	1	Mainly a marine genus with some freshwater species (Round *et al*. 1990).
AMPHHOLS	18	25	25	6	Marine species (Sims, 1996).
COCCcfth	0	0	13	0	Genus is freshwater to marine (Round *et al*. 1990).
CYLICLOS	16	31	39	6	Marine epipelon (Round *et al*. 1990).
PARLBERK	34	35	38	2	Marine widespread (Lange-Bertalot, 2000). Marine (Sims, 1996).
PLEUDELI	2	4	27	2	Type locality Baakens River, Port Elizabeth. Also Sundays Estuary & Great Fish Estuary (Archibald 1983).
PROSBUbu	21	29	35	0	Marine benthic & planktonic genus (Round *et al*. 1991).
SEMIsp02	37	37	38	2	Marine epipelic genus (Round *et al*. 1990).
SEMIsp05	15	24	33	1	Marine epipelic genus (Round *et al*. 1990).

Table 6. The epipelic diatoms found as dominants on 2 occasions. The salinity values of the water are provided as $g.l^{-1}$ (* = number of occasions found as sub-dominant).

Code name	Salinity values		Sub-D*	Comments
ACHNKUEL	30	35	0	Oligotrophic medium brak (Lange-Bertalot & Krammer 1989).
ACHNMIgr	26	26	0	No habitat description in literature.
AMPHARCU	26	34	3	Marine species (Lange-Bertalot 2000 and Sims 1996).
AMPHHELE	24	27	4	Marine Arctic to South Africa (Lange-Bertalot 2000).
COCCPLAC	7	28	2	Freshwater (Sims 1996).
CYMBTURG	0	30	1	Mainly tropical freshwater (Hustedt 1976).
DIPLPUEL	16	23	4	Genus mainly marine but some freshwater species Round *et al*. (1990).
NAVIBREM	2	27	0	Freshwater (Sims 1996).
NAVIcfun	31	36	4	No habitat description in literature.
NAVICIle	0	33	1	No habitat description in literature.
NAVIDEHI	13	18	0	No habitat description in literature.
NAVINORM	12	14	2	Brak species (Lange-Bertalot 2000). Very high salinity in Sundays, Great Fish and St Lucia (Archibald 1983).
NAVIsp01	33	34	1	No habitat description in literature.
NAVIsp02	35	38	0	No habitat description in literature.
NITZAREM	34	39	0	Brak to marine South Africa (Lange-Bertalot 2000).
NITZCLAU	1	14	0	Brak species (Lange-Bertalot 2000).
NITZDIdi	17	35	1	Marine (Lange-Bertalot 2000).
NITZFRfr	30	38	1	Brak to marine (Lange-Bertalot 2000).
NITZPALE	0	3	1	Freshwater (Sims 1996).
NITZPERS	23	35	0	Brak-marine coasts South Africa (Lange-Bertalot 2000)
OPEPMINU	18	25	1	Marine species (Lange-Bertalot 2000).
PARLDELO	0	5	2	Marine species (Lange-Bertalot 2000).

Table 7. The epipelic diatoms found as dominants on 1 occasion. The salinity values of the water are provided as g.l^{-1}. (* = number of occasions found as sub-dominant).

Code name	Salinity	Sub-D*	Code name	Salinity	Sub-D*
ACHNAMOE	25	0	NAVICRYL	20	0
ACHNCONS	10	0	NAVIERIF	33	0
ACHNMINU	0	0	NAVIHAST	0	0
ACHNOBLO	0	1	NAVIMOLL	13	0
AMPHABLU	26	1	NAVIRAmu	29	0
AMPHcfCO	27	0	NAVIARro	28	0
AMPHCOMM	5	0	NAVIVAva	4	0
AMPHCOv1	4	0	NAVIVIro	0	0
AMPHCYMB	30	0	NITZafpe	35	1
AMPHDECU	36	0	NITZANGU	26	3
AMPHJOST	30	0	NITZCAPI(2)	34	0
AMPHOVaf	30	0	NITZFONT	35	1
AMPHPROT	35	2	NITZLINK	39	1
AMPHPSEU	33	0	NITZPELL	30	1
BERKsp01	14	0	NITZSIGM	1	2
CALOcfHY	5	0	NITZSPAT	35	0
COCCcfAR	29	0	OPEPHORS	34	3
CYLIGRAC	34	2	OPEPMARI	29	0
DIPLMINI	33	0	PARLsp01	10	1
DIPLOBLO	2	0	PETRHUva	24	1
DONKRECT	32	0	PLACcfCL	3	0
DONKsp01	25	1	PLACcfEL	22	0
ENTOPApa	34	2	PLAGMAXI	34	0
EUTIcfSO	0	0	PLAGTAYR	30	2
FALLTENE	13	0	PLEUAEST	36	0
GYROPRcl	24	3	PLEUSALI	25	0
GYROSCAL	0	3	SEMIsp01	8	2
GYROsp01	24	0	SEMIsp04	35	0
HASLCRUC	35	2	STAUPACH	0	0
HASLSPIC	20	0	SURIBREB	26	0
MAGLEXIG	26	0	TABIFLOC	0	0
NAVIARar	20	0	TRYBCALI	0	1
NAVIcfin	25	0	TRYBCONS	33	1
NAVIcfpe	26	0	TRYBHUNG	20	0
NAVICIle	0	1	TRYBLITT	10	2
NAVICINC	4	0			

5.3 RIVER PELON

5.3.1 Dominants

There were a total of 212 sites in the river study, from which 121 taxa were either dominant or sub-dominant (>10%). Of the 121 taxa, 68 were found as dominants while 53 were never dominant. The data have been arranged in Table 8 as follows:

* by **all** count (the number of times that the taxon was present as either the dominant or a sub-dominant)
* by **dominant** count, and (the number of times the taxon was found as the dominant species)
* by **frequency (%)** count (when dominant the maximum frequency at which it was found).

Water quality data for the various dominant and sub-dominant taxa are shown in Section 3 which has the images of the individual taxa. The data are presented as the average water quality values reported from the sites where the taxa were found, together with an interpretation of the South African Water Quality Class into which the taxon falls for each factor.

NAVIGREG (*Navicula gregaria* Donkin) was found at 46 sites and was present as the dominant (31 sites) and the sub-dominant (15 sites) on most occasions, but the frequency (%) at which it occurred was not the highest (72%). The highest frequency counts (95%) were for SELLPUpu (*Sellaphora pupula* var. *pupula* (Kutzing) Mereschkowsky) and PINNGIli (*Pinnularia gibba* var. *linearis* Hustedt). Although the water quality data for NAVIGREG, and all the taxa, are presented in the pages showing their images, it seems appropriate to describe some of the water quality considerations for those taxa that occurred as dominants in the highest number during this study. NAVIGREG is a ubiquitous species described in numerous texts as occurring in a great many habitats, including fresh, brak and marine water (Lange-Bertalot 2000; Schoeman & Archibald 1976). In South Africa, NAVIGREG was found in water with very variable quality. The data in Table 9 show the wide range of water quality values.

NAVIGREG was considered a marine and brak species until Schoeman and Archibald (1976) reported that it was widespread in South African rivers and quoted Cholnoky (1953a; 1953b) as corroborating evidence. In an attempt to determine whether the species was responding to any particular mineral element, the maximum and minimum percentile was calculated to see whether those parameters could provide some indication. It is interesting to see that sodium (Na) and chloride (Cl) are the two with the highest minimum percentiles, but not TDS. It is possible that these data are indicating that NAVIGREG is a species that has a minimum requirement for sodium chloride and that some rivers in South Africa provide that minimum amount.

Table 8. List of all the taxa found in the river study arranged in order of, either number of times each was found as either, dominant of sub-dominant, the number of times each taxon was dominant and the maximum frequency that each taxon was found.

	By all count					By Dom count					By % frequency			
	Code	All Count	% Freq	Dom Count		Code	All Count	% Freq	Dom Count		Code	All Count	% Freq	Dom Count
1	NAVIGREG	46	72	31	1	NAVIGREG	46	72	31	5	SELLPUpu	17	95	11
2	ACHNMINU	27	65	9	5	SELLPUpu	17	95	11	118	PINNGIli	1	95	1
3	NITZPALE	24	70	10	3	NITZPALE	24	70	10	18	PLACDECU	7	88	7
4	NAVIVIro	17	75	7	7	NAVIHESI	12	39	10	44	ACHNEXIG	2	78	2
5	SELLPUpu	17	95	11	2	ACHNMINU	27	65	9	54	EUTIINCI	2	77	2
6	FALATERA	13	40	5	4	NAVIVIro	17	75	7	4	NAVIVIro	17	75	7
7	NAVIHESI	12	39	10	8	FRAGELLI	11	47	7	65	SURIANGU	2	75	2
8	FRAGELLI	11	47	7	10	NITZFRUS	11	28	7	116	NITZUMBO	1	75	1
9	NAVICAPI	11	31	4	15	NAVIMEme	8	50	7	1	NAVIGREG	46	72	31
10	NITZFRUS	11	28	7	18	PLACDECU	7	88	7	3	NITZPALE	24	70	10
11	NAVIHUca	10	33	3	6	FALATERA	13	40	5	14	CYMBTURG	8	66	5
12	NAVIPHYL	9	37	5	12	NAVIPHYL	9	37	5	2	ACHNMINU	27	65	9
13	ACHNENGE	8	23	2	14	CYMBTURG	8	66	5	15	NAVIMEme	8	50	7
14	CYMBTURG	8	66	5	9	NAVICAPI	11	31	4	31	NAVICIle	4	50	2
15	NAVIMEme	8	50	7	11	NAVIHUca	10	33	3	64	PLEUDELI	2	50	1
16	NITZDESE	7	29	2	19	BACIPAXI	6	20	3	88	FRAGFASC	1	50	1
17	NITZGRAF	7	31	2	20	DINEPUEL	6	22	3	23	ACHNOBLO	5	49	2
18	PLACDECU	7	88	7	22	NAVIMENI	6	25	3	63	PLACsp01	2	47	2
19	BACIPAXI	6	20	3	26	NAVIPSHA	5	32	3	8	FRAGELLI	11	47	7
20	DINEPUEL	6	22	3	13	ACHNENGE	8	23	2	34	NAVITRIV	4	45	2
21	NAVICRYP	6	37	1	16	NITZDESE	7	29	2	99	NAVIPUPU	1	44	1
22	NAVIMENI	6	25	3	17	NITZGRAF	7	31	2	38	COCCPEDI	3	40	2
23	ACHNOBLO	5	49	2	23	ACHNOBLO	5	49	2	6	FALATERA	13	40	5
24	DIATVULG	5	31	2	24	DIATVULG	5	31	2	76	CALOTHER	1	39	1
25	NAVIHEIM	5	27	2	25	NAVIHEIM	5	27	2	7	NAVIHESI	12	39	10
26	NAVIPSHA	5	32	3	31	NAVICIle	4	50	2	81	CYMBTUMI	1	38	1
27	NITZDISS	5	20	1	33	NAVITELO	4	30	2	112	NITZNANA	1	38	0

By all count				By Dom count				By % frequency			
Code	All Count	% Freq	Dom Count	Code	All Count	% Freq	Dom Count	Code	All Count	% Freq	Dom Count
28 NITZPACE	5	18	1	34 NAVITRIV	4	45	2	30 EUTITENE	4	38	1
29 ENTOALAT	4	21	1	38 COCCPEDI	3	40	2	21 NAVICRYP	6	37	1
30 EUTITENE	4	38	1	44 ACHNEXIG	2	78	2	12 NAVIPHYL	9	37	5
31 NAVICIle	4	50	2	48 AMPHSUBT	2	19	2	84 EUTIFALA	1	37	1
32 NAVICONF	4	32	1	51 COCCPLAC	2	27	2	108 NITZDIST	1	36	1
33 NAVITELO	4	30	2	54 EUTIINCI	2	77	2	11 NAVIHUca	10	33	3
34 NAVITRIV	4	45	2	63 PLACsp01	2	47	2	37 ACHNABUN	3	33	1
35 STAUCRUC	4	13	1	65 SURIANGU	2	75	2	26 NAVIPSHA	5	32	3
36 TRYBCONS	4	17	0	21 NAVICRYP	6	37	1	32 NAVICONF	4	32	1
37 ACHNABUN	3	33	1	27 NITZDISS	5	20	1	119 PLACCLEM	1	32	1
38 COCCPEDI	3	40	2	28 NITZPACE	5	18	1	89 FRUSROST	1	31	1
39 CYMBTURG	3	28	0	29 ENTOALAT	4	21	1	24 DIATVULG	5	31	2
40 NITZCAPI	3	28	1	30 EUTITENE	4	38	1	9 NAVICAPI	11	31	4
41 NITZFASC	3	12	0	32 NAVICONF	4	32	1	17 NITZGRAF	7	31	2
42 NITZFONT	3	29	0	35 STAUCRUC	4	13	1	52 CRATPERR	2	30	1
43 NITZLINE	3	17	0	37 ACHNABUN	3	33	1	98 NAVIPSLA	1	30	1
44 ACHNEXIG	2	78	2	40 NITZCAPI	3	28	1	33 NAVITELO	4	30	2
45 ACHNHUNG	2	13	0	47 AMPHLIBI	2	16	1	42 NITZFONT	3	29	0
46 ACHNMIMI	2	17	0	50 CALOSCHU	2	21	1	16 NITZDESE	7	29	2
47 AMPHLIBI	2	16	1	52 CRATPERR	2	30	1	10 NITZFRUS	11	28	7
48 AMPHSUBT	2	19	2	56 NAVICRex	2	18	1	61 PLACELel	2	28	0
49 BRACsp01	2	21	0	57 NAVIMOLL	2	21	1	39 CYMBTURG	3	28	0
50 CALOSCHU	2	21	1	64 PLEUDELI	2	50	1	40 NITZCAPI	3	28	1
51 COCCPLAC	2	27	2	73 AMPHPEDI	1	22	1	103 NAVISUTI	1	28	0
52 CRATPERR	2	30	1	76 CALOTHER	1	39	1	25 NAVIHEIM	5	27	2
53 CYMBASPE	2	21	0	81 CYMBTUMI	1	38	1	51 COCCPLAC	2	27	2
54 EUTIINCI	2	77	2	83 ENTOsp02	1	20	1	62 PLACELGI	2	25	0
55 GONECLja	2	14	0	84 EUTIFALA	1	37	1	22 NAVIMENI	6	25	3
56 NAVICRex	2	18	1	88 FRAGFASC	1	50	1	68 ACHNKRYO	1	25	0

Code	By all count All Count	% Freq	Dom Count	Code	By Dom count All Count	% Freq	Dom Count	Code	By % frequency All Count	% Freq	Dom Count
57 NAVIMOLL	2	21	1	89 FRUSROST	1	31	1	125 SYNETABU	1	24	1
58 NAVIVAND	2	13	0	93 MAGLELLI	1	16	1	13 ACHNENGE	8	23	2
59 NITZPAAE	2	16	0	98 NAVIPSLA	1	30	1	110 NITZLIte	1	22	1
60 NITZRECT	2	16	0	99 NAVIPUPU	1	44	1	20 DINEPUEL	6	22	3
61 PLACELel	2	28	0	108 NITZDIST	1	36	1	123 SURIBREB	1	22	1
62 PLACELGI	2	25	0	109 NITZGRAC	1	18	1	73 AMPHPEDI	1	22	1
63 PLACsp01	2	47	2	110 NITZLIte	1	22	1	49 BRACsp01	2	21	0
64 PLEUDELI	2	50	1	116 NITZUMBO	1	75	1	72 AMPHCOGN	1	21	0
65 SURIANGU	2	75	2	117 PINNBRAU	1	13	1	53 CYMBASPE	2	21	0
66 RHOPGIBA	2	10	0	118 PINNGIli	1	95	1	29 ENTOALAT	4	21	1
67 ACHNDELI	1	19	0	119 PLACCLEM	1	32	1	50 CALOSCHU	2	21	1
68 ACHNKRYO	1	25	0	123 SURIBREB	1	22	1	57 NAVIMOLL	2	21	1
69 AMPHcfMO	1	18	0	125 SYNETABU	1	24	1	19 BACIPAXI	6	20	3
70 ACHNSUAT	1	11	0	36 TRYBCONS	4	17	0	83 ENTOsp02	1	20	1
71 AMPHCOFF	1	18	0	39 CYMBTURG	3	28	0	104 NAVITENT	1	20	0
72 AMPHCOGN	1	21	0	41 NITZFASC	3	12	0	27 NITZDISS	5	20	1
73 AMPHPEDI	1	22	1	42 NITZFONT	3	29	0	67 ACHNDELI	1	19	0
74 BRACBREB	1	14	0	43 NITZLINE	3	17	0	48 AMPHSUBT	2	19	2
75 CALOsp01	1	15	0	45 ACHNHUNG	2	13	0	87 FRAGCAva	1	19	0
76 CALOTHER	1	39	1	46 ACHNMIMI	2	17	0	85 EUTITRIN	1	19	0
77 COCCsp01	1	13	0	49 BRACsp01	2	21	0	56 NAVICRex	2	18	1
78 CYMALIBR	1	10	0	53 CYMBASPE	2	21	0	69 AMPHcfmo	1	18	0
79 CYMBKAPP	1	15	0	55 GONECLja	2	14	0	92 HANTDIST	1	18	0
80 CYMBMINU	1	12	0	58 NAVIVAND	2	13	0	96 NAVIHUNG	1	18	0
81 CYMBTUMI	1	38	1	59 NITZPAAE	2	16	0	109 NITZGRAC	1	18	1
82 CYMBOAHU	1	12	0	60 NITZRECT	2	16	0	28 NITZPACE	5	18	1
83 ENTOsp02	1	20	1	61 PLACELel	2	28	0	71 AMPHCOFF	1	18	0

Table 8 continued.

	Code	By all count All Count	% Freq	Dom Count		Code	By Dom count All Count	% Freq	Dom Count		Code	By % frequency All Count	% Freq	Dom Count
84	EUTIFALA	1	37	1	62	PLACELGI	2	25	0	36	TRYBCONS	4	17	0
85	EUTITRIN	1	19	0	66	RHOPGIBA	2	10	0	43	NITZLINE	3	17	0
86	FALATENE	1	15	0	67	ACHNDELI	1	19	0	46	ACHNMIMI	2	17	0
87	FRAGCAva	1	19	0	68	ACHNKRYO	1	25	0	105	NAVIVIli	1	17	0
88	FRAGFASC	1	50	1	69	AMPHcfMO	1	18	0	93	MAGLELLI	1	16	1
89	FRUSROST	1	31	1	70	ACHNSUAT	1	11	0	47	AMPHLIBI	2	16	1
90	GOMPANGU	1	15	0	71	AMPHCOFF	1	18	0	59	NITZPAAE	2	16	0
91	GONEPARV	1	10	0	72	AMPHCOGN	1	21	0	60	NITZRECT	2	16	0
92	HANTDIST	1	18	0	74	BRACBREB	1	14	0	115	NITZSOLI	1	16	0
93	MAGLELLI	1	16	1	75	CALOsp01	1	15	0	75	CALOsp01	1	15	0
94	NAVIAGUL	1	15	0	77	COCCsp01	1	13	0	79	CYMBKAPP	1	15	0
95	NAVIDULC	1	13	0	78	CYMALIBR	1	10	0	86	FALATENE	1	15	0
96	NAVIHUNG	1	18	0	79	CYMBKAPP	1	15	0	90	GOMPANGU	1	15	0
97	NAVIPERI	1	10	0	80	CYMBMINU	1	12	0	94	NAVIAGUL	1	15	0
98	NAVIPSLA	1	30	1	82	CYMBOAHU	1	12	0	114	NITZSIGM	1	15	0
99	NAVIPUPU	1	44	1	85	EUTITRIN	1	19	0	122	SELLPUny	1	15	0
100	NAVIRHYN	1	14	0	86	FALATENE	1	15	0	55	GONECLja	2	14	0
101	NAVISCHR	1	11	0	87	FRAGCAva	1	19	0	100	NAVIRHYN	1	14	0
102	NAVISELU	1	11	0	90	GOMPANGU	1	15	0	121	RHOICURV	1	14	0
103	NAVISUTI	1	28	0	91	GONEPARV	1	10	0	74	BRACBREB	1	14	0
104	NAVITENT	1	20	0	92	HANTDIST	1	18	0	127	TABEFLOC	1	14	0
105	NAVIVIli	1	17	0	94	NAVIAGUL	1	15	0	77	COCCsp01	1	13	0
106	NEIDAFFI	1	12	0	95	NAVIDULC	1	13	0	117	PINNBRAU	1	13	1
107	NITZACUL	1	13	0	96	NAVIHUNG	1	18	0	35	STAUCRUC	4	13	1
108	NITZDIST	1	36	1	97	NAVIPERI	1	10	0	107	NITZACUL	1	13	0
109	NITZGRAC	1	18	1	100	NAVIRHYN	1	14	0	58	NAVIVAND	2	13	0
110	NITZLlte	1	22	1	101	NAVISCHR	1	11	0	95	NAVIDULC	1	13	0

Table 8 continued.

By all count					By Dom count					By % frequency				
	Code	All Count	% Freq	Dom Count		Code	All Count	% Freq	Dom Count		Code	All Count	% Freq	Dom Count
111	NITZMICE	1	12	0	102	NAVISELU	1	11	0	45	ACHNHUNG	2	13	0
112	NITZNANA	1	38	0	103	NAVISUTI	1	28	0	120	PLMAACUM	1	12	0
113	NITZPUMI	1	12	0	104	NAVITENT	1	20	0	41	NITZFASC	3	12	0
114	NITZSIGM	1	15	0	105	NAVIVIli	1	17	0	80	CYMBMINU	1	12	0
115	NITZSOLI	1	16	0	106	NEIDAFFI	1	12	0	106	NEIDAFFI	1	12	0
116	NITZUMBO	1	75	1	107	NITZACUL	1	13	0	113	NITZPUMI	1	12	0
117	PINNBRAU	1	13	1	111	NITZMICE	1	12	0	124	STNEsp1	1	12	0
118	PINNGIli	1	95	1	112	NITZNANA	1	38	0	111	NITZMICE	1	12	0
119	PLACCLEM	1	32	1	113	NITZPUMI	1	12	0	82	CYMBOAHU	1	12	0
120	PLMAACUM	1	12	0	114	NITZSIGM	1	15	0	70	ACHNSUAT	1	11	0
121	RHOICURV	1	14	0	115	NITZSOLI	1	16	0	102	NAVISELU	1	11	0
122	SELLPUny	1	15	0	120	PLMAACUM	1	12	0	128	TRYBANGU	1	11	0
123	SURIBREB	1	22	1	121	RHOICURV	1	14	0	101	NAVISCHR	1	11	0
124	STNEsp1	1	12	0	122	SELLPUny	1	15	0	126	SYNEULNA	1	10	0
125	SYNETABU	1	24	1	124	STNEsp1	1	12	0	66	RHOPGIBA	2	10	0
126	SYNEULNA	1	10	0	126	SYNEULNA	1	10	0	97	NAVIPERI	1	10	0
127	TABEFLOC	1	14	0	127	TABEFLOC	1	14	0	78	CYMALIBR	1	10	0
128	TRYBANGU	1	11	0	128	TRYBANGU	1	11	0	91	GONEPARV	1	10	0

Table 8 continued.

Table 9. The water quality components (mg.l^{-1}, except for pH and EC) in which NAVIGREG was found as the dominant species from all the sites sampled in RSA. The data compare the minimum and maximum concentrations in which NAVIGREG was found by comparison with the minimum and maximum values for all the rivers from which samples were taken. The maximum and minimum percentiles are shown for each mineral element.

	NAVIGREG Data		All Rivers data		%ile	%ile
Component	Min.	Max.	Min.	Max.	Min.	Max.
Ca	3.00	62	1	504	3	88
Cl	15.10	698	0	6844	13	80
EC	14.60	299	4.01	1979	-	-
F	0.00	0.3	0	119	0	68
K	0.70	190.4	0.15	242.6	5	99
Mg	4.00	63	1	690	8	83
Na	10.17	471	3.171	3645	12	85
NH_4	0.00	0.7	0	295	0	95
NO_3	0.00	1.32	0	340.16	0	80
pH	6.60	8.99	4.2	9.57	5	97
PO_4	0.01	96.1	0.002	336	7	98
SiO_2	0.50	7.2	0.5	47	1	85
SO_4	5.00	127	2.06	2114	2	72
Alkalinity	16.00	530	6	851	5	99
TDS	92.18	2258	34	14139	1	90
AVERAGE WATER QUALITY CLASS WITHOUT pH = 1.79						

After NAVIGREG, NAVIHEIM (*Navicula heimansii* Van Dam and Kooyam) was dominant on the most occasions (12). The data in Table 10 show the maximum and minimum percentiles for the sites where NAVIHEIM was dominant.

This species was found in water with low TDS and a narrow pH range. Using the percentiles as a guide, NAVIHEIM appears to have a high requirement for Si but a low requirement for all other mineral elements except Na and Cl. Surprisingly, although in our sampling NAVIHEIM has never been found in a brak environment, it nevertheless appears to have a requirement for Na and Cl. In fact, the minimum percentile values for this taxon were higher than those for the ubiquitous NAVIGREG discussed earlier. No explanation is offered for this apparent requirement for Na and Cl.

Table 10. The water quality components ($mg.l^{-1}$, except for pH and EC) in which NAVIHEIM was found as the dominant species from all the sites sampled in RSA. The data compare the minimum and maximum concentrations by comparison with the minimum and maximum values for all the rivers from where samples were taken. The maximum and minimum percentiles are shown for each mineral element.

	NAVIHEIM data		All rivers data		%ile	%ile
n=12	Min	Max	Min	Max	Min	Max
Ca	2.00	4.00	1.00	504.00	0.5	7.8
Cl	40.00	51.00	0.00	6844.00	34	45
F	0.00	0.10	0.00	0.12	0	8
K	0.60	0.90	0.15	242.60	4	12
Mg	3.00	5.00	1.00	690.00	6	16
Na	24.00	30.00	3.17	3645.00	31	42
NH_4	0.00	0.07	0.00	295.00	0	70
NO_3	0.00	0.05	0.00	340.16	0	21
pH	7.00	7.48	4.20	9.57	12	38
PO_4	0.01	0.06	0.00	336.00	6	53
Si	2.00	2.90	0.50	47.00	82	88
SO_4	5.00	16.00	2.06	2114.00	2	25
Alkalinity	7.00	22.00	6.00	851.00	1	10
TDS	95.00	122.00	34.00	14139.00	9	19
AVERAGE WATER QUALITY CLASS WITHOUT pH = 1.14						

SELLPUpu (*Sellaphora pupula* var. *pupula)* was dominant the next most frequently, having been dominant on 11 occasions. The data in Table 11 show the maximum and minimum percentiles. SELLPUpu has a South African Water Quality Index of 2.2 while that for NAVIGREG is 1.7 and that for NAVIHEIM is 1.14.

In the case of SELLPUpu, there appears to be a requirement for, or tolerance to, Cl but not Na as is the case for NAVIGREG and NAVIHEIM. This may account for why it was never found in estuaries. Si appears to be important, as does a fairly high concentration of PO_4. The species occurred in a fairly narrow range of Cl and K (Table 11).

While it may be permissible to make interpretations of this nature for taxa where n is large, it certainly is not possible to draw the same conclusions for taxa where n is small. In those latter cases, all that can be ascertained is that the taxon occurred in water of the quality analysed, which may have been at a time when a mineral "spike" was passing. The question is, how large must n be before a reliable WQ index can be awarded?

Table 11. The water quality components (mg.l^{-1}, except for pH and EC) in which SELLPUpu was found as the dominant species from all the sites sampled in RSA. The data compare the minimum and maximum concentrations in which SELLPUpu was found by comparison with the minimum and maximum values for all the rivers sampled. The maximum and minimum percentiles are shown for each mineral element.

	SELLPUpu Data		All Rivers data		%ile	%ile
	Min.	Max.	Min.	Max.	Min.	Max.
Ca	2.29	54.08	1.00	504.00	0.5	82
Cl	21.20	49.00	0.00	6844.00	17	43
F	0.11	0.32	0.00	0.12	20	84
K	1.20	4.27	0.15	242.60	17	48
Mg	1.29	32.92	1.00	690.00	0.5	70
Na	3.47	33.00	3.17	3645.00	2	41
NH_4	0.00	0.43	0.00	295.00	0	53
NO_3	0.00	4.67	0.00	340.16	0	95
pH	7.01	8.90	4.20	9.57	13	81
PO_4	0.03	336.00	0.00	336.00	33	100
Si	3.70	16.00	0.50	47.00	60	99
SO_4	8.11	79.42	2.06	2114.00	11	59
Alkalinity	11.94	179.33	6.00	851.00	3	77
TDS	26.07	406.90	34.00	14139.00	0	55
AVERAGE WATER QUALITY CLASS WITH pH = 2.2						

Data analysis showed that the distribution of minerals in the river water around South Africa is very skewed, with many low values and only a few high values. The WQ data in the case of the sites where NAVIGREG was dominant were much more normally distributed, indicating that the values represented are not the result of unusually high or low mineral element concentrations. The conclusion from this is that while the mineral element concentration for the whole country may be skewed, the distribution for individual species may well not be.

After SELLPUpu, the next taxon found most frequently as a river epipelon dominant was NITZPALE (*Nitzschia palea* (Kutzing) W. Smith). This was dominant at 10 sites. NITZPALE had a fairly high Water Quality score of 2.93 and, using percentiles, had a fairly high requirement for F and K but a medium requirement for P, Si and alkalinity. It was dominant in the Orange River at Vioolsdrif and Pella, the Mzinduzi and Karkloof rivers in Natal, the Crocodile River near

Pretoria and on three occasions in site D of the Swartkops River (EC), the Olifants River in Mpumalanga and the Salskanaal in the Western Cape.

It fell into a narrow pH range but appears to require some Na and Cl in the same way as did NAVIGREG; indeed its requirements for Na and Cl are also higher that those for NAVIGREG. Despite this, it has not been recorded in any of the estuaries sampled in RSA.

ACHNMINU (*Achnanthes minutissima* Kutzing) was the diatom next most frequently found as a dominant (n=9). It had a calculated Water Quality Class of 2.0. The use of percentiles shows the taxon to fall into the range 57-97%ile for Ca, 0 to 34%ile for Cl, 38-96%ile for F, 37-65%ile for K, 22-85%ile for Mg, 10-59%ile for Na, 0-88%ile for NH_4, 39-96%ile for NO_3, 30-99% for pH, 6-74%ile for PO_4, 1-55%ile for Si, 62-97%ile for SO4, 16-50%ile for alkalinity and 18-60%ile for TDS. This implies it has a fairly high requirement for Ca, F, NH_4, NO_3 and Si but a fairly low requirement for Cl, Mg, Na and PO_4. It falls into the mid-range for alkalinity, K, pH, SO_4 and TDS.

NAVIVIro, FRAGELLI, NITZFRUS, NAVIMEme and NAVIDECU were each dominant at 7 sites.

Although NAVIVIro (*Navicula viridula* var. *rostellata* (Kutzing) Cleve), with a SWQC of 1.92, was dominant at 7 sites, there were no WQ data for one of the sites and only partial data for another. This means that the data represent only 5 full WQ sets. However, using the available data, this species does not seem to be sensitive to Ca, F, NH_4, NO_3, or PO_4 because of the spread between the min and the max percentiles. It was found in the mid-range of percentiles for Mg, pH and alkalinity but in a fairly low range for Cl, K, Na, SO_4, and TDS. In the case of Si, it only occurred at sites where the percentiles were greater than 84.

FRAGELLI (*Fragilaria elliptica* Schumann), with a SWQC of 2.1 appears to be insensitive to F, NH_4, NO_3, PO_4 or Si since it occurred over a wide range of these dissolved minerals. It appears to have a fair requirement for Ca, Cl, K, Mg, Na,SO4, Alk and TDS. It was found in the low to mid-pH range.

NAVIMEme (*Navicula menisculus* var. *menisculus* Schumann), with a SWQC of 1.64 had no data for Cl, but Ca, pH and Alk all fell into a narrow mid-%ile range of about 30-80. F, K, Mg, PO_4 and TDS fell into the low to mid-range. Na and SO_4 in high concentration appear to be unsuitable. The species occurred in water with a very wide range of NH_4 and NO_3, but it appears to have a high requirement for Si.

NITZFRUS (*Nitzschia frustulum* (Kutzing) Grunow) has one of the highest recorded SWQC values at 3.57. Because of this, the data are presented in Table 12.

These data imply that NITZFRUS is not a good indicator for Ca, F, NO_3, pH or PO_4, but has a fairly high requirement for Cl and medium/high requirements for K, Na, Mg and SO_4 and TDS, but a low to medium requirement for NH_4, Si and Alk.

Table 12. Calculated percentile data for NITZFRUS for each of the minerals analysed.

	%ile	
	Min	Max
Ca	31	100
Cl	66	100
F	8	88
K	69	89
Mg	52	100
Na	68	100
NH_4	0	69
NO3	0	88
pH	7	98
PO_4	0	92
Si	1	58
SO_4	46	100
Alkalinity	43	92
TDS	60	100

NAVIDECU (*Navicula decussis* Oestrup) with a SWQC value of 1.31 was dominant at 6 sites, but the WQ data for one of the sites is not available. The species was dominant in all the KwaZulu Natal rivers sampled (i.e. Mooi, Kleinmooi, Boesmans, Klein Boesmans and Ncibidwane) except for the Hlatikulu River where NAVIHESE was the dominant. This latter species also has a very low SWQC of 1.14. The KwaZuluNatal sites were all in the Midlands area where urbanisation and industrialisation is low and, therefore, pollution into the rivers is also low.

FALLTENE, NAVIPHYL and CYMTURG were each dominant 5 times. FALLTENE (*Fallacia tenera* (Hustedt) Mann) had a high SWQC of 3.77. It was found on all occasions in the Swartkops River at sites E (4 times) and F (once). These sites are near Despatch and the river is polluted at these two positions. Using percentile data, Ca, Cl, K, Mg, Na, NO_3, PO4, SO_4, Alk and TDS all fall into the upper ranges, while F, pH and Si fell into the mid-ranges. The species was found in water where NH_4 was between the percentiles of 0 and 98.

Although NAVIPHYL (*Navicula phyllepta* Kutzing) was a dominant on 5 occasions, there were no data from one of the sites. This means that n=4, which is believed to be too small to draw valid conclusions. It has a SWQC of 3.21, which is high and was found at site E in the

Swartkops River on three occasions and in the Sundays River at site SR6 on the single occasion that the river was sampled.

CYMBTURG (*Cymbella turgidula* Grunow) had a SWQC of 1.64 having been dominant in the Kruger National Park on 2 occasions in the Palala River and in the Harts and Orange rivers, once each. The concentrations of each of the mineral elements found in these rivers, expressed as the minimum and maximum percentiles, are shown in Table 13.

The interpretation of the data in Table 13, is that CYMBTURG had a medium to high requirement for Ca, F, NO_3 and Si, but a medium to low requirement for Cl, K, Mg, Na, PO_4, SO_4 and alkalinity. The species was found in river water with a wide range of NH_4, and is therefore considered to be insensitive to ammonium ion concentration. It was found in a narrow pH range between the 65th and 82nd percentiles. The species was only found in river with a low TDS content (10th and 23rd percentiles).

We believe that n=5 is the lowest number required in order to arrive at any conclusions regarding the indications of water quality by benthic diatoms.

Table 13. Calculated percentile data for CYMBTURG for each of the minerals analysed.

	%ile	
	Min	Max
Ca	22	56
Cl	0	23
F	23	96
K	11	45
Mg	23	44
Na	9	34
NH_4	0	97
NO_3	28	87
pH	65	82
PO_4	0	65
Si	55	95
SO_4	1	53
Alkalinity	33	65
TDS	10	23

6. CONCLUSIONS

The data presented in this report include information gathered in WRC project K5/814, which was used by JS van der Molen for his PhD thesis at the University of Port Elizabeth, Project K5/1107 and an MSc project on water quality and benthic diatoms in estuaries, by Ms C. Minné. The latter project was a co-operative effort between K5/1107, RQS and Ms C. Minné.

The question of how to analyse benthic diatom data is complex, largely because the purpose of using benthic diatoms is to determine the time-integrated water quality. Where analytical tools such as Canonical Correspondence Analysis are used, the very information that is being sought is lost because a brief spike in water quality may be captured in the chemical analysis but there may be no change in the benthic species. To follow the analytical route taken by the majority of the international diatom community, who are employing indices derived from all the species present, is not considered practical for the present because of the labour required to undertake 100% species identification. This will only be possible in heavily funded laboratories, such as in the USA, until an adequate computer recognition system is available.

In attempting to understand the data produced in this project and in projects undertaken elsewhere in the world, it may not be sufficient to just analyse the water quality and species data collected. An understanding of the physiology of diatom growth and particularly of mineral uptake is required. Many groups of plants take up "luxury" quantities of mineral elements when a supply presents itself. These minerals are stored and used as required. Consider a body of water where the dominant species is X and the sub-dominant species is Y. If the TDS of the water is low, then the likelihood is reasonably high that Y is sub-dominant rather than dominant because mineral M is too dilute for it to grow as fast as X, which does not have the same requirement for mineral M at a higher concentration. If mineral M presents itself as a strong "spike" for a short period (hours), the possibility is that species X and Y will take up luxury quantities. The end effect, however, may be to allow species Y to out-compete species X and become the dominant. When the spike is no longer present, however, standard data analysis methods would expect species Y to return to its sub-dominant state but, because of luxury consumption, this will not happen until the store of M within the cell is depleted. CCA and correlation analyses may not pick up these correlated changes because they are separated in time. In the same way, species Z may be dominant at a site where mineral M arrives in short term spikes, that may only occasionally be measured.

It is clear that the diatom data set available in South Africa will still be too small after this project for it to be used routinely in the determination of water quality. Not withstanding this, the recommendation is that the system should be implemented where possible and the data retained until the number of replications is large. If it could be implemented in only a single Water Board, such as Umgeni Water Board, Rand Water Board or Mhlathuze Water, the data would accumulate quickly from only a limited number of sites and it would soon become apparent what individual taxa are indicating. What is very important is to determine the relationship between the length of an integrated water quality and the change of dominant taxa. At the same time, it is necessary to remember that even though the mineral content of the water may not change, a species change may occur in response to other habitat features such as sediment type, water flow rate or shading.

This project (K5/1107) and its predecessor (K5/814) have achieved the following:

(1) The South African diatom literature has been reviewed from an international perspective. The review has shown that what is available is largely taxonomic but extremely valuable from the perspective of future work that will and must be undertaken on the benthic diatoms in the rivers and estuaries of South Africa. In most of the existing references examined, sites have referred to rivers, e.g. Swartkops River, with little indication of the location. This means that inferences are required from the species concerned as to whether it is a freshwater, brak or marine specimen. Despite this shortcoming, the species have been named and are well known in the international literature. This study has placed many of the benthic diatoms into specific ecological niches and, while this is by no means complete, it must be seen as a valuable start.

(2) The project has resulted in a collection of benthic diatom specimens from rivers in most of the phytogeographical regions of the country. These are preserved as images, as slides and in specimens of the diatoms contained in 1ml vials that are preserved in the herbarium of the University of Port Elizabeth.

(3) Specimens on benthic diatoms have been collected from estuaries located all around the South African coast. As is the case for the river benthic diatoms they are preserved as images, as slides and in specimens of the diatoms contained in 1ml vials that are preserved in the herbarium of the University of Port Elizabeth.

(4) The basis of a genus identification system has been prepared for researchers starting out in benthic diatom research. At the same time, a substantial number of diatom images are now available from which more advanced researchers can make identifications.

(5) During this study, students have been trained in the methods of collecting specimens in the field, of cleaning and preparing slides for light and scanning microscopy and in identifying dominant taxa.

(6) The facilities at the University of Port Elizabeth have been made freely available to researchers from other institutions.

(7) This report will be freely available to all who request it from the Water Research Commission. In addition to the written report, a compact disk (CD) will be made available to anyone who wishes to use the data in that format. The CD will be important to researchers interested in identifying species. The diatom images are

presented at 1000 x magnification but this can be increased electronically by expanding the image. We have noticed that this sometimes improves the resolution of certain aspects such as striae, raphes and end configurations, even though there is an overall loss of resolution.

This study has shown that diatoms are good indicators of water quality but it has failed to show how diatoms respond temporally to short changes in water quality. It has also failed to show whether dissolved inorganic and organic components are linked or whether they are capable of changing in response to changes in the concentration of individual mineral elements. There is a strong indication, as shown by CCA, that the major response is to total dissolved solids, i.e. salinity. In the estuary component, there are strong indications that benthic diatoms are more sensitive to salinity (freshwater, brak or marine) than to other mineral elements. Indeed the fact that the CCA results indicate responses within rivers to be salinity (TDS) driven provides strong evidence to their sensitivity to salinity.

The estuarine component of this study was never designed to show whether tidal changes in salinity are responsible for species dominance change, but common sense suggests that those species dominant within the tidal range are not sensitive to daily fluctuations. At the same time, the use of benthic diatoms to record the fresh/saline changes in estuaries over periods greater than diurnal is important. If diatoms are to be useful in estuarine monitoring protocols then studies to elucidate behaviour when freshwater is flowing into estuaries should be an urgent extension to this study. The Swartkops River study, undertaken in project K5/814, showed clearly that season played little part in the diatom dominance. This is because in the upper (pristine) reaches of the river the same species were dominant throughout the year. In the lower reaches, where sources of water were more variable due to agricultural, industrial and municipal pollutants influencing the quality, the species changed from month to month. The project was unable to identify whether these changes were due to single elements or multiple mineral combinations.

This project achieved its immediate objectives, but has illustrated the need for further research. Recommendations for further research include:

1. The identification of how short-term changes (duration and amplitude) of water quality are able to modify the dominant epipellic species. This research probably needs to be undertaken in the field rather than under highly controlled conditions, because controlled conditions would likely make too many assumptions regarding the physiology of these micro-organisms. These data need to be applied to both river and estuary diatoms. For this reason this recommendation implies two separate projects.

2. The images of all the benthic diatoms produced in this project need to be identified in order to produce a large database that can be taken forward towards the construction of an index system such as has already been implemented in France.
3. More data needs to be collected from a few sites in one or two rivers that experience changes in water quality. The probability is that the most suitable site will be one where the water quality fluctuates from Class 1 to 3 or 4 from time to time. A suitable site may be one where flow becomes severely restricted during drought periods or one near agricultural or industrial sources of pollution. Because industry may produce pollution with a high frequency, an agricultural site may be preferable. Weekly data are required to resolve the information.
4. This project has clearly illustrated the need for more data to be collected. This need not necessarily be an extension in terms of new sites. The most suitable extension may well be to resample all the rivers.
5. An important question is what NAVIGREG (*Navicula gregaria*) is indicating. This species may be more than a single taxon or it may be indicating changing conditions. Because it occurred in the greatest frequency it is clearly very important. In this project slight differences in morphology were observed but the differences could not be associated with any differences in water quality.

7. PROJECT OUTPUTS

MSc dissertation

Minne, C. (to graduate in 2004). Diatoms as indicators of water quality in estuaries: a preliminary investigation. Department of Botany, University of Port Elizabeth. 140 pp.

Conferences

Bate, GC, PA Smailes and JB Adams. Epipelic diatoms as indicators of water quality in the rivers and estuaries of South Africa. 19th congress of the Phycological Society of Southern Africa, Mpekweni Sun, 19-21 January 2003. (oral presentation).

Bate, GC. 2002. Diatoms as indicators of water quality in South African rivers and estuaries. Oral presentation at the 17th International Diatom Symposium (IDS 2002). 25 – 31 August 2002, Ottawa, Canada.

Workshops

Bate, GC and JB Adams. The use of diatoms in the assessment of water quality in the rivers and estuaries of South Africa. Paper to Diatom Workshop at the University of Potchefstroom. 6 August 2001.

Collaboration / technology transfer

14 November 2000. GC Bate talked to laboratory staff at Umgeni Water, demonstrated and explained laboratory and field methods for diatom collection and processing.

23-26 March 2003. GC Bate sampled Durban estuaries with CSIR to demonstrate field and laboratory methods. CSIR are now using these methods routinely.

P. Hiraal and S. Mundree from the CSIR, Durban spent time at the University of Port Elizabeth learning the different techniques.

8. REFERENCES

Archibald, R.E.M. 1983. The diatoms of the Sundays and Great Fish rivers in the Eastern Cape Province of South Africa. *Bibliotheca Diamotologica*. J Cramer. 431 pp.

Barber, H.G. and E.Y. Haworth 1981. A guide to the morphology of the diatom frustule (with a key to the British freshwater genera). *Freshwater Biological Association. Scientific publication No. 44*. 112 pp.

Bate, G.C. and Heelas, B.V. 1974. Studies on the nitrate nutrition of two indigenous Rhodesian grasses. *Journal of Applied Ecology 12*: 941-952.

Bornman, T.G., J.B.Adams, and G. C. Bate 2002. Freshwater Requirements of a Semi-arid Supratidal and Floodplain Salt Marsh. *Estuaries 25(6B)*:1394-1405

Cholnoky, B.J. 1953a. Studien zur Ökologie der Diatomeen eines eutrophen sub-tropischen Gewässers. *Ber. Dt. Bot. Ges. 66*:347-356

Cholnoky, B.J. 1953b. Diatomeenassoziationen aus den Hennops- rivier bei Pretoria. *Verh. Zool.-bot. Ges. Wien. 93*:134-149

Hustedt, F. 1976. Die Süsswasser- flora Mitteleeuropas. Otto Koeltz Science Publishers. Koenigstein, Germany. 466 pp.

Krammer, K. and Lange-Bertalot, H. 1991. Süsswasser von Mitteleuropa. Bacillariophyceae. Teil 3: Centrales Fragillariaceae and Eunotiaceae. Gustav Fischer Verlag. Stuttgart. 230 pp.

Lange-Bertalot, H. (Ed.) 2000. Iconographia Diatomologica. Volume 7. Koeltz Scientific Books, Germany. 925 pp.

Lange-Bertalot, H. and Krammer, K 1989. Achnanthes Eine Monographie der Gattung. *Bibliotheca Diatomologica*. Band 18. J Cramer. Berlin. 393 pp.

Minne, C. 2003. Diatoms as indicators of water quality in estuaries. A preliminary investigation. MSc Dissertation. Department of Botany, University of Port Elizabeth.

Round, F.E. 2001. Personal communication. Emeritus Professor, Department of Botany, University of Bristol, U.K.

Round, F.E. and Bukhtiyarova, L. 1996. Four new genera based on *Achnanthes* (*Achnanthidium*) together with a redefinition of *Achnanthidium*. *Diatom Research 11*: 345-361.

Round, F.E.; Crawford, R.M. and D.G. Mann 1990. The Diatoms. Biology and Morphology of the Genera. Cambridge University Press. Cambridge. 747 pp.

Round, F.E. 1981. The Ecology of Algae. Cambridge University Press, London.

Schoeman, F.R. and Archibald, R.E.M 1976. The diatom flora of Southern Africa. *Special Report WAT 50*. CSIR, South Africa.

Sims, P.A. 1996. An Atlas of British Diatoms. Arranged by B. Hartley and based on illustrations by H. G. Barbour and J. R. Carter.[Ed. P.A. Sims]. Biopress Ltd. Bristol. 601 pp.

Van Dam, H., Mertens, A. & Sinkeldam, J. (1994). A coded checklist and ecological indicator values of freshwater diatoms from the Netherlands. *Netherlands Journal of Aquatic Ecology*, 28(1), 177-133.

Van der Molen, J.S. 2000. Diatoms as indicators of water quality in South African River systems. PhD thesis. Department of Botany, University of Port Elizabeth. 128 pp + appendix.

SECTION 1 : APPENDIX
Codenames assigned to the diatoms.

Genus	species	Codename
Achnanthes	*abundans*	ACHNABUN
Achnanthes	*amoena*	ACHNAMOE
Achnanthes	*brevipes var bervipes*	ACHNBRbr
Achnanthes	*conspicua*	ACHNCONS
Achnanthes	*cf oblongata*	ACHNcfOB
Achnanthes	*delicatula*	ACHNDELI
Achnanthes	*engelbrechtii*	ACHNENGE
Achnanthes	*exigua v exigua*	ACHNEXex
Achnanthes	*hungarica*	ACHNHUNG
Achnanthes	*kryophila*	ACHNKRYO
Achnanthes	*kuelbsii*	ACHNKUEL
Achnanthes	*minutisima*	ACHNMINUi
Achnanthes	*minutissima var gracillima*	ACHNMIgr
Achnanthes	*oblongella*	ACHNOBLO
Achnanthes	*subatomoides*	ACHNSUBA
Amphora	*abludens*	AMPHABUL
Amphora	*acutiuscula*	AMPHACUT
Amphora	*angusta*	AMPHANGU
Amphora	*arcus*	AMPHARCU
Amphora	*castellata*	AMPHCAST
Amphora	*cf coffeaeformis*	AMPHcfCO
Amphora	*cf montana*	AMPHCFMO
Amphora	*cf lucaie*	AMPHcfLU
Amphora	*cf strigosa*	AMPHcfST
Amphora	*coffeaeformis*	AMPHCOFF
Amphora	*coffeaeformis var.1*	AMPHCOv1
Amphora	*coffeaeformis var 2*	AMPHCOv2
Amphora	*cognata*	AMPHCOGN
Amphora	*communtata*	AMPHCOMM
Amphora	*decussata*	AMPHDECU
Amphora	*exigua*	AMPHEXIG
Amphora	*helenensis*	AMPHHELE
Amphora	*holsatica*	AMPHHOLS
Amphora	*jostesorum*	AMPHJOST
Amphora	*libyca*	AMPHLIBY
Amphora	*ovalis var affinis*	AMPNOVaf
Amphora	*pediculus*	AMPHPEDI
Amphora	*proteoides*	AMPHPROT
Amphora	*proteus*	AMPHPRUS
Amphora	*pseudohyalina*	AMPHPSEU
Amphora	*subacutiscula*	AMPHSUBA
Amphora	*sublaevis*	AMPHSUBL
Amphora	*terroris*	AMPHTERR
Astartiella	*punctifera*	ASTAPUNC
Astartiella	*cf bahusiensis*	ASTAcfBA
Astartiella	*sp01*	ASTAsp01

Bacillaria	*paxillifer*	BACIPAXI
Berkeleya	*rutilans*	BERKRUTI
Berkeleya	*micans*	BERKMICA
Berkeleya	*sp01*	BERKsp01
Brachysira	*brebissonii*	BRACBREB
Brachysira	*sp.1*	BRACsp01
Caloneis	*cfhyalina*	CALOcfHY
Caloneis	*schumanniana*	CALOSCHU
Caloneis	*sp.01*	CALOsp01
Caloneis	*thermalis*	CALOTHER
Cocconeis	*cf thienemannii*	COCCcfTH
Cocconeis	*cfarenicola*	COCCcfAR
Cocconeis	*engelbrechtii*	COCCENGE
Cocconeis	*pediculus*	COCCPEDI
Cocconeis	*placentula*	COCCPLAC
Cocconeis	*placentula var euglypta*	COCCPLeu
Cocconeis	*scutellum*	COCCSCUT
Cocconies	sp.1	COCCsp01
Craticula	*halophila*	CRATHALO
Craticula	*perrotettii*	CRATPERR
Cylindrotheca	*closterium*	CYLICLOS
Cylindrotheca	*gracilis*	CYLIGRAC
Cymatopleura	*librile*	CYMALIBR
Cymbella	*aspera*	CYMBASPE
Cymbella	*kappii*	CYMBKAPP
Cymbella	*minuta*	CYMBMINU
Cymbella	*oahuensis*	CYMBOAHU
Cymbella	*tumida*	CYMBTUMI
Cymbella	*turgidula*	CYMBTURG
Diatoma	*vulgaris*	DIATVULG
Diploneis	*caffra*	DIPLCAFF
Diploneis	*elliptica*	DIPLELLI
Diploneis	*interrupta*	DIPLINTE
Diploneis	*minima*	DIPLMINI
Diploneis	*oblongella*	DIPLOBLO
Diploneis	*parma*	DIPLPARM
Diploneis	*puella*	DIPLPUEL
Donkinia	*recta*	DONKRECT
Donkinia	*sp.*	DONKsp01
Encyonema	*minutum*	ENCYMINU
Entomoneis	*alata*	ENTOALAT
Entomoneis	*paludosa var paludosa*	ENTOPApa
Entomoneis	*sp.01*	ENTOsp01
Eunotia	*fallax v groenlandica*	EUNOFAgr
Eunotia	*incisa*	EUNOINCI
Eunotia	*intermedia*	EUNOINTE
Eunotia	*soleirollil*	EUNOSOLE
Eunotia	*tenella*	EUNOTENE
Eunotia	*trinacria*	EUNOTRIN

Fallacia	*tenera*	FALLTENE
Fragilaria	*capucina v vaucheriae*	FRAGCAva
Fragilaria	*elliptica*	FRAGELLI
Fragilaria	*fasciculata*	FRAGFASC
Fragilaria	*sp.1*	FRAGsp01
Frustulia	*rostrata*	FRUSROST
Gomphonema	*angustum*	GOMPANGU
Gomphonema	*clevei v javanica*	GOMPCLja
Gomphonema	*parvulum*	GOMPPARV
Gyrosigma	*acuminatum*	GYROACUM
Gyrosigma	*fasciola var arcuatum*	GYROFAar
Gyrosigma	*prolongatum v closteroides*	GYROPRcl
Gyrosigma	*scalproides*	GYROSCAL
Gyrosigma	*sp.*	GYROsp01
Gyrosigma	*stompsii*	GYROSTOM
Hantzschia	*distinctpunctata*	HANTDIST
Haslea	*crucigera*	HASLCRUC
Haslea	*ostrearia*	HASLOSTE
Haslea	*spicula*	HASLSPIC
Mastogloia	*elliptica*	MASTELLI
Mastogloia	*exigua*	MASTEXGU
Navicula	*abscondita*	NAVIABSC
Navicula	*aequora*	NAVIAEQU
Navicula	*agulhasica*	NAVIAGUL
Navicula	*arenaria var arenaria*	NAVIARar
Navicula	*arenaria var rostellata*	NAVIARro
Navicula	*bahusiensis*	NAVIBAHU
Navicula	*besarensis*	NAVIBESA
Navicula	*bremensis*	NAVIBREM
Navicula	*capitatoradiata*	NAVICAPI
Navicula	*cf cincta*	NAVIcfCI
Navicula	*cf dulcis*	NAVIcfDU
Navicula	*cf erifuga*	NAVIcfER
Navicula	*cf incerta*	NAVIcfIN
Navicula	*cf perminuta*	NAVIcfPE
Navicula	*cincta*	NAVICINC
Navicula	*cincta v leptocephala*	NAVICIle
Navicula	*confervacea*	NAVICONF
Navicula	*crucicula v cruciculoides*	NAVICRcr
Navicula	*cryptocephala*	NAVICRYP
Navicula	*cryptocephala v exilis*	NAVICRex
Navicula	*cryptolyra*	NAVICRRA
Navicula	*cryptotenella*	NAVICRLA
Navicula	*decussis*	NAVIDECU
Navicula	*dehissa*	NAVIDEHI
Navicula	*duerrenbergiana*	NAVIDUER
Navicula	*erifuga*	NAVIERIF
Navicula	*fracta*	NAVIFRAC
Navicula	*frugalis*	NAVIFRUG

Navicula	*gregaria*	NAVIGREG
Navicula	*gregaria var 1*	NAVIGRv1
Navicula	*haseaformis*	NAVIHAST
Navicula	*heimansii*	NAVIHEIM
Navicula	*hungarica*	NAVIHUNG
Navicula	*hungarica var. capitata*	NAVIHUca
Navicula	*menisculus*	NAVIMENI
Navicula	*menisculus v menisculus*	NAVIMEme
Navicula	*mollis*	NAVIMOLL
Navicula	*normaloides*	NAVINORM
Navicula	*peregrina*	NAVIPERI
Navicula	*perminuta*	NAVIPERM
Navicula	*phyllepta*	NAVIPHYL
Navicula	*pseudolanceolata*	NAVIPSEU
Navicula	*ramossima var mucosa*	NAVIRAmu
Navicula	*rhynchocephala*	NAVIRHYN
Navicula	*salinicola*	NAVISALI
Navicula	*schroeterii*	NAVISCHR
Navicula	*sp 01*	NAVIsp01
Navicula	*sp 02*	NAVIsp02
Navicula	*sp 03*	NAVIsp03
Navicula	*subcostulata*	NAVISUBC
Navicula	*subtilissima*	NAVISUBT
Navicula	*tenelloides*	NAVITENE
Navicula	*trivialis*	NAVITRIV
Navicula	*vandamii*	NAVIVAND
Navicula	*vandamii var vandamii*	NAVIVAva
Navicula	*viridula var.rostellata*	NAVIVIro
Neidium	*affine*	NEIDAFFI
Nitzschia	*acula*	NITZACUL
Nitzschia	*aff perindistincta*	NITZafFP
Nitzschia	*angularis var (?)*	NITZANGv
Nitzschia	*aremonica*	NITZAREM
Nitzschia	*capitellata*	NITZCAPI
Nitzschia	*capitellata (2)*	NITZCAP2
Nitzschia	*cf linkei*	NITZCFLI
Nitzschia	*clausii*	NITZCLAU
Nitzschia	*compressa*	NITZCOMP
Nitzschia	*desertorum*	NITZDESE
Nitzschia	*dissipata*	NITZDISS
Nitzschia	*distans var distans*	NITZDIdi
Nitzschia	*erosa*	NITZEROS
Nitzschia	*fasciculata*	NITZFASC
Nitzschia	*fonticola*	NITZFONT
Nitzschia	*fontifuga*	NITZFOGA
Nitzschia	*frustulum*	NITZFRUS
Nitzschia	*graciliformis*	NITZGRAC
Nitzschia	*gracilis*	NITZGRIS
Nitzschia	*hybridaeformis*	NITZHYBR

Nitzschia	*linearis*	NITZLINE
Nitzschia	*linearis v tenuis*	NITZLIte
Nitzschia	*linkei*	NITZLINK
Nitzschia	*littoralis*	NITZLITT
Nitzschia	*microcephala*	NITZMICR
Nitzschia	*nana*	NITZNANA
Nitzschia	*palea*	NITZPALE
Nitzschia	*paleacea*	NITZPAEA
Nitzschia	*paleaeformis*	NITZPAIS
Nitzschia	*pellucida*	NITZPELL
Nitzschia	*perspicua*	NITZPERS
Nitzschia	*pumila*	NITZPUMI
Nitzschia	*recta*	NITZRECT
Nitzschia	*scalpelliformis*	NITZSCAL
Nitzschia	*scalpelloides*	NITZSCES
Nitzschia	*sigma*	NITZSIGM
Nitzschia	*siliqua*	NITZSILI
Nitzschia	*solita*	NITZSOLI
Nitzschia	*sp 01*	NITZsp01
Nitzschia	*spathulata*	NITZSPAT
Nitzschia	*umbonata*	NITZUMBO
Nitzschia	*vacillata*	NITZVACI
Opephora	*horstiana*	OPEPHORS
Opephora	*marina*	OPEPMARI
Opephora	*minuta*	OPEPMINU
Parlibellus	*berkeleyi*	PARLBERK
Parlibellus	*delogna*	PARLDELO
Petroneis	*humerosa*	PETRHUME
Pinnularia	*braunii*	PINNBRAU
Pinnularia	*gibba var linearis*	PINNGIli
Pinnularia	*yarrensis*	PINNYARR
Placoneis	*cfclementis*	PLACCFCL
Placoneis	*cfelginensis*	PLACCFEL
Placoneis	*clementis*	PLACCLEM
Placoneis	*decussis*	PLACDECU
Placoneis	*elginensis*	PLACELGI
Placoneis	*elginensis v elginensis*	PLACELel
Placoneis	*sp.01*	PLACsp01
Plagiotropis	*lepidoptera*	PLAGLEPI
Plagiotropis	*maxima*	PLAGMAXI
Plagiotropis	*tayrecta*	PLAGTAYR
Planothidium	*delicatulum*	PLANDELI
Pleurasigma	*aestuarii*	PLEUAEST
Pleurasigma	*delicatulum*	PLEUDELI
Pleurasigma	*salinarum*	PLEUSALI
Proschkinia	*bulnheimii var bulnheimii*	PROSBUbu
Rhoiscophenia	*curvata*	RHOICURV
Rhopalodia	*gibba*	RHOPGIBB
Sellaphora	*pupula var nyassensis*	SELLPUny

Sellaphora	*pupula var pupula*	SELLPUpu
Seminavis	*sp 01*	SEMIsp01
Seminavis	*sp.02*	SEMIsp02
Seminavis	*sp.03*	SEMIsp03
Seminavis	*sp.04*	SEMIsp04
Stauroneis	*crucicula*	STAUCRUC
Stauroneis	*dubitabilis*	STAUDUBI
Stauroneis	*pachcephala*	STAUPACH
Stauroneis	*tackei*	STAUTACK
Surirella	*angusta*	SURIANGU
Surirella	*atomus*	SURIATOM
Surirella	*brebisonii*	SURIBREB
Surirella	*brebisonii var kuetzingii*	SURIBRku
Surirella	*scalaris*	SURISCAL
Surirella	*striatula*	SURISTRI
Synedra	*tabulata*	SYNETABU
Synedra	*ulna*	SYNEULNA
Tabellaria	*flocculosa*	TABEFLOC
Tryblionella	*apiculata*	TRYBAPIC
Tryblionella	*calida*	TRYBCALI
Tryblionella	*constricta*	TRYBCONS
Tryblionella	*hungarica*	TRYBHUNG
Tryblionella	*sp 01*	TRBYsp01
Tryblionella	*littoralis*	TRYBLITT

BENTHIC DIATOMS IN THE RIVERS AND ESTUARIES OF SOUTH AFRICA

SECTION 2 : RIVER DIATOMS

Report to the Water

Research Commission

GC Bate, PA Smailes, JB Adams

Department of Botany, University of Port Elizabeth

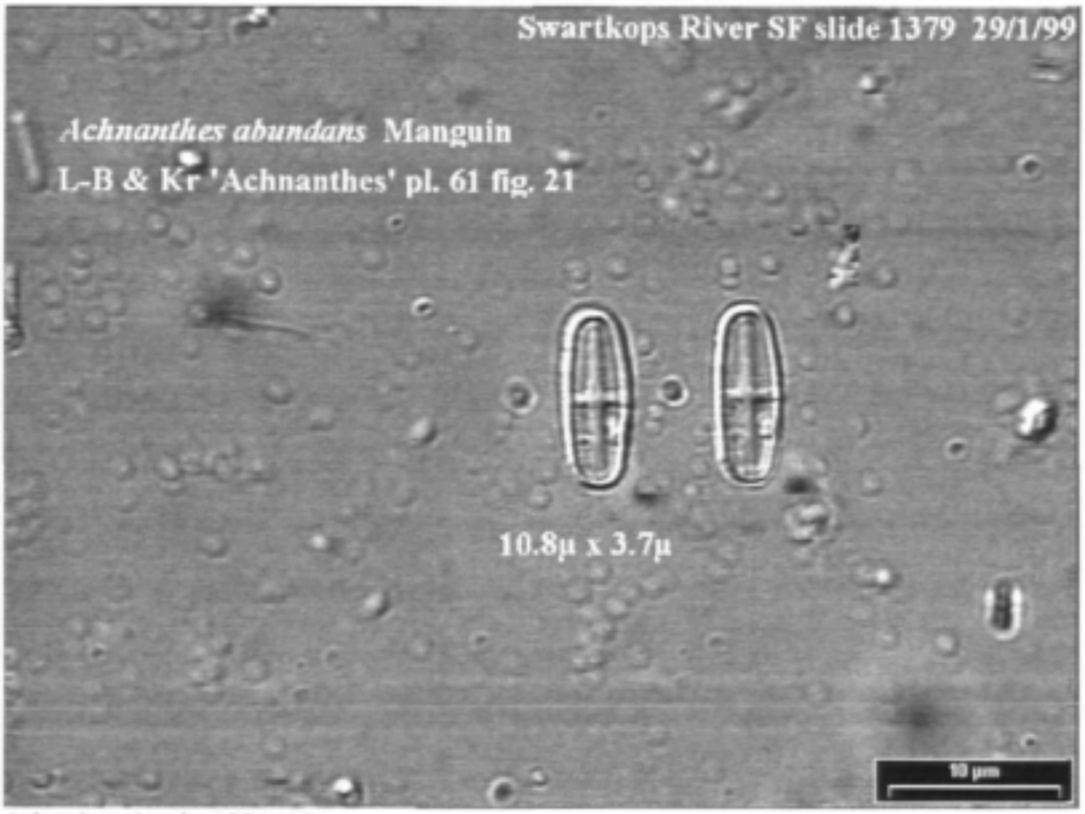
January 2004

RIVER DOMINANTS

RIVER SUB-DOMINANTS

RIVER DOMINANTS

ACHNABUN



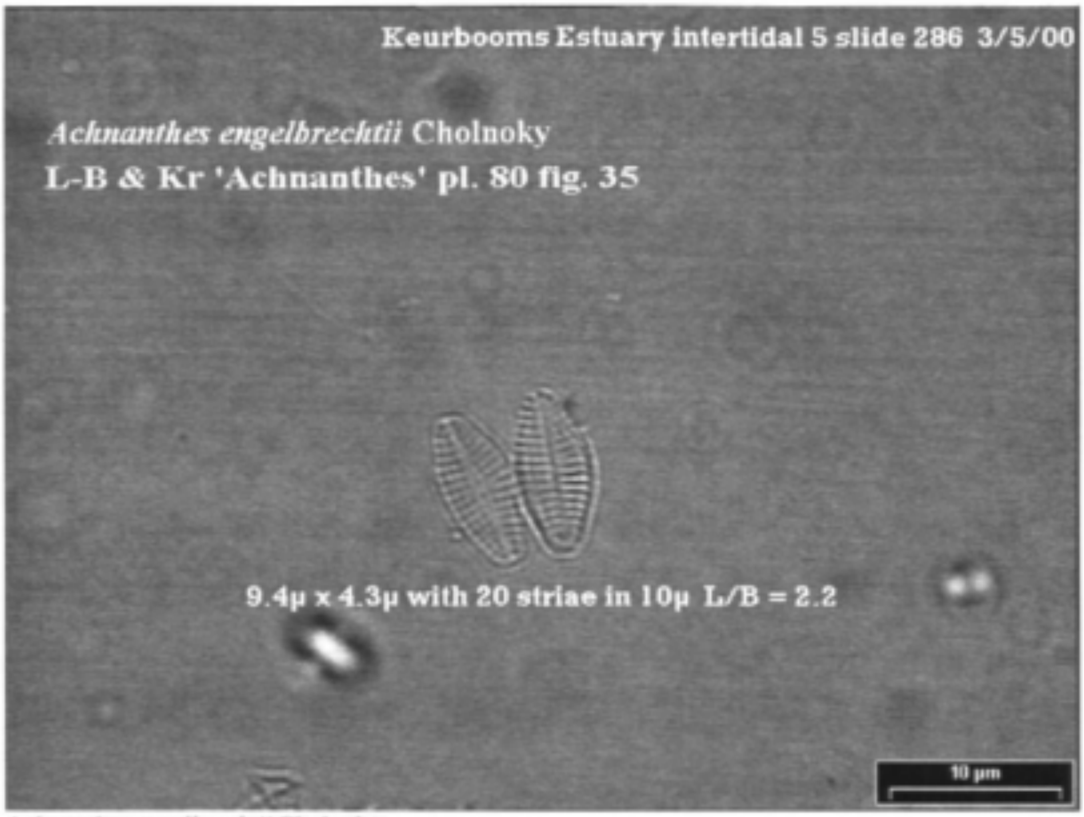
Achanthes abundans Manguin
Reference used for identification: Lange-Bertalot and Krammer 1989. Plate 61. Figure 20.
Locations – Dominant in epipelon – Keurbooms River Site KR3 (DWAF Site K6H011).

ACHNABUN		Class	Class
n=1	$(mg.l^{-1})$	Mean	Mode
Ca	-	-	-
Cl	-	-	-
EC	-	-	-
F	-	-	-
K	-	-	-
Mg	-	-	-
Na	-	-	-
NH_4	-	-	-
NO_3	0.04	1	-
pH	7.26	2	-
PO_4	0.00	1	-
SiO_2	-	-	-
SO_4	-	-	-
Alkalinity	-	-	-
TDS	-	-	-
Mean without pH		1.00	-

NOTES

This is a heterovalvar genus having one raphid and one rapheless valve.

ACHNENGE



Achnanthes engelbrechtii Cholnoky
Reference used for identification: Lange-Bertalot and Krammer 1989. Plate 80. Figure 35.
Locations – Dominant in epipelon - Olifants River Sites K05 & K08.

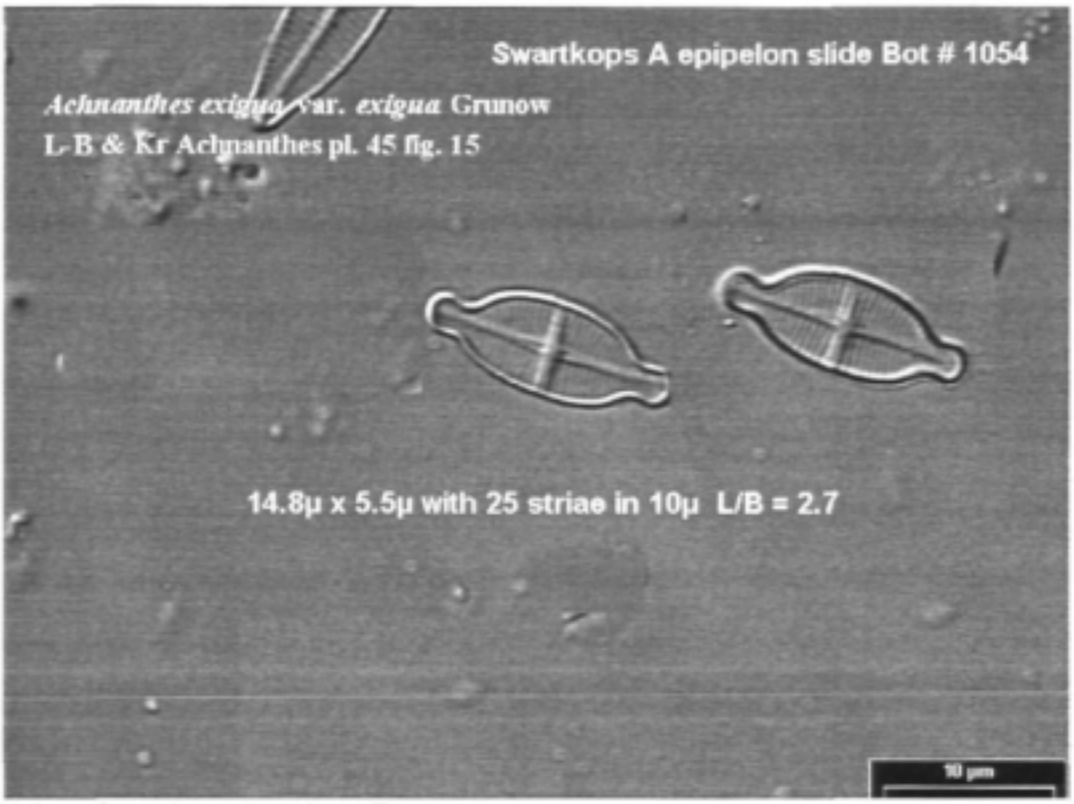
ACHNENGE (n=2)	$(mg.l^{-1})$ Mean	Class Mean	$(mg.l^{-1})$ Mode
Ca	34.50	2	-
Cl	15.50	1	-
EC	49.30	1	-
F	0.30	4	-
K	8.05	1	-
Mg	17.00	1	-
Na	37.00	1	-
NH_4	0.00	-	-
NO_3	2.33	2	-
pH	9.27	5	-
PO_4	0.73	1	-
SiO_2	-	-	-
SO_4	123.00	2	-
Alkalinity	88.50	1	-
TDS	364.00	1	-
Mean class without pH		1.42	-

NOTES

This is a heterovalvar genus having one raphid and one rapheless valve.

Note: This image is taken from the river site of the estuary.

ACHNEXex



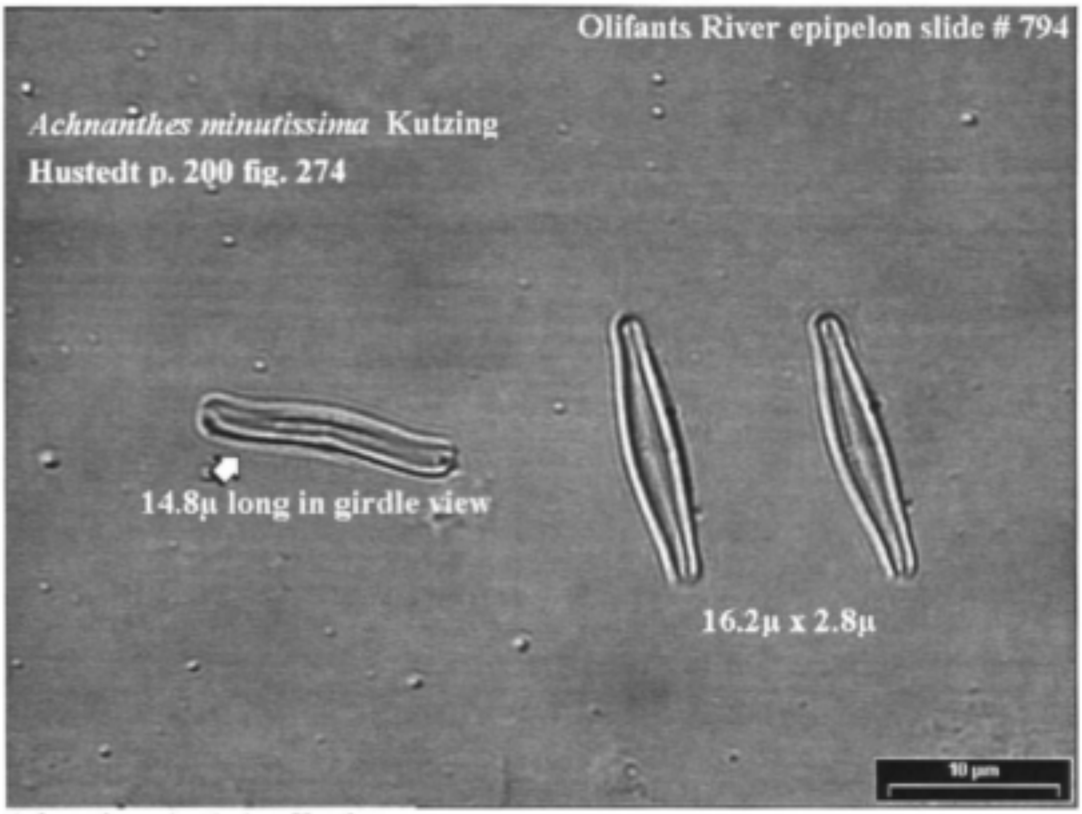
Achnanthes exigua var. *exigua* Grunow
Reference used for identification: Lange-Bertalot & Krammer 1989. Plate 45. Figure 15.
Locations - Dominant in epipelon - Eerste River Site ER 6 (DWAF Site ER720E); Swartkops River Site C11.

ACHNEXex (n=2)	($mg.l^{-1}$) Mean	Class Mean	($mg.l^{-1}$) Mode	Class Mode
Ca	23.00	2	-	-
Cl	259.00	2	-	-
EC	124.30	1	-	-
F	0.20	3	-	-
K	47.00	2	-	-
Mg	26.00	2	-	-
Na	169.00	2	-	-
NH_4	0.00	-	-	-
NO_3	1.24	2	-	-
pH	7.60	3	-	-
PO_4	0.70	1	-	-
SiO_2	2.40	2	-	-
SO_4	47.00	1	-	-
Alkalinity	180.00	2	-	-
TDS	792.00	2	-	-
Mean class without pH		1.42	-	-

NOTES

This is a heterovalvar genus having one raphid and one rapheless valve.

ACHNMINU



Achnanthes minutissima Kutzing.

Reference used for identification: Hustedt 1930. Page 200. Figure 274.

Locations - Dominant in epipelon – Olifants River Sites O4, O6, O9, O10, O11, W3, W4, W6 & W7.

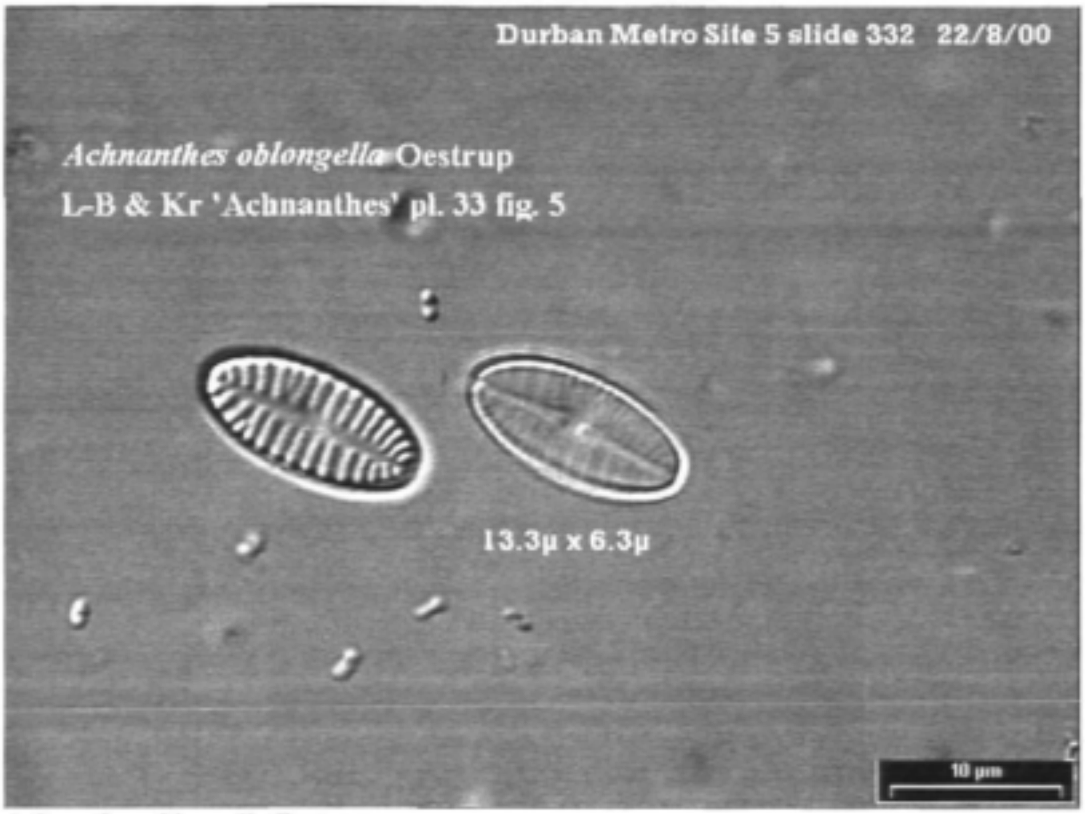
ACHNMINU (n=9)	($mg.l^{-1}$) Mean	Class Mean	($mg.l^{-1}$) Mode	Class Mode
Ca	41.78	3	34.00	2
Cl	7.67	1	0.00	1
EC	50.52	1	40.00	1
F	0.32	4	0.30	4
K	4.66	1	2.20	1
Mg	19.56	2	14.00	1
Na	32.33	1	49.00	1
NH_4	0.04	1	0.00	1
NO_3	1.73	2	0.12	1
pH	7.97	3	-	3
PO_4	0.07	1	0.01	1
SiO_2	1.82	2	0.50	1
SO_4	163.56	2	-	2
Alkalinity	59.56	1	-	1
TDS	360.89	1	-	1
Mean class without pH		1.57		1.38

NOTES

The Genus is heterovalvar, having a raphid and an araphid valve. It is important that both are observed for correct identification.

We have used the Hustedt (1930) reference because the illustrations are the clearest. Lange-Bertalot & Krammer (1989 p. 100) refer to the '*Achnathes minutissma* komplex' and there appear to be many varieties that are not clearly distinguishable.

ACHNOBLO



Achnanthes oblongella Oestrup
Reference used for identification: Lange-Bertalot & Krammer 1989. Plate 33. Figure 5.
Locations - Dominant in epipelon – Bot River BR2 (DWAF Site BR400B); Keurbooms River Site KR1 (DWAF Site K6H011).

ACHNOBLO (n=2)	(mg.l^{-1}) Mean	Class Mean	(mg.l^{-1}) Mode	Class Mode
Ca	-	-	-	-
Cl	-	-	-	-
EC	-	-	-	-
F	-	-	-	-
K	-	-	-	-
Mg	-	-	-	-
Na	-	-	-	-
NH_4	0.00	1	-	-
NO_3	2.27	2	-	-
pH	6.68	1	-	-
PO_4	0.01	1	-	-
SiO_2	-	-	-	-
SO_4	-	-	-	-
Alkalinity	-	-	-	-
TDS	-	-	-	-
Mean class without pH		1.33	-	-

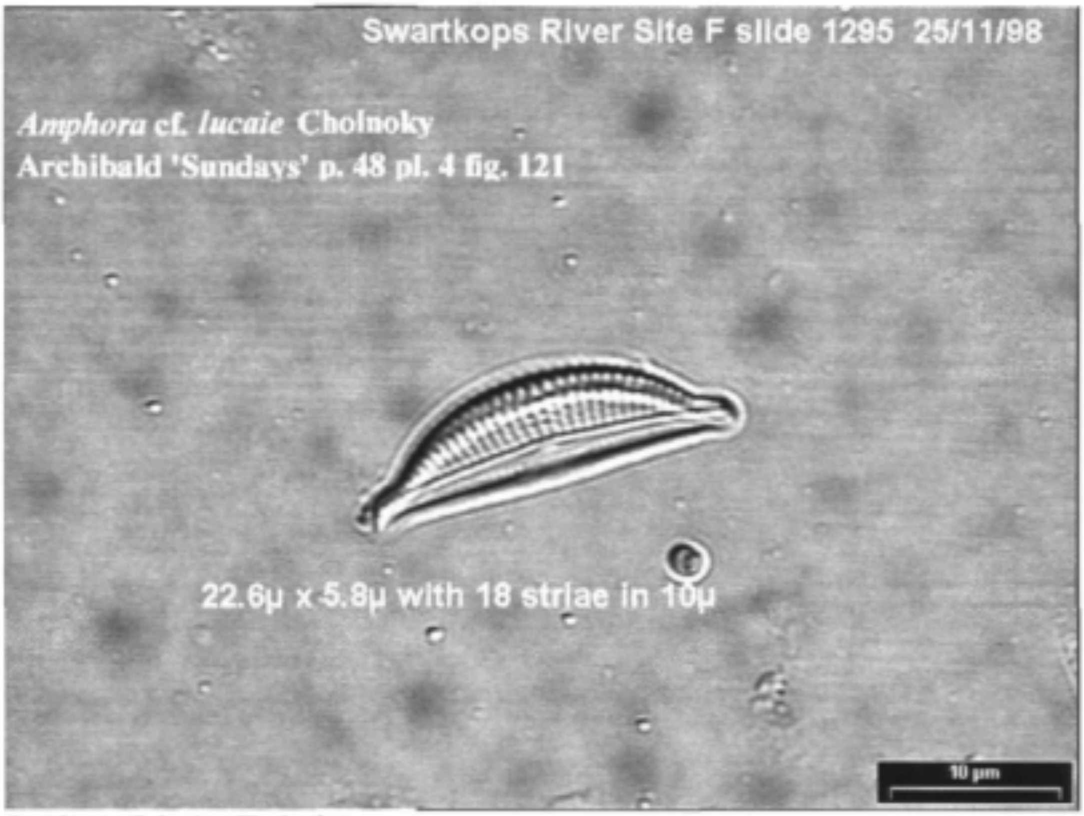
NOTES

The Genus is heterovalvar, having a raphid and an araphid valve.

This species has been found in both rivers and estuaries, but only on two occasions as the dominant in a river. Unfortunately the river water was only partially analyzed.

The high nitrate value attributed to this species was not consistent at both sites where it was found.

AMPHcfLU

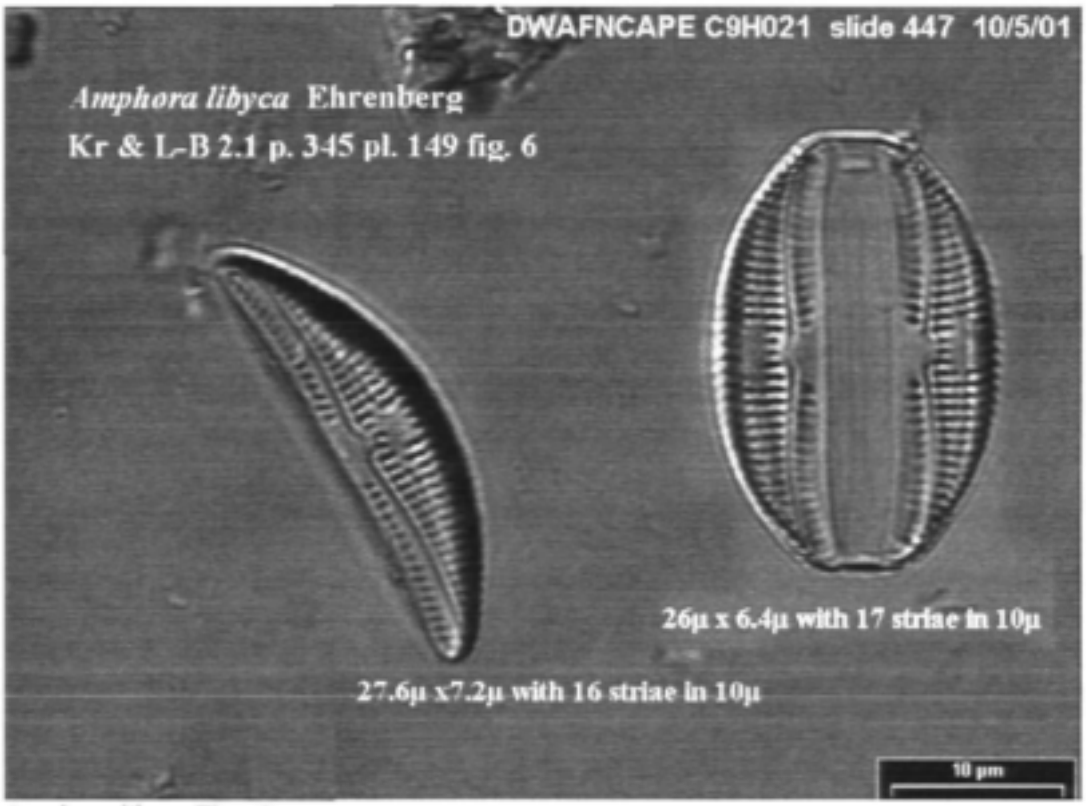


Amphora cf. *luciae* Cholnoky
Reference used for identification: Archibald 1983. Page 48. Plate 4. Figure 121.
Locations - Dominant in epipelon – Swartkops River F15 & F16.

AMPHcflu (n=2)	($mg.l^{-1}$) Mean	Class Mean	($mg.l^{-1}$) Mode	Class Mode
Ca	56.50	3	-	-
Cl	944.50	3	-	-
EC	340.50	2	-	-
F	0.30	4	-	-
K	19.50	1	-	-
Mg	73.50	3	-	-
Na	589.00	4	-	-
NH_4	0.00	1	-	-
NO_3	0.00	1	-	-
pH	6.97	1	-	-
PO_4	3.36	3	-	-
SiO_2	2.6	2	-	-
SO_4	189.00	2	-	-
Alkalinity	187.00	2	-	-
TDS	2110.50	3	-	-
Mean class without pH		2.43	-	-

NOTES

AMPHLIBY



Amphora libyca Ehrenberg

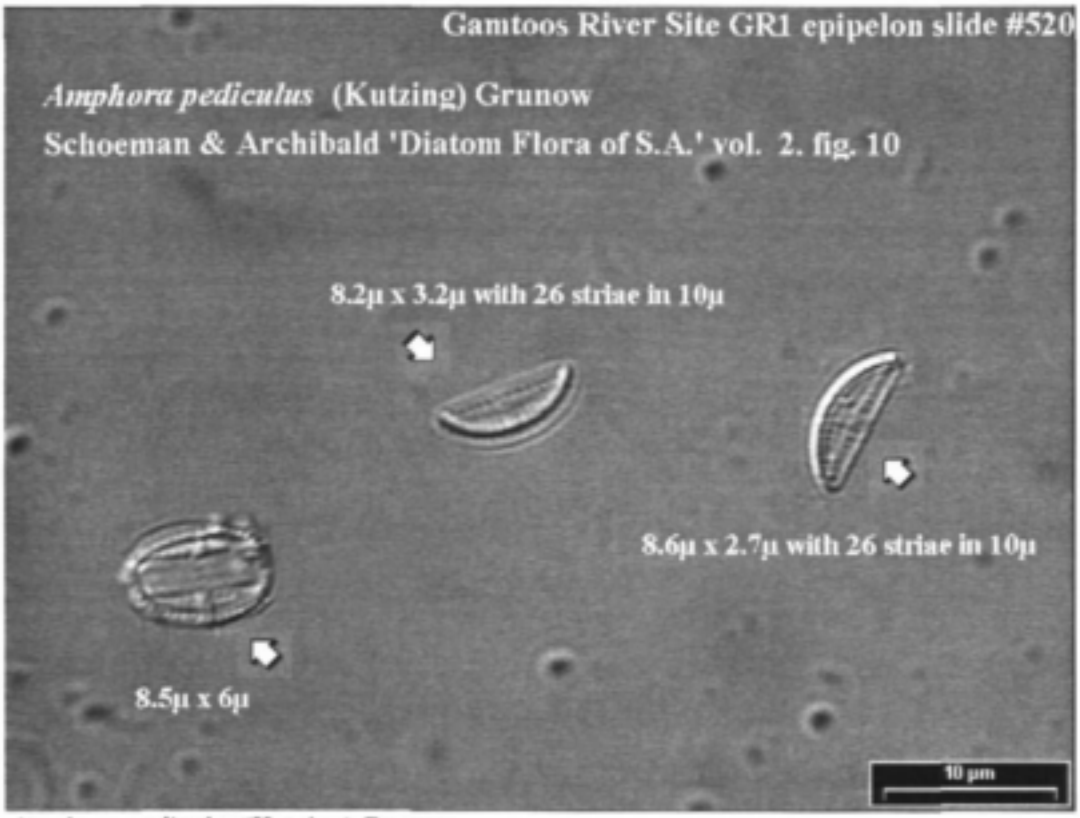
Reference used for identification: Krammer & Lange-Bertalot 1986. Page 345. Plate149. Figure 6.

Locations - Dominant in epipelon – DWAF Northern Province Sites C9H021, C9H010 & D7H002.

AMPHLIBI	($mg.l^{-1}$)	Class	Class
n=1	Mean	Mean	Mode
Ca	22.88	2	-
Cl	16.89	1	-
EC	26.10	1	-
F	0.19	3	-
K	1.76	1	-
Mg	8.21	1	-
Na	14.54	1	-
NH_4	0.01	1	-
NO_3	0.42	1	-
pH	8.35	4	-
PO_4	0.07	1	-
SiO_2		ND	-
SO_4	10.57	1	-
Alkalinity		ND	-
TDS		ND	-
Mean class without pH		1.27	-

NOTES

AMPHPEDI

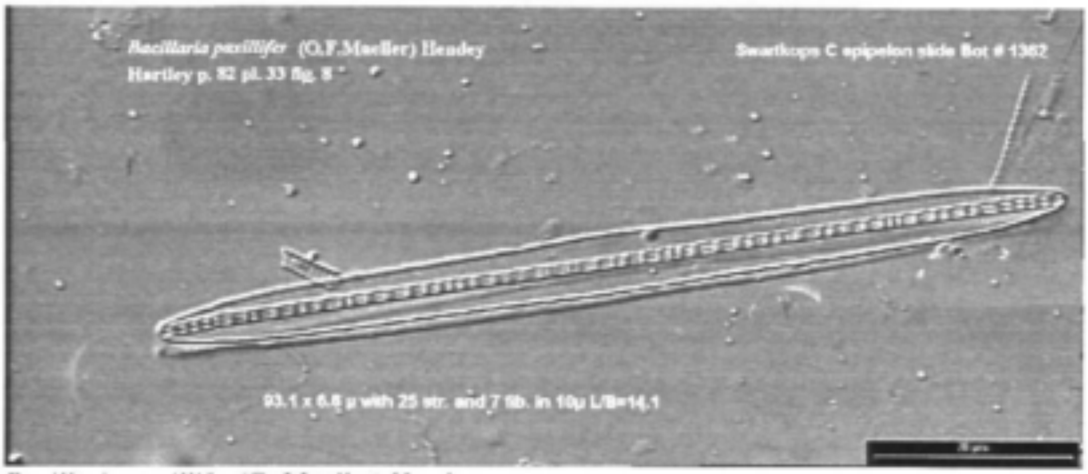


Amphora pediculus (Kutzing) Grunow
Reference used for identification: Schoeman & Archibald 1976. Volume 2. Figure 10.
Locations - Dominant in epipelon – Gamtoos River Site GR1.

AMPHPEDI ($mg.l^{-1}$)		Class	Class
n=1	Mean	Mean	Mode
Ca	69	4	-
Cl	463	2	-
EC	238	2	-
F	0.5	5	-
K	8.9	1	-
Mg	46	2	-
Na	319	2	-
NH_4	0.02	1	-
NO_3	0.02	1	-
pH	8.35	4	-
PO_4	0.043	1	-
SiO_2	2.4	2	-
SO_4	245	3	-
Alkalinity	196	2	-
TDS	1391.0	3	-
Mean without pH		2.21	-

NOTES

BACIPAXI

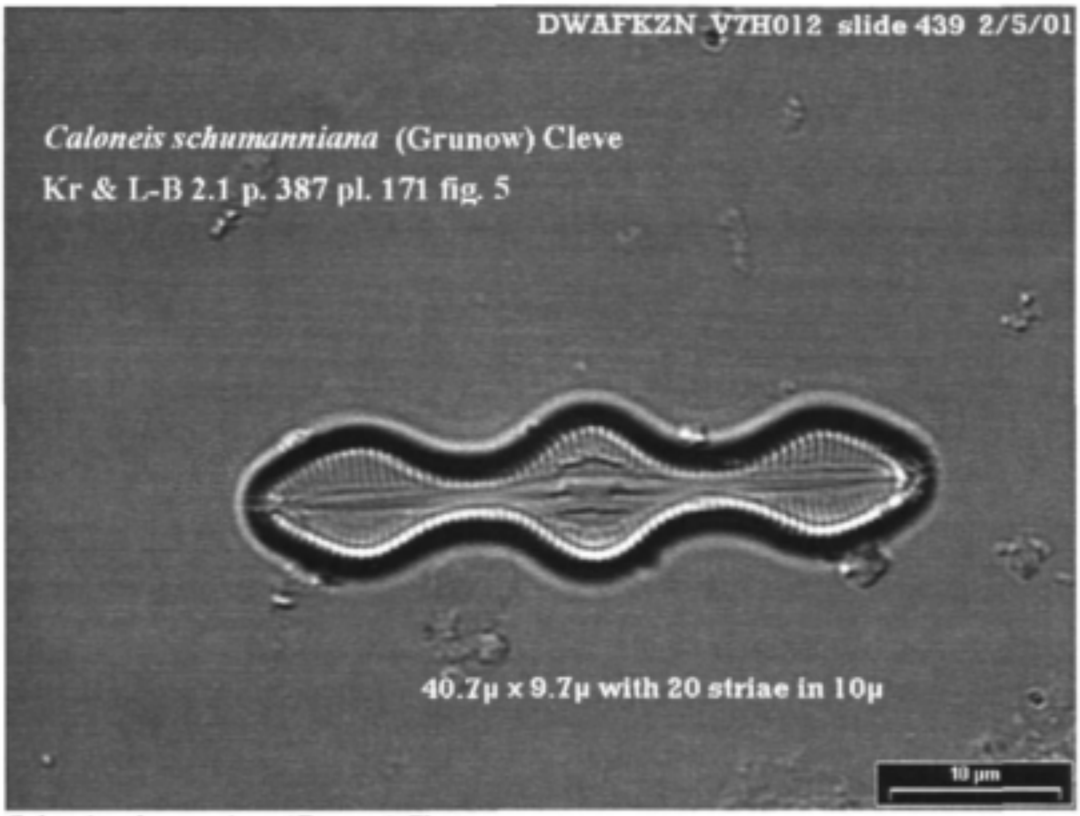


Bacillaria paxillifer (O. Mueller) Hendey
Reference used for identification: Hartley 1996. Page 82. Plate 33. Figure 8.
Locations - Dominant in epipelon – Swartkops River Sites F12 & F14. C18.

BACIPAXI (n=3)	($mg.l^{-1}$) Mean	Class Mean	($mg.l^{-1}$) Mode	Class Mode
Ca	45.33	3	-	3
Cl	689.67	3	-	3
EC	283.00	2	-	2
F	0.23	3	0.20	3
K	47.93	2	-	2
Mg	58.00	3	-	3
Na	422.00	3	-	3
NH_4	0.15	1	-	1
NO_3	1.40	2	-	2
pH	7.83	3	7.38	2
PO_4	1.15	2	-	2
SiO_2	1.7	2	-	2
SO_4	134.67	2	-	2
Alkalinity	220.67	2	-	2
TDS	1674.00	3	-	3
Mean class without pH		2.36		2.36

NOTES

CALOSCHU

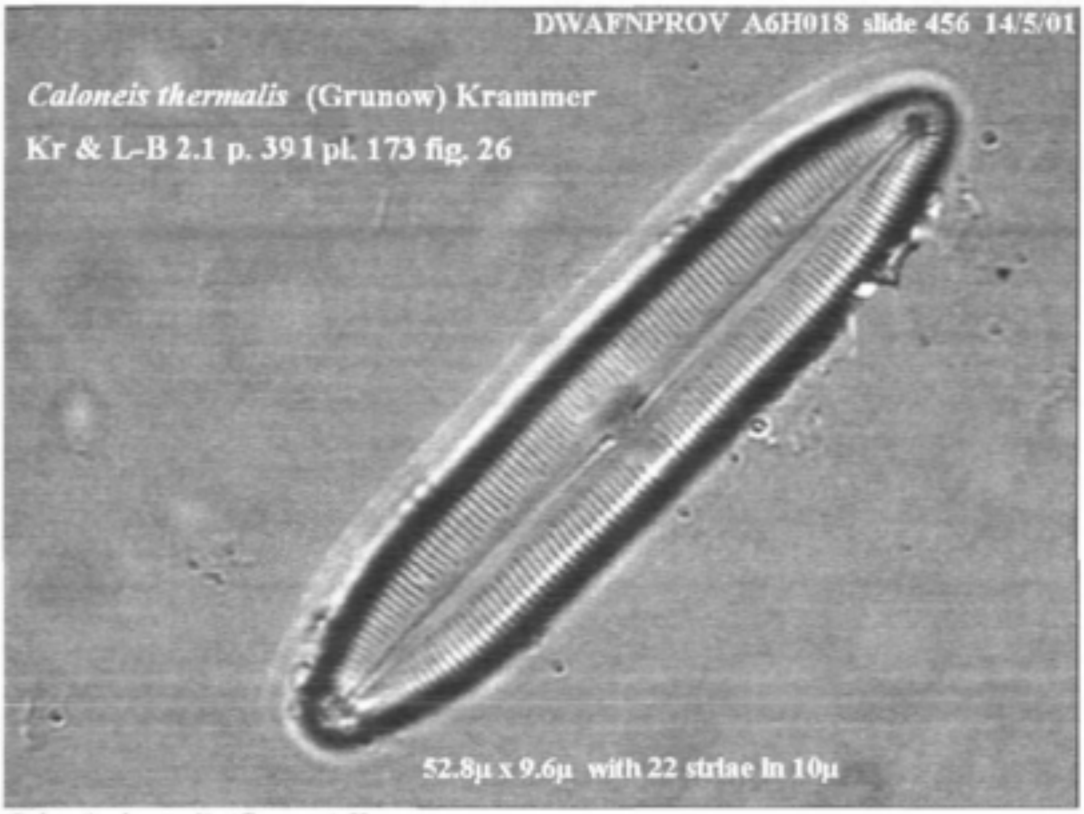


Caloneis schumanniana (Grunow) Cleve
Reference used for identification: Krammer & Lange-Bertalot 1986. Page 387. Plate 171. Figure 5.
Locations - Dominant in epipelon – Olifants River Site O1.

CALOSCHU		Class	Class
n=1	($mg.l^{-1}$)	Mean	Mode
Ca	26	2	-
Cl	39	1	-
EC	43.7	1	-
F	0.3	4	-
K	2.7	1	-
Mg	16	1	-
Na	45	1	-
NH_4	0.06	1	-
NO_3	0.15	1	-
pH	8.79	5	-
PO_4	0.04	1	-
SiO_2	4.5	3	-
SO_4	24	1	-
Alkalinity	166	2	-
TDS	356.0	1	-
Mean class without pH		1.50	-

NOTES

CALOTHER

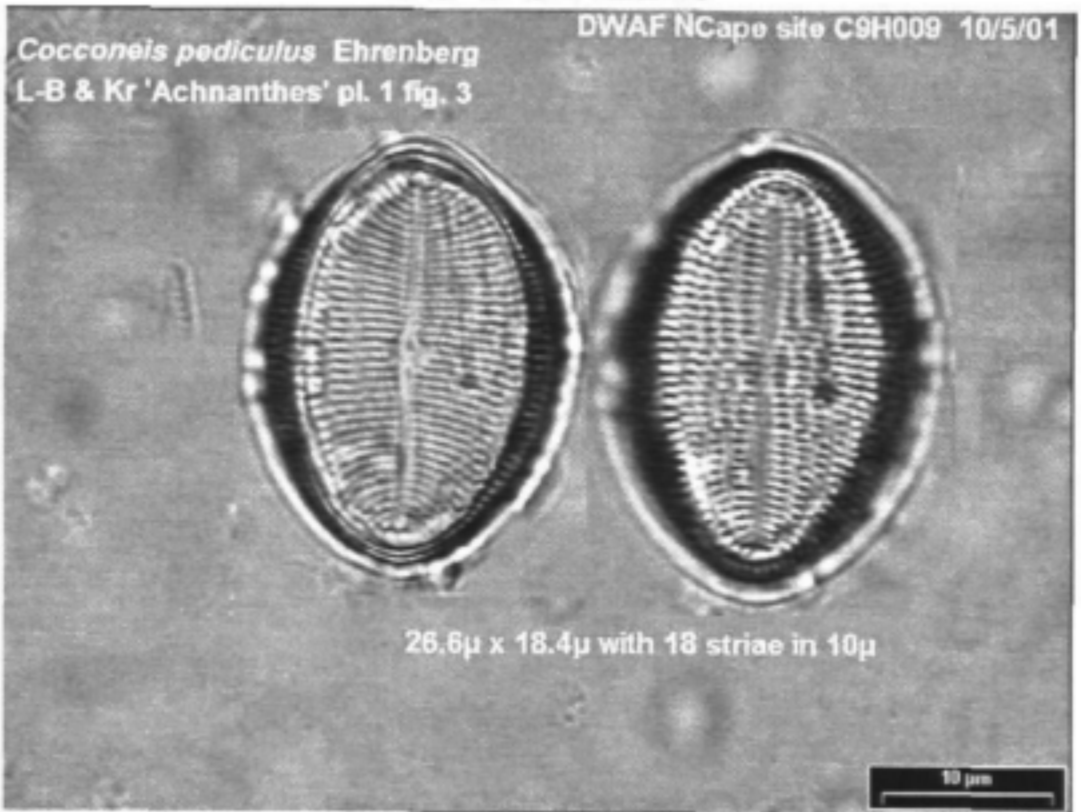


Caloneis thermalis (Grunow) Krammer
Ref. used for identification: Krammer & Lange-Bertalot 1986. 2.1 Page 391. Plate 173. Figure 26.
Locations - Dominant in epipelon – DWAF Northern Province Site A6H018.

CALOTHER		Class	Class
n=1	$(mg.l^{-1})$	Mean	Mode
Ca	2.50	1	-
Cl	3.00	1	-
EC	4.18	1	-
F	0.13	2	-
K	0.46	1	-
Mg	1.46	1	-
Na	3.17	1	-
NH_4	0.01	1	-
NO_3	0.19	1	-
pH	7.23	2	-
PO_4	0.07	1	-
SiO_2	5.29	3	-
SO_4	1.00	1	-
Alkalinity	12.11	1	-
TDS	27.17	1	-
Mean class without pH		1.21	-

NOTES

COCCPEDI



Cocconeis pediculus Ehrenberg

Reference used for identification: Lange-Bertalot & Krammer 1989. Plate 1. Figure 3.

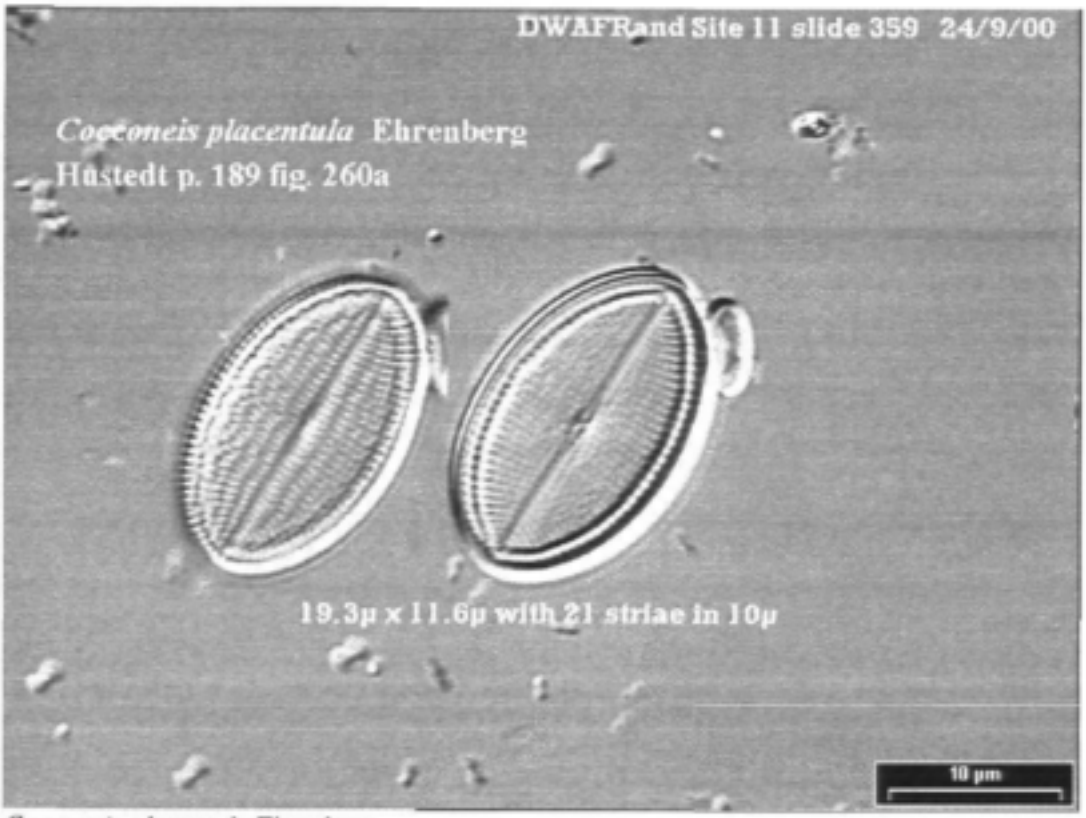
Locations - Dominant in epipelon – Rand Water Site Blesbokspruit B14; DWAF Northern Cape Vaal River Site C9H009.

COCCPEDI (n=2)	($mg.l^{-1}$) Mean	Class Mean	($mg.l^{-1}$) Mode	Class Mode
Ca	84.72	5	-	-
Cl	82.27	1	-	-
EC	81.90	1	-	-
F	0.25	3	-	-
K	8.14	1	-	-
Mg	16.01	1	-	-
Na	69.64	1	-	-
NH_4	0.05	1	-	-
NO_3	0.30	1	-	-
pH	8.06	3	-	-
PO_4	0.05	1	-	-
SiO_2	1.5815	2	-	-
SO_4	34.30	1	-	-
Alkalinity	138.79	2	-	-
TDS	532.35	2	-	-
Mean class without pH		1.64	-	-

NOTES

This is a heterovalvar genus having one valve with a raphe-sternum and the other lacking the raphe, but having a corresponding sternum.

COCCPLAC



Cocconeis placentula Ehrenberg

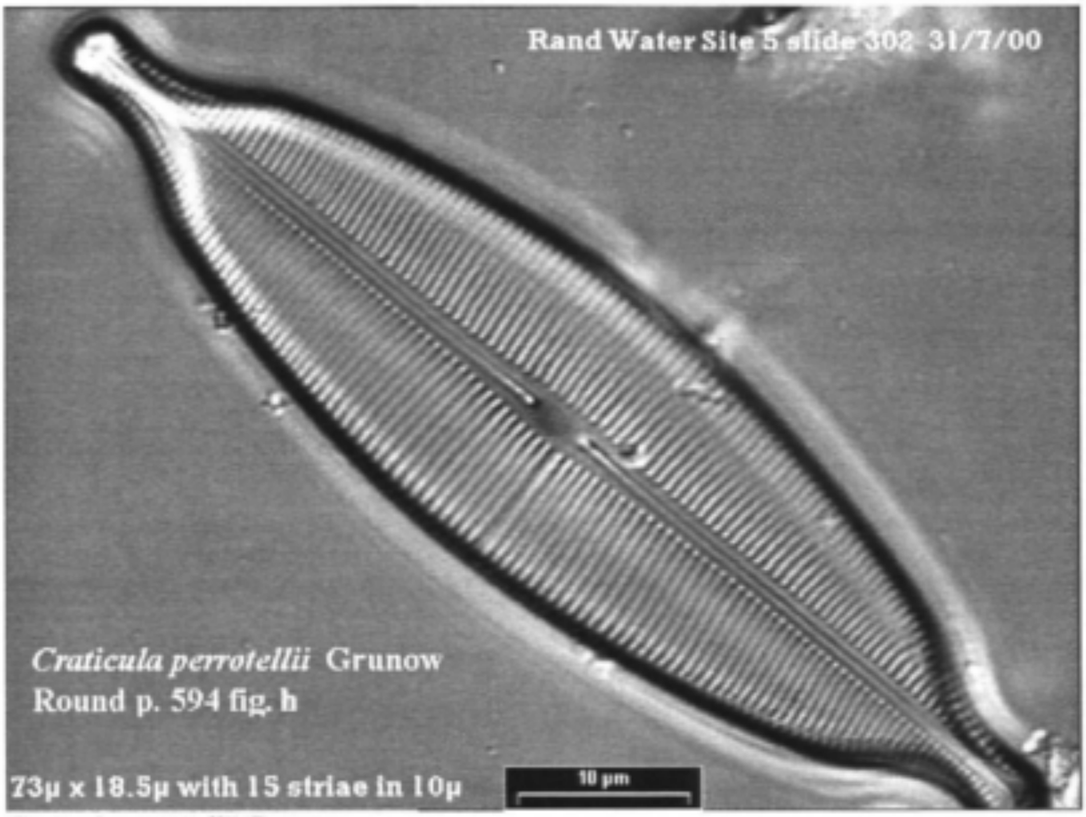
Reference used for identification: Hustedt 1976. Page 189. Figure 260.

Locations - Dominant in epipelon – DWAF Rand Crocodile River Site A2H045; Olifants River Site K04.

COCCPLAC (n=2)	($mg.l^{-1}$) Mean	Class Mean	($mg.l^{-1}$) Mode	Class Mode
Ca	48.01	3	-	-
Cl	38.64	1	-	-
EC	65.10	1	-	-
F	0.27	4	-	-
K	9.17	1	-	-
Mg	22.00	2	-	-
Na	45.19	1	-	-
NH_4	0.07	1	-	-
NO_3	6.69	5	-	-
pH	8.51	4	-	-
PO_4	1.44	2	-	-
SiO_2	4.3505	3	-	-
SO_4	103.72	2	-	-
Alkalinity	142.49	2	-	-
TDS	463.18	1	-	-
Mean class without pH		2.07	-	-

NOTES

CRATPERR



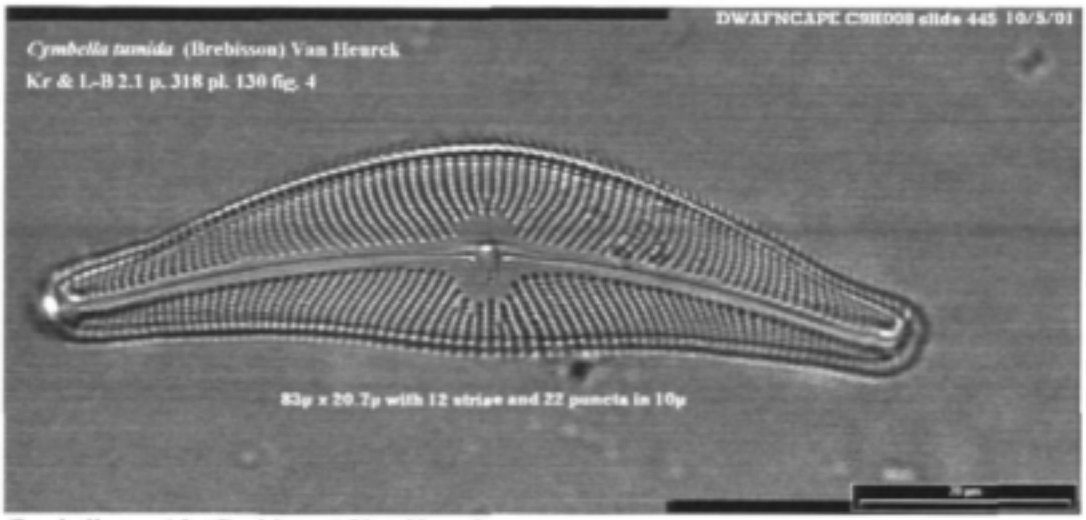
Craticula perrotellii Grunow

Reference used for identification: Round, Crawford & Mann 1990. Page 594. Figure h.

Locations - Dominant in epipelon – Rand Water Kliprivier Sites K6 & K8.

No analytical data available.	<u>NOTES</u>

CYMBTUMI

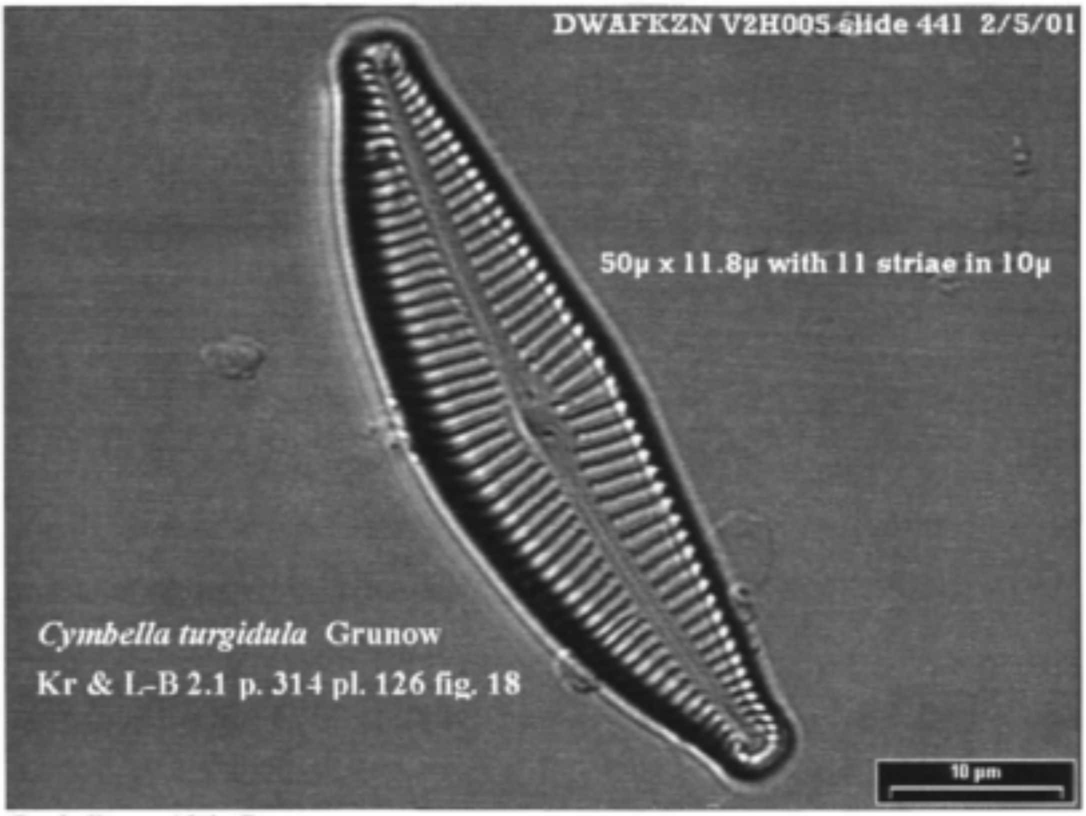


Cymbella tumida (Brebisson) Van Heurck
Ref. used for identification: Krammer & Lange-Bertalot 1986. 2.1 Page 318. Plate 130. Figure 4.
Locations - Dominant in epipelon – DWAF Northern Cape Vaal River Site C9H008.

CYMBTUMI	($mg.l^{-1}$)	Class	Class
n=1	Mean	Mean	Mode
Ca	32.43	2	-
Cl	25.85	1	-
EC	42.80	1	-
F	0.24	3	-
K	5.47	1	-
Mg	14.68	1	-
Na	26.98	1	-
NH_4	0.05	1	-
NO_3	0.25	1	-
pH	8.01	3	-
PO_4	0.53	1	-
SiO_2	1.71	2	-
SO_4	65.45	2	-
Alkalinity	109.01	1	-
TDS	278.20	1	-
Mean without pH		1.36	-

NOTES

CYMBTURG



Cymbella turgidula Grunow

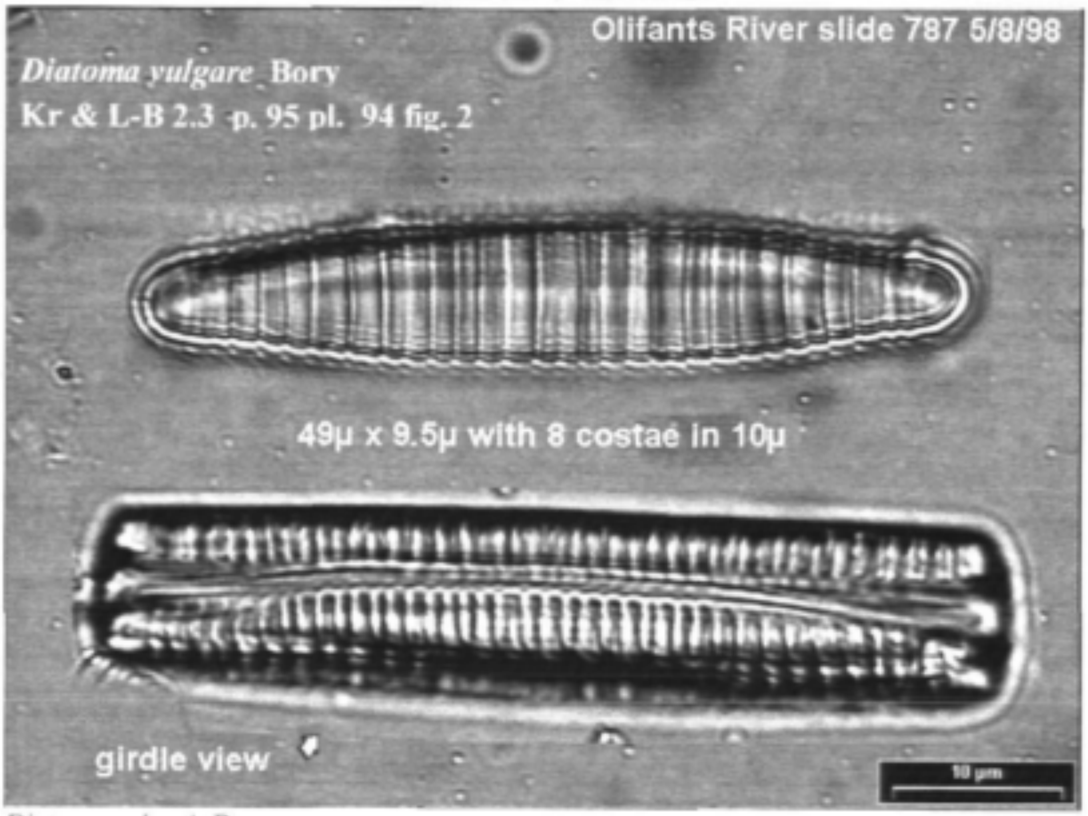
Ref. used for identification: Krammer & Lange-Bertalot 1986. 2.1 Page 314. Plate 126. Figure 18.

Locations - Dominant in epipelon – DWAF Northern Cape Harts River Site C3H003 & Orange River D3H008-A01; DWAF Northern Province Palala River Site A5H008; Kruger National Park DWAF Sabie River Site X3H015 & Luvuvhu River Site A9H008.

CYMBTURG (n=5)	($mg.l^{-1}$) Mean	Class Mean	($mg.l^{-1}$) Mode	Class Mode
Ca	17.00	2	-	-
Cl	17.93	1	-	-
EC	24.62	1	-	-
F	0.18	3	-	-
K	1.52	1	-	-
Mg	9.03	1	-	-
Na	15.85	1	-	-
NH_4	0.04	1	-	-
NO_3	0.42	1	-	-
pH	8.16	4	-	-
PO_4	0.05	1	-	-
SiO_2	5.8028	4	-	-
SO_4	17.28	1	-	-
Alkalinity	81.55	1	-	-
TDS	160.03	1	-	-
Mean class without pH		1.43		-

NOTES

DIATVULG



Diatoma vulgaris Bory

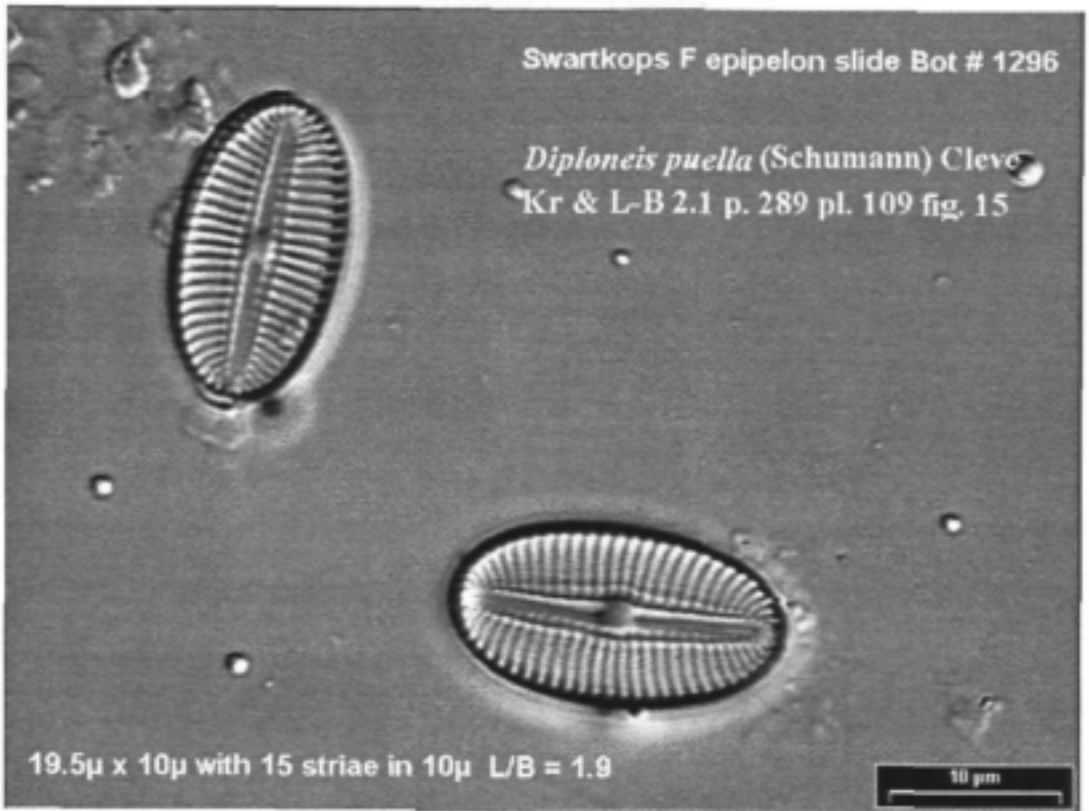
Ref. used for identification: Krammer & Lange-Bertalot 1986. 2.3 Page 95. Plate 94. Figure 2.

Locations - Dominant in epipelon – Olifants River Sites K01 & W5.

DIATVULG (n=2)	($mg.l^{-1}$) Mean	Class Mean	($mg.l^{-1}$) Mode	Class Mode
Ca	42.50	3	-	-
Cl	113.00	1	-	-
EC	55.00	1	-	-
F	0.30	4	-	-
K	6.95	1	-	-
Mg	32.00	2	-	-
Na	25.00	1	-	-
NH_4	0.00	1	-	-
NO_3	0.18	1	-	-
pH	8.22	4	-	-
PO_4	0.01	1	-	-
SiO_2	1.2	2	-	-
SO_4	177.50	2	-	-
Alkalinity	82.50	1	-	-
TDS	402.00	1	-	-
Mean class without pH		1.50	-	-

NOTES

DIPLPUEL

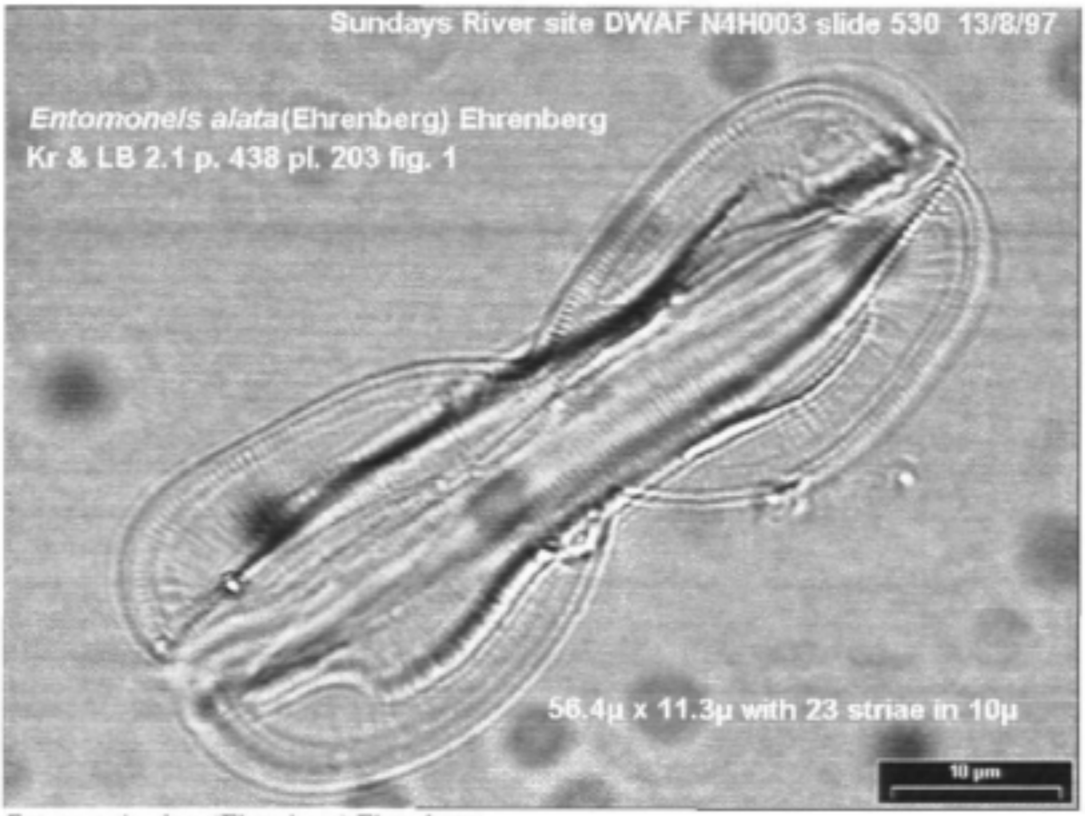


Diploneis puella (Schumann) Cleve
Ref. used for identification: Krammer & Lange-Bertalot 1986. 21. Page 289. Plate 109. Figure 15.
Locations - Dominant in epipelon – Gamtoos River Site GR4; Swartkops River Site D 17 & F 17.

DIPLPUEL (n=2)	($mg.l^{-1}$) Mean	Class Mean	($mg.l^{-1}$) Mode	Class Mode
Ca	33.50	2	-	-
Cl	461.00	2	-	-
EC	172.35	2	-	-
F	0.20	3	-	-
K	9.65	1	-	-
Mg	39.00	2	-	-
Na	280.50	2	-	-
NH_4	0.01	1	-	-
NO_3	0.03	1	-	-
pH	7.69	3	-	-
PO_4	1.20	2	-	-
SiO_2	2.00	2	-	-
SO_4	108.00	2	-	-
Alkalinity	121.00	2	-	-
TDS	1083.50	2	-	-
Mean class without pH		1.86	-	-

NOTES

ENTOALAT



Entomoneis alata (Ehrenberg) Ehrenberg

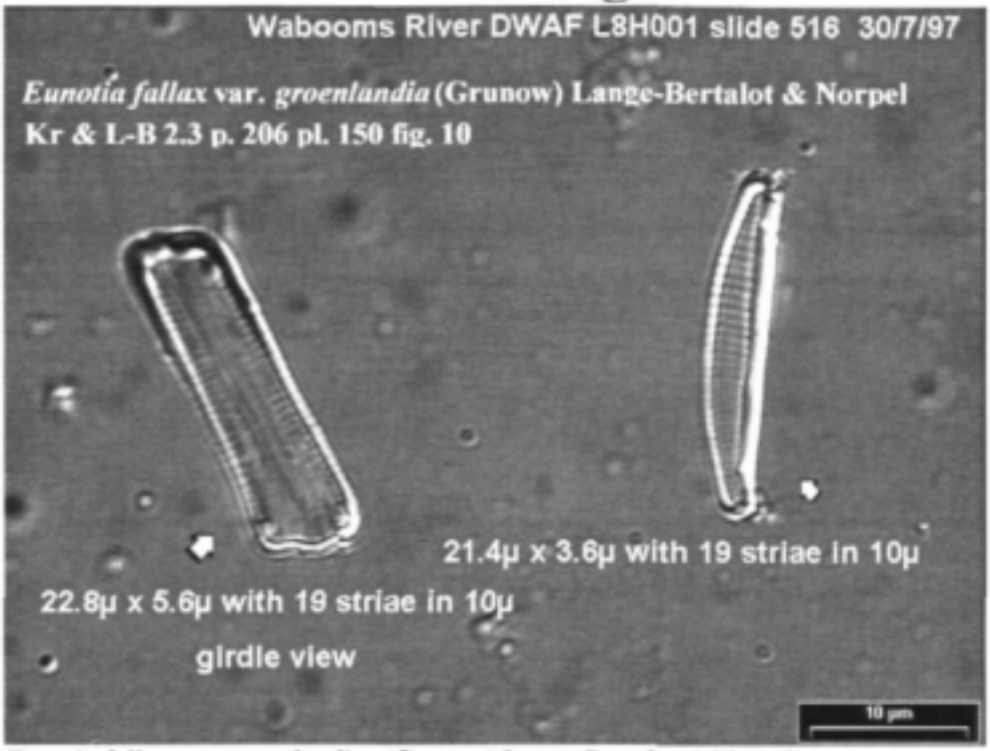
Ref. used for identification: Krammer & Lange-Bertalot 1986. 2.1 Page 438. Plate 203. Figure 1.

Locations - Dominant in epipelon – Swartkops River F13.

ENTOALAT	($mg.l^{-1}$)	Class	Class
n=1		Mean	Mode
Ca	45	3	-
Cl	752	3	-
EC	289	2	-
F	0.2	3	-
K	19.3	1	-
Mg	63	3	-
Na	443	3	-
NH_4	0.04	1	-
NO_3	1.06	2	-
pH	7.82	3	-
PO_4	1.412	2	-
SiO_2	1.1	1	-
SO_4	162	2	-
Alkalinity	153	2	-
TDS	1680.0	3	-
Mean class without pH		2.00	-

NOTES

EUNOFAgr

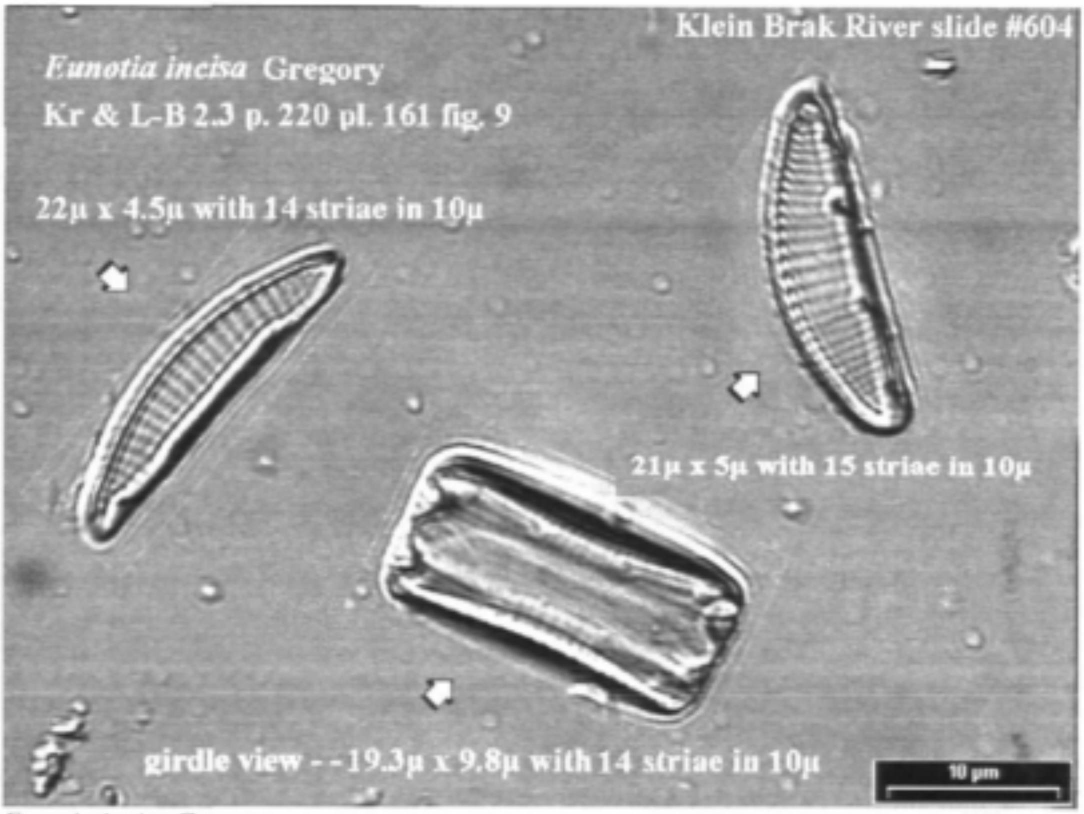


Eunotia fallax var. *groenlandica* (Grunow) Lange-Bertalot & Norpel
Reference used for identification: Krammer & Lange-Bertalot 1986. 2..3 Page 206. Plate 150. Figure 10.
Locations - Dominant in epipelon – Gamtoos River Site GT2.

EUNOFAgr n=1	(mg.l^{-1})	Class Mean	Class Mode
Ca	1.00	1	-
Cl	10.00	1	-
EC	5.50	1	-
F	0.05	2	-
K	0.15	1	-
Mg	1.00	1	-
Na	6.00	1	-
NH_4	0.02	1	-
NO_3	0.20	1	-
pH	4.90	1	-
PO_4	0.01	1	-
SiO_2	2.00	2	-
SO_4	7.00	1	-
Alkalinity	6.00	1	-
TDS	34.00	1	-
Mean class without pH		1.14	-

NOTES

EUNOINCI

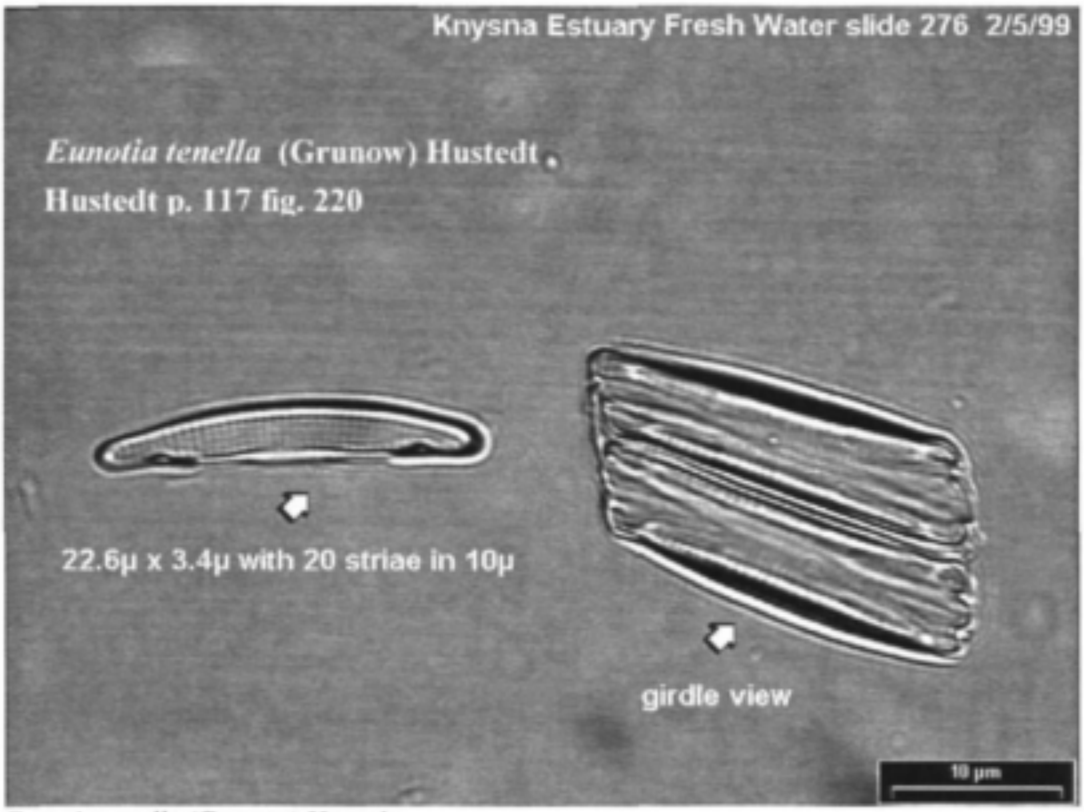


Eunotia incisa Gregory
Ref. used for identification: Krammer & Lange-Bertalot 1986. 2. 3 Page 220. Plate 161. Figure 9.
Locations - Dominant in epipelon – West Cape Bedeke River KB1 (DWAF Site K1H002).

EUNOINCI (n=2)	($mg.l^{-1}$) Mean	Class Mean	Class Mode
Ca			
Cl	-	-	-
EC	-	-	-
F	-	-	-
K	-	-	-
Mg	-	-	-
Na	-	-	-
NH_4	-	-	-
NO_3	0.02	1	-
pH	0.65	1	-
PO_4	4.72	1	-
SiO_2	0.02	1	-
SO_4	-	-	-
Alkalinity	-	-	-
TDS	-	-	-
Mean class without pH		-	-

NOTES

EUNOTENE

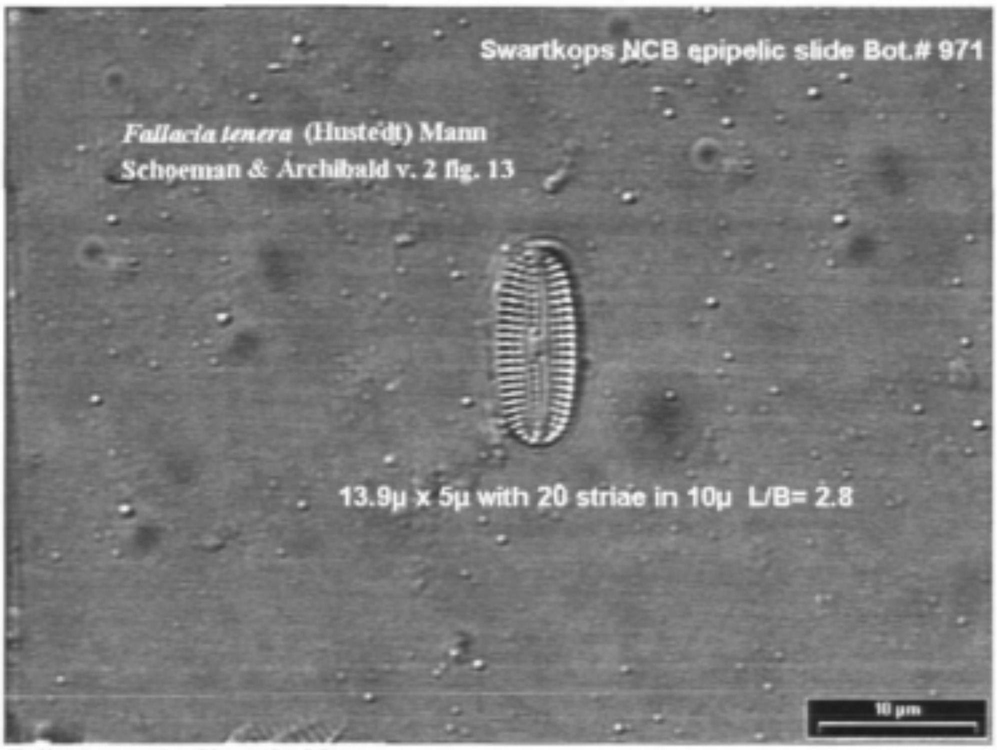


Eunotia tenella (Grunow) Hustedt.
Reference used for identification: Hustedt 1976. Page 177. Figure 220.
Locations - Dominant in epipelon – Palmiet River Site PR3 (DWAF Site PR400C).

EUNOTENE (mg.l^{-1}) n=1		Class Mean	Class Mode
Ca	-	-	-
Cl	-	-	-
EC	-	-	-
F	-	-	-
K	-	-	-
Mg	-	-	-
Na	-	-	-
NH_4	0.00	1	-
NO_3	1.90	2	-
pH	6.20	1	-
PO_4	-	-	-
SiO_2	-	-	-
SO_4	-	-	-
Alkalinity	-	-	-
TDS	-	-	-
Mean class without pH		1.50	-

NOTES

FALLTENE

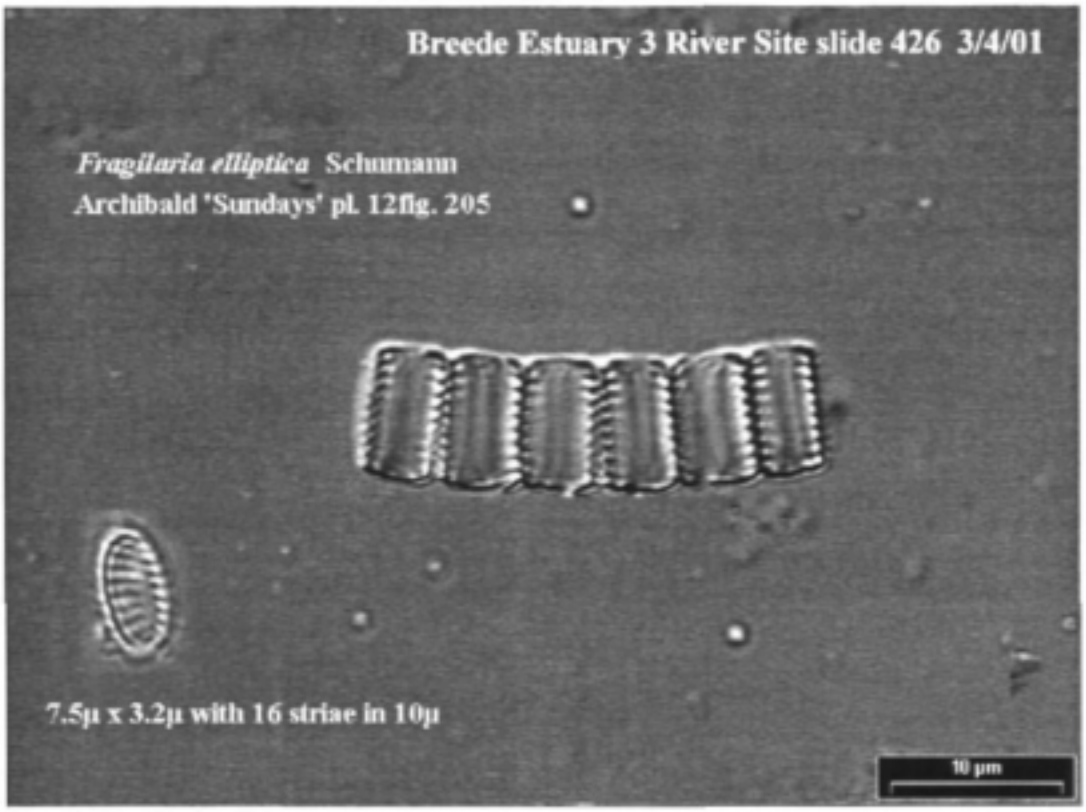


Fallacia tenera (Hustedt) Mann
Reference used for identification: Schoeman & Archibald 1976. Figure 13.
Locations – Sub-dominant in epipelon: Swartkops River Sites E10, E11, E18, E21 & F11.

FALLTENE (n=5)	($mg.l^{-1}$) Mean	Class Mean	($mg.l^{-1}$) Mode	Class Mode
Ca	60.00	4	-	4
Cl	1080.80	4	-	4
EC	470.20	3	-	3
F	0.32	4	0.30	4
K	25.00	1	-	1
Mg	85.80	4	-	4
Na	641.20	4	-	4
NH4	0.63	2	-	2
NO3	2.16	2	-	2
pH	7.91	3	-	3
PO4	1.77	2	-	2
SiO2	2.5	2	-	2
SO4	206.80	3	-	3
Alkalinity	227.20	2	-	2
TDS	2393.20	4	-	4
Mean class without pH		2.64		2.64

NOTES

FRAGELLI

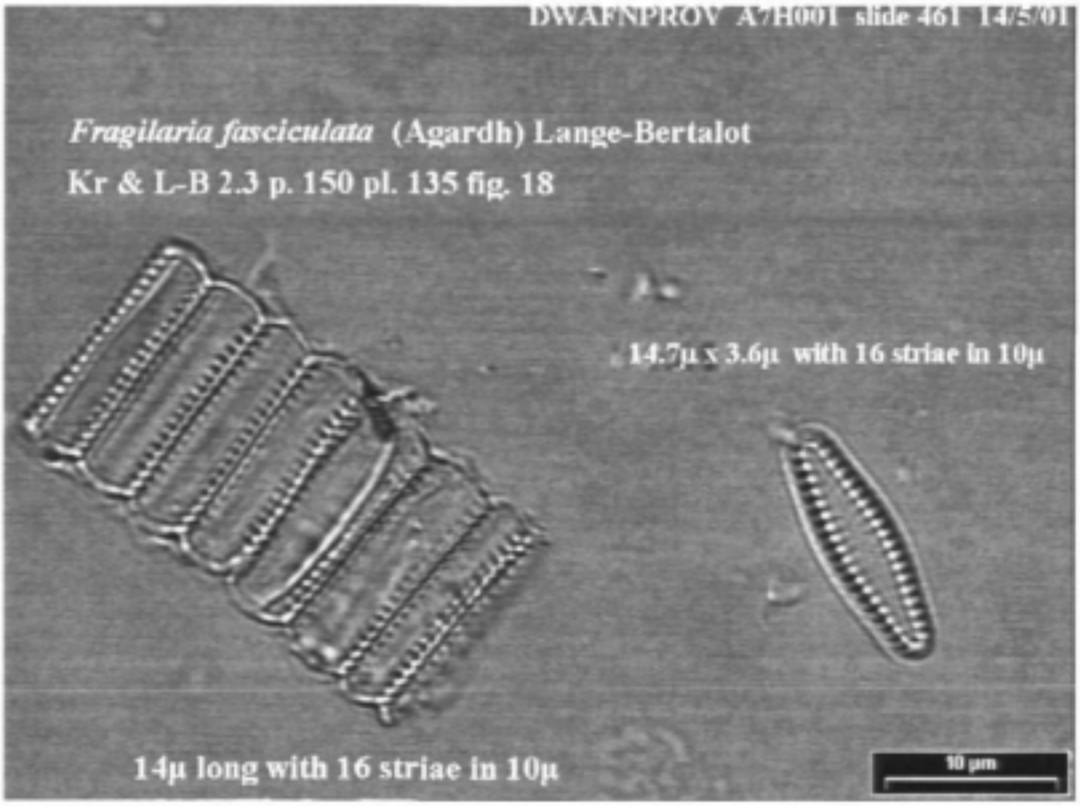


Fragilaria elliptica Schumann
Reference used for identification: Archibald 1983. Page 104. Plate 12. Figures 202 & 205.
Locations - Dominant in epipelon – Swartkops River Sites C09, C12, C17, F09, F10, F17, F20 & F21.

FRAGELLI (n=7)	($mg.l^{-1}$) Mean	Class Mean	($mg.l^{-1}$) Mode	Class Mode
Ca	34.43	2	-	2
Cl	504.00	2	-	2
EC	205.03	2	-	2
F	0.23	3	0.10	2
K	25.51	1	-	1
Mg	41.00	2	-	2
Na	315.71	2	-	2
NH_4	0.02	1	0.00	1
NO_3	0.32	1	-	1
pH	7.39	2	-	2
PO_4	1.82	2	-	2
SiO_2	2.87	2	3.3	5
SO_4	119.29	2	-	2
Alkalinity	154.14	2	-	2
TDS	1234.57	2	-	2
Mean class without pH		1.71		1.86

NOTES

FRAGFASC

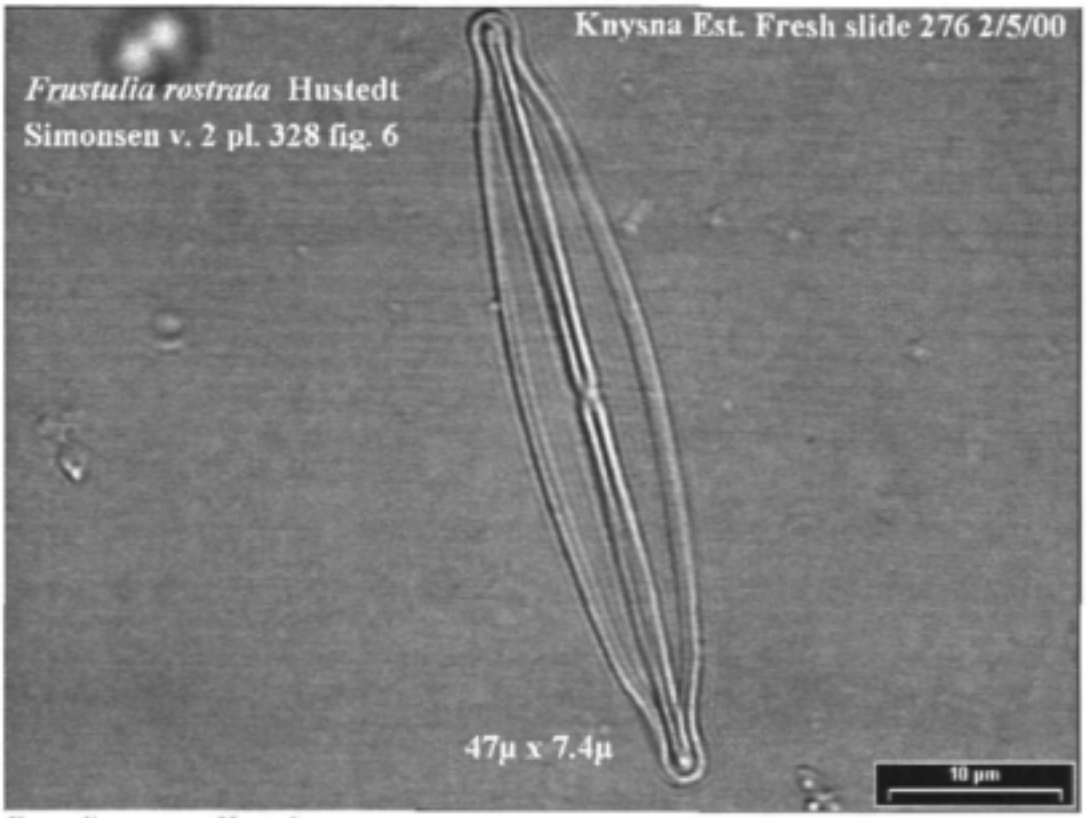


Fragilaria fasciculata (Agardh) Lange-Bertalot
Ref. used for identification: Krammer & Lange-Bertalot 1986. 2. 3 Page 150. Plate 135. Figure 18.
Locations - Dominant in epipelon – DWAF Northern Province Sand River Site A7H001.

FRAGFASC n=1	($mg.l^{-1}$)	Class Mean	Class Mode
Ca	11.73	1	-
Cl	36.26	1	-
EC	24.90	1	-
F	0.14	2	-
K	1.48	1	-
Mg	8.48	1	-
Na	23.63	1	-
NH_4	0.09	1	-
NO_3	0.09	1	-
pH	7.84	3	-
PO_4	0.06	1	-
SiO_2	6.33	4	-
SO_4	18.03	1	-
Alkalinity	56.68	1	-
TDS	161.85	1	-
Mean class without pH		1.29	-

NOTES

FRUSROST

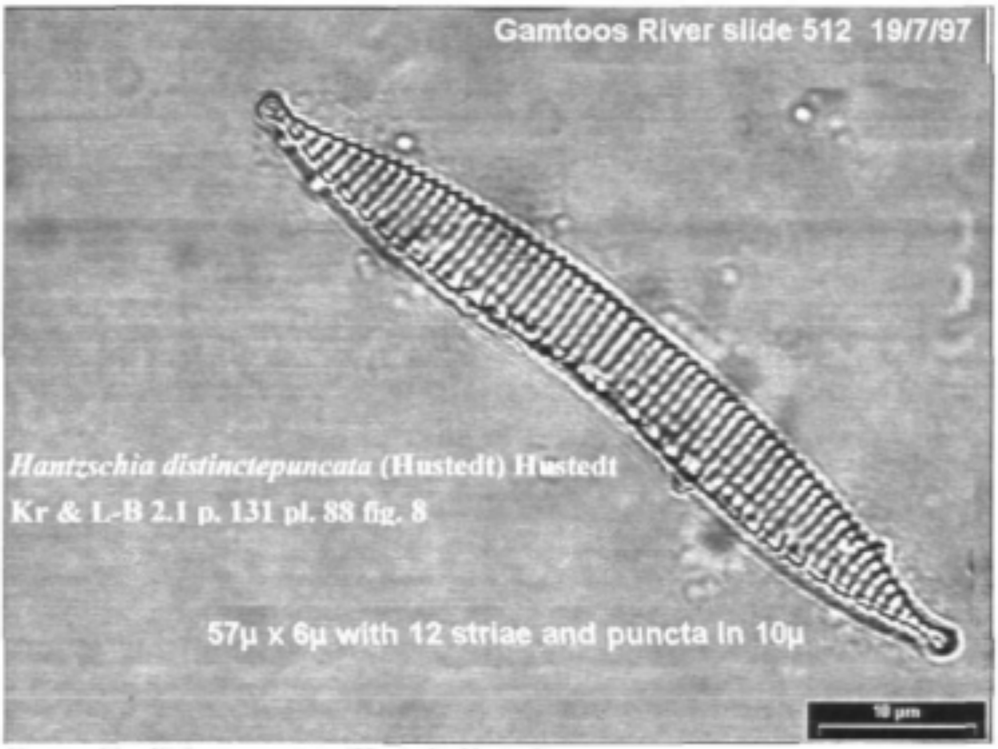


Frustulia rostrata Hustedt
Reference used for identification: Simonsen 1987. Volume 2. Plate 328. Figure 6.
Locations - Dominant in epipelon – Palmiet River Site PR1 (DWAF Site PR400A).

FRUSROST		Class	Class
n=1	($mg.l^{-1}$)	Mean	Mode
Ca	-	-	-
Cl	-	-	-
EC	-	-	-
F	-	-	-
K	-	-	-
Mg	-	-	-
Na	-	-	-
NH_4	0	1	-
NO_3	0	1	-
pH	4.2	1	-
PO_4	-	-	-
SiO_2	-	-	-
SO_4	-	-	-
Alkalinity	-	-	-
TDS	-	-	-
Mean class without pH		1.00	-

NOTES

HANTDIST

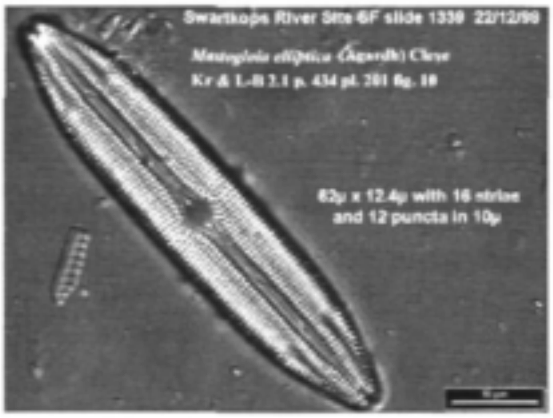


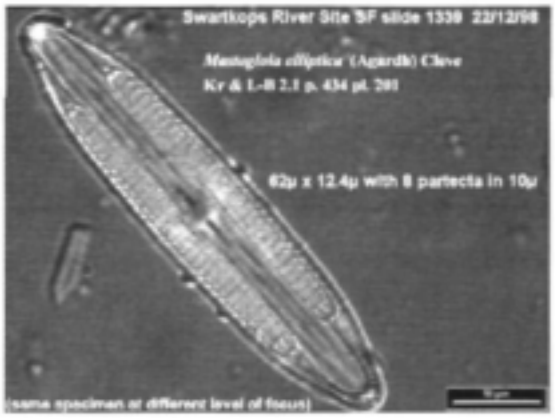
Hantzschia distinctepunctata (Hustedt) Hustedt
Reference used for identification: Krammer & Lange-Bertalot 1986. 2. 3 Page 131. Plate 88. Figure 8.
Locations - Dominant in epipelon – Gamtoos River Site GR6.

HANTDIST n=1	($mg.l^{-1}$) Mean	Class Mean	Class Mode
Ca	14.00	2	-
Cl	112.00	1	-
EC	49.70	1	-
F	0.10	2	-
K	1.90	1	-
Mg	13.00	1	-
Na	65.00	1	-
NH_4	0.02	1	-
NO_3	0.92	1	-
pH	7.10	2	-
PO_4	0.02	1	-
SiO_2	6.80	4	-
SO_4	36.00	1	-
Alkalinity	51.00	1	-
TDS	309.00	1	-
Mean class without pH		1.36	-

NOTES

MASTELLI



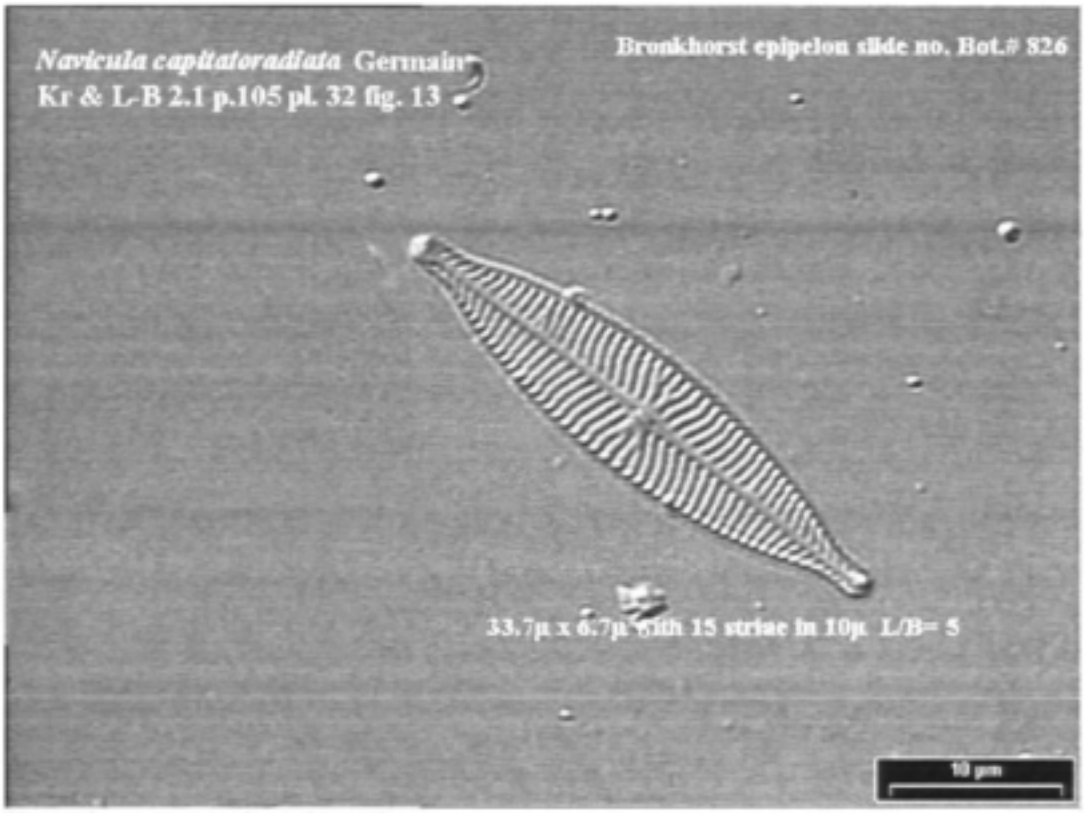


Mastogloia elliptica (Agardh) Cleve
Ref. used for identification: Krammer & Lange-Bertalot 1986. 2.1 Page 434. Plate 201. Figure 10.
Locations - Dominant in epipelon – Swartkops River Site A17.

MASTELLI	($mg.l^{-1}$)	Class	Class
n=1	Mean	Mean	Mode
Ca	3.00	1	-
Cl	45.00	1	-
EC	17.40	1	-
F	0.10	2	-
K	0.70	1	-
Mg	4.00	1	-
Na	28.00	1	-
NH_4	0.00	1	-
NO_3	0.11	1	-
pH	7.31	2	-
PO_4	0.02	1	-
SiO_2	2.20	2	-
SO_4	7.00	1	-
Alkalinity	17.00	1	-
TDS	109.00	1	-
Mean class without pH		1.15	-

NOTES

NAVICAPI



Navicula capitatoradiata Germain

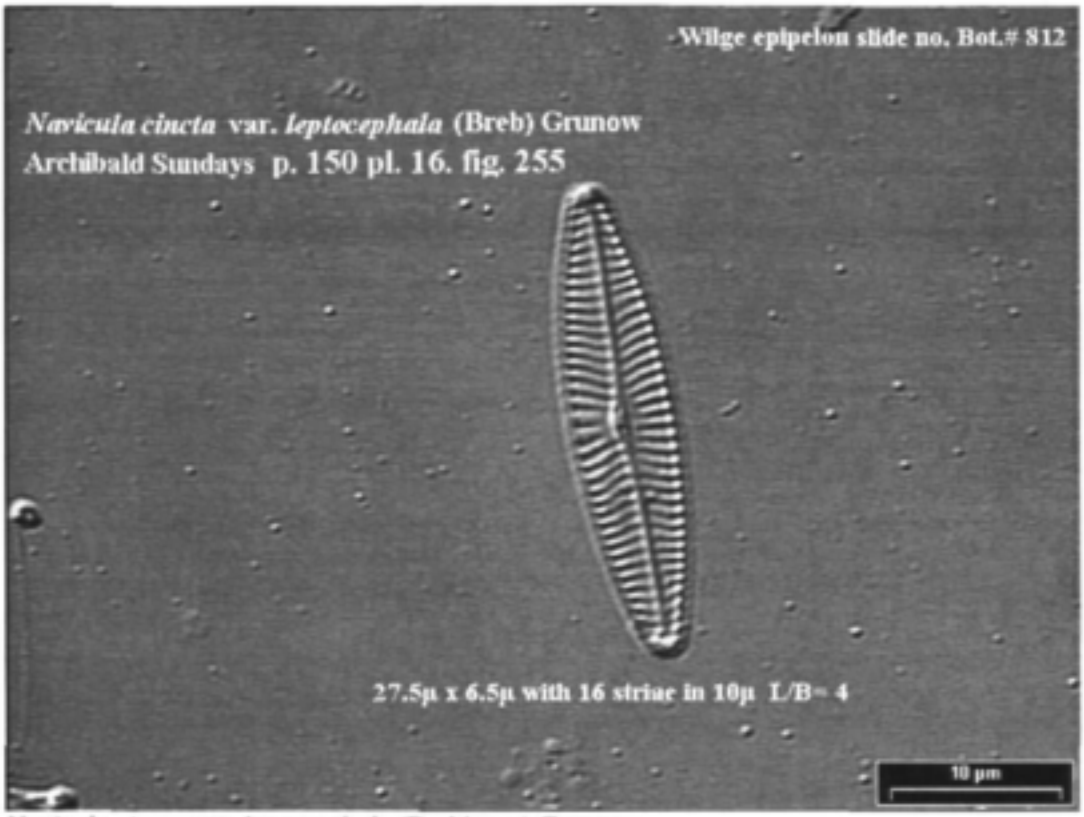
Ref. used for identification: Krammer & Lange-Bertalot 1986. 2.1 Page 105. Plate 32. Figure 13.

Locations - Dominant in epipelon – Olifants River Sites Klein Olifants K03; Wilge River W2, Bedeke River B2 & B3.

NAVICAPI (n=4)	($mg.l^{-1}$) Mean	Class Mean	($mg.l^{-1}$) Mode	Class Mode
Ca	27.00	2	-	2
Cl	0.00	0	0	-
EC	35.00	1	-	1
F	0.28	4	0.20	1
K	4.33	1	-	1
Mg	18.25	1	18	2
Na	16.75	1	21	2
NH_4	0.00	1	0	1
NO_3	0.16	1	-	1
pH	8.27	4	-	4
PO_4	0.17	1	0.007	1
SiO_2	2.825	2	-	2
SO_4	55.50	1	-	1
Alkalinity	116.00	2	-	2
TDS	277.75	1	-	1
Mean class without pH		1.36		1.29

NOTES

NAVICIIe

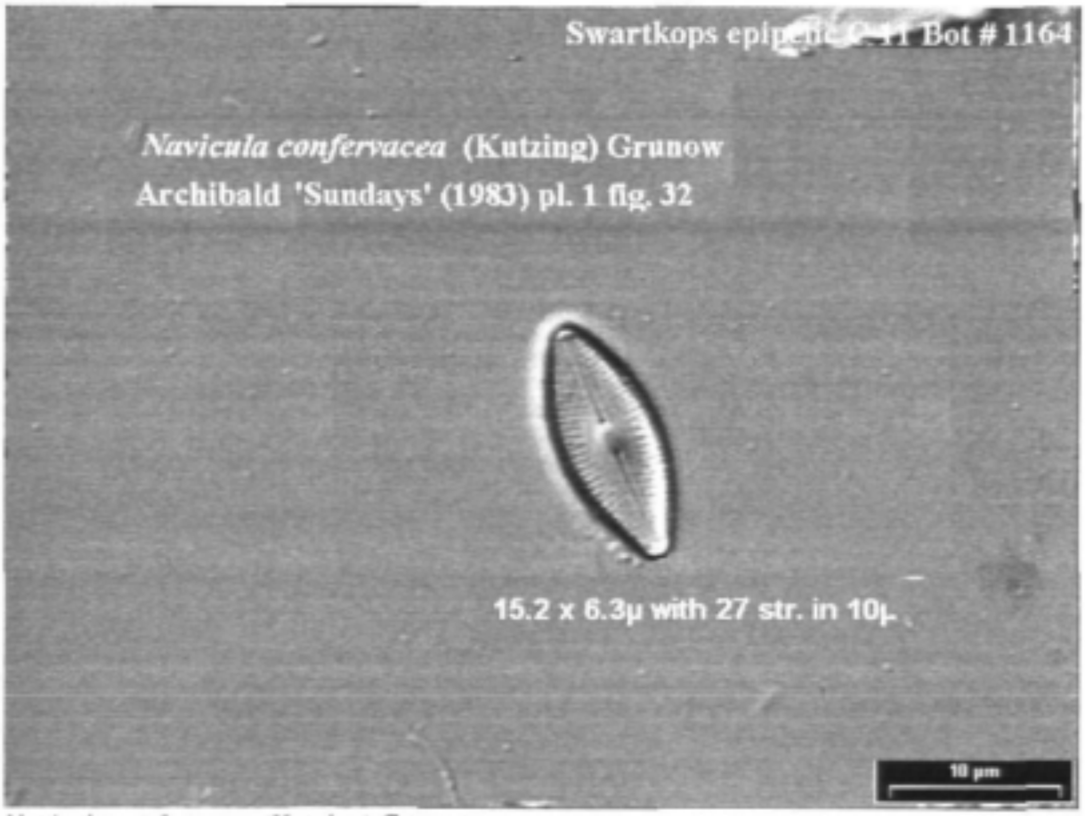


Navicula cincta var. *leptocephala* (Brebisson) Grunow
Reference used for identification: Archibald 1983. Page 150. Plate 16. Figure 255.
Locations - Dominant in epipelon – DWAF Northern Cape Douglas Bridge; Swartkops River Site D21.

NAVICIIe (n=2)	($mg.l^{-1}$) Mean	Class Mean	($mg.l^{-1}$) Mode	Class Mode
Ca	64.00	4	-	-
Cl	1074.00	4	-	-
EC	405.20	3	-	-
F	0.20	3	-	-
K	47.60	2	-	-
Mg	94.00	4	-	-
Na	598.00	4	-	-
NH_4	0.42	1	-	-
NO_3	1.40	2	-	-
pH	8.15	4	-	-
PO_4	0.07	1	-	-
SiO_2	2.8	2	-	-
SO_4	246.00	3	-	-
Alkalinity	197.00	2	-	-
TDS	2371.00	4	-	-
Mean class without pH		2.79	-	-

NOTES

NAVICONF

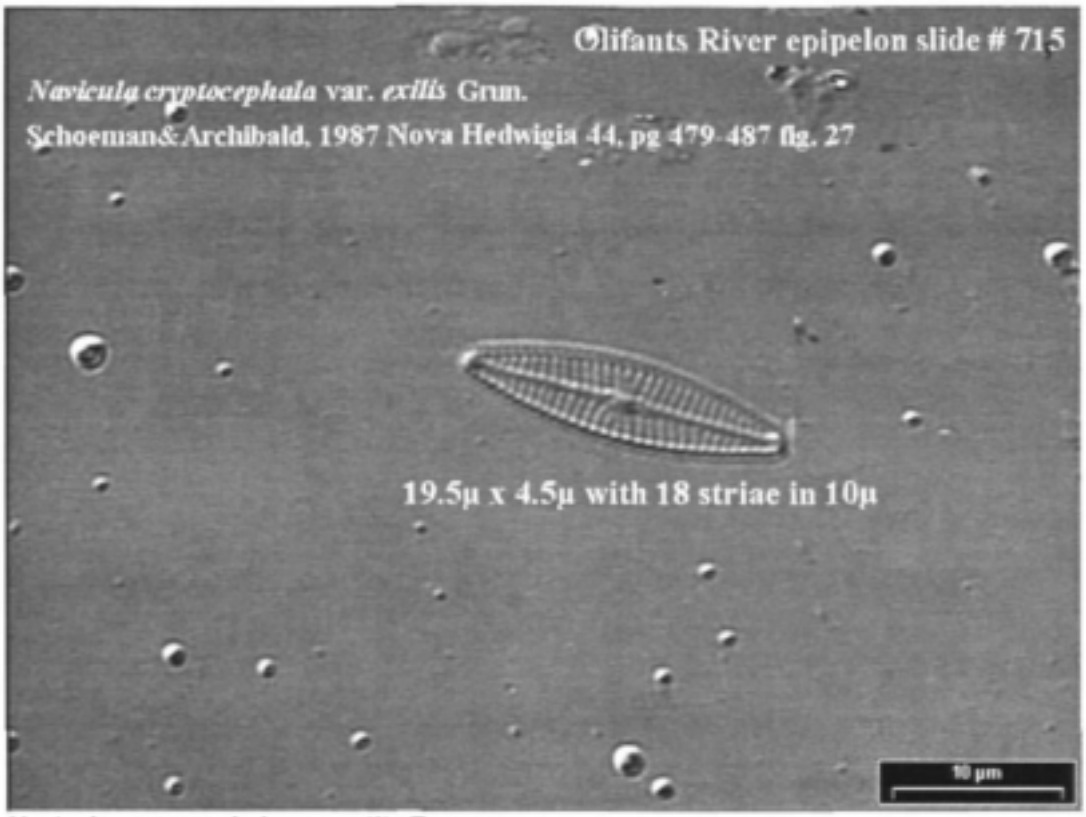


Navicula confervacea (Kutzing) Grunow
Reference used for identification: Archibald 1983. Plate 1. Figure 32.
Locations - Dominant in epipelon – Swartkops River Site F19.

NAVICONF n=1	($mg.l^{-1}$) Mean	Class Mean	Class Mode
Ca	42.00	3	-
Cl	791.00	3	-
EC	284.00	2	-
F	0.30	4	-
K	21.60	1	-
Mg	57.00	3	-
Na	505.00	3	-
NH_4	0.09	1	-
NO_3	0.00	1	-
pH	6.85	1	-
PO_4	6.97	5	-
SiO_2	3.00	2	-
SO_4	144.00	2	-
Alkalinity	190.00	2	-
TDS	1813.00	3	-
Mean class without pH		2.50	-

NOTES

NAVICRex

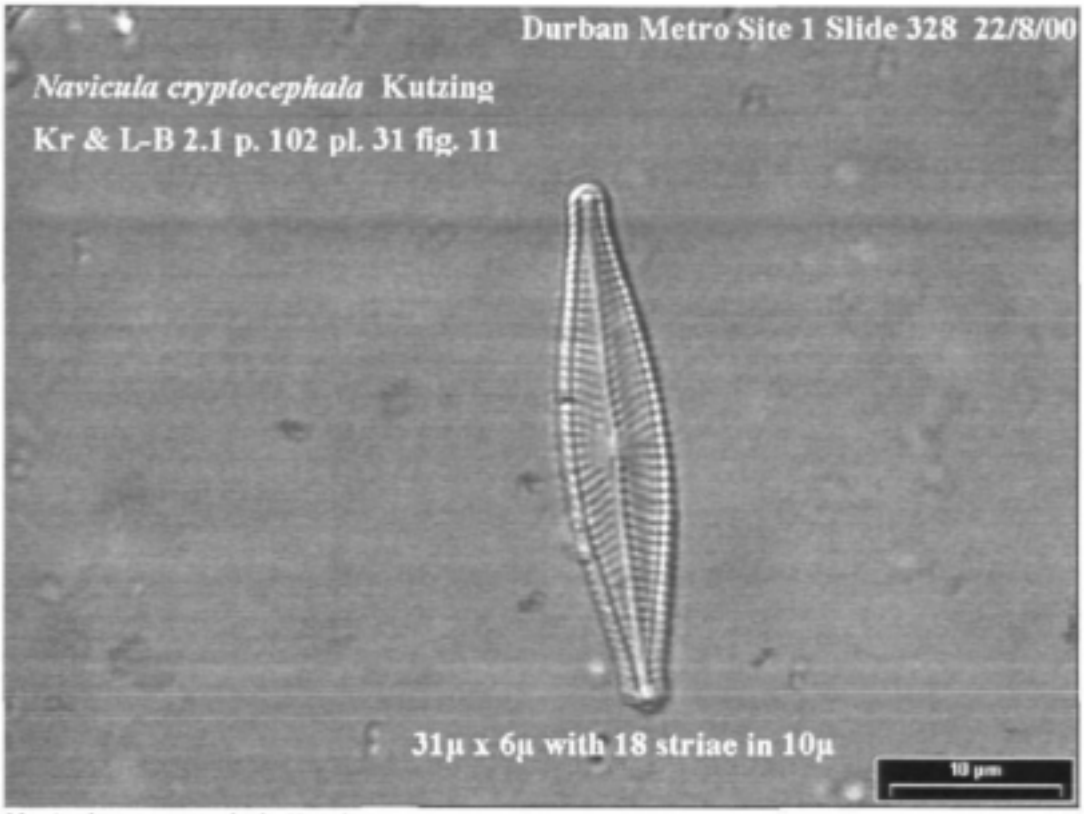


Navicula cryptocephala var. *exilis* Grunow
Reference used for identification: Schoeman & Archibald 1987. Pages. 479 - 487. Figure 27.
Locations - Dominant in epipelon – Olifants River Site Wilgerivier W1.

NAVICRex n=1	($mg.l^{-1}$)	Class Mean	Class Mode
Ca	168.00	5	-
Cl	222.00	1	-
EC	299.00	2	-
F	0.20	3	-
K	3.80	1	-
Mg	255.00	5	-
Na	196.00	2	-
NH_4	0.00	1	-
NO_3	0.09	1	-
pH	8.24	4	-
PO_4	0.01	1	-
SiO_2	1.60	2	-
SO_4	1240.00	5	-
Alkalinity	358.00	3	-
TDS	2524.00	4	-
Mean class without pH		2.57	-

NOTES

NAVICRYP



Navicula cryptocephala Kutzing

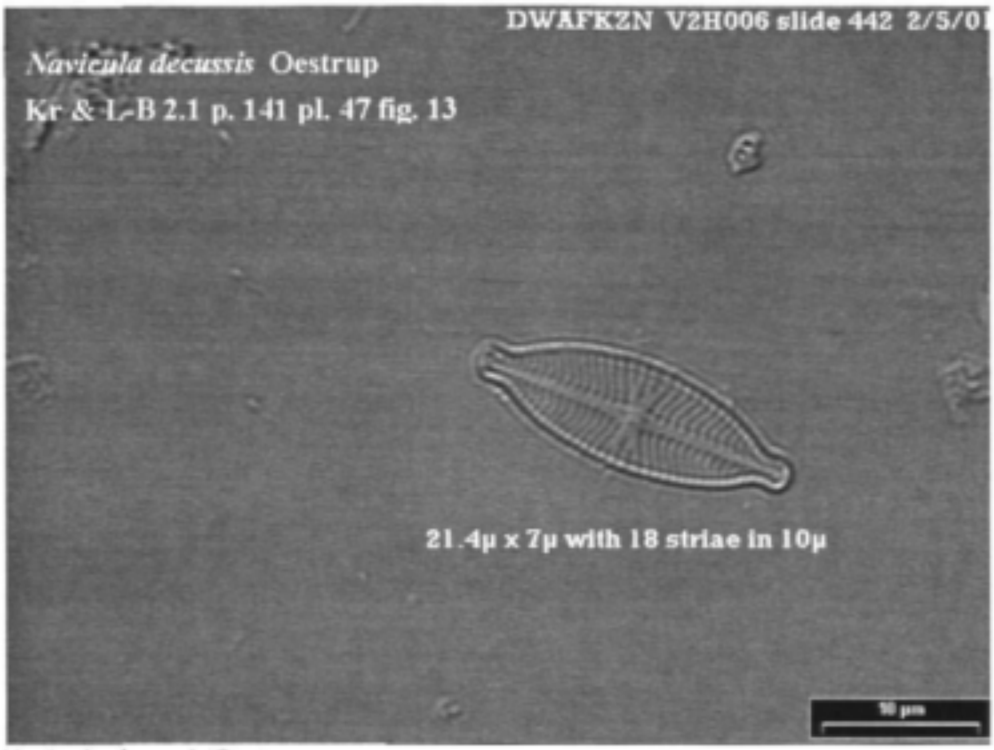
Ref. used for identification: Krammer & Lange-Bertalot 1986. 2.1 Page 102. Plate 31. Figure 11.

Locations - Dominant in epipelon – Durban Metro Site Umbilo River 27.

NAVICRYP n=1	($mg.l^{-1}$)	Class Mean	Class Mode
Ca	18.00	2	-
Cl	46.00	1	-
EC	37.00	1	-
F	0.22	3	-
K	23.00	1	-
Mg	4.80	1	-
Na	46.00	1	-
NH_4	-	-	-
NO_3	0.50	1	-
pH	7.80	3	-
PO_4	0.88	1	-
SiO_2	-	-	-
SO_4	-	-	-
Alkalinity	-	-	-
TDS	240.50	1	-
Mean without pH		1.30	-

NOTES

NAVIDECU

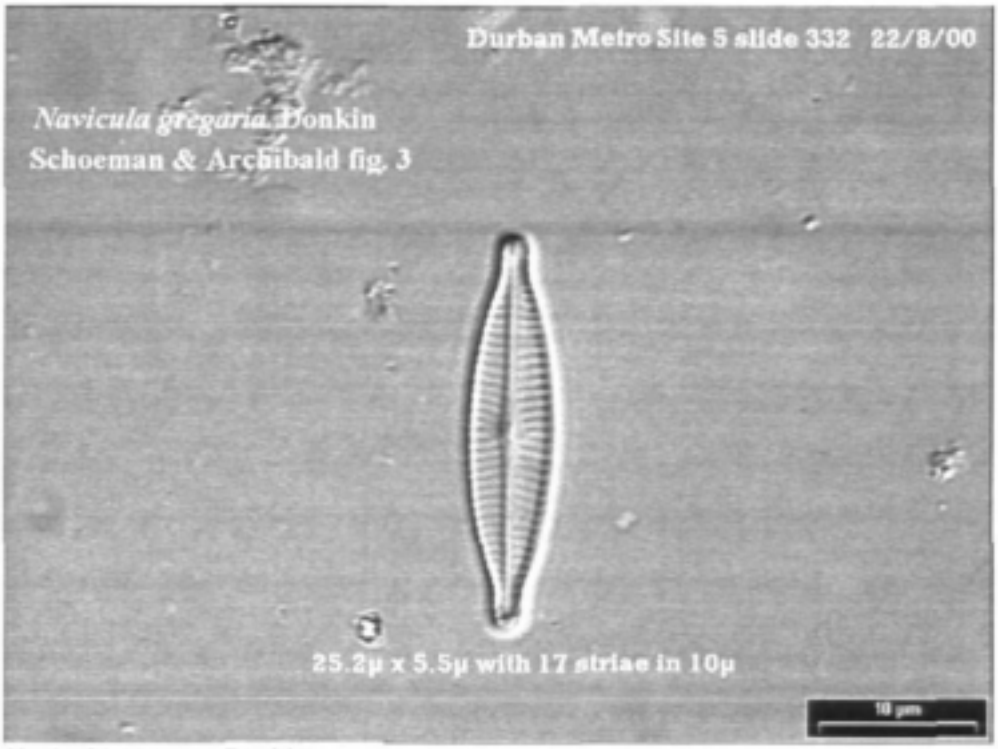


Navicula decussis Oestrup
Reference used for identification Krammer & Lange-Bertalot 1986. 2.1 Page 141. Plate 47. Figure 13.
Locations - Dominant in epipelon – DWAF KZN Sites Mooi River V2H002, V2H004, V2H005, Kleinmooi V2h006, Kleinboesmans V2H012, Ncibidwane V7H016 & Boesmansriver V7H017.

NAVIDECU n=7	($mg.l^{-1}$) Mean	Class Mean	($mg.l^{-1}$) Mode	Class Mode
Ca	6.86	1	-	-
Cl	ND	ND	-	-
EC	8.65	1	-	-
F	0.13	2	-	-
K	0.67	1	-	-
Mg	3.16	1	-	-
Na	5.41	1	-	-
NH_4	0.07	1	-	-
NO_3	0.26	1	-	-
pH	7.45	2	-	-
PO_4	0.13	1	-	-
SiO_2	4.517	3	-	-
SO_4	2.09	1	-	-
Alkalinity	32.91	1	-	-
TDS	65.34	1	-	-
Mean class without pH		1.23		-

NOTES

NAVIGREG



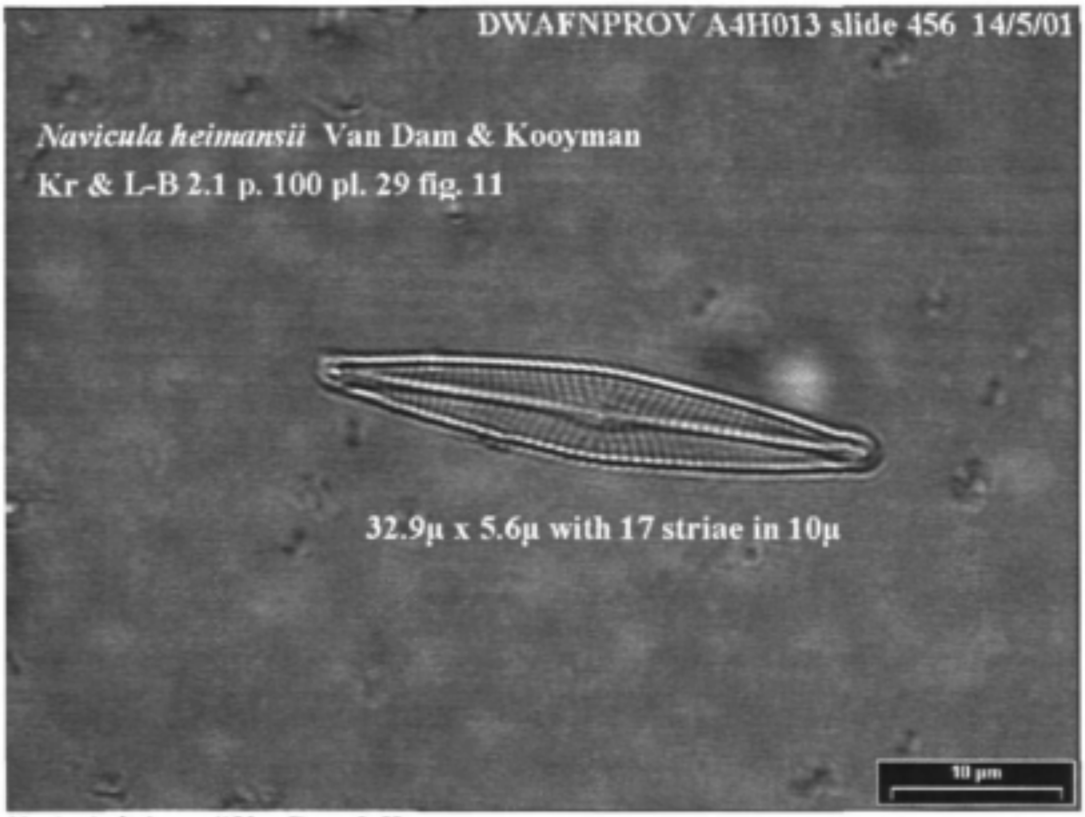
Navicula gregaria Donkin
Reference used for identification: Schoeman & Archibald 1976. Figure 3.
Locations - Dominant in epipelon – Durban Metro Site 5; Palmiet River 09; DWAF RAND Crocodile A2H051, Jukskei River A2H023; Umgeni Water Sites Umzimduzi River UmWat 62, UmWat 63, UmWat 65; Buffalo River Site BR4; Gamtoos River Sites GR5, GR6, GT3, GT4; Sundays River Site ST1; Moordkuil River Site KB3; Brandwag River KB2; Swartkops River A10, B9-B15, B17–B21, D12-D14, C13-C16.

NAVIGREG n=31	($mg.l^{-1}$) Mean	Class Mean	($mg.l^{-1}$) Mode	Class Mode
Ca	15.18	2	10.00	1
Cl	173.68	1	144.00	1
EC	76.44	1	17.60	1
F	0.12	2	0.20	3
K	15.30	1	1.50	1
Mg	17.58	1	8.00	1
Na	108.04	1	90.00	1
NH_4	0.08	1	0.00	1
NO_3	0.28	1	0.00	1
pH	7.41	2	7.60	3
PO_4	5.69	4	0.03	1
SiO_2	3.02	2	1.90	2
SO_4	39.80	1	28.00	1
Alkalinity	79.94	1	42.00	1
TDS	467.77	1	104.00	1
Mean class without pH		1.43		1.21

NOTES

This species was the most dominant at all sites in South Africa i.e. 31 sites.

NAVIHEIM



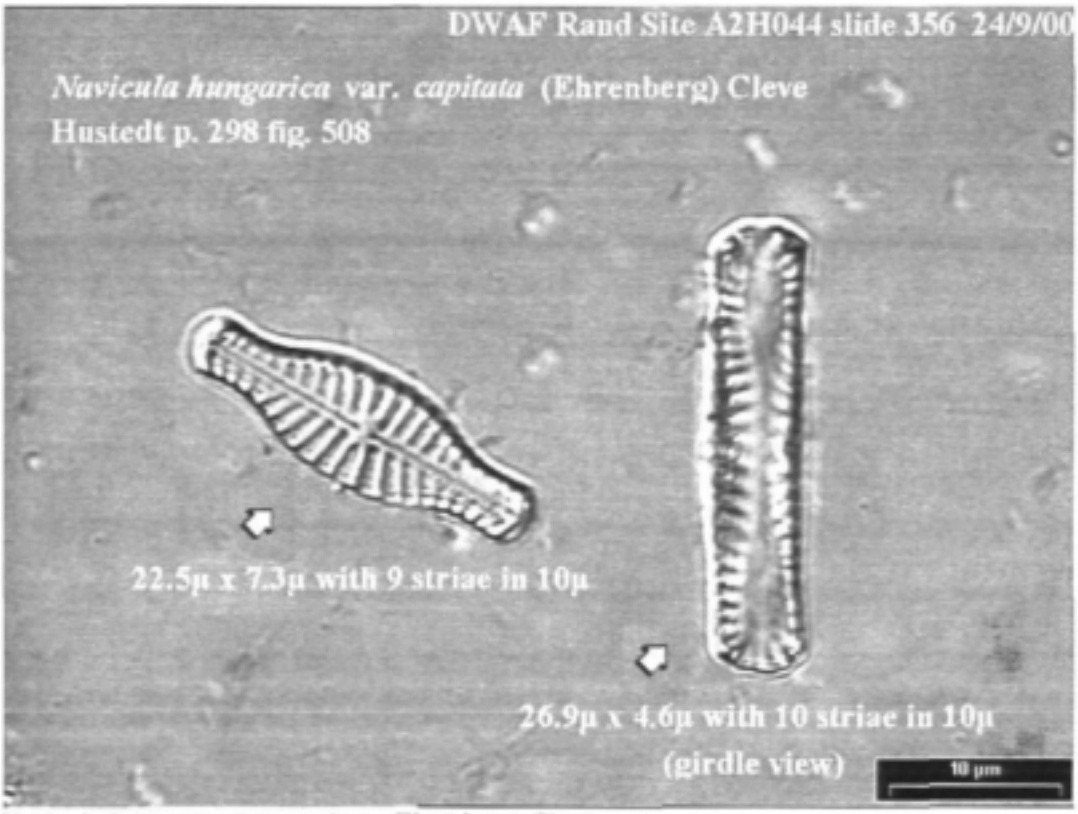
Navicula heimansii Van Dam & Kooyman
Ref. used for identification: Krammer & Lange-Bertalot 1986. 2.1 Page 100. Plate 29. Figure 11.
Locations - Dominant in epipelon – DWAF KZN Hlatikulu Site V2H007; Umgeni Water Karkloof River Site 5.2; Swartkops River Sites A11 – A16, A18 – A21.

NAVIHEIM n=12	($mg.l^{-1}$) Mean	Class Mean	($mg.l^{-1}$) Mode	Class Mode
Ca	2.67	1	3.00	1
Cl	42.83	1	42.00	3
EC	45.64	1	-	1
F	0.05	2	0.10	1
K	0.75	1	0.70	1
Mg	3.83	1	4.00	1
Na	26.17	1	28.00	2
NH_4	0.00	1	0.00	1
NO_3	0.02	1	0.00	1
pH	7.21	2	-	2
PO_4	0.03	1	-	1
SiO_2	2.28	2	2.10	1
SO_4	9.50	1	7.00	1
Alkalinity	12.17	1	14.00	2
TDS	100.83	1	-	1
Mean class without pH		1.14		1.29

NOTES

NAVIHEIM is the second most dominant in the South African rivers, i.e.12 sites.

NAVIHUca

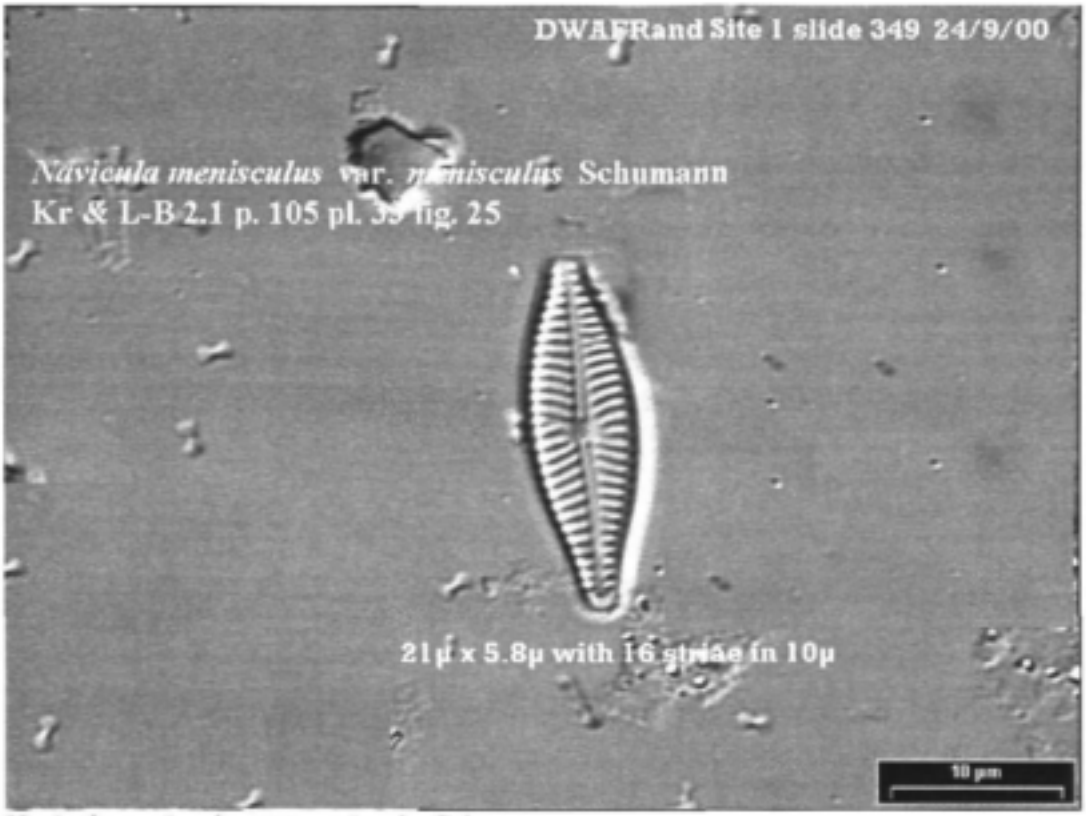


Navicula hungarica var. *capitata* (Ehrenberg) Cleve.
Reference used for identification: Hustedt 1976. Page 298. Figure 508.
Locations - Dominant in epipelon – Rand Water Toxic City Site B16; DWAF Rand Crocodile River A2H012 & Juksei River A2H044.

NAVIHUca n=3	(mg.l^{-1}) Mean	Class Mean	(mg.l^{-1}) Mode	Class Mode
Ca	49.55	3	-	-
Cl	55.47	1	-	-
EC	63.20	1	-	-
F	0.27	4	-	-
K	10.43	1	-	-
Mg	15.08	1	-	-
Na	47.01	1	-	-
NH_4	0.11	1	-	-
NO_3	5.18	4	-	-
pH	8.06	3	-	-
PO_4	0.38	1	-	-
SiO_2	8.162	5	-	-
SO_4	57.44	1	-	-
Alkalinity	147.06	2	-	-
TDS	410.80	1	-	-
Mean class without pH		1.93		-

NOTES

NAVIMEme



Navicula menisculus var. *menisculus* Schumann

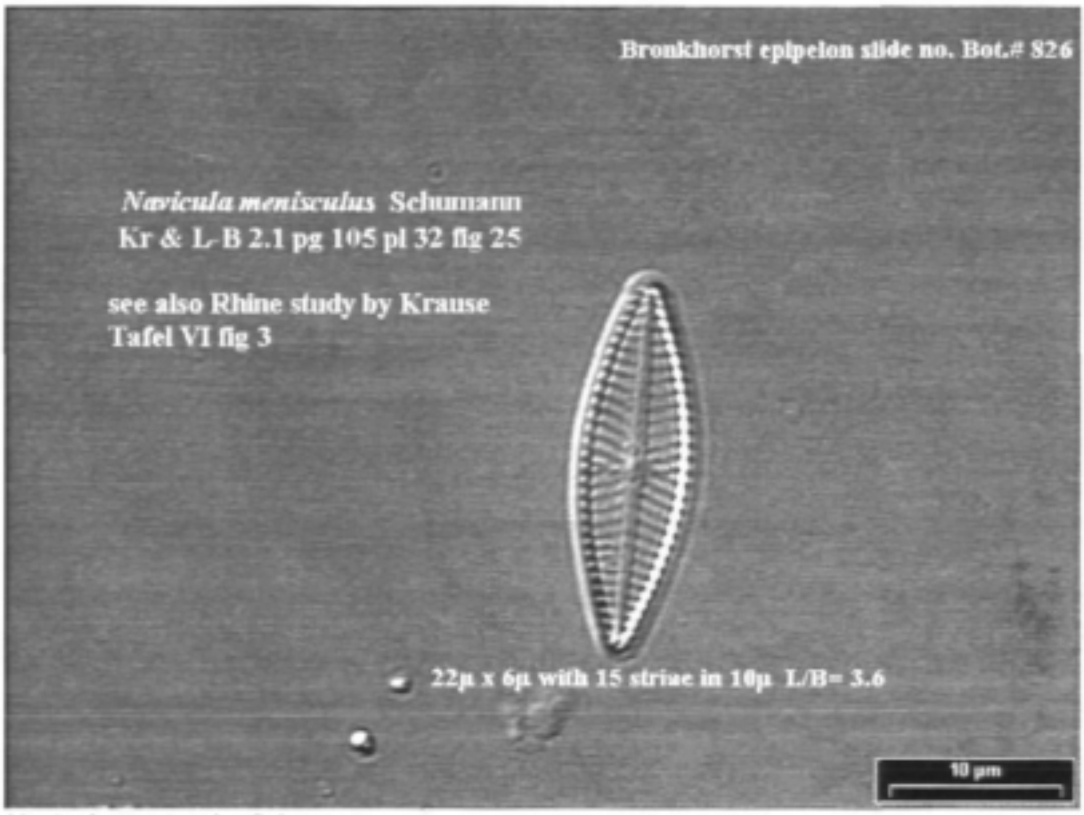
Ref. used for identification: Krammer & Lange-Bertalot 1986. 2.1 Page 105. Plate 33. Figure 25.

Locations - Dominant in epipelon – DWAF RAND Magalies Site A2H013; DWAF OFS Caledon River Sites D2H035, D2H012 &D2H017, Kornetspruit Sites D1H006 & D1H034, Oranjedraai Site D1H009.

NAVIMEme	($mg.l^{-1}$)	Class	($mg.l^{-1}$)	Class
n=7	Mean	Mean	Mode	Mode
Ca	22.90	2	-	2
Cl	1.00	1	1.00	1
EC	22.58	1	-	1
F	0.16	3	-	3
K	1.21	1	-	1
Mg	9.66	1	-	1
Na	6.87	1	-	1
NH_4	0.02	1	0.01	1
NO_3	0.38	1	-	1
pH	8.04	3	-	3
PO_4	0.04	1	-	1
SiO_2	9.03	5	-	5
SO_4	11.36	1	-	1
Alkalinity	97.16	1	-	1
TDS	282.75	1	-	1
Mean class without pH		1.50		1.50

NOTES

NAVIMENI



Navicula meniscutus Schumann

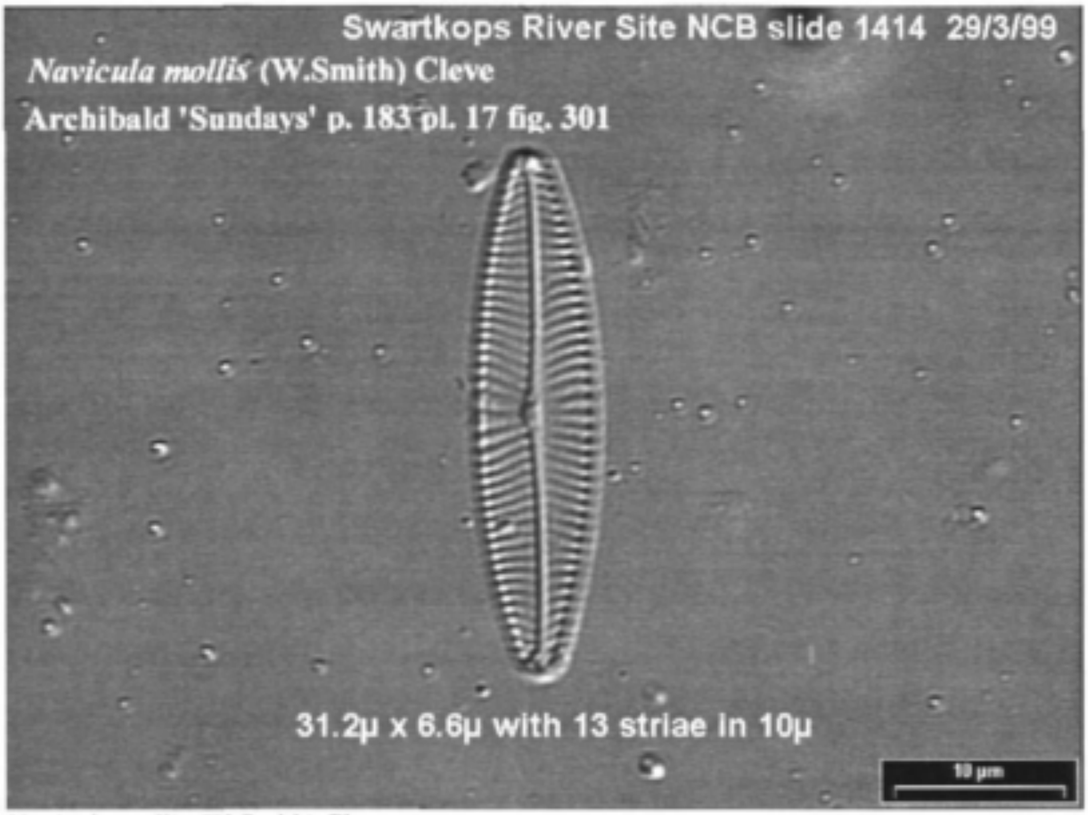
Ref. used for identification: Krammer & Lange-Bertalot 1986. 2.1 Page 105. Plate 32. Figure 25.

Locations - Dominant in epipelon – DWAF Northern Cape Vaal River Sites C9H021 & C9H009; Olifants River Site B1.

NAVIMENI	($mg.l^{-1}$)	Class	($mg.l^{-1}$)	Class
n=3	Mean	Mean	Mode	Mode
Ca	31.28	2	-	-
Cl	18.32	1	-	-
EC	41.07	1	-	-
F	0.24	3	-	-
K	7.23	1	-	-
Mg	16.37	1	-	-
Na	25.93	1	-	-
NH_4	0.09	1	-	-
NO_3	0.18	1	-	-
pH	8.23	4	-	-
PO_4	0.40	1	-	-
SiO_2	4.46	3	-	-
SO_4	46.96	1	-	-
Alkalinity	129.20	2	-	-
TDS	291.48	1	-	-
Mean class without pH		1.43		-

NOTES

NAVIMOLL

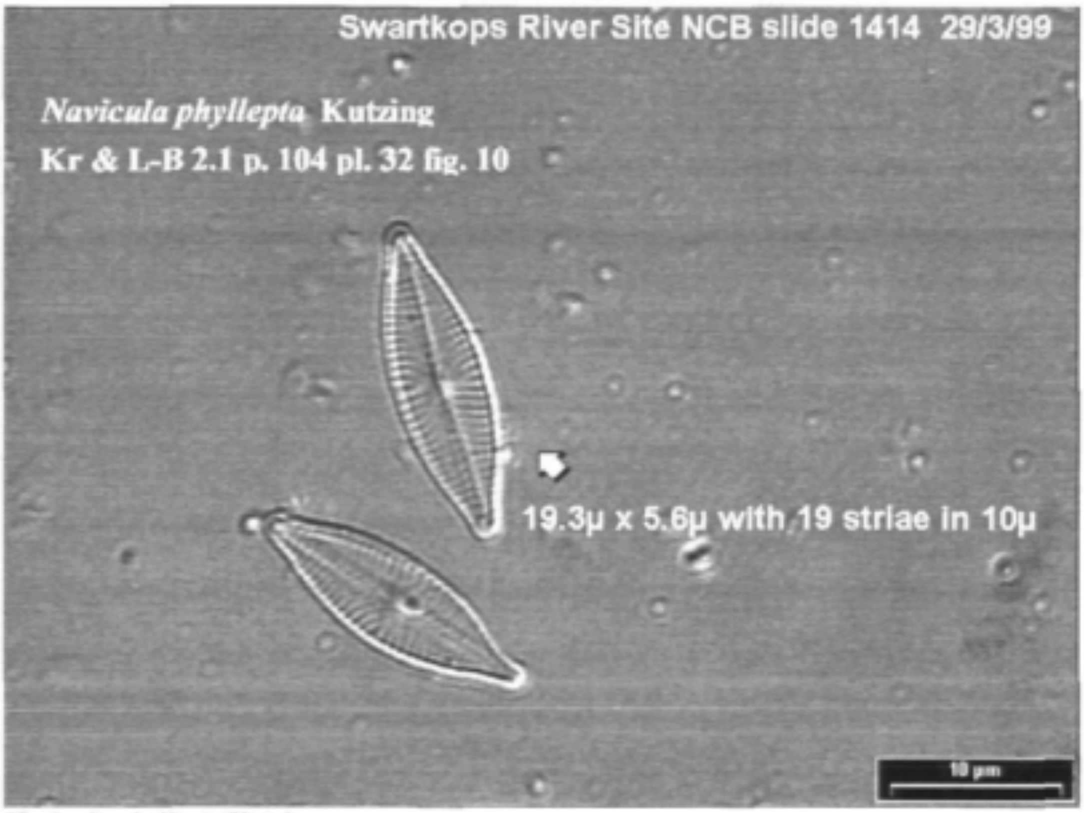


Navicula mollis (W.Smith) Cleve
Reference used for identification: Archibald 1983. Page 183. Page 17. Figure 303.
Locations - Dominant in epipelon – Sundays River Site SR5.

NAVIMOLL		Class	Class
n=1	$(mg.l^{-1})$	Mean	Mode
Ca	54.00	3	-
Cl	178.00	1	-
EC	106.90	1	-
F	0.50	5	-
K	5.00	1	-
Mg	33.00	2	-
Na	138.00	2	-
NH_4	0.62	2	-
NO_3	0.05	1	-
pH	8.80	5	-
PO_4	0.06	1	-
SiO_2	5.90	4	-
SO_4	55.00	1	-
Alkalinity	262.00	2	-
TDS	785.00	2	-
Mean class without pH		2.00	-

NOTES

NAVIPHYL



Navicula phyllepta Kutzing

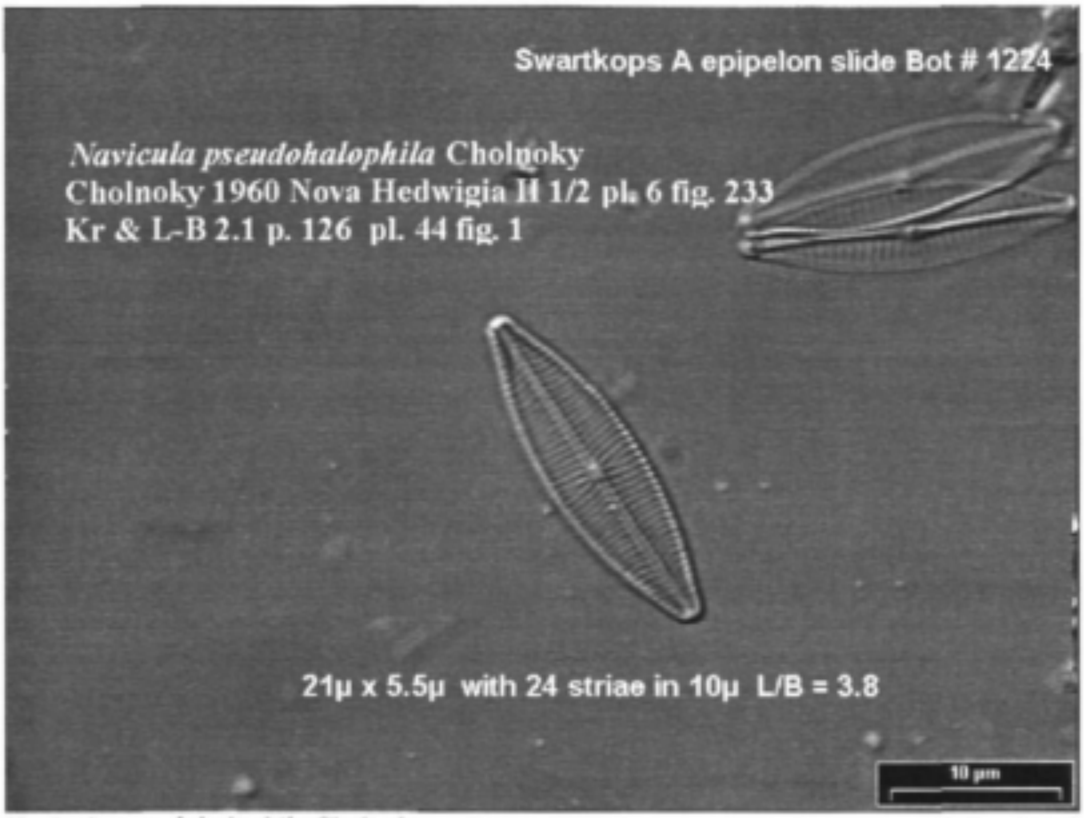
Reference used for identification: Lange-Bertalot 2000. Page 298. Plate 122. Figure 5.

Locations - Dominant in epipelon – Sundays River Site SR6; Swartkops River Sites E12, E13, E14, & E20.

NAVIPHYL	($mg.l^{-1}$)	Class	($mg.l^{-1}$)	Class
n=5	Mean	Mean	Mode	Mode
Ca	58.50	4	-	-
Cl	857.75	3	-	-
EC	357.30	3	-	-
F	0.35	5	0.20	3
K	15.75	1	-	-
Mg	78.00	3	-	-
Na	556.50	3	-	-
NH_4	0.03	1	0.04	1
NO_3	1.62	2	-	-
pH	8.42	4	-	-
PO_4	0.72	1	-	-
SiO_2	2.775	2	-	-
SO_4	278.75	3	-	-
Alkalinity	230.75	2	-	-
TDS	2136.25	3	-	-
Mean class without pH		2.57		2.57

NOTES

NAVIPSEU

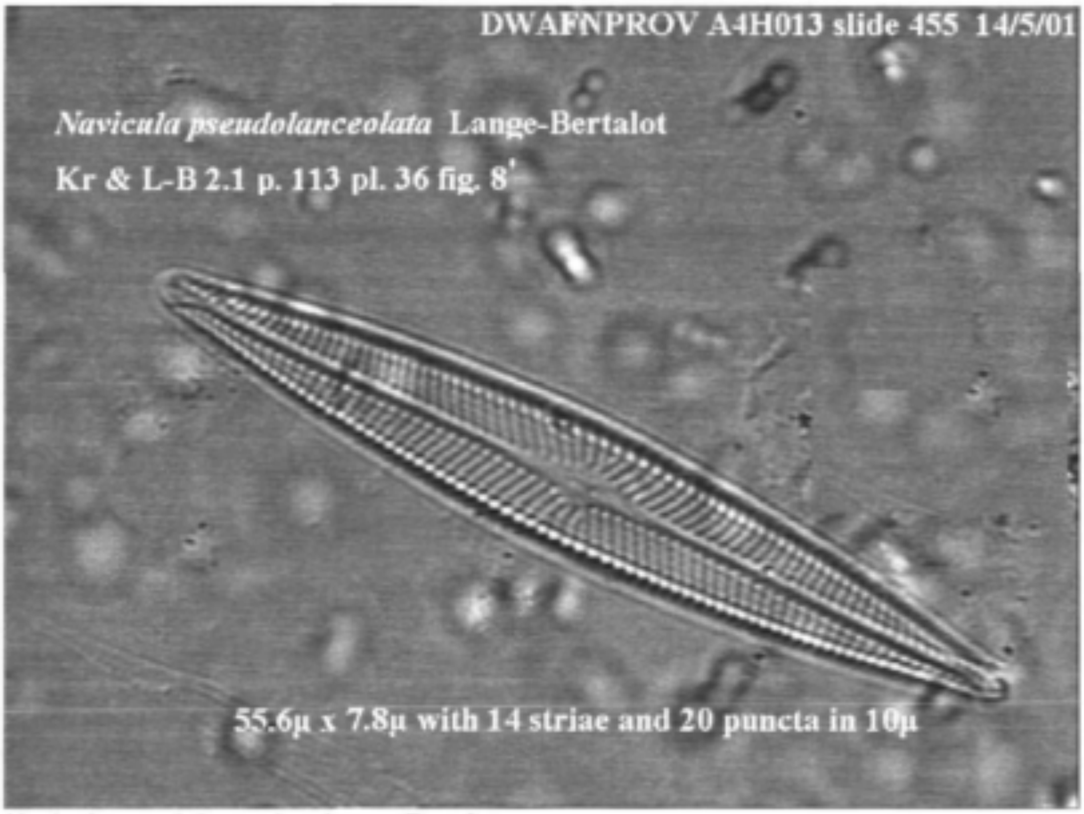


Navicula pseudohalophila Cholnoky
Ref. used for identification: Krammer & Lange-Bertalot 1986. 2.1 Page 126. Plate 44. Figure 11.
Locations - Dominant in epipelon – Swartkops River Sites C19, C20 & C21.

NAVIPSEU	($mg.l^{-1}$)	Class	($mg.l^{-1}$)	Class
n=3	Mean	Mean	Mode	Mode
Ca	69.67	4	-	4
Cl	786.67	3	-	3
EC	362.80	3	-	3
F	0.27	4	0.30	4
K	186.10	4	-	4
Mg	76.33	3	91	4
Na	525.00	3	-	3
NH_4	0.29	1	-	1
NO_3	0.08	1	-	1
pH	8.20	4	-	4
PO_4	0.58	1	-	1
SiO_2	5.33	3	-	3
SO_4	126.67	2	-	2
Alkalinity	594.67	4	-	4
TDS	2497.67	4	-	4
Mean class without pH		2.86		2.93

NOTES

NAVIPSTA

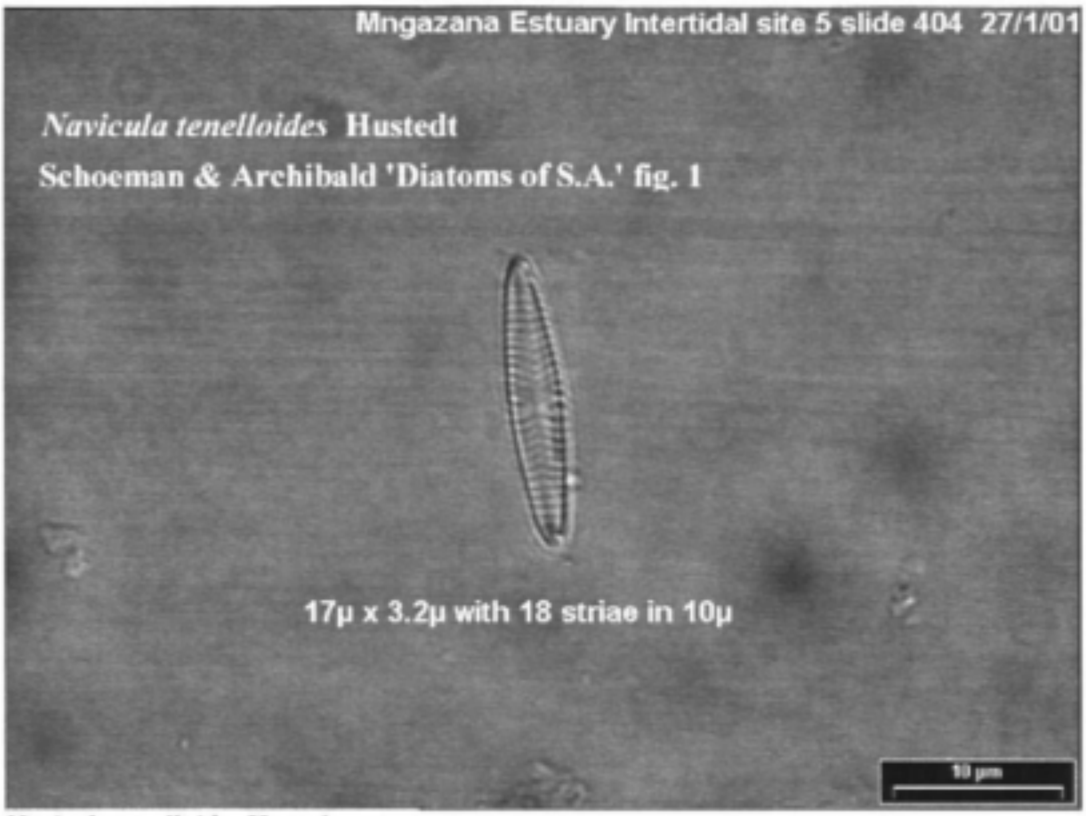


Navicula pseudolanceolata Lange-Bertalot
Ref. used for identification: Krammer & Lange-Bertalot 1986. 2.1 Page 113. Plate 36. Figure 8'.
Locations - Dominant in epipelon – DWAF Northern Province Mokolo River Site A4H013.

NAVIPSTA		Class	Class
n=1	(mg.l^{-1})	Mean	Mode
Ca	4.94	1	-
Cl	-	5	-
EC	8.08	1	-
F	0.16	3	-
K	0.84	1	-
Mg	2.19	1	-
Na	7.38	1	-
NH_4	0.62	2	-
NO_3	0.05	1	-
pH	7.47	2	-
PO_4	0.09	1	-
SiO_2	3.20	2	-
SO_4	10.78	1	-
Alkalinity	26.35	1	-
TDS	52.52	1	-
Mean class without pH		1.57	-

NOTES

NAVITENE



Navicula tenelloides Hustedt

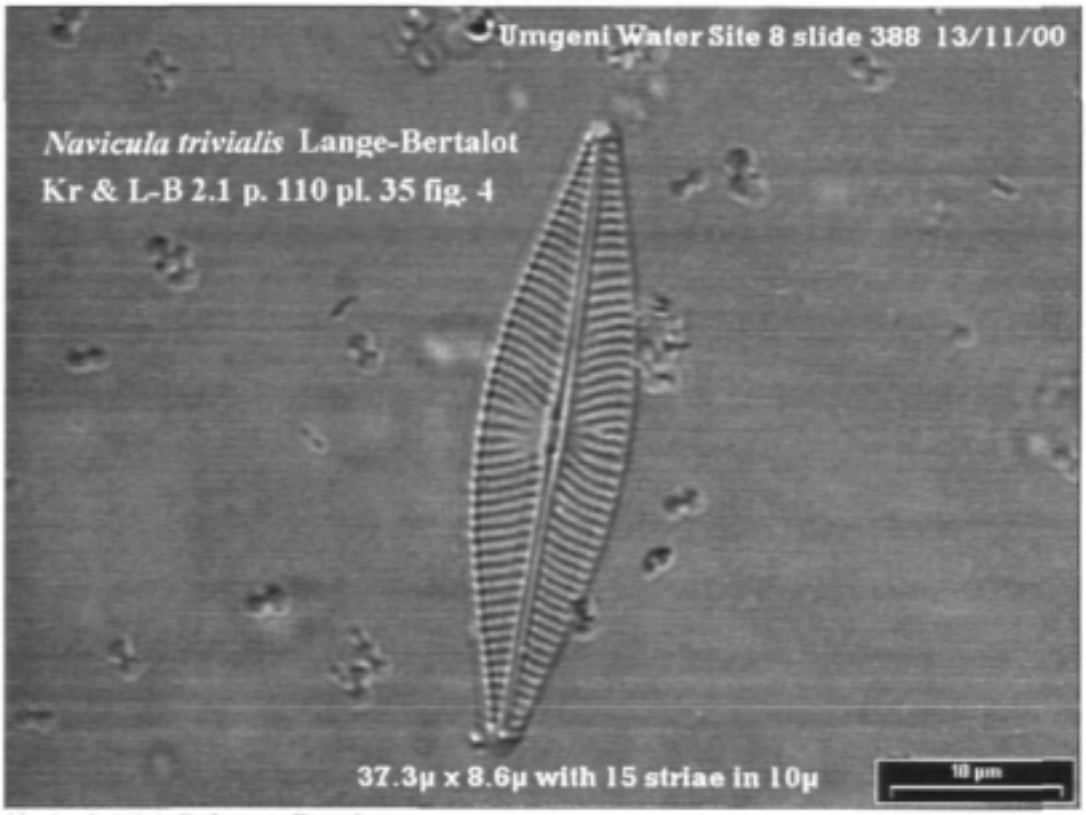
Reference used for identification: Simonsen 1987. Volume 2. Plate 329. Figure 27.

Locations - Dominant in epipelon – Palmiet River Site PR2; Houhoek River Site BT1 (DWAF Site JR400A).

NAVITENE (n=2)	($mg.l^{-1}$) Mean	Class Mean	($mg.l^{-1}$) Mode	Class Mode
Ca	-	-	-	-
Cl	-	-	-	-
EC	-	-	-	-
F	-	-	-	-
K	-	-	-	-
Mg	-	-	-	-
Na	-	-	-	-
NH_4	0.00	ND	-	-
NO_3	1.95	2	-	-
pH	5.20	1	-	-
PO_4	-	-	-	-
SiO_2	-	-	-	-
SO_4	-	-	-	-
Alkalinity	-	-	-	-
TDS	-	-	-	-
Mean class without pH		2.00	-	-

NOTES

NAVITRIV



Navicula trivialis Lange-Bertalot

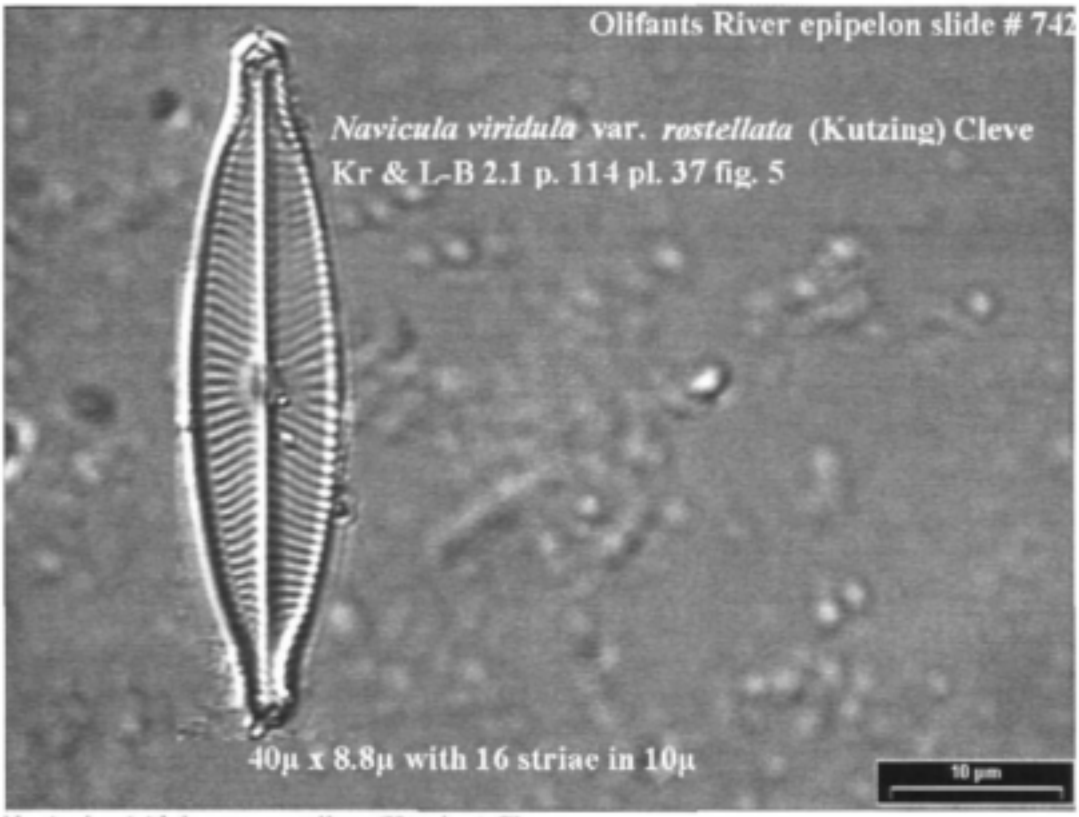
Ref. used for identification: Krammer & Lange-Bertalot 1986. 2.1 Page 110. Plate 35. Figure 16.

Locations - Dominant in epipelon – Umgeni Water Mzimduzi River UmWat 624; DWAF RAND Walker's Spruit Site A2H062.

NAVITRIV (n=2)	(mg.l⁻¹) Mean	Class Mean	(mg.l⁻¹) Mode	Class Mode
Ca	37.72	3	-	-
Cl	39.79	1	-	-
EC	32.50	1	-	-
F	0.19	3	-	-
K	3.43	1	-	-
Mg	15.90	1	-	-
Na	22.90	1	-	-
NH_4	0.13	1	-	-
NO_3	1.02	2	-	-
pH	7.60	3	-	-
PO_4	57.53	5	-	-
SiO_2	7.423	4	-	-
SO_4	28.10	1	-	-
Alkalinity	133.90	2	-	-
TDS	209.64	1	-	-
Mean class without pH		1.93	-	-

NOTES

NAVIVIro



Navicula viridula var. *rostellata* (Kutzing) Cleve

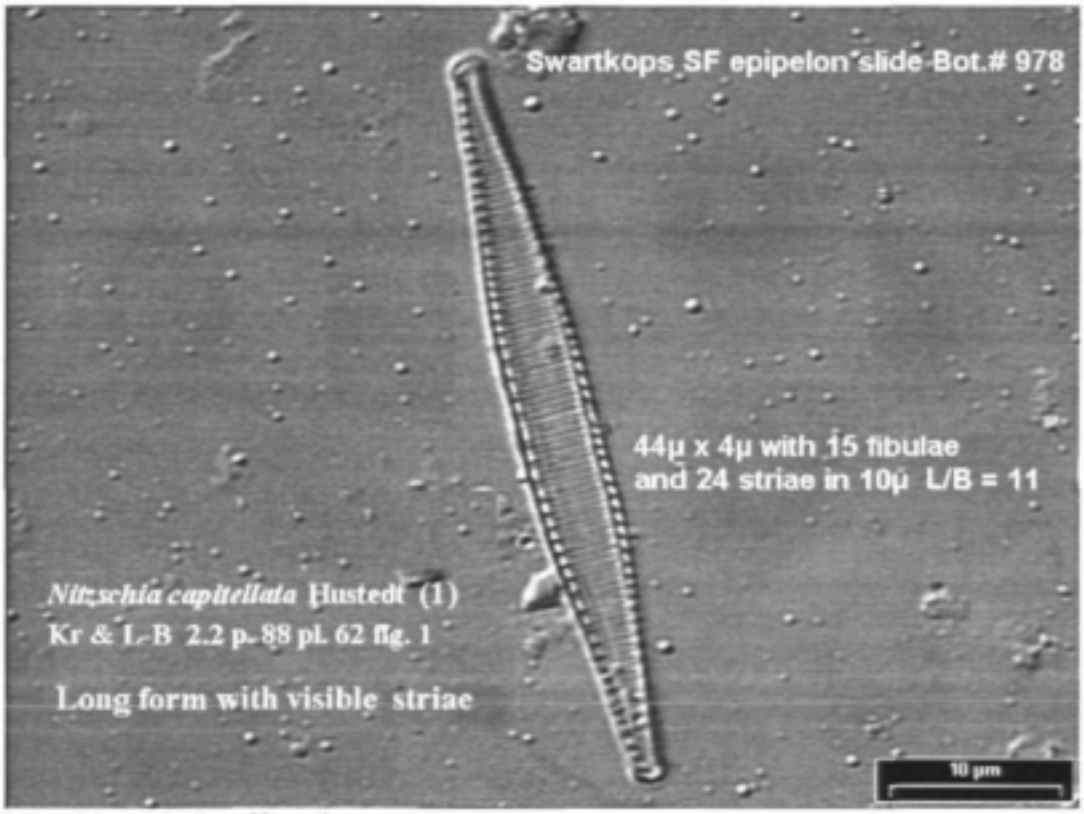
Ref. used for identification: Krammer & Lange-Bertalot 1986. Page 114. Plate 37. Figure 5.

Locations - Dominant in epipelon – DWAF Northern Cape Vaal River Site C9H024; Umgeni Water Karkloof River 5.1; Kruger National Park DWAF Sabie River Site X3H912, Crocodile River Sites X3H016, X3H048 & Olifants River Site B7H015; Northern Province Orange River Site D7H002.

NAVIVIro n=7	($mg.l^{-1}$) Mean	Class Mean	($mg.l^{-1}$) Mode	Class Mode
Ca	26.93	2	-	-
Cl	29.35	1	-	-
EC	32.21	1	-	-
F	0.26	4	-	-
K	2.88	1	-	-
Mg	14.26	1	-	-
Na	24.40	1	-	-
NH_4	0.02	1	-	-
NO_3	0.21	1	-	-
pH	8.05	3	-	-
PO_4	4.66	4	-	-
SiO_2	8.5875	5	-	-
SO_4	33.57	1	-	-
Alkalinity	123.68	2	-	-
TDS	217.04	1	-	-
Mean class without pH		1.86		-

NOTES

NITZCAPI



Nitzschia capitellata Hustedt

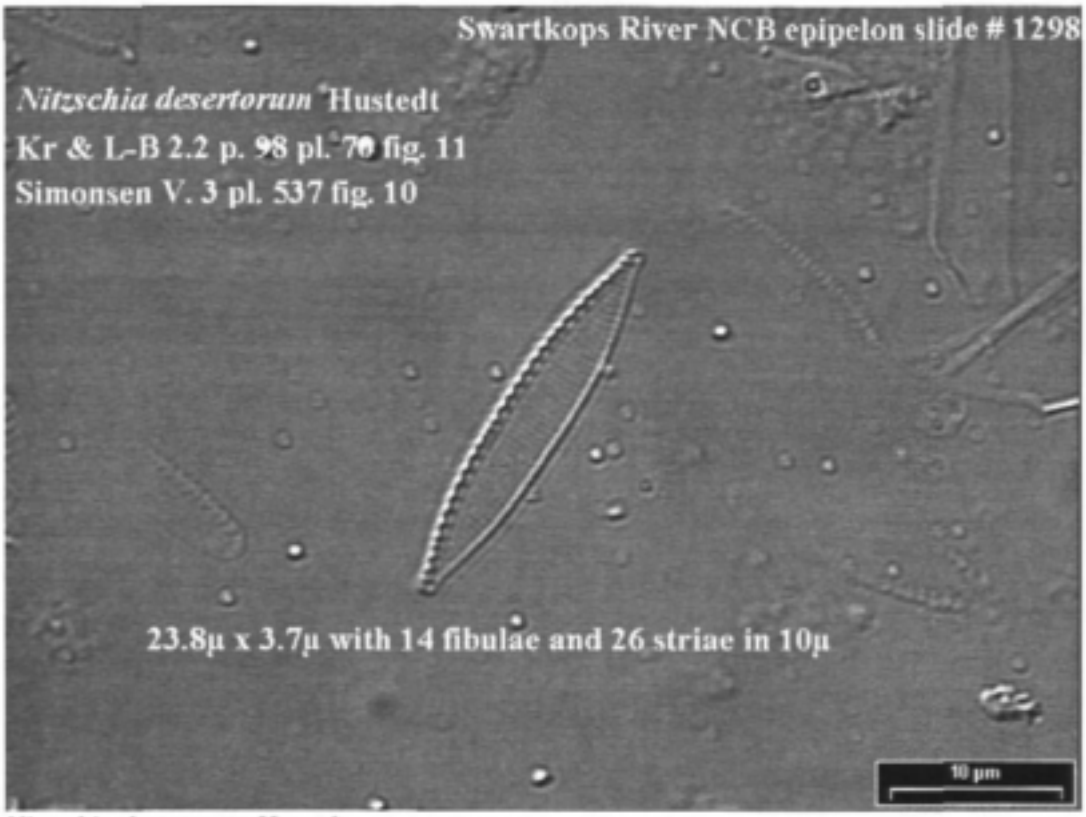
Ref. used for identification: Krammer & Lange-Bertalot 1986. 2.2 Page 88. Plate 62. Figure 1.

Locations - Dominant in epipelon – Swartkops River Site D15.

NITZCAPI		Class	Class
n=1	$(mg.l^{-1})$	Mean	Mode
Ca	45.00	3	-
Cl	838.00	3	-
EC	303.00	2	-
F	0.20	3	-
K	27.80	1	-
Mg	72.00	3	-
Na	488.00	3	-
NH_4	0.50	2	-
NO_3	0.82	2	-
pH	8.59	4	-
PO_4	0.09	1	-
SiO_2	0.70	1	-
SO_4	143.00	2	-
Alkalinity	187.00	2	-
TDS	1847.00	3	-
Mean class without pH		2.21	-

NOTES

NITZDESE

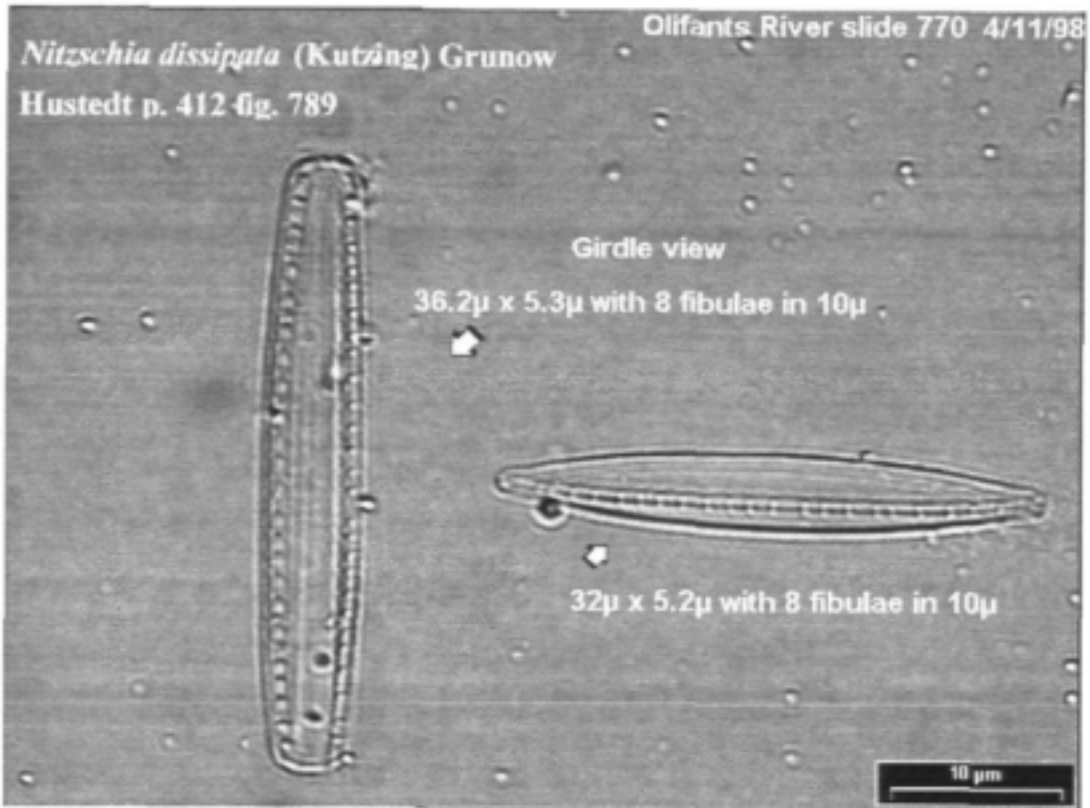


Nitzschia desertorum Hustedt
Ref. used for identification: Krammer & Lange-Bertalot 1986. 2.2 Page 98. Plate 70. Figure 11.
Locations - Dominant in epipelon – Swartkops River Sites E16 & E19.

NITZDESE (n=2)	($mg.l^{-1}$) Mean	Class Mean	($mg.l^{-1}$) Mode	Class Mode
Ca	62.50	4	-	-
Cl	1149.00	4	-	-
EC	413.00	3	-	-
F	0.35	5	-	-
K	23.30	1	-	-
Mg	90.00	4	-	-
Na	696.50	4	-	-
NH_4	0.99	2	-	-
NO_3	2.61	3	-	-
pH	7.89	3	-	-
PO_4	1.81	2	-	-
SiO_2	3.15	2	-	-
SO_4	227.00	3	-	-
Alkalinity	207.50	2	-	-
TDS	2519.00	4	-	-
Mean class without pH		3.07	-	-

NOTES

NITZDISS



Nitzschia dissipata (Kutzing) Grunow

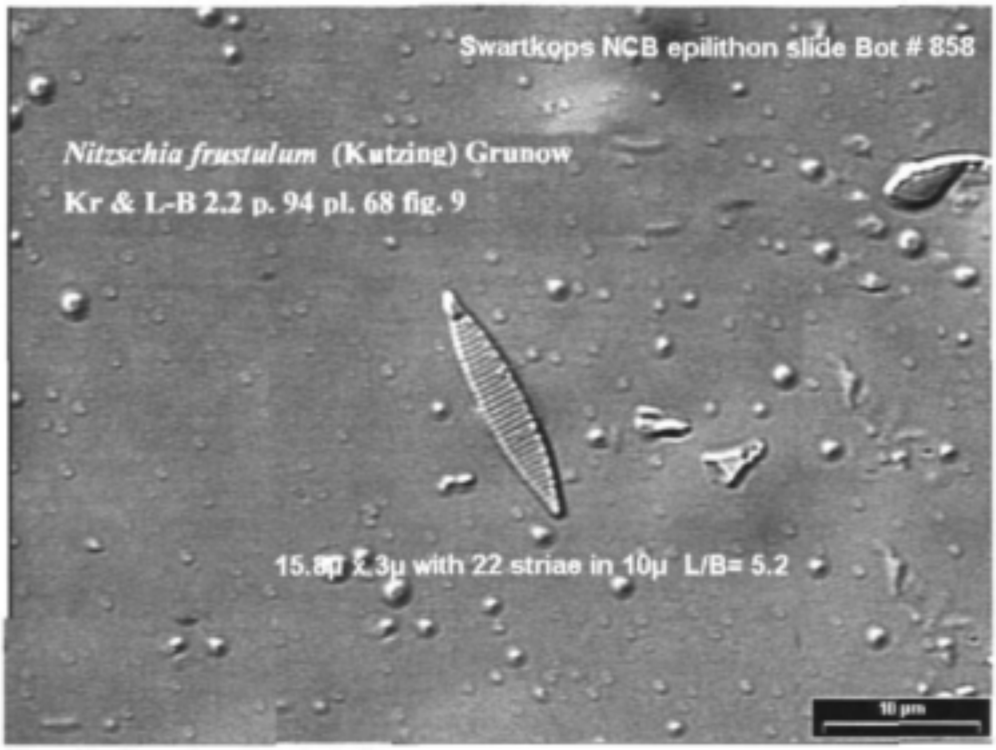
Reference used for identification: Hustedt 1976. Page 412. Figure 789.

Locations - Dominant in epipelon – Olifants River Sites 07.

NITZDISS		Class	Class
n=1	($mg.l^{-1}$)	Mean	Mode
Ca	14.00	2	-
Cl	112.00	1	-
EC	49.70	1	-
F	0.10	2	-
K	1.90	1	-
Mg	13.00	1	-
Na	65.00	1	-
NH_4	0.02	1	-
NO_3	0.92	2	-
pH	7.10	2	-
PO_4	0.02	1	-
SiO_2	6.80	4	-
SO_4	36.00	1	-
Alkalinity	51.00	1	-
TDS	309.00	1	-
Mean class without pH		1.43	-

NOTES

NITZFRUS

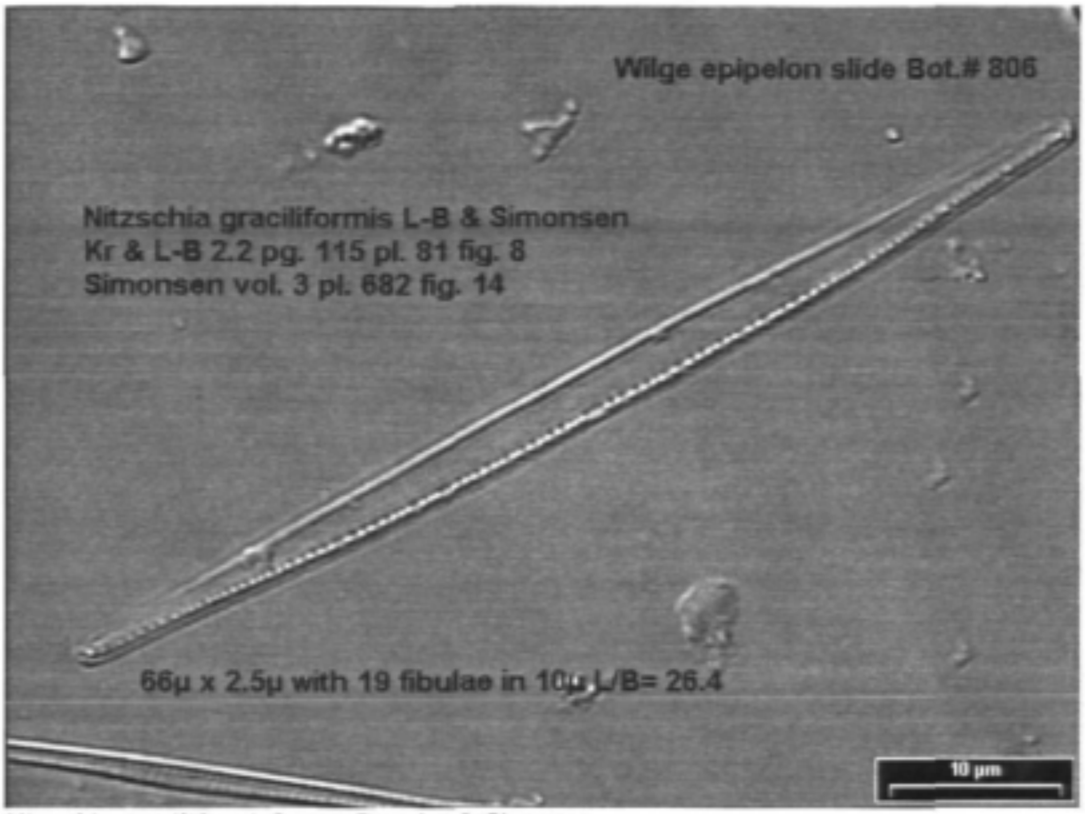


Nitzschia frustulum (Kutzing) Grunow
Reference used for identification: Krammer & Lange-Bertalot 1986. 2.2 Page 94. Plate 68. Figure 9.
Locations - Dominant in epipelon – Gamtoos River Sites GR2 & GR3; Swartkops River Sites D9, D10, D16, E9 & F18.

NITZFRUS n=7	($mg.l^{-1}$) Mean	Class Mean	($mg.l^{-1}$) Mode	Class Mode
Ca	116.00	5	-	5
Cl	1666.17	5	-	5
EC	617.40	4	-	4
F	0.23	3	0.20	3
K	19.90	1	-	1
Mg	157.83	5	-	5
Na	929.50	5	-	5
NH_4	0.13	1	0	1
NO_3	0.58	1	-	1
pH	7.88	3	-	3
PO_4	0.95	2	-	2
SiO_2	2.27	2	0.5	1
SO_4	459.83	5	-	5
Alkalinity	163.33	2	-	2
TDS	4070.07	5	-	5
Mean class without pH		3.29		3.21

NOTES

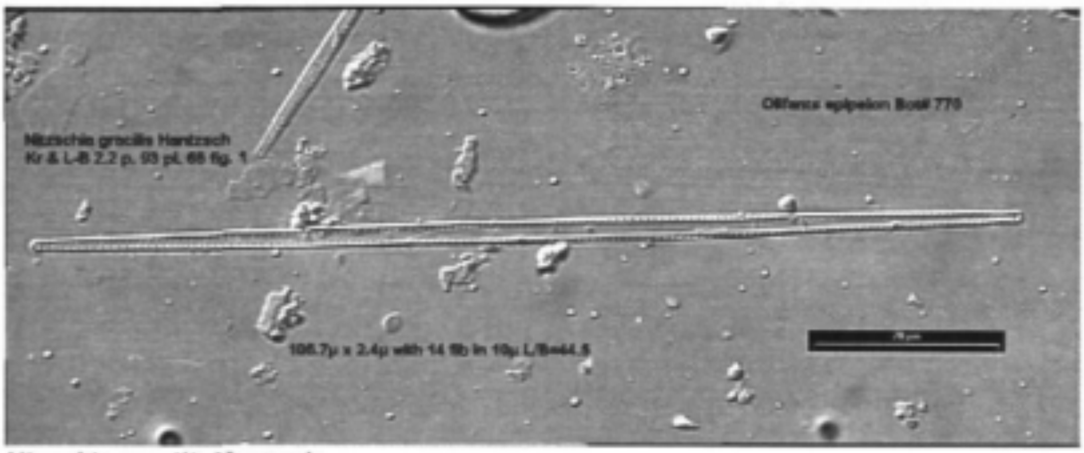
NITZGRAC



Nitzschia graciliformis Lange-Bertalot & Simonsen
Ref. used for identification: Krammer & Lange-Bertalot 1986. 2.2 Page 115. Plate 81. Figure 8.
Locations - Dominant in epipelon – Olifants River Sites 02 & K02.

NITZGRAC		Class	Class	NOTES
n=1	($mg.l^{-1}$)	Mean	Mode	
Ca	112.00	5	-	
Cl	44.00	1	-	
EC	138.50	2	-	
F	0.50	5	-	
K	7.60	1	-	
Mg	85.00	4	-	
Na	77.00	1	-	
NH_4	0.00	-	-	
NO_3	0.09	1	-	
pH	8.52	4	-	
PO_4	0.02	1	-	
SiO_2	0.70	1	-	
SO_4	585.00	5	-	
Alkalinity	149.00	2	-	
TDS	1094.00	2	-	
Mean class without pH		2.38	-	

NITZGRIS



Nitzschia gracilis Hantzsch

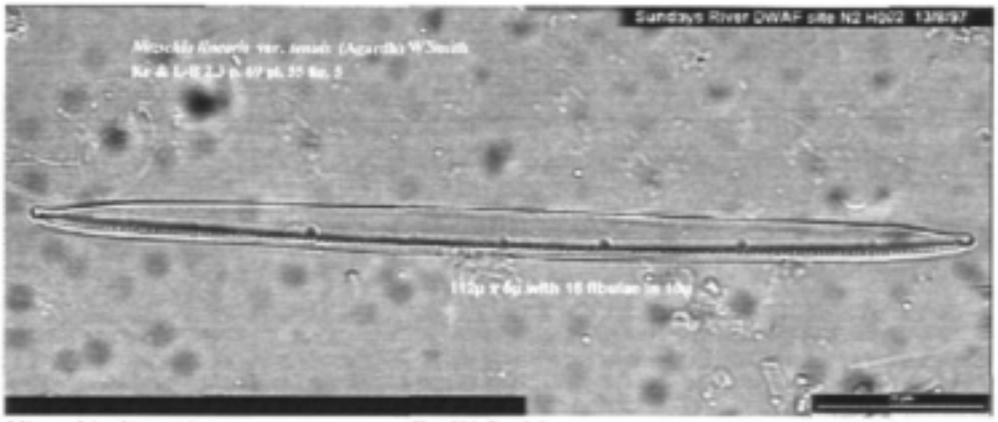
Reference used for identification: Krammer & Lange-Bertalot 1986. 2.2 Page 93. Plate 65. Figure 1.

Locations - Dominant in epipelon – Olifants River Site 03.

NITZGRIS (n=2)	($mg.l^{-1}$) Mean	Class Mean	($mg.l^{-1}$) Mode	Class Mode
Ca	26.50	2	-	-
Cl	0.00	-	-	-
EC	38.55	1	-	-
F	0.35	5	-	-
K	4.65	1	-	-
Mg	17.50	1	-	-
Na	24.50	1	-	-
NH_4	0.05	1	-	-
NO_3	0.16	1	-	-
pH	8.27	4	-	-
PO_4	0.03	1	-	-
SiO_2	1.95	2	-	-
SO_4	63.00	1	-	-
Alkalinity	113.00	2	-	-
TDS	291.00	1	-	-
Mean class without pH		1.54	-	-

NOTES

NITZLIte

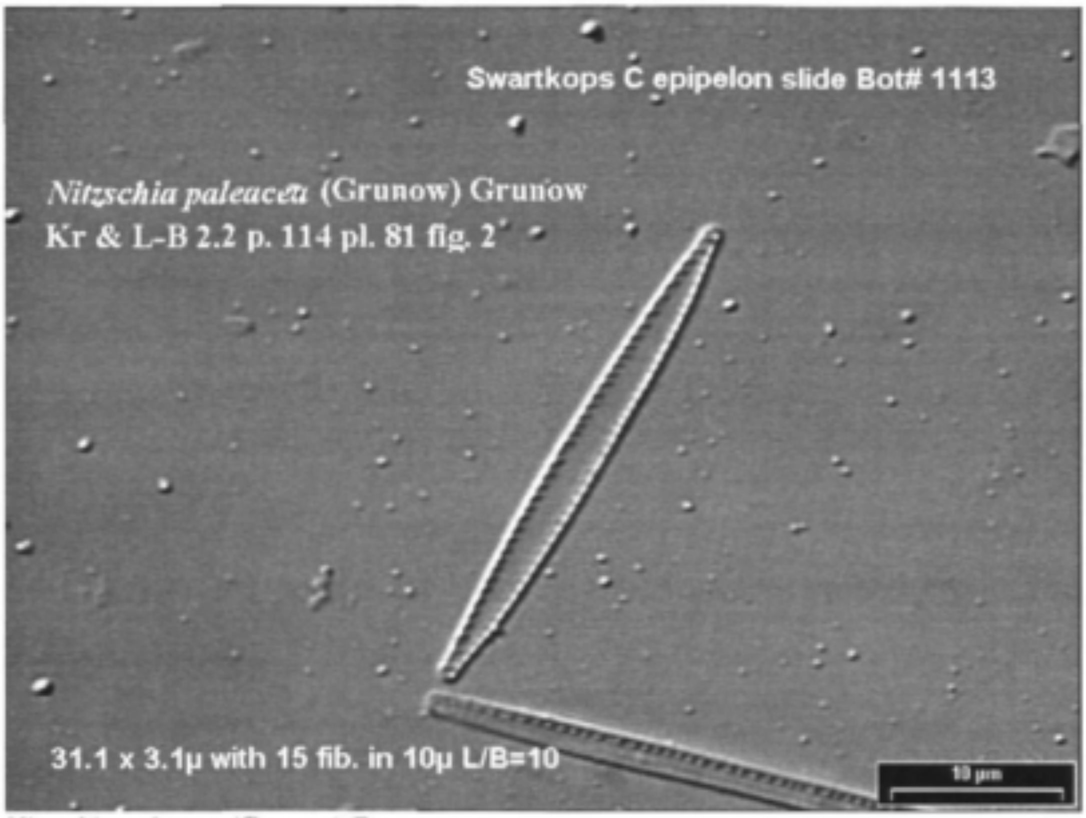


Nitzschia linearis var. *tenuis* (Agardh) W.Smith
Ref. used for identification: Krammer & Lange-Bertalot 1986. 2.2 Page 69. Plate 55. Fig. 5.
Locations - Dominant in epipelon – Sundays River DWAF Site SR2.

NITZLIte		Class	Class
n=1	$(mg.l^{-1})$	Mean	Mode
Ca	-	-	-
Cl	-	-	-
EC	590	4	-
F	-	-	-
K	-	-	-
Mg	-	-	-
Na	-	-	-
NH_4	-	-	-
NO_3	-	-	-
pH	8.05	3	-
PO_4	-	-	-
SiO_2	-	-	-
SO_4	-	-	-
Alkalinity	-	-	-
TDS	3835.0	5	-
Mean class without pH		-	-

NOTES

NITZPAEA

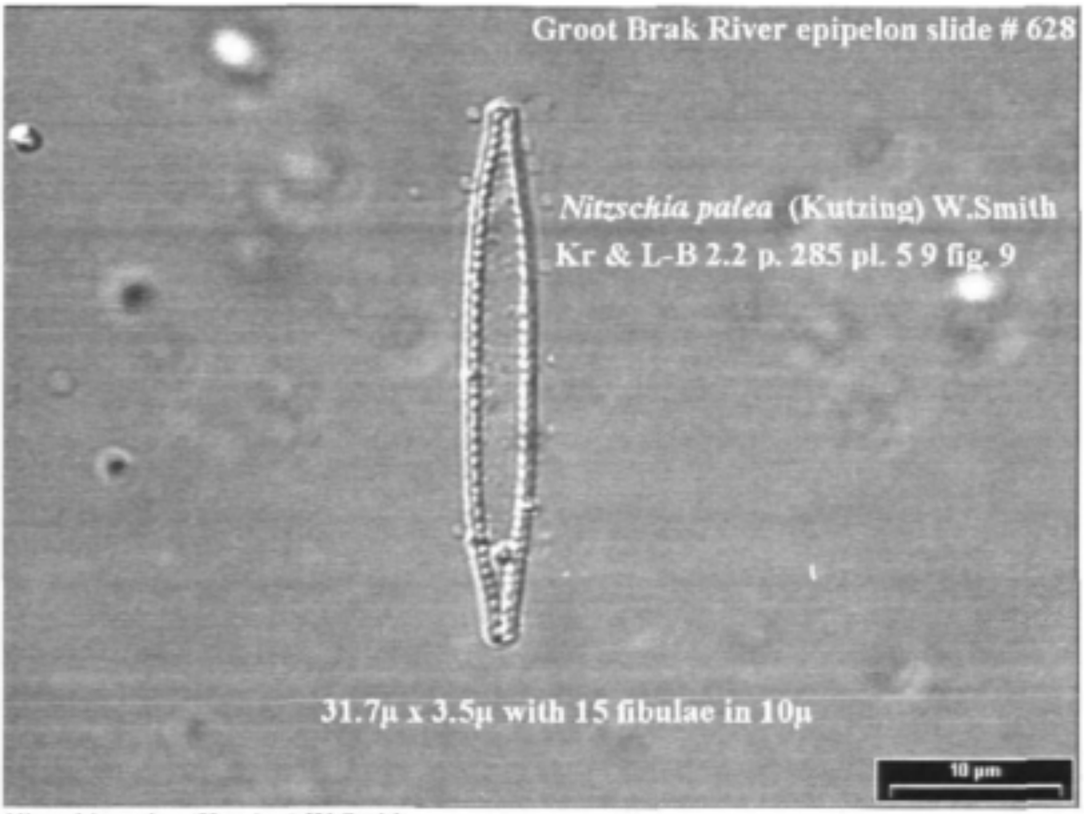


Nitzschia paleacea (Grunow) Grunow
Ref. used for identification: Krammer & Lange-Bertalot 1986. 2.2 Page 114. Plate 81. Figure 2.
Locations - Dominant in epipelon – Swartkops River Site C10.

NITZPAEA		Class	Class
n=1	$(mg.l^{-1})$	Mean	Mode
Ca	20.00	2	-
Cl	248.00	2	-
EC	108.80	1	-
F	0.10	2	-
K	28.90	1	-
Mg	23.00	2	-
Na	152.00	2	-
NH_4	0.00	-	-
NO_3	0.10	1	-
pH	7.34	2	-
PO_4	0.01	1	-
SiO_2	3.20	2	-
SO_4	47.00	1	-
Alkalinity	135.00	2	-
TDS	684.00	2	-
Mean class without pH		1.62	-

NOTES

NITZPALE



Nitzschia palea (Kutzing) W.Smith

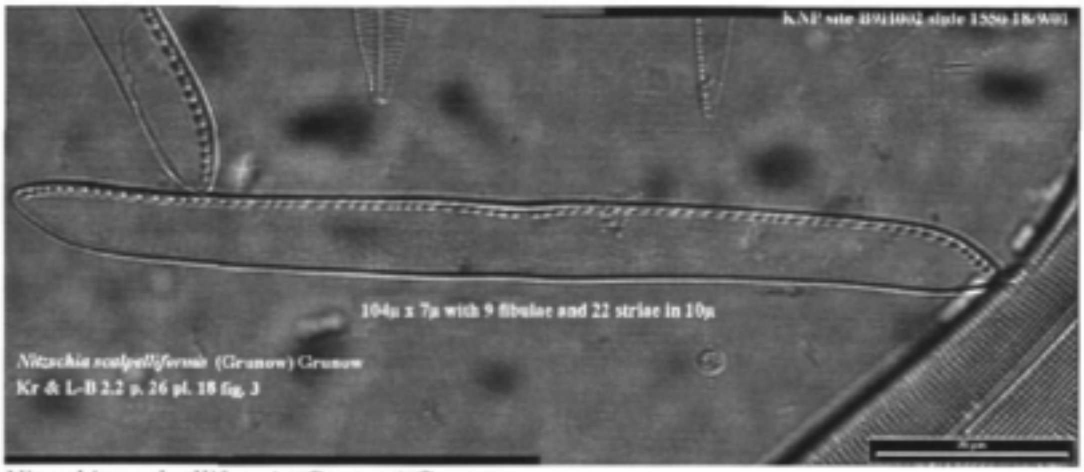
Ref. used for identification: Krammer & Lange-Bertalot 1986. 2.2 Page 285. Plate 59. Figure 9.

Locations - Dominant in epipelon – Durban Metro Site 3; DWAF RAND Crocodile River Site A2H050; Umgeni Water Sites Duzi Dirt Road UmWat 56.2, Karkloof 5.2; Eerste River Site ER5 (DWAF Site ER720D); Salskanaal GB1 (DWAF Site K2H003); Olifants River Sites 05; Kruger National Park DWAF Sites B7H015 & A9H011; Orange River Vioolsdrif and Pella Sites; Swartkops River Sites D11, D19 & D20.

NITZPALE ($mg.l^{-1}$) n=10	Mean	Class Mean	($mg.l^{-1}$) Mode	Class Mode
Ca	42.09	3	-	3
Cl	459.00	2	-	2
EC	188.56	2	-	2
F	0.27	4	0.20	3
K	18.62	1	-	1
Mg	44.26	2	-	2
Na	282.74	2	-	2
NH_4	1.30	1	0.00	1
NO_3	4.80	4	-	4
pH	7.12	2	-	2
PO_4	10.48	5	-	5
SiO_2	5.20	3	-	3
SO_4	115.85	2	-	2
Alkalinity	155.87	2	-	2
TDS	1177.30	2	-	2
Mean class without pH		2.50		2.43

NOTES

NITZSCAL

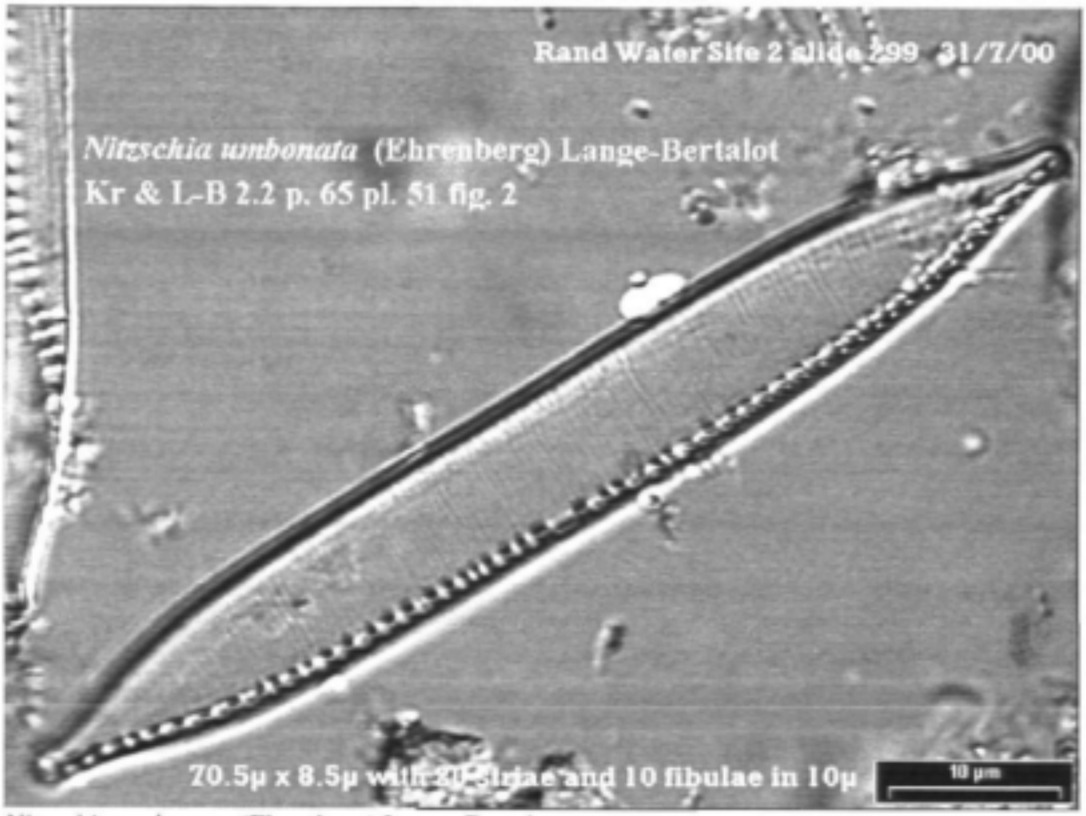


Nitzschia scalpelliformis (Grunow) Grunow
Ref. used for identification: Krammer & Lange-Bertalot 1986. 2.2 Page 26. Plate 18. Figure 3.
Locations - Dominant in epipelon – Kruger National Park DWAF Site B9H002.

NITZSCAL		Class	Class
n=1	($mg.l^{-1}$)	Mean	Mode
Ca	92.51	5	-
Cl	182.49	1	-
EC	145.00	2	-
F	0.32	4	-
K	6.00	1	-
Mg	30.60	2	-
Na	176.11	2	-
NH_4	0.06	1	-
NO_3	0.00	5	-
pH	8.64	5	-
PO_4	0.02	1	-
SiO_2	6.52	4	-
SO_4	15.49	1	-
Alkalinity	492.60	3	-
TDS	942.50	2	-
Mean class without pH		2.62	-

NOTES

NITZUMBO

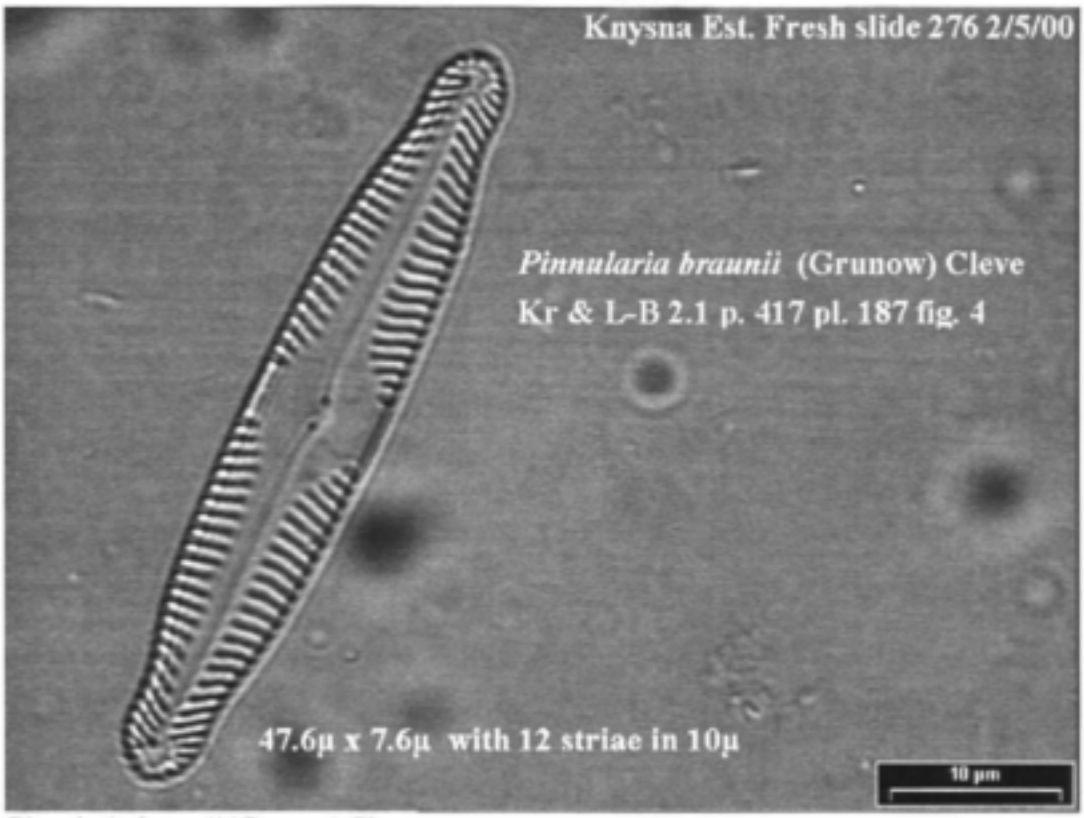


Nitzschia umbonata (Ehrenberg) Lange-Bertalot
Reference used for identification: Krammer & Lange-Bertalot 1986. 2.2 Page 65. Plate 51. Figure 2.
Locations - Dominant in epipelon – Rand Water Paddabaai 1.

NITZUMBO	($mg.l^{-1}$)	Class	Class
n=1	Mean	Mean	Mode
Ca	3.00	5	-
Cl	45.00	5	-
EC	17.40	2	-
F	0.10	5	-
K	0.70	2	-
Mg	4.00	3	-
Na	28.00	1	-
NH_4	0.00	5	-
NO_3	0.11	5	-
pH	7.31	1	-
PO_4	0.02	5	-
SiO_2	2.20	3	-
SO_4	7.00	5	-
Alkalinity	17.00	1	-
TDS	109.00	3	-
Mean class without pH		3.85	-

NOTES

PINNBRAU

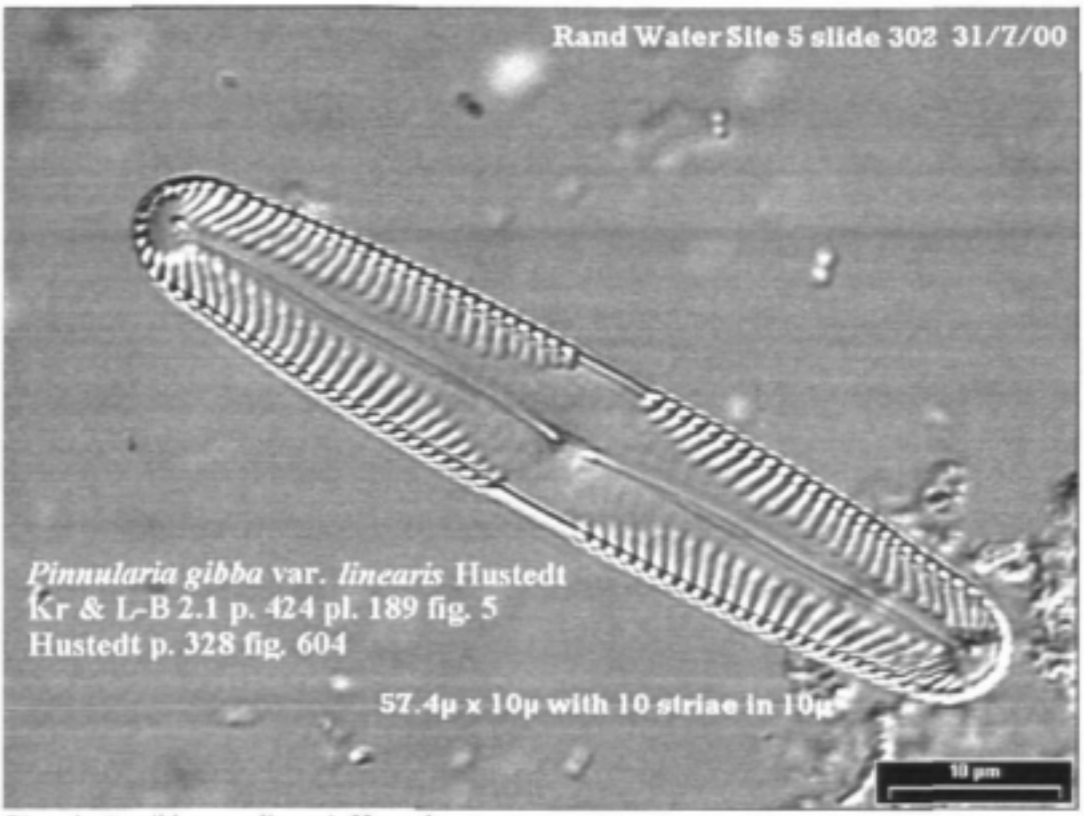


Pinnularia braunii (Grunow) Cleve
Ref. used for identification: Krammer & Lange-Bertalot 1986. 2.1 Page 417. Plate 187. Figure 4.
Locations - Dominant in epipelon – Palmiet River PR5 (DWAF Site PR400E).

PINNBRAU		Class	Class
n=1	($mg.l^{-1}$)	Mean	Mode
Ca	270.00	5	-
Cl	-	5	-
EC	220.00	2	-
F	60.00	5	-
K	82.00	2	-
Mg	75.00	3	-
Na	110.00	1	-
NH_4	295.00	5	-
NO_3	340.16	5	-
pH	5.15	1	-
PO_4	27.00	5	-
SiO_2	4.60	3	-
SO_4	490.00	5	-
Alkalinity	9.10	1	-
TDS	1430.00	3	-
Mean without pH		3.85	-

NOTES

PINNGIli



Pinnularia gibba var. *linearis* Hustedt

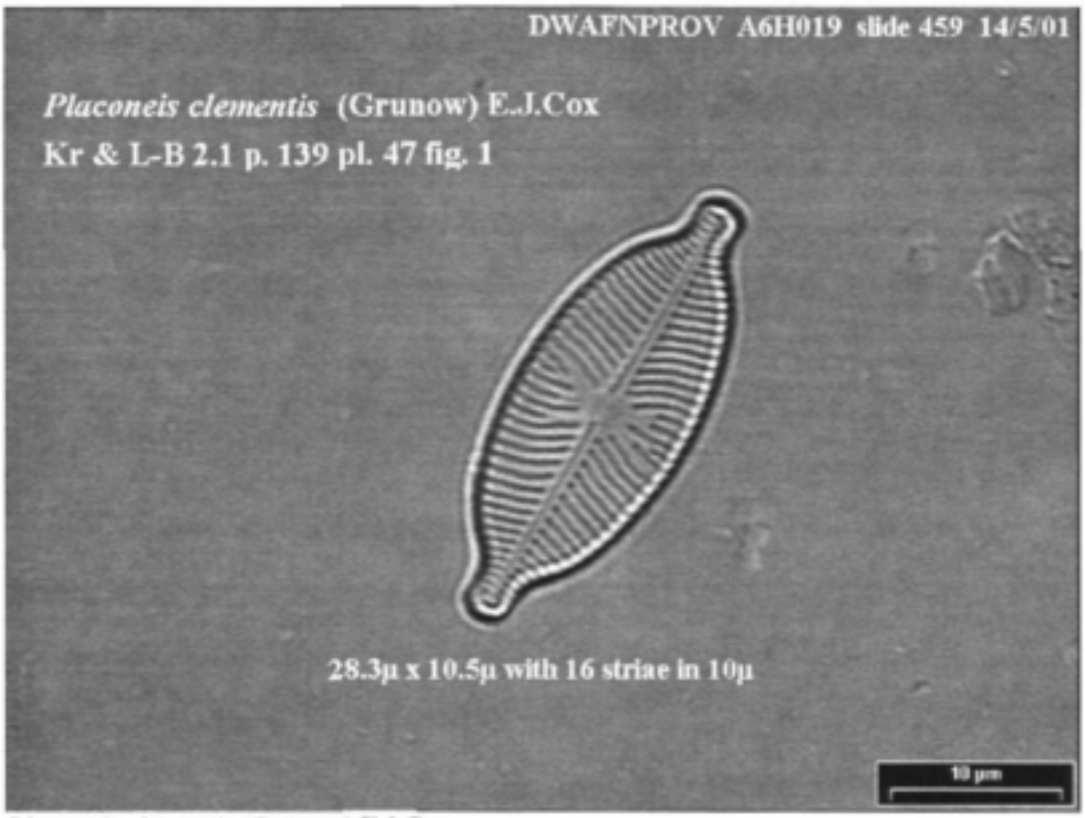
Ref. used for identification: Krammer & Lange-Bertalot 1986. 2.1 Page 424. Plate 189. Figure 5.

Locations - Dominant in epipelon – Rand Water Site Blesbokspruit B9.

PINNGLli		Class	Class
n=1	($mg.l^{-1}$)	Mean	Mode
Ca	39.00	3	-
Cl	190.00	1	-
EC	105.00	1	-
F	0.24	3	-
K	11.00	1	-
Mg	15.00	1	-
Na	105.00	1	-
NH_4	0.74	2	-
NO_3	0.16	1	-
pH	7.40	2	-
PO_4	0.13	1	-
SiO_2	<0.1	5	-
SO_4	100.00	2	-
Alkalinity	115.00	2	-
TDS	682.50	2	-
Mean without pH		1.86	-

NOTES

PLACCLEM

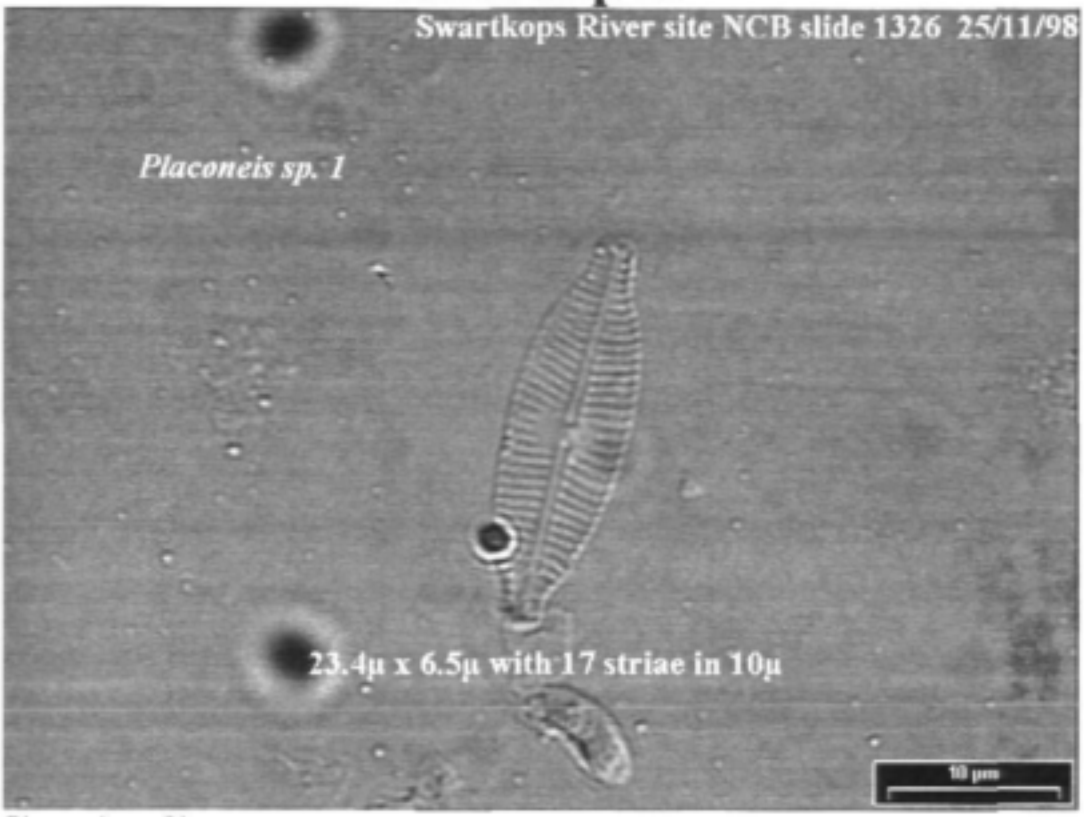


Placoneis clementis (Grunow) E.J.Cox
Reference used for identification: Krammer & Lange-Bertalot 1986. 2.1 Page 139. Plate 47. Figure 1. Hartley 1996. Plate 134. Figure 6.
Locations - Dominant in epipelon – DWAF Northern Province Hessie-se-water A6H019.

PLACCLEM		Class	Class
n=1	($mg.l^{-1}$)	Mean	Mode
Ca	2.29	1	-
Cl	0.00	1	-
EC	4.01	1	-
F	0.14	2	-
K	1.55	1	-
Mg	1.29	1	-
Na	3.47	1	-
NH_4	0.04	1	-
NO_3	0.05	1	-
pH	7.01	1	-
PO_4	0.61	1	-
SiO_2	6.64	4	-
SO_4	8.11	1	-
Alkalinity	11.94	1	-
TDS	26.07	1	-
Mean without pH		1.29	-

NOTES

PLACsp01



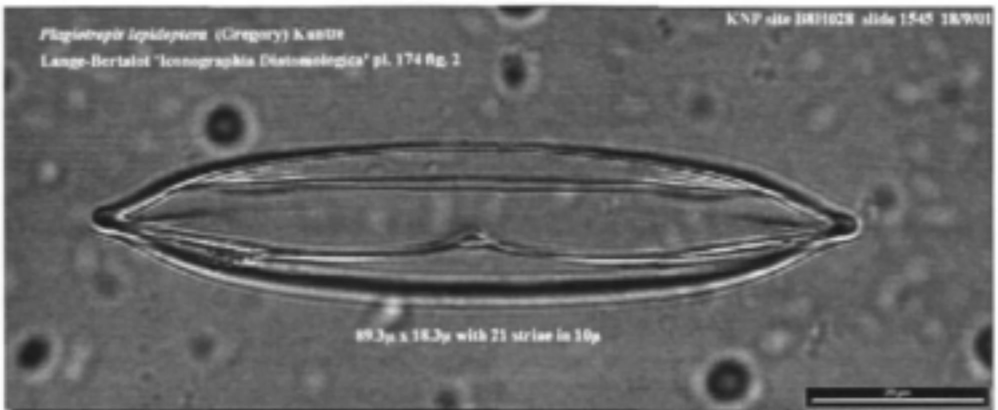
Placoneis sp. 01

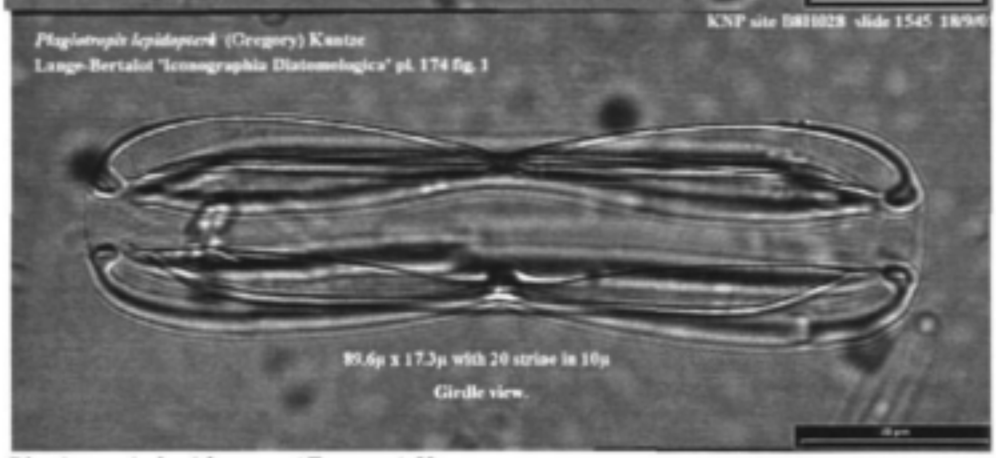
Locations - Dominant in epipelon – Kruger National Park Letaba River DWAF Site B8H018; Swartkops River Site E17.

PLACSP01 (mg.l⁻¹) (n=2)	Mean	Class Mean	(mg.l⁻¹) Mode	Class Mode
Ca	35.44	3	-	-
Cl	394.91	2	-	-
EC	151.10	2	-	-
F	0.27	4	-	-
K	12.95	1	-	-
Mg	43.41	2	-	-
Na	253.38	2	-	-
NH_4	0.00	1	-	-
NO_3	0.47	1	-	-
pH	8.15	4	-	-
PO_4	0.54	1	-	-
SiO_2	2.9925	2	-	-
SO_4	75.35	2	-	-
Alkalinity	188.16	2	-	-
TDS	1040.40	2	-	-
Mean class without pH		1.93	-	-

NOTES

PLAGLEPI





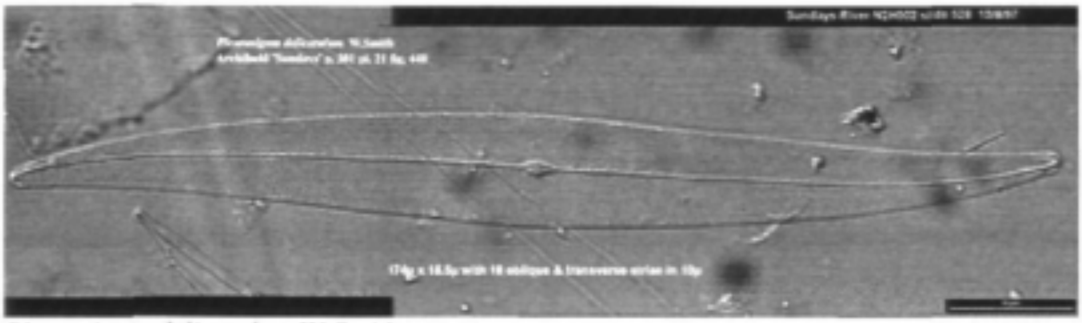
Plagiotropis lepidoptera (Gregory) Kuntze
Reference used for identification: Lange-Bertalot 2000. Plate 174. Figures 1 & 2.
Locations - Dominant in epipelon – Kruger National Park Letaba River B8H028.

PLAGLEPI		Class	Class
n=1	($mg.l^{-1}$)	Mean	Mode
Ca	21.19	2	-
Cl	63.25	1	-
EC	47.70	1	-
F	0.21	3	-
K	1.92	1	-
Mg	16.14	1	-
Na	39.73	1	-
NH_4	0.05	1	-
NO_3	0.06	1	-
pH	8.27	4	-
PO_4	0.03	1	-
SiO_2	6.03	4	-
SO_4	15.01	1	-
Alkalinity	115.93	2	-
TDS	310.05	1	-
Mean without pH		1.43	-

NOTES

Although this is considered a marine genus, Round *et. al.* (1990) note that *P.lepidoptera*, the most commonly recorded species, is reported from alkaline streams in the United States. In the Letaba River, where it was dominant in South Africa, the pH was 8.27.

PLEUDELI



Pleurosigma delicatulum W.Smith

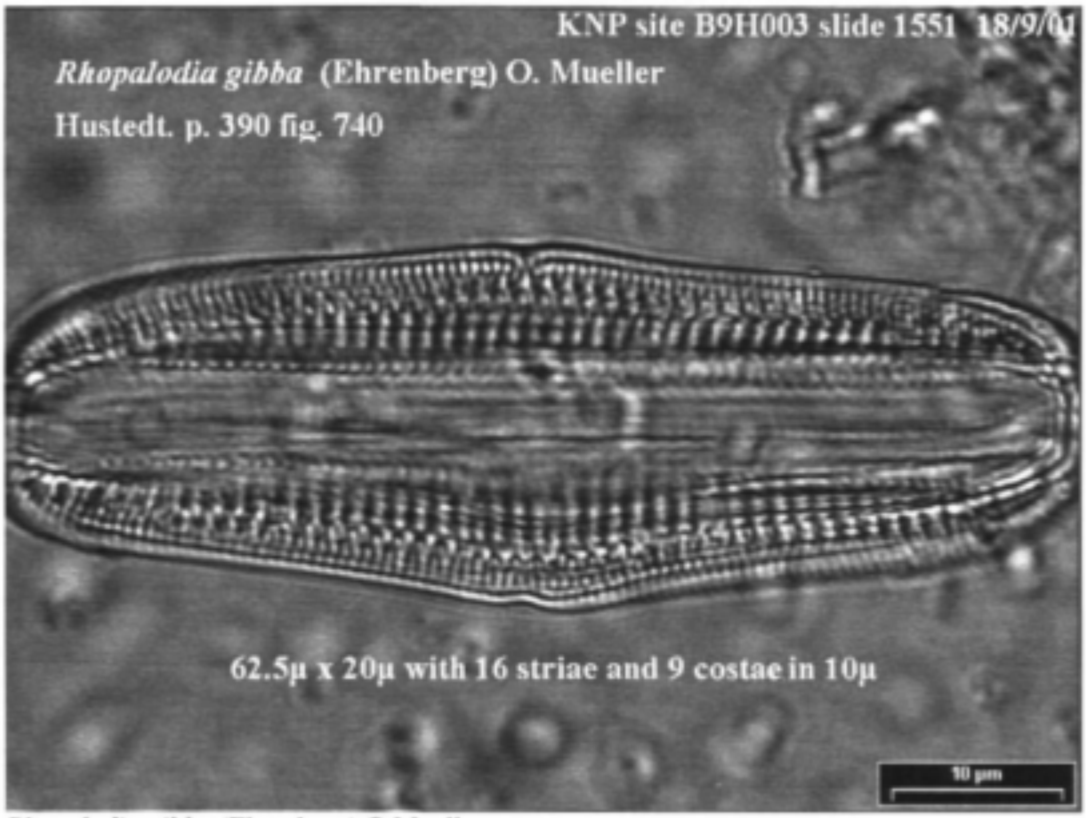
Reference used for identification: Archibald 1983. Page 303. Plate 21. Figure 448.

Locations - Dominant in epipelon – DWAF Northern Province Sandrivier Site A7H009.

PLEUDELI		Class	Class
n=1	$(mg.l^{-1})$	Mean	Mode
Ca	93.55	5	-
Cl	729.55	3	-
EC	317.00	2	-
F	0.37	5	-
K	8.07	1	-
Mg	111.69	4	-
Na	400.94	3	-
NH_4	0.00	1	-
NO_3	0.00	1	-
pH	8.07	3	-
PO_4	0.07	1	-
SiO_2	11.79	5	-
SO_4	-	-	-
Alkalinity	247.90	2	-
TDS	2060.50	3	-
Mean without pH		2.77	-

NOTES

RHOPGIBB

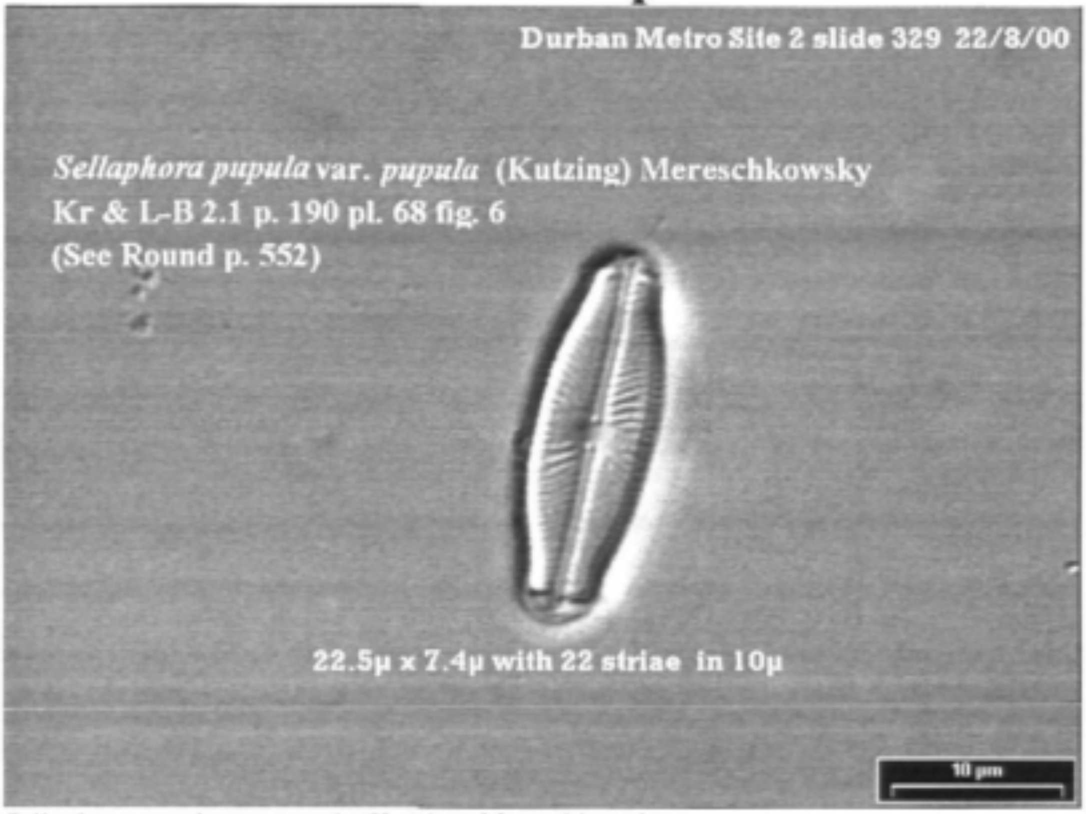


Rhopalodia gibba (Ehrenberg) O.Mueller
Reference used for identification: Hustedt 1976. Page 390. Figure 740.
Locations – Dominant in epipelon – Kruger National Park DWAF Site B9H003.

RHOPGIBB		Class	Class
n=1	($mg.l^{-1}$)	Mean	Mode
Ca	37.47	3	-
Cl	165.90	1	-
EC	122.00	1	-
F	0.33	4	-
K	6.99	1	-
Mg	45.27	2	-
Na	145.38	2	-
NH_4	0.01	1	-
NO_3	0.01	1	-
pH	8.72	5	-
PO_4	0.04	1	-
SiO_2	5.60	4	-
SO_4	17.56	1	-
Alkalinity	375.08	3	-
TDS	793.00	2	-
Mean without pH		2.08	-

NOTES

SELLPUpu



Sellaphora pupula var. *pupula* (Kutzing) Mereschkowsky

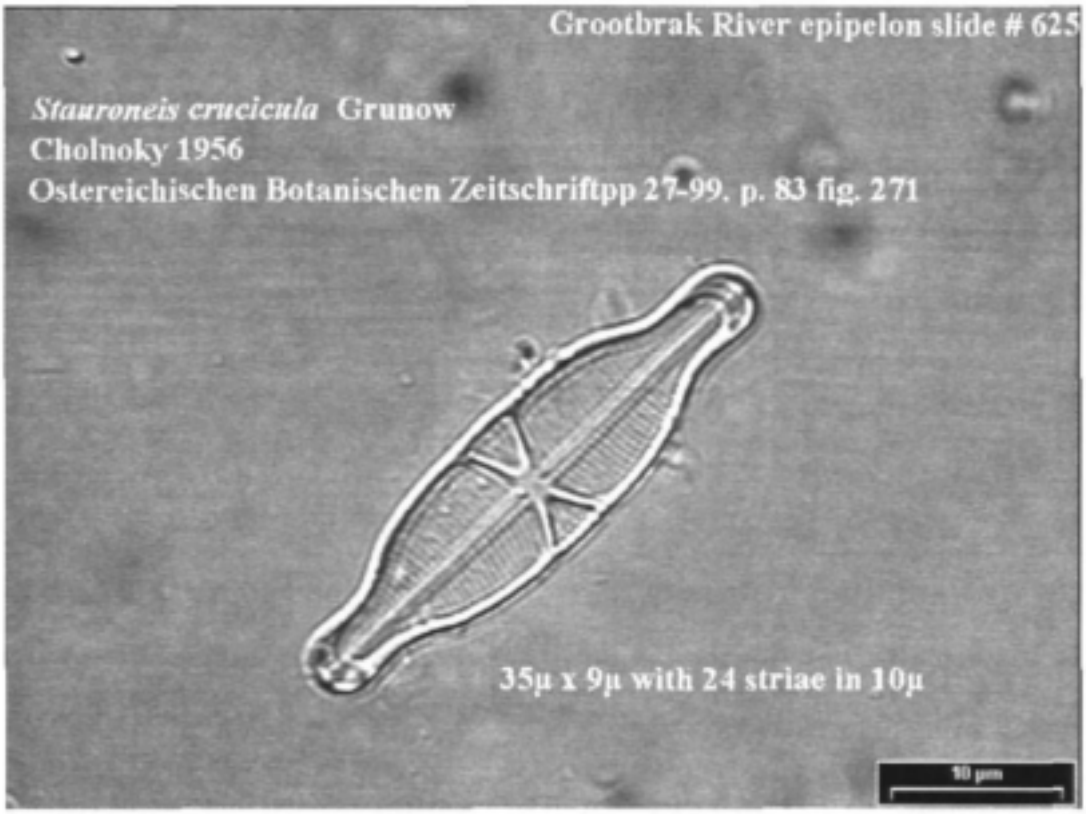
Ref. used for identification: Krammer & Lange-Bertalot 1986. 2.1 Page 190. Plate 68. Figure 6.

Locations - Dominant in epipelon – DWAF RAND Sites Bloubankrivier A0H048, Little Jukskei A2H047, Moordenaarspruit A2H055; Umgeni Water Umzimduzi River UmWat 64, UmWat 67, UmWat 662, UmWat 66.3, Slangspruit UmWat 61; Northern Province Hessies-se-Water A6H019; Durban Metro Palmiet River Site 05; DWAF KZN Site V2H012; Orange River Site at Upington; Eerste Rivier Site ER7.

SELLPUpu ($mg.l^{-1}$) n=7	Mean	Class Mean	($mg.l^{-1}$) Mode	Class Mode
Ca	26.52	2	-	2
Cl	31.24	2	-	2
EC	38.26	1	-	1
F	0.20	3	0.12	2
K	2.67	1	-	1
Mg	13.08	1	5.9	1
Na	19.93	1	20	1
NH_4	0.24	1	-	1
NO_3	1.67	2	1.4	2
pH	7.91	3	7.7	3
PO_4	68.44	5	-	5
SiO_2	9.08	5	-	5
SO_4	31.13	1	-	1
Alkalinity	106.93	1	-	1
TDS	246.95	1	-	1
Mean class without pH		1.93		1.86

NOTES

STAUCRUC



Stauroneis crucicula Grunow

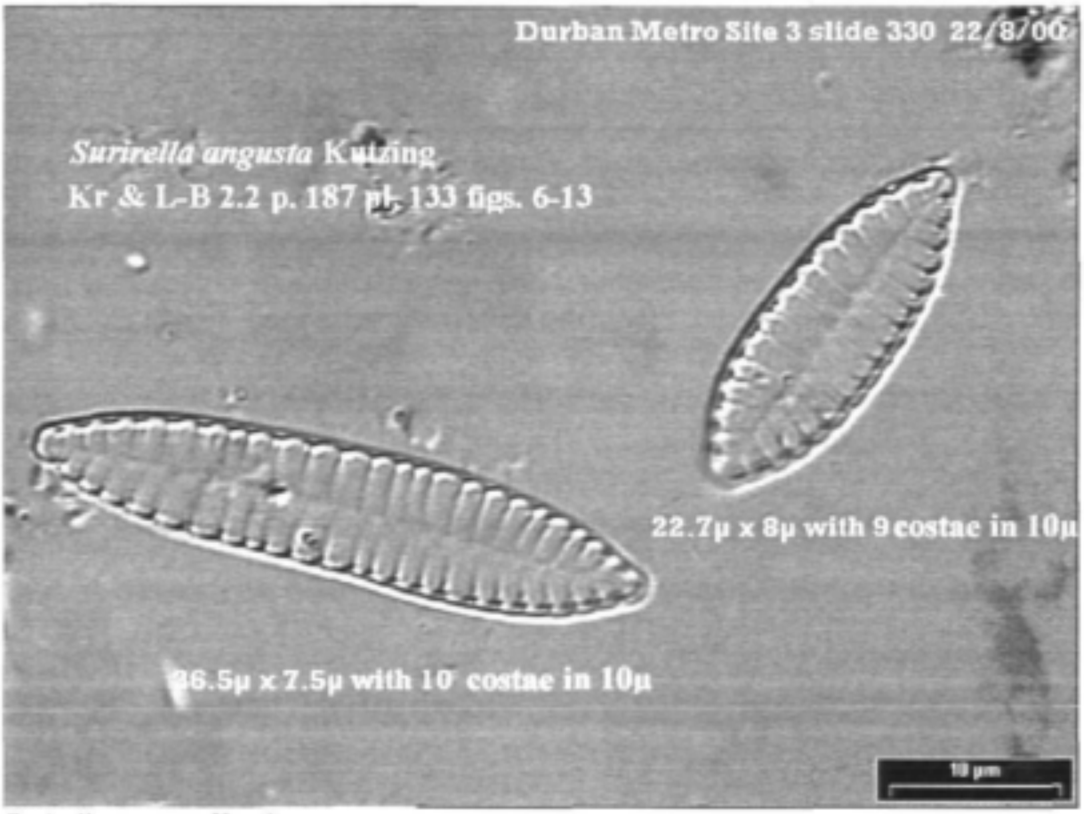
Reference used for identification: Cholnoky 1956. Plate 83. Figure 271.

Locations – Dominant in epipelon – Kruger National Park DWAF Sabie River Site X3H015.

STAUCRUC		Class	Class
n=1	$(mg.l^{-1})$	Mean	Mode
Ca	10.04	1	-
Cl	14.42	1	-
EC	20.00	1	-
F	0.15	2	-
K	1.28	1	-
Mg	9.30	1	-
Na	11.88	1	-
NH_4	0.04	1	-
NO_3	0.08	1	-
pH	8.03	3	-
PO_4	0.02	1	-
SiO_2	5.67	4	-
SO_4	9.11	1	-
Alkalinity	64.34	1	-
TDS	130.00	1	-
Mean without pH		1.29	-

NOTES

SURIANGU



Surirella angusta Kutzing

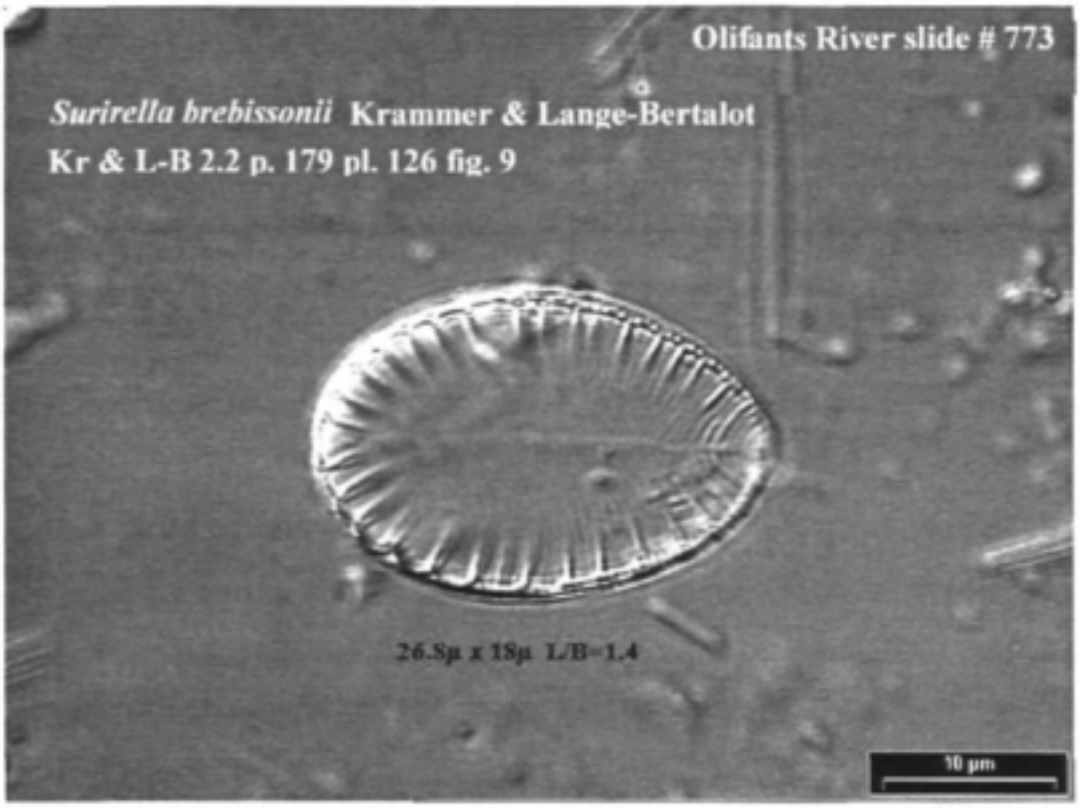
Ref. used for identification: Krammer & Lange-Bertalot 1986. 2.2 Page 187. Plate 133. Figures 6-13.

Locations - Dominant in epipelon – Durban Metro Sites Palmietrivier Palm06 & Palm07.

SURIANGU (n=2)	$(mg.l^{-1})$ Mean	Class Mean	$(mg.l^{-1})$ Mode	Class Mode
Ca	-	-	-	-
Cl	-	-	-	-
EC	72.00	1	-	-
F	0.32	4	-	-
K	8.50	1	-	-
Mg	2.40	1	-	-
Na	45.00	1	-	-
NH_4	-	-	-	-
NO_3	30.00	5	-	-
pH	8.00	3	-	-
PO_4	0.70	1	-	-
SiO_2	-	-	-	-
SO_4	-	-	-	-
Alkalinity	-	-	-	-
TDS	468.00	1	-	-
Mean class without pH		1.88	-	-

NOTES

SURIBREB

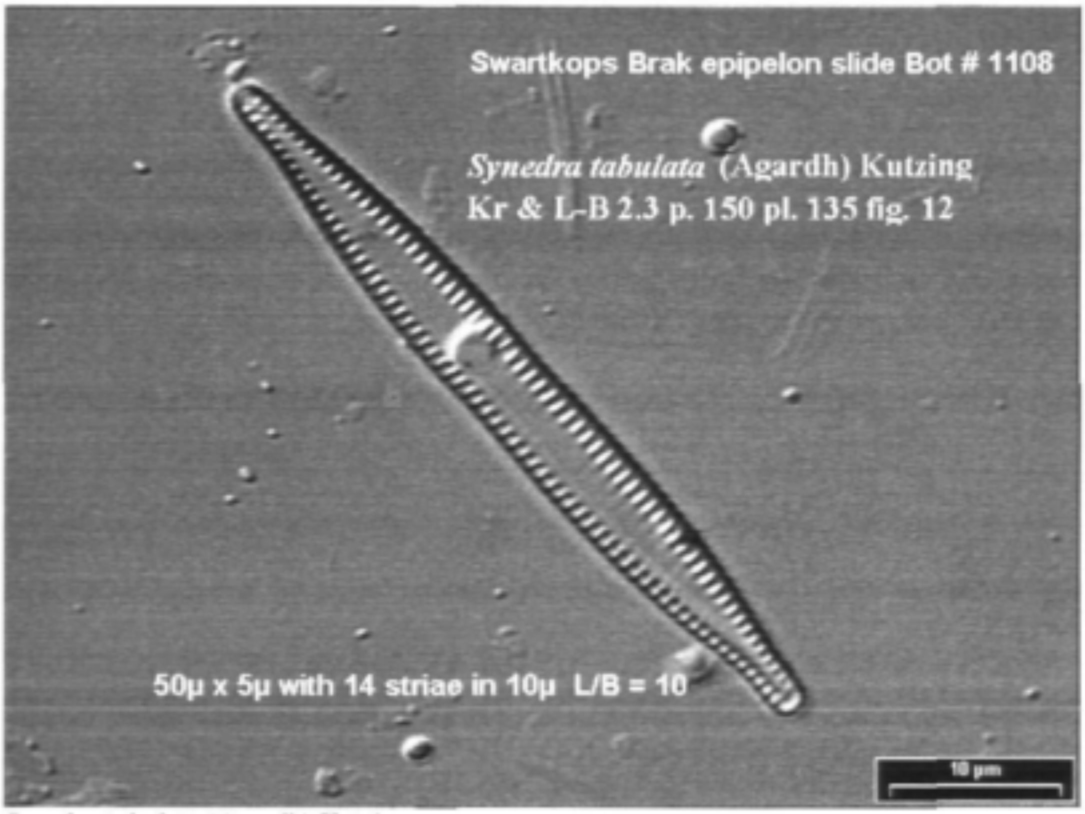


Surirella brebissonii Krammer & Lange-Bertalot
Ref. used for identification: Krammer & Lange-Bertalot 1986. 2.2 Page 179. Plate 126. Figure 9.
Locations - Dominant in epipelon – Rand Water Taaibosspruit TW2.

SURIBREB		Class	Class
n=1	($mg.l^{-1}$)	Mean	Mode
Ca	100.00	5	-
Cl	150.00	1	-
EC	100.00	1	-
F	0.44	5	-
K	10.00	1	-
Mg	21.00	2	-
Na	110.00	1	-
NH4	0.05	1	-
NO3	1.20	2	-
pH	7.36	2	-
PO4	0.27	1	-
SiO2	20.00	5	-
SO4	100.00	2	-
Alkalinity	0.00	-	-
TDS	650.0	2	-
Mean without pH		2.23	-

NOTES

SYNETABU



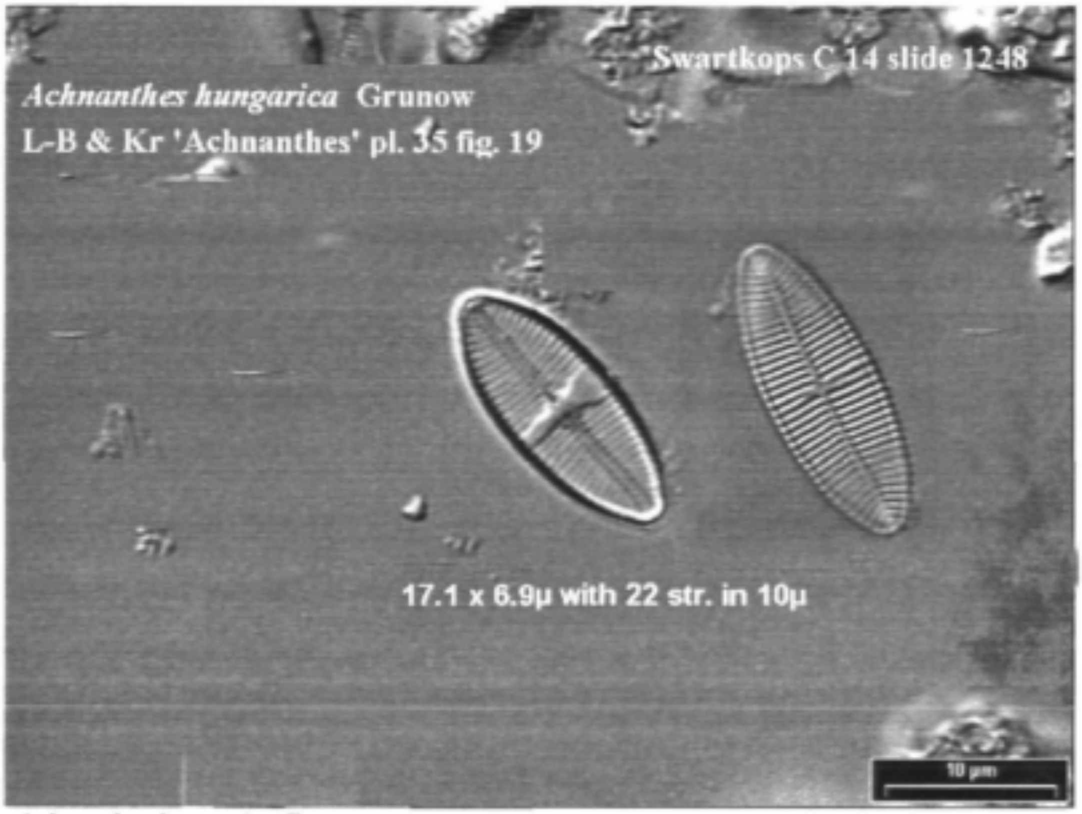
Synedra tabulata (Agardh) Kutzing
Ref. used for identification: Krammer & Lange-Bertalot 1986. 2. 3 Page 150. Plate 135. Figure 12.
Locations - Dominant in epipelon – Swartkops River Site E15.

SYNETABU		Class	Class
n=1	($mg.l^{-1}$)	Mean	Mode
Ca	72.00	4	-
Cl	1365.00	4	-
EC	489.00	3	-
F	0.30	4	-
K	20.70	1	-
Mg	112.00	4	-
Na	821.00	5	-
NH_4	0.00	1	-
NO_3	6.22	5	-
pH	8.52	4	-
PO_4	1.92	2	-
SiO_2	0.60	1	-
SO_4	269.00	3	-
Alkalinity	226.00	2	-
TDS	2969.00	4	-
Mean without pH		3.07	-

NOTES

RIVER SUB-DOMINANTS

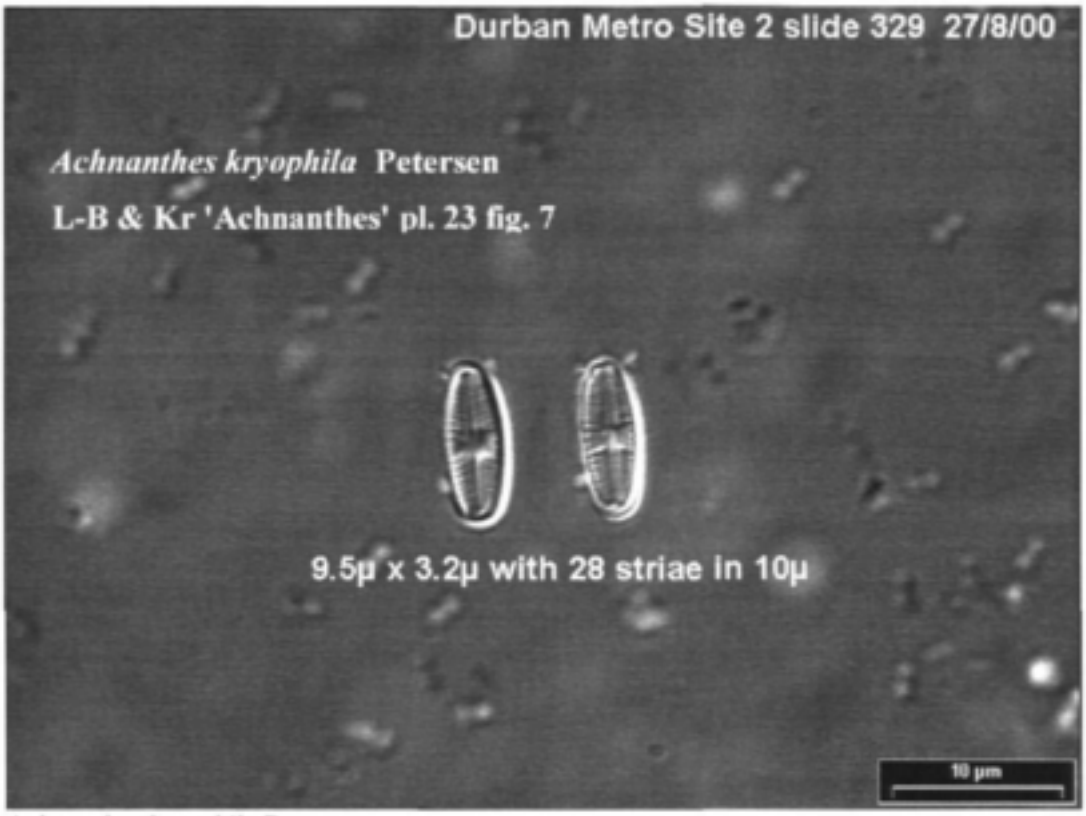
ACHNHUNG



Achnanthes hungarica Grunow
Reference used for identification: Lange-Bertalot & Krammer 1989. Plate 35. fig. 19.
Locations – Sub-dominant in epipelon – Swartkops River Sites C14 & C19.

NOTES	NOTES
Only found as a sub-dominant, therefore water quality not presented.	This is a heterovalvar genus having one raphid and one rapheless valve.

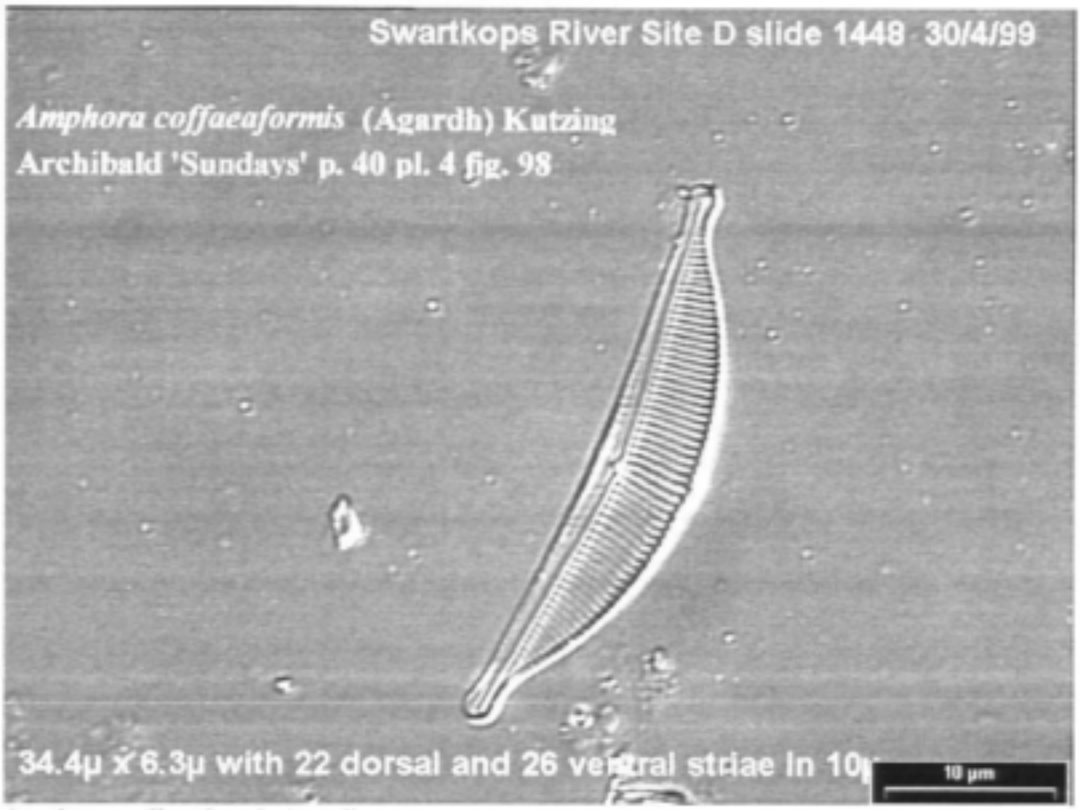
ACHNKRYO



Achnanthes kryophila Petersen
Reference used for identification: Lange-Bertalot & Krammer 1989. Plate 23. Figure 6.
Locations – Sub-dominant in epipelon – Durban Metro Palmiet River Site 05.

NOTES	NOTES
Only found as a sub-dominant, therefore water quality not presented.	This is a heterovalvar genus having one raphid and one rapheless valve.

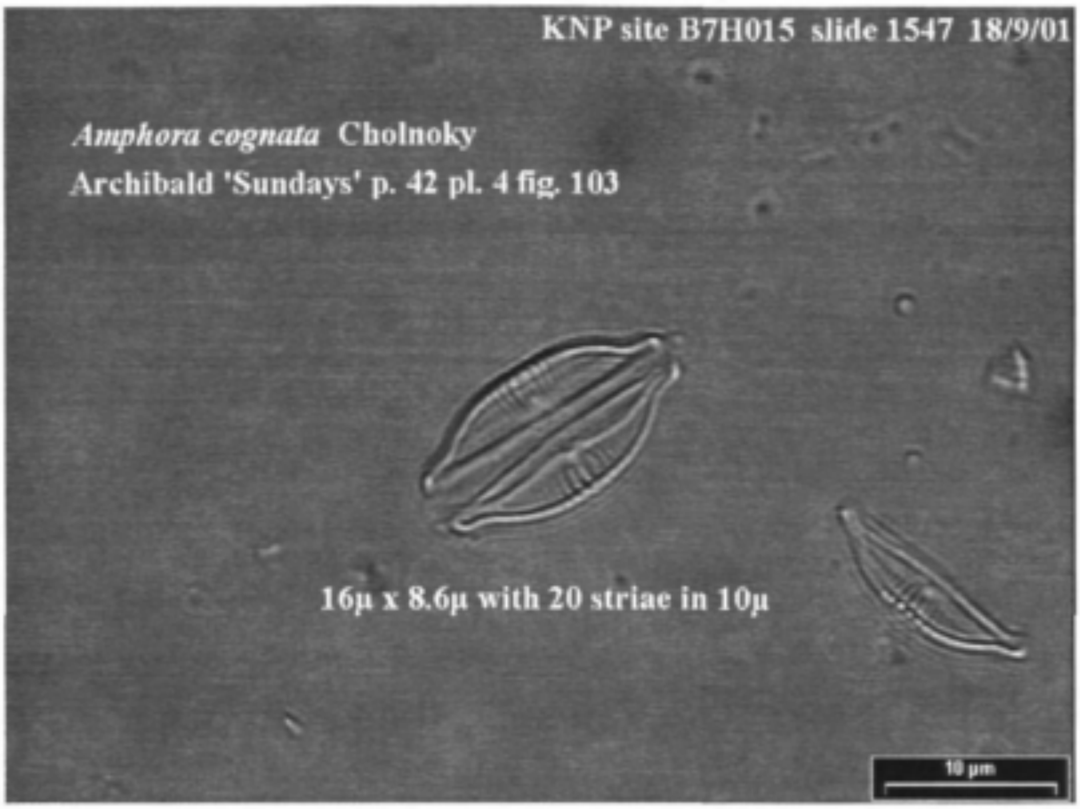
AMPHCOFF



Amphora coffeaeformis Agardh
Reference used for identification: Hustedt 1976. Page 344. Figure 634.
Locations – Sub-dominant in epipelon – Swartkops River Site D21.

NOTES	NOTES
Only found as a sub-dominant, therefore water quality not presented.	

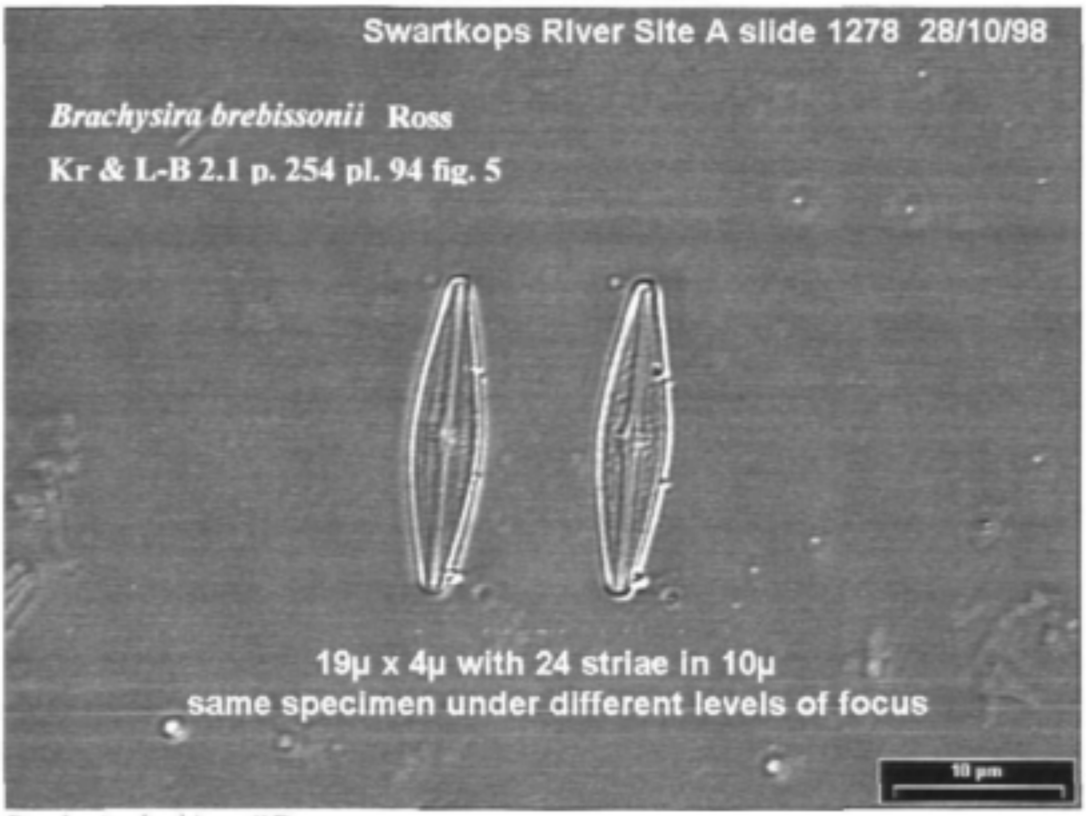
AMPHCOGN



Amphora cognata Cholnoky
Reference used for identification: Archibald 1983. Page 42. Plate 4. Figure 103.
Locations – Sub-dominant in epipelon – Kruger National Park Olifants River B7H015; Gamtoos River GR6.

NOTES	NOTES
Only found as a sub-dominant, therefore water quality not presented.	

BRACBREB



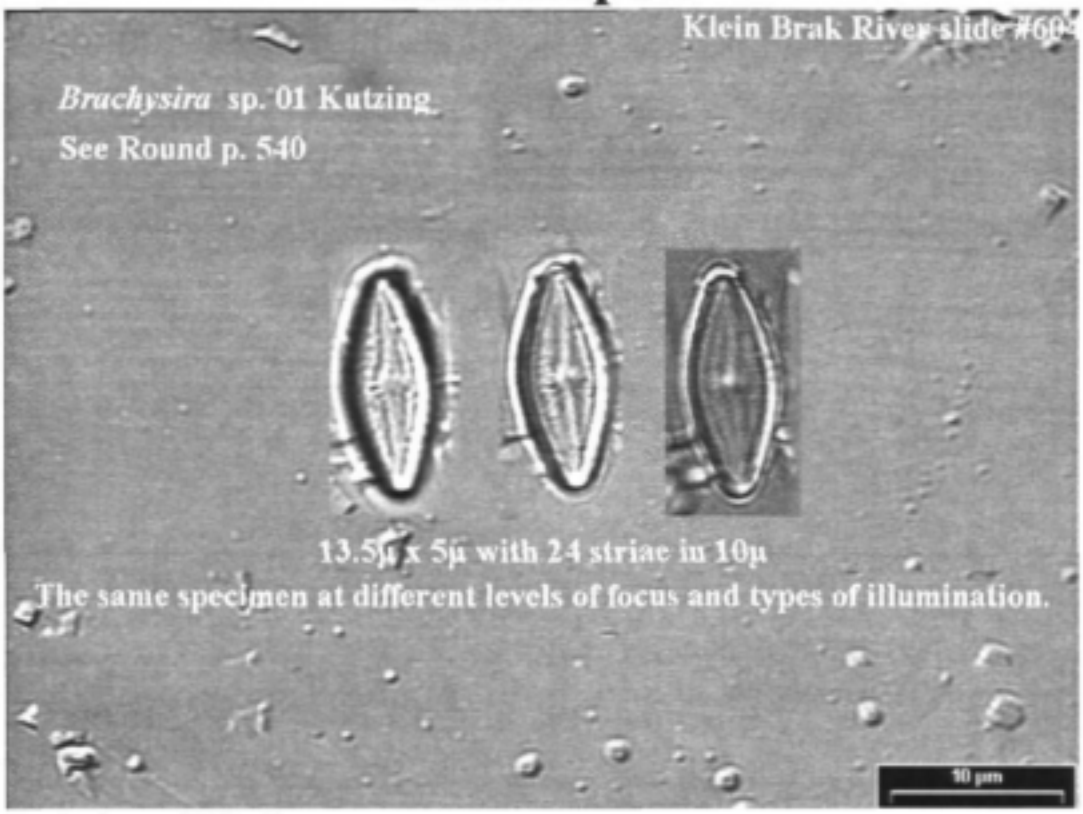
Brachysira brebissonii Ross

Reference used for identification: Krammer & Lange-Bertalot 1986. Page 254. Plate 94. Figure 9.

Locations – Sub-dominant in epipelon – Swartkops River Site B15.

NOTES	NOTES
Only found as a sub-dominant, therefore water quality not presented.	

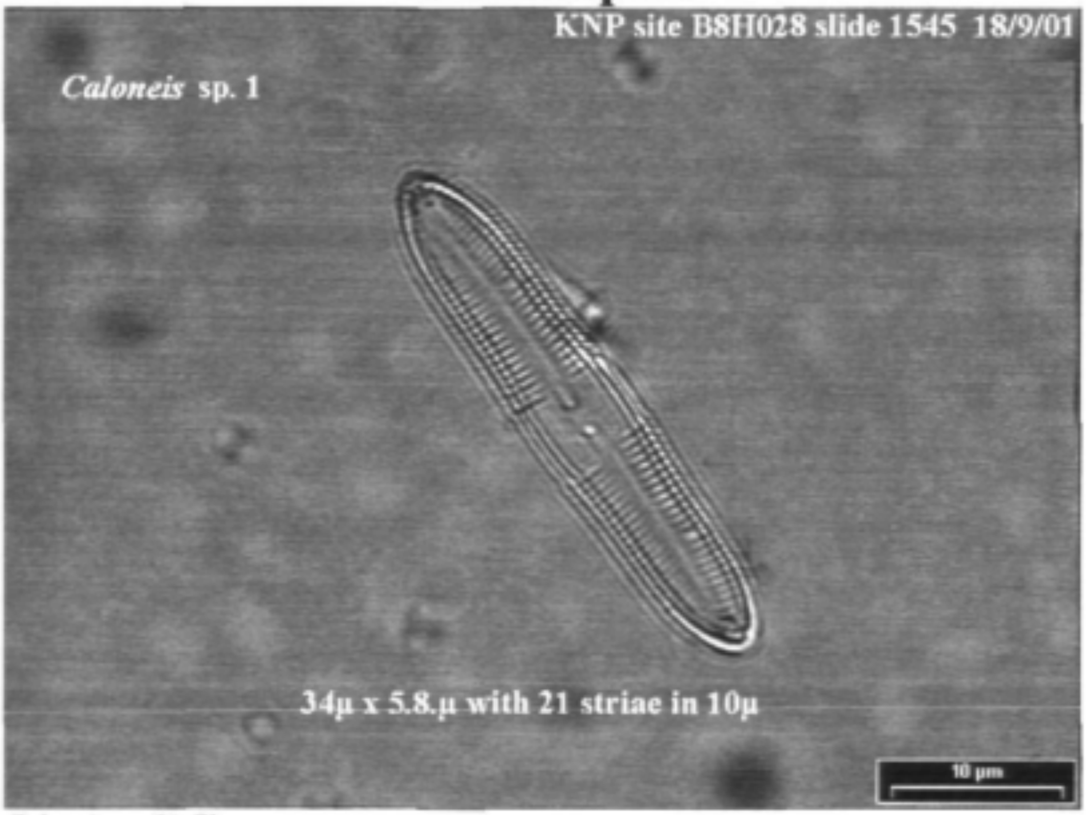
BRACsp01



Brachysira sp. 01 Kutzing
Reference used for identification: Round, Crawford & Mann 1990. Page 540.
Locations – Sub-dominant in epipelon – Bedeke River Site KB1.

NOTES	NOTES
Only found as a sub-dominant, therefore water quality not presented.	

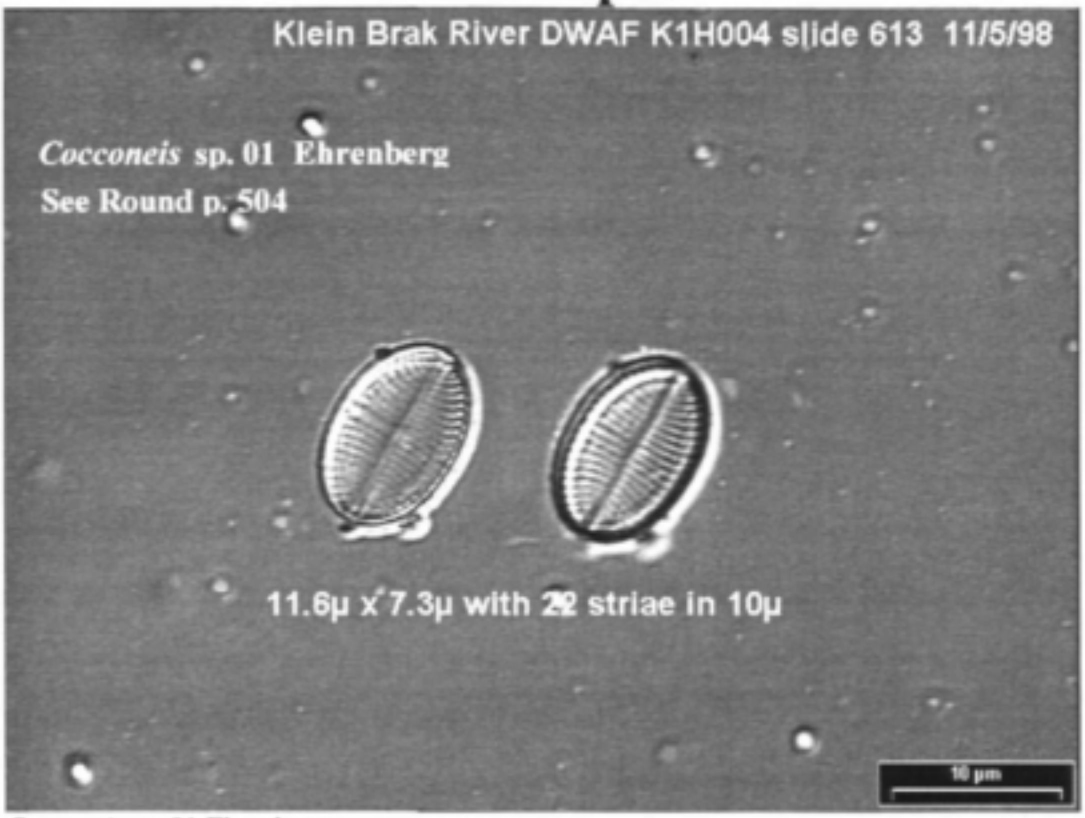
CALOsp01



Caloneis sp. 01 Cleve
Reference used for identification: Hustedt 1976. See page 235. Figure 356.
Locations – Sub-dominant in epipelon – Kruger National Park Letaba River DWAF Site B8H028.

NOTES	NOTES
Only found as a sub-dominant, therefore water quality not presented.	

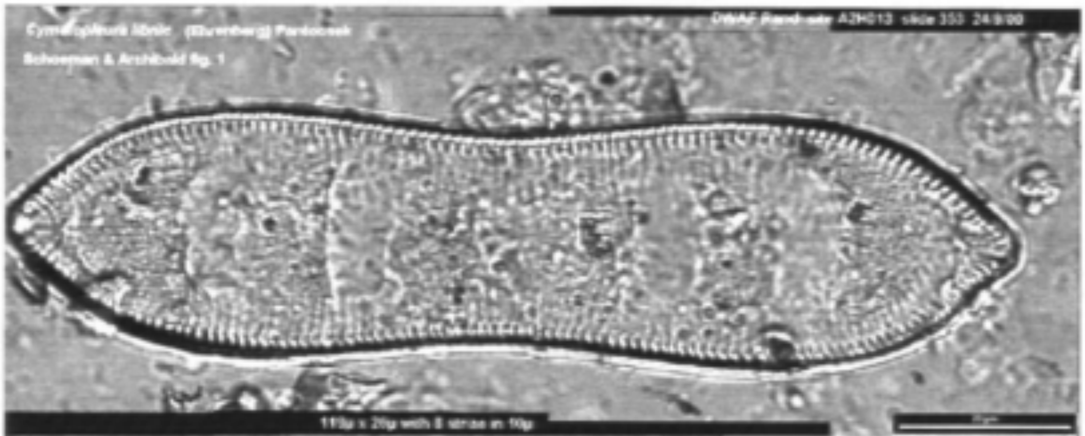
COCCsp01

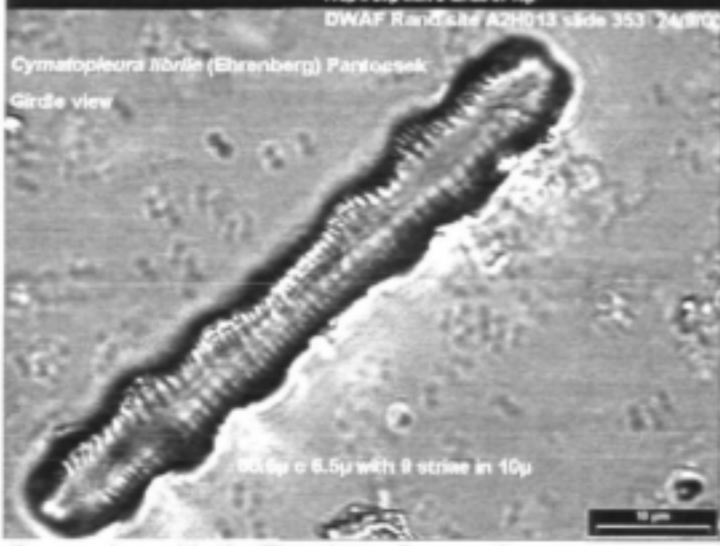


Cocconeis sp. 01 Ehrenberg
Reference used for identification: Round, Crawford & Mann 1990. Page 504.
Locations – Sub-dominant in epipelon – Brandwag River DWAF Site KB2.

NOTES	NOTES
Only found as a sub-dominant, therefore water quality not presented.	This is a heterovalvar genus having one valve with a raphe-sternum and the other lacking the raphe, but having a corresponding sternum.

CYMALIBR





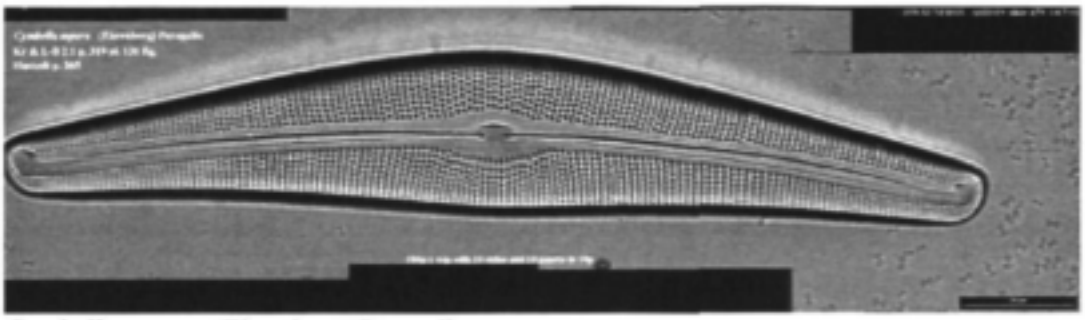
Cymatopleura librile (Ehrenberg) Pantocsek

Reference used for identification: Schoeman & Archibald 1976. Figure 1.

Locations – Sub-dominant in epipelon: DWAF Northern Cape Vaal River C9H021.

NOTES	NOTES
Only found as a sub-dominant, therefore water quality not presented.	

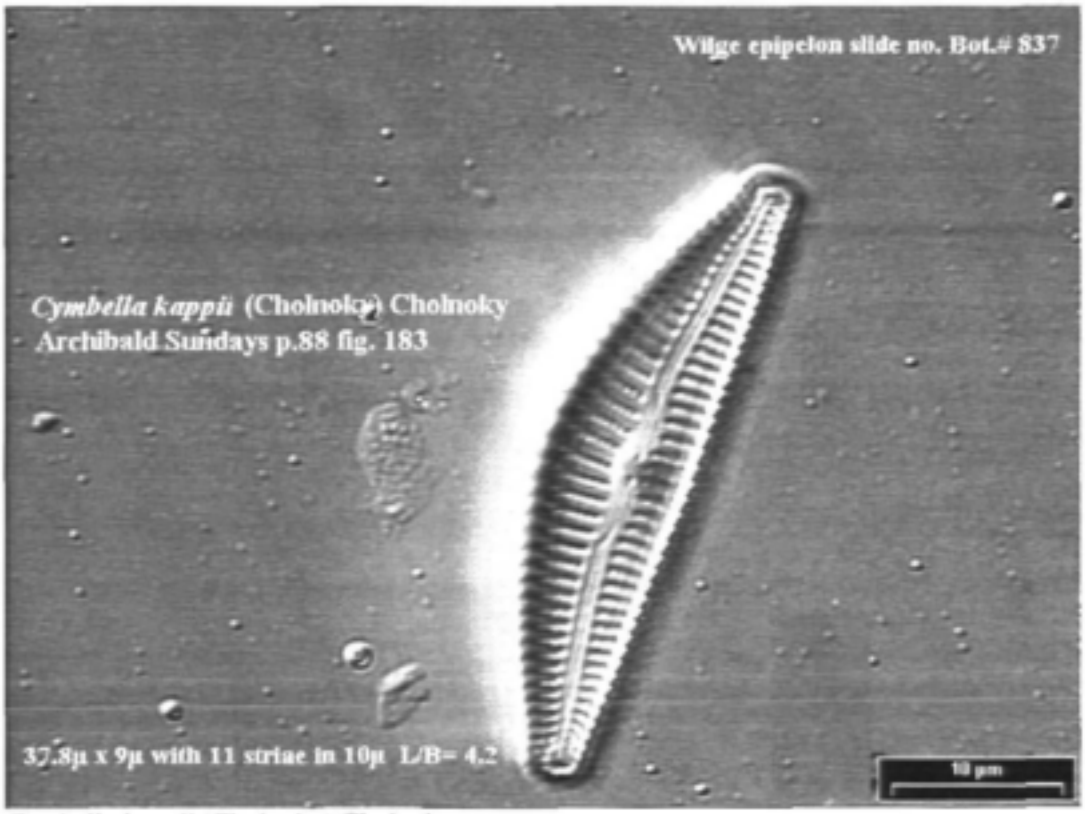
CYMBASPE



Cymbella aspera (Ehrenberg) Peragallo
Reference used for identification: Hustedt 1976. Page 365. Figure 680.
Locations – Sub-dominant in epipelon: DWAF Northern Province Sand River A7H009; Umgeni Water Karkloof River Site 5.2

NOTES	NOTES
Only found as a sub-dominant, therefore water quality not presented.	

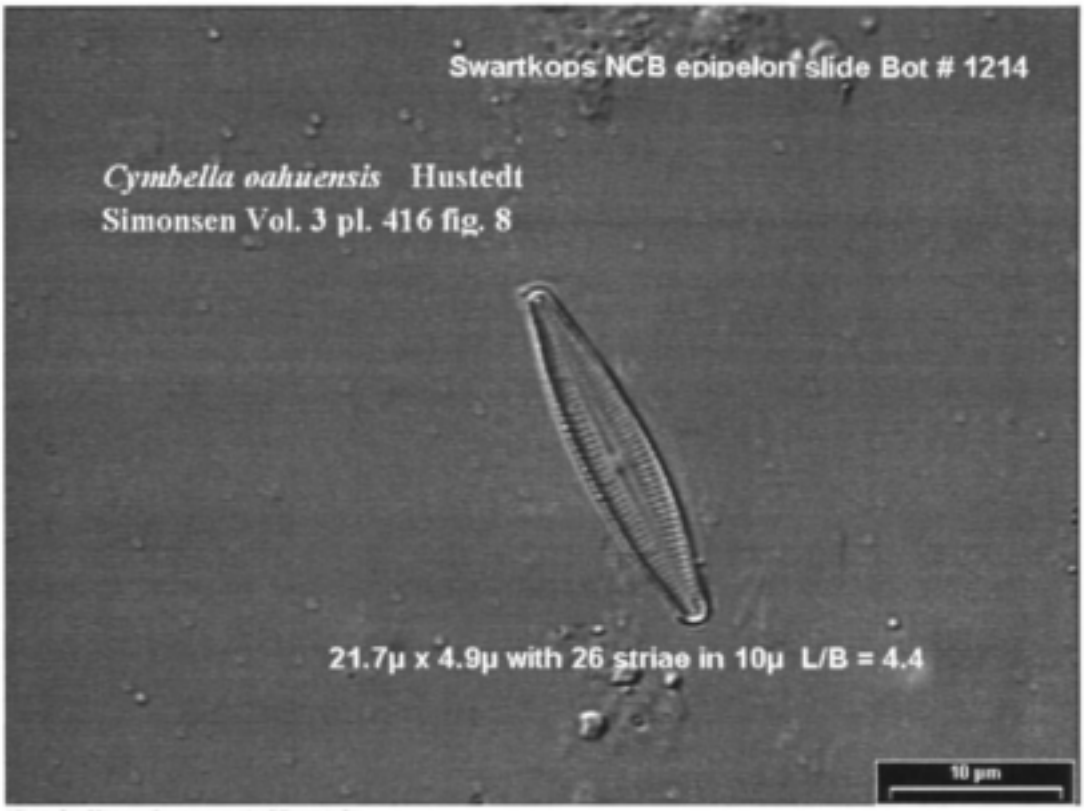
CYMBKAPP



Cymbella kappii (Cholnoky) Cholnoky
Reference used for identification: Archibald 1983. Page 88. Plate 10. Figure 183.
Locations – Sub-dominant in epipelon – Umgeni Water Mzimduzi River Site UmWat62.

NOTES	NOTES
Only found as a sub-dominant, therefore water quality not presented.	

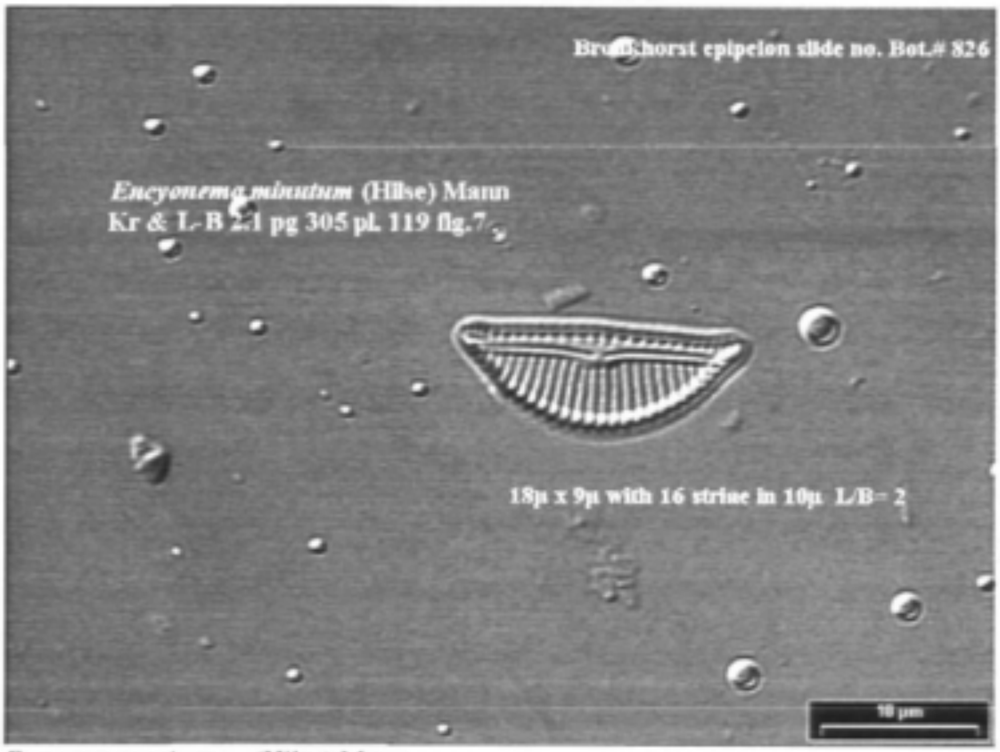
CYMBOAHU



Cymbella oahuenensis Hustedt
Reference used for identification: Simonsen 1987. Volume 3. Plate 416. Figure 8.
Locations – Sub-dominant in epipelon – Swartkops River Site E15.

NOTES	NOTES
Only found as a sub-dominant, therefore water quality not presented.	

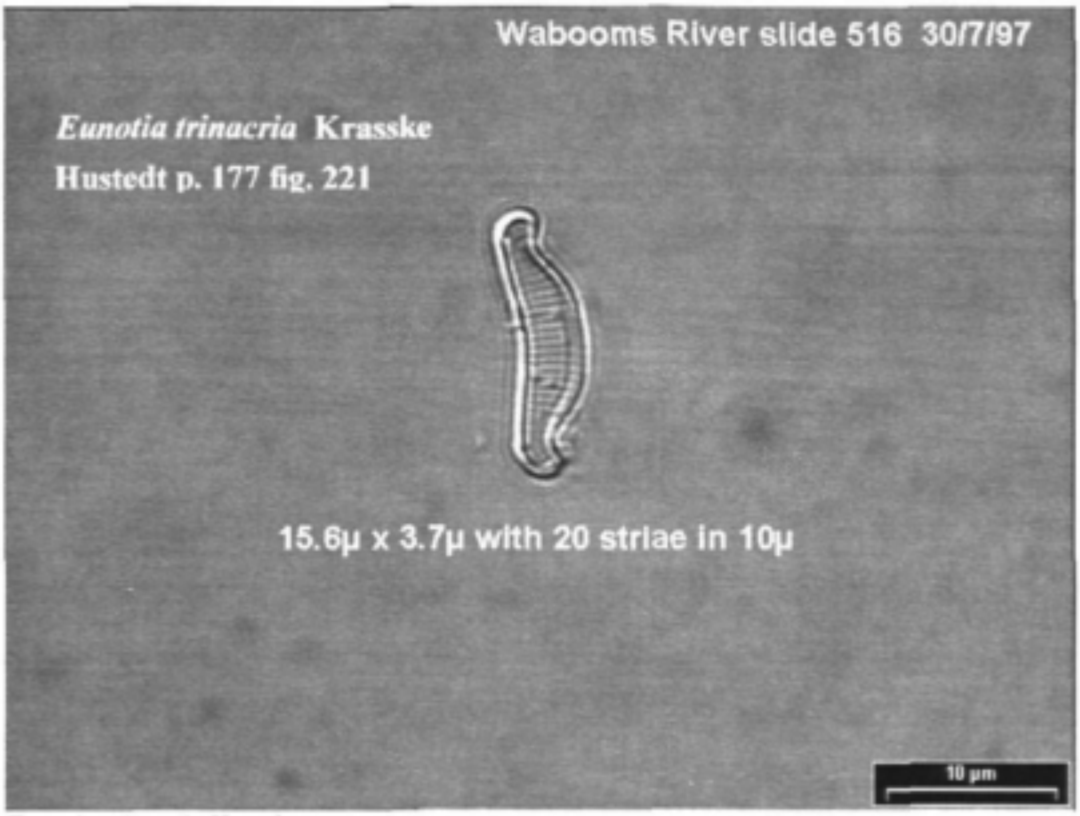
ENCYMINU



Encyonema minutum (Hilse) Mann
Ref. used for identification: Krammer & Lange-Bertalot 1986. 2.1 Page 305. Plate 119. Figure 7.
Locations – Sub-dominant in epipelon – Kruger National Park Sabie River Site X3H015.

NOTES	NOTES
Only found as a sub-dominant, therefore water quality not presented.	

EUNOTRIN



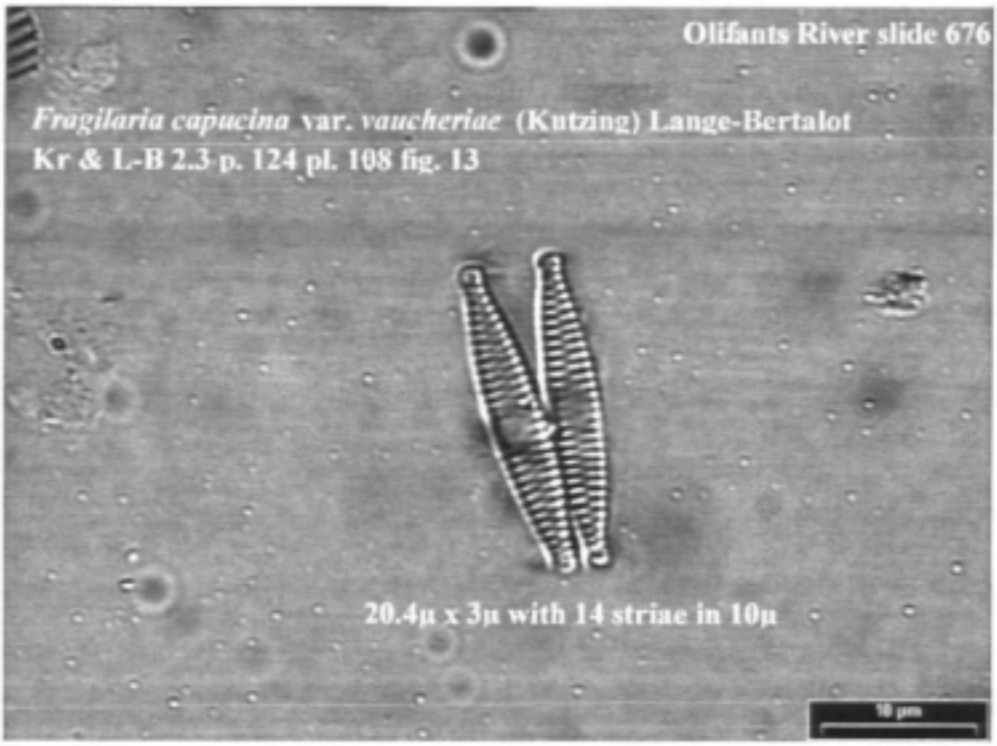
Eunotia trinacria Krasske

Reference used for identification: Hustedt 1976. Page 177. Figure 221b.

Locations – Sub-dominant in epipelon – Gamtoos River GT2.

NOTES	NOTES
Only found as a sub-dominant, therefore water quality not presented.	

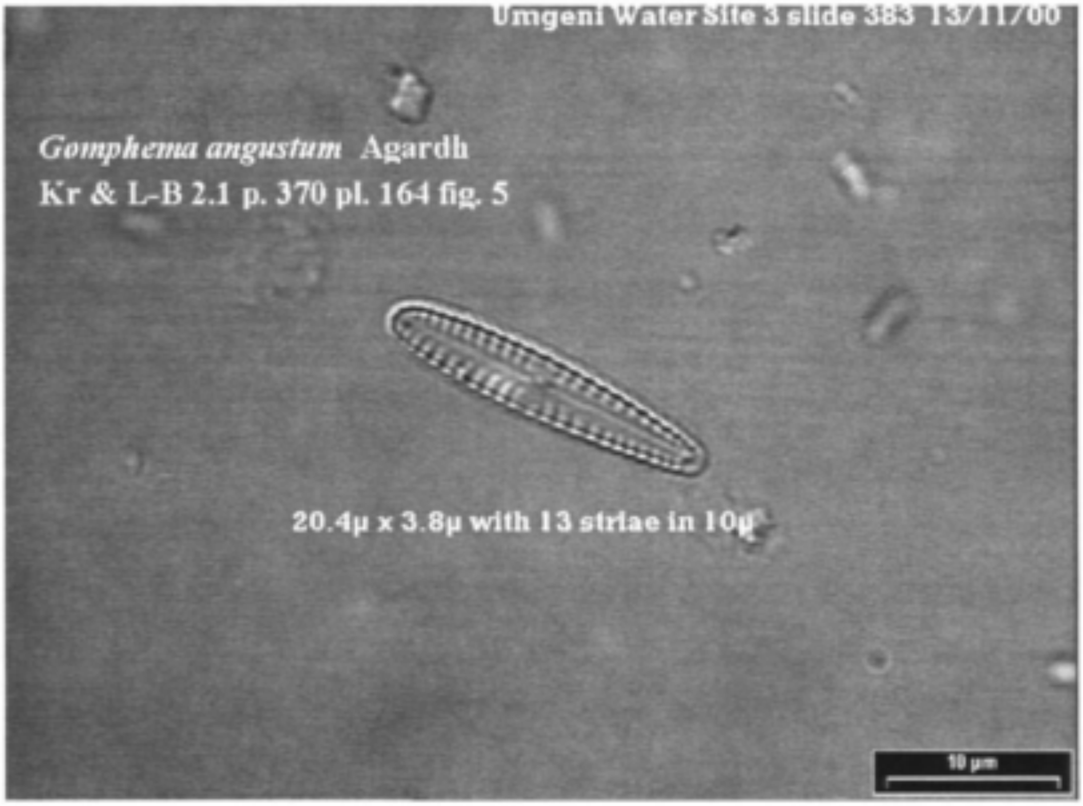
FRAGCAva



Fragilaria capucina var. *vaucheriae* (Kutzing) Lange-Bertalot
Reference used for identification: Krammer & Lange-Bertalot 1986. 2.3. Page 124. Plate 108. Figure 13.
Locations – Sub-dominant in epipelon – Olifants River Site 09.

NOTES	NOTES
Only found as a sub-dominant, therefore water quality not presented.	

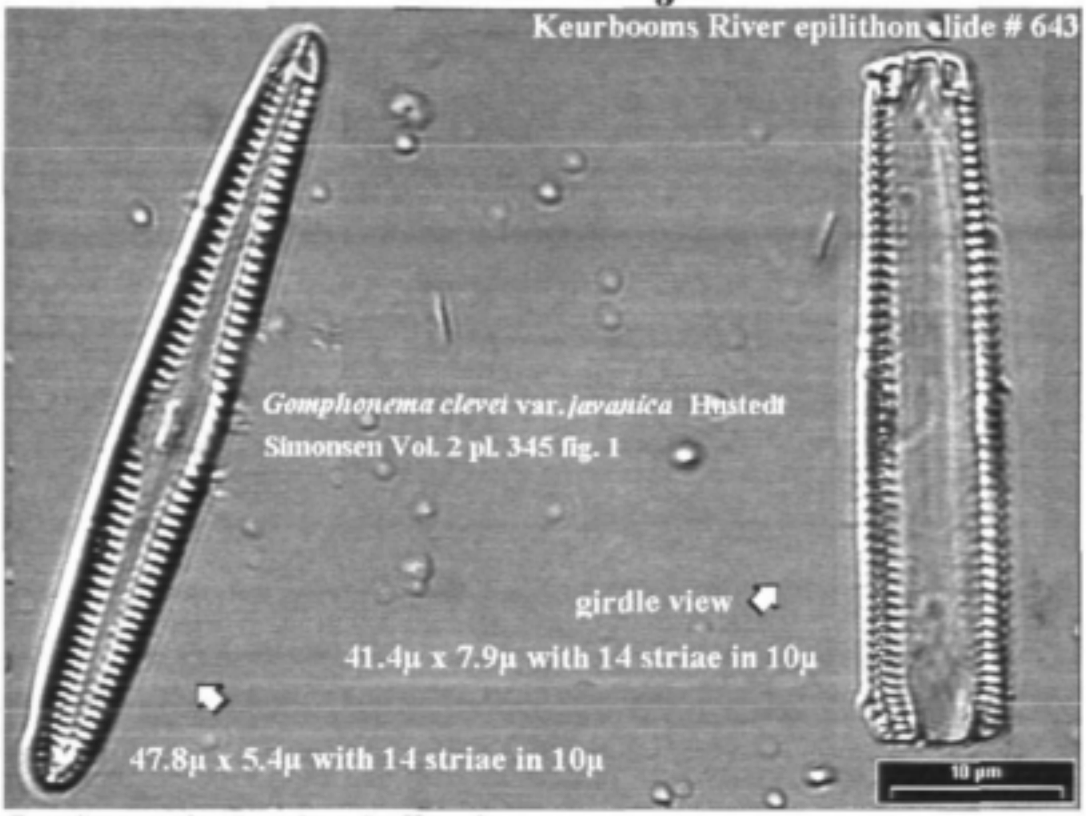
GOMPANGU



Gomphonema angustum Agardh
Ref. used for identification: Krammer & Lange-Bertalot 1986. 2.1 Page 370. Plate 164. Figure 5.
Locations – Sub-dominant in epipelon – Umgeni Water Site Mzimduzi River UmWat 63.

NOTES	NOTES
Only found as a sub-dominant, therefore water quality not presented.	

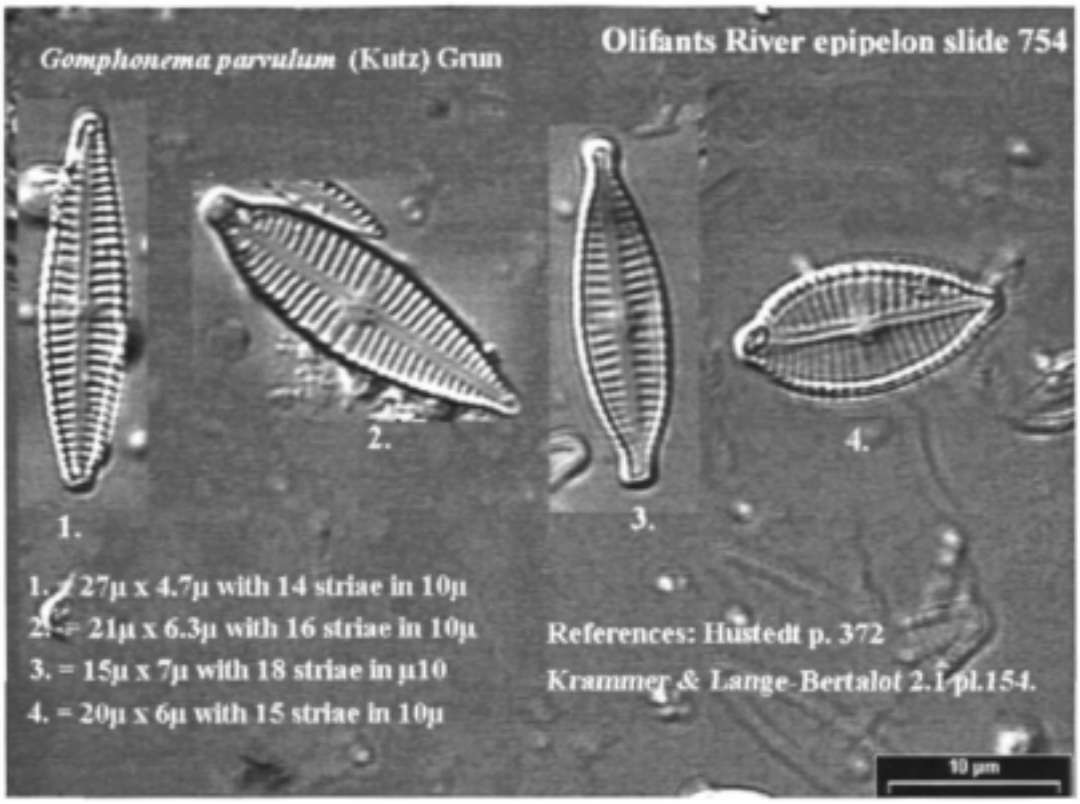
GOMPCLja



Gomphonema clevei var. *javanica* Hustedt.
Reference used for identification: Simonsen 1987. Volume 2. Plate 345. Figure 3.
Locations – Sub-dominant in epipelon – Olifants River Sites W6 & W7.

NOTES	NOTES
Only found as a sub-dominant, therefore water quality not presented.	

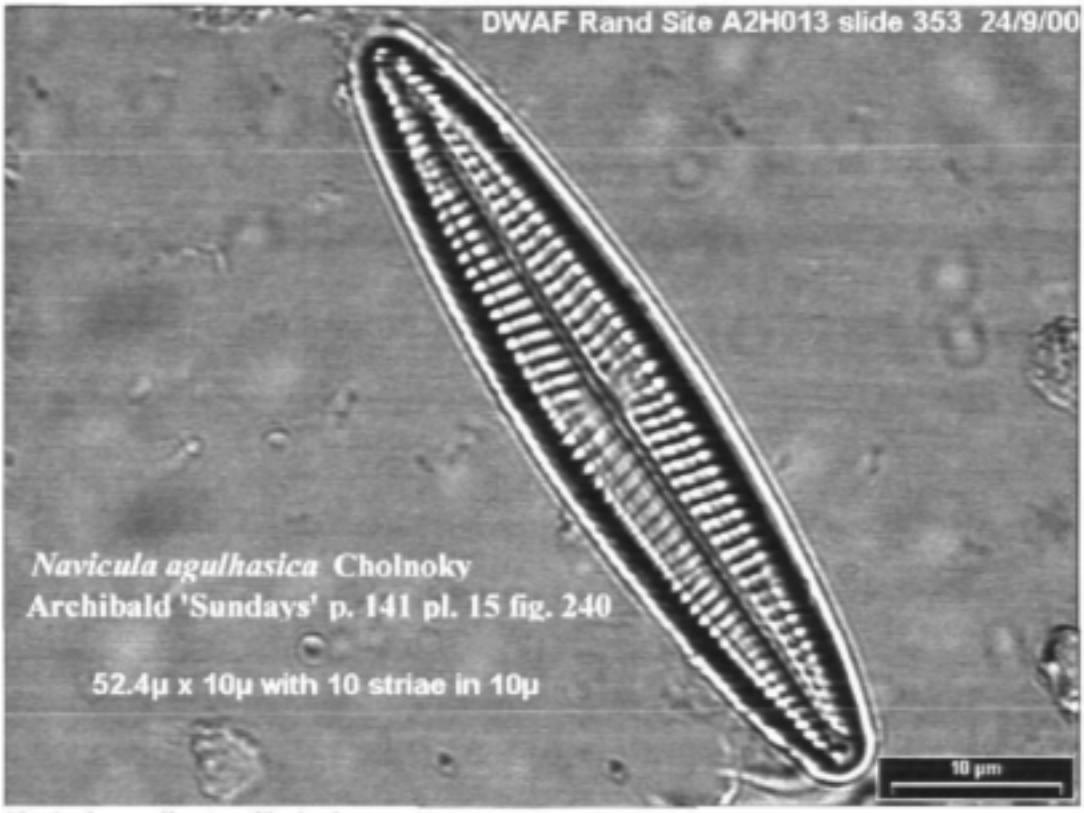
GOMPPARV



Gomphonema parvulum (Kutzing) Grunow
Ref. used for identification: Krammer & Lange-Bertalot 1986. 2.1 Pl. 154. Hustedt 1976. Page 372.
Locations – Sub-dominant in epipelon – Gamtoos River Site GR5.

NOTES	NOTES
Only found as a sub-dominant, therefore water quality not presented.	

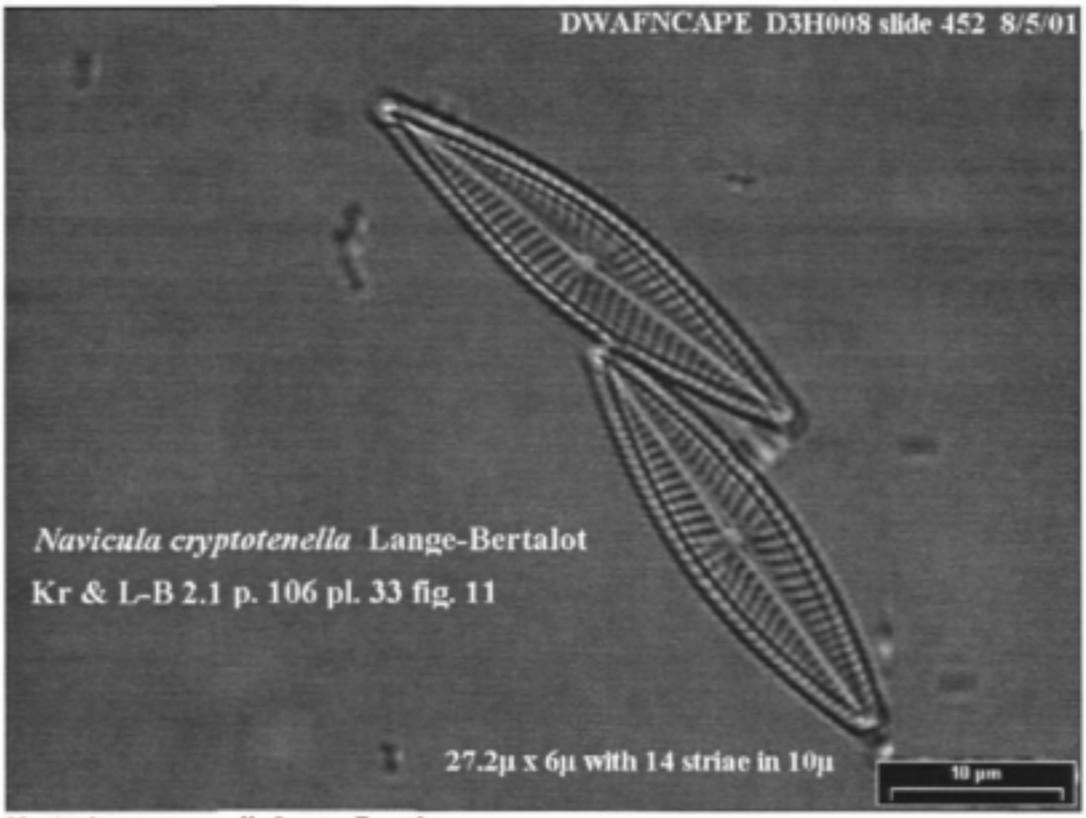
NAVIAGUL



Navicula agulhasica Cholnoky
Reference used for identification: Archibald 1983. Page 141. Plate 15. Figures 240 & 241.
Locations – Sub-dominant in epipelon – DWAF Rand Magaliesrivier A2H013.

NOTES	NOTES
Only found as a sub-dominant, therefore water quality not presented.	

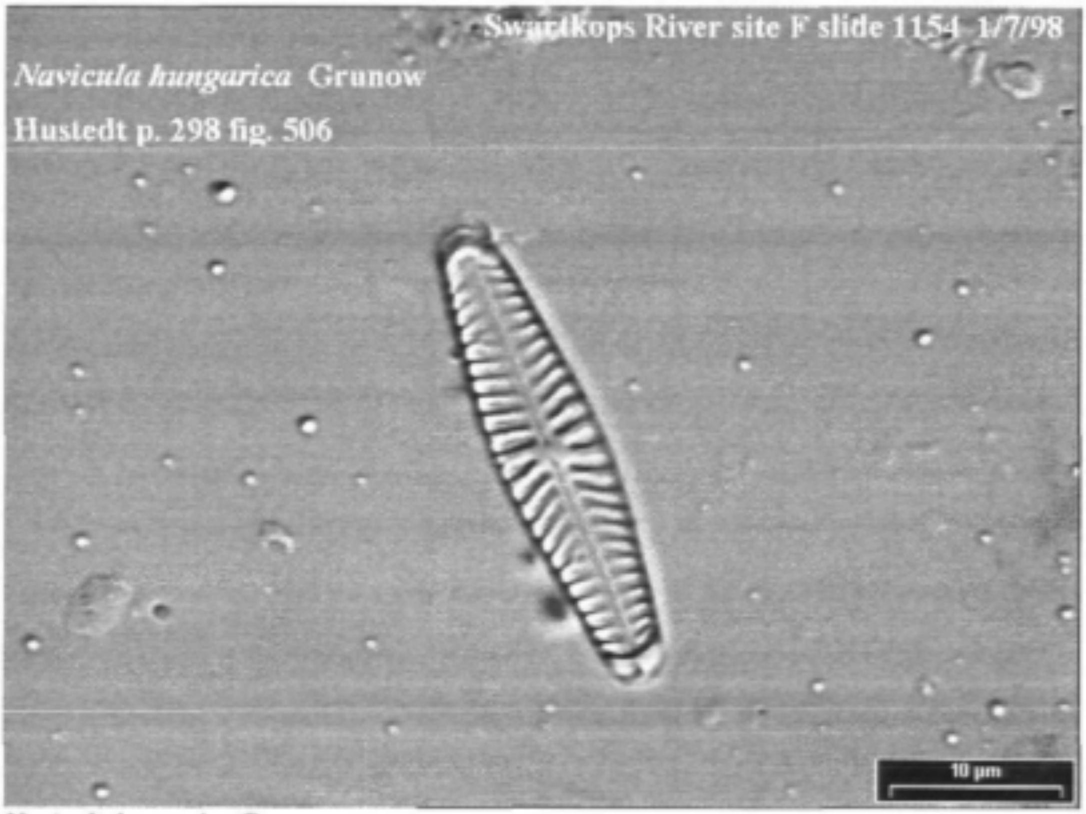
NAVICRLA



Navicula cryptotenella Lange-Bertalot
Ref. used for identification: Krammer & Lange-Bertalot 1986. 2.1 Page 106. Plate 33. Figure 11.
Locations – Sub-dominant in epipelon – DWAF Northern Cape Sites D3H008 & Orange River Site D7H002; Kruger National Park Letaba River DWAF Site B8H028.

NOTES	NOTES
Only found as a sub-dominant, therefore water quality not presented.	

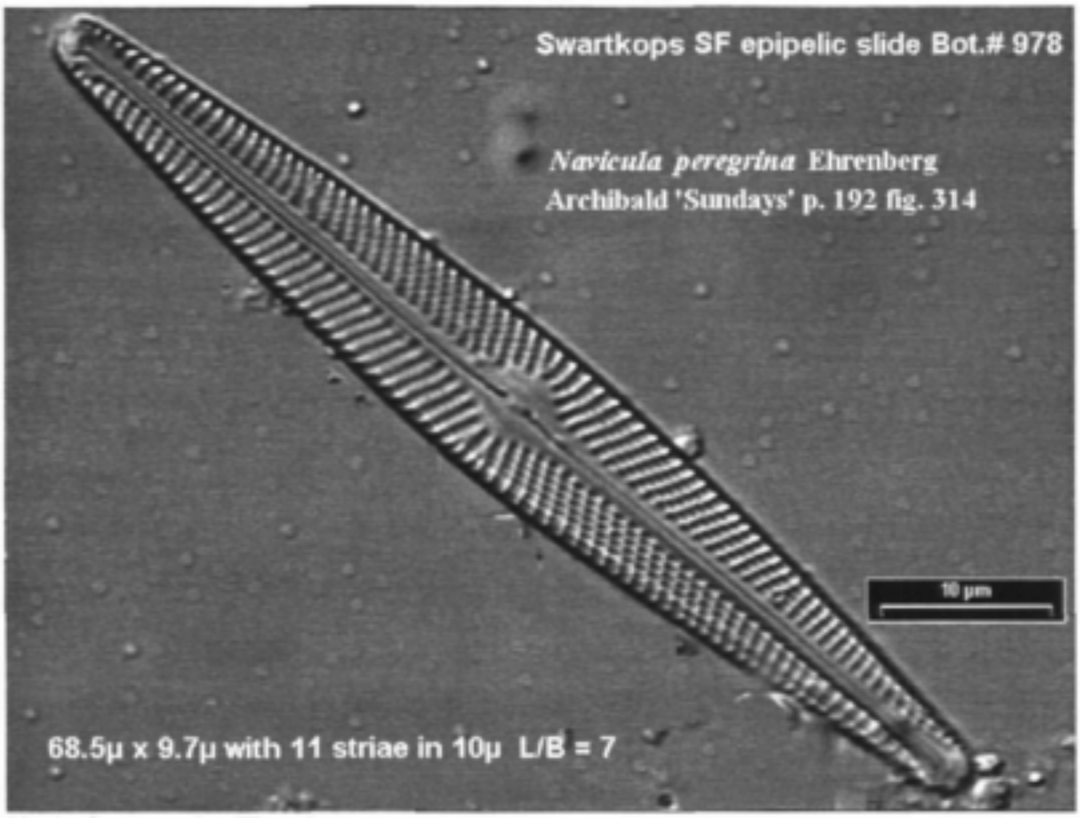
NAVIHUNG



Navicula hungarica Grunow
Reference used for identification: Hustedt 1976. Page 298. Figure 506.
Locations – Sub-dominant in epipelon – Eerste River ER7.

NOTES	NOTES
Only found as a sub-dominant, therefore water quality not presented.	

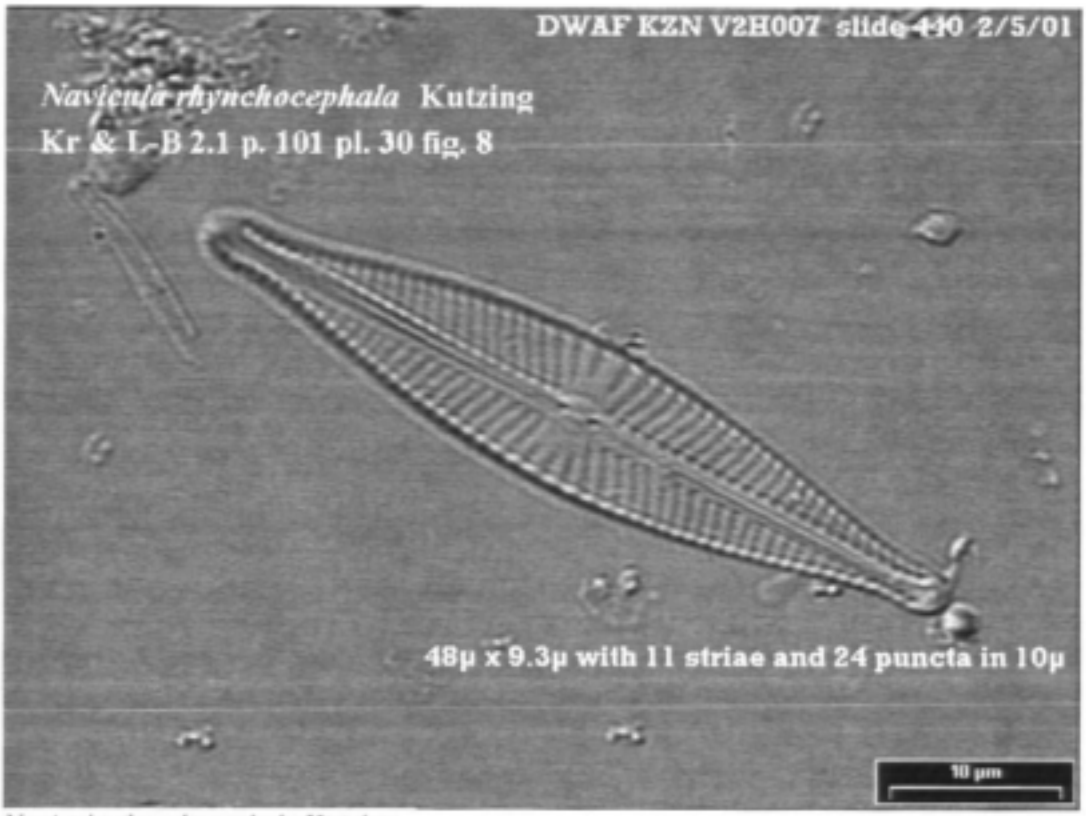
NAVIPERI



Navicula peregrina Ehrenberg
Reference used for identification: Archibald 1983. Page 192. Plate 17. Figure 314.
Locations – Sub-dominant in epipelon – Olifants River Site W1.

NOTES	NOTES
Only found as a sub-dominant, therefore water quality not presented.	

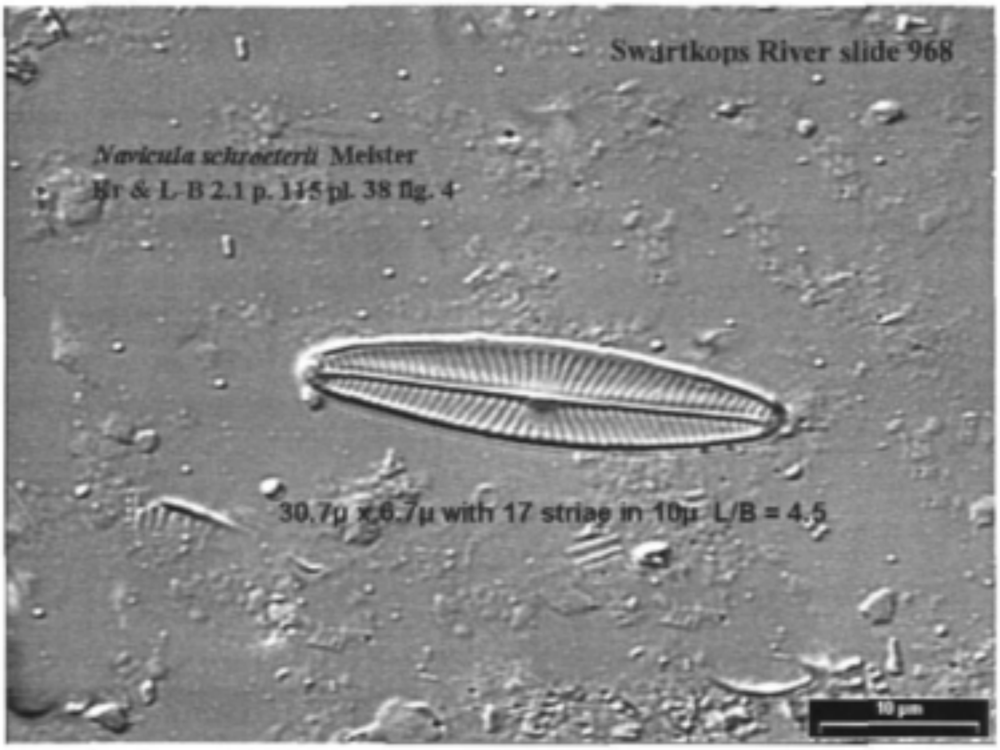
NAVIRHYN



Navicula rhynchocephala Kutzing
Ref. used for identification: Krammer & Lange-Bertalot 1986. 2.1 Page 101. Plate 30. Figure 8.
Locations – Sub-dominant in epipelon – DWAF KzN Hlatikulu River Site V2H007.

NOTES	NOTES
Only found as a sub-dominant, therefore water quality not presented.	

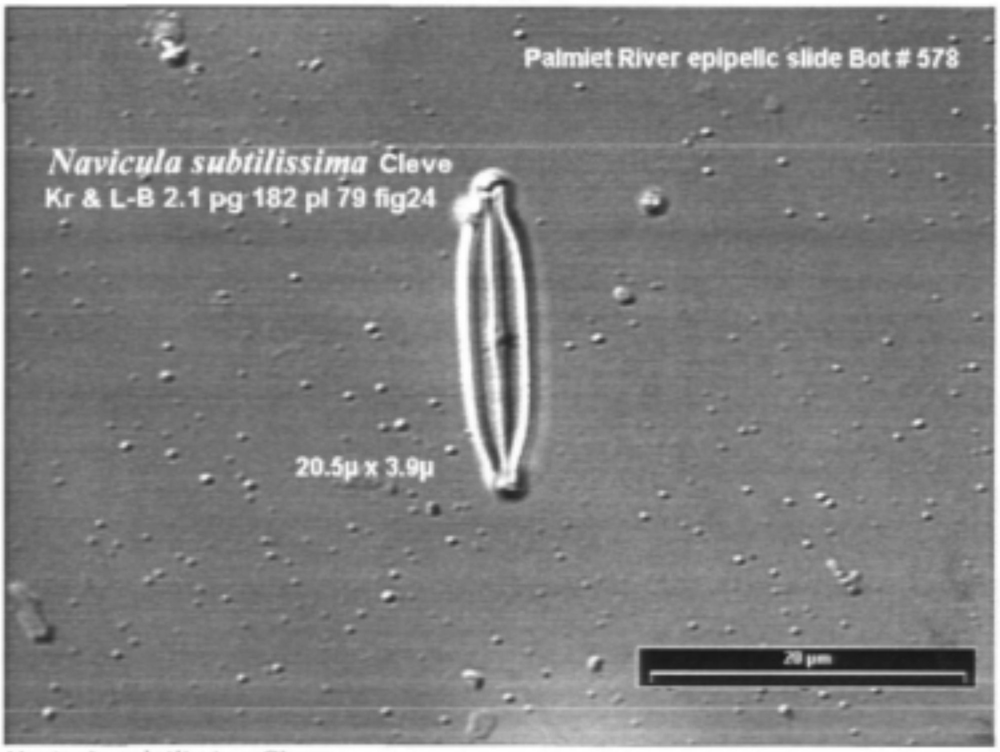
NAVISCHR



Navicula schroeterii Meister
Ref. used for identification: Krammer & Lange-Bertalot 1986. 2.1 Page 115 plate 38. Fig.4.
Locations – Sub-dominant in epipelon – Gamtoos River Site GR4.

NOTES	NOTES
Only found as a sub-dominant, therefore water quality not presented.	

NAVISUBT



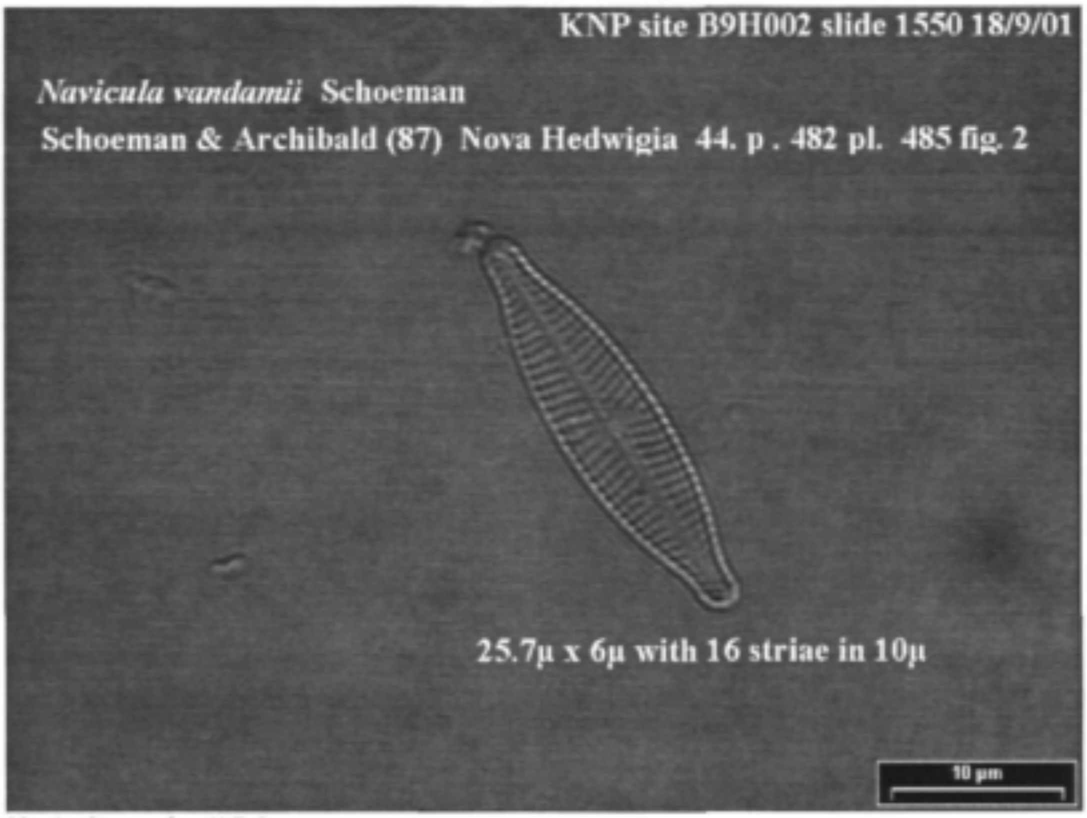
Navicula subtilissima Cleve

Ref. used for identification: Krammer & Lange-Bertalot 1986. 2.1 Page 182. Plate 79. Figure 24.

Locations - Dominant in epipelon – Palmiet River Site PR1 (DWAF Site PR400A).

NOTES	NOTES
Only found as a sub-dominant, therefore water quality not presented.	

NAVIVAND



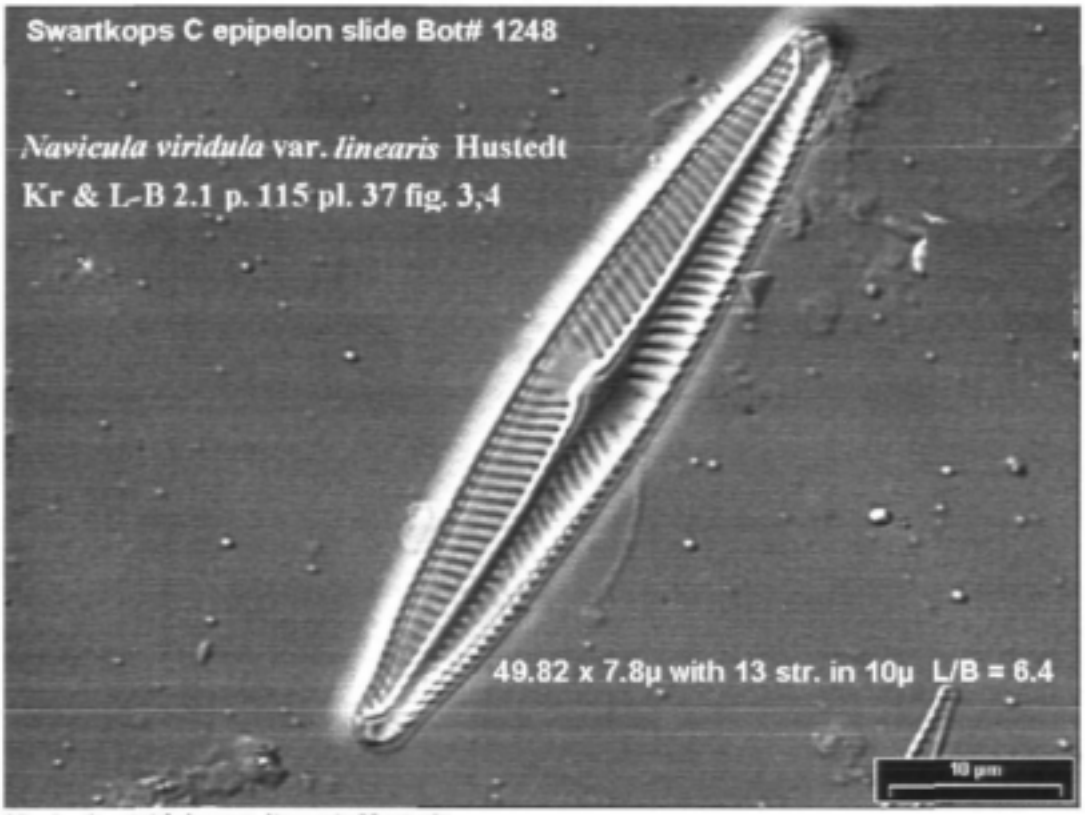
Navicula vandamii Schoeman

Ref. used for identification: Schoeman & Archibald 1987. Nova Hedwigia 44. Page 482. Plate 485. Figure 2.

Locations – Sub-dominant in epipelon – Swartkops A12 & A13.

NOTES	NOTES
Only found as a sub-dominant, therefore water quality not presented.	

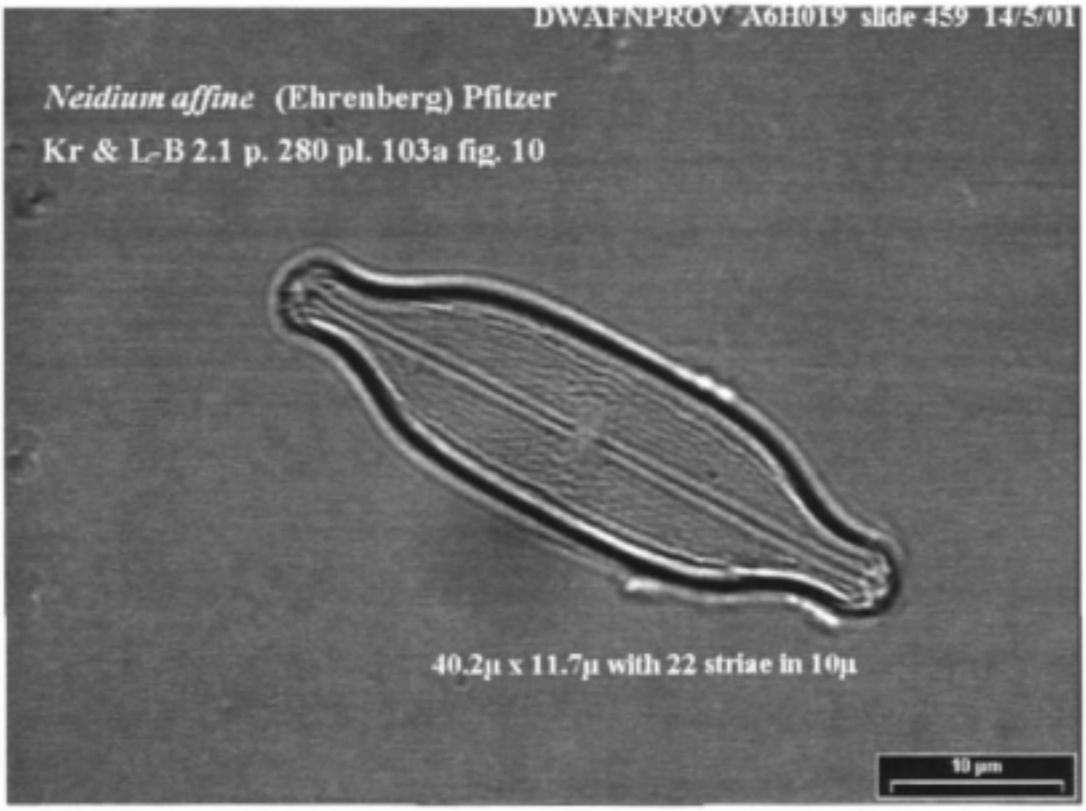
NAVIVIli



Navicula viridula var. *linearis* Hustedt
Ref. used for identification: Krammer & Lange-Bertalot 1986. 2.1 Page 115. Plate 37. Figures 3, 4.
Locations – Sub-dominant in epipelon – Rand Water Site Toxic City Blesbokspruit B16.

NOTES	NOTES
Only found as a sub-dominant, therefore water quality not presented.	

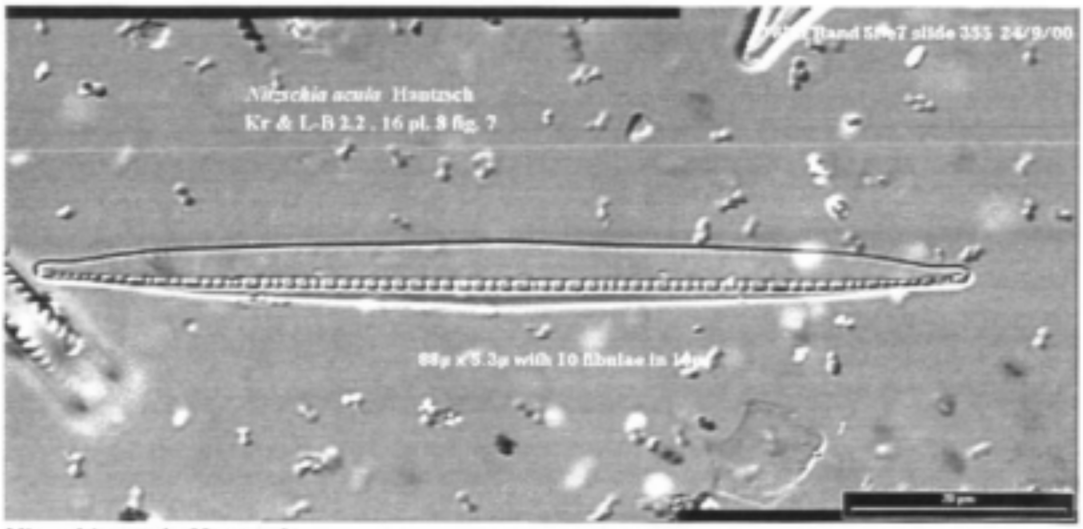
NEIDAFFI



Neidium affine (Ehrenberg) Pfitzer
Ref. used for identification: Krammer & Lange-Bertalot 1986. 2.1 Page 280. Plate 103a. Figure 10.
Locations – Sub-dominant in epipelon – DWAF Northern Province Site Hessie-se-water A6H019.

NOTES	NOTES
Only found as a sub-dominant, therefore water quality not presented.	

NITZACUL



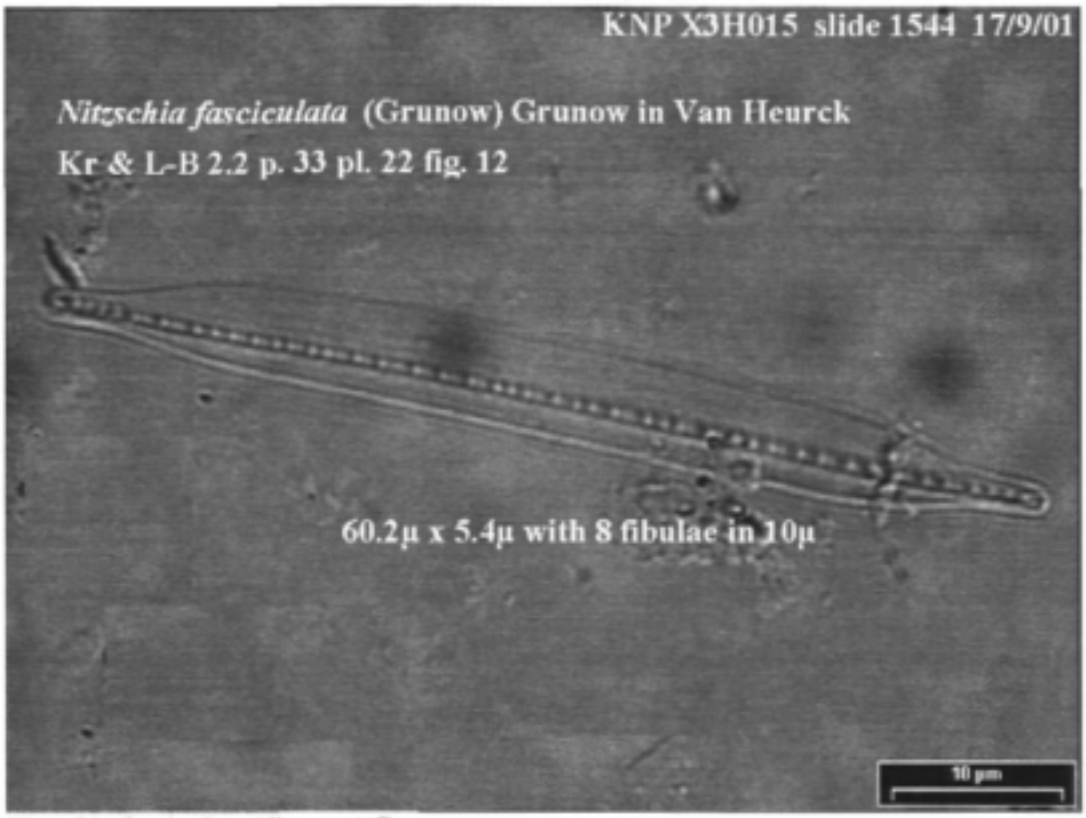
Nitzschia acula Hantzsch

Ref. used for identification: Krammer & Lange-Bertalot 1986. 2.2 Page 16. Plate 8. Figure 7.

Locations – Sub-dominant in epipelon – DWAF RAND Crocodile River Site A2H051.

NOTES	NOTES
Only found as a sub-dominant, therefore water quality not presented.	

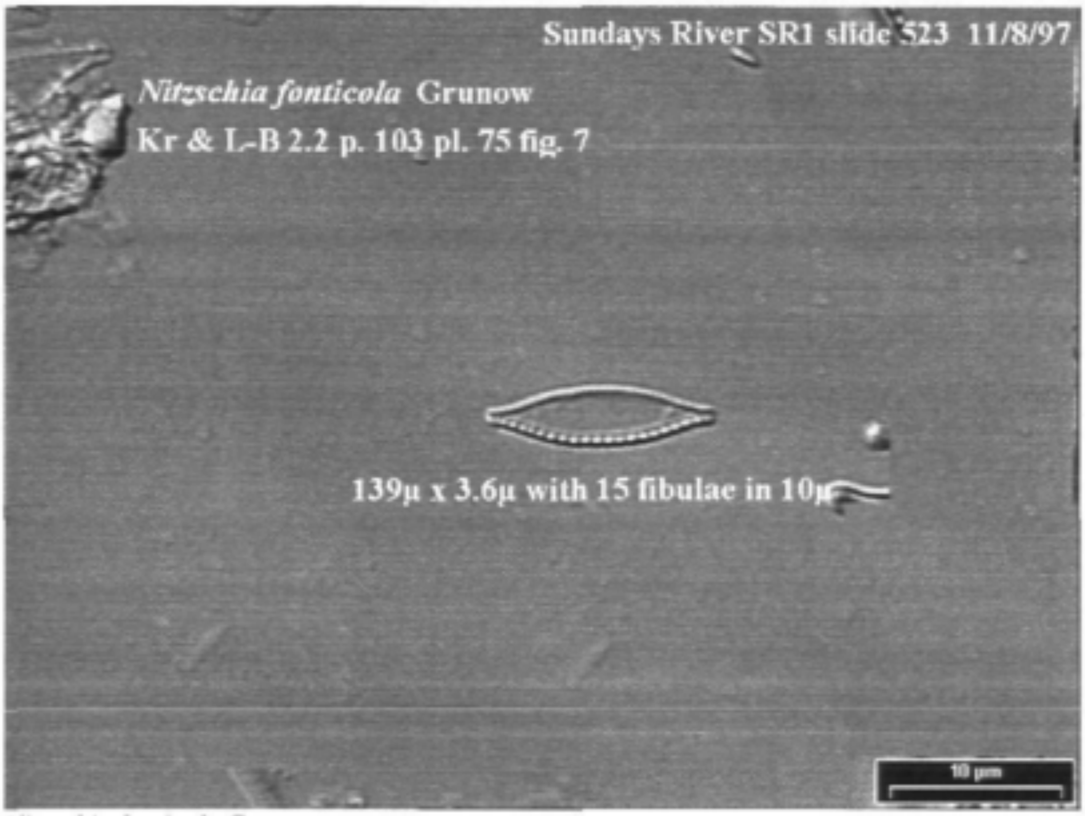
NITZFASC



Nitzschia fasciculata (Grunow) Grunow
Ref. used for identification: Krammer & Lange-Bertalot 1986 2.2 Page 33. Plate 22. Figure 12.
Locations – Sub-dominant in epipelon – Kruger National Park DWAF Sites Sabie River X3H015, Luvuvhu River A9H008 & A9H011.

NOTES	NOTES
Only found as a sub-dominant, therefore water quality not presented.	

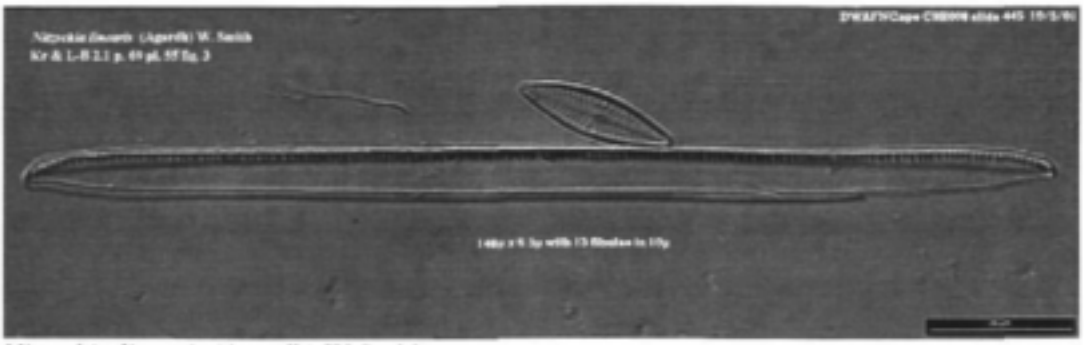
NITZFONT



Nitzschia fonticola Grunow
Ref. used for identification: Krammer & Lange-Bertalot 1986. 2.2 Page 103. Plate 75. Figure 7.
Locations – Sub-dominant in epipelon – Gamtoos River Sites GR1, GR2 & GR3.

NOTES	NOTES
Only found as a sub-dominant, therefore water quality not presented.	

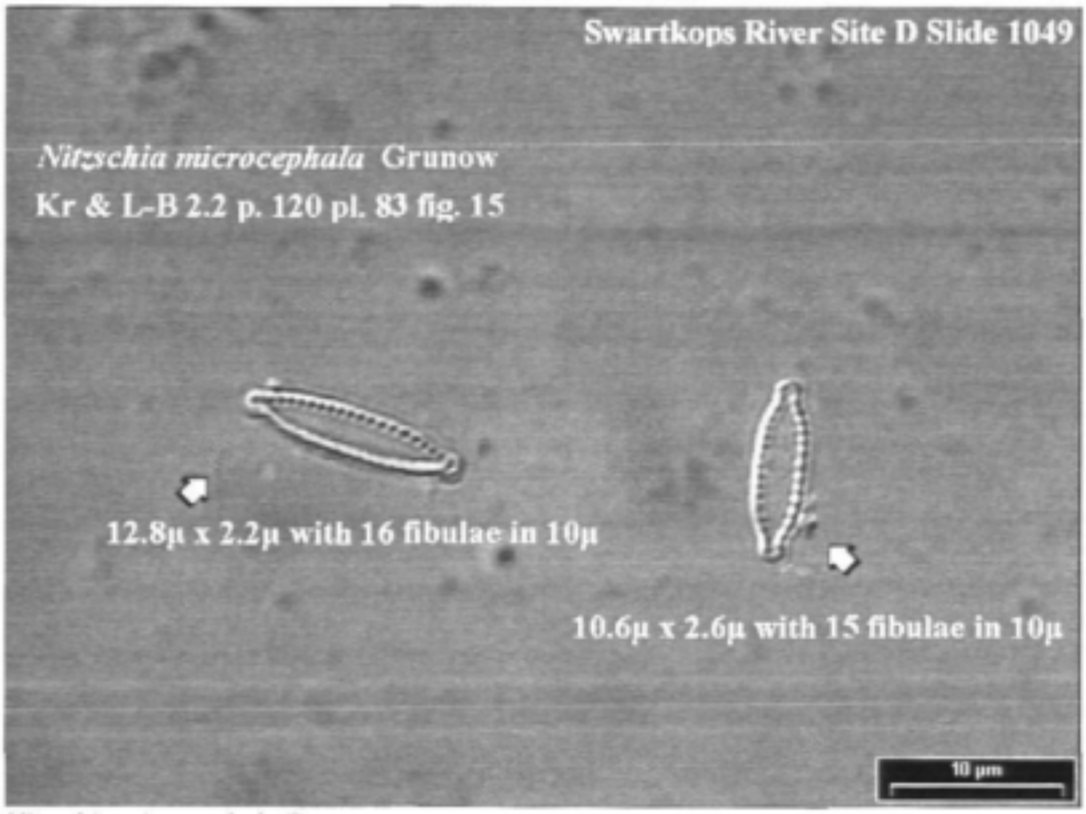
NITZLINE



Nitzschia linearis (Agardh) W.Smith.
Ref. used for identification: Krammer & Lange-Bertalot 1986. 2.2 Page 69. Plate 55. Figure 3.
Locations – sub-dominant in epipelon – DWAF Northern Cape Site Vaal River C9H008; Rand Water Sites Taaibosspruit TW2 & B1esbokspruit Toxic City B16.

NOTES	NOTES
Only found as a sub-dominant, therefore water quality not presented.	

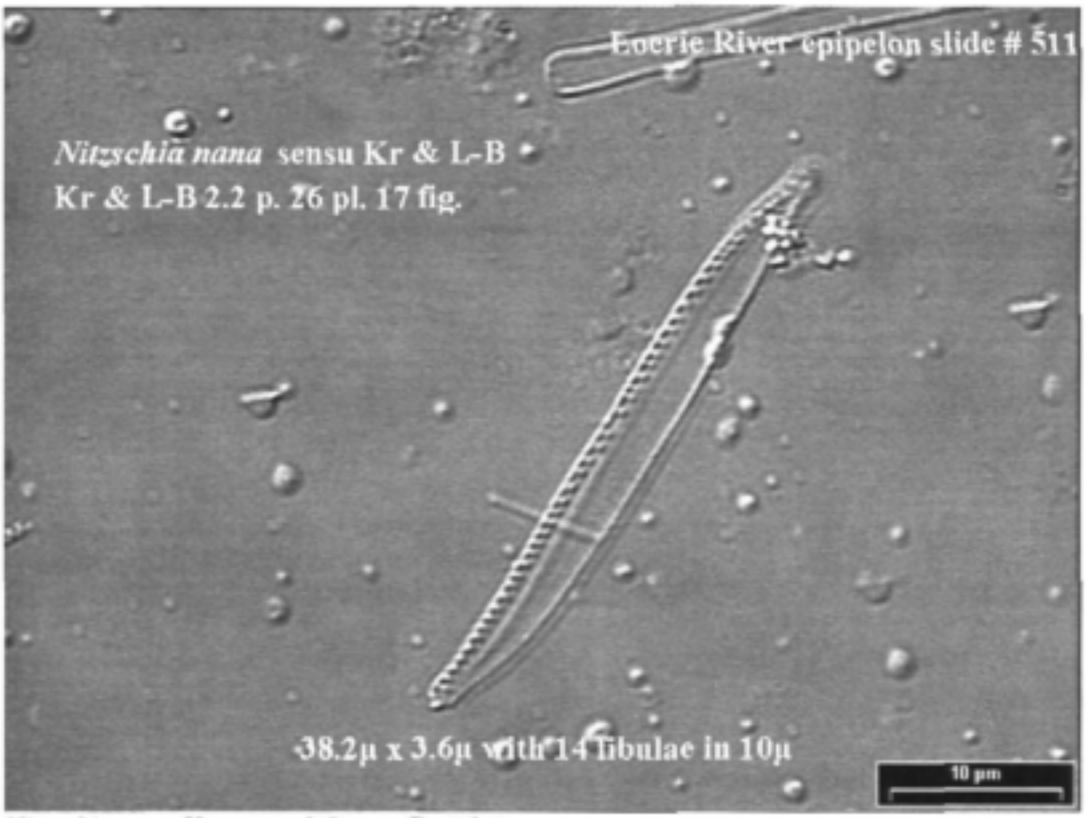
NITZMICR



Nitzschia microcephala Grunow
Reference used for identification: Krammer & Lange-Bertalot 1986. 2.2 Page 120. Plate 83. Figure 15.
Locations – sub-dominant in epipelon: Swartkops River Site A13.

NOTES	NOTES
Only found as a sub-dominant, therefore water quality not presented.	

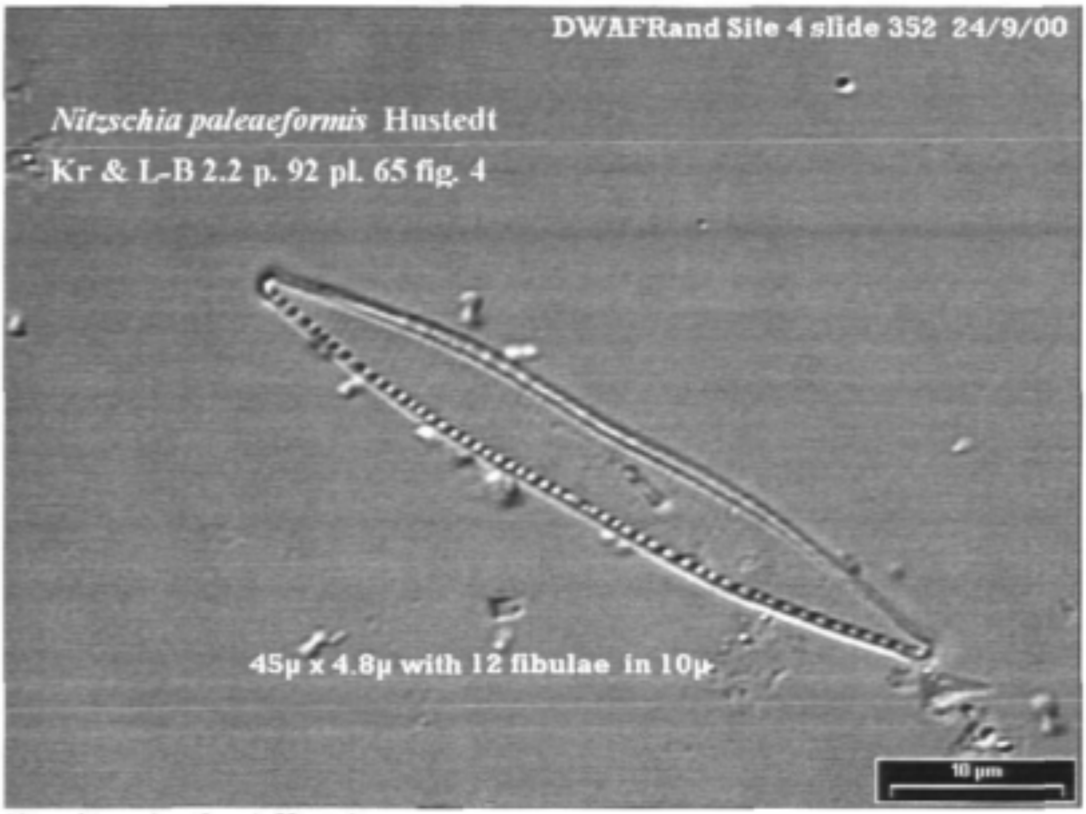
NITZNANA



Nitzschia nana Krammer & Lange-Bertalot
Ref. used for identification: Krammer & Lange-Bertalot 1986. 2.2 Page 26. Plate 17. Figure 9.
Locations – Sub-dominant in epipelon – Gamtoos River Site GT4.

NOTES	NOTES
Only found as a sub-dominant, therefore water quality not presented.	

NITZPAIS



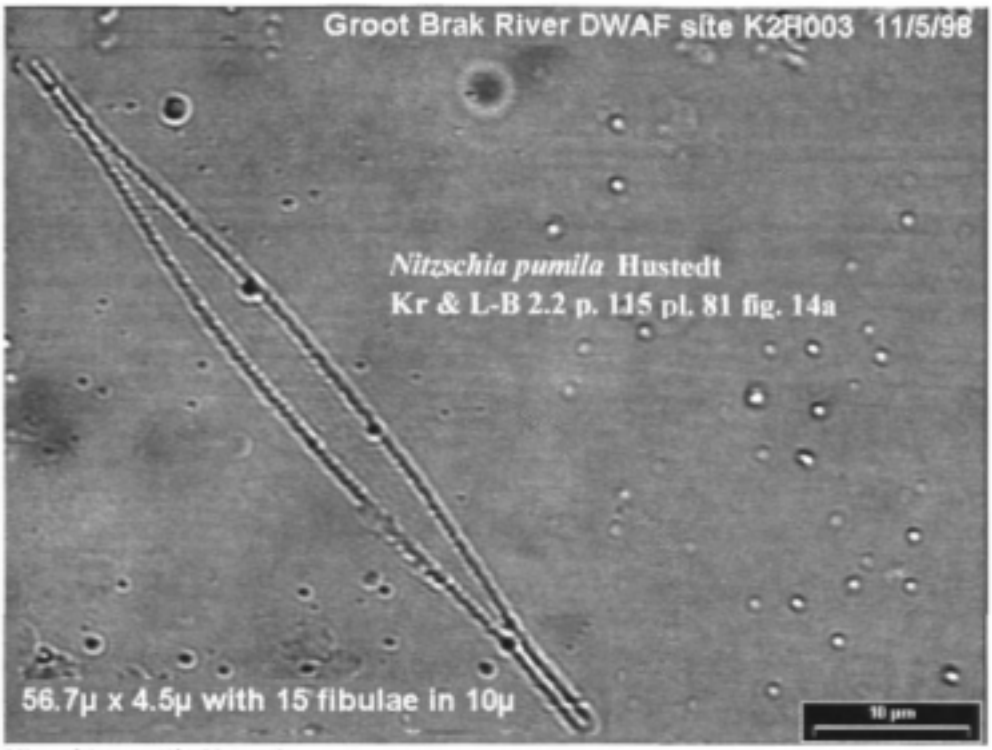
Nitzschia paleaeformis Hustedt

Ref. used for identification: Krammer & Lange-Bertalot 1986, 2.2 Page 92. Plate 65. Figure 4.

Locations – Sub-dominant in epipelon – DWAF RAND Jukskei River Sites A2H044 & A2H023.

NOTES	NOTES
Only found as a sub-dominant, therefore water quality not presented.	

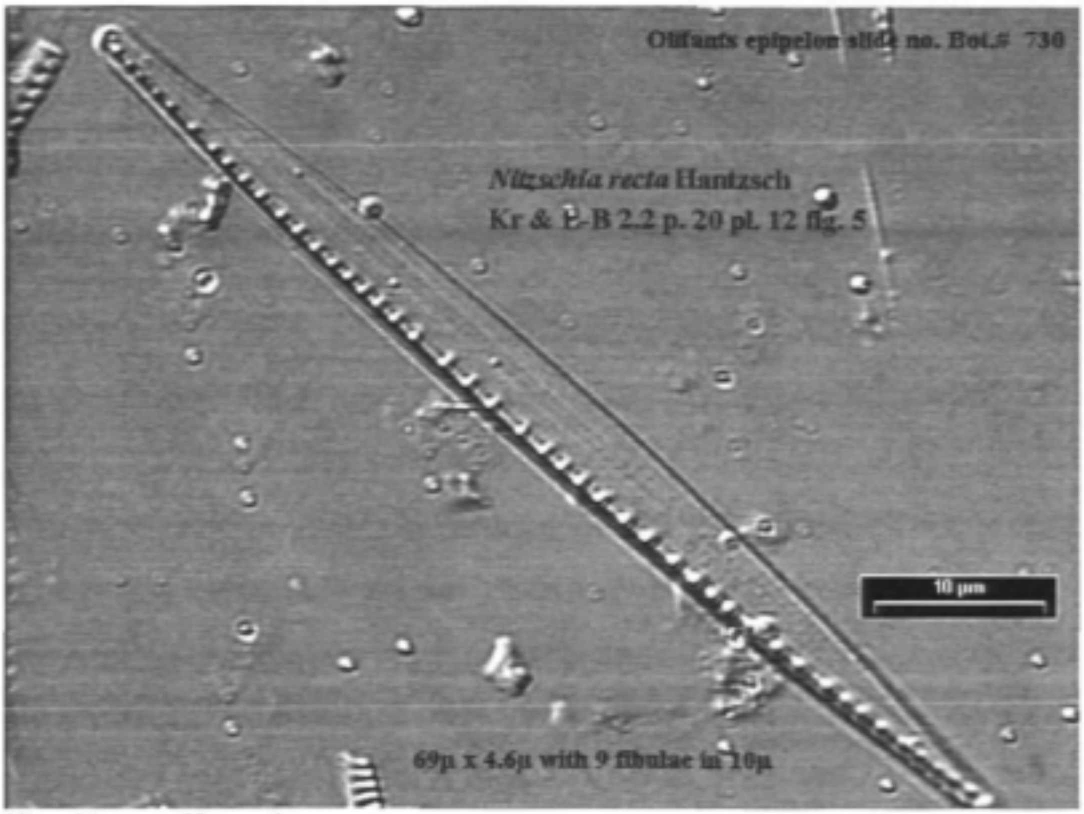
NITZPUMI



Nitzschia pumila Hustedt
Ref. used for identification: Krammer & Lange-Bertalot 1986. 2.2 Page 115. Plate 81. Figure 14a.
Locations –Sub-dominant in epipelon – Grootbrak River DWAF Site Salskanaal GB1.

NOTES	NOTES
Only found as a sub-dominant, therefore water quality not presented.	

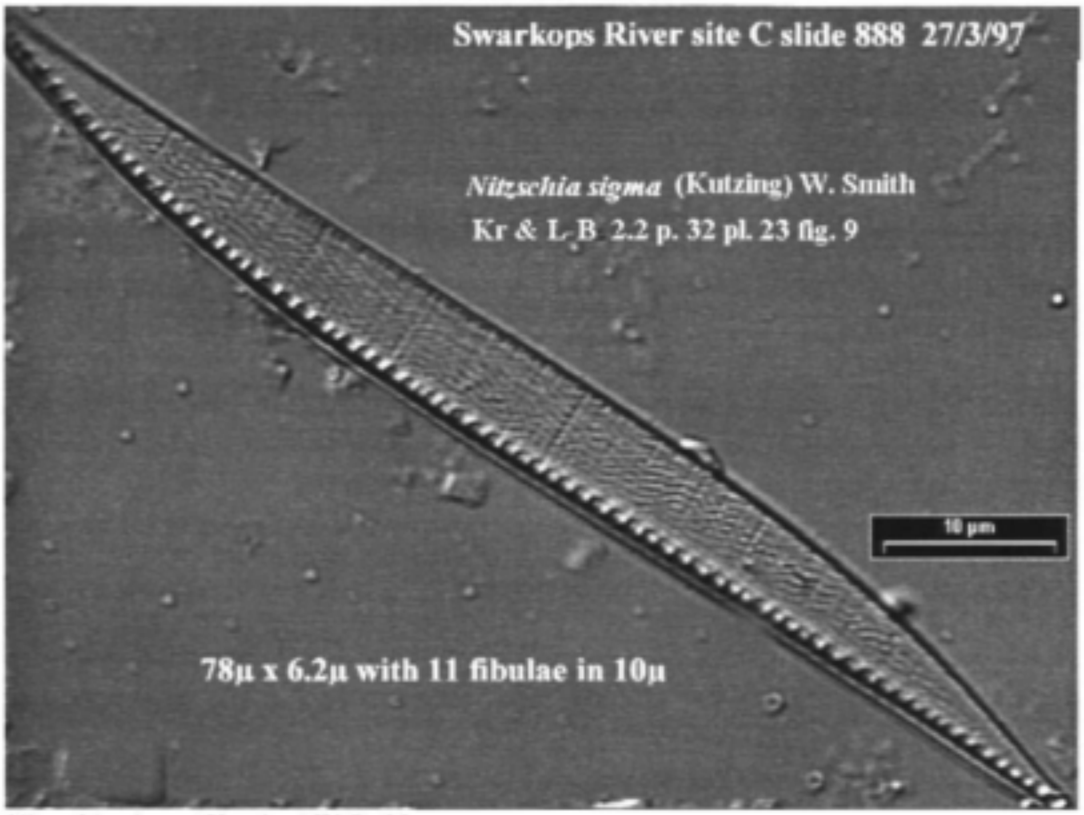
NITZRECT



Nitzschia recta Hantzsch
Ref. used for identification: Krammer & Lange-Bertalot 1986. 2.2 Page 20. Plate 12. Figure 5.
Locations – Sub-dominant in epipelon – Olifants River Sites B1 & B2.

NOTES	NOTES
Only found as a sub-dominant, therefore water quality not presented.	

NITZSIGM



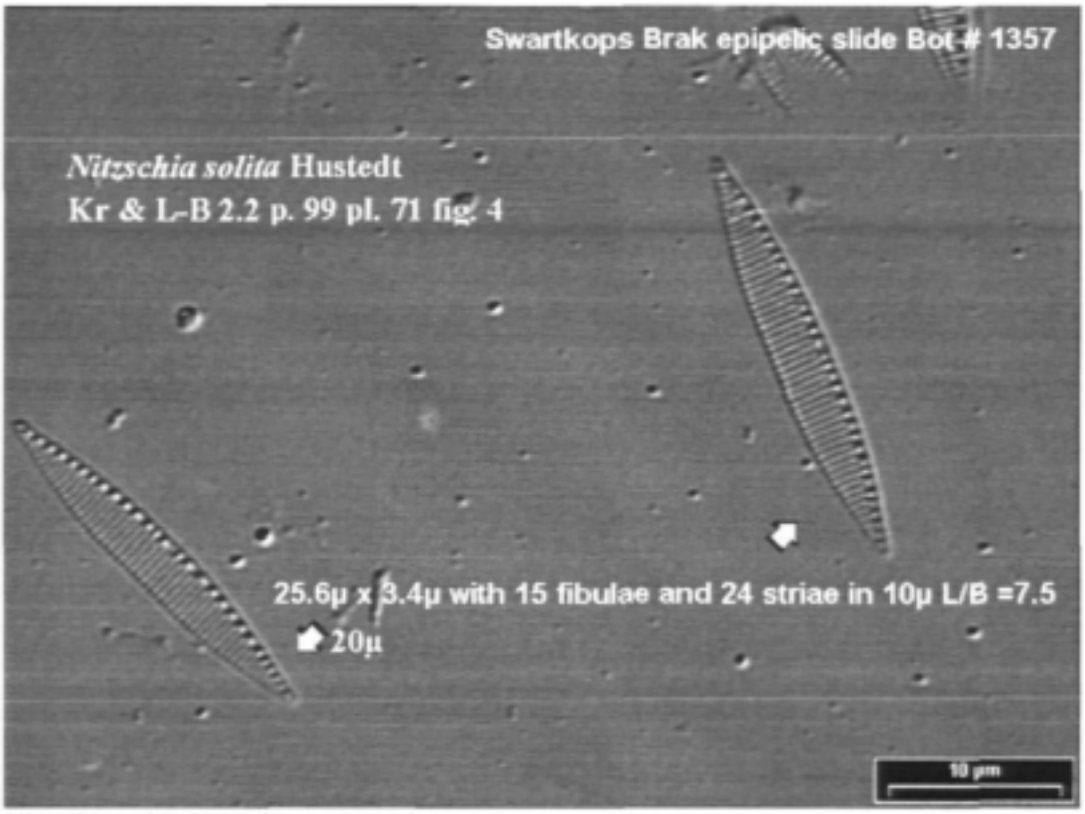
Nitzschia sigma (Kutzing) W.Smith

Ref. used for identification: Krammer & Lange-Bertalot 1986. 2.2 Page 32. Plate 23. Figure 9.

Locations – Sub-dominant in epipelon – DWAF RAND Crocodile River Site 2H050.

NOTES	NOTES
Only found as a sub-dominant, therefore water quality not presented.	

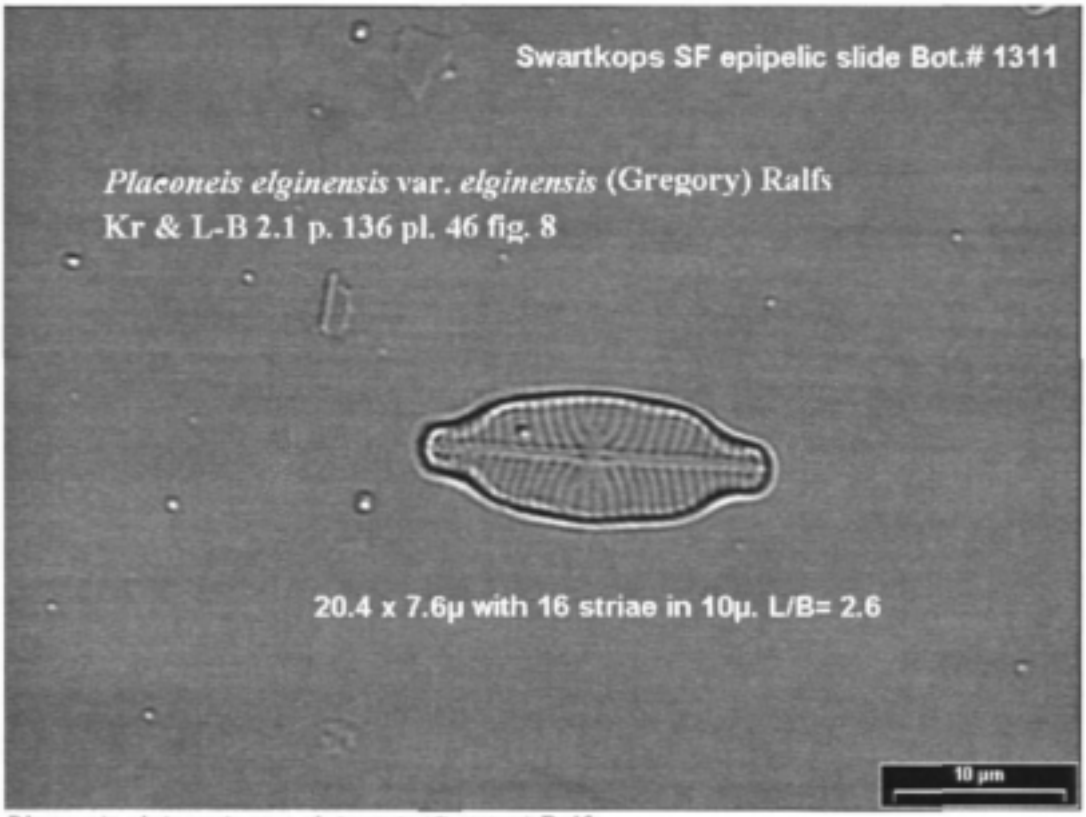
NITZSOLI



Nitzschia solita Hustedt
Ref. used for identification: Krammer & Lange-Bertalot 1986. 2.2 Page 99. Plate 71. Figure 4.
Locations – Sub-dominant in epipelon – Swartkops River Site C20.

NOTES	NOTES
Only found as a sub-dominant, therefore water quality not presented.	

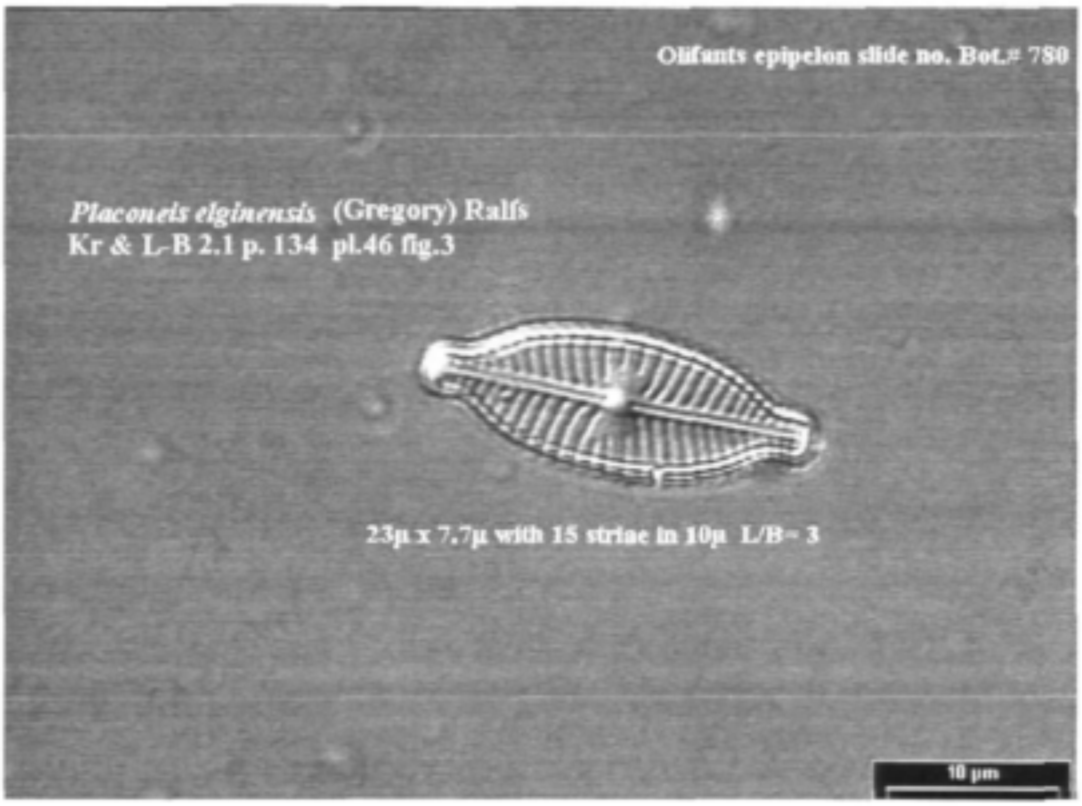
PLACELel



Placoneis elginensis var. *elginensis* (Gregory) Ralfs
Ref. used for identification: Krammer & Lange-Bertalot 1986. 2.1 Page 136. Plate 46. Figure 8.
Locations – Sub-dominant in epipelon – Houhoek River BT1 (DWAF Site JR400A); Swartkops River Site A20.

NOTES	NOTES
Only found as a sub-dominant, therefore water quality not presented.	

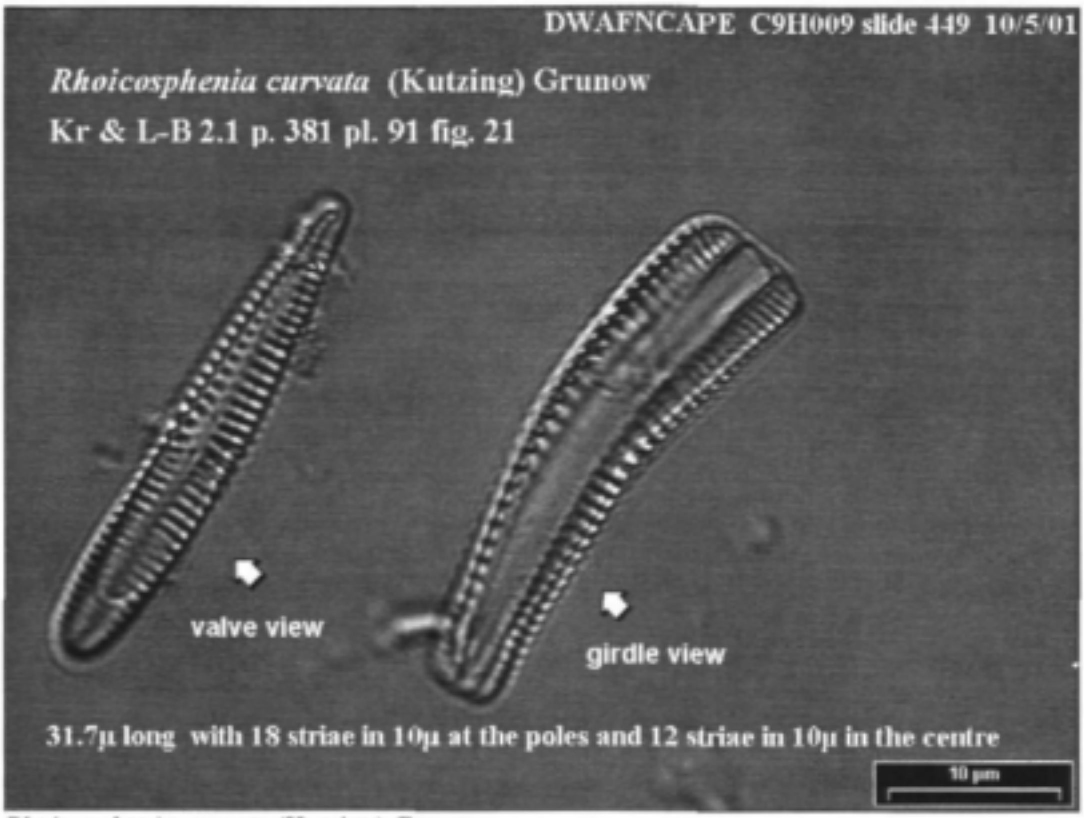
PLACELGI



Placoneis elginensis (Gregory) Ralfs
Ref. used for identification: Krammer & Lange-Bertalot 1986. 2.1 Page 134. Plate 46. Figure 3.
Locations – Sub-dominant in epipelon – DWAF Northern Province Site Rasloop River A6H018; DWAF OFS Caledon River D2H035.

NOTES	NOTES
Only found as a sub-dominant, therefore water quality not presented.	

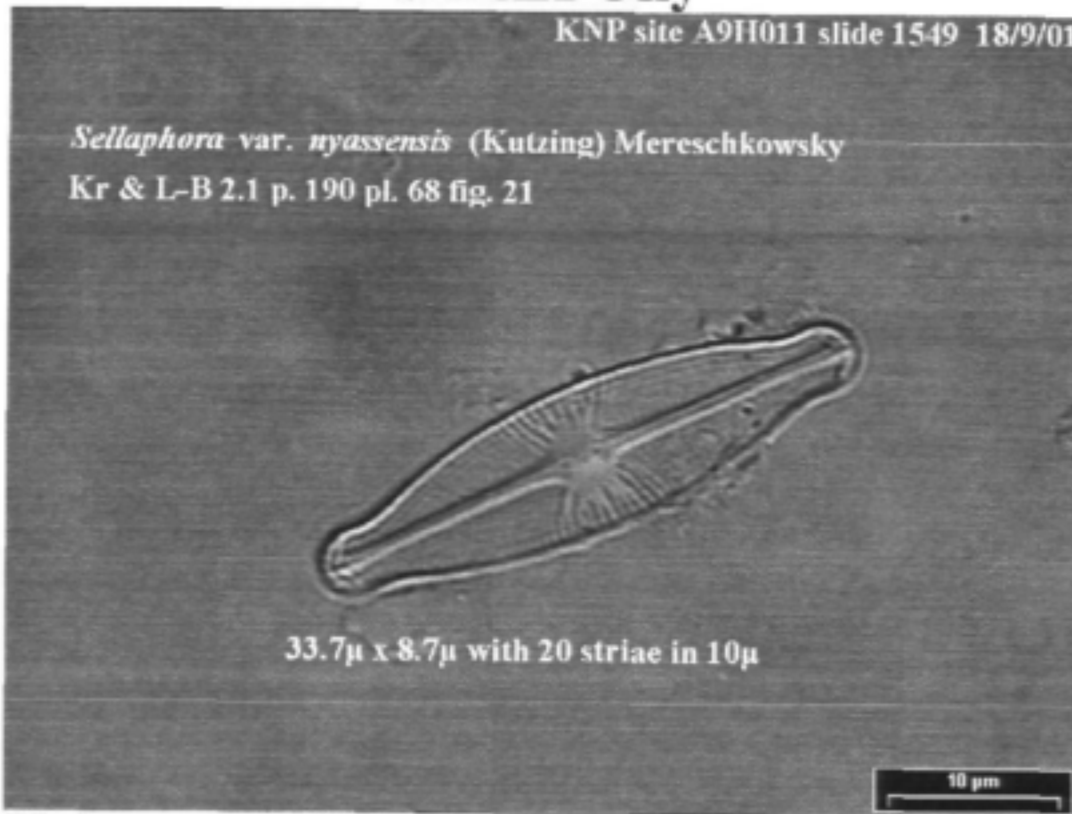
RHOICURV



Rhoicosphenia curvata (Kutzing) Grunow
Ref. used for identification: Krammer & Lange-Bertalot 1986. 2.1 Page 381. Plate 91. Figure 21.
Locations – Sub-dominant in epipelon – DWAF Northern Cape Vaal River Site C9H009.

NOTES	NOTES
Only found as a sub-dominant, therefore water quality not presented.	

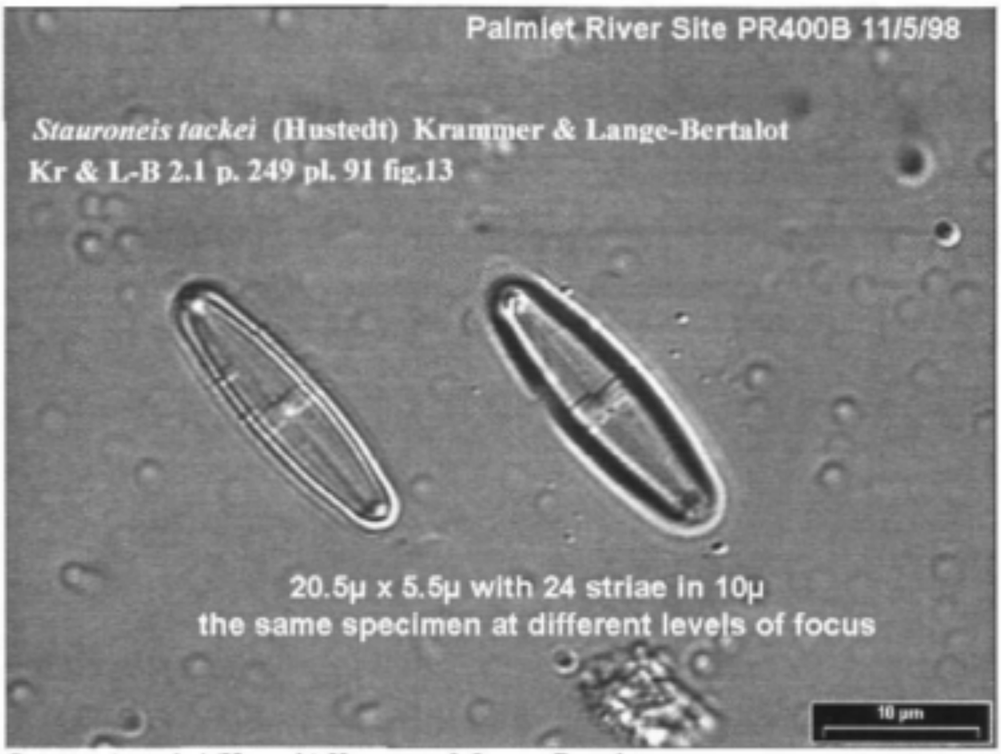
SELLPUny



Sellaphora var. nyassensis (Kutzing) Mereschkowsky
Ref. used for identification: Krammer & Lange-Bertalot 1986. 2.1 Page 190. Plate 68. Figure 21.
Locations – Sub-dominant in epipelon – Kruger National Park DWAF Site Luvuvhu River A9H011.

NOTES	NOTES
Only found as a sub-dominant, therefore water quality not presented.	

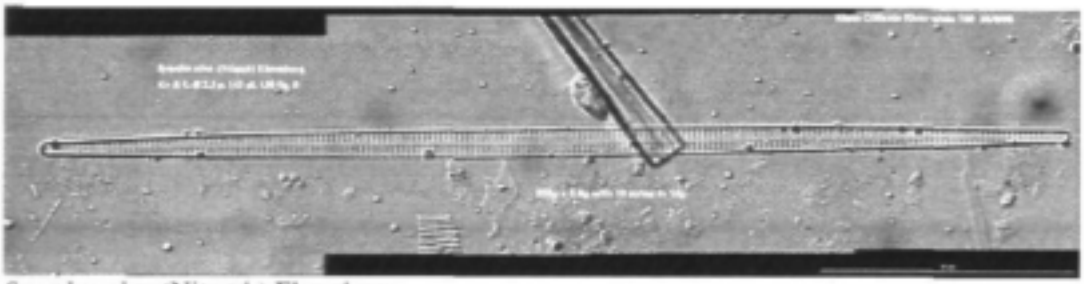
STAUTACK



Stauroneis tackei (Hustedt) Krammer & Lange-Bertalot
Reference used for identification: Krammer & Lange-Bertalot 1986. Page 249. Plate 91. Figure 13.
Locations – Sub-dominant in epipelon – Palmiet River Site PR400B.

NOTES	NOTES
Only found as a sub-dominant, therefore water quality not presented.	

SYNEULNA



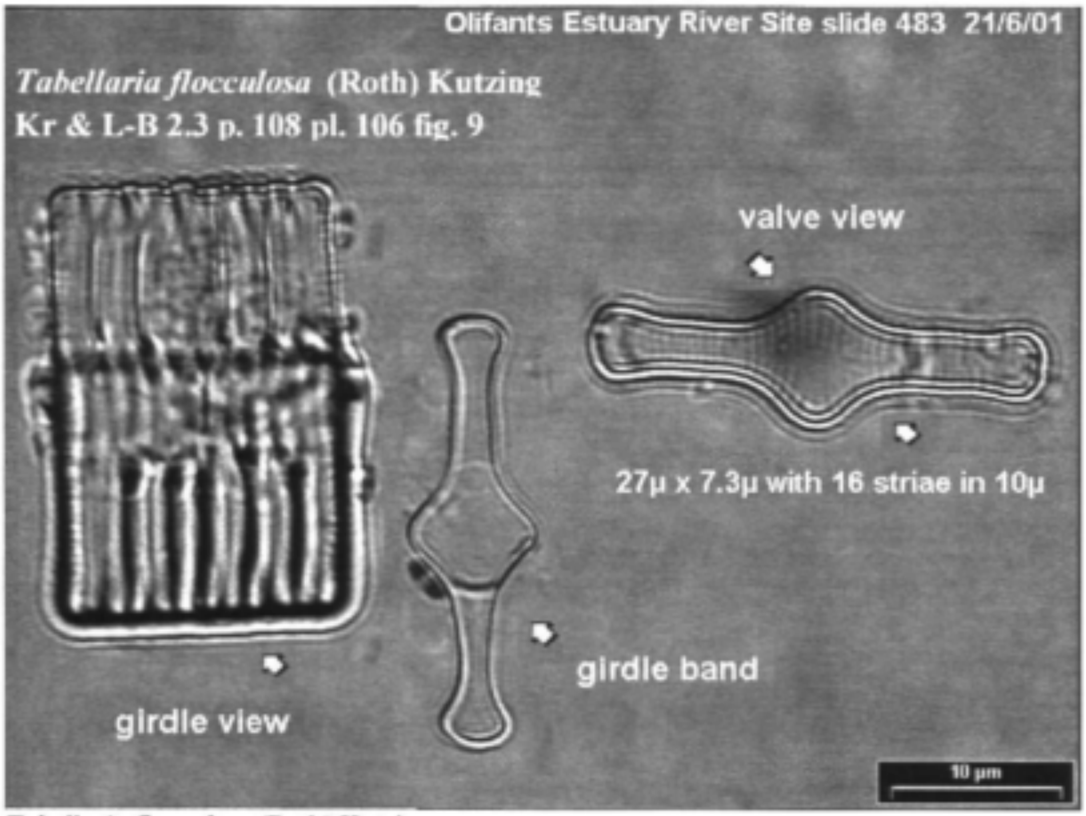
Synedra ulna (Nitzsch) Ehrenberg

Ref. used for identification: Krammer & Lange-Bertalot 1986. 2.3 Page 143. Plate 120. Figure 8.

Locations - Dominant in epipelon –Olifants River Site K02.

NOTES	NOTES
Only found as a sub-dominant, therefore water quality not presented.	

TABEFLOC



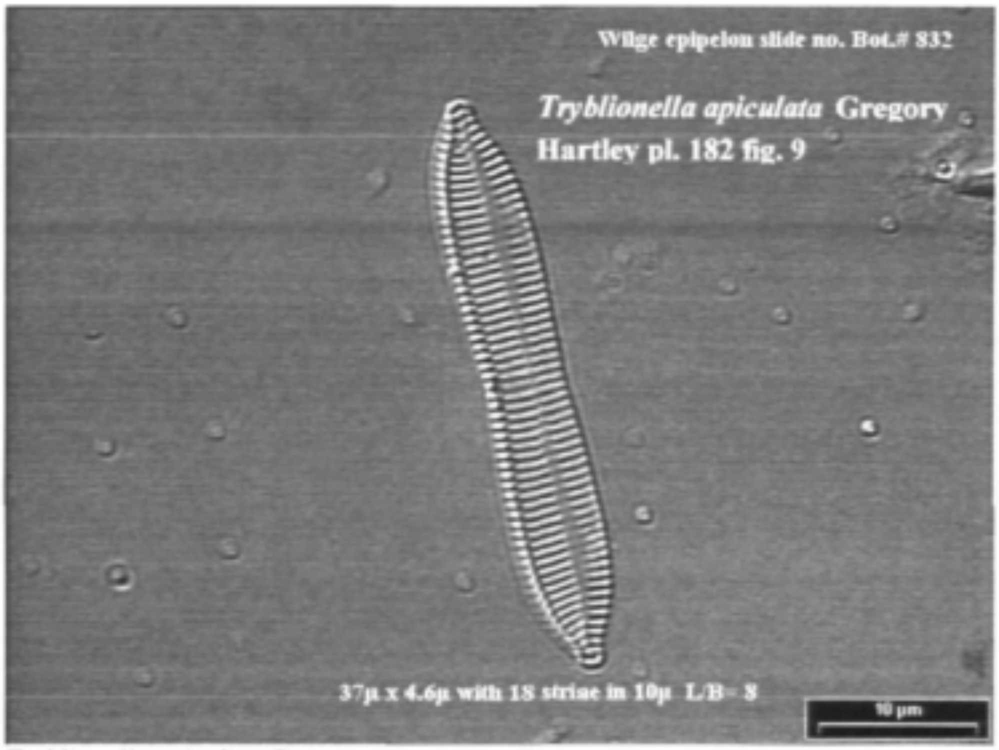
Tabellaria flocculosa (Roth) Kutzing

Ref. used for identification: Krammer & Lange-Bertalot 1986. 2.3 Page 108. Plate 106. Figure 9.

Locations - Dominant in epipelon –Palmiet River Site PR2 (DWAF Site PR400B).

NOTES	NOTES
Only found as a sub-dominant, therefore water quality not presented.	

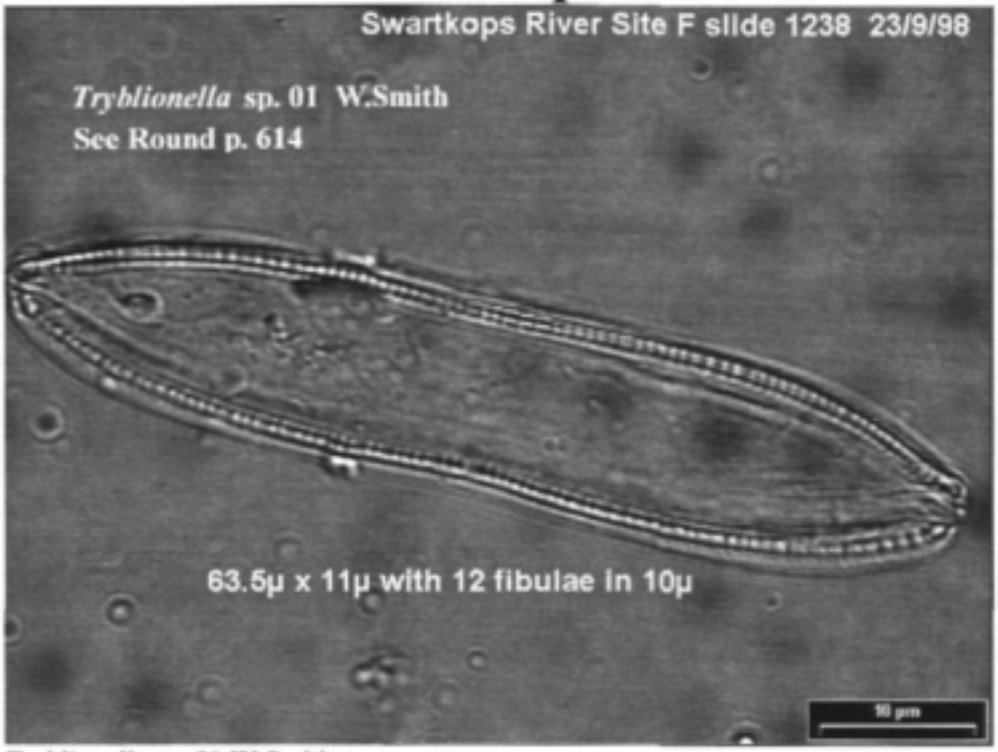
TRYBAPIC



Tryblionella apiculata Gregory
Reference used for identification: Hartley 1996. Plate 182. Figure 9.
Locations – Sub-dominant in epipelon: Swartkops River Sites D12, S13, D14 & D15.

NOTES	NOTES
Only found as a sub-dominant, therefore water quality not presented.	

TRYBsp01



Tryblionella sp. 01 W.Smith
Reference used for identification: Round, Crawford & Mann 1990. Page 614.
Locations – Sub-dominant in epipelon: Swartkops River Site F15.

NOTES	NOTES
Only found as a sub-dominant, therefore water quality not presented.	

RIVER DOMINANTS THAT WERE ALSO SUB-DOMINANTS

Achnanthes abundans sub-dominant at: Durban Metro Site 2; Gamtoos River Site GR5; Swartkops River Sites, A13, A16, A17 & A21.

Achnanthes engelbrechtii sub-dominant at: Keurbooms Estuary Intertidal Site 5 (DWAF Site ER720E); Swartkops River Sites D10, D11, D13, D14, D16 & D17.

Achnanthes oblongella sub-dominant at: Durban Metro Site 5; Eerste River Site ER1 (DWAF Site ER720A1); Palmiet River Site PR4 (DWAF Site PR400D); Houhoek Site BT1 (DWAF Site JR400A); Brandwag Site KR2 (DWAF Site K1H004; Grootbrak River Site GB2 (DWAF Site K2H006); Keurbooms River Site KT2 (DWAF Site K6H008).

Achnanthes subatomoides sub-dominant at: Eerste River Site ER2 (DWAF Site ER720B); Palmiet River Site PR2 (DWAF Site PR400B); Grootbrak River Site GR2 (DWAF Site K2H006); Keurbooms River Site KR2 (DWAF Site K6H007).

Amphora pediculus sub-dominant at: Gamtoos Site GR1.

Bacillaria paxillifer sub-dominant at: Swartkops River Sites F 10, F13 & F17.

Caloneis schumanniana sub-dominant at: Olifants River Site 2.

Cocconeis pediculus sub-dominant at: DWAF Northern Cape Site C9H009 & Olifants River Site K04.

Cocconeis placentula sub-dominant at: Eerste River Site ER2 (DWAF Site ER720B) & ER3 (DWAF Site ER720B1)

Craticula perotelli sub-dominant at: Umgeni Water Site 8;

Cymbella turgidula sub-dominant at: Umgeni Water Sites 1 & 9; Olifants River Sites 101, 011 and W7.

Diatoma vulgaris sub-dominant at: Olifants River Sites 05 & B2.

Diploneis puella sub-dominant at: Sundays River Site SR6.

Entomoneis alata sub-dominant at: Sundays River Site SR6.

Eunotia incisa sub-dominant at: Eerste River Site ER1 (DWAF Site ER720A10).

Eunotia trinacria sub-dominant at: Gamtoos River Site GT2.

Fragilaria elliptica sub-dominant at: Swartkops River Sites C 16,18 & 20, F19.

Gomphonema clevei* var. *javanica sub-dominant at: Olifants River Sites W6 & W7.
Gomphonema parvulum sub-dominant at: Gamtoos River Site GR6.

Hantzschia distinctepuncta sub-dominant at: KNP DWAF Site X3H048 & DWAF Northern Province Site A7H009.

Navicula capitoradiata sub-dominant at: DWAF Rand Site 1; Olifants River Sites K01,W3, W5 & B1.
Navicula cincta* var. *leptocephala sub-dominant at: Umgeni Water Site 10; Orange River Site at Pella.
Navicula confervacea sub-dominant at: Swartkops River Sites C11, C17 & F20.
Navicula cryptocephala – sub-dominant at: Rand Water Site 4; KNP DWAF Site A9H008.
Navicula heimansii sub-dominant at: DWAF KNP Site V2H005; DWAF Northern Province Site A6H018; Umgeni Water Site 12; Palmiet River Site 4.
Navicula hungarica* var. *capitata sub-dominant at: DWAF Northern Cape Sites C9H010 & C9H021; Umgeni Water Site 11; DWAF KZN Site V2H004.
Navicula menisculus sub-dominant at: DWAF Northern Cape Site C3H003; Olifants River Sites 07, W2 & B1.
Navicula menisculus* var. *menisculus sub-dominant at: DWAF Rand Site 3.
Navicula mollis sub-dominant at: DWAF OFS Site 3; Sundays River Sites SR3, SR4 & ST1.
Navicula pseudohalophila sub-dominant at: Sundays River Site SR5; Swartkops River Site C18.
Navicula trivialis sub-dominant at: DWAF Rand Site 7; Olifants River Site K03.
Navicula viridula* var. *rostellata sub-dominant at: Sundays River Sites SR 4 & 5; DWAF Northern Cape Sites C9H008 & D3H008; DWAF KZN Sites V2H004 & V2H012; Orange River at Vioolsdrif.

Nitzschia capitata sub-dominant at: Swartkops River Sites D16 & E19.

Nitzschia desertorum sub-dominant at: Swartkops River Sites E17, E09, E10, E15, E17, E18.

Nitzschia dissipata sub-dominant at: Olifants River Sites 06,08,W4 & W5.

Nitzschia capitellata sub-dominant at: Swartkops River Sites D16 & E19.

Nitzschia elliptica* var. *alexandrine sub-dominant at: Swartkops River Site B16.

Nitzschia fonticola sub-dominant at: Gamtoos River Sites GR2, GR3 & GR6; Sundays River Sites SR1 & ST1.

Nitzschia graciliformis sub-dominant at: Olifants River Sites 03, K01 & W1.

Nitzschia palea sub-dominant at: Durban Metro Site 3; Umgeni Water Sites 2, 10 & 12; Eerste River Site SR5 (DWAF Site ER720D); Olifants River Sites K03, 08, K05; DWAF KNP Sites B7H015 & A9H011.

Nitzschia paleacea sub-dominant at: Olifants River Site 06.

Nitzschia sigma sub-dominant at: DWAF Rand Site 5.

Sellaphora pupula sub-dominant at: DWAF Rand Sites 2, 4, 8 & 10; DWAFNPROV Site A6H019; DWAFKZN Site V2H012.

RIVER SAMPLING SITES

Gauteng: Rand Water

River	Site	GPS co-ordinates	Date sampled
Taaibosspruit	TW2	S 26°49' E 27°56'	31 July 2000
	Paddabaai No 1	S 26°49'E 27°52'	31 July 2000
Blesbokspruit	B14	S 26°27' E 28°27'	31 July 2000
"Toxic City"	B16	S 26°16' E 28°30'	31 July 2000
Blesbokspruit	B9	S 26°12' E 28°27'	31 July 2000
Kliprivier	K1	S 26°10' E 27°49'	31 July 2000
Kliprivier	K6	S 26°27' E 28°06'	31 July 2000

Kruger National Park

River	Site	GPS co-ordinates	Date sampled
Sabie	X3H015	S 23°08'44" E 31°56'42"	17 September 2001
Crocodile	X3H016	S 25°21'44" E 31°57'24"	17 September 2001
Crocodile	X3H048	S 25°27'35" E 31°32'04"	17 September 2001
Sabie	X3H012	S 24°59'31" E 31°15'00"	17 September 2001
Letaba	B8H018	S 23°50'19" E 31°38'27"	18 September 2001
Olifants	B7H015	S 24°03'32" E 31°14'14"	18 September 2001
Letaba	B8H028	S 23°38'53" E 31°08'50"	18 September 2001
Shingwedzi	B9H002	S 23°12'55" E 31°13'12"	19 September 2001
Shingwedzi	B9H003	S 23°08'40" E 31°27'17"	19 September 2001
Luvuvhu	A9H008	S 22°38'08" E 30°57'33"	19 September 2001
Luvuvhu	A9H011	S 22°25'18" E 31°13'04"	19 September 2001

DWAF: Rand Water

River	Site	GPS co-ordinates	Date sampled
Magalies	1. A2HO13	S 25°46'37.4" E 27°45'40.7"	24 September 2000
Crocodile	2. A2HO12	S 25°48'58.8" E 27°53'34.3"	24 September 2000
Crocodile	3. A2HO45	S 25°53'35.6" E 27°54'4.8"	24 September 2000
Jukskei	4. A2HO44	S 25°53'43.0" E 27°56'03.8"	24 September 2000
Crocodile	5. A2HO50	S 25°59'23.1" E 27°50'35.3"	24 September 2000
Bloubank	6. A2HO49	S 25°58'37.7" E 27°50'09.3"	24 September 2000
Crocodile	7. A2HO51	S 26°01'58.7" E 27°50'34.2"	24 September 2000
Jukskei	8. A2H023	S 25°57'15.6" E 27°57'48.8"	24 September 2000
Little Jukskei	9. A2HO47	S 26°04'07.1" E 27°58' 22.9"	24 September 2000
Walkersspruit	10. A2HO62	S 25°45'32.7" E 28°13'11.5"	24 September 2000
Morelettaspruit	11. A2HO55	S 25°41'33.7" E 28°17'32.7"	24 September 2000

Orange Free State

River	Site	GPS co-ordinates	Date sampled
Caledon	1. D2HO35	S 28°53'00.7'' E 27°53'20.6''	7 November 2000
Caledon	2. D2HO12	S 28°41'40.6'' E 28°14''04.9'	7 November 2000
Caledon	3. D2HO375	S 29°36'33.3'' E 27°03'51.2''	7 November 2000
Kornetspruit	4. D1HO06	S 30°09'38.2'' E 27°24'06.0''	7 November 2000
Kornetspruit	5. D1HO34	S 30°09'53.0'' E 27°23'45.2''	7 November 2000
Orangedraai	6. D1HO09	S 30°20'12.8'' E 27°21'50.4''	7 November 2000

Orange River

River	Site	GPS co-ordinates	Date sampled
Orange	1. Upington	S 28°27'27'' E 21°14'35''	2 June 2002
Orange	2. Vioolsdrif	S 28°45'57'' E 17°37'16"	2 June 2002
Orange	3. Pella	S 28°57'51'' E 19°09'18''	2 June 2002
Orange	4. Marchand	S 28°43'24'' E 20°30'44''	2 June 2002

Northern Province

River	Site	GPS co-ordinates	Date sampled
Mokolo	A4H013	S 23°35'57" E 27°44'31"	14 May 2001
Rasloop	A4H018	S 23°46'15" E 28°20'55"	14 May 2001
Palala	A5H008	S 23°13'01" E 27°46'36"	14 May 2001
Mokolo	A4H002	S 24°16'58" E 28°05'25"	14 May 2001
Hessie se Water	A6H019	S 23°39'45" E 28°27'19"	14 May 2001
Sand	A7H009	S 22°29'26" E 29°59'00"	14 May 2001
Sand	A7H001	S 22°54'30" E 29°59'26"	14 May 2001
Limpopo	A7H008	S 22°13'32" E 29°59'51"	14 May 2001

Northern Cape

River	Site	GPS co-ordinates	Date sampled
Harts	C3H003	S 27°34'23" E 24°44'47"	10 May 2001
Harts	C3H016	S 28°22'45" E 24°18'06"	10 May 2001
Vaal	C9H008	S 28°06'51" E 24°54'06"	10 May 2001
Vaal	C9H009	S 28°30'57" E 24°36'04"	10 May 2001
Vaal	C9H010	S 28 °24'21"E 24°16'18"	10 May 2001
Vaal	C9H021	S 27°40'09" E 25°37'05"	10 May 2001
Vaal	C9H024	S 28°42'40" E 24°04'25"	10 May 2001
Orange	D3H003-A01	S 29°09'42" E 23°41'47"	8 May 2001
Vaal	Douglas B	S 27°34'23" E 24°44'47"	8 May 2001
Orange	D7H002	S 27°34'23" E 24°44'47"	8 May 2001

KwaZulu-Natal: Durban Metro

River	Site	GPS co-ordinates	Date sampled
Mbilo	1. Mbilo 27. R-Bilo-27	S 29°49'40.3" E 30°52'40.8"	22 August 2000
Palmiet	2. Birdhurst Rd, Pinetown	S 29°49'13.4" E 30°53'31.1"	22 August 2000
Palmiet	3. Palm 06	S 29°48'53.0" E 30°52 52.8"	22 August 2000
Palmiet	4. Palm 07 New Germany	S 29°48'39.8" E 30°52'14.1"	22 August 2000
Palmiet	5. Palm 09	S 28°48'05.1" E 30°51'56.0"	22 August 2000

KwZulu-Natal: Umgeni Water

River	Site	GPS co-ordinates	Date sampled
Mzinduzi	UmWat 65	S 29°36'07.5" E 30°24'48.0"	13 November 2000
Mzinduzi	UmWat 64	S 29°35'55.6" E 30°24'03.2"	13 November 2000
Mzinduzi	UmWat 63	S 29°36'21.1" E 30°23'29.1"	13 November 2000
Mzinduzi	UmWat 67	S 29°36'27.2" E 30°27'00.4"	13 November 2000
Mzinduzi	UmWat 662	S 29°35'48.6" E 30°26'20.1"	13 November 2000
Mzinduzi	UmWat 66.3	S 29°35'57.4" E 30°26'36.0"	13 November 2000
Mzinduzi	UmWat 626	S 29°36'05.2" E 30°25'26.9"	13 November 2000
Mzinduzi	UmWat 624	S 29°36'52.3" E 30°22'37.3"	13 November 2000
Mzinduzi	UmWat 62	S 29°37'50.9" E 30°21'11.8"	13 November 2000
Slangspruit	UmWat 61	S 29°38'29.6" E 30°21'55.6"	13 November 2000
Duzi Dirt Rd	UmWat 56.2	S 29°40'25.2" E 30°10'11.0"	13 November 2000
Karskloof	Karskloof 5.2	S 29°22'38.4" E 30°16'48.5"	13 November 2000
Karskloof	Karskloof 5.1	S 29°22'55.3" E 30°16'40.1"	13 November 2000

KwaZulu-Natal: DWAF

River	Site	GPS co-ordinates	Date sampled
Mooi	V2H002	S 29°00'16.4" E 29°53'00"	2 May 2001
Mooi	V2H004	S 29°04'15.1" E 30°14'52.5"	2 May 2001
Mooi	V2H005	S 29°21'35.0" E 29°52'53.0"	2 May 2001
Kleinmooi	V2H006	S 29°14'19.0" E 29°47'18"	2 May 2001
Hlatikulu	V2H007	S 29°11'14.4" E 29°38'15.1"	2 May 2001
Klein Boesmans	V7H012	S 29°04'15.1" E 29°14'52.5"	2 May 2001
Ncibidwane	V7H016	S 29°04'15.1" E 29°14'52.5"	2 May 2001
Boesmans	V7H017	S 29°11'10.2" E 29°38'15.5"	2 May 2001

Eastern Cape: Swartkops River catchment

Location	Site	GPS co-ordinates	Date sampled
Springfontein	A	S 33°44'10.5" E 25°19'11.3"	March 1997- April 1999
Bulmer drift	B	S 33°45'07.6" E 25°20'33.4"	March 1997- April 1999
Gubb & Ingg's	C	S 33°45'51.2" E 25°22'32.9"	March 1997- April 1999
Niven Bridge	D	S 33°46'19.5" E 25°23'16.5"	March 1997- April 1999
Nic Claasen Bridge / Brak River	E	S 33°47'33.1" E 25°24'48.4"	March 1997- April 1999
Despatch Bridge	F	S 33°47'25.2" E 25°29'18.6"	March 1997- April 1999

Mpumalanga: Olifants River catchment

River	Site	GPS co-ordinates	Date sampled
Olifants	O1	S 26°15'40.6" E 29°41'29.1"	4 August 1998
Olifants	O2	S 26°13'11.5" E 29°27'42.9"	4 August 1998
Olifants	O3	S 26°06'20.2" E 29°19'20.2"	4 August 1998
Olifants	O4	S 25°51'13.4" E 29°17'35.7"	4 August 1998
Olifants	O5	S 25°50'28.6" E 29°15'58.3"	4 August 1998
Olifants	O6	S 25°47'0.7" E 29°18'35.3"	3 August 1998
Olifants	O7	S 25°45'37.5" E 29°19'9.1"	3 August 1998
Olifants	O8	S 25°37'24.6" E 29°13'0.3"	23 June 1998
Olifants	O9	S 25°35'47.7" E 29°12'28.5"	23 June 1998
Olifants	O10	S 25°32'58.0" E 29°13'48.0"	24 June 1998
Olifants	O11	S 25°30'54.2" E 29°15'59.9"	22 June 1998
Klein Olifants	KO1	S 25°49'1.4" E 29°35'26.4"	26 June 1998
Klein Olifants	KO2	S 25°46'4.9" E 29°29'21.6"	25 June 1998
Klein Olifants	KO3	S 25°45'0.7" E 29°27'38.7"	25 June 1998
Klein Olifants	KO4	S 25°43'18.0"E 29°26'7.2"	25 June 1998
Klein Olifants	KO5	S 25°40'25.7 E 29°19'1.3"	25 June 1998
Wilge	W1	S 26°15'40.6 E 28°50'56.2"	6 August 1998
Wilge	W2	S 25°54'7.2 E 28°51'5.2"	7 August 1998
Wilge	W3	S 25°45'12.5 E 28°57'44.8"	7 August 1998
Wilge	W4	S 26°00'52.3 E 28°52'8.8"	5 August 1998
Wilge	W5	S 25°46'50.2 E 28°53'2.9"	5 August 1998
Wilge	W6	S 25°37'12.6 E 28°59'57.1"	5 August 1998
Bronkhorstspruit	B1	S 26°00'36.3 E 28°40'34.6"	6 August 1998
Bronkhorstspruit	B2	S 25°57'09.8 E 28°41'18.0"	6 August 1998
Bronkhorstspruit	B3	S 25°49'33.2 E 28°43'14.0"	6 August 1998

Western Cape

River	Site	GPS co-ordinates	Date sampled
Eerste	ER720E (ER6)	S 34°00'31" E 18°45'41"	4 May 1998
Eerste	ER720F (ER7)	S 34°03'45" E 18°44'52"	4 May 1998
Palmiet	PR400A (PR1)	S 34°05' E 19°02'	11 May 1998
Palmiet	PR400B (PR2)	S 34°07' E 19°01'	11 May 1998
Palmiet	PR400C (PR3)	S 34°09' E 19°01'	11 May 1998
Palmiet	PR400E (PR5)	S 33°20' E 18°59'	11 May 1998
Bot	BR400B (BR2)	S 34°14' E 19°12'	11 May 1998
Bot	JR400A (T1)	S 34°12' E 19°08'	11 May 1998
Klein Brak	K1H002 (KB1)	S 33°56'06" E 22°07'17"	7 May 1998
Klein Brak	K1H004 (KB2)	S 34°01'55"E 22°03'12"	7 May 1998
Klein Brak	K1H005 (KB3)	S 34°02'23"E 22°08'00"	7 May 1998
Groot Brak	K2H003 (GB1)	S 34°01'25" E 22°12'15"	7 May 1998
Keurbooms	K6H002 (R1)	S 33°56'18"E 23°22'04"	2 June1998
Keurbooms	K6H011 (R3)	S 33°48'41"E 23°10'31"	3 June 1998

Eastern Cape

River	Site	GPS co-ordinates	Date sampled
Gamtoos	L3R001 (GR1)	S 32°57'21" E 23°22'27"	12 August 1997
Gamtoos	Ad hoc (GR2)	S 33°11'48" E 23°59'14"	12 August1997
Gamtoos	L7H007 (GR3)	S 33°26'19" E 24°32'32"	12 August 1997
Gamtoos	L7H006 (GR4)	S 33°39'10" E 24°40'14"	29 July 1997
Gamtoos	Ad hoc (GR5)	S 33°45'30" E 24°38'12"	29 July 1997
Gamtoos	Ad hoc (GR6)	S 33°45'38" E 24°48'17"	29 July 1997
Gamtoos	L8H001 (GT2)	S 33°49'24" E 23°45'58"	30 July 1997
Gamtoos	L8H005 (GT3)	S 32°57'21" E 23°22'27"	30 July 1997
Gamtoos	L9H005 (GT4)	S 32°57'21" E 23°22'27"	29 July 1997
Sundays	N2H002 (SR2)	S 32°56'43" E 24°39'00"	13 August 1997
Sundays	N4H001 (SR5)	S 33°48'45" E 24°05'19"	13 August 1997
Sundays	N4H003 (SR6)	S 33°52'08" E 25°02'04"	13 August 1997

REFERENCES

Archibald, R.E.M. 1983. The diatoms of the Sundays and Great Fish rivers in the Eastern Cape Province of South Africa. *Bibliotheca Diamotologica*. J Cramer. 431 pp.

Cholnoky, B.J. 1966. Diatomaceae I Nova Hedwegia. Heft 21. J Cramer. 269 pp.

Hustedt, F. 1976. Die Süsswasser- flora Mitteleeuropas. Otto Koeltz Science Publishers. Koenigstein, Germany. 466 pp.

Krammer, K. and Lange-Bertalot, H. 1986. Süsswasser von Mitteleuropa. Bacillariophyceae. Teil 1: Naviculaceae. Gustav Fischer Verlag. Stuttgart. 440 pp.

Lange-Bertalot, H. (Ed.) 2000. *Iconographia Diatomologica*. Volume 7. Koeltz Scientific Books, Germany. 925 pp.

Lange-Bertalot, H. and Krammer, K 1989. *Achnanthes* Eine Monographie der Gattung. *Bibliotheca Diatomologica*. Band 18. J Cramer. Berlin. 393 pp.

Round, F.E., Crawford, R.M. and D.G. Mann 1990. The Diatoms. Biology and Morphology of the Genera. Cambridge University Press. Cambridge. 747 pp.

Schoeman, F.R. and Archibald, R.E.M 1976. The diatom flora of Southern Africa. *Special Report WAT 50*. CSIR, South Africa.

Schoeman, F.R. and Archibald, R.E.M 1987. *Navicula vandamii*. nom. nov. (Bacillariophyceae), a new name for *Navicula acephala* Schoeman, and a consideration of its taxonomy. *Nova Hedwegia. 44*: 479-487.

Simonsen, R. 1987. Atlas and catalogue of the diatom types of Friedrich Hustedt. Vol 1:Catalogue. J. Cramer, Stuttgart. 525 pp.

Simonsen, R. 1987. Atlas and catalogue of the diatom types of Friedrich Hustedt. Vol 2: Atlas, Plates 1-395. 395 pp. J. Cramer, Stuttgart

Simonsen, R. 1987. Atlas and catalogue of the diatom types of Friedrich Hustedt. Vol 3: Atlas, Plates 396 -772. J. Cramer, Stuttgart. 772 pp.

Sims, P.A. 1996. An Atlas of British Diatoms. Arranged by B. Hartley and based on illustrations by H. G. Barbour and J. R. Carter.[Ed. P.A. Sims]. Biopress Ltd. Bristol. 601 pp.

BENTHIC DIATOMS IN THE RIVERS AND ESTUARIES OF SOUTH AFRICA

SECTION 3 : ESTUARY DIATOMS

Report to the Water Research Commission

GC Bate, PA Smailes, JB Adams

Department of Botany, University of Port Elizabeth

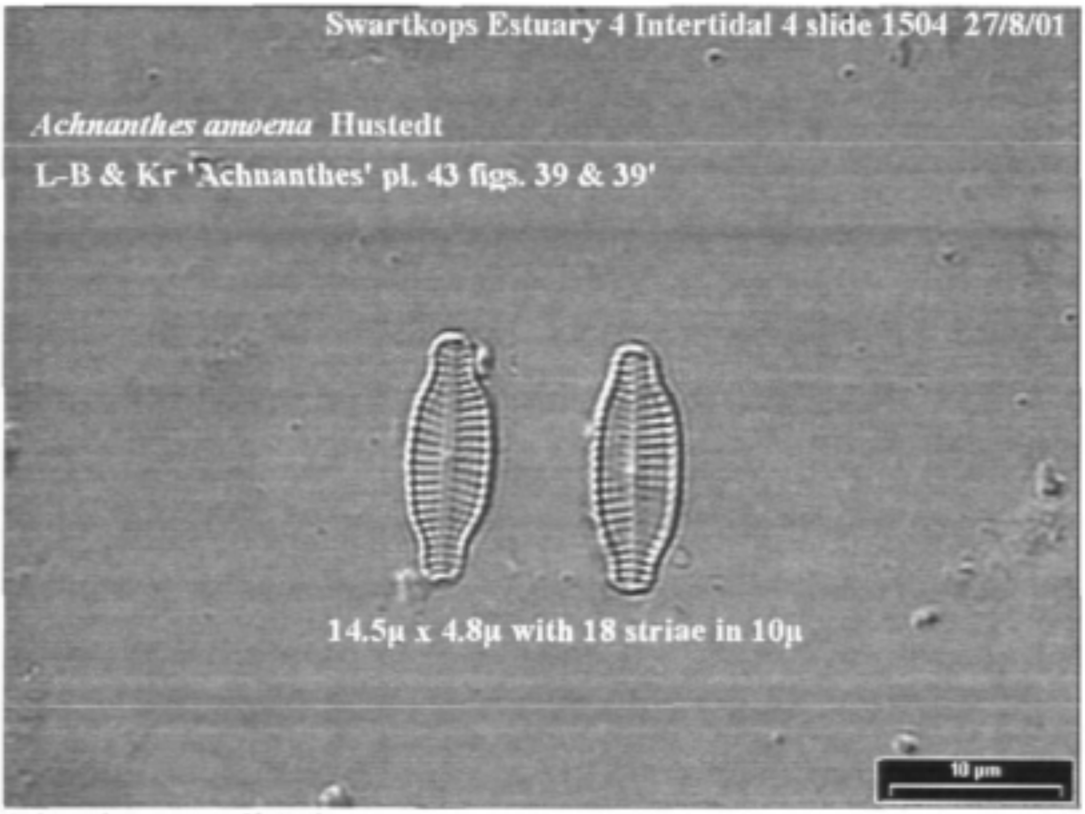
January 2004

ESTUARINE DOMINANTS

ESTUARINE SUB-DOMINANTS

ESTUARINE DOMINANTS

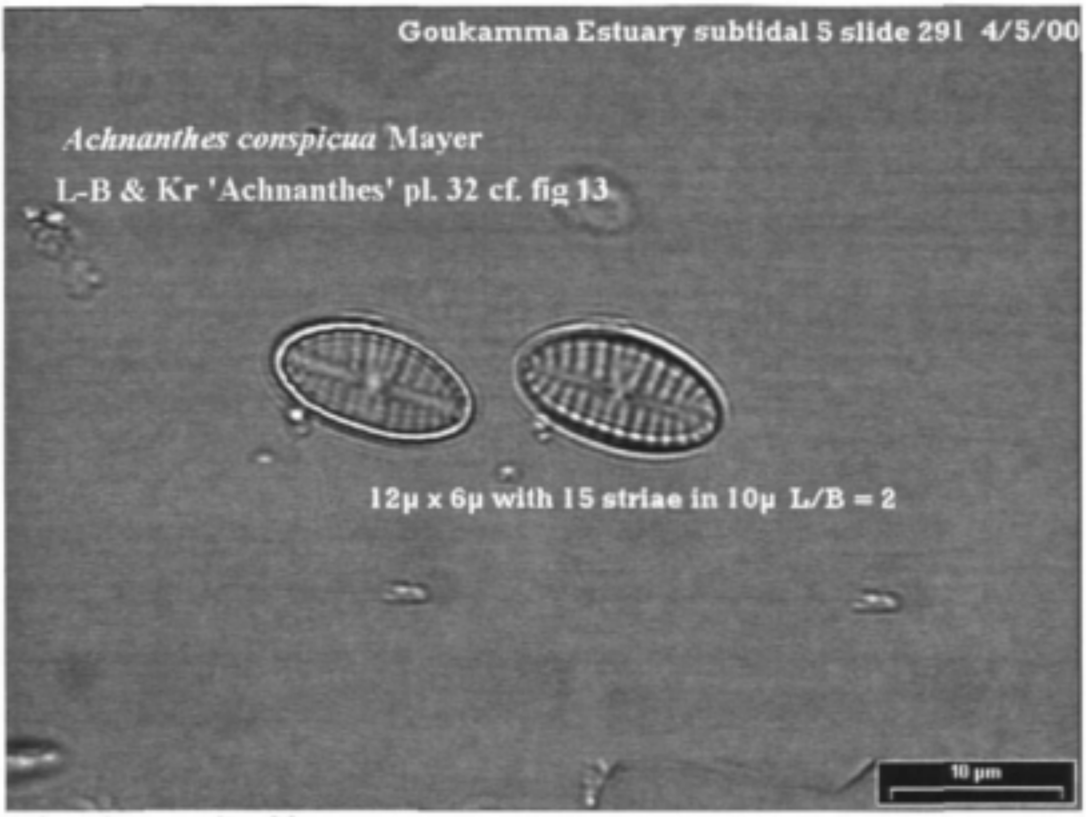
ACHNAMOE



Achnanthes amoena Hustedt
Reference used for identification: Lange-Bertalot and Krammer 1989. Plate 252. Figure 38.
Locations –Dominant in epipelon– Swartkops Estuary Intertidal Site 4.

NOTES	NOTES
Found at salinity 25 ppt. Lange-Bertalot: Brak water	This is a heterovalvar genus having one raphid and one rapheless valve.

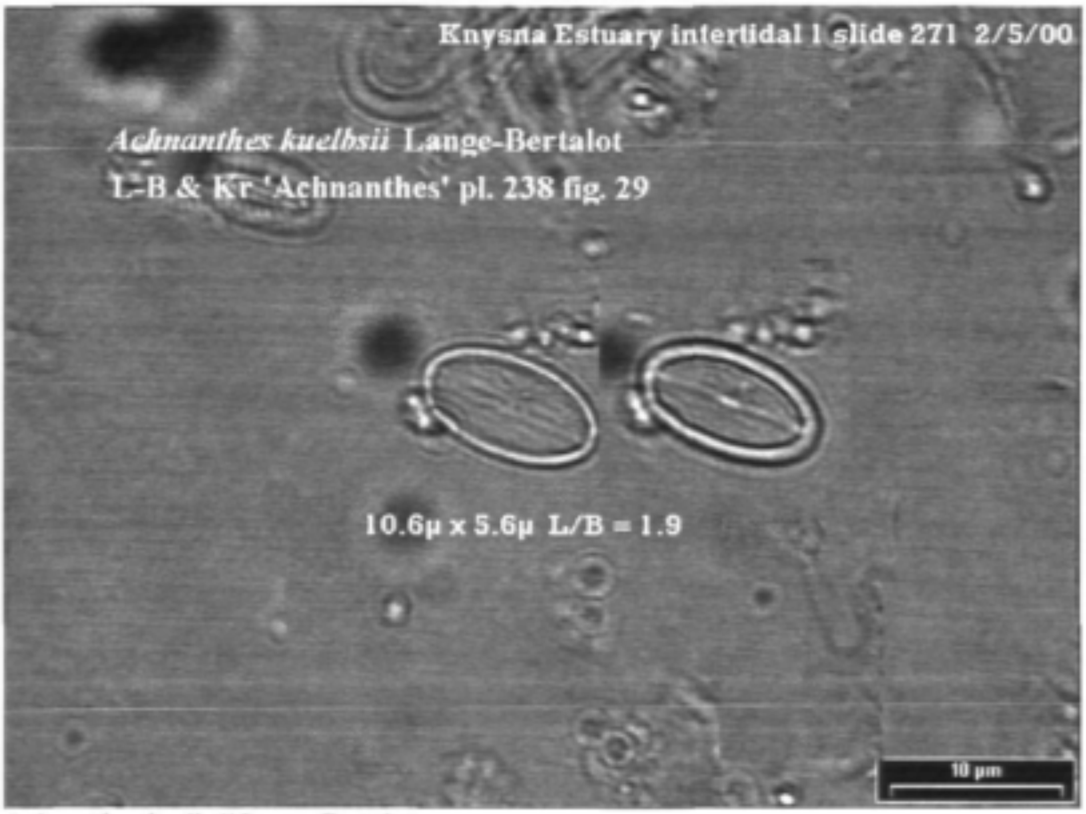
ACHNCONS



Achnanthes conspicua Mayer
Reference used for identification: Lange-Bertalot and Krammer 1989. Plate 32. Figure cf. 13.
Locations – Dominant in epipelon – Goukamma Estuary Subtidal Site 5.

NOTES	NOTES
Found at salinity 10 ppt. Sims (1996): Fresh water.	This is a heterovalvar genus having one raphid and one rapheless valve.

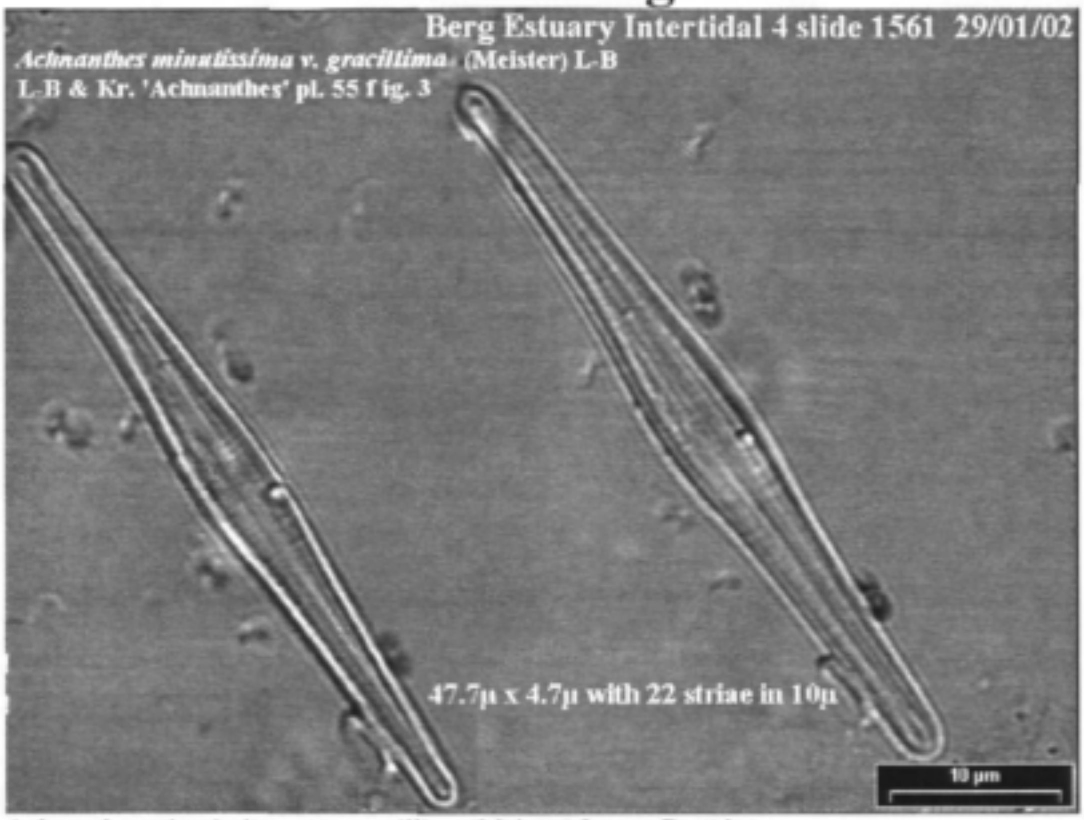
ACHNKUEL



Achnanthes kuelbsii Lange-Bertalot
Reference used for identification: Lange-Bertalot & Krammer 1989. Plate 238. Figure 29.
Locations - Dominant in epipelon – Knysna Estuary Intertidal Site 1; Mngazana Intertidal Site1.

NOTES	NOTES
Found at salinity 30 - 35 ppt.	This is a heterovalvar genus having one raphid and one rapheless valve.

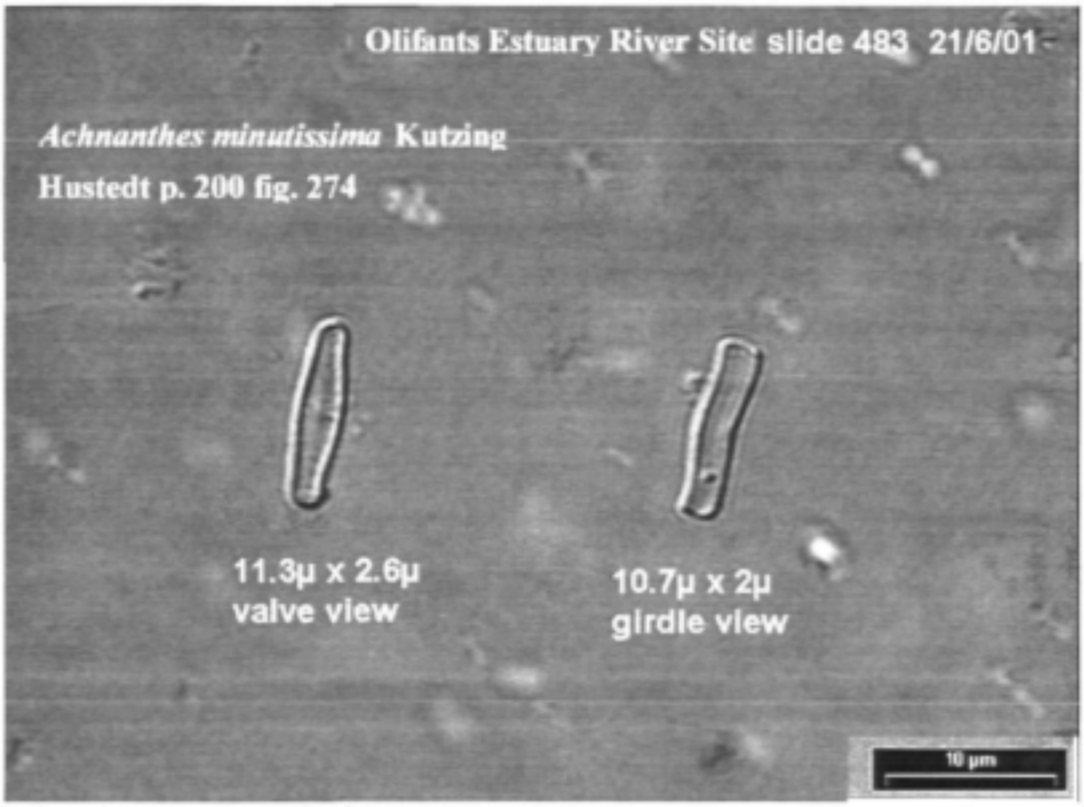
ACHNMIgr



Achnanthes minutissima var. *gracillima* (Meister) Lange-Bertalot
Reference used for identification: Lange-Bertalot & Krammer 1989. Plate 55. Figure 3.
Locations - Dominant in epipelon – Great Berg Estuary Intertidal & Subtidal Site 4.

NOTES	NOTES
Found at salinity: 26 ppt.	This is a heterovalvar genus having one raphid and one rapheless valve.

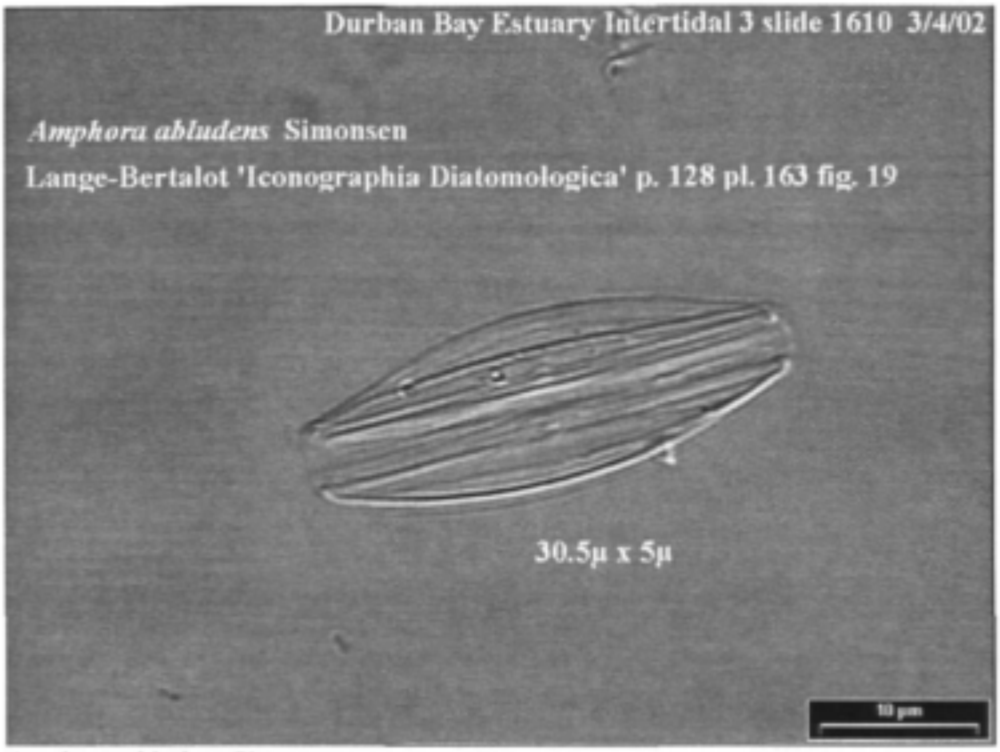
ACHNMINU



Achnanthes minutissima Kutzing.
Reference used for identification: Lange-Bertalot & Krammer 1989. Plate 51. Figure 10.
Locations – Sub-dominant in epipelon –Olifants Estuary River Site.

NOTES	NOTES
Found at salinity: 0 ppt. NB. This was found at the River site, therefore in fresh water Sims (1996): Fresh water.	This is a heterovalvar genus having one raphid and one rapheless valve. We have used the Hustedt (1930) reference because the illustrations are the clearest. Lange-Bertalot & Krammer (1989 p. 100) refer to the '*Achnathes minutissima* komplex' and there appear to be many varieties that are not clearly distinguishable.

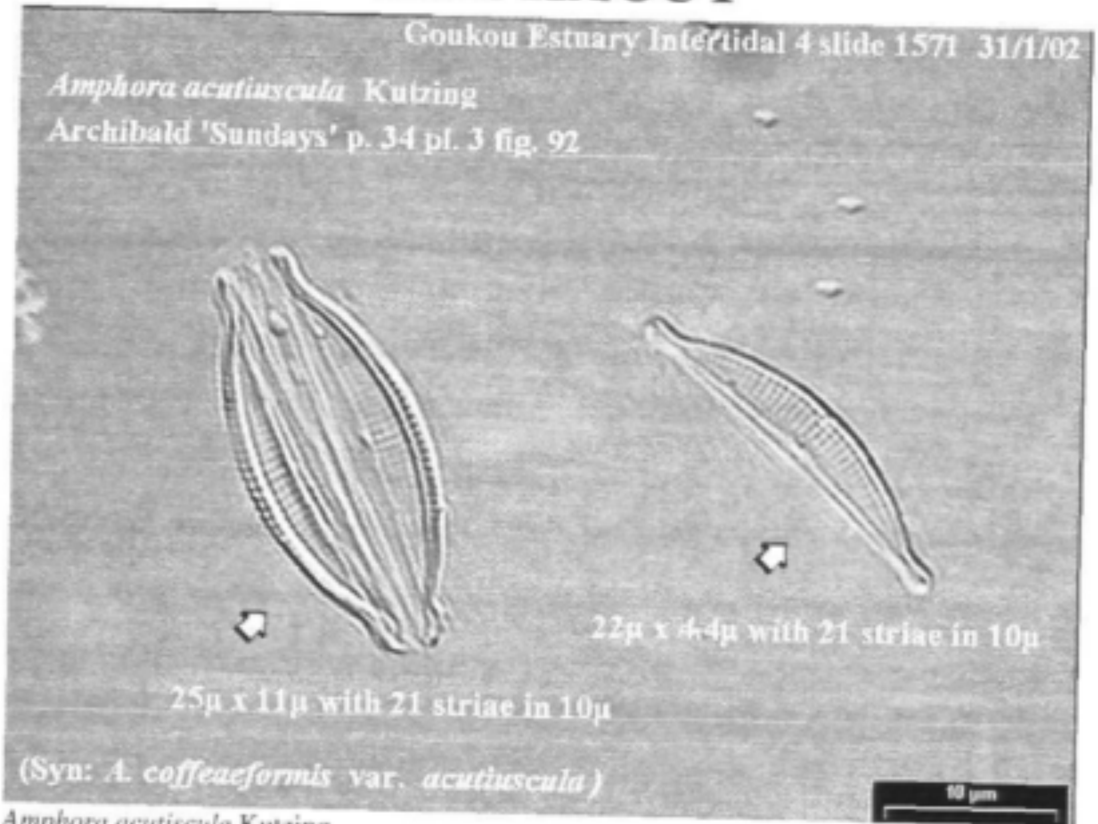
AMPHABLU



Amphora abludens Simonsen
Reference used for identification: Lange-Bertalot 2000. Page 128. Plate 163. Figure 19.
Locations - Dominant in epipelon – Durban Bay Subtidal Site 4.

NOTES	NOTES
Found at salinity: 30 ppt. Lange-Bertalot (2000): Marine.	

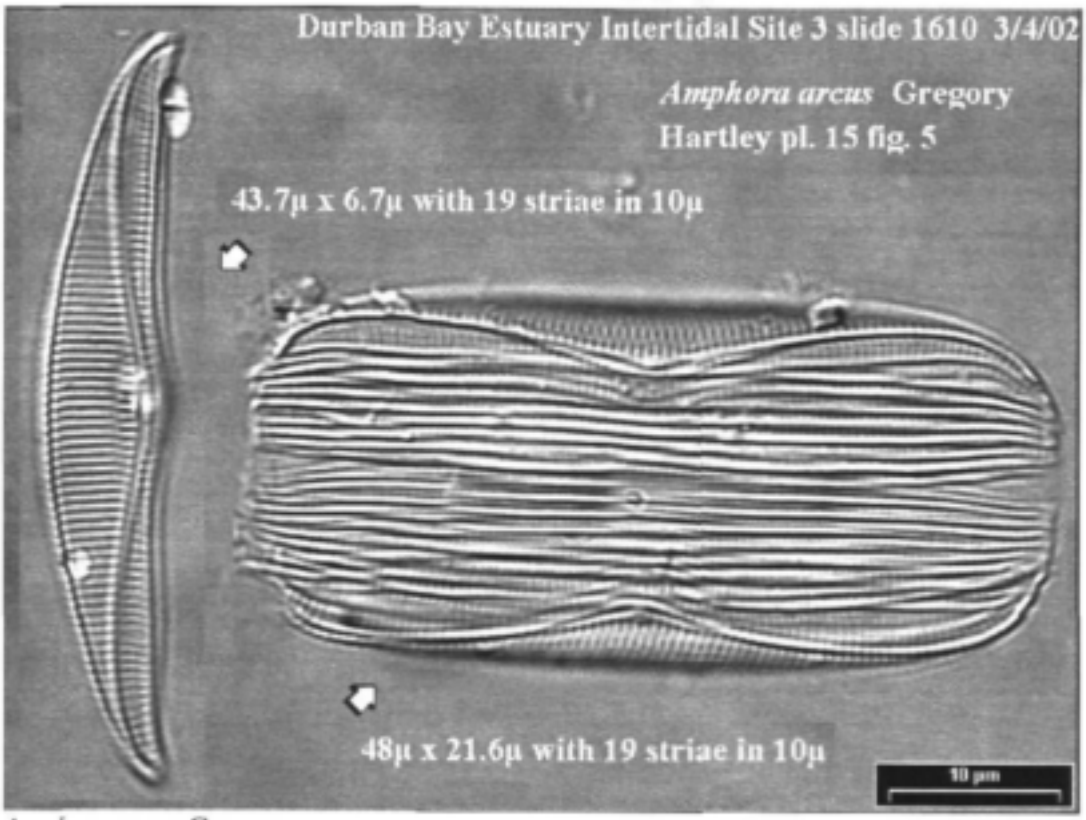
AMPHACUT



Amphora acutiscula Kutzing
Reference used for identification: Archibald 1983. Page 34. Plate 3. Figure 92.
Locations - Dominant in epipelon – Great Berg Estuary Subtidal Site 5; Goukou Estuary Intertidal Sites 3, 4 & 5.

NOTES	NOTES
Found at salinity: 5 - 23 ppt. Lange-Bertalot (2000): Brak – Marine.	

AMPHARCU



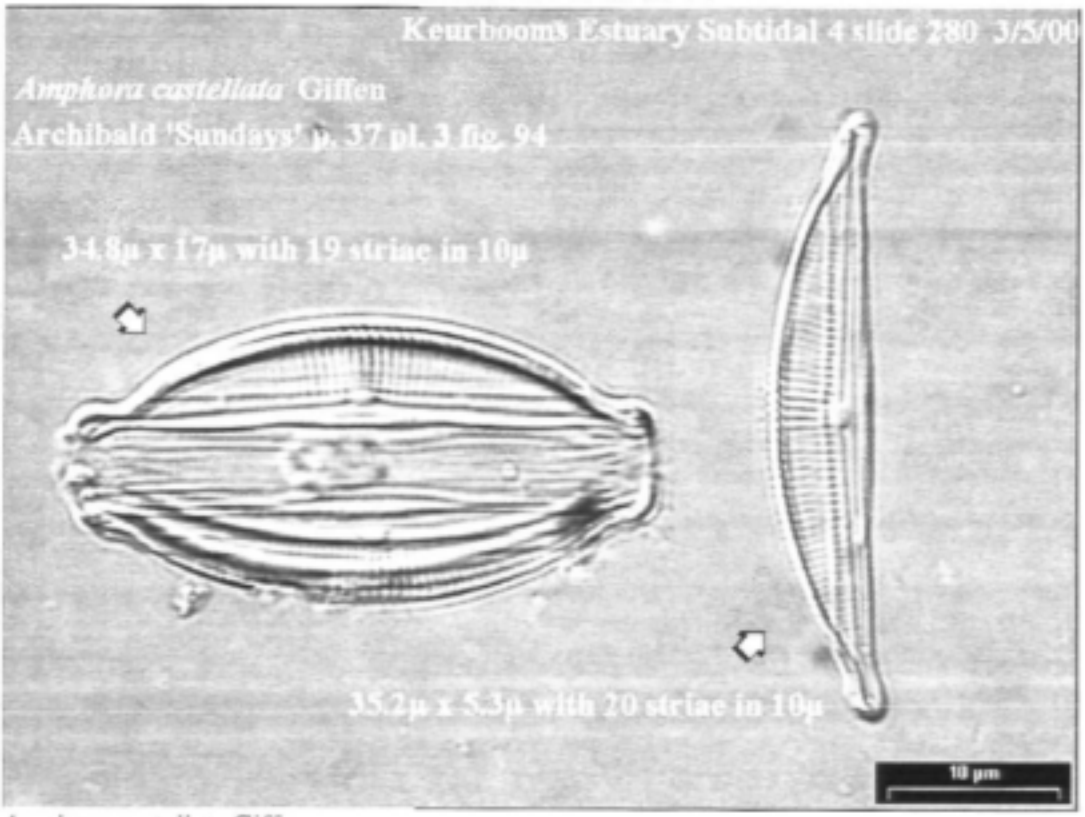
Amphora arcus Gregory

Reference used for identification: Hartley 1996. Plate 15. Figure 5. See also Lange-Bertalot 2000. Page 129. Plate 165. Figure 15.

Locations - Dominant in epipelon – Knysna Estuary Subtidal Site 2; Durban Bay Estuary Intertidal Site 3.

NOTES	NOTES
Found at salinity: 26 - 34 ppt. Lange-Bertalot: Marine.	

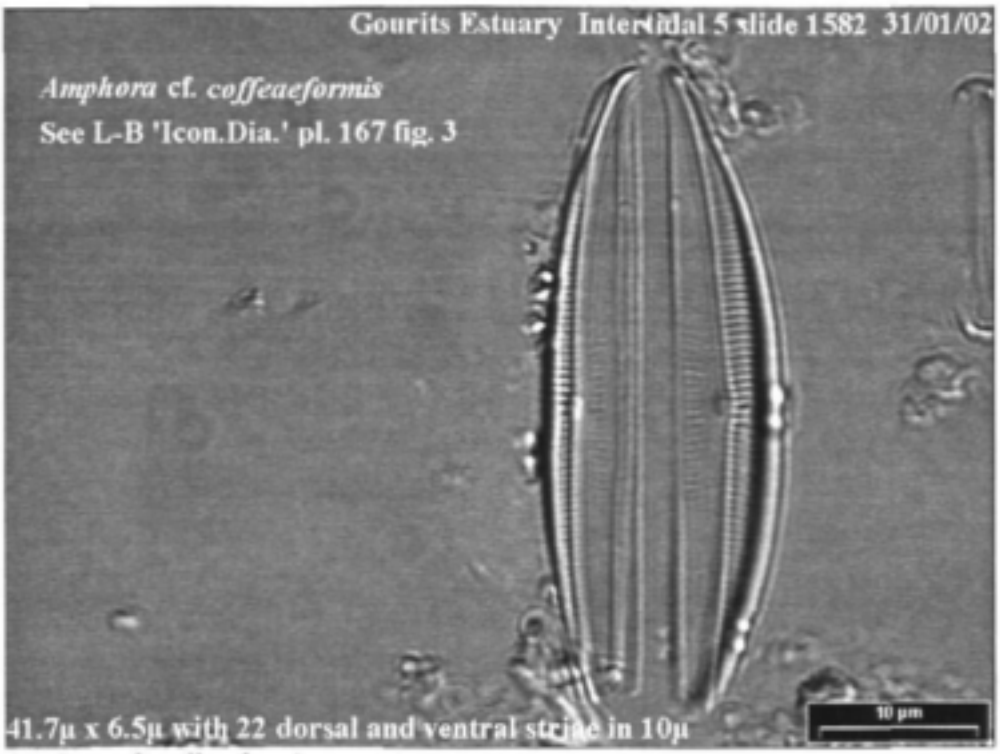
AMPHCAST



Amphora castellata Giffen
Reference used for identification: Archibald 1983. Page 37. Plate 3. Figure 95.
Locations – Dominant in epipelon – Keurbooms Estuary Subtidal Sites 2 & 4; Knysna Estuary Intertidal Site 5; Nhlabane Intertidal Site G.

NOTES	NOTES
Found at salinity: 9-32 ppt.	

AMPHcfCO



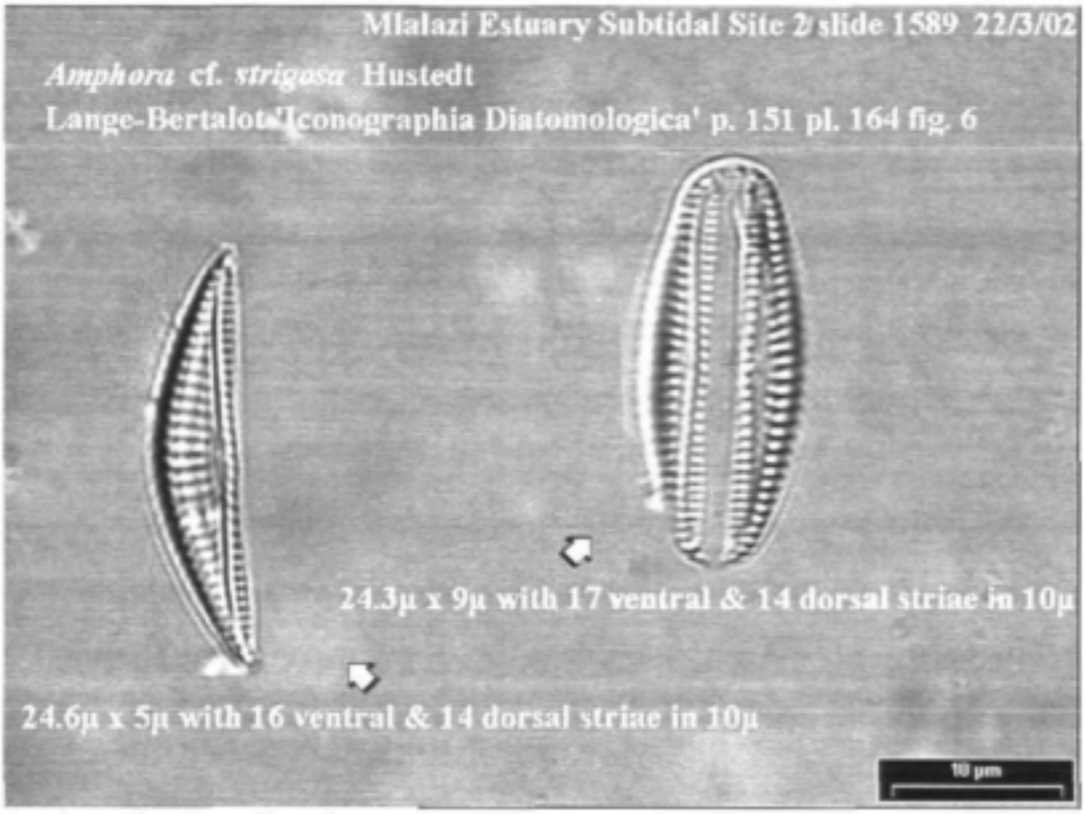
Amphora cf. *coffeaeformis*

Reference used for identification: Lange-Bertalot 2000. Plate 167. Figure 3.

Locations - Dominant in epipelon – Gouritz Intertidal Site 5.

NOTES	NOTES
Found at salinity: 27 ppt.	

AMPHcfSt



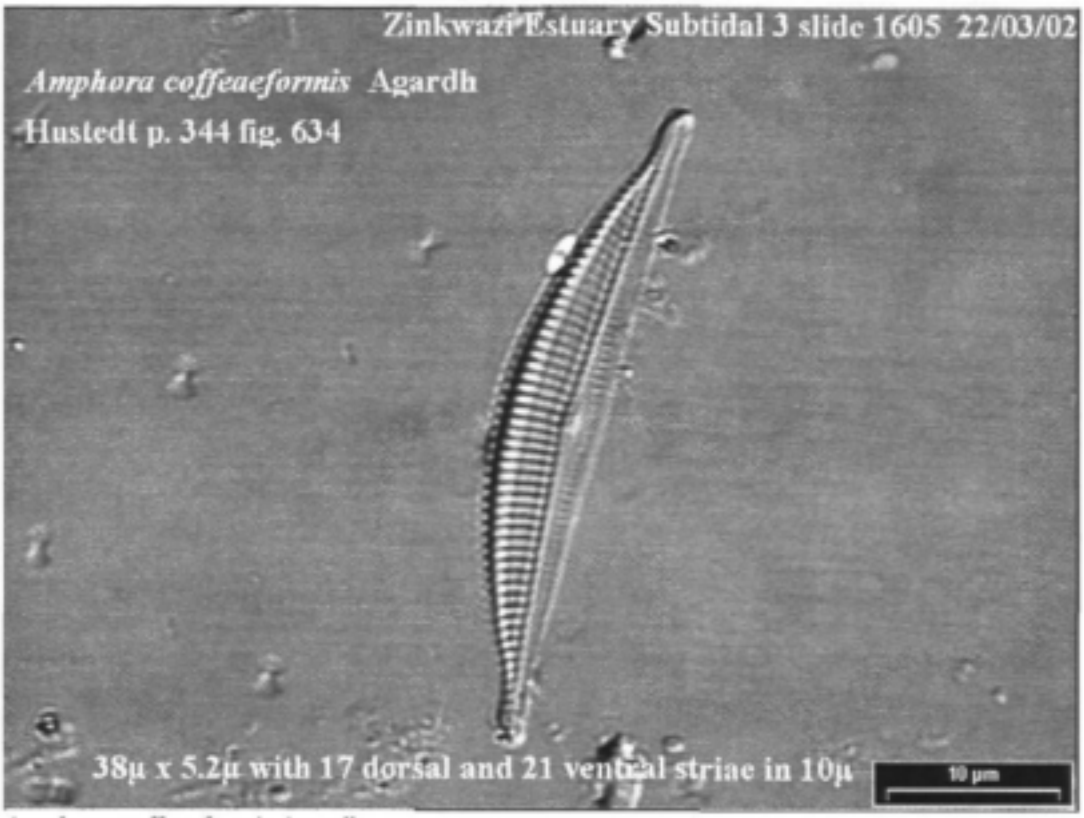
Amphora cf. *strigosa* Hustedt

Reference used for identification: Lange-Bertalot 2000. Page 151. Plate 164. Figure 6.

Locations - Dominant in epipelon – Mlalazi Estuary Subtidal Sites 4 & 5: Breede Estuary 3 Subtidal Sites 2 & 3.

NOTES	NOTES
Found at salinity: 14 – 33 ppt.	.

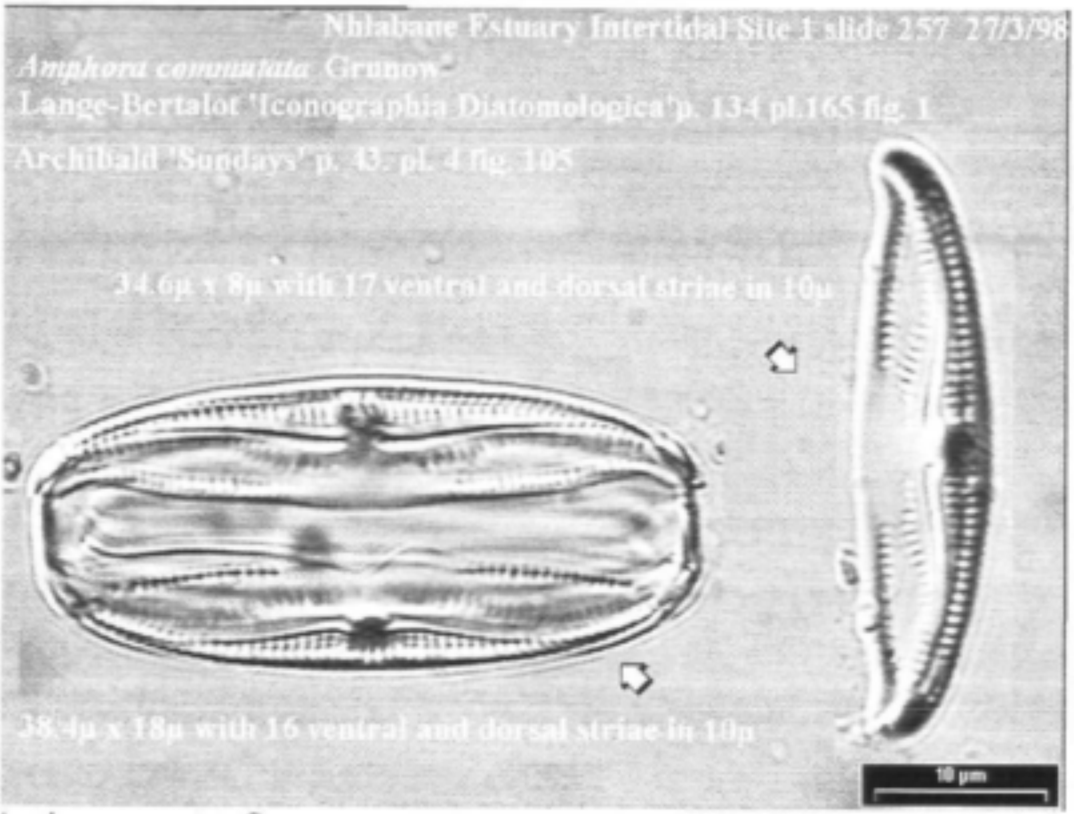
AMPHCOFF



Amphora coffeaeformis Agardh
Reference used for identification: Hustedt 1976. Page 344. Figure 634.
Locations - Dominant in epipelon –Keurbooms Estuary Intertidal Site 3; Mngazana Estuary Subtidal Site 5; Swartkops Estuary 1 Subtidal Site 4; Swartkops 4 Subtidal Site 3; Zinkwazi Estuary Subtidal Sites 2, 3 & 4; Mlalazi Intertidal Site 5.

NOTES	NOTES
Found at salinity: 12 –31 ppt. Hustedt (1976): Brak. Lange-Bertalot (2000): Brak – Marine. Sims (1996): Brak – Marine.	

AMPHCOMM



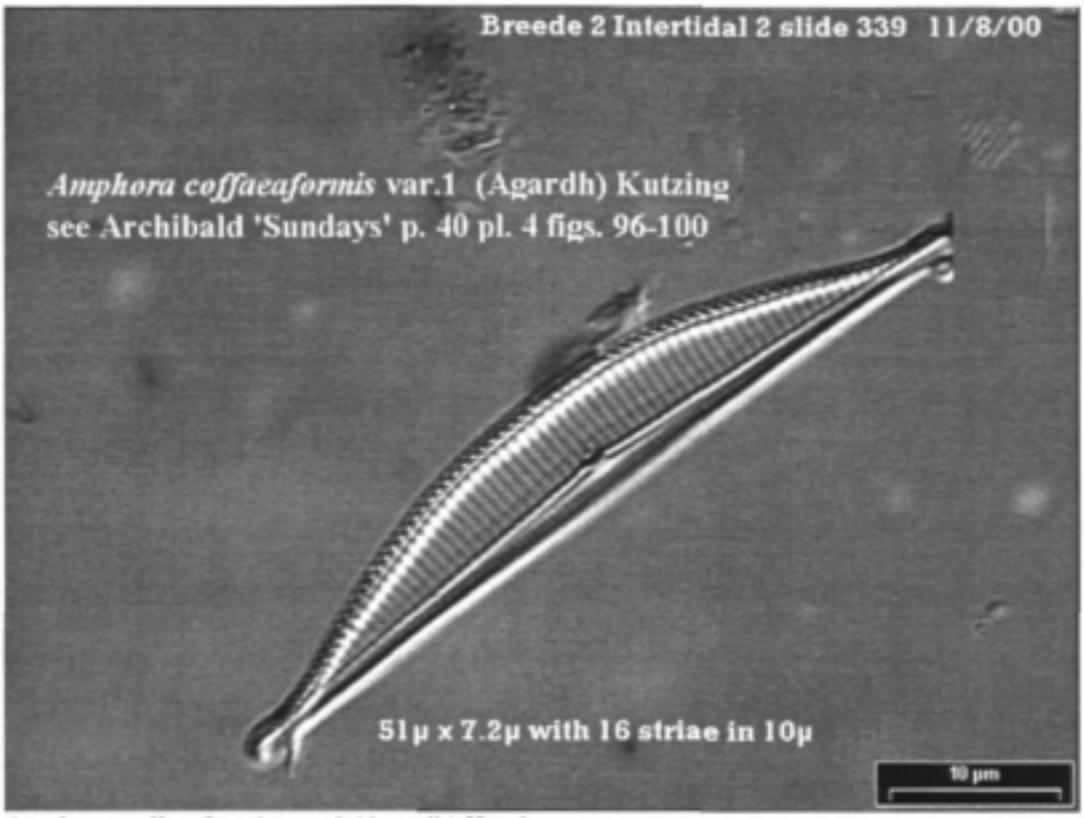
Amphora commutata Grunow

Reference used for identification: Lange-Bertalot 2000. Page 134. Plate 165. Figure 1. Archibald 1983. Plate 4. Figure 105.

Locations - Dominant in epipelon – Nhlabane Estuary Intertidal Site D.

NOTES	NOTES
Found at salinity 5 ppt. Hustedt (1976): Brak. Lange-Bertalot (2000): Brak. Sims (1996): Marine.	

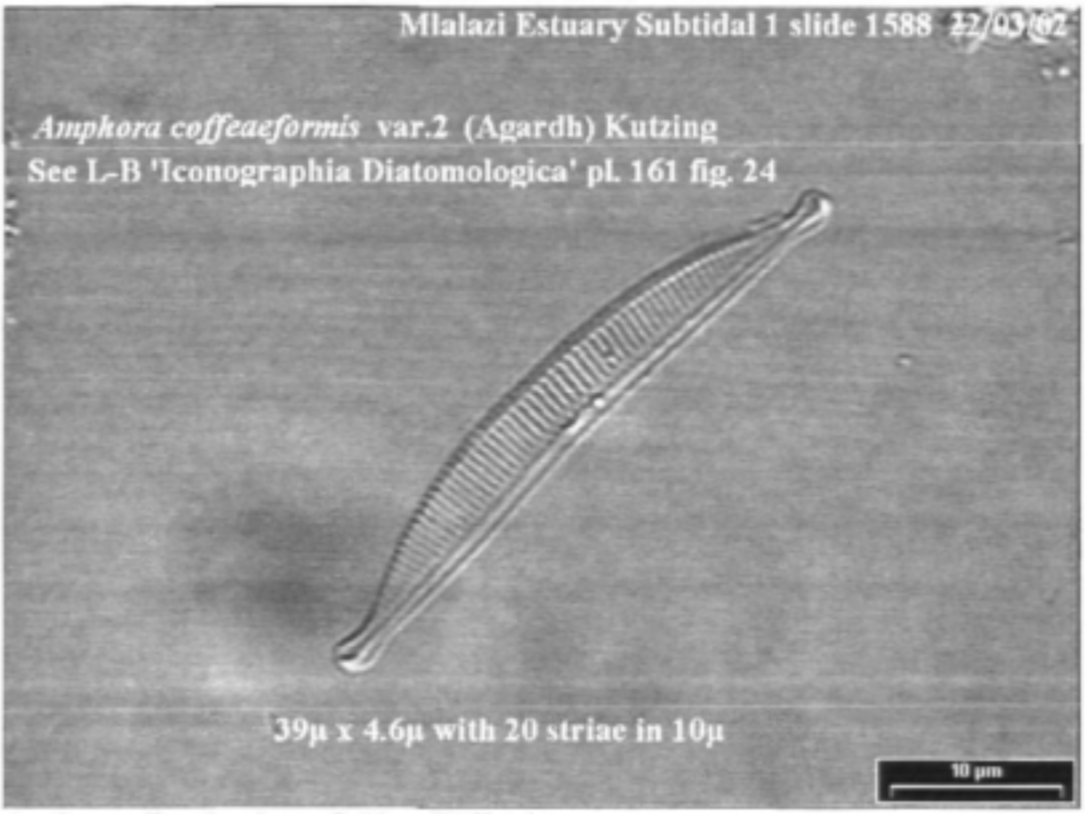
AMPHCOV1



Amphora coffeaeformis var. 1 (Agardh) Kutzing
Reference used for identification: Archibald 1983. Plate 4. Figure 100.
Locations - Dominant in epipelon – Breede Estuary 2 Intertidal Site 2.

NOTES	NOTES
Found at salinity 4 ppt.	

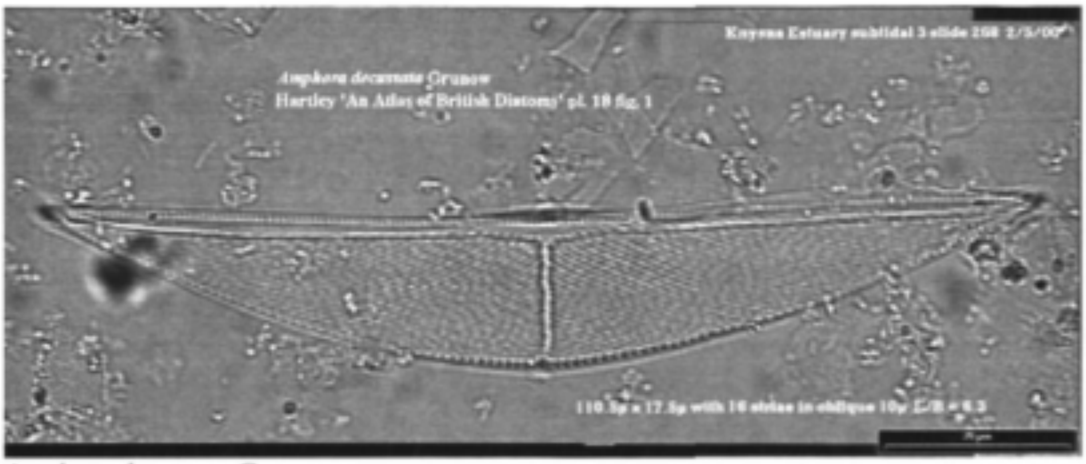
AMPHCOV2



Amphora coffeaeformis var. 2 (Agardh) Kutzing
Reference used for identification: Lange-Bertalot 2000. Plate 161. Figure 24.
Locations - Dominant in epipelon – Durban Bay Estuary Intertidal & Subtidal Site 1; Mlalazi Estuary Subtidal Site 1.

NOTES	NOTES
Found at salinity: 34 - 35 ppt.	.

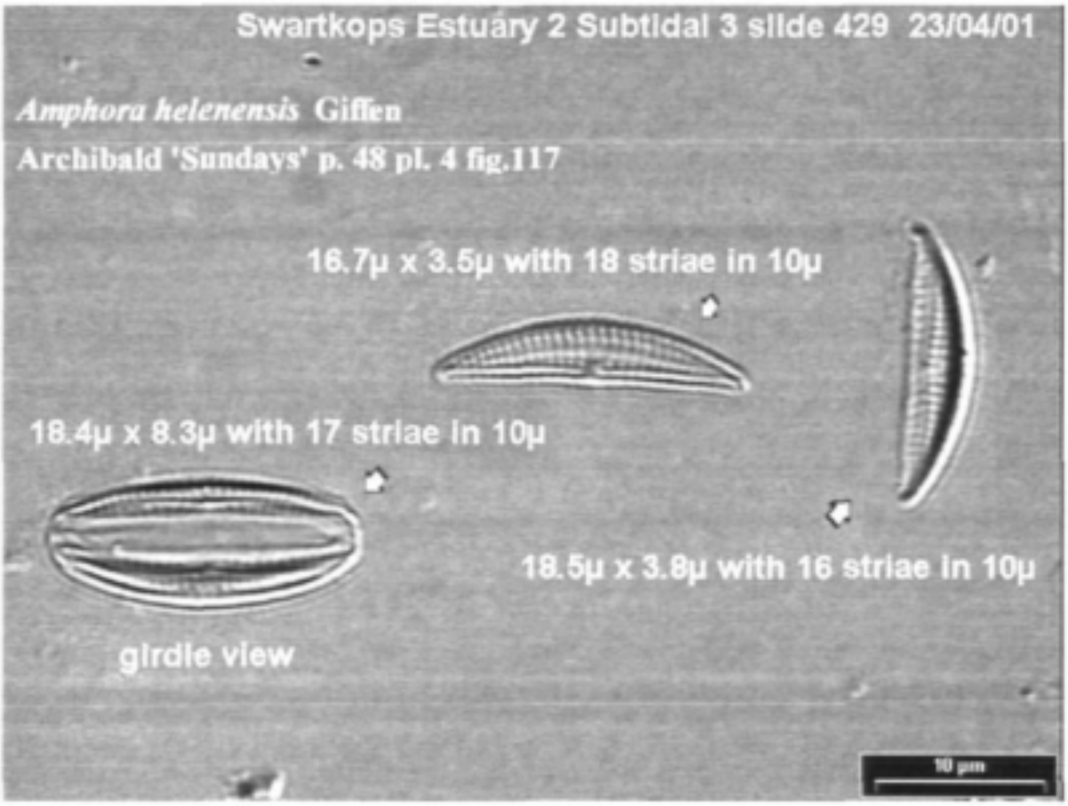
AMPHDECU



Amphora decussata Grunow
Reference used for identification: Hartley 1996. Plate 18. Figure 1.
Locations - Dominant in epipelon – Knysna Estuary Subtidal Site 3.

NOTES	NOTES
Found at salinity 36 ppt. Sims (1996): Marine.	

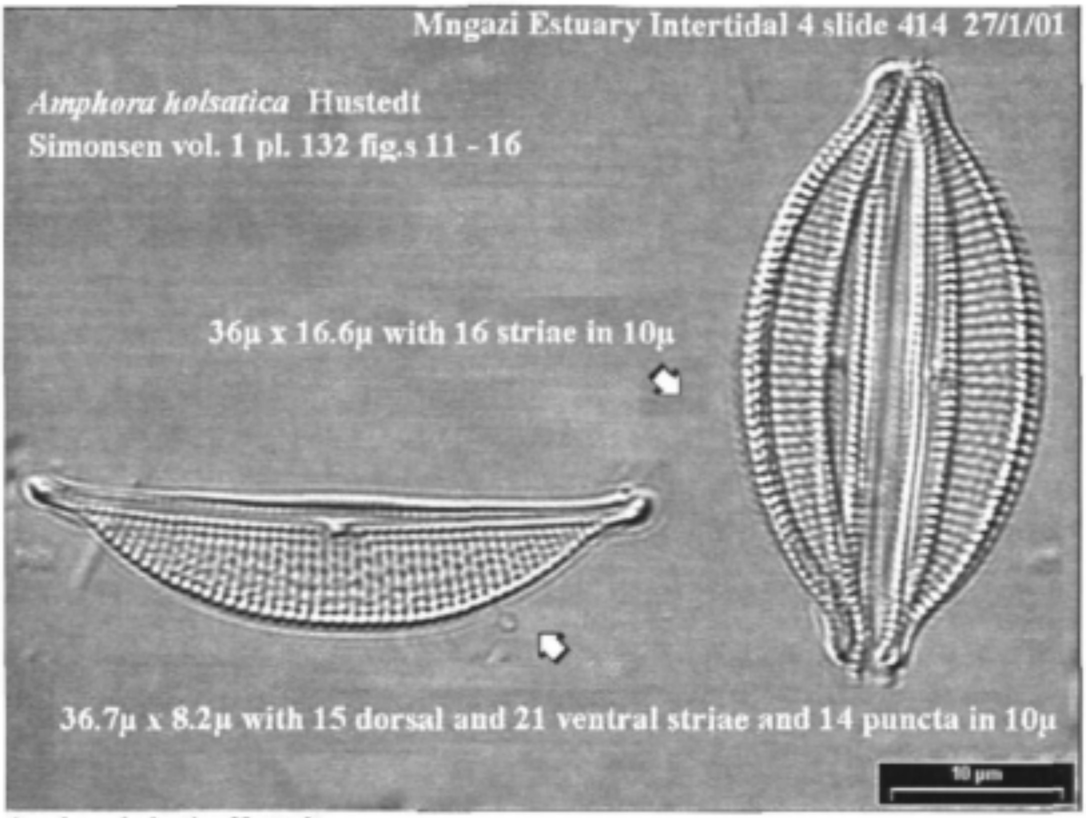
AMPHHELE



Amphora helenensis Giffen
Reference used for identification: Archibald 1983. Page 48. Plate 4. Figures 114 -118.
Locations - Dominant in epipelon – Swartkops Estuary 2 Subtidal Sites 2 & 3.

NOTES	NOTES
Found at salinity: 24 – 26 ppt. Archibald (1983): Brak. Lange-Bertalot (2000): Marine.	

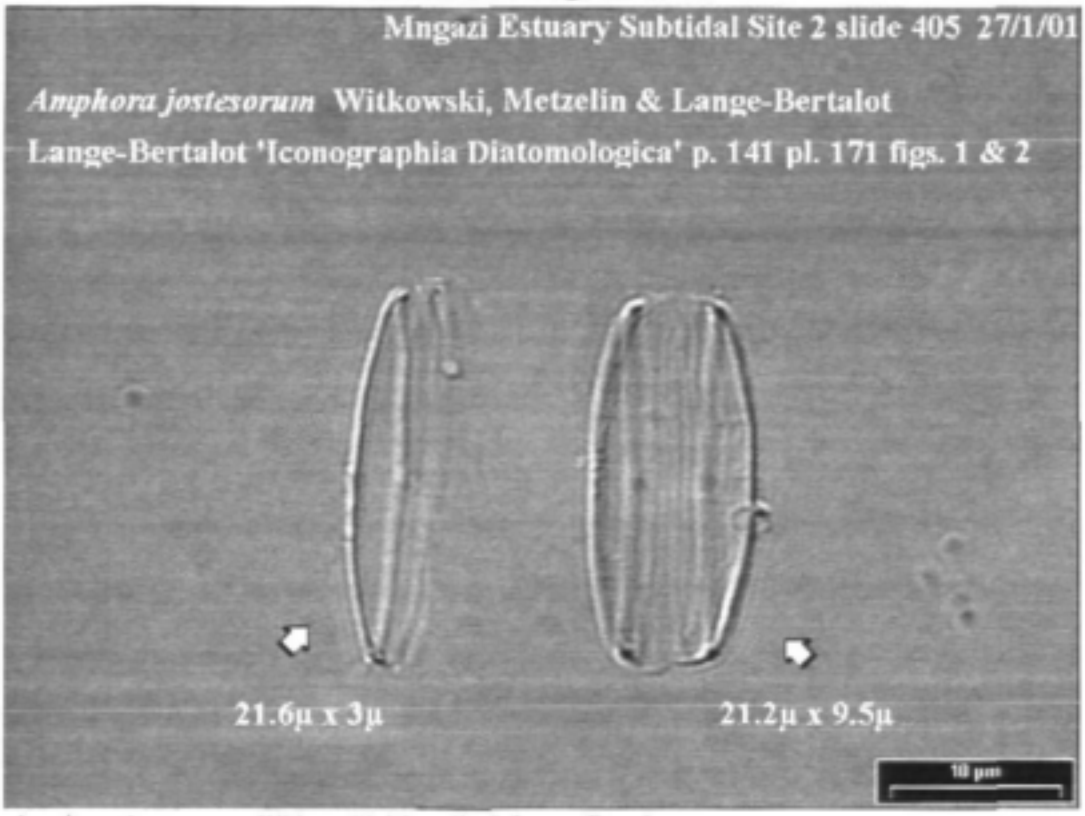
AMPHHOLS



Amphora holsatica Hustedt
Ref. used for identification: Simonsen 1987. Volume 1. Plate 132. Figures 11 – 16. Hartley 1996. Plate 19. Figure 5.
Locations – Dominant in epipelon – Great Brak Subtidal Sites 4 & 5; Nhlabane Subtidal D.

NOTES	NOTES
Found at salinity: 18 – 25 ppt. Hustedt (1976): Brak. Sims (1996): Marine.	.

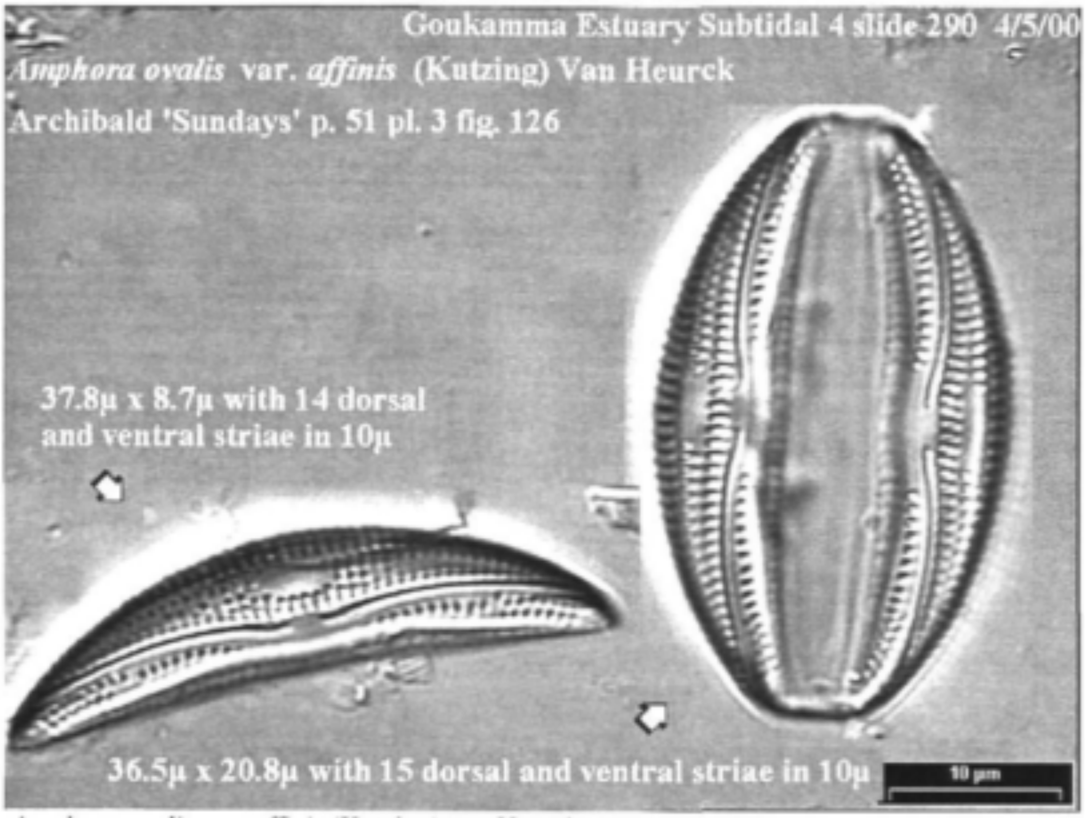
AMPHJOST



Amphora jostesorum Witkowski, Metzelin & Lange-Bertalot
Reference used for identification: Lange-Bertalot 2000. Page 141. Plate 171. Figure 1.
Locations - Dominant in epipelon – Mngazi Estuary Subtidal Site 1.

NOTES	NOTES
Found at salinity 30 ppt. Lange-Bertalot (2000): Marine.	

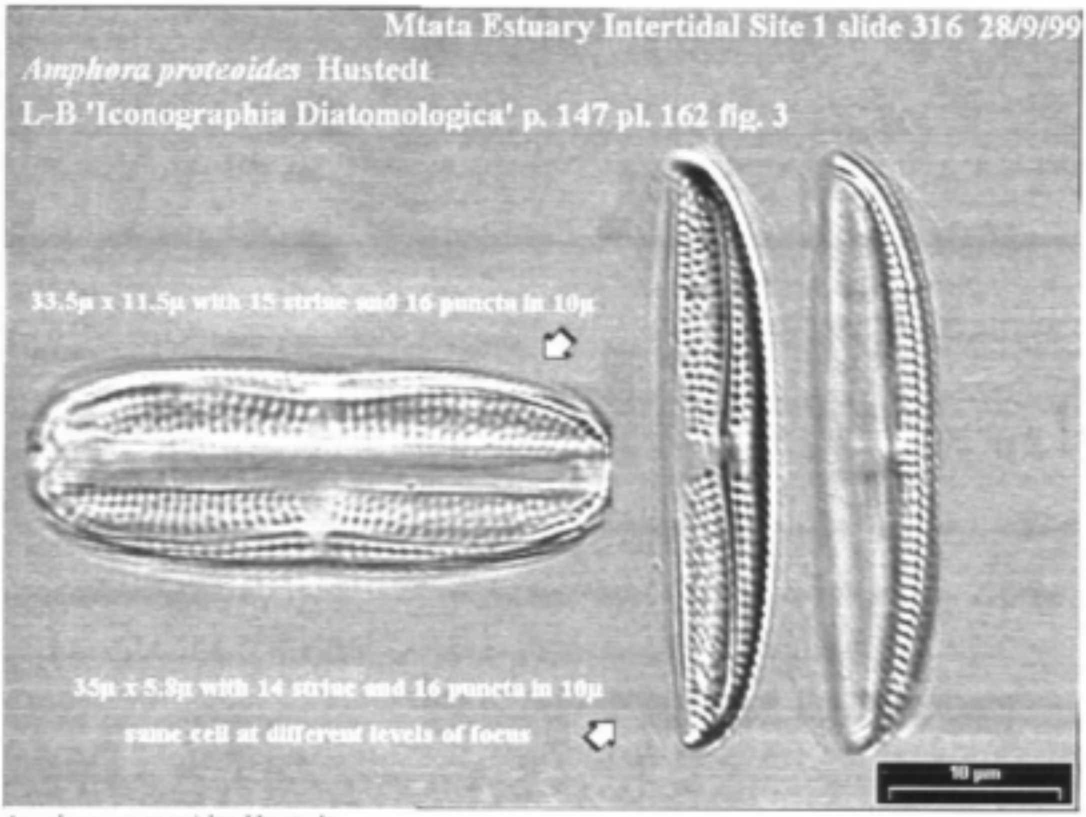
AMPHOVaf



Amphora ovalis var. *affinis* (Kutzing) van Heurck
Reference used for identification: Archibald 1983. Page 51. Plate 5. Figure 127.
Locations - Dominant in epipelon – Goukamma Estuary Subtidal Site 4.

NOTES	NOTES
Found at salinity: 30 ppt.	

AMPHPROT



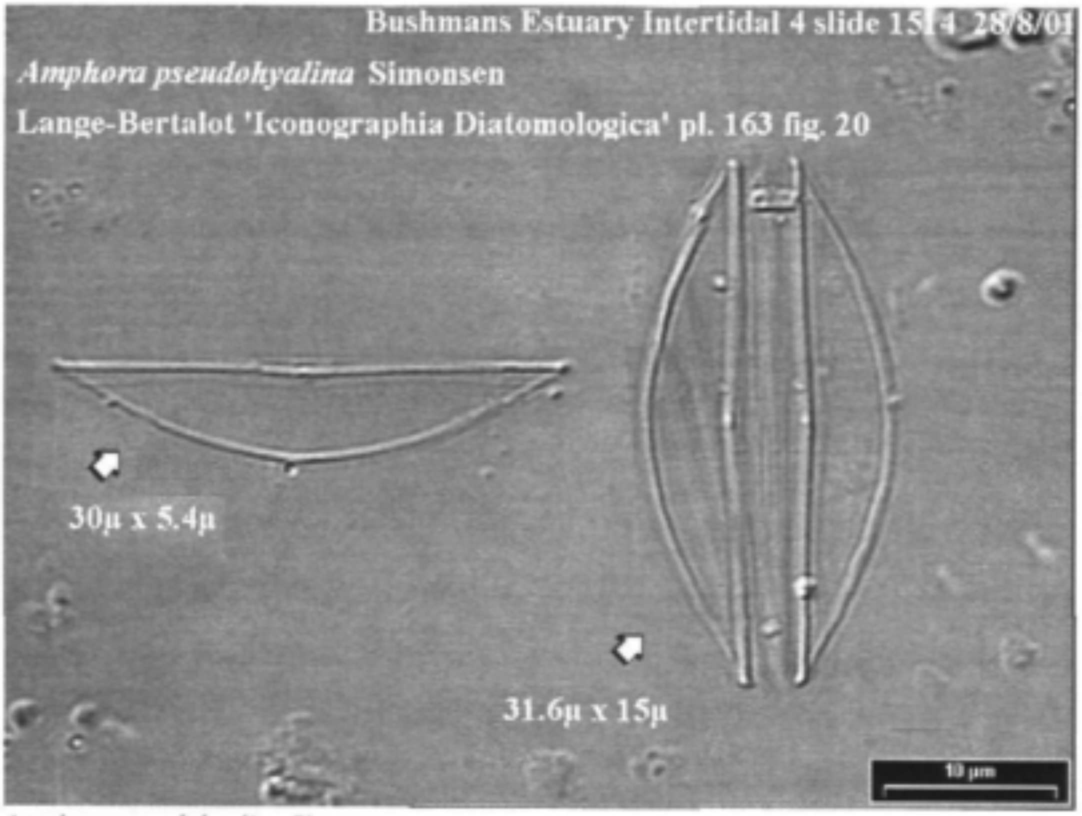
Amphora proteoides Hustedt

Reference used for identification: Lange-Bertalot 2000. Page 147. Plate 162. Figures 3 & 4. Simonsen 1987. Volume 3. Plate 625. Figure 4.

Locations - Dominant in epipelon – Mtata Estuary Intertidal Site 1.

NOTES	NOTES
Found at salinity: 35 ppt. Lange-Bertalot (2000): Marine.	

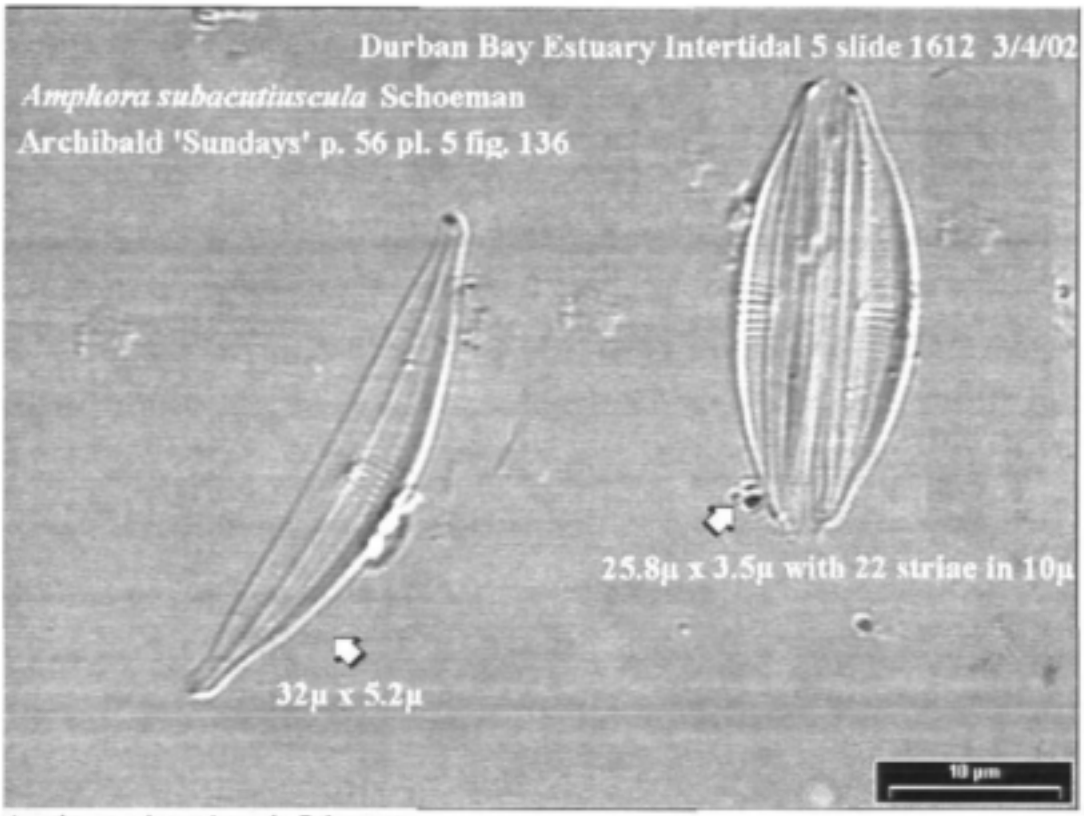
AMPHPSEU



Amphora pseudohyalina Simonsen
Reference used for identification: Lange-Bertalot 2000. Plate 163. Figure 21.
Locations - Dominant in epipelon – Bushmans Estuary Intertidal Site 4.

NOTES	NOTES
Found at salinity: 33 ppt.	

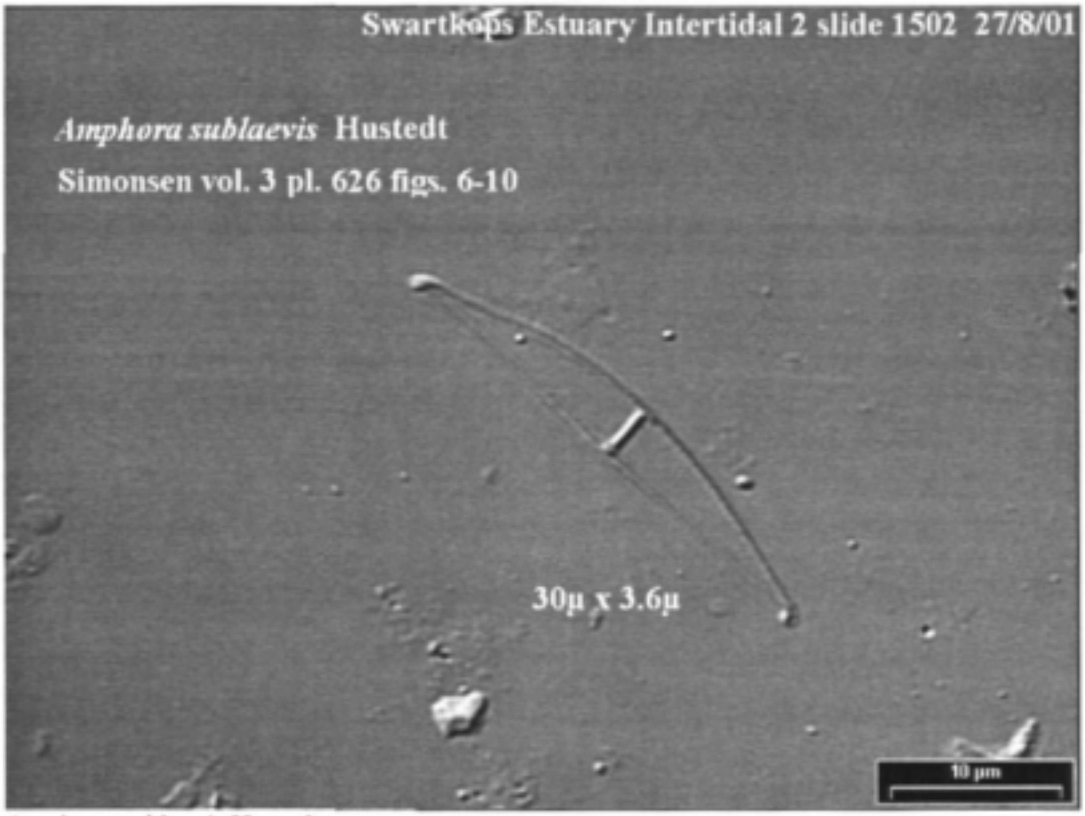
AMPHSUBA



Amphora subacutiuscula Schoeman
Reference used for identification: Archibald 1983. Page 56. Plate 5. Figure 136.
Lange-Bertalot 2000. Page 151. Plate 161. Figure 7.
Locations - Dominant in epipelon – Mngazana Estuary Intertidal & Subtidal Site 3; Great Fish Estuary Subtidal Site 1; Gourits Estuary Subtidal Site 3; Mtata Estuary Intertidal Site 3; Great Berg Estuary Subtidal Site 2; Durban Bay Estuary Intertidal Site 5; Bushmans Subtidal 4.

NOTES	NOTES
Found at salinity: 3 ppt.* & 20 – 34 ppt. *Mtata salinity very low by comparison with all other sites. This estuary had an extremely high TSS which may account for the species at this salinity Lange-Bertalot (2000) – Brak.	

AMPHSUBL



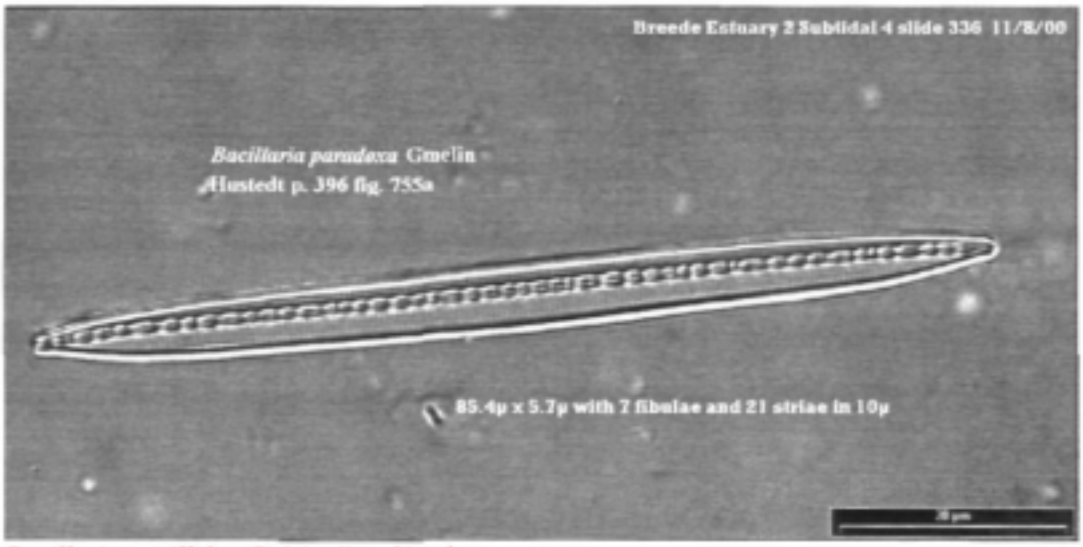
Amphora sublaevis Hustedt

Reference used for identification: Simonsen 1987. Volume 3. Plate 626. Figures 7-10.

Locations - Dominant in epipelon – Breede Estuary 3 Subtidal Site 1; Knysna Estuary Subtidal Site 1; Olifants Estuary Intertidal Site 1; Swartkops Estuary 1 Intertidal Site3; Swartkops 3 Intertidal & Subtidal 1; Swartkops Estuary 4 Intertidal Site 1 & 2; Kowie Estuary Intertidal Site 2; Mhlathuze Estuary Mouth Site.

NOTES	NOTES
Found at salinity: 28 – 37 ppt.	

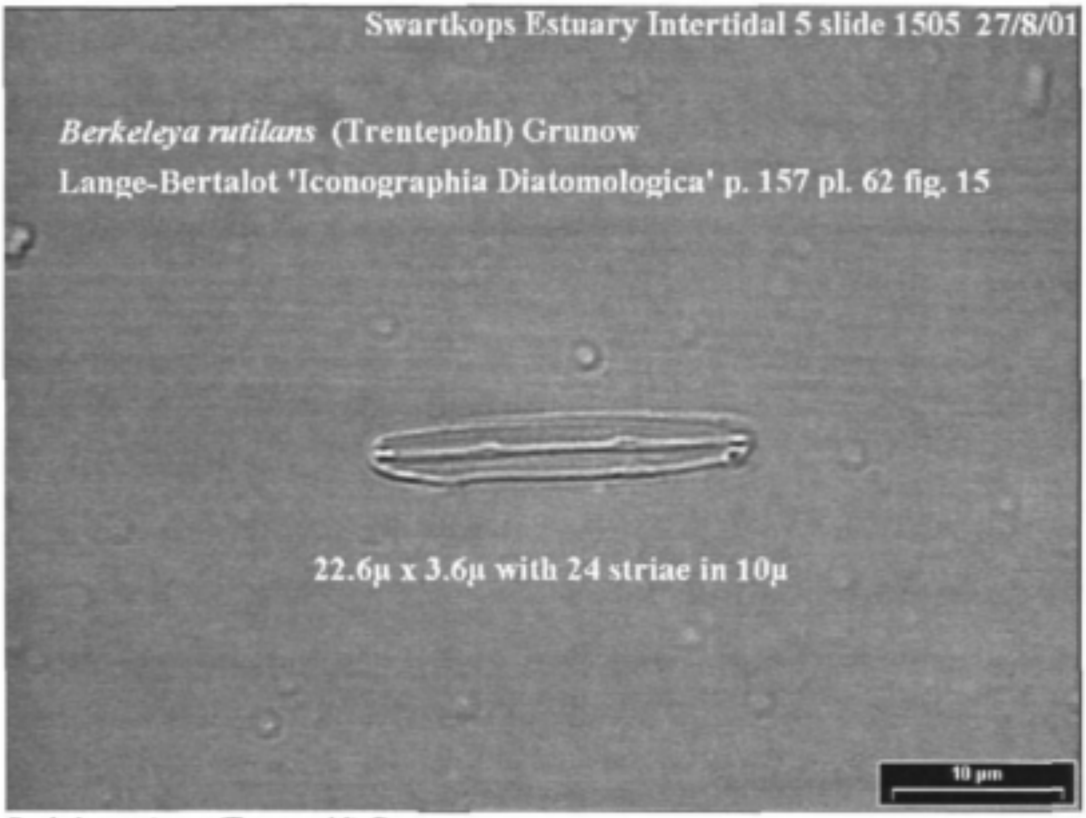
BACIPAXI



Bacillaria paxillifer (O. Mueller) Hendey
Reference used for identification: Hartley 1996. Page 82. Plate 33. Figure 8.
Locations - Dominant in epipelon – Breede Estuary 2 Intertidal Site 4, Subtidal Sites 4 & 5; Nhlabane Estuary Subtidal Sites F & H; Mhlathuze Estuary Bridge Site & Subtidal Site 2; Great Berg Estuary Intertidal Site 5.

NOTES	NOTES
Found at salinity: 0 – 25 ppt. Hustedt (1976): Brak. Lange-Bertalot (2000): Brak. Sims (1996): Brak.	

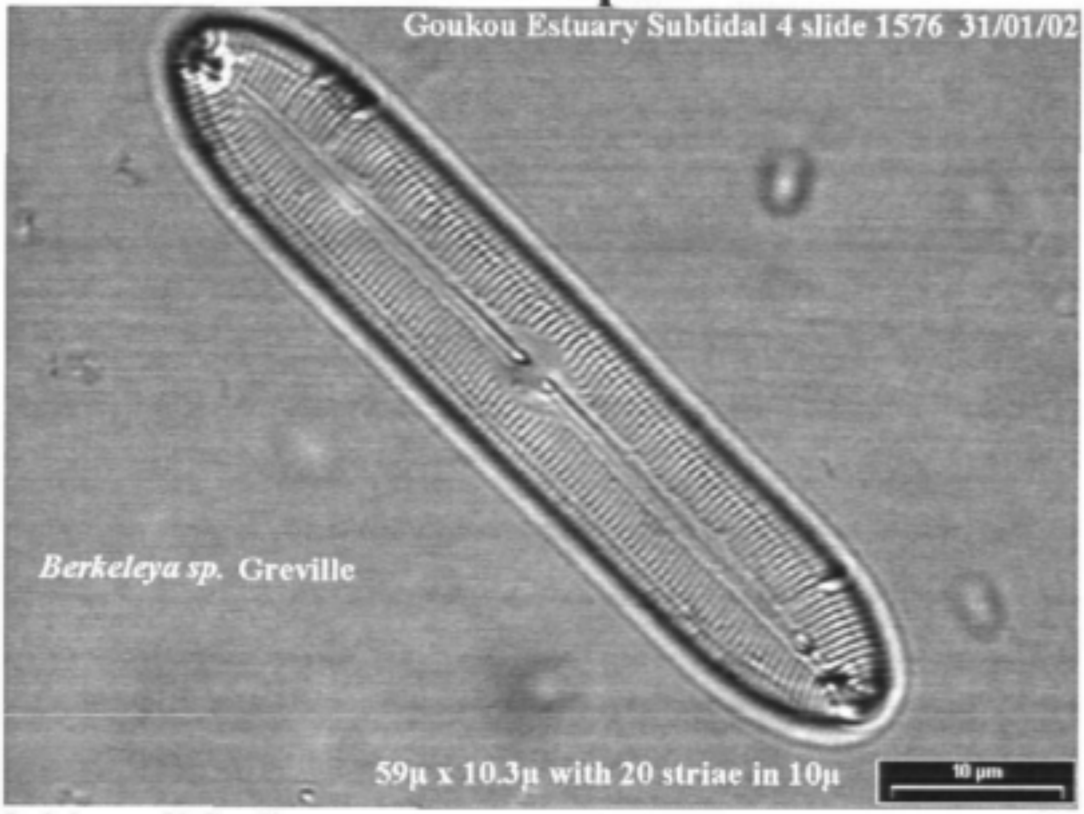
BERKRUTI



Berkeleya micans (Trentepohl) Grunow
Reference used for identification: Lange-Bertalot 2000. Page 157. Plate 62. Figure 15.
Locations - Dominant in epipelon – Keurbooms Estuary Subtidal Site 1.

NOTES	NOTES
Found at salinity: 33 ppt. Archibald (1983): Brak-Marine. Krammer & Lange-Bertalot (1986): Marine. Lange-Bertalot (2000): Brak-Marine. Sims (1996): Marine.	

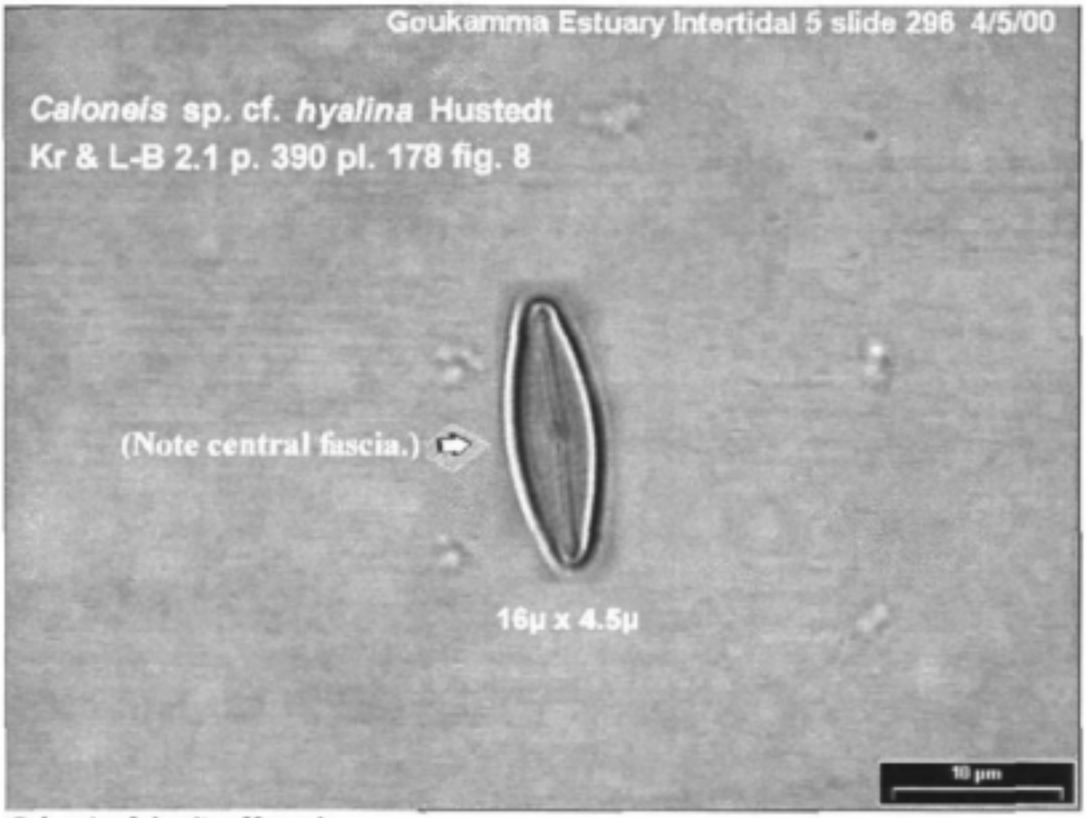
BERKsp01



Berkeleya sp. 01 Greville
Reference used for identification: Round, Crawford & Mann 1990. See page 518.
Locations - Dominant in epipelon – Goukou Estuary Subtidal Site 4.

NOTES	NOTES
Found at salinity: 14 ppt. Round *et al.* (1990): Marine genus.	

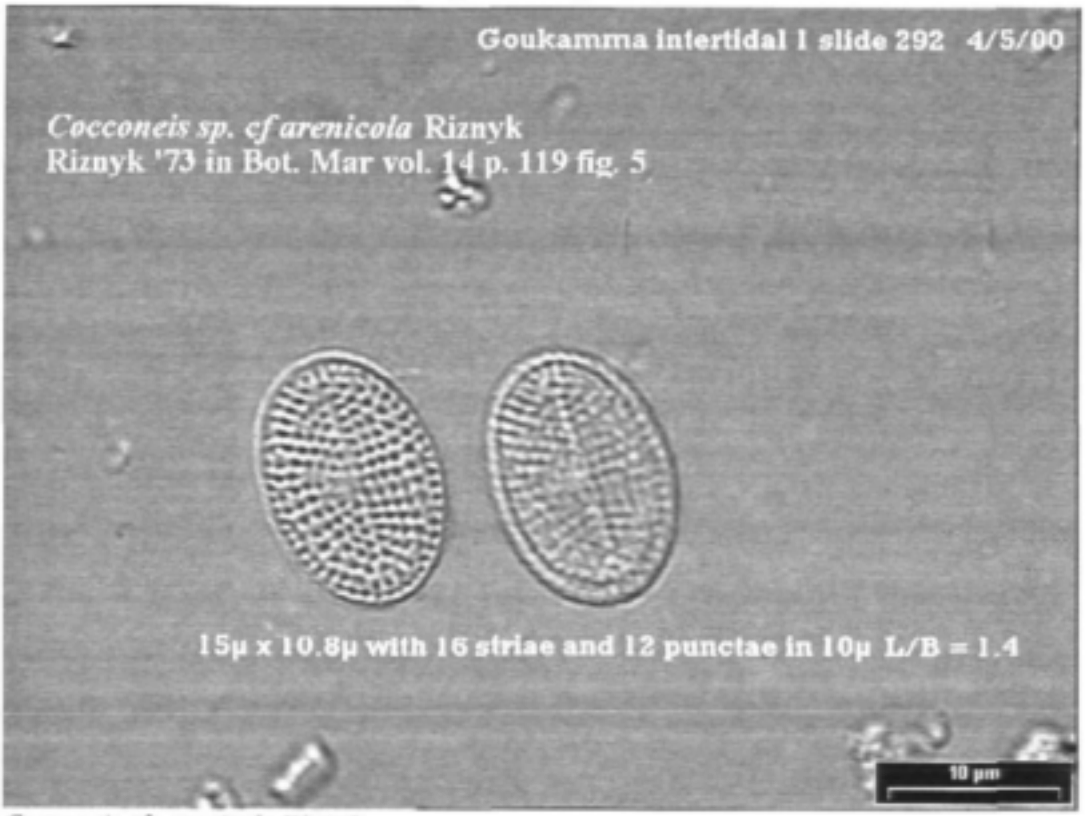
CALOcfHY



Caloneis cf. *hyalina* Hustedt
Reference used for identification: Krammer & Lange-Bertalot 1986. Page 390. Plate 178. Figure 8.
Locations - Dominant in epipelon – Goukamma Estuary Intertidal Site 5.

NOTES	NOTES
Found at salinity: 5 ppt.	

COCCcfAR



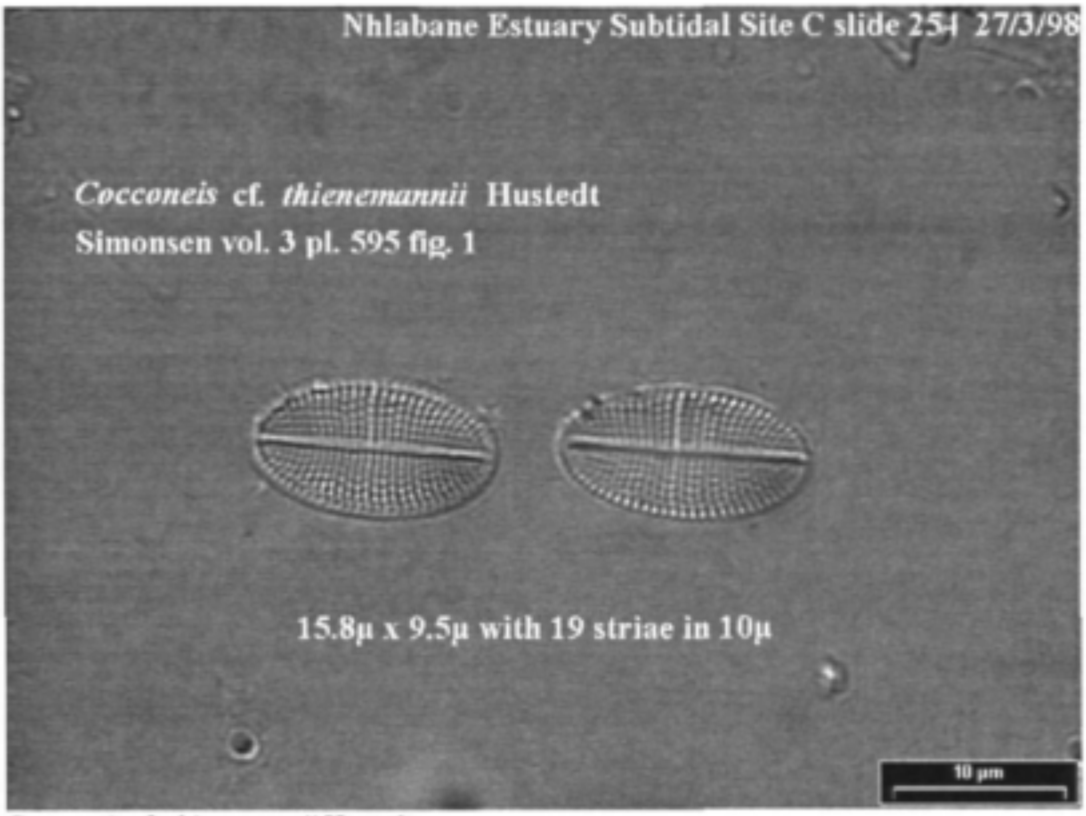
Cocconeis cf. *arenicola* Riznyk

Reference used for identification: Botanica Marina. 1973. Volume 14. Page 119. Figure 5.

Locations - Dominant in epipelon – Goukamma Estuary Intertidal Site 1.

<u>NOTES</u>	<u>NOTES</u>
Found at salinity: 29 ppt.	This is a heterovalvar genus having one valve with a rahpe-sternum and the other lacking the raphe, but having a corresponding sternum.

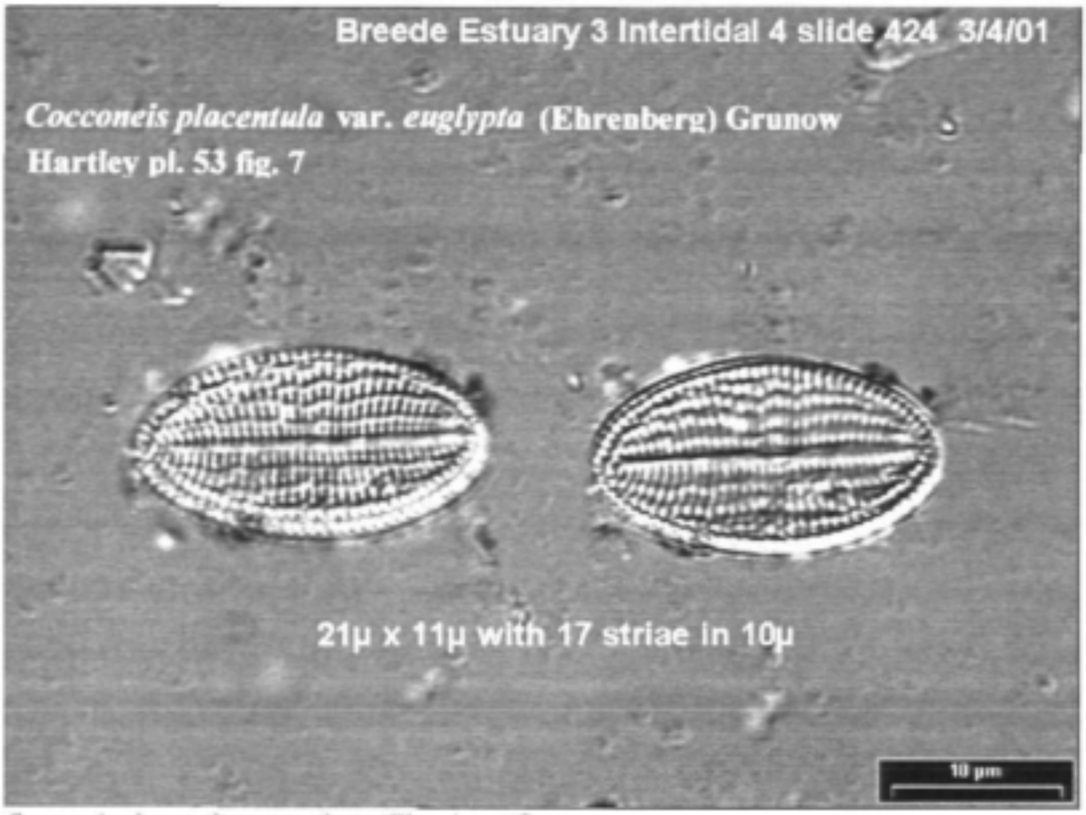
COCCcfTH



Cocconeis cf. *thienemannii* Hustedt
Reference used for identification: Simonsen 1987. Volume 3. Plate 595. Figure 1.
Locations - Dominant in epipelon – Nhlabane Estuary Subtidal Sites A, B & C.

NOTES	NOTES
Found at salinity: 0 – 13 ppt.	This is a heterovalvar genus having one valve with a rahpe-sternum and the other lacking the raphe, but having a corresponding sternum.

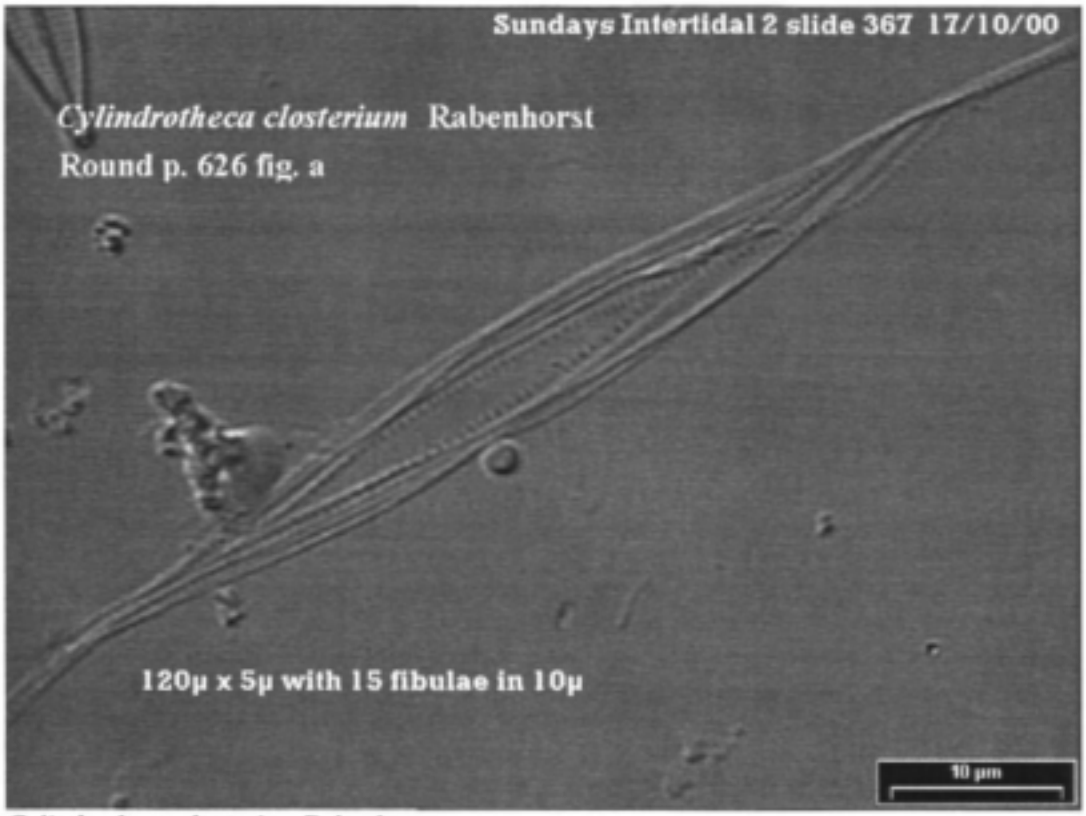
COCCPLeu



Cocconeis placentula var. *euglypta* (Ehrenberg) Grunow
Reference used for identification: Hustedt 1976. Page 189. Figure 260.
Locations - Dominant in epipelon – Breede Estuary 3 Intertidal Site 4; Knysna Subtidal Site 4.

NOTES	NOTES
Found at salinity: 7- 28 ppt. Patrick & Reimer (1975) : Fresh water – Brak. Sims (1996): Fresh water.	This is a heterovalvar genus having one valve with a raphe-sternum and the other lacking the raphe, but having a corresponding sternum.

CYLICLOS



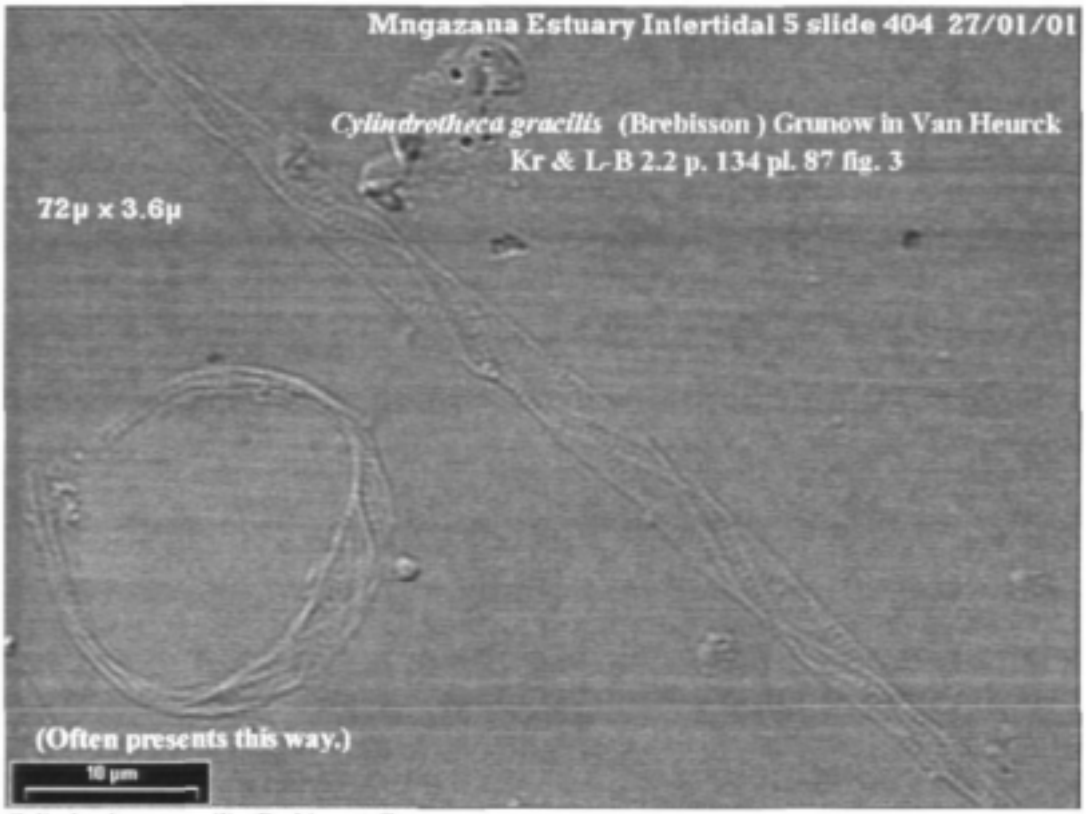
Cylindrotheca closterium Rabenhorst

Reference used for identification: Round, Crawford & Mann 1990. Page 626. Figure a.

Locations - Dominant in epipelon – Olifants Estuary Intertidal Site 2; Gourits Estuary Subtidal Site 1; Keurbooms Subtidal 1.

NOTES	NOTES
Found at salinity: 16 - 39 ppt. Krammer & Lange-Bertalot (1986): Brak.	

CYLIGRAC



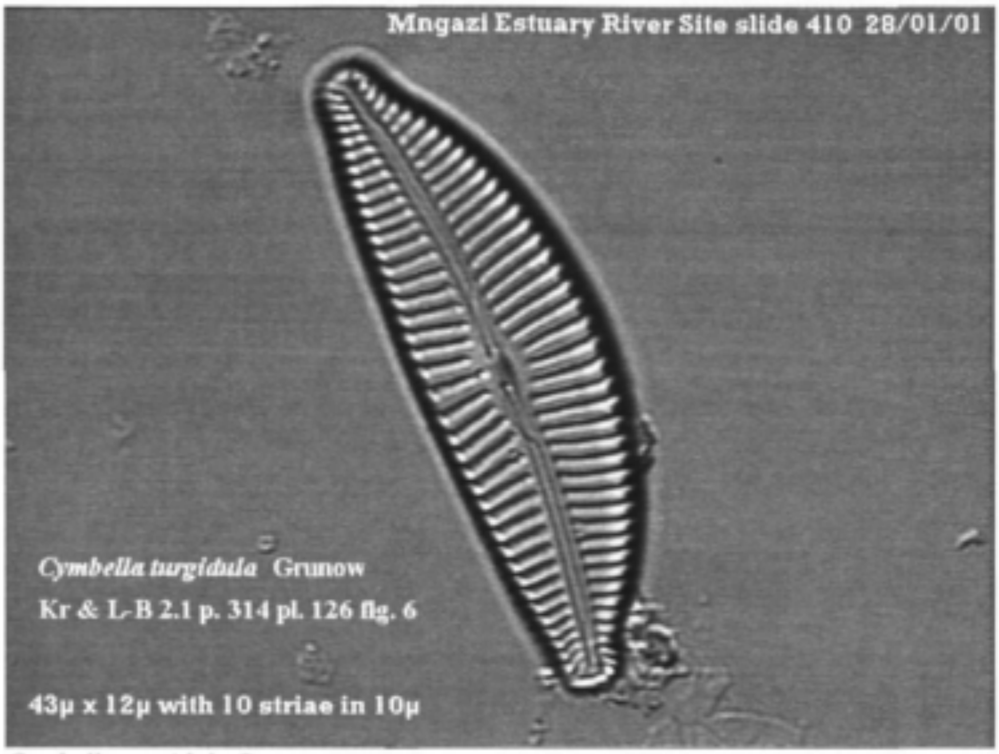
Cylindrotheca gracilis (Brebisson) Grunow

Reference used for identification: Krammer & Lange-Bertalot 1986. 2.2 Page 134. Plate 87. Figure 3.

Locations - Dominant in epipelon –Bushmans Estuary Subtidal 2; Mzimkulu Estuary Intertidal Site 2; Mngazana Intertidal Site 5.

NOTES	NOTES
Found at salinity: 5 – 34 ppt. Hustedt (1976): Brak. Lange-Bertalot (2000): Marine. Sims (1996): Brak – Marine.	

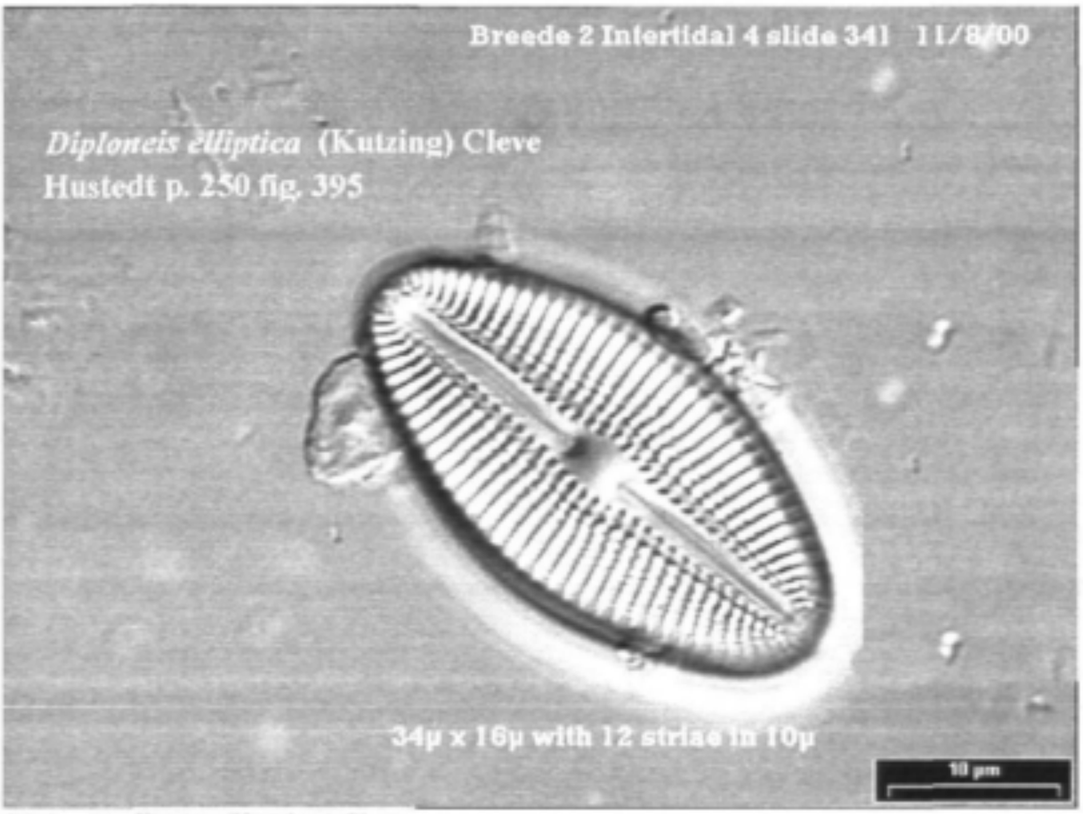
CYMBTURG



Cymbella turgidula Grunow
Ref. used for identification: Krammer & Lange-Bertalot 1986. 2.1. Page 314. Plate 126. Figure 11.
Locations - Dominant in epipelon – Mngazi Estuary River Site.

NOTES	NOTES
Found at salinity 0 ppt and also at 30 ppt.	This species, which is a fresh water species, was also found at Mzimkulu Estuary at site Subtidal 3 where the salinity was 30 ppt at dominance of 16 %. Because it is a fresh water species, this high salinity can only be the result of a recent seawater intrusion.

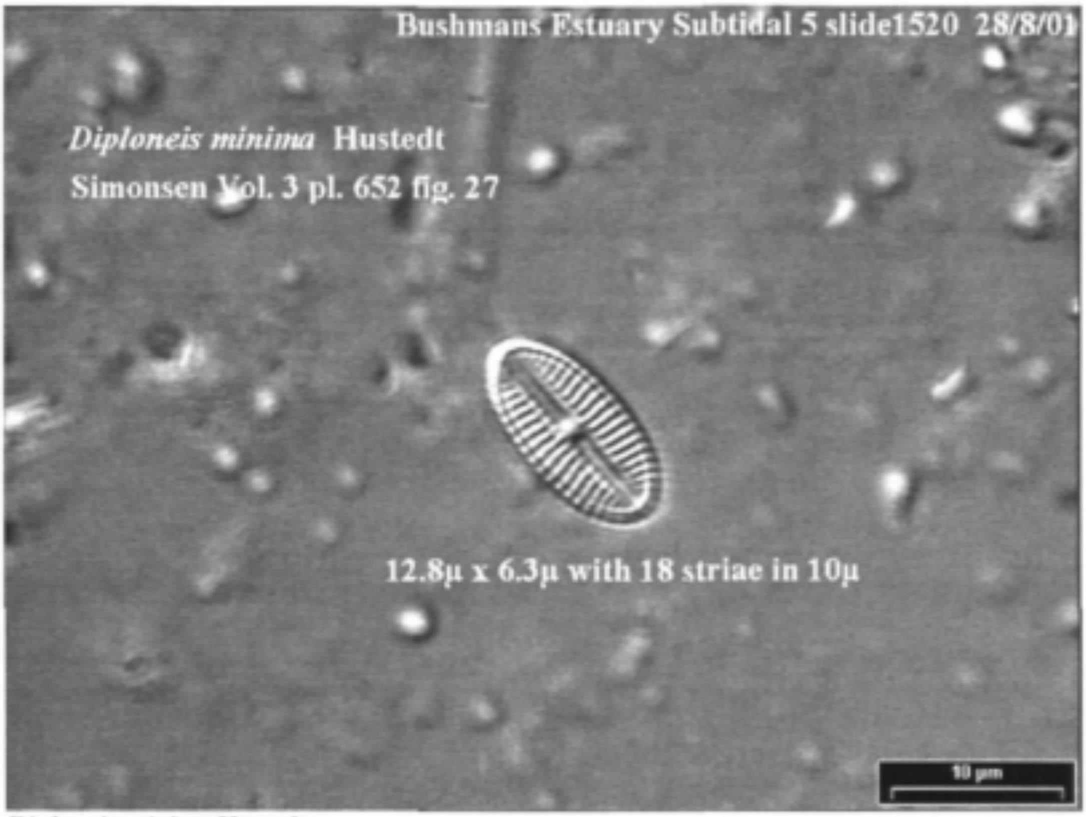
DIPLELLI



Diploneis elliptica (Kutzing) Cleve
Reference used for identification: Hustedt 1976. Page 250. Figure 395.
Locations - Dominant in epipelon – Olifants Estuary Subtidal Sites 2, 3 & 4; Sundays Estuary Subtidal Site 3 & 4; Mlalazi Estuary Intertidal Site 1.

NOTES	NOTES
Found at salinity: 9 – 28 ppt. Patrick & Reimer (1975): Fresh water – Brak. Sims (1996): Fresh water – Brak.	

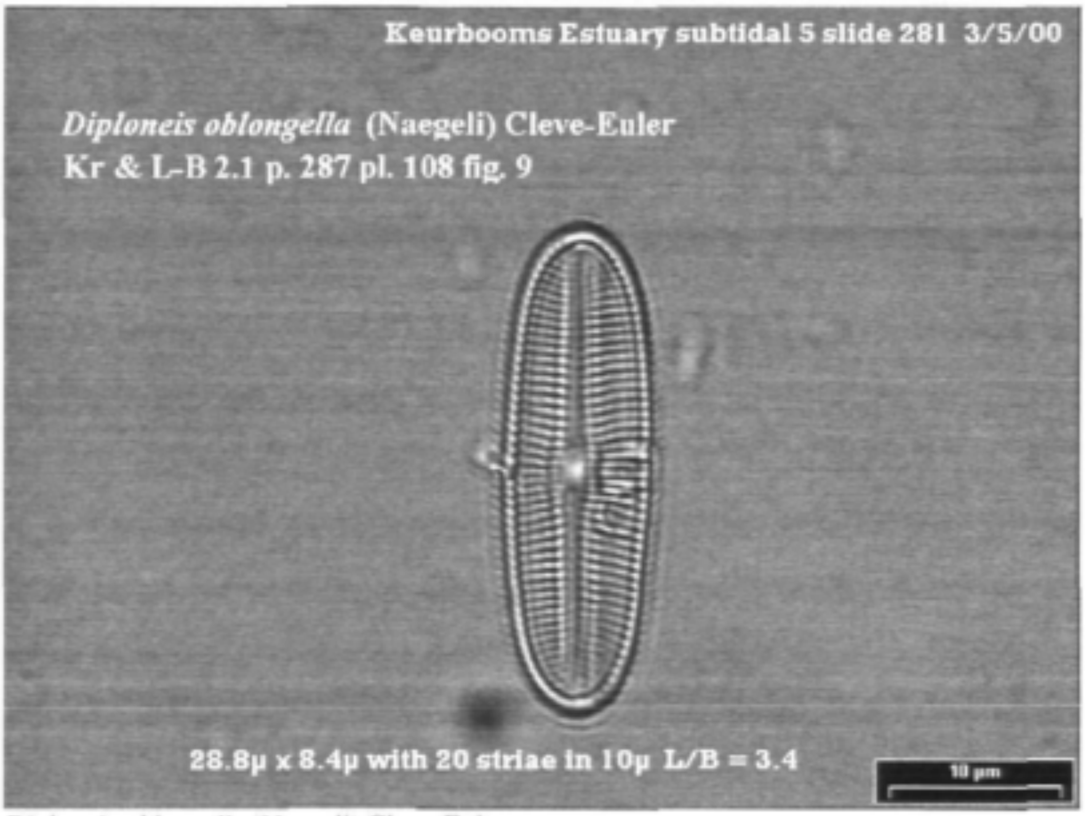
DIPLMINI



Diploneis minima Hustedt
Reference used for identification: Simonsen 1987. Volume 3. Plate 652. Figure 27.
Locations - Dominant in epipelon – Bushmans Estuary Subtidal Site 5.

NOTES	NOTES
Found at salinity 33 ppt.	

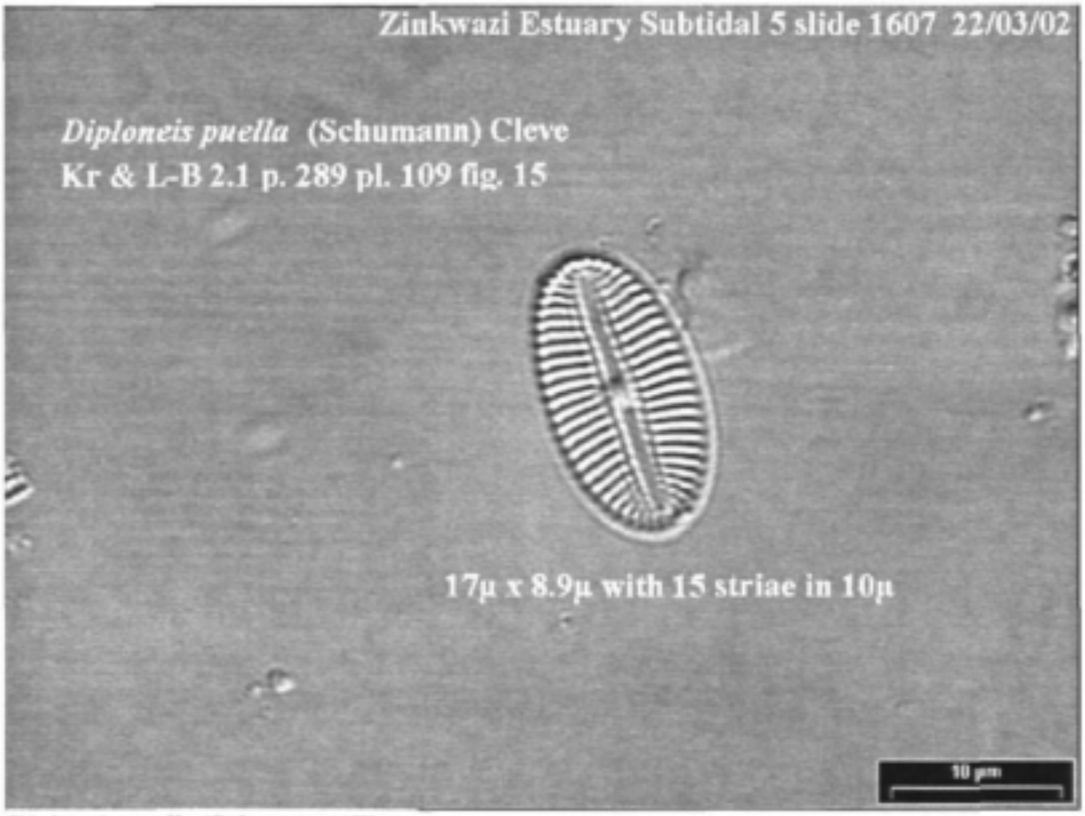
DIPLOBLO



Diploneis oblongella (Naegeli) Cleve-Euler
Reference used for identification: Krammer & Lange-Bertalot 1986. 2.1 Page 287. Plate 108. Figure 9.
Locations - Dominant in epipelon – Keurbooms Estuary Subtidal Site 5.

NOTES	NOTES
Found at salinity 2 ppt. Patrick & Reimer (1975): Fresh water – Brak. Sims (1996): Fresh water.	

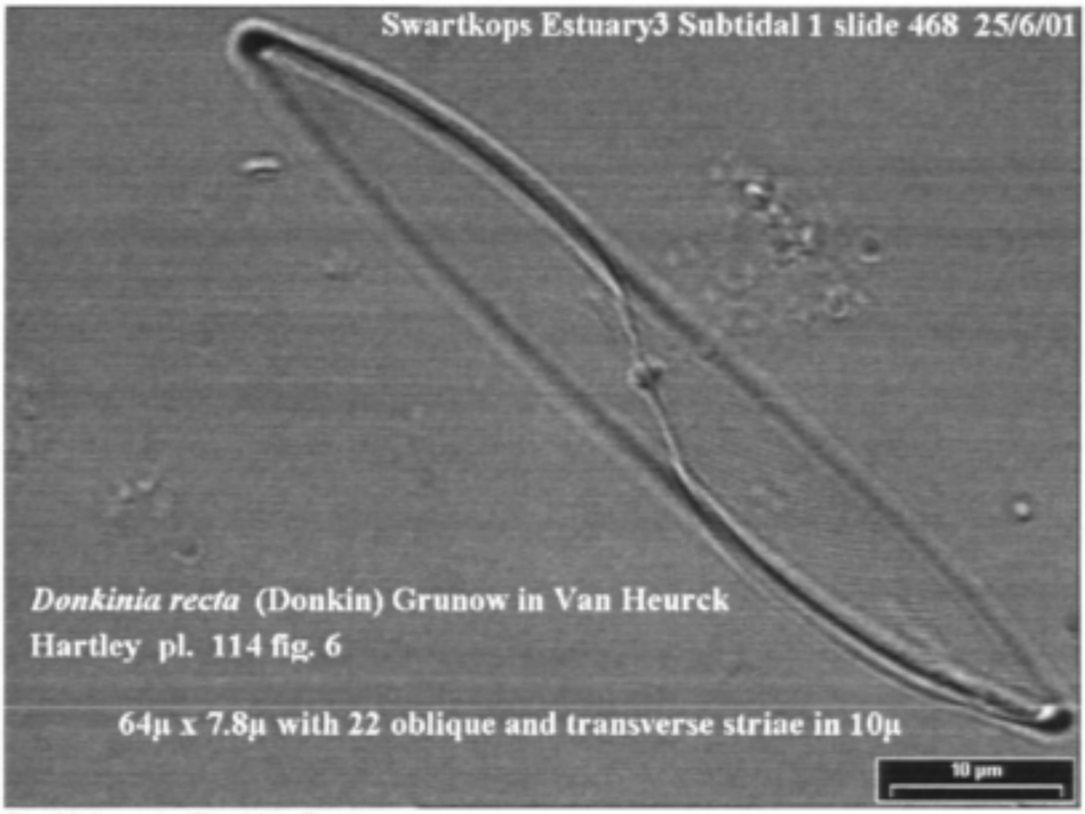
DIPLPUEL



Diploneis puella (Schumann) Cleve
Ref. used for identification: Krammer & Lange-Bertalot 1986. 2.1 Page 289. Plate 109. Figure 15.
Locations - Dominant in epipelon –Nhlabane Estuary Intertidal & Subtidal Site G.

NOTES	NOTES
Found at salinities 16 – 23 ppt. Patrick & Reimer (1975): Fresh water – Brak.	

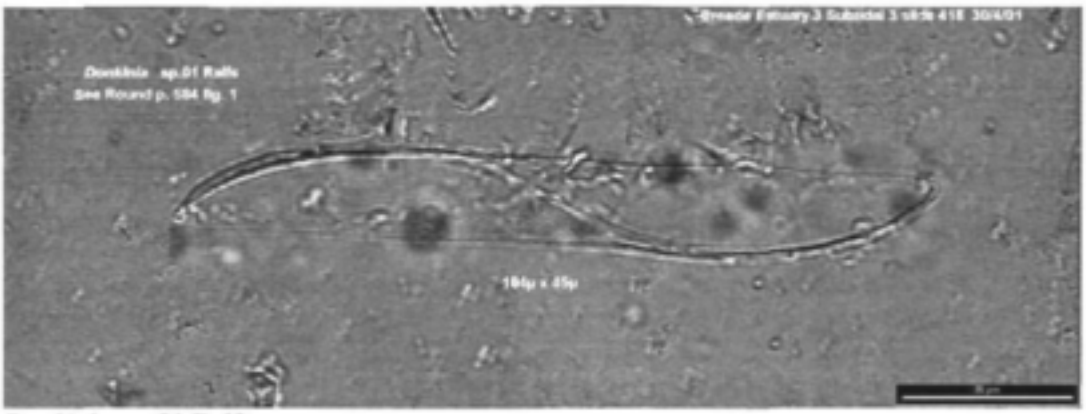
DONKRECT



Donkinia recta (Donkin) Grunow
Reference used for identification: Hartley 1996. Plate 114. Figure 6.
Locations - Dominant in epipelon – Swartkops Estuary 2 Intertidal Site 1.

NOTES	NOTES
Found at salinity 32 ppt. Sims (1996): Marine.	

DONKSP01



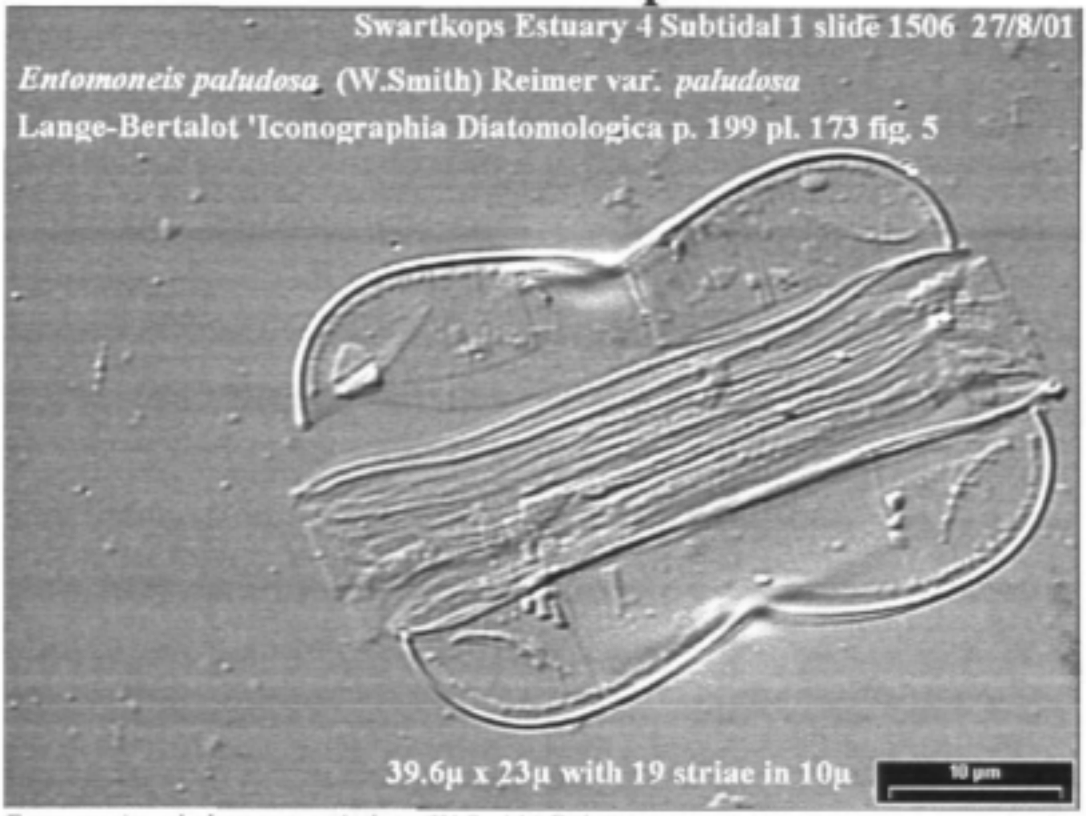
Donkinia sp. 01 Ralfs

Reference used for identification: Round, Crawford & Mann 1990. Page 584. Figure a.

Locations – Dominant in epipelon – Breede Estuary 3 Subtidal Sites 2.

<u>NOTES</u>	<u>NOTES</u>
Found at salinity 25 ppt. Round *et al*. (1990): Marine genus.	

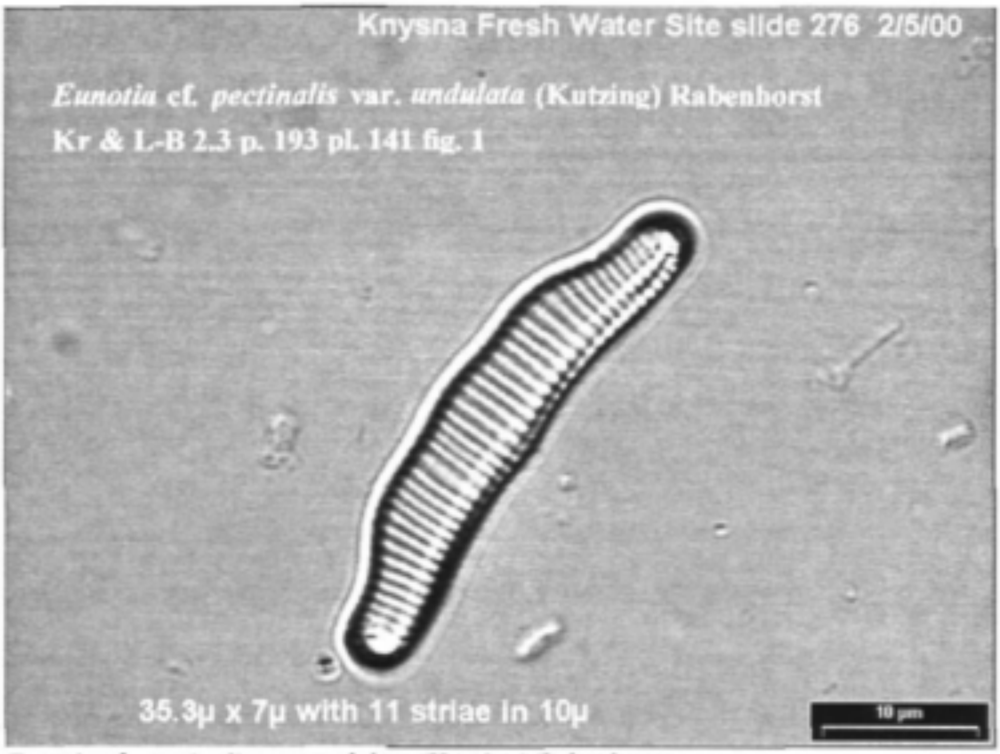
ENTOPApa



Entomoneis paludosa var. *paludosa* (W.Smith) Reimer
Reference used for identification: Lange-Bertalot 2000. Page 199. Plate 173. Figure 5.
Locations - Dominant in epipelon – Bushmans Estuary Intertidal Site 1.

NOTES	NOTES
Found at salinity 34 ppt. Sims (1996) : Marine.	

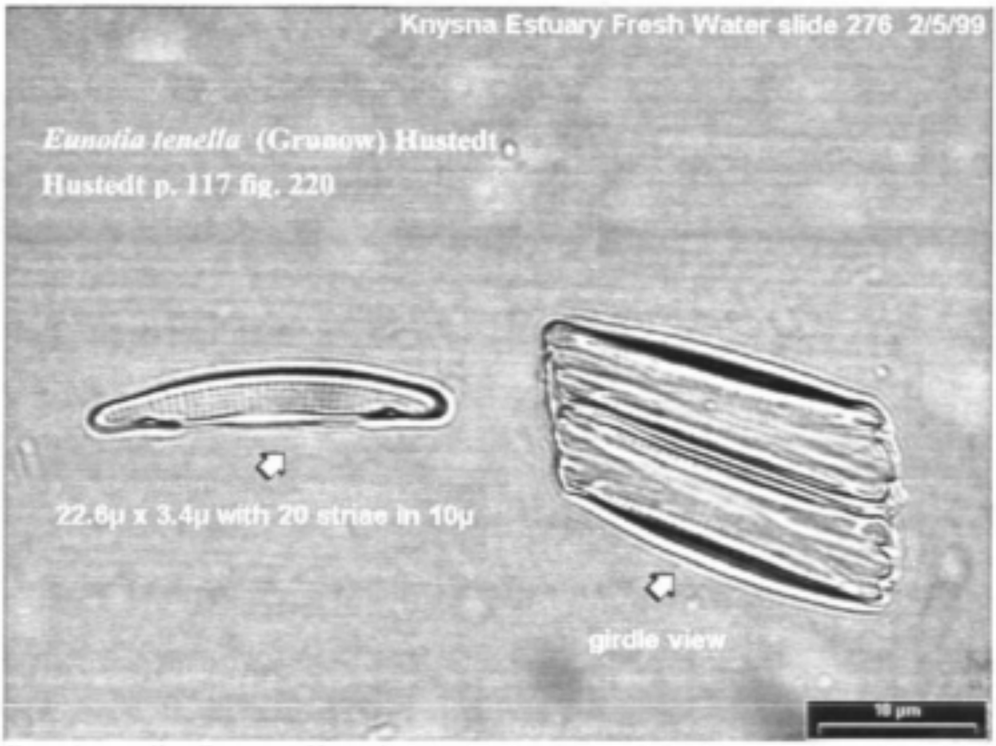
EUNOcfPE



Eunotia cf. *pectinalis* var. *undulata* (Kutzing) Rabenhorst
Reference used for identification: Krammer & Lange-Bertalot 1986.
Locations - Dominant in epipelon – Knysna Fresh Water Site.

NOTE	NOTE
This is a fresh water genus, found at the fresh water site of the Knysna Estuary.	

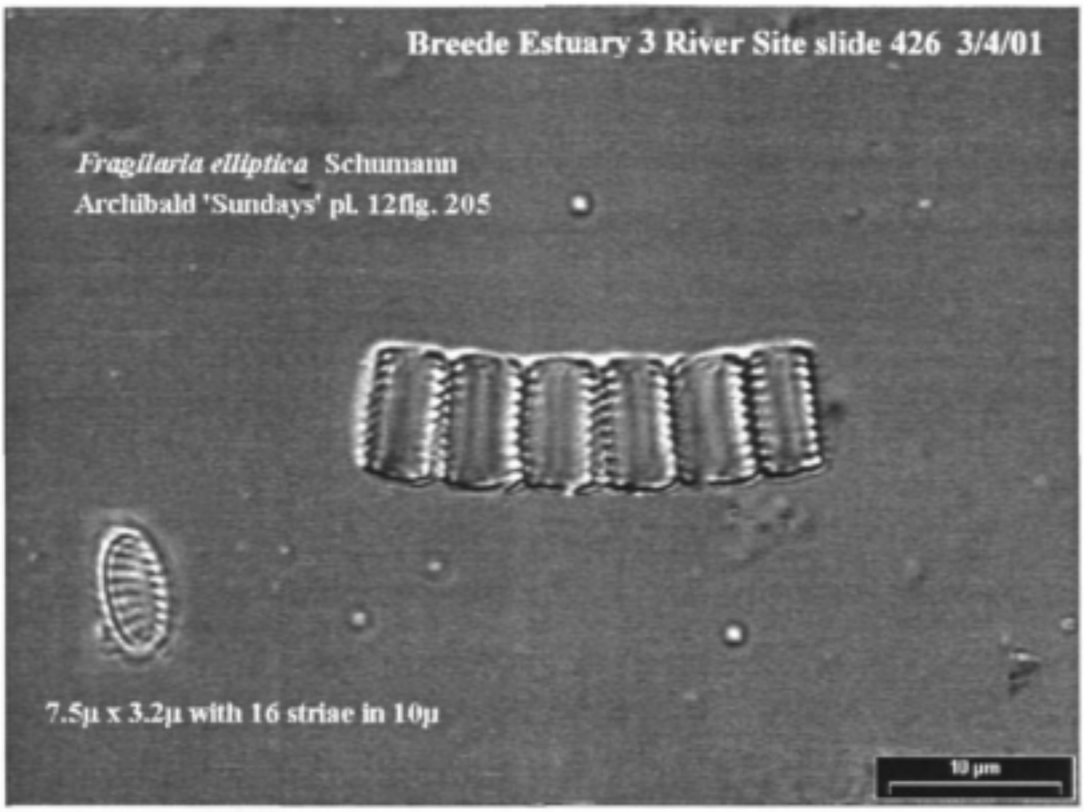
EUNOTENE



Eunotia tenella (Grunow) Hustedt
Reference used for identification: Hustedt 1976. Page 117. Figure 220.
Locations - Dominant in epipelon – Knysna Fresh Water Site.

NOTES	NOTES
Found at the fresh water site of the Knysna Estuary. Hustedt (1976): Fresh water. Sims (1996): Fresh water.	

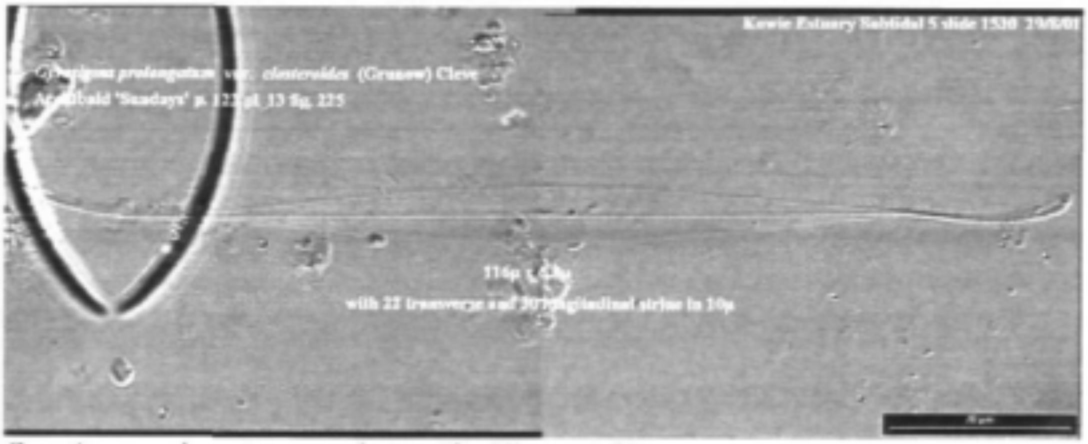
FRAGELLI



Fragilaria elliptica Schumann
Reference used for identification: Archibald 1983. Page 104. Plate 12. Figures 202 & 205.
Locations - Dominant in epipelon – Breede Estuary 3 Intertidal Site 5, Subtidal Sites 4 & 5 & River Site; Swartkops Estuary 1 Intertidal Site 5; Keurbooms Intertidal Site 2.

NOTES	NOTES
Found at salinity 0 & 38 ppt. Usually found in fresh water. The one site where the salinity was very high is difficult to understand.	

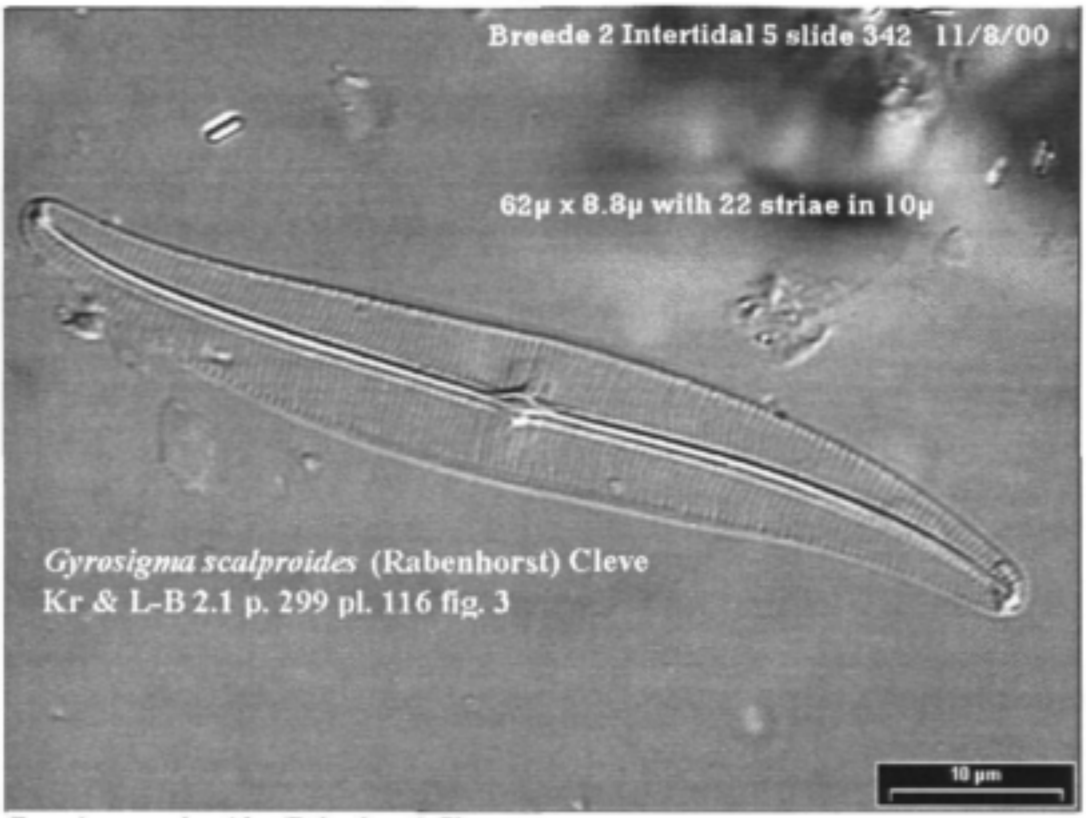
GYROPRcl



Gyrosigma prolongatum var. *closteroides* (Grunow) Cleve
Reference used for identification: Archibald 1983. Page 123. Plate 13. Figure 225.
Locations - Dominant in epipelon –Swartkops Estuary 3 Subtidal Site 3.

NOTES	NOTES
Found at salinity 24 ppt.	

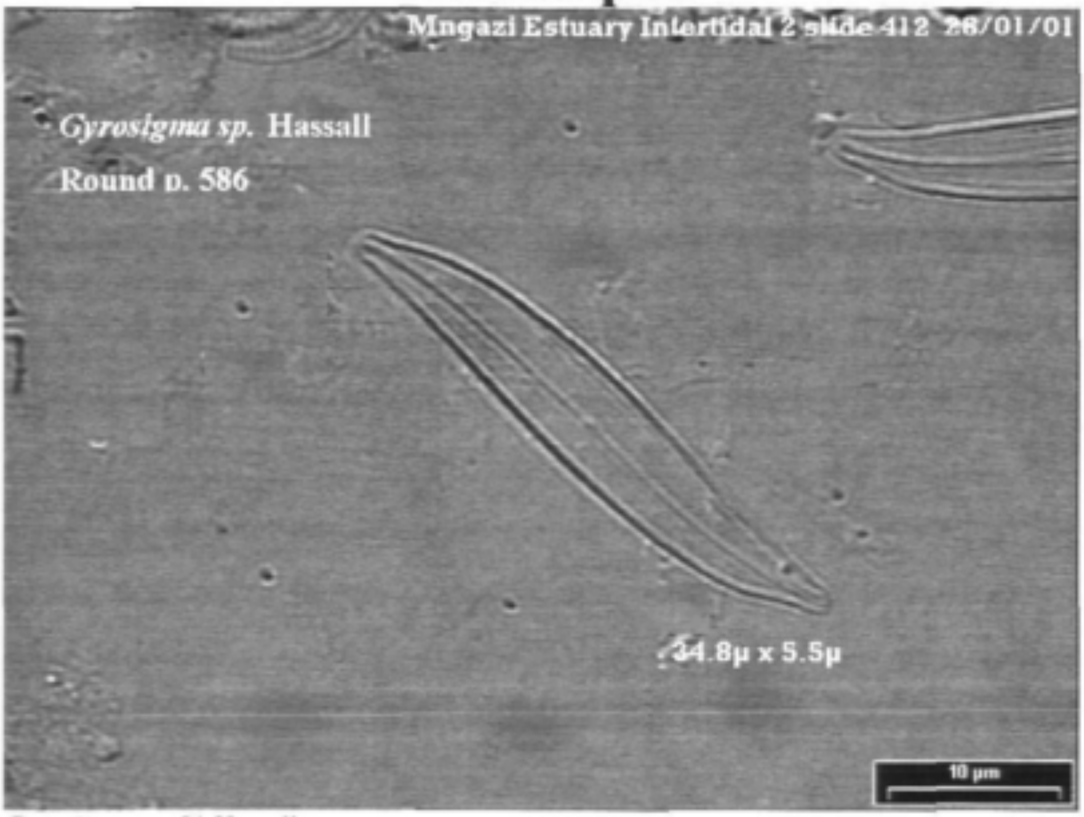
GYROSCAL



Gyrosigma scalproides (Rabenhorst) Cleve
Ref. used for identification: Krammer & Lange-Bertalot 1986. 2.1 Page 299. Plate 116. Figure 3.
Locations - Dominant in epipelon – Breede Estuary 2 Intertidal Site 5.

NOTES	NOTES
Found at salinity 0 ppt. Hustedt (1976): Brak. Krammer & Lange-Bertalot (1986): Fresh water. Schoeman & Archibald (1976): Fresh water. Sims (1996): Marine.	

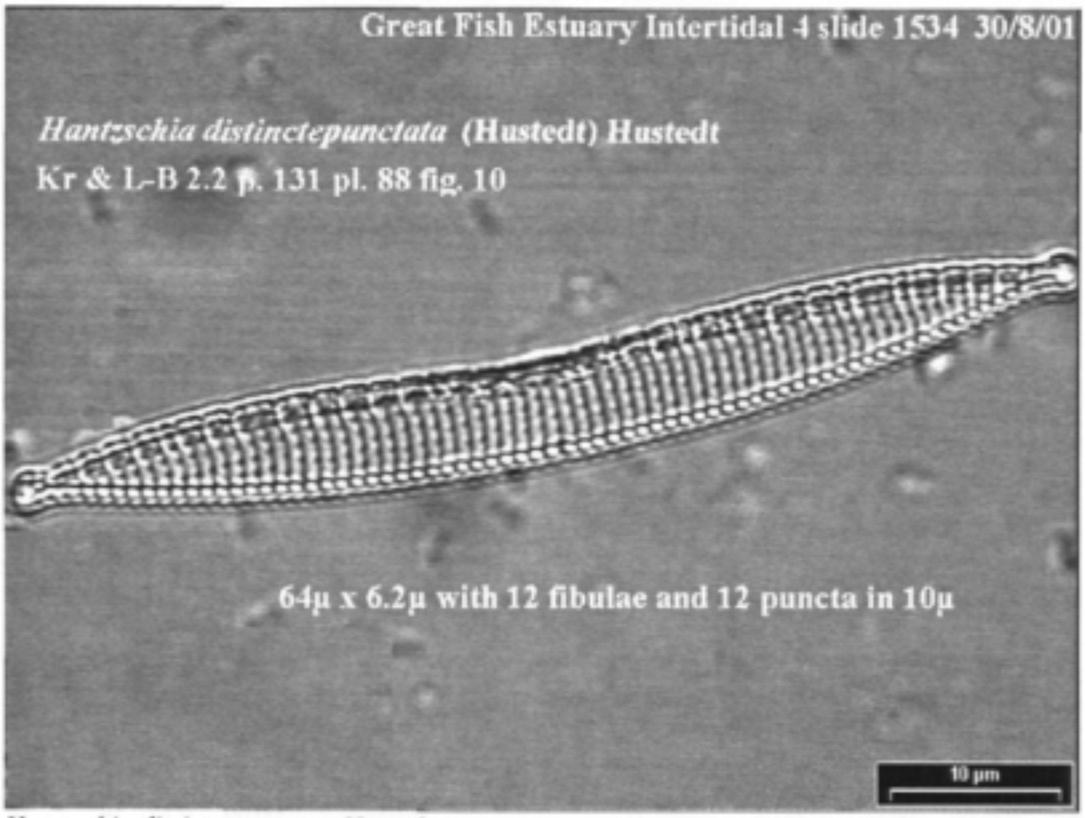
GYROsp01



Gyrosigma sp. 01 Hassall
This species had to be taken to scanning electron microscopy, as no striae are visible in light microscopy. There is was determined that it was a *Gyrosigma*.
Locations - Dominant in epipelon – Mngazi Estuary Intertidal Site 2.

NOTES	NOTES
Found at salinity 24 ppt.	

HANTDIST



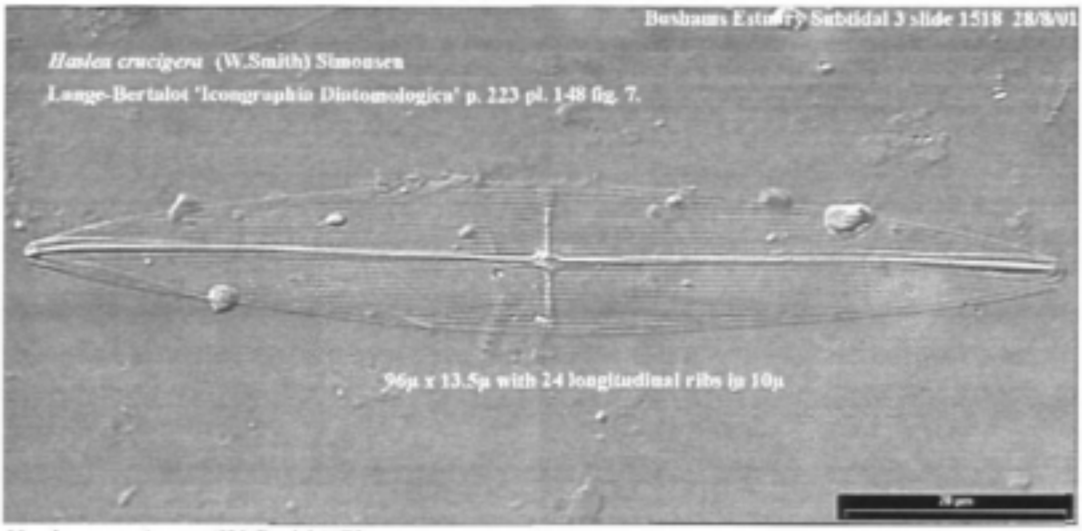
Hantzschia distinctepunctata Hustedt

Reference used for identification: Krammer & Lange-Bertalot 1986. 2.2 Page 131. Plate 88. Figure 10.

Locations - Dominant in epipelon – Keurbooms Estuary Intertidal Site 4; Nhlabane Estuary Intertidal Sites E, F & H; Sundays Estuary River Site.

NOTES	NOTES
Found at salinity 0 – 17 ppt. Krammer & Lange-Bertalot (1986): Fresh – Brak. Lange-Bertalot (2000): Fresh water – Marine.	

HASLCRUC



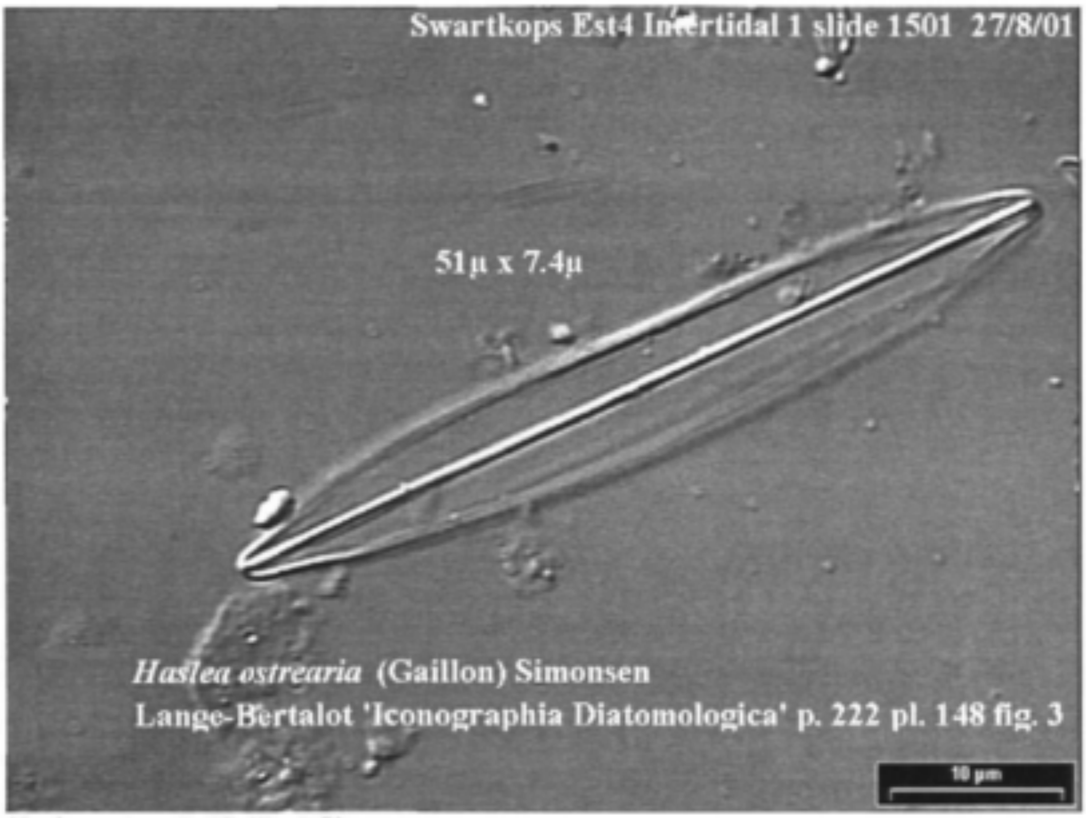
Haslea crucigera (W.Smith) Simonsen

Reference used for identification: Lange-Bertalot 2000. Page 223. Plate 147. Figure 2.

Locations - Dominant in epipelon –Kowie Estuary Subtidal Site 2.

NOTES	NOTES
Found at salinity 35 ppt. Lange-Bertalot (2000): Marine. Sims (1996): Marine.	

HASLOSTR



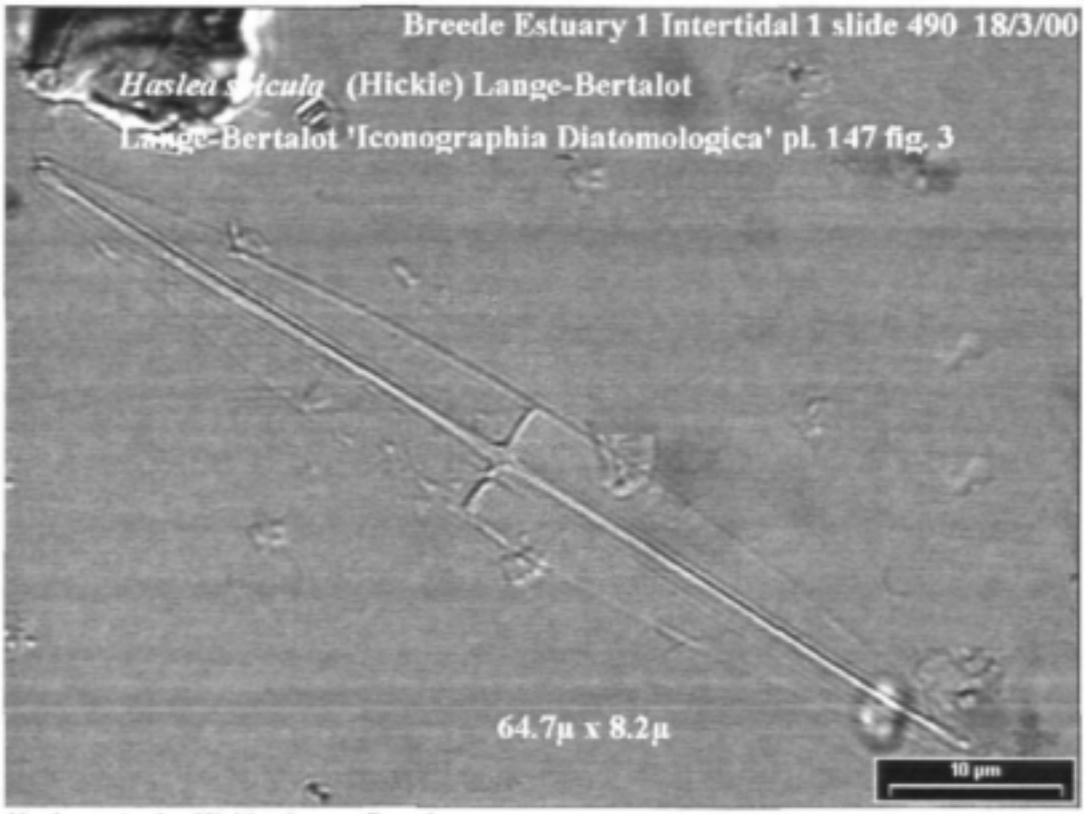
Haslea ostrearia (Gaillon) Simonsen

Reference used for identification: Lange-Bertalot 2000. Page 222. Plate 148. Figure 3.

Locations - Dominant in epipelon – Swartkops Estuary 3 Intertidal Site 5; Swartkops Estuary 4 Intertidal Site 1 & 3; Mpekqweni Subtidal Site 1.

NOTES	NOTES
Found at salinity 17 - 38 ppt. Lange-Bertalot (2000): Marine.	

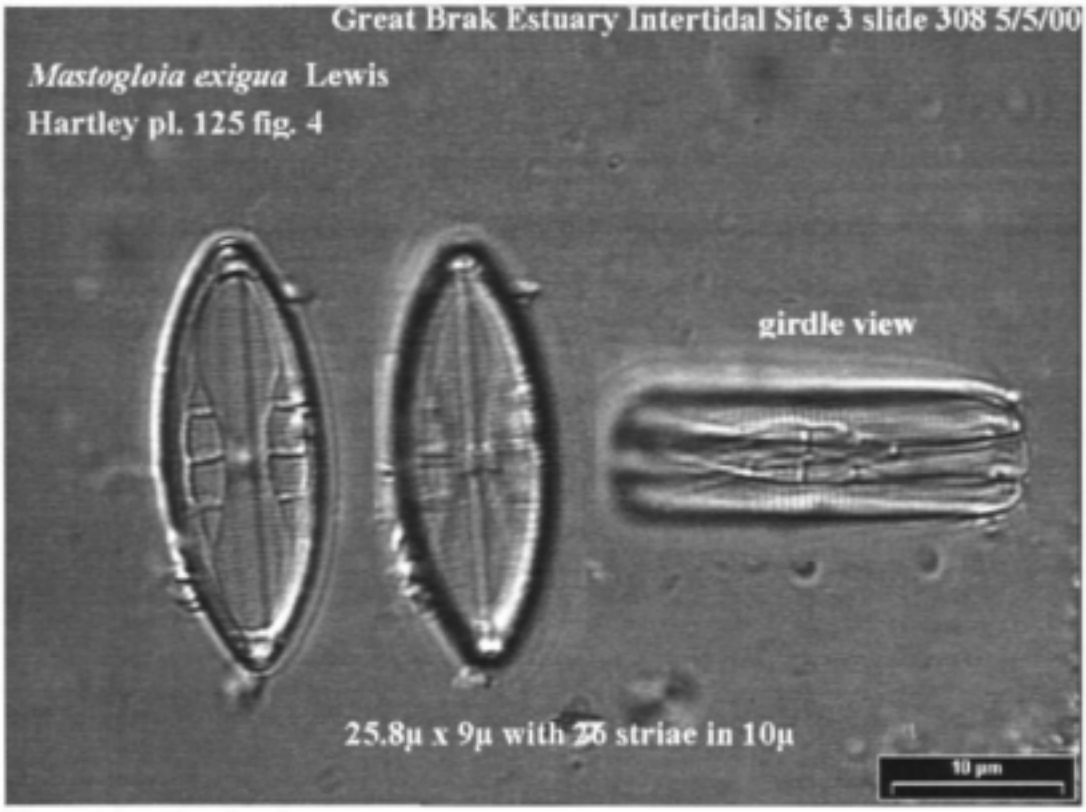
HASLSPIC



Haslea spicula (Hickie) Lange-Bertalot
Reference used for identification: Lange-Bertalot 2000. Plate 147. Figure 3.
Locations - Dominant in epipelon – Breede Estuary 1 Intertidal Site 1.

NOTES	NOTES
Found at salinity 20 ppt.	

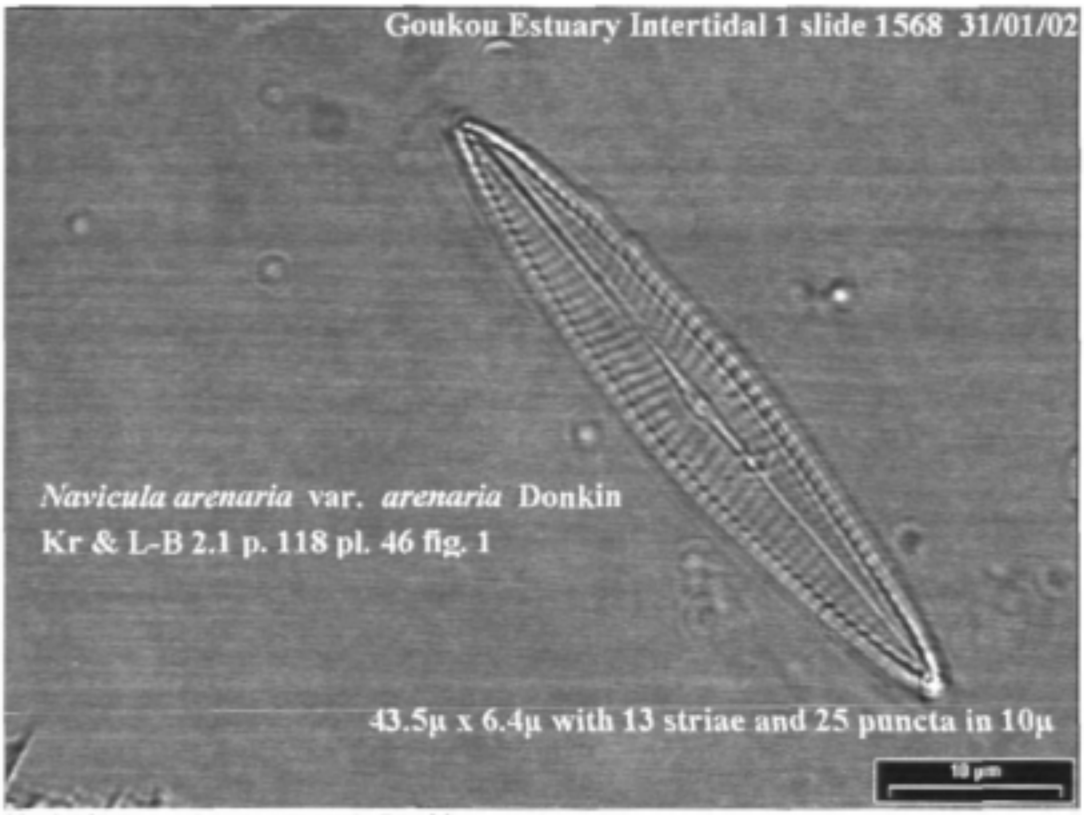
MASTEXIG



Mastogloia exigua Lewis
References used for identification: Hartley 1996. Plate 125. Figure 4. Lange-Bertalot 2000. Page 246. Plate 83. Figures 9 & 10.
Locations - Dominant in epipelon – Great Brak Estuary Intertidal Site 3.

NOTES	NOTES
Found at salinity 26 ppt. Sims (1996): Fresh water.	

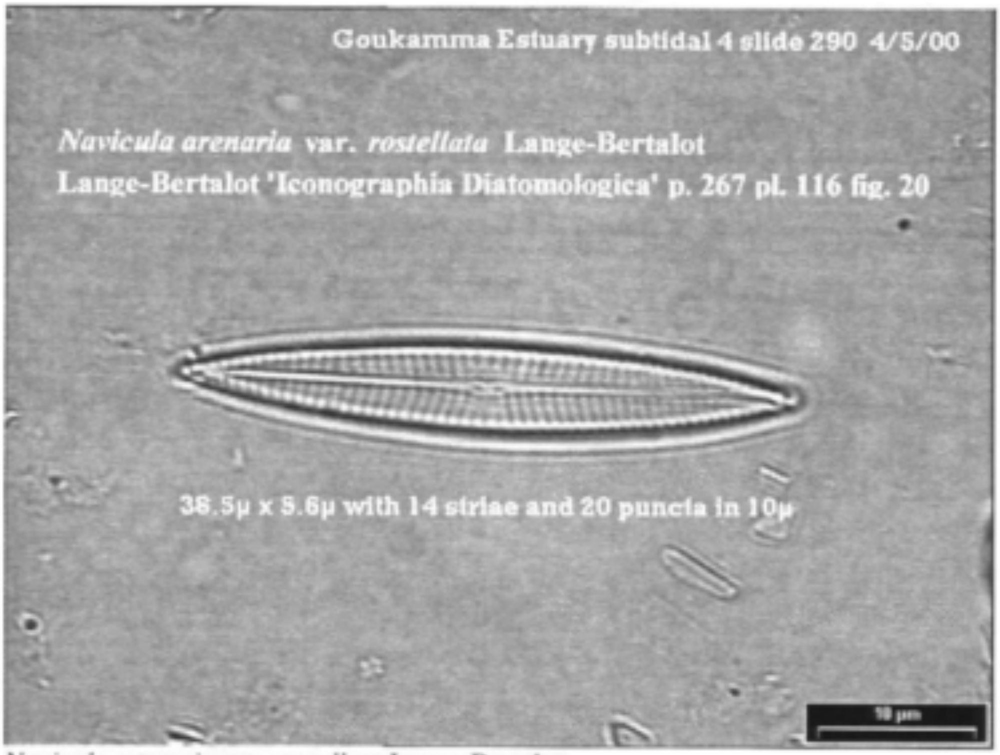
NAVIARar



Navicula arenaria var. *arenaria* Donkin
Reference used for identification: Krammer & Lange-Bertalot 1986. 2.1 Page 118. Plate 46. Figure 1.
Locations - Dominant in epipelon – Goukou Estuary Intertidal Site 1.

<u>NOTES</u>	<u>NOTES</u>
Found at salinity 20 ppt. Patrick & Reimer (1975): Brak. Sims (1996): Marine.	

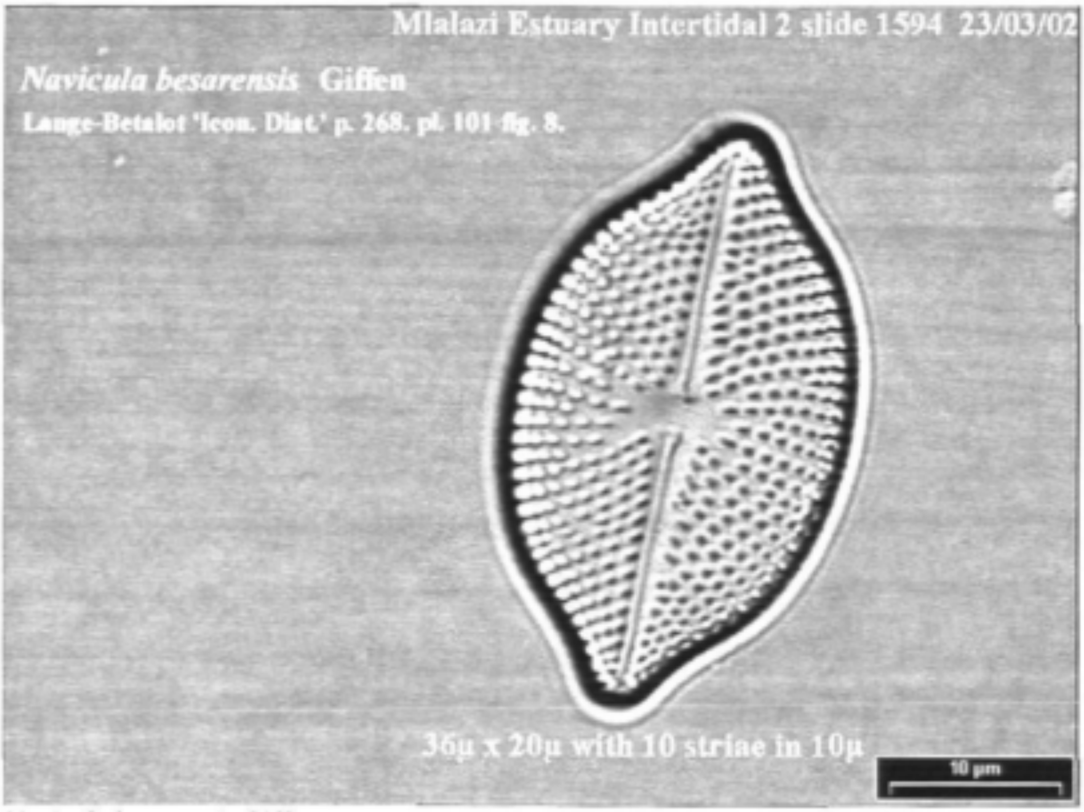
NAVIARro



Navicula arenaria var. *rostellata* Lange-Bertalot
Reference used for identification: Lange-Bertalot 2000. Page 267. Plate 116. Figure 20.
Locations - Dominant in epipelon – Mhalthuze Estuary Site 1.

NOTES	NOTES
Found at salinity 30 ppt. Lange-Bertalot (2000): Marine. Sims (1996): Marine.	

NAVIBESA



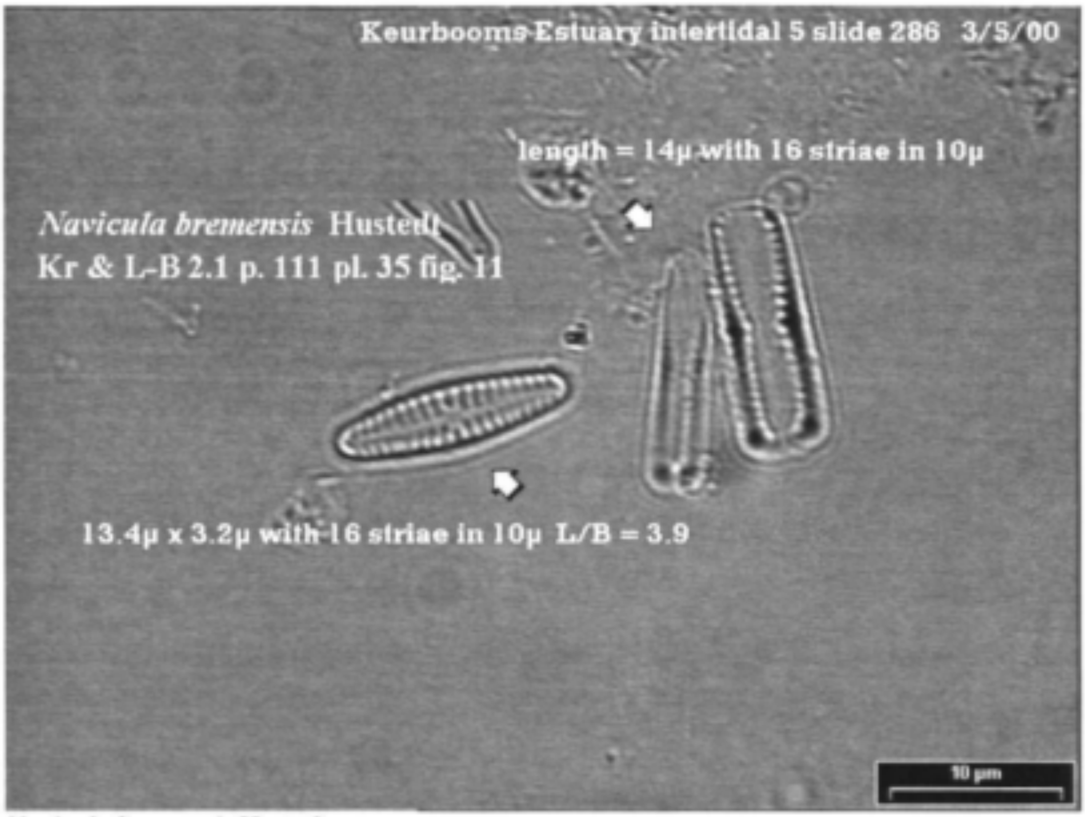
Navicula besarensis Giffen

Reference used for identification: Lange-Bertalot 2000. Page 268. Plate 101. Figure 8.

Locations - Dominant in epipelon – Mlalazi Estuary Intertidal Sites 2.

NOTES	NOTES
Found at salinity 24 ppt. Lange-Bertalot (2000): Marine.	

NAVIBREM



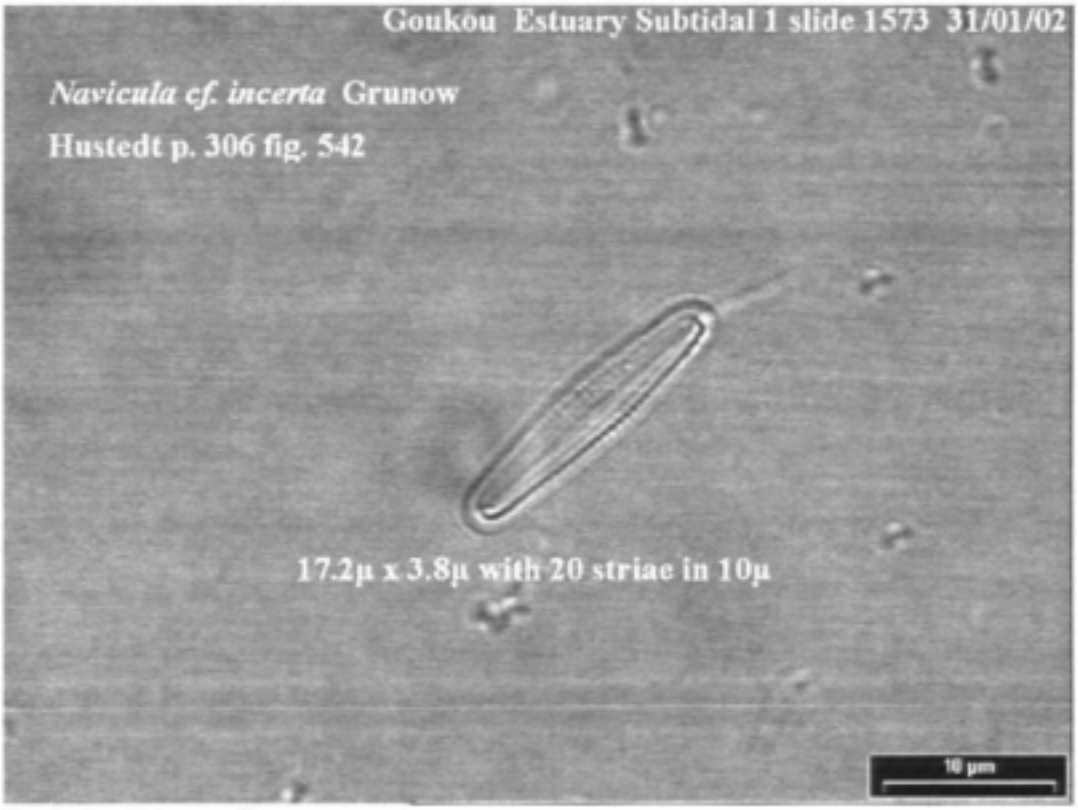
Navicula bremensis Hustedt

Reference used for identification: Krammer & Lange-Bertalot 1986. 2.1 Page 111. Plate 35. Figure 11.

Locations - Dominant in epipelon – Keurbooms Estuary Intertidal Site 5; Gourits Estuary Subtidal Site 5.

NOTES	NOTES
Found at salinity 2 – 27 ppt. Sims (1996): Fresh water.	

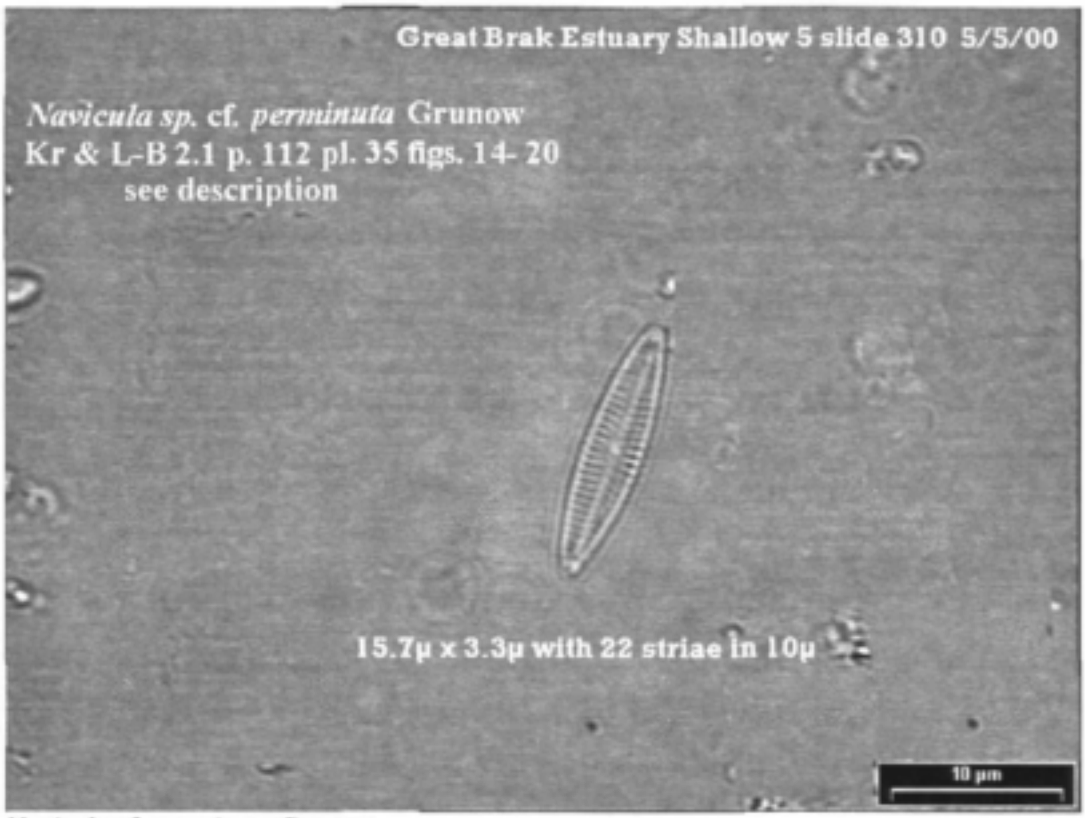
NAVIcfIN



Navicula cf. *incerta* Grunow
Reference used for identification: Hustedt 1976. Page 306. Figure 542.
Locations - Dominant in epipelon – Goukou Estuary Subtidal Sites 1 & 3.

NOTES	NOTES
Found at salinity 25 ppt.	

NAVIcfPE



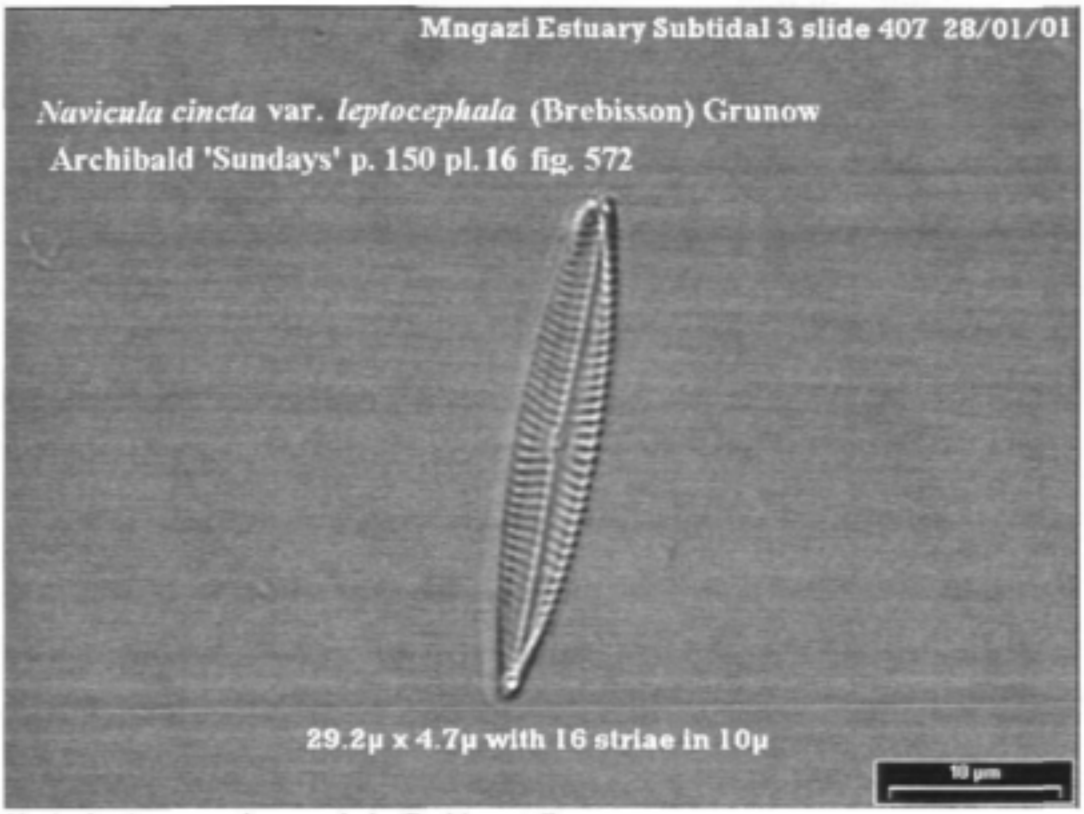
Navicula cf. *perminuta* Grunow

Ref. used for identification: Krammer & Lange-Bertalot 1986. 2.1. Page 112. Plate 35. Figures 14 - 20.

Locations - Dominant in epipelon – Great Brak Estuary Intertidal Site 5.

NOTES	NOTES
Found at salinity 26 ppt.	

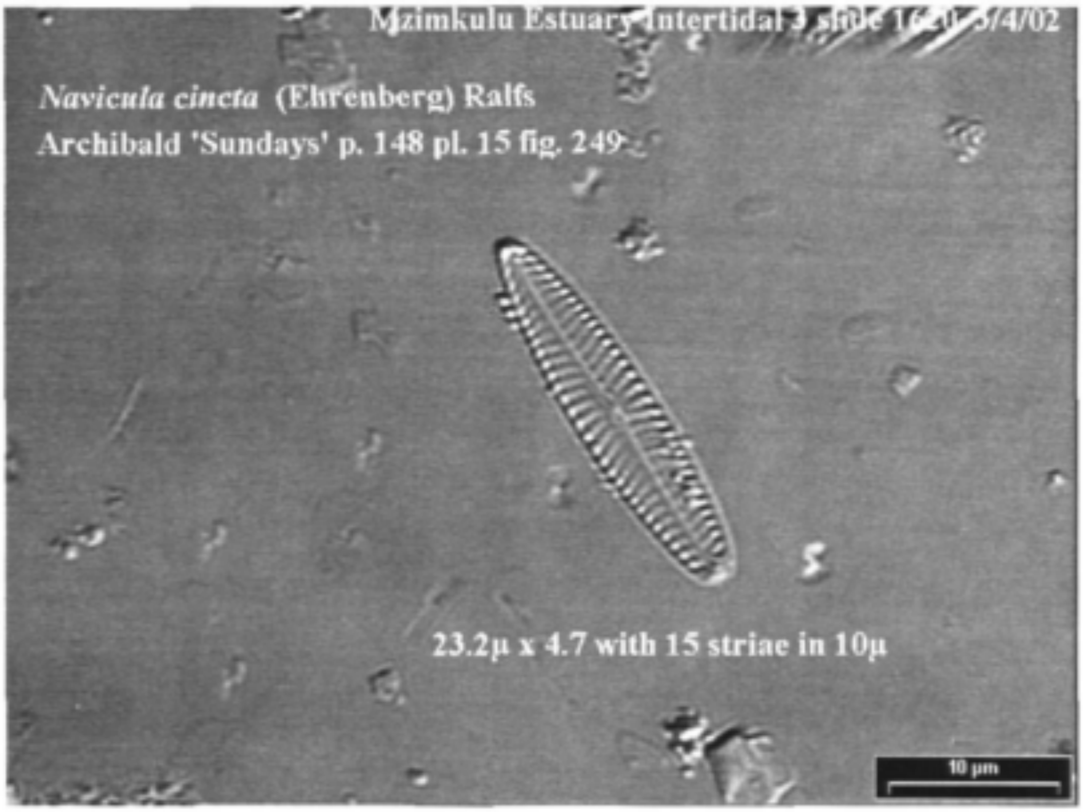
NAVICIIe



Navicula cincta var. *leptocephala* (Brebisson) Grunow
Reference used for identification: Archibald 1983. Page 150. Plate 16. Figure 255.
Locations - Dominant in epipelon – Mkomazi Intertidal Site 2; Great Fish Estuary Intertidal Site 5; Mngazi Subtidal Site 3.

NOTES	NOTES
Found at salinity: 0 - 33 ppt. Patrick & Reimer (1975): Brak.	

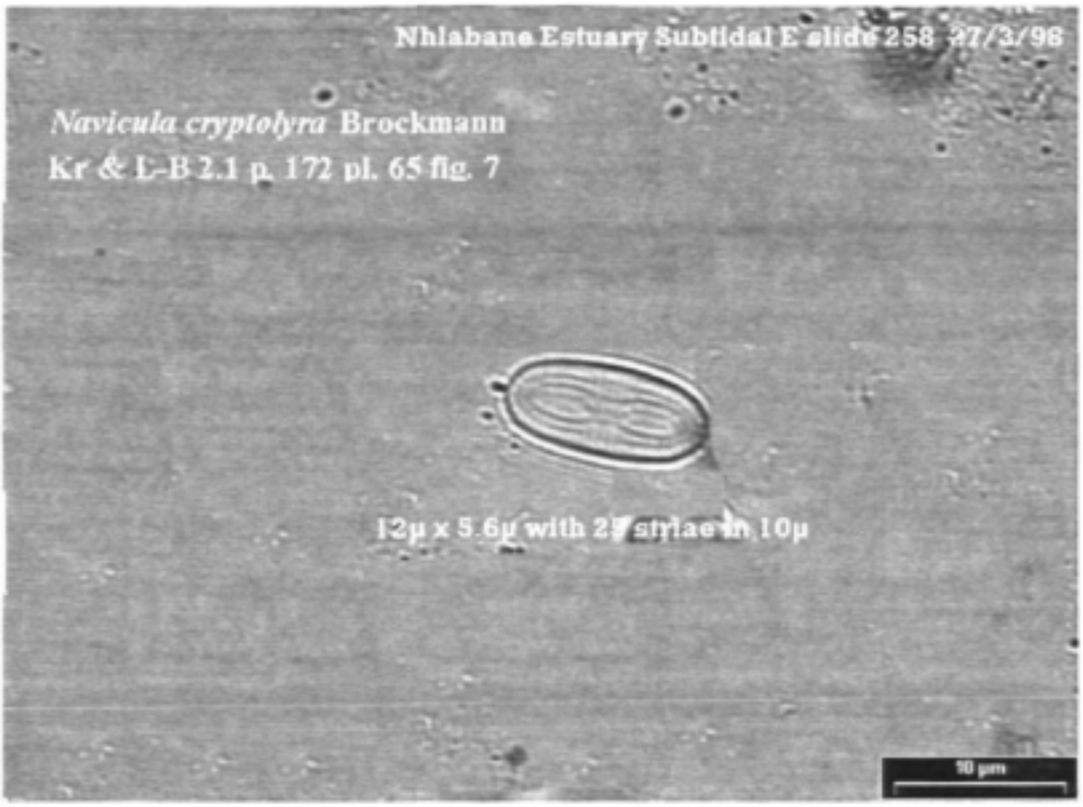
NAVICINC



Navicula cincta (Ehrenberg) Ralfs
Reference used for identification: Archibald 1983. Page 148. Plate 15. Figure 249.
Locations - Dominant in epipelon – Mzimkulu Estuary Intertidal Site 3.

NOTES	NOTES
Found at salinity 4 ppt. Hustedt (1976): Fresh – Brak. Krammer & Lange-Bertalot (1986): Fresh – Brak. Lange-Bertalot (2000): Fresh water – Brak. Sims (1996): Fresh water. Patrick & Reimer (1975): Brak.	

NAVICRRA



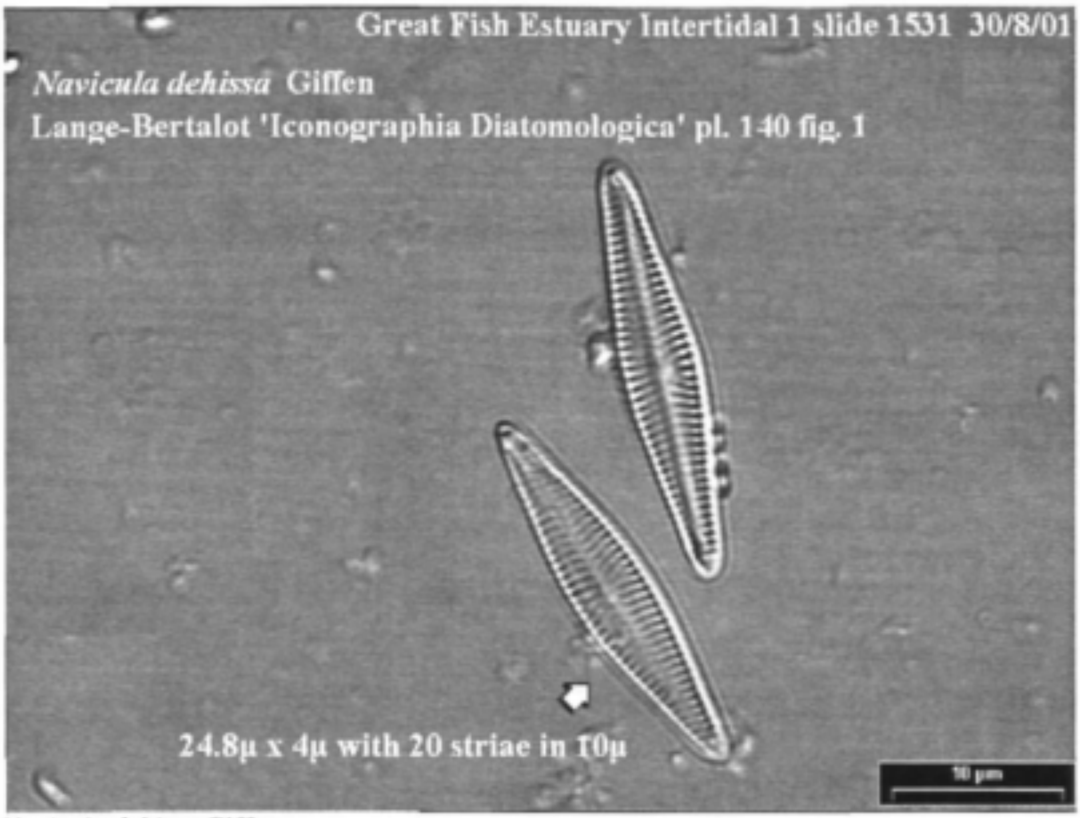
Navicula cryptolyra Brockmann

Reference used for identification: Krammer & Lange-Bertalot 1986. 2.1 Page 172. Plate 65. Figure 7.

Locations - Dominant in epipelon – Nhlabane Estuary Subtidal Site E.

NOTES	NOTES
Found at salinity 20 ppt. Patrick & Reimer (1975): Fresh water – Brak.	

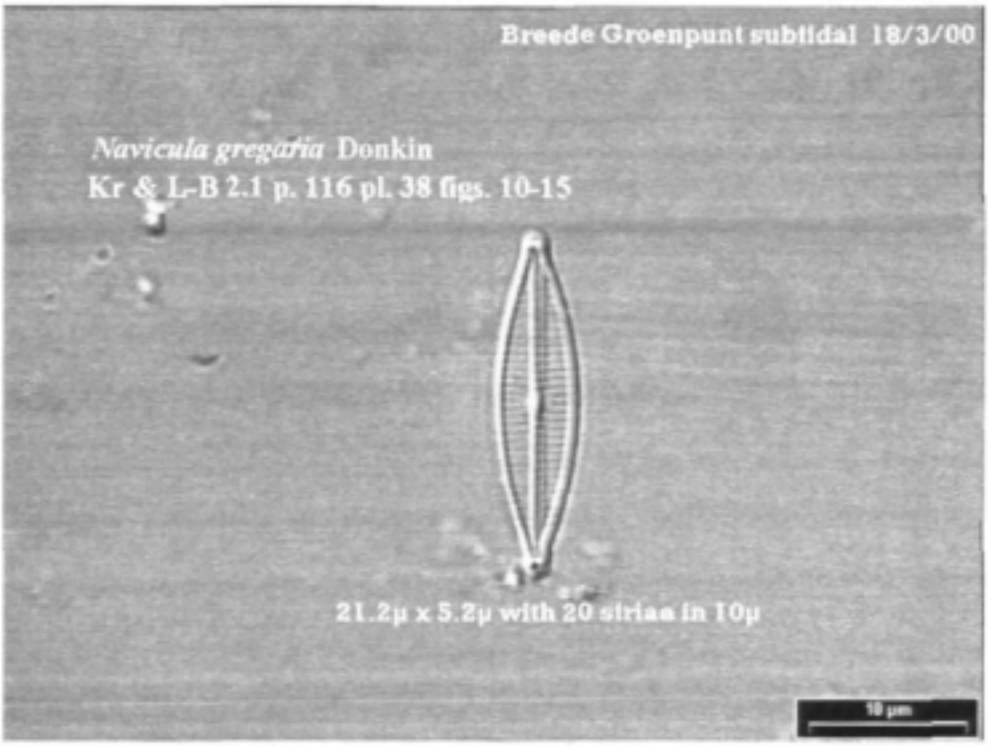
NAVIDEHI



Navicula dehissa Giffen
Reference used for identification: Lange-Bertalot 2000. Plate 140. Figure 1.
Locations - Dominant in epipelon – Great Fish Estuary Intertidal Sites 1 & 2; Gourits Estuary Intertidal Site 2.

NOTES	NOTES
Found at salinity 13 – 38 ppt.	

NAVIGREG



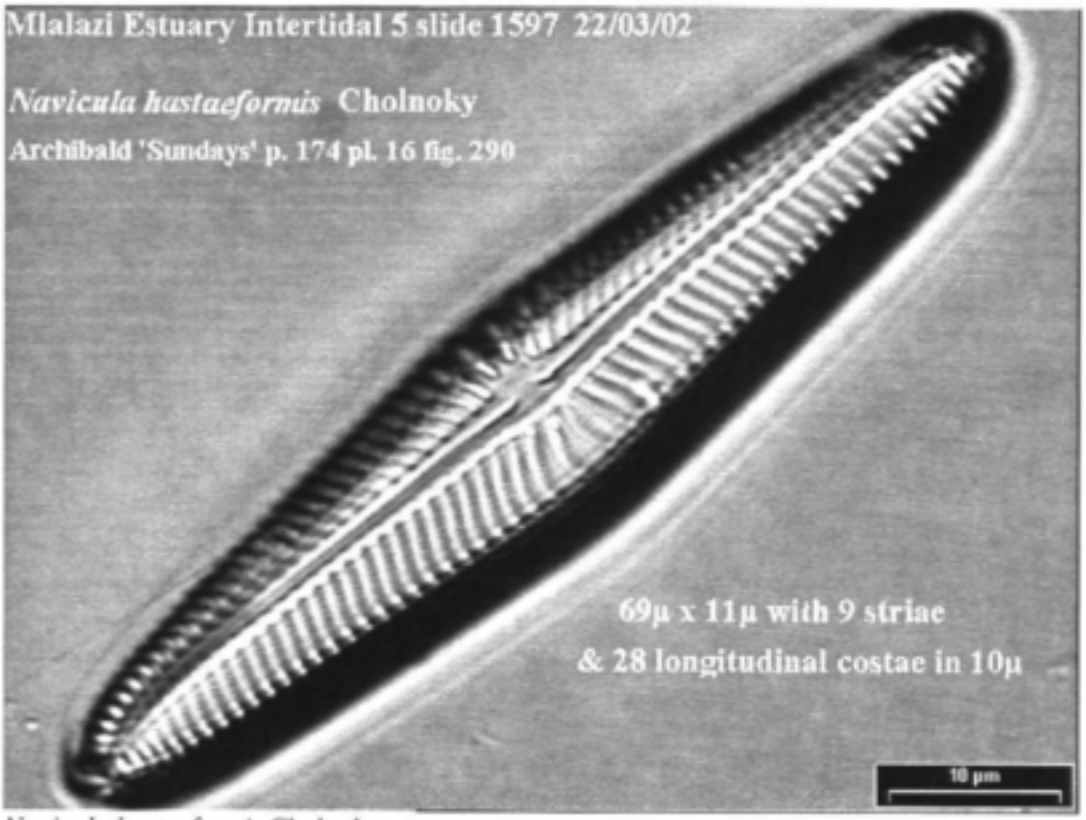
Navicula gregaria Donkin

Reference used for identification: Krammer & Lange-Bertalot 1986. 2.1 Page 116. Plate 38. Figures 10 – 15.

Locations - Dominant in epipelon - Breede Estuary 2 Subtidal Site 3; Breede Estuary 1 Groenpunt Intertidal & Subtidal Sites, Intertidal & Subtidal Sites 1 & 2; Mngazi Estuary Subtidal Site 4; Mtata Estuary Intertidal Site 2, Subtidal Site 3; Olifants Estuary Intertidal Sites 3 & 4, Subtidal Site 5; Sundays Estuary Subtidal Sites 1 & 2, Intertidal Sites 1, 2, 3 & 5; Swartkops Estuary 1 Intertidal Sites 1 & 4 & Subtidal Site 5; Swartkops Estuary 2 Intertidal Sites 1 & 3; Swartkops Estuary 3 Intertidal Sites 2 & 3 & Subtidal Site 3; Bushmans Estuary Subtidal Site 4; Kowie Estuary Intertidal & Subtidal Sites 4 & 5; Mpekweni Estuary Subtidal Sites 1 & 3; Gourits Estuary Intertidal Site 5 & Subtidal 4.

NOTES	NOTES
Found at salinity 1 – 36 ppt. This wide range of habitat has been reported in the literature (Hartley *et al.* 1996; Lange-Bertalot 2000; Schoeman and Archibald 1976), who also showed that the species has a widely variable morphology.	NAVIGREG was found in estuaries all around the coast of South Africa from the Olifants Estuary on the west coast to the Mngazana Estuary just south of Durban on the east coast. It seems unlikely therefore, that it has a specific temperature preference. It seems to have been well named but is not a useful species as a specific habitat indicator because it is also very common in South African rivers. There were no morphological relationships that could be associated with any salinity value or range. Sims (1996) showed that *N. gregaria* is considered to occur in fresh, brak or marine habitats. Sims (1966) also indicated that the taxon is quite variable; a point also made clearly by Round (2001).

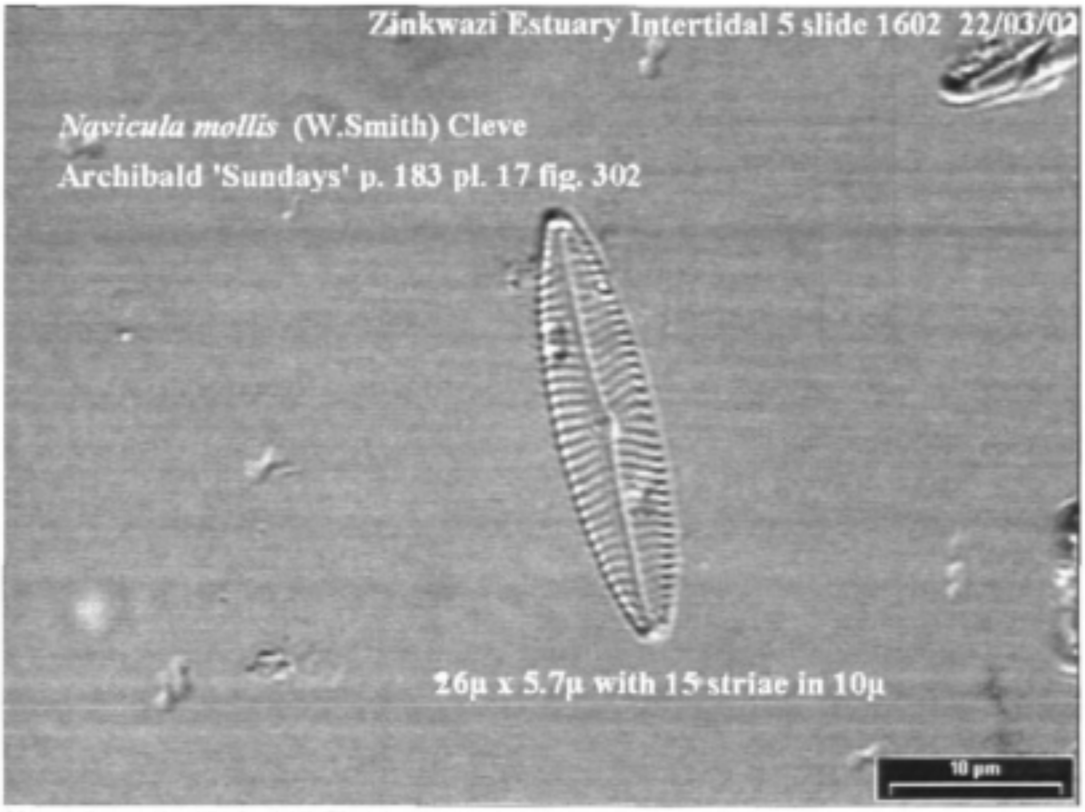
NAVIHAST



Navicula hasteaformis Cholnoky
Reference used for identification: Archibald 1983. Page 174. Plate 16. Figure 290.
Locations - Dominant in epipelon – Mlalazi Estuary Subtidal Site 5.

NOTES	NOTES
Found at salinity 0 ppt.	

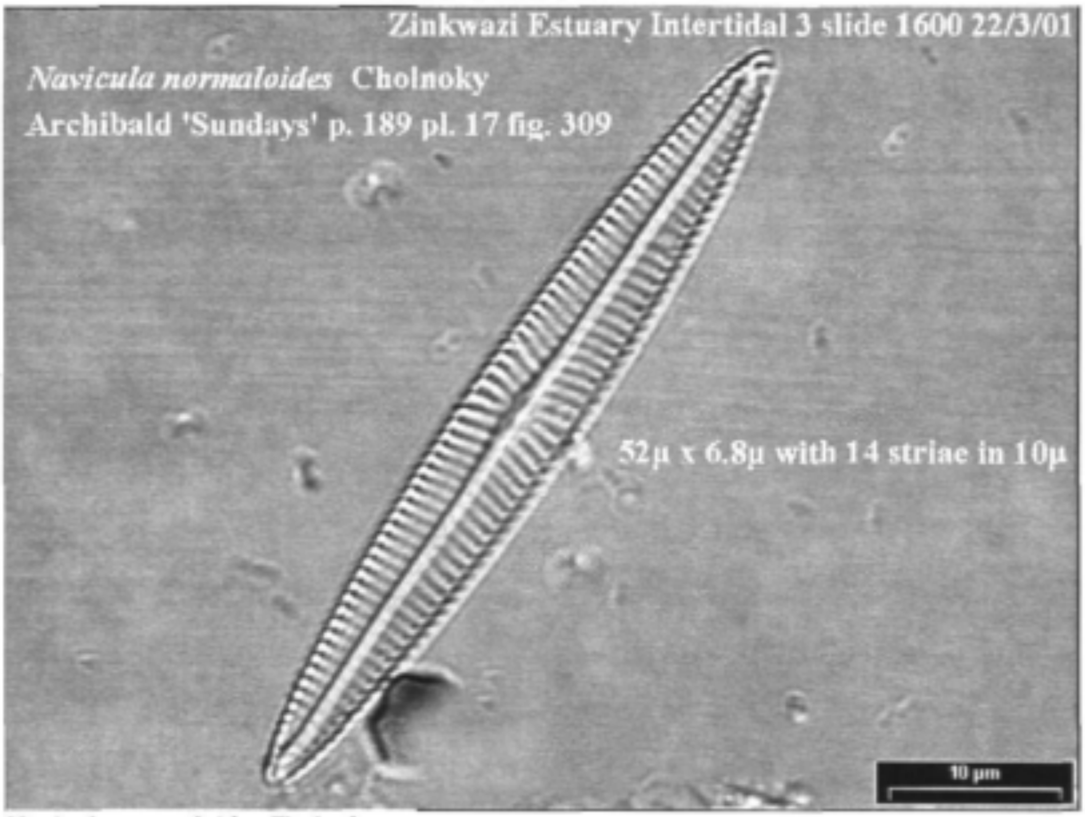
NAVIMOLL



Navicula mollis (W.Smith) Cleve
Reference used for identification: Archibald 1983. Page 183. Page 17. Figure 303.
Locations - Dominant in epipelon – Zinkwazi Estuary Intertidal Site 5.

NOTES	NOTES
Found at salinity 13 ppt. Lange-Bertalot (2000): Brak – Marine.	

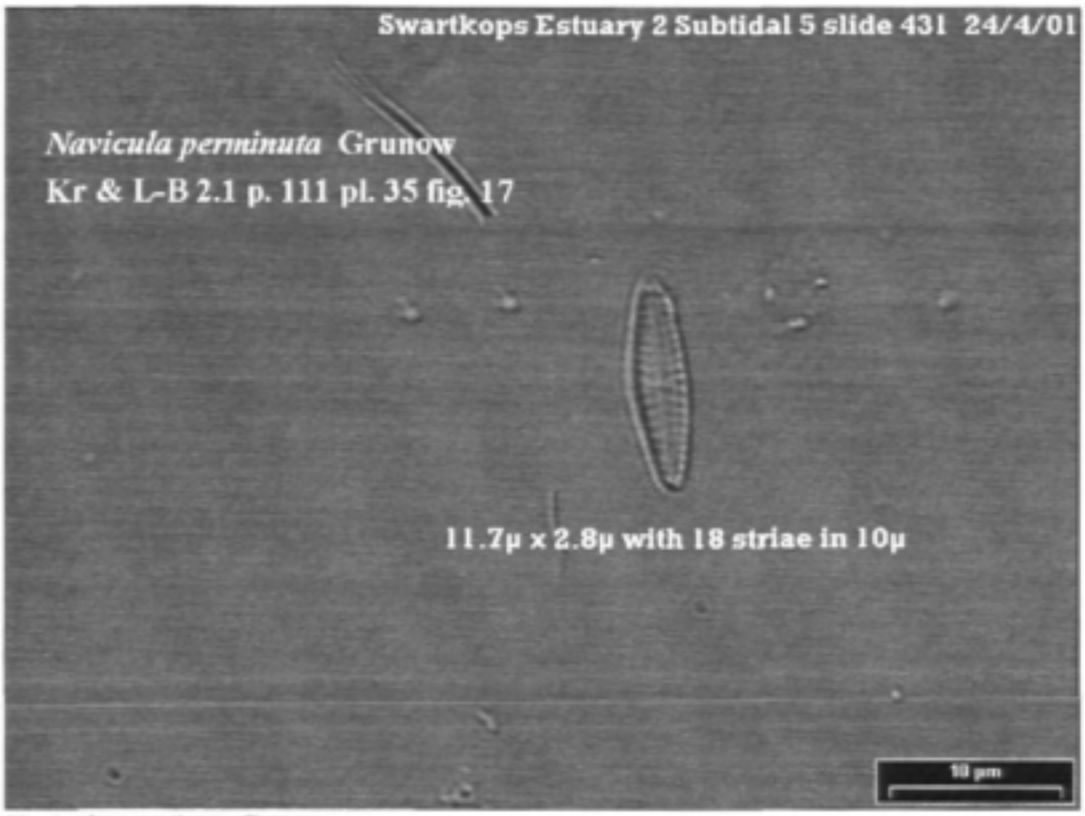
NAVINORM



Navicula normaloides Cholnoky
Reference used for identification: Archibald 1983. Page 189. Plate 17. Figure 309.
Locations - Dominant in epipelon – Zinkwazi Estuary Intertidal Sites 3 & 4.

NOTES	NOTES
Found at salinity 12 – 14 ppt. Archibald (1983): Brak. Lange-Bertalot (2000): Brak.	

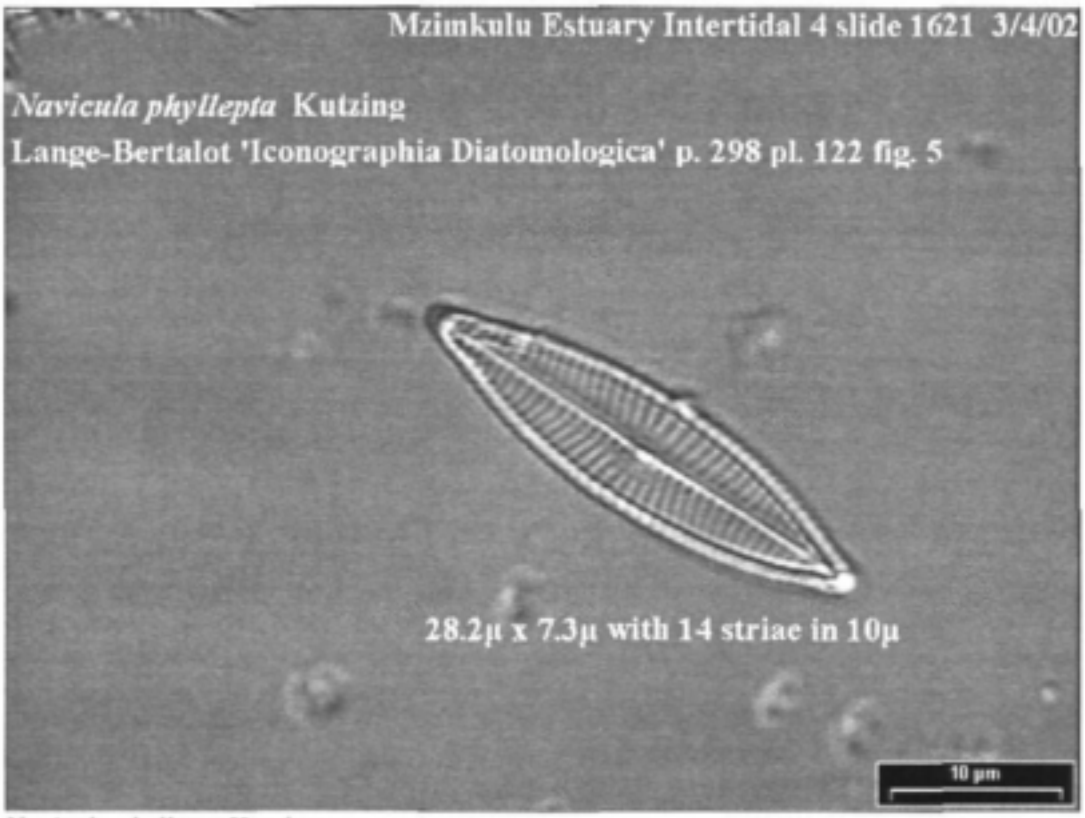
NAVIPERM



Navicula perminuta Grunow
Reference used for identification: Krammer & Lange-Bertalot 1986. 2.1 Page 111. Plate 35. Figure 17.
Locations - Dominant in epipelon – Swartkops Estuary 2 Subtidal Site 5, Intertidal Sites 4 & 5; Mpekweni Estuary Subtidal Site 5.

NOTES	NOTES
Found at salinities 17 - 18 ppt. Lange-Bertalot (2000): Brak. Krammer & Lange-Bertalot (1986): Brak.	

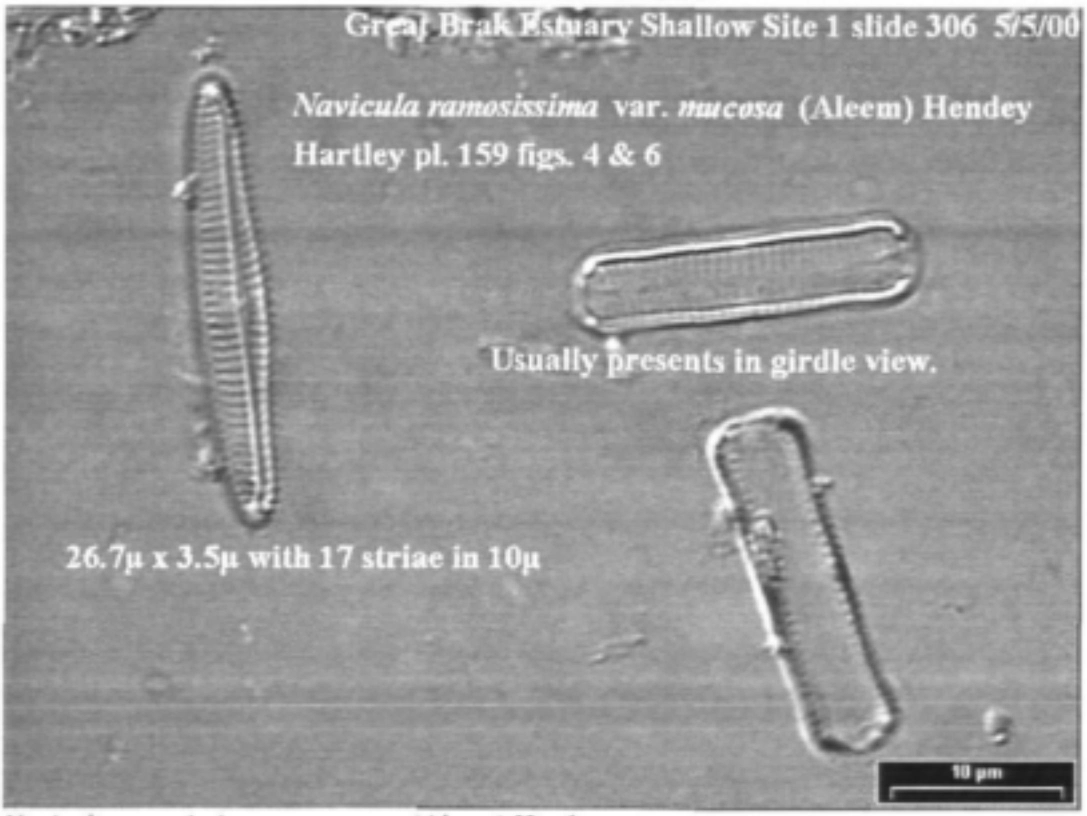
NAVIPHYL



Navicula phyllepta Kutzing
Reference used for identification: Lange-Bertalot 2000. Page 298. Plate 122. Figure 5.
Locations - Dominant in epipelon – Mzimkulu Estuary Intertidal & Subtidal Sites 4 & 5.

NOTES	NOTES
Found at salinity 5 – 14 ppt. Lange-Bertalot (2000): Brak – Marine. Sims (1996): Fresh water.	

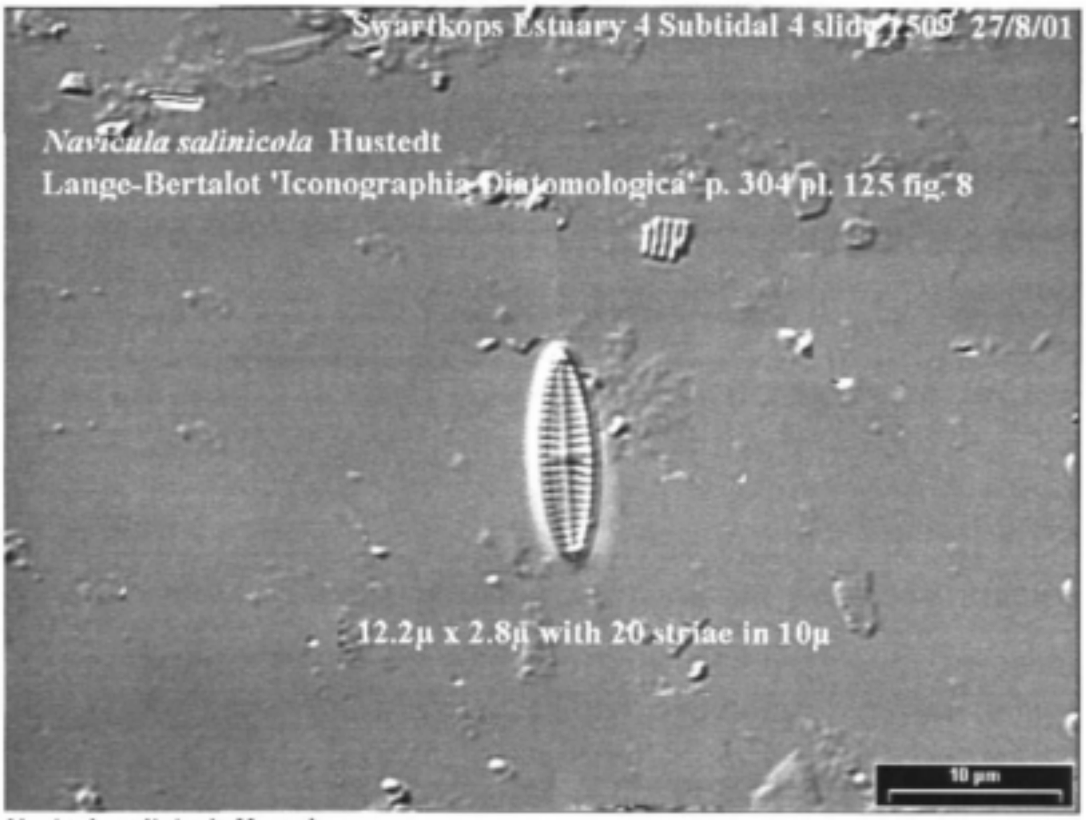
NAVIRAmu



Navicula ramosissima var. *mucosa* (Aleem) Hendey
Reference used for identification: Hartley 1996. Plate 159. Figures 4 & 6.
Locations - Dominant in epipelon – Great Brak Estuary Intertidal Site 1.

NOTES	NOTES
Found at salinity 29 ppt. Sims (1996): Marine.	

NAVISALI



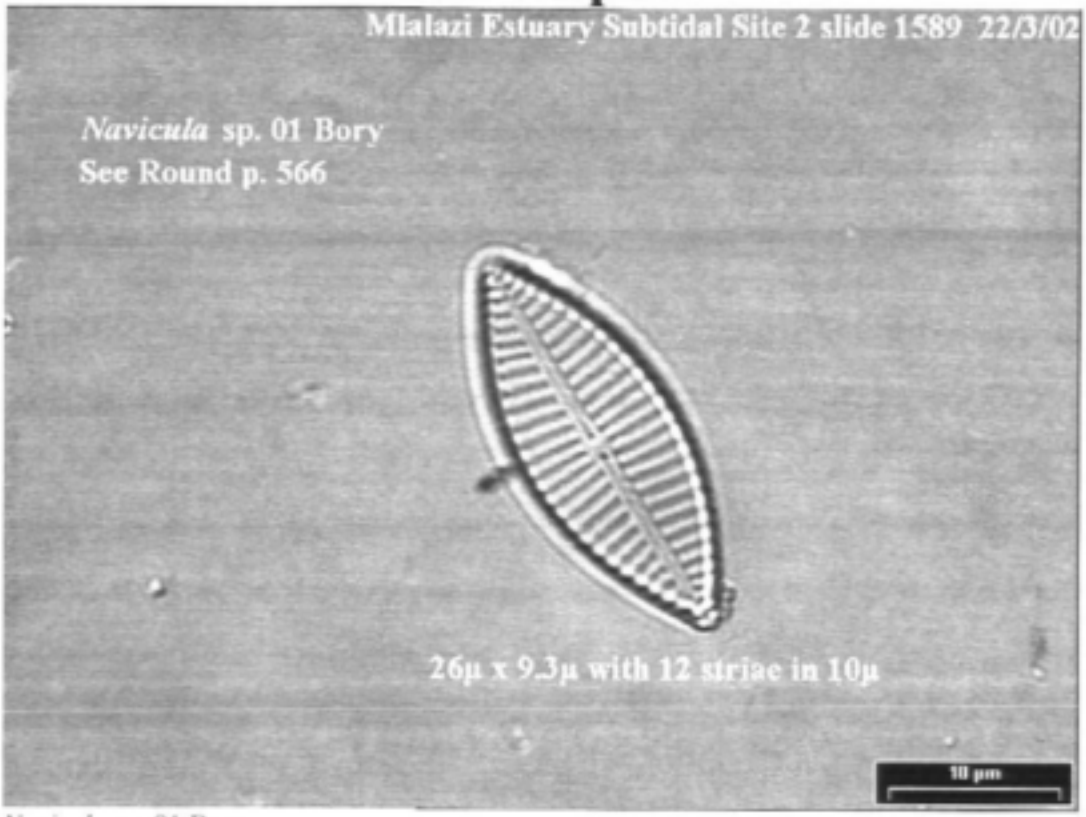
Navicula salinicola Hustedt

Reference used for identification: Lange-Bertalot 2000. Page 304. Plate 125. Figure 8.

Locations - Dominant in epipelon – Mngazi Estuary Intertidal Site 3, Subtidal Sites 2 & 5; Breede Estuary 1 Intertidal Site 4; Kowie Estuary Subtidal Site 3; Mzimkulu Estuary Intertidal & Subtidal Site 1; Swartkops Estuary 4 Subtidal Sites 4 & 5; Mngazana Estuary Intertidal Site 2, Subtidal Sites 2, 4 & 5; Mpekweni Estuary Subtidal Site 5; Keurbooms Estuary Intertidal Site 5; Gourits Estuary Subtidal Site 5.

NOTES	NOTES
Found at salinity 27 – 33 ppt. Archibald (1983): Brak. Krammer & Lange-Bertalot (1986): Brak. Lange-Bertalot (2000): Fresh water – Brak. Patrick & Reimer (1975): Fresh water – Brak.	

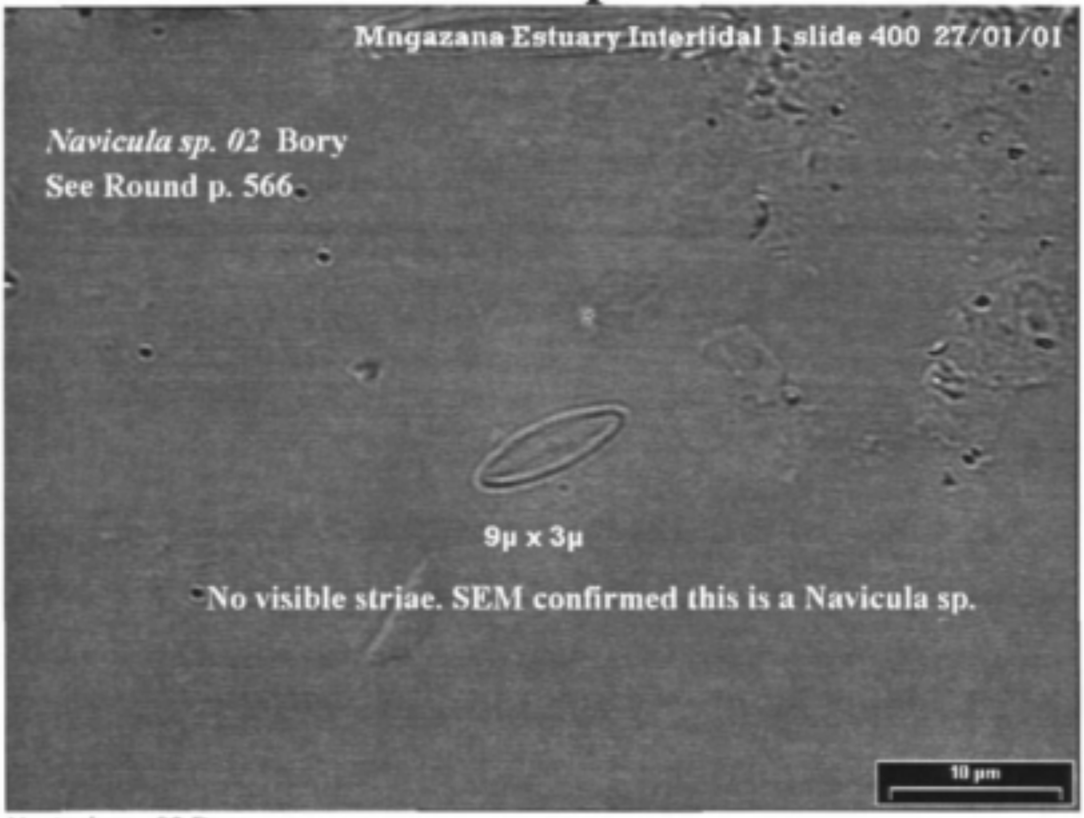
NAVIsp01



Navicula sp. 01 Bory
Reference used for identification: Round, Crawford & Mann 1990. Page 566.
Locations - Dominant in epipelon – Mlalazi Estuary Subtidal Sites 2 & 4.

NOTES	NOTES
Found at salinity 33 & 34 ppt.	

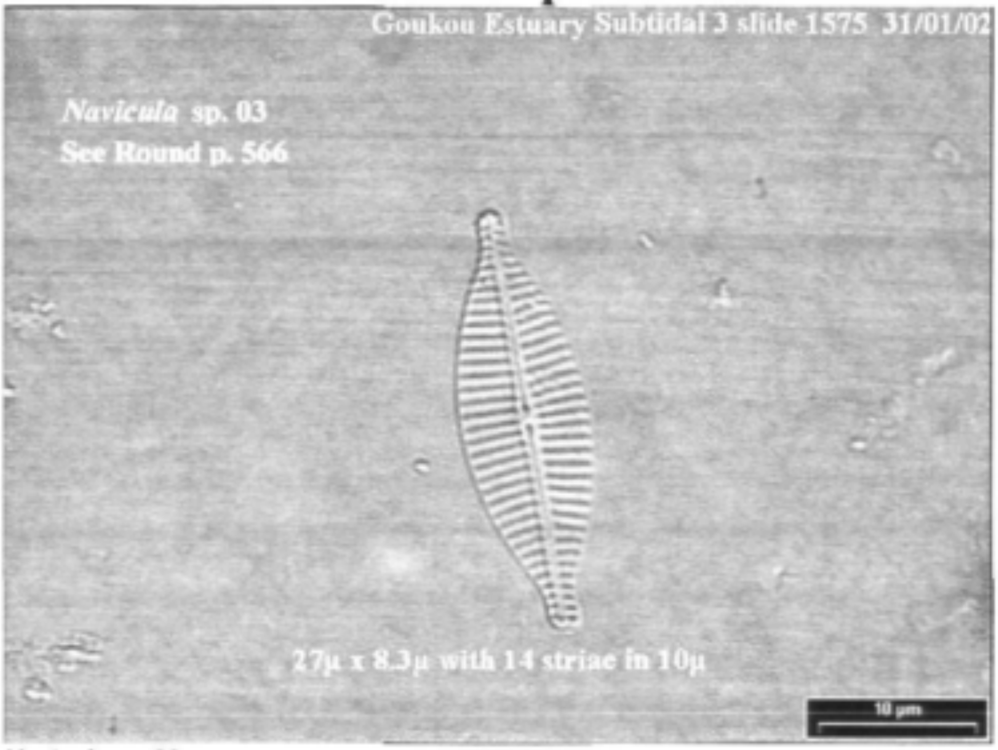
NAVIsp02



Navicula sp. 02 Bory
Reference used for identification: Round, Crawford & Mann 1990. Page 566.
Locations - Dominant in epipelon – Great Berg Intertidal Site 3; Mngazana Estuary Intertidal Site 1.

NOTES	NOTES
Found at salinity 35 – 38 ppt.	

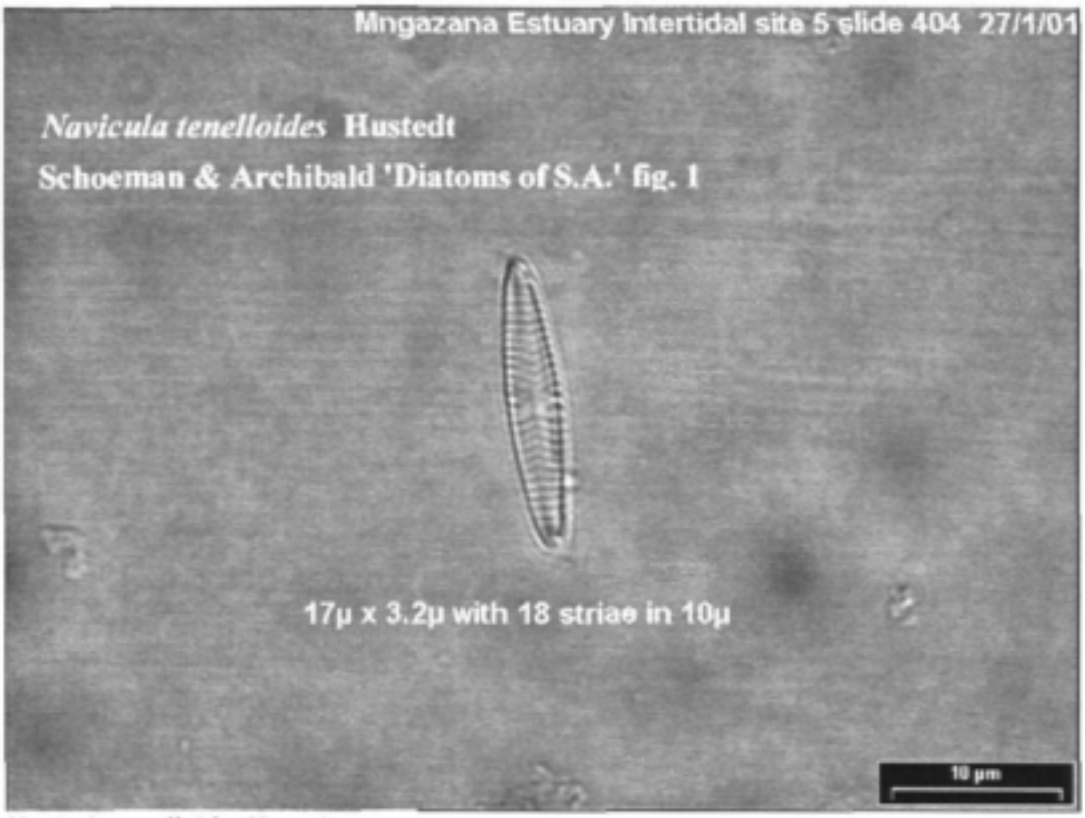
NAVIsp03



Navicula sp. 03
Reference used for identification: Round, Crawford & Mann. 1990. Page 566.
Locations - Dominant in epipelon: Goukou Estuary Intertidal Site 2; Knysna Estuary Intertidal Sites 3 & 4.

NOTES	NOTES
Found at salinity: 27 – 36 ppt.	

NAVITENE



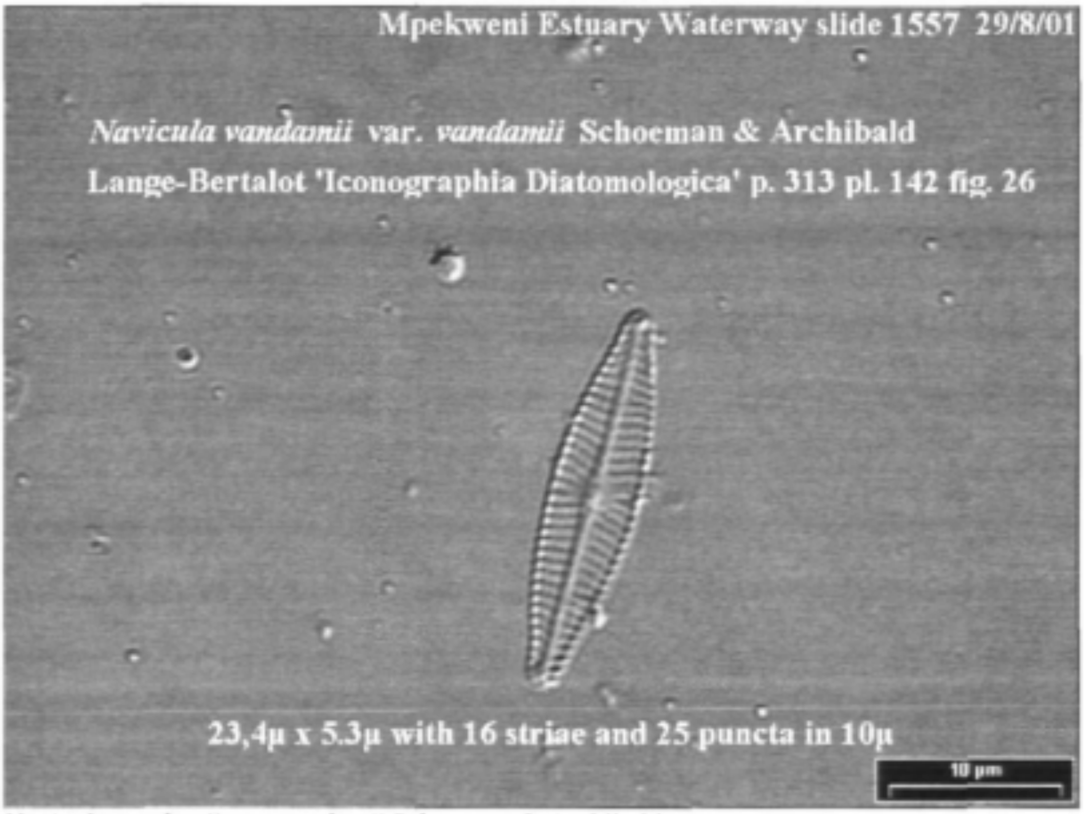
Navicula tenelloides Hustedt

Reference used for identification: Simonsen 1987. Volume 2. Plate 329. Figure 27.

Locations - Dominant in epipelon – Mngazana Estuary Intertidal Site 5; Bushmans Estuary Intertidal Site 5; Kowie Estuary Subtidal Site 3. Breede Estuary 1 Intertidal Site1; Mzimkulu Intertidal & Subtidal Site 1.

NOTES	NOTES
Found at salinity: 0 – 32 ppt. Sims (1996): Fresh water.	

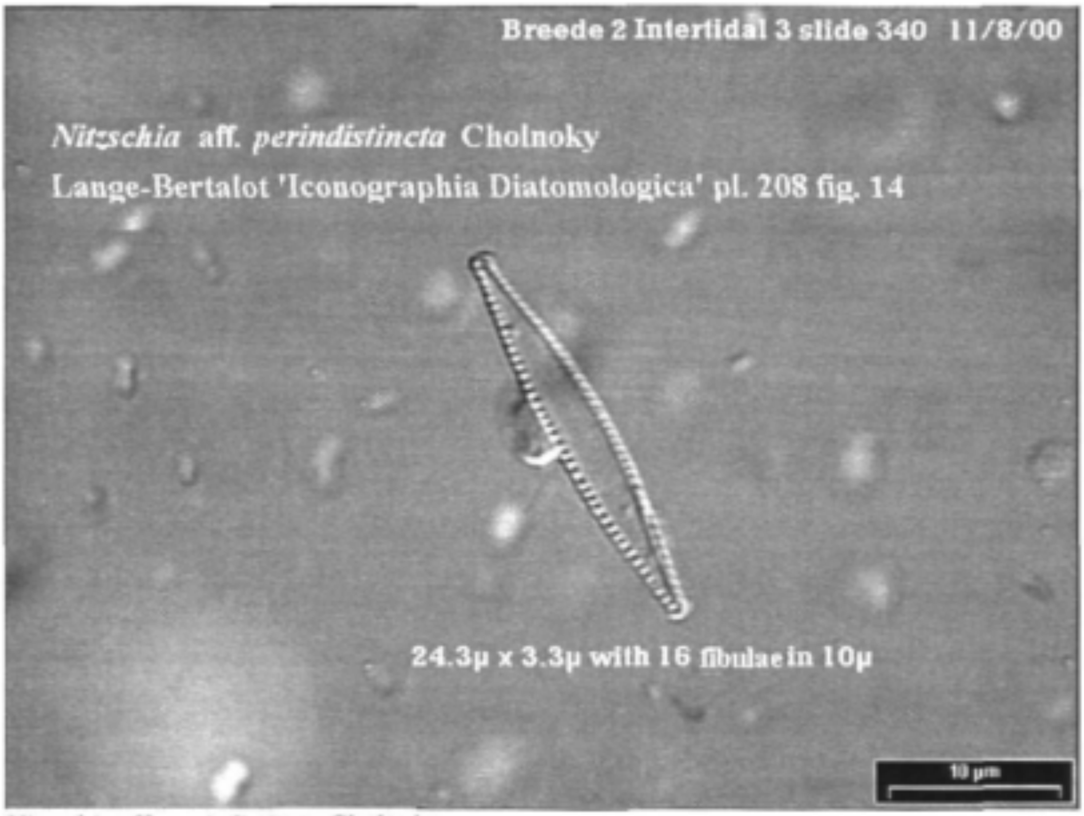
NAVIVAva



Navicula vandamii var. *vandamii* Schoeman & Archibald
Reference used for identification: Lange-Bertalot 2000. Page 313. Plate 142. Figure 26.
Locations - Dominant in epipelon – Mpekweni Estuary Waterway Site.

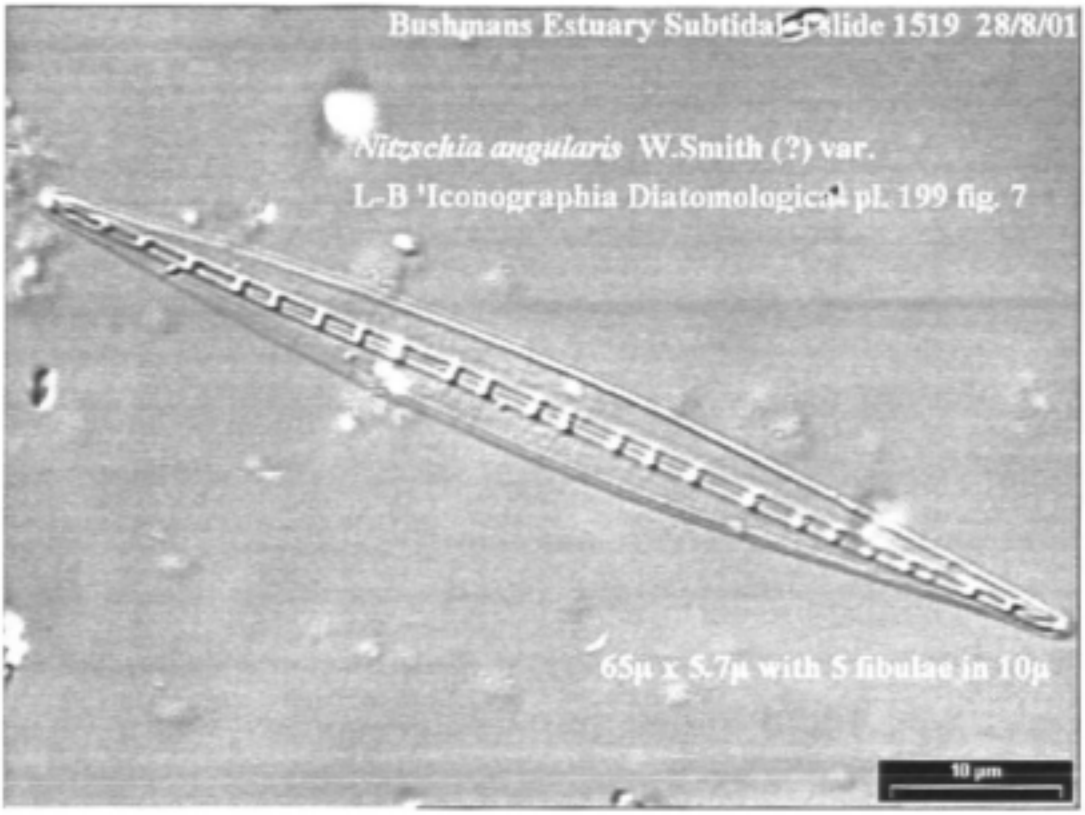
NOTES	NOTES
Found at salinity 4 ppt. Lange-Bertalot (2000): Brak.	

NITZafPE



Nitzschia aff. *perindistincta* Cholnoky
Reference used for identification: Lange-Bertalot 2000. Plate 208. Figure 12.
Locations - Dominant in epipelon –Great Fish Estuary Subtidal Site 2.

NOTES	NOTES
Found at salinity 35 ppt.	

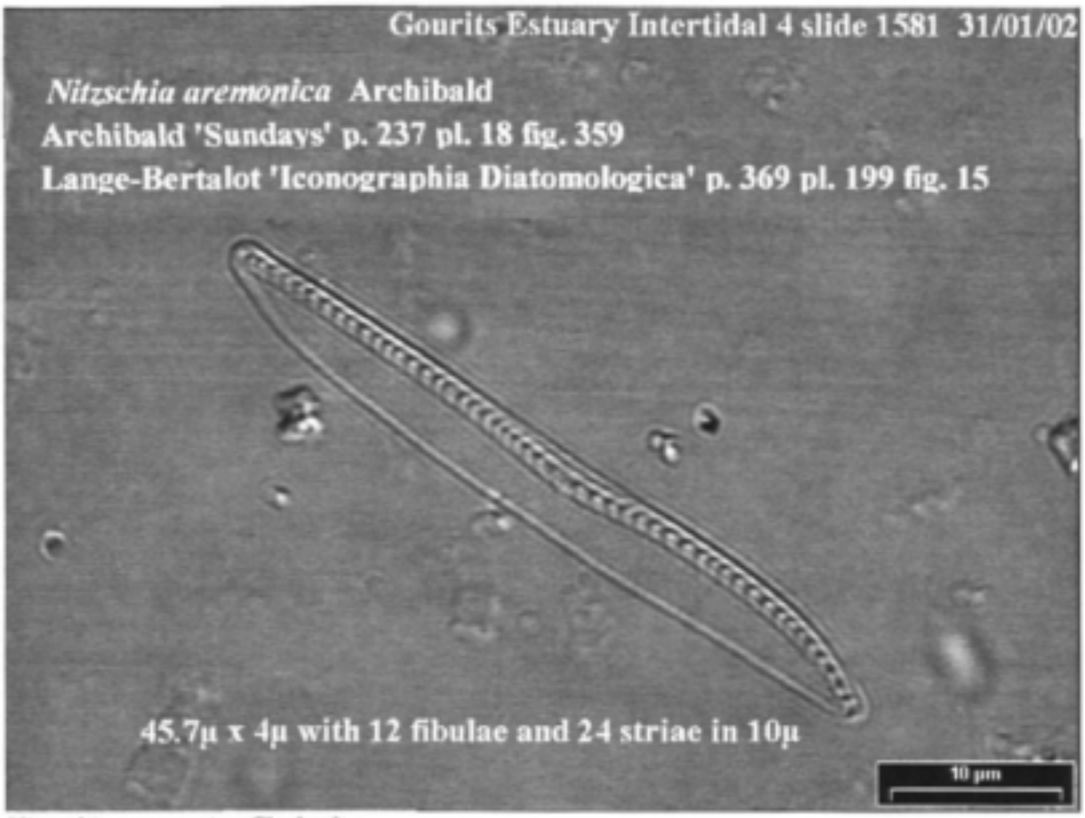


NITZANva

Nitzschia angularis W.Smith (?) var.
Reference used for identification: Lange-Bertalot 2000. Plate 199. Figure 7.
Locations - Dominant in epipelon – Swartkops Estuary 2 Subtidal Site 1; Swartkops Estuary 3 Subtidal Sites 4 & 5; Mngazana Estuary Intertidal Site 4; Olifants Estuary Subtidal Site 1.

NOTES	NOTES
Found at salinity 18 – 33 ppt.	

NITZAREM



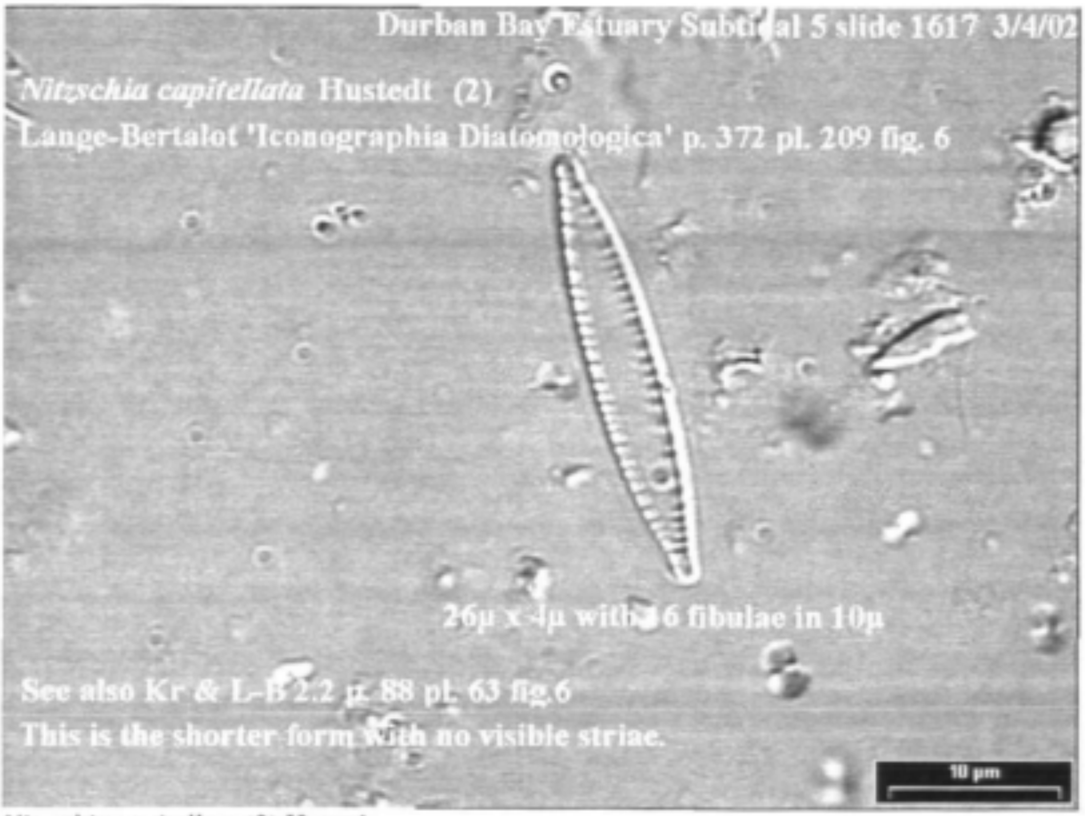
Nitzschia aremonica Cholnoky

Reference used for identification: Archibald 1983. Page 237. Plate 18. Figure 359. Lange-Bertalot 2000. Page 369. Plate 199. Figure 15.

Locations - Dominant in epipelon – Gourits Estuary Intertidal Site 4 & Subtidal Site 1.

NOTES	NOTES
Found at salinity 34 - 39 ppt. Lange-Bertalot (2000): Brak – Marine.	

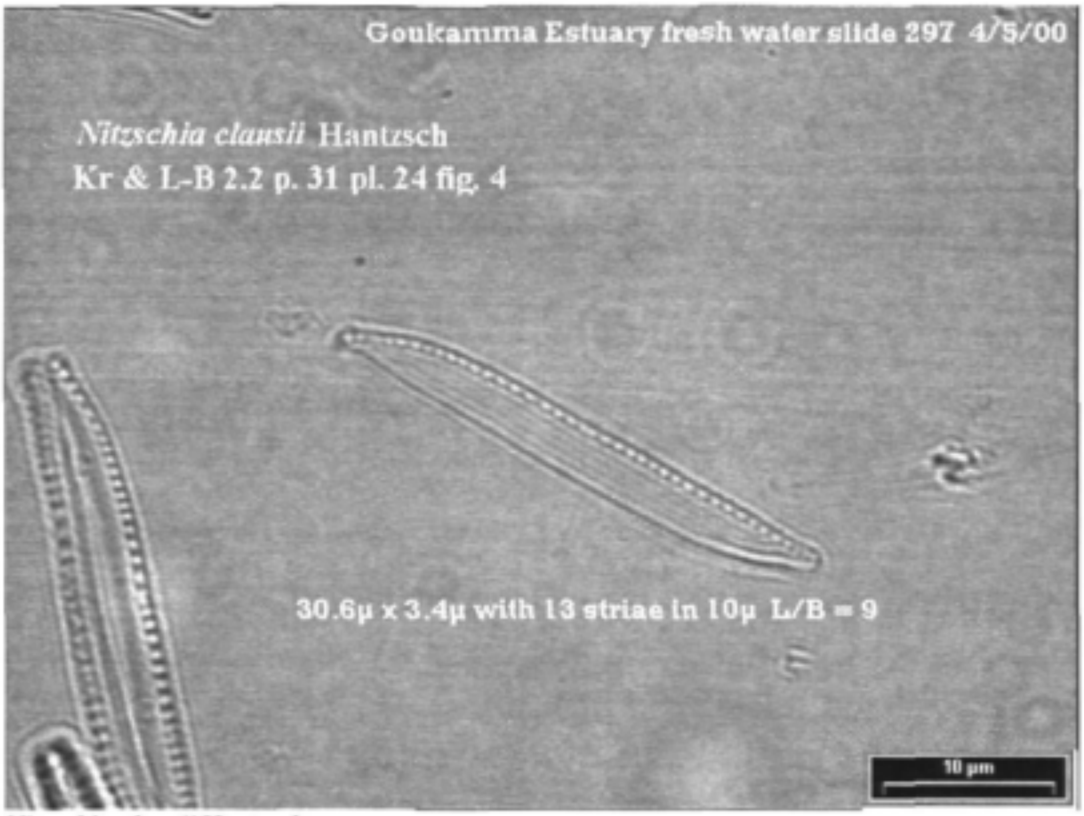
NITZCAP2



Nitzschia capitellata (2) Hustedt
Reference used for identification: Lange-Bertalot 2000. Page 372. Plate 209. Figure 6.
Locations - Dominant in epipelon – Durban Bay Estuary Subtidal Site 5.

NOTES	NOTES
Found at salinity 34 ppt. Lange-Bertalot (2000): Brak – Marine. Sims (1996): Fresh water.	

NITZCLAU



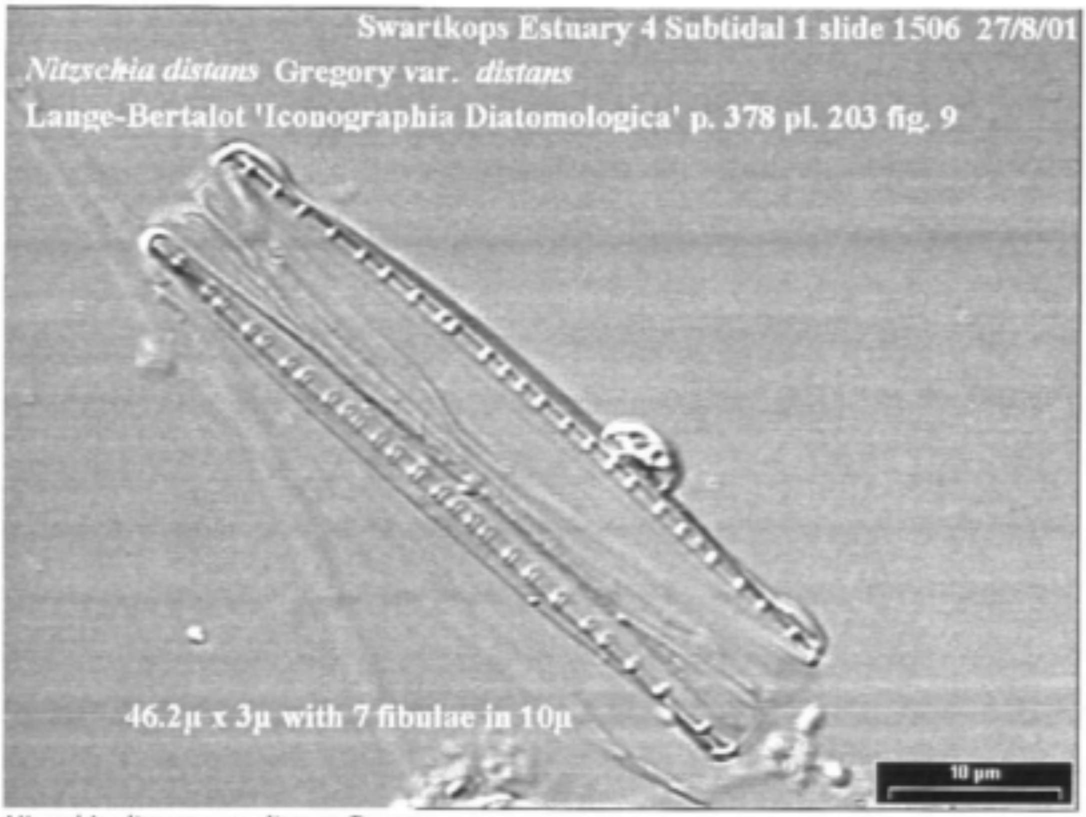
Nitzschia clausii Hantzsch

Reference used for identification: Krammer & Lange-Bertalot 1986. 2.2 Page 31. Plate 24. Figure 4. Lange-Bertalot 2000. Page 373. Plate 199. Figure 8.

Locations - Dominant in epipelon – Goukamma Estuary Fresh Water Site and Intertidal Site 4.

NOTES	NOTES
Found at salinity 1 – 14 ppt. Krammer & Lange-Bertalot (1986): Brak. Lange-Bertalot (2000): Brak.	

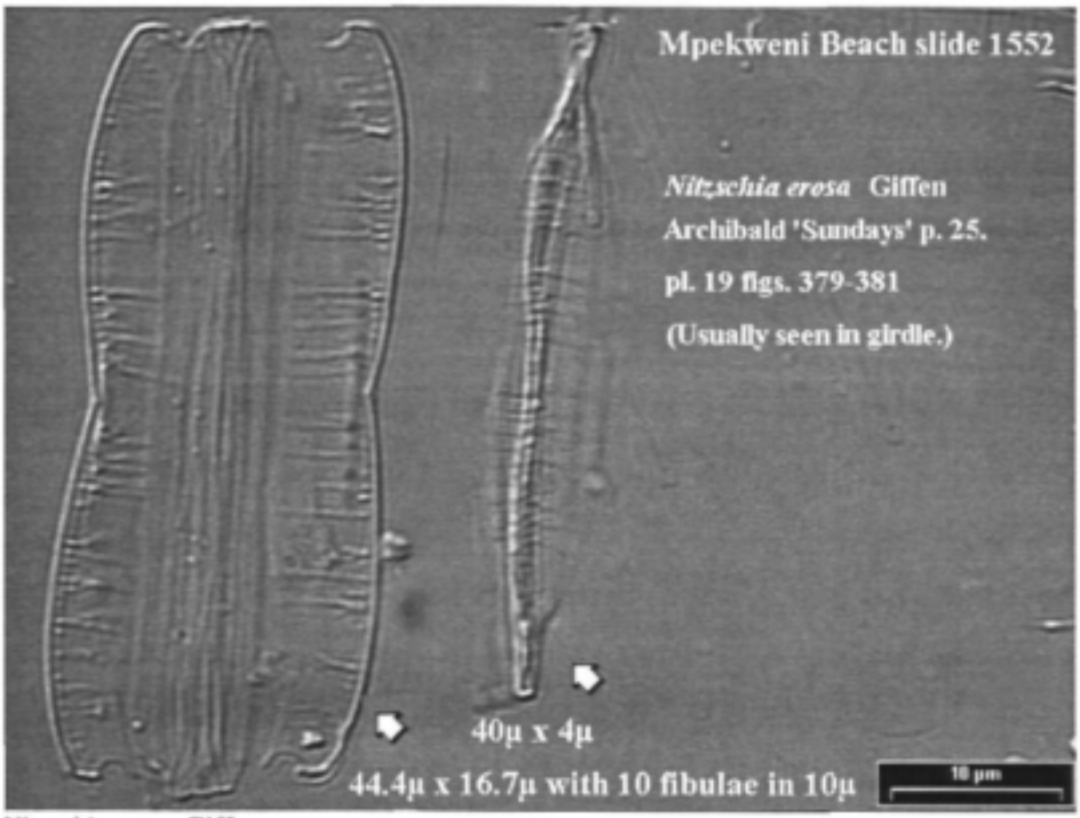
NITZDIdi



Nitzschia distans var. *distans* Gregory
Reference used for identification: Lange-Bertalot 2000. Page 378. Plate 203. Figure 9.
Locations – Dominant in epipelon – Mpekweni Beach Site and Subtidal Site 3.

NOTES	NOTES
Found at salinity 17 - 35 ppt. Lange-Bertalot (2000): Marine.	

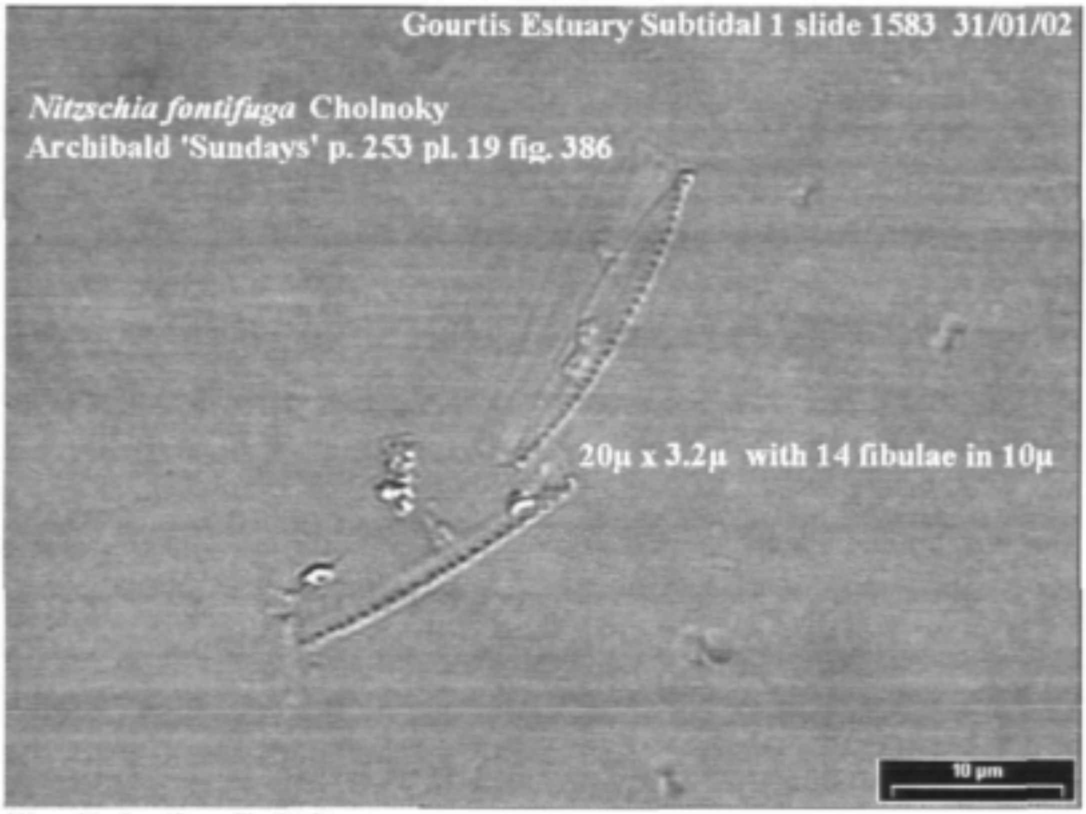
NITZEROS



Nitzschia erosa Giffen
Reference used for identification: Archibald 1983. Page 25. Plate 19. Figures 379 - 381.
Locations - Dominant in epipelon – Mpekweni Beach Site and Intertidal Site 3.

NOTES	NOTES
Found at salinity 17 - 35 ppt. Lange-Bertalot (2000): Marine.	

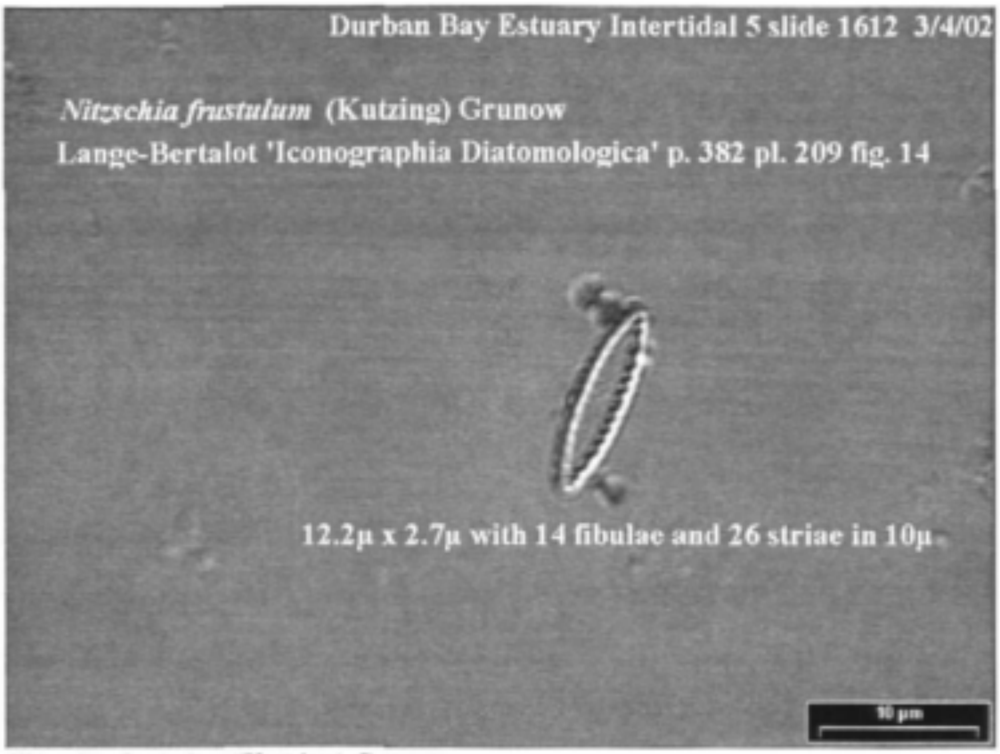
NITZFOGA



Nitzschia fontifuga Cholnoky
Reference used for identification: Archibald 1983. Page 252. Plate 19. Figure 386.
Locations - Dominant in epipelon – Mtata Estuary Subtidal Site 1.

NOTES	NOTES
Found at salinity: 35 ppt.	

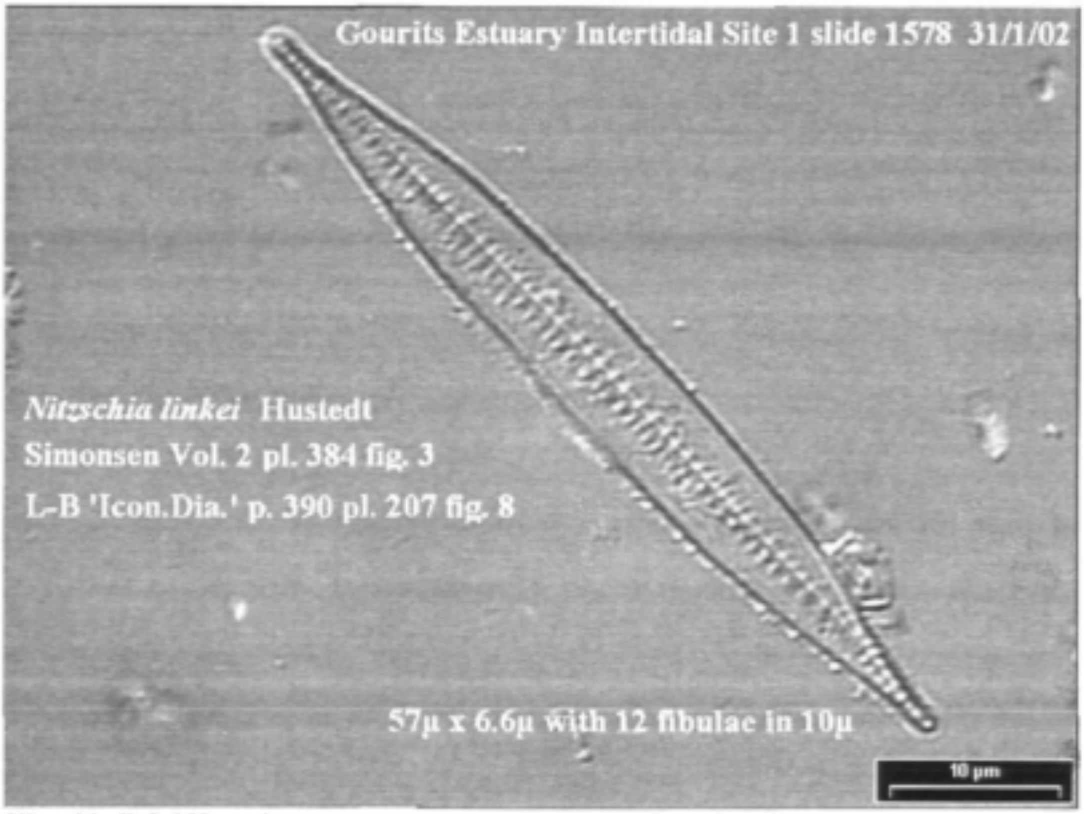
NITZFRUS



Nitzschia frustulum (Kutzing) Grunow
Reference used for identification: Lange-Bertalot 2000. Page 382. Plate 209. Figure 14.
Locations - Dominant in epipelon – Keurbooms Estuary Intertidal Site 2; Kowie Estuary Subtidal Site 3.

NOTES	NOTES
Found at salinity: 29 & 38 ppt. Sims (1996): Fresh water – Brak. Lange-Bertalot (2000): Brak – Marine.	

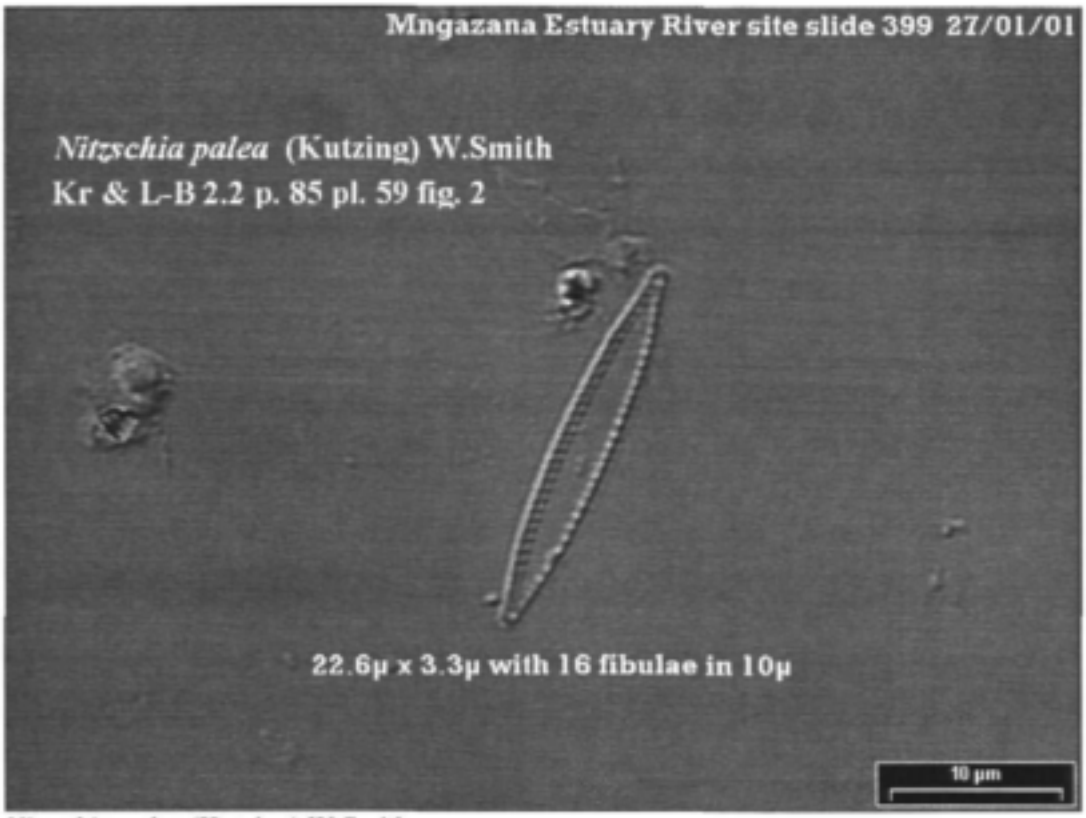
NITZLINK



Nitzschia linkei Hustedt
Reference used for identification: Lange-Bertalot 2000. Page 390. Plate 207. Figure 8.
Locations - Dominant in epipelon– Gourits Estuary Intertidal Site 1.

NOTES	NOTES
Found at salinity 39 ppt. Lange-Bertalot (2000): Brak – Marine.	

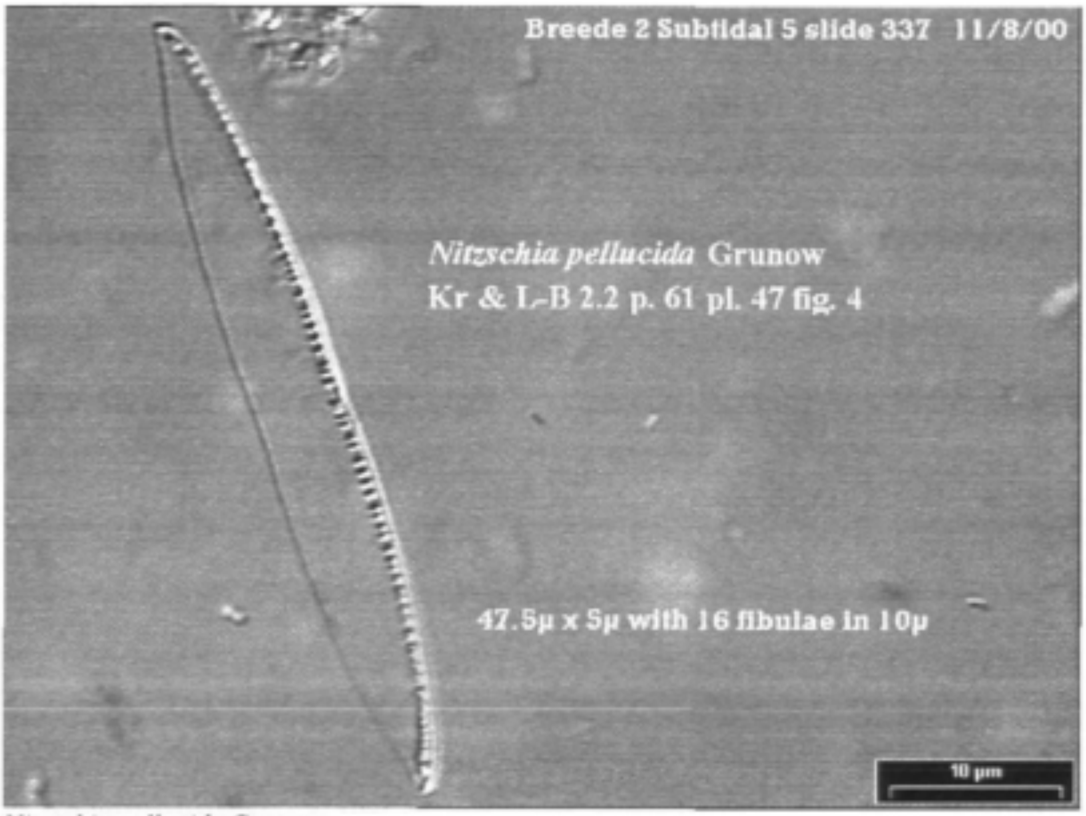
NITZPALE



Nitzschia palea (Kutzing) W.Smith
Reference used for identification: Krammer & Lange-Bertalot 1986. 2.2 Page 285. Plate 59. Figure 9.
Locations - Dominant in epipelon – Mngazana Estuary River Site; Breede 2 Intertidal Site 3.

NOTES	NOTES
Found at salinity 0 – 3 ppt. Hustedt (1976): Fresh water. Sims (1996): Fresh water.	

NITZPELL



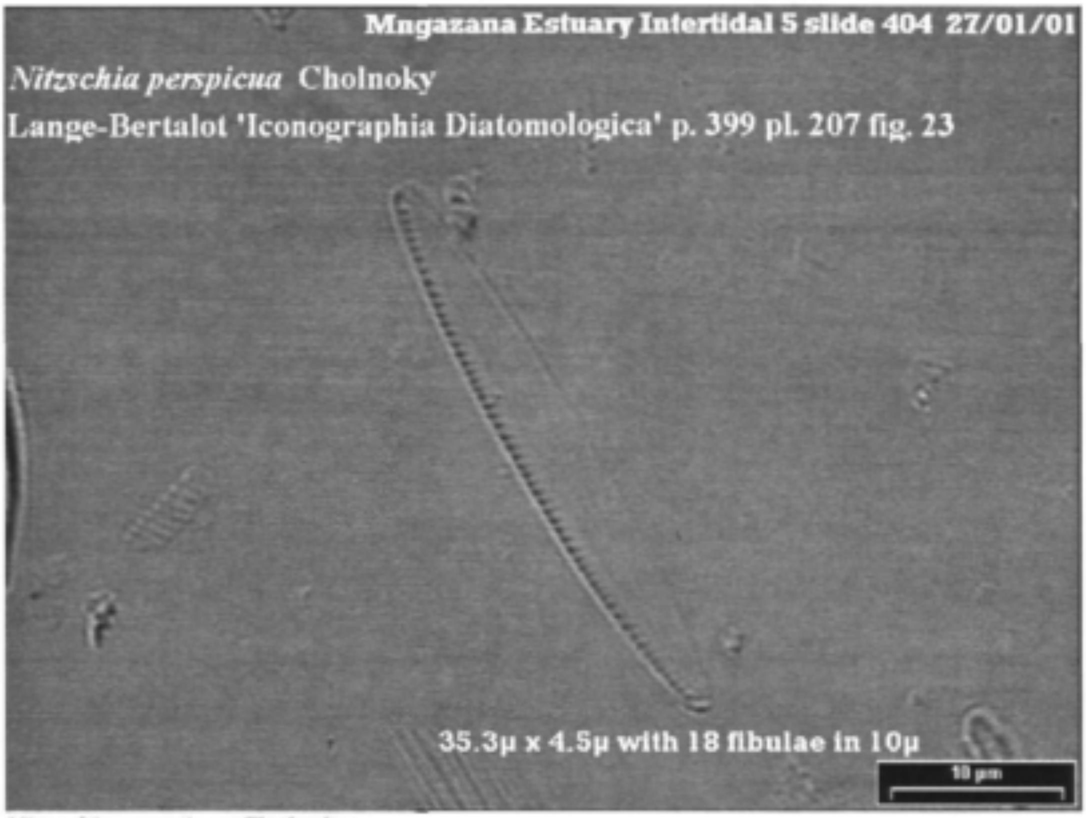
Nitzschia pellucida Grunow

Reference used for identification: Krammer & Lange-Bertalot 1986. 2.2 Page 61. Plate 47. Figure 4.

Locations - Dominant in epipelon – Mngazi Estuary Intertidal Site 1.

NOTES	NOTES
Found at salinity 30 ppt. Lange-Bertalot (2000): Marine. Krammer & Lange-Bertalot (1986): Brak.	Lange-Bertalot (2000) makes the point that this species is "difficult to distinguish from similar established taxa" p. 399.

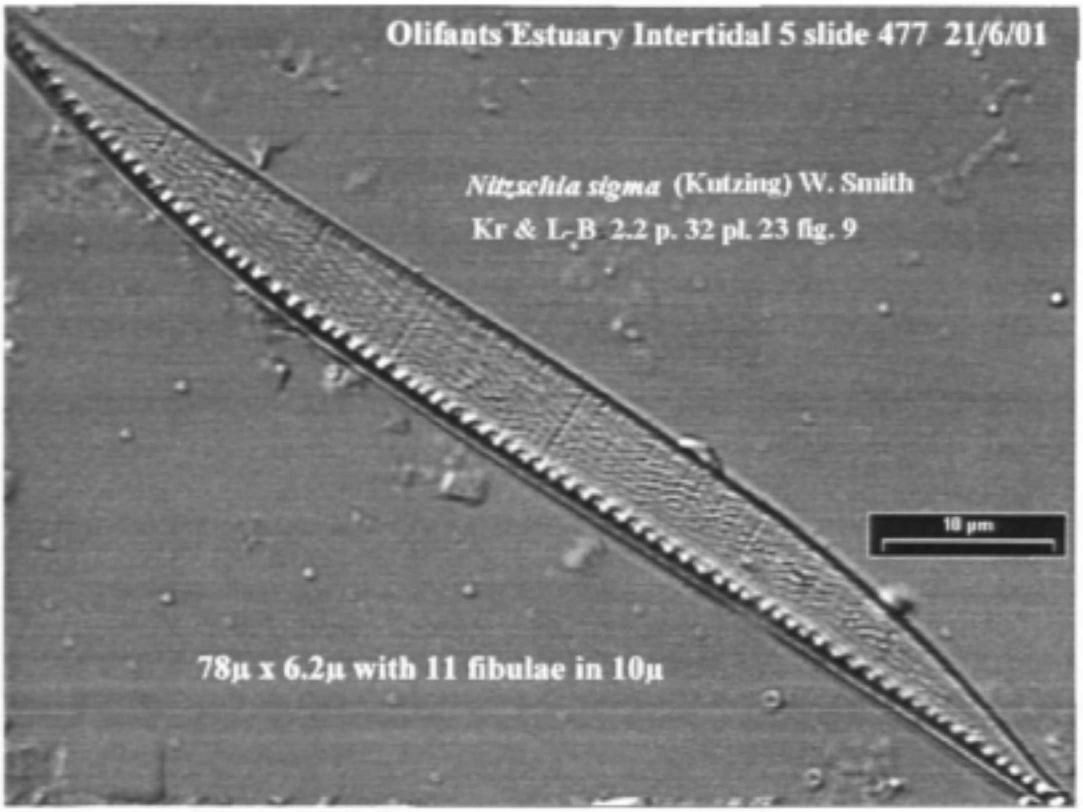
NITZPERS



Nitzschia perspicua Cholnoky
Reference used for identification: Lange-Bertalot 2000. Page 399. Plate 207. Figure 23.
Locations - Dominant in epipelon – Great Berg Intertidal Site 1; Mngazana Estuary Intertidal Site 5.

NOTES	NOTES
Found at salinity 23 – 35 ppt. Krammer & Lange-Bertalot (1986): Brak – Marine. Lange-Bertalot (2000): Brak.	

NITZSIGM



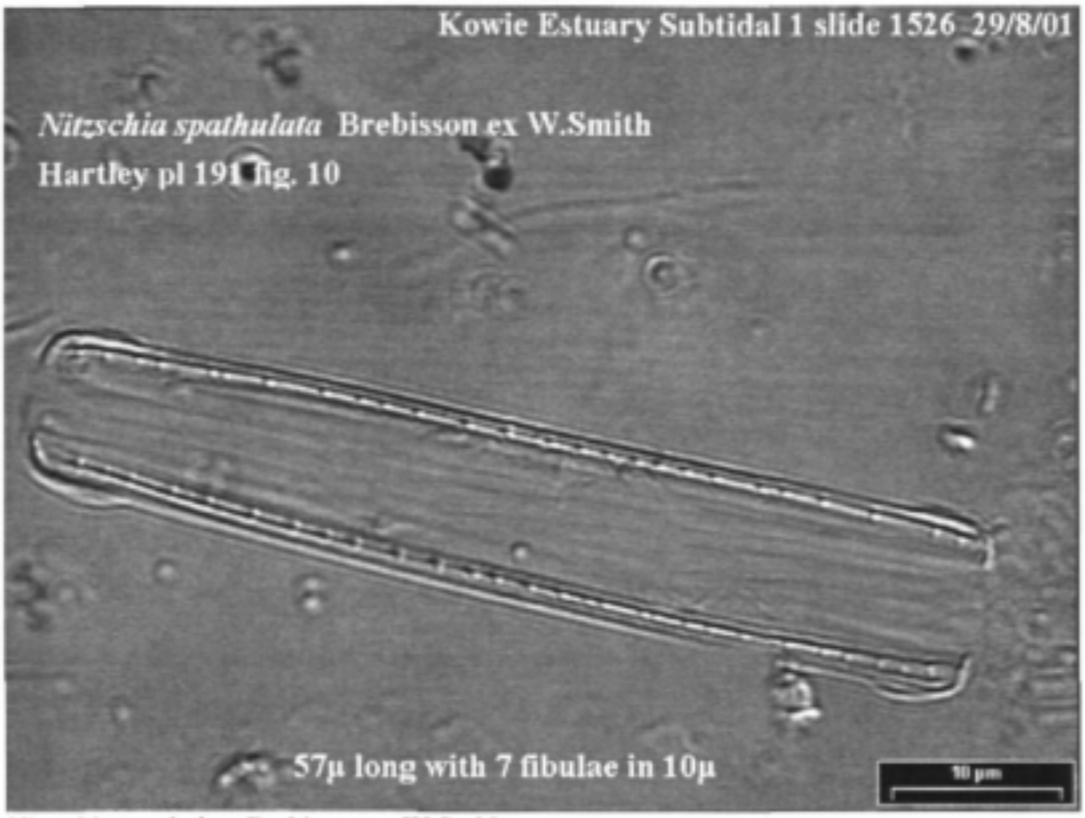
Nitzschia sigma (Kutzing) W.Smith

References used for identification: Krammer & Lange-Bertalot 1986. 2.2 Page 32. Plate 23. Figure 9. Lange-Bertalot 2000. Page 404. Plate 206. Figure 6.

Locations - Dominant in epipelon –Olifants Estuary Intertidal Site 5.

NOTES	NOTES
Found at salinity 1 ppt. Sims (1996): Brak. Lange-Bertalot (2000): Fresh, Brak, Marine.	The length of this species varies from 35µ - 1000µ, and is seldom as short as the specimen shown here.

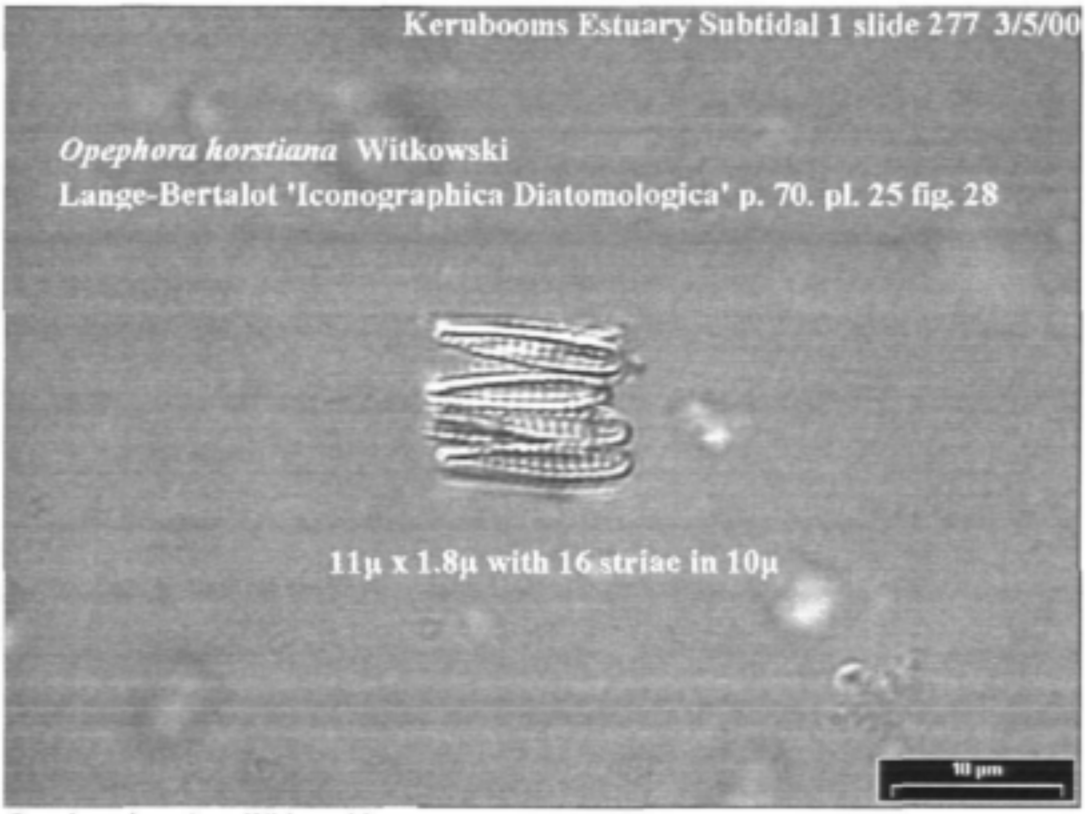
NITZSPAT



Nitzschia spathulata Brebisson ex W.Smith
Reference used for identification: Hartley 1996. Plate 191. Figure 10.
Locations - Dominant in epipelon – Kowie Estuary Subtidal Site 1.

NOTES	NOTES
Found at salinity 35 ppt. Lange-Bertalot (2000): Marine. Sims (1996): Marine.	

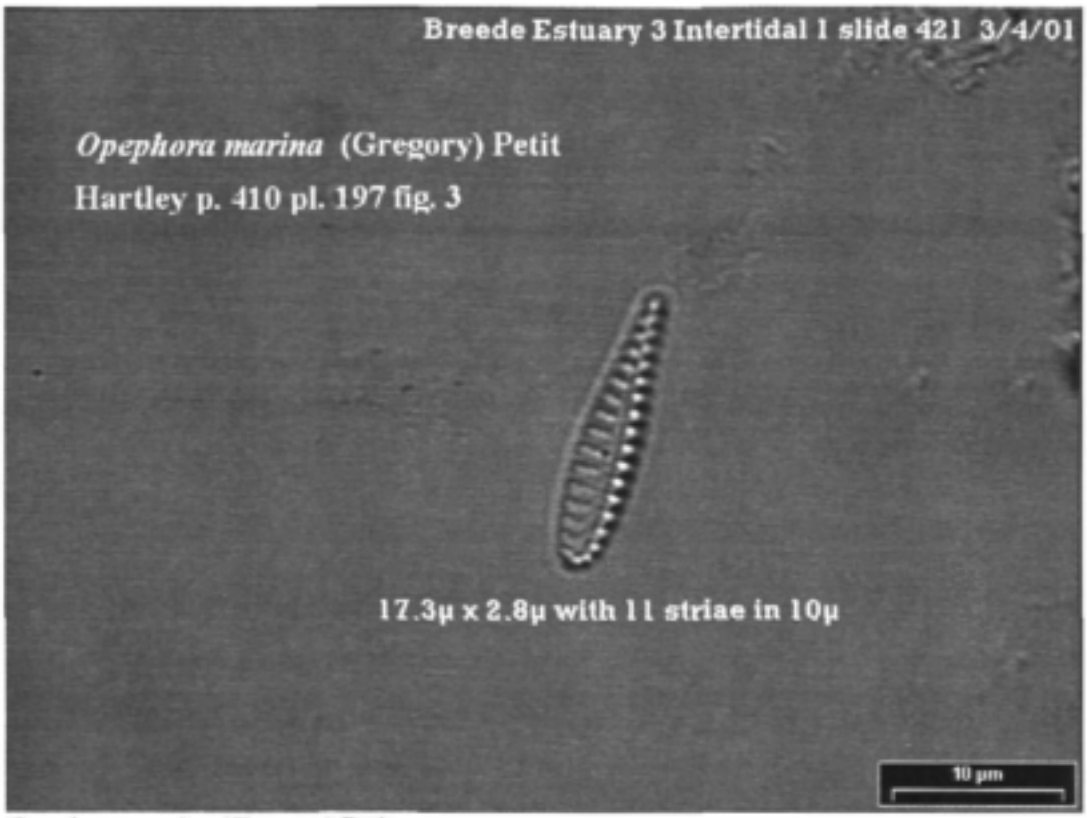
OPEPHORS



Opephora horstiana Witkowski
Reference used for identification: Lange-Bertalot 2000. Page 70. Plate 25. Figure 28.
Locations - Dominant in epipelon – Great Berg Estuary Intertidal Site 2.

NOTES	NOTES
Found at salinity: 34 ppt. Lange-Bertalot (2000): Brak – Marine.	

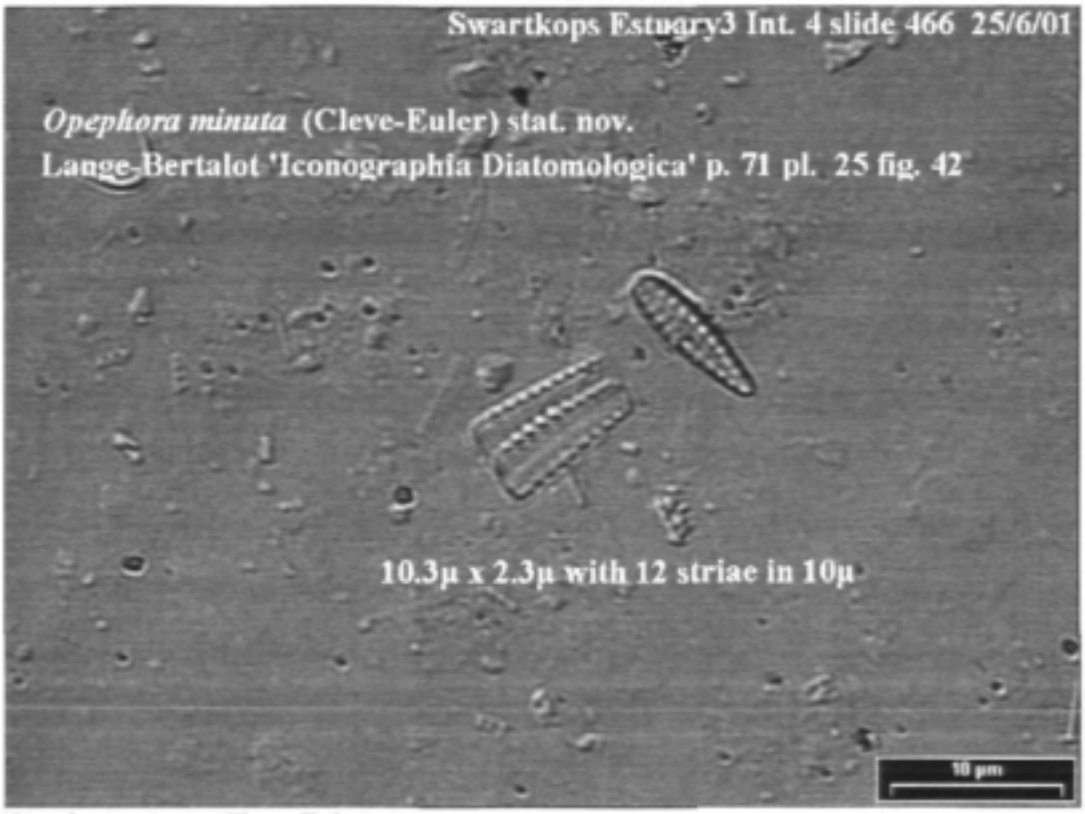
OPEPMARI



Opephora marina (Gregory) Petit
References used for identification: Hartley 1996. Page 410. Plate 197. Figure 3. Lange-Bertalot (2000) Page 71. Plate 25. Figure 6.
Locations - Dominant in epipelon – Breede Estuary 3 Intertidal Site 1.

NOTES	NOTES
Found at salinity: 29 ppt. Sims (1996): Marine. Lange-Bertalot (2000): Marine.	

OPEPMINU



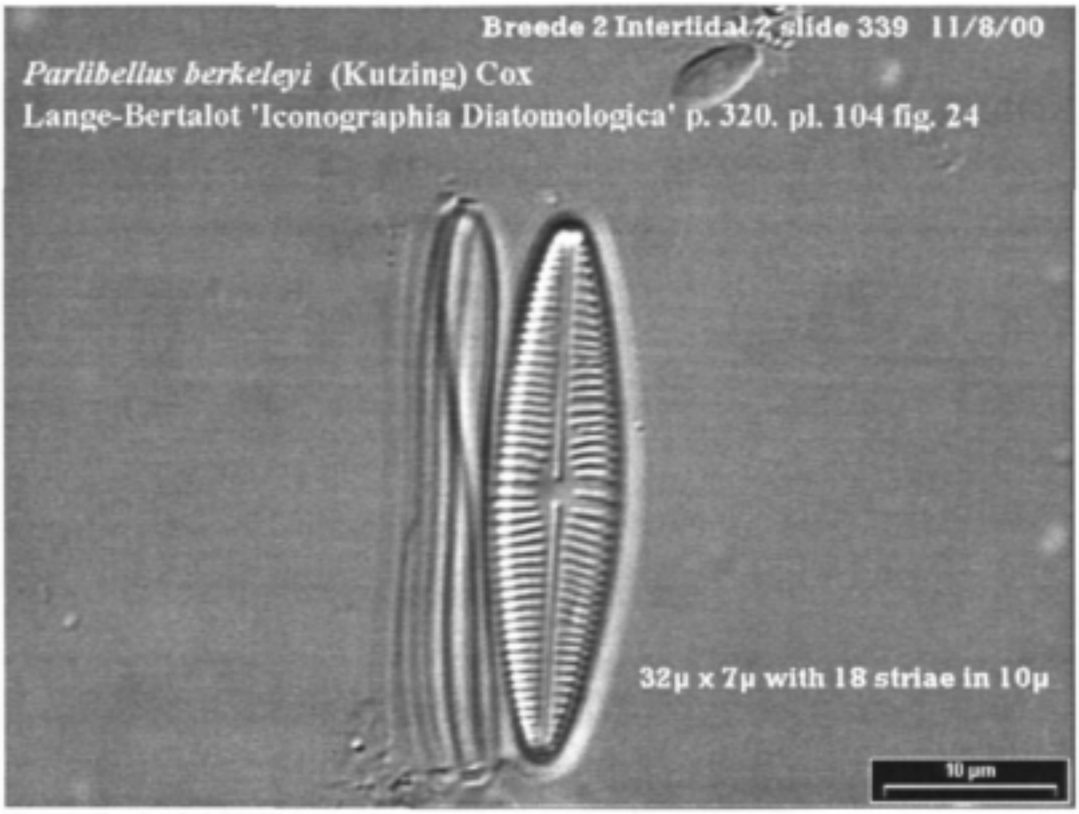
Opephora minuta (Cleve-Euler) stat.nov.

Reference used for identification: Lange-Bertalot 2000. Page 71. Plate 25. Figure 42.

Locations - Dominant in epipelon – Swartkops Estuary 3 Intertidal Site 4; Swartkops Estuary 4 Intertidal Site 4.

NOTES	NOTES
Found at salinity: 18 - 25 ppt. Lange-Bertalot (2000): Marine.	

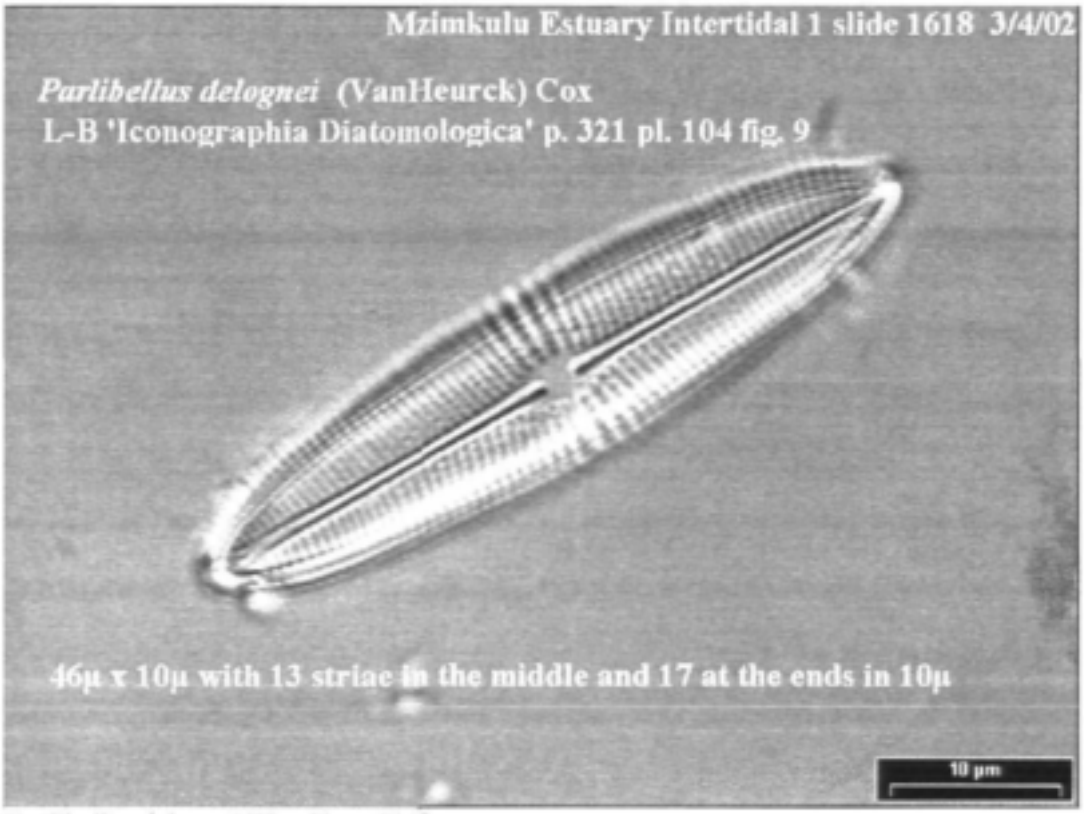
PARLBERK



Parlibellus berkeleyi (Kutzing) Cox
Reference used for identification: Lange-Bertalot 2000. Page 320. Plate 104. Figure 24.
Locations - Dominant in epipelon –Great Brak Estuary Subtidal Site 1; Sundays Estuary Subtidal Site 3; Great Berg Estuary Intertidal Site 3 & Subtidal Site 1.

NOTES	NOTES
Found at salinity: 34 – 35 ppt. Lange-Bertalot (2000): Marine.	

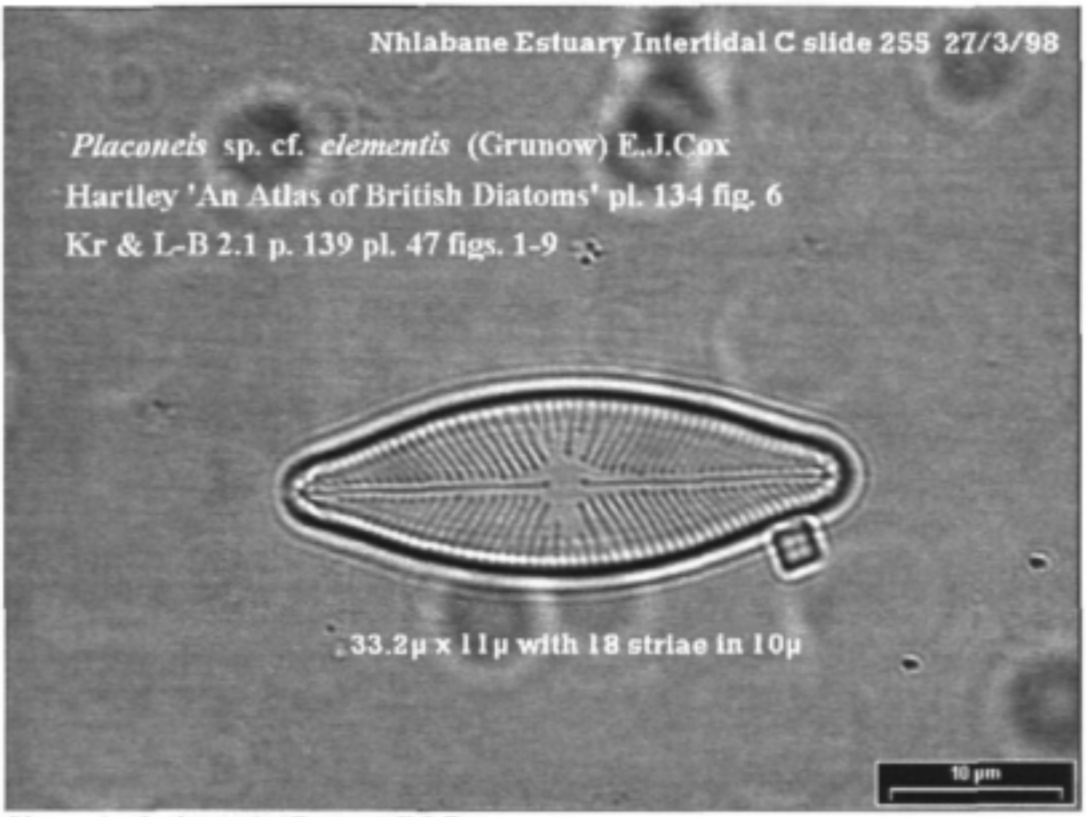
PARLDELO



Parlibellus delognei (Van Heurck) Cox
Reference used for identification: Lange-Bertalot 2000. Page 321. Plate 104. Figure 9.
Locations - Dominant in epipelon –Mlalazi Estuary Intertidal Site 5; Mzimkulu Estuary Intertidal Site 5; Great Fish Estuary Intertidal Site 4.

NOTES	NOTES
Found at salinity: 0 – 5 ppt. Lange-Bertalot (2000): Marine Sims (1996): Marine.	All authorities describe *Parlibellus* as a marine genus except for Sims (1996) who shows the revision by EJ Cox of *Navicula plicata* Donkin to *P. plicatus* Donkin as a brak species. From this it appears that the genus is not exclusively marine and our specimens, found in low brak sites may be correct. Note: In 2002 Dr Eileen Cox from the British Museum identified our specimen as *P. delognei*.

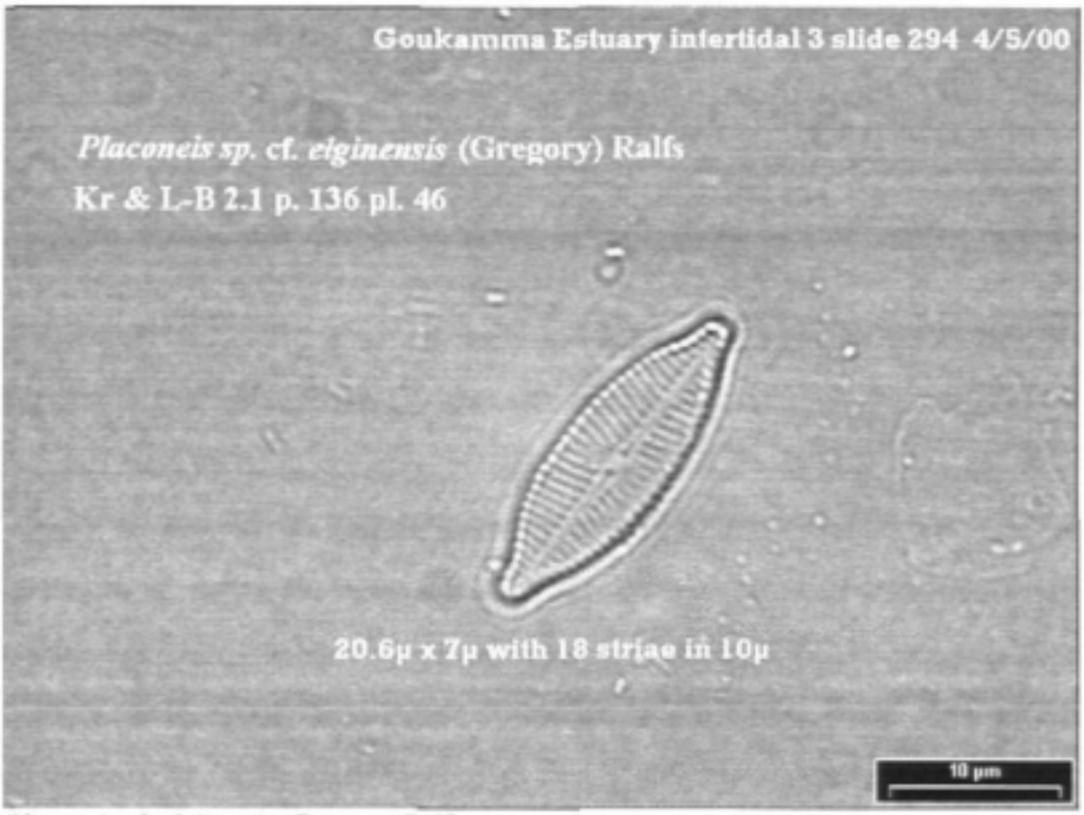
PLACcfCL



Placoneis cf. *clementis* (Grunow) E.J.Cox
Reference used for identification: Hartley 1996. Plate 134. Figure 6.
Locations - Dominant in epipelon – Nhlabane Estuary Intertidal Site 3.

NOTES	NOTES
Found at salinity: 3 ppt.	

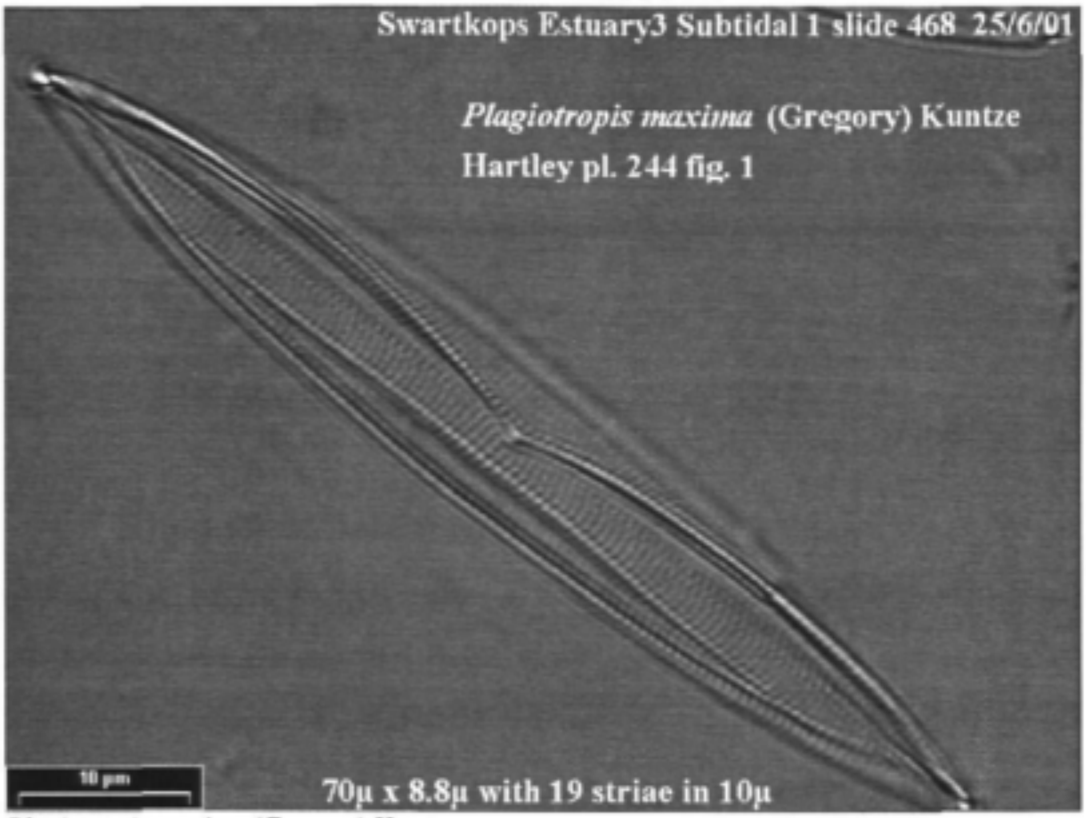
PLACcfEL



Placoneis cf. *elginensis* (Gregory) Ralfs
Reference used for identification: Krammer & Lange-Bertalot 1986. 2.1 Page 136. Plate 136. Figure 46.
Locations - Dominant in epipelon – Goukamma Estuary Intertidal Site 3.

NOTES	NOTES
Found at salinity: 22 ppt.	

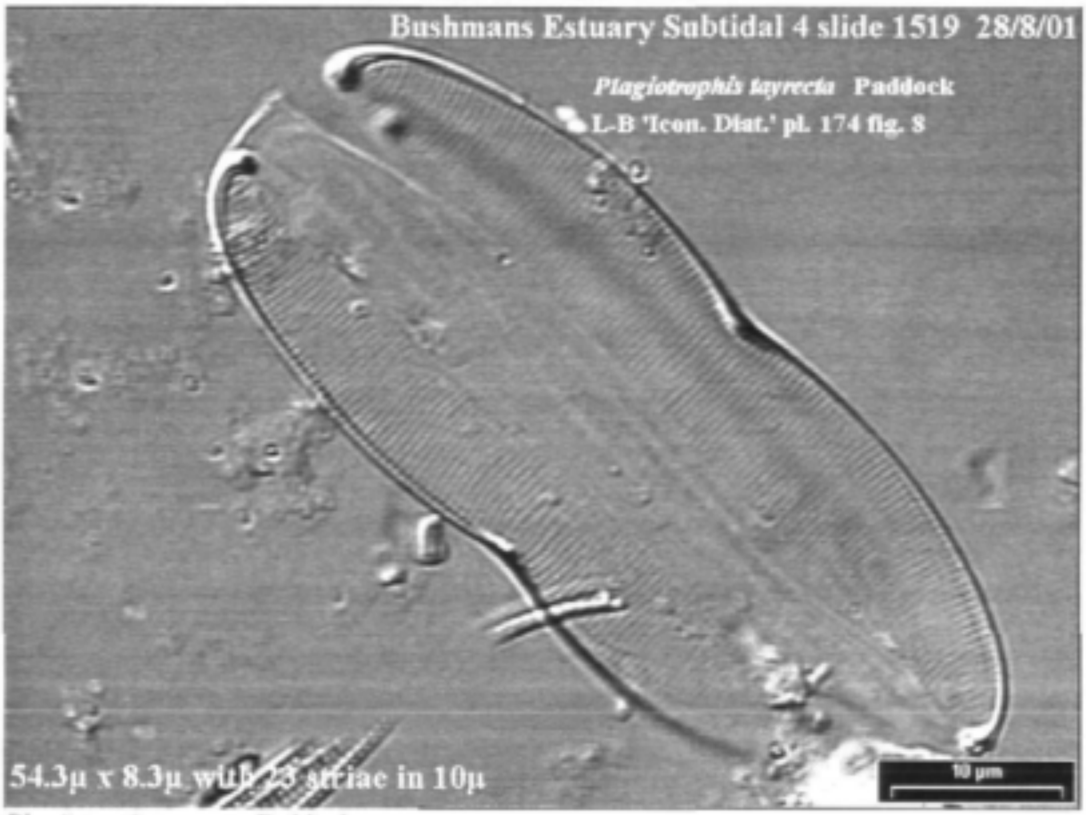
PLAGMAXI



Plagiotropis maxima (Gregory) Kuntze
Reference used for identification: Hartley 1996. Plate 244. Figure 1.
Locations - Dominant in epipelon – Keurbooms Estuary Intertidal Site 1.

NOTES	NOTES
Found at salinity: 34 ppt. Sims (1996): Marine.	

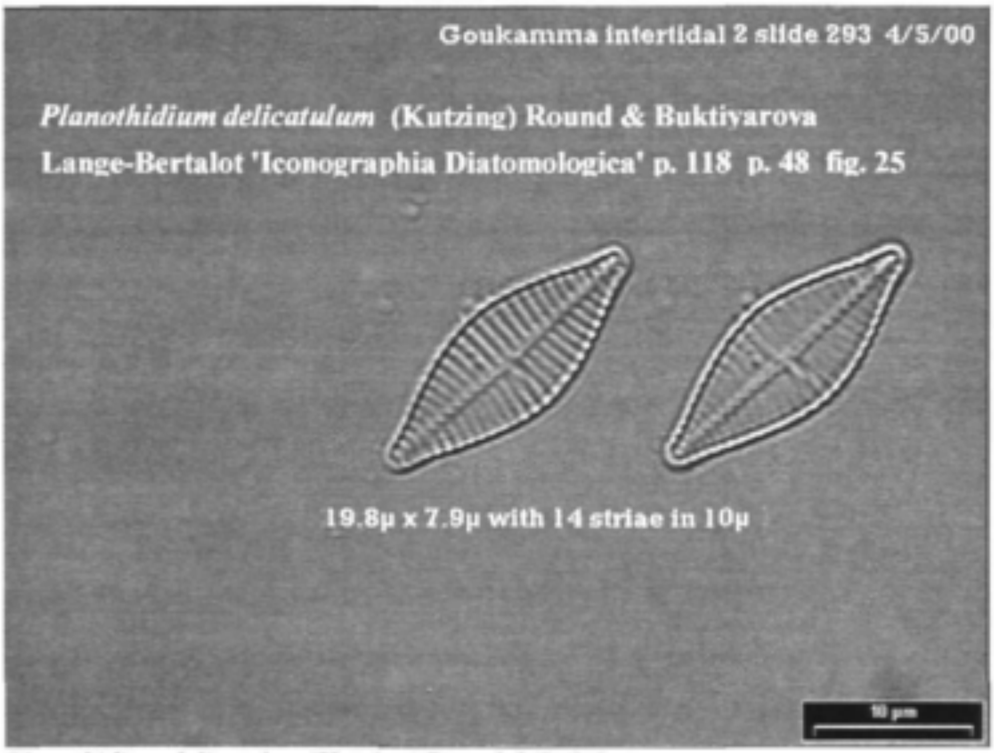
PLAGTAYR



Plagiotropis tayrecta Paddock
Reference used for identification: Lange-Bertalot 2000. Plate 174. Figure 8.
Locations - Dominant in epipelon – Kowie Estuary Subtidal Site 3.

NOTES	NOTES
Found at salinity: 30 ppt. Sims (1996): Marine.	

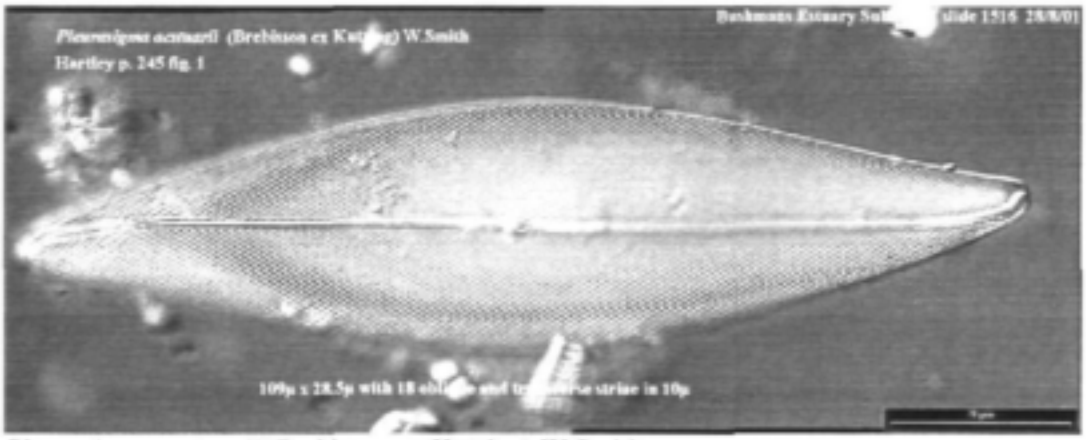
PLANDELI



Planothidium delicatulum (Kutzing) Round & Buktiyatova
Reference used for identification: Lange-Bertalot 2000. Page 118. Plate 48. Figure 25.
Locations - Dominant in epipelon – Goukou Estuary Subtidal Site 5; Swartkops Estuary 2 Subtidal Site 4; Swartkops Estuary 4 Subtidal Site 2; Breede Estuary 3 Intertidal Site 2; Goukamma Estuary Subtidal Sites 1, 2 & 3; Mngazana Estuary Subtidal Site 1. Bushmans Subtidal 3; Great Brak Subtidal Site 3; Gourits Subtidal Site 2.

NOTES	NOTES
Found at salinity: 10 – 36 ppt.	

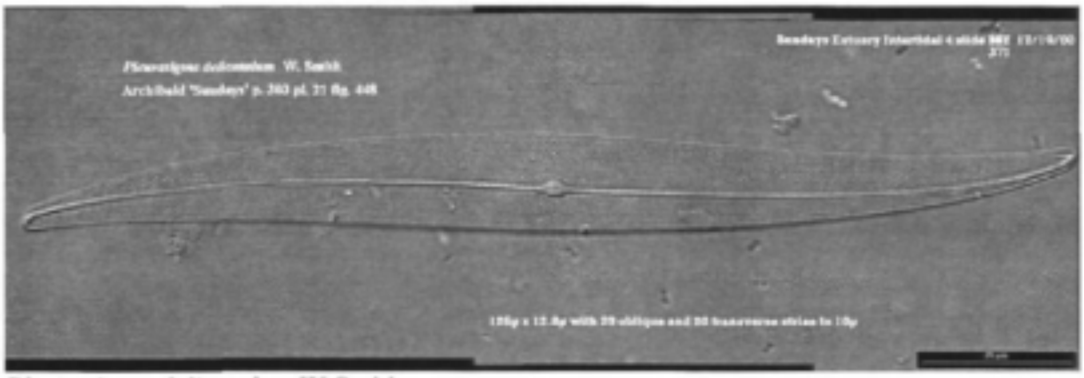
PLEUAEST



Pleurosigma aestuarii (Brebisson ex Kutzing) W.Smith
Reference used for identification: Hartley 1996. Plate 245. Figure 1.
Locations - Dominant in epipelon- Bushmans Estuary Subtidal Site 1.

NOTES	NOTES
Found at salinity: 36 ppt. Sims (1996): Brak.	

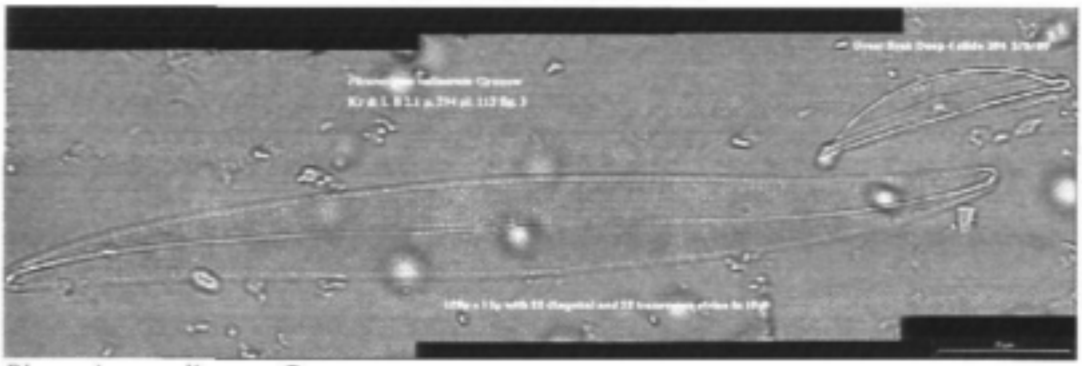
PLEUDELI



Pleurosigma delicatulum W.Smith
Reference used for identification: Archibald 1983. Page 303. Plate 21. Figure 448.
Locations - Dominant in epipelon – Sundays Estuary Subtidal & Intertidal Site 4; Goukou Estuary Subtidal Site 2; Keurbooms Subtidal Site 5.

NOTES	NOTES
Found at salinity: 2 - 27 ppt. Patrick & Reimer (1975): Brak - Marine.	

PLEUSALI



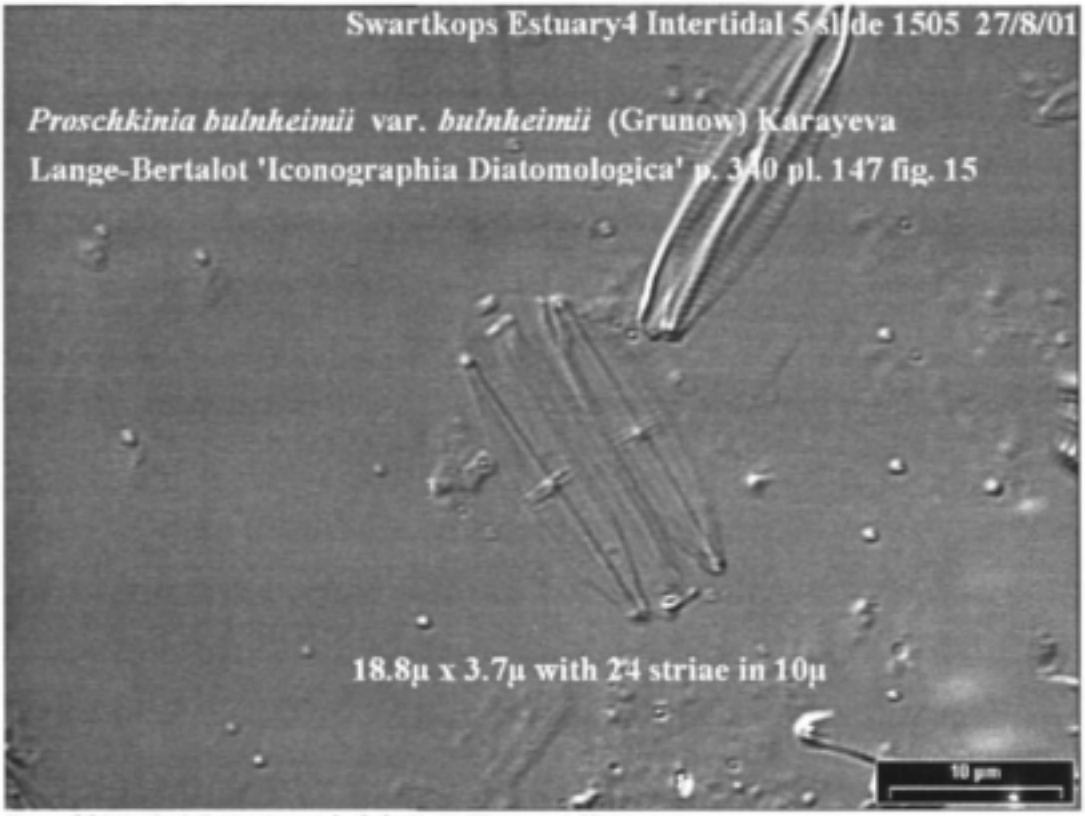
Pleurosigma salinarum Grunow

Reference used for identification: Krammer & Lange-Bertalot 1986. 2.1 Page 294. Plate 133. Figure 3.

Locations - Dominant in epipelon – Great Brak Estuary Subtidal Site 4.

NOTES	NOTES
Found at salinity: 25 ppt. Hustedt (1976): Brak. Krammer & Lange-Bertalot (1986): Brak – Marine. Patrick & Reimer (1975): Fresh – Brak.	

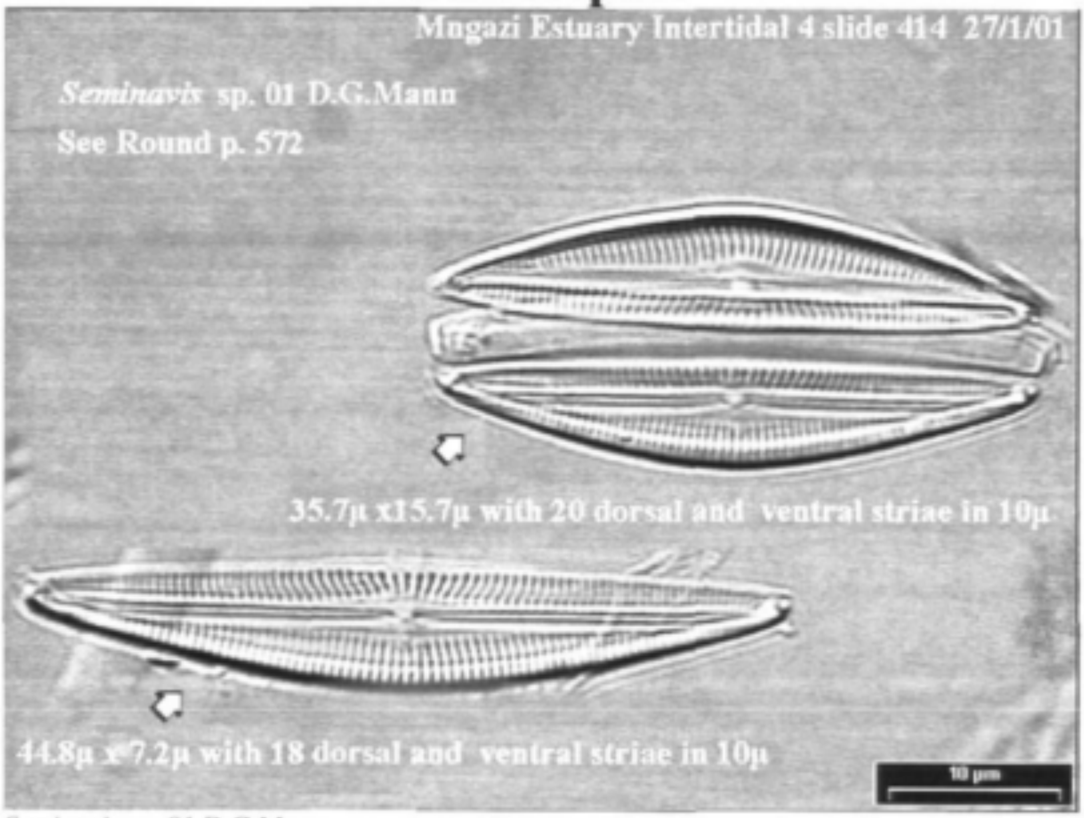
PROSBUbu



Proschkinia bulnheimii var. *bulnheimii* (Grunow) Karayeva
Reference used for identification: Lange-Bertalot 2000. Page 340. Plate 147. Figure 15.
Locations - Dominant in epipelon – Swartkops Estuary 4 Intertidal Site 5; Kowie Estuary Intertidal Site 3; Gourits Estuary Intertidal Site 3.

NOTES	NOTES
Found at salinity: 21 - 35 ppt. Lange-Bertalot (2000): Marine.	

SEMIsp01



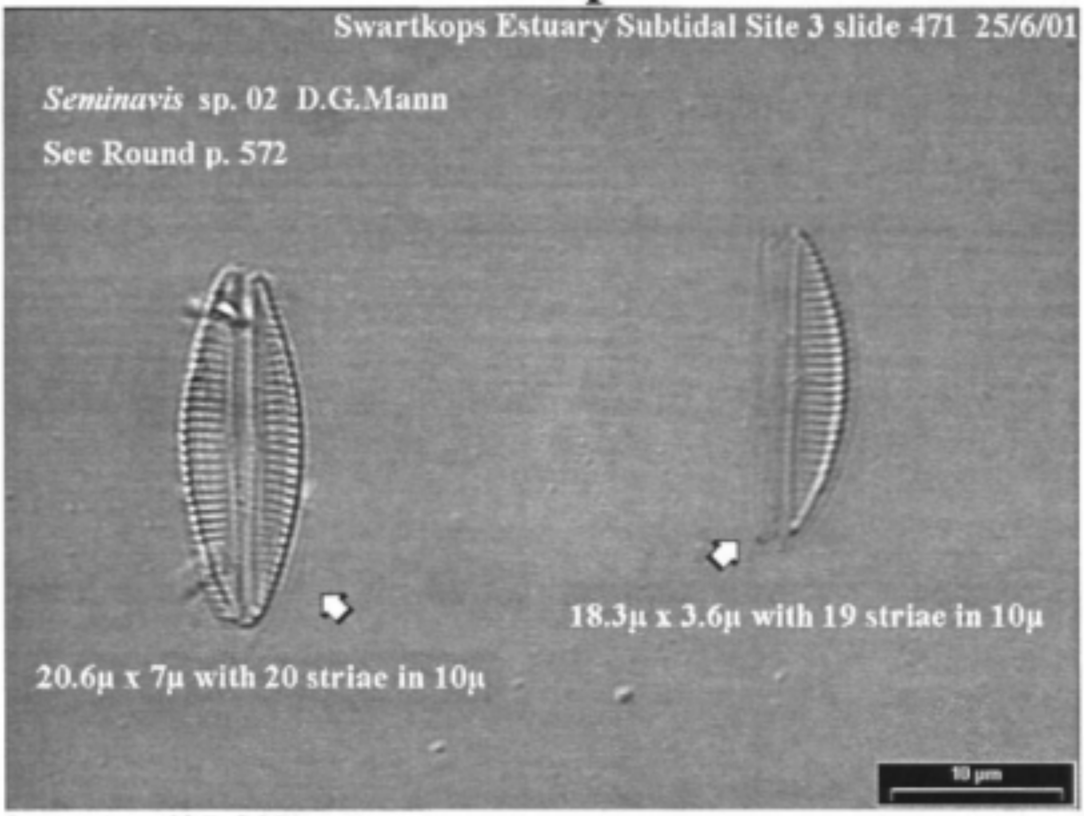
Seminavis sp. 01 D.G.Mann

Reference used for identification: Round, Crawford & Mann 1990. Page 572.

Locations - Dominant in epipelon – Mngazi Estuary Intertidal Site 4. Mhlathuze Boat Launch Site.

NOTES	NOTES
Found at salinity: 8 ppt. Round *et al.* (1990): Marine genus.	

SEMIsp02



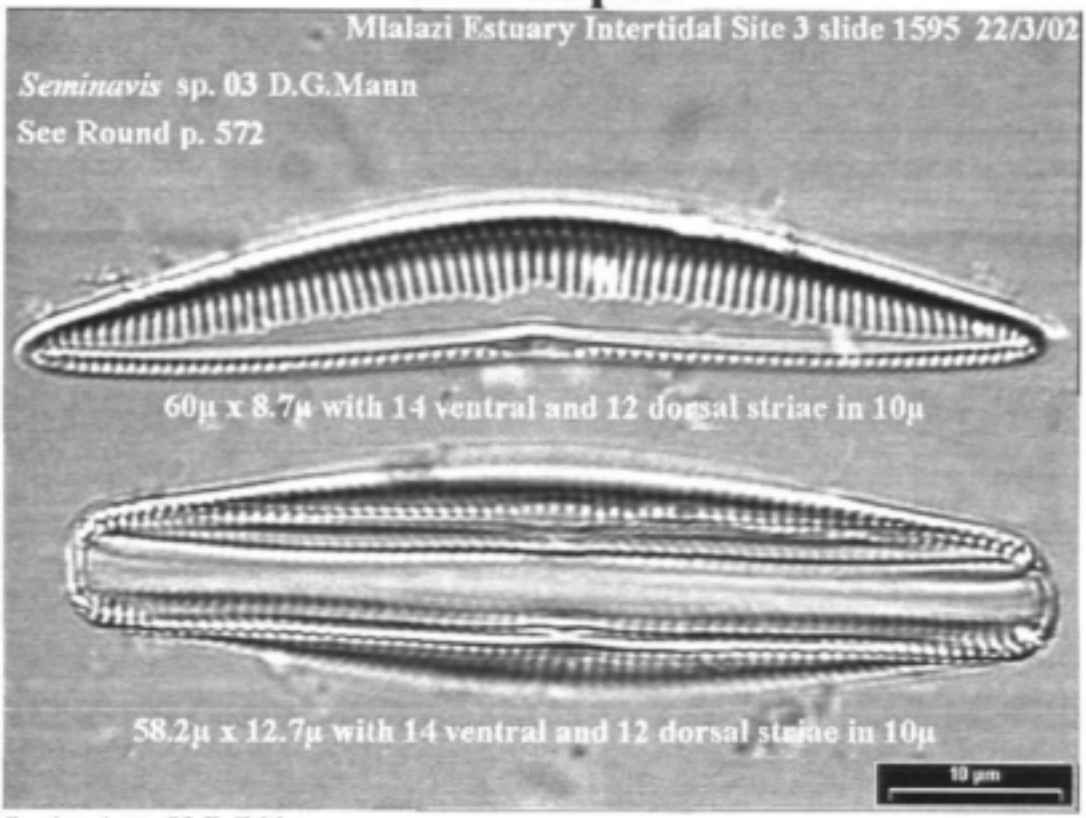
Seminavis sp. 02 D.G.Mann

Reference used for identification: Round, Crawford & Mann 1990. Page 572.

Locations - Dominant in epipelon – Swartkops Estuary 1 Intertidal & Subtidal Site 1; Swartkops Estuary 4 Subtidal Site 1.

NOTES	NOTES
Found at salinity: 37 – 38 ppt. Round *et al.* (1990): Marine genus.	

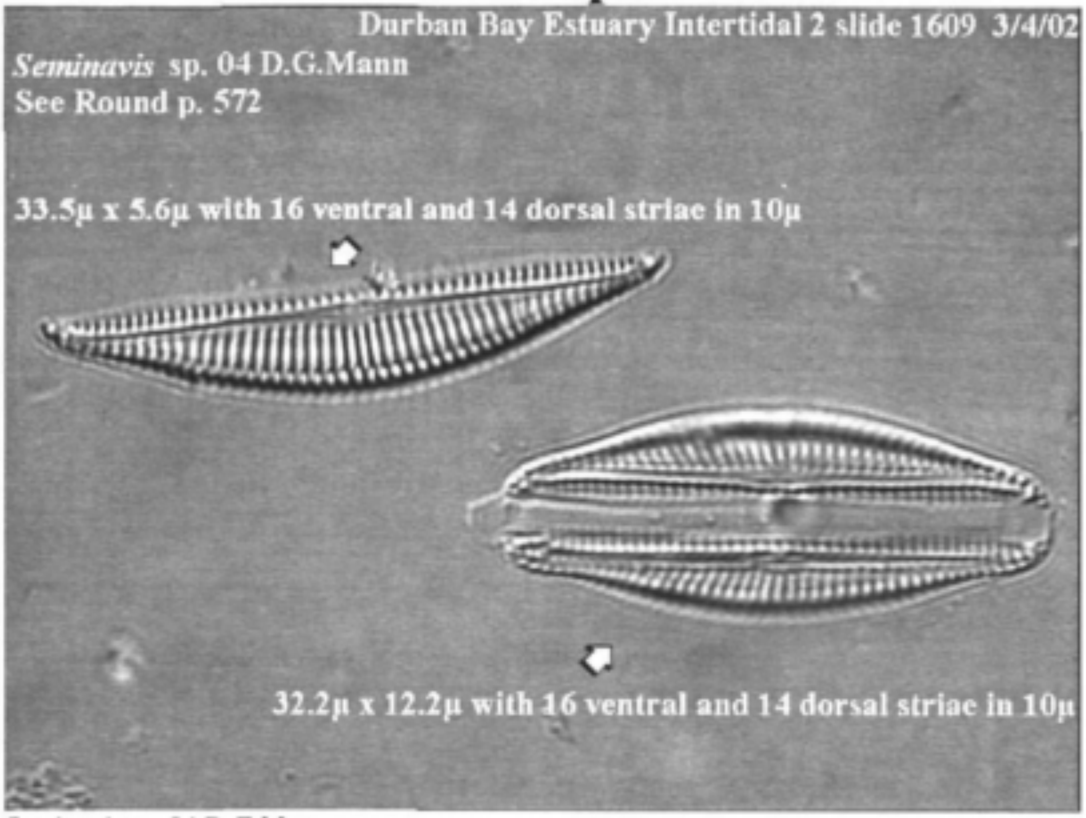
SEMIsp03



Seminavis sp. 03 D.G.Mann
Reference used for identification: Round, Crawford & Mann 1990. Page 572.
Locations - Dominant in epipelon – Mlalazi Estuary Intertidal Sites 3 & 4; Zinkwazi Estuary Intertidal Site 1.

NOTES	NOTES
Found at salinity: 15 – 33 ppt. Round *et al.* (1990): Marine genus.	

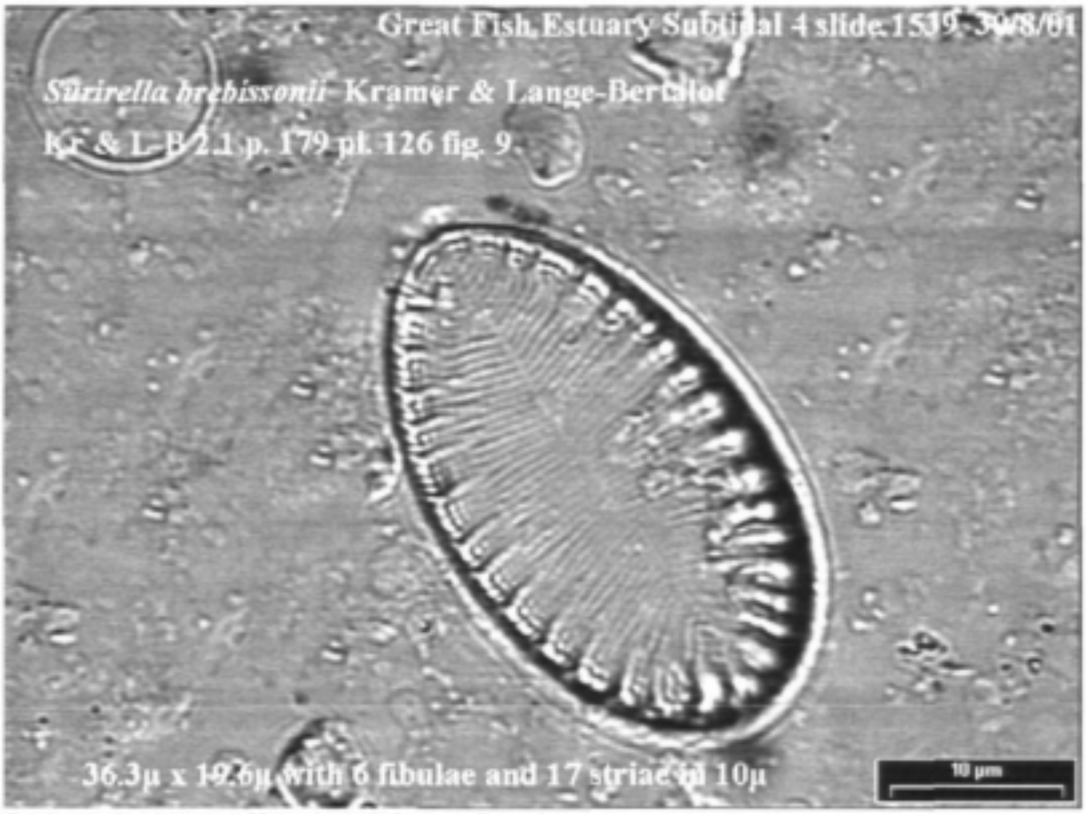
SEMIsp04



Seminavis sp. 04 D.G.Mann
Reference used for identification: Round, Crawford & Mann 1990. Page 572.
Locations - Dominant in epipelon – Durban Bay Estuary Intertidal Site 2.

NOTES	NOTES
Found at salinity: 35 ppt. Round *et al.* (1990): Marine genus.	

SURIBREB



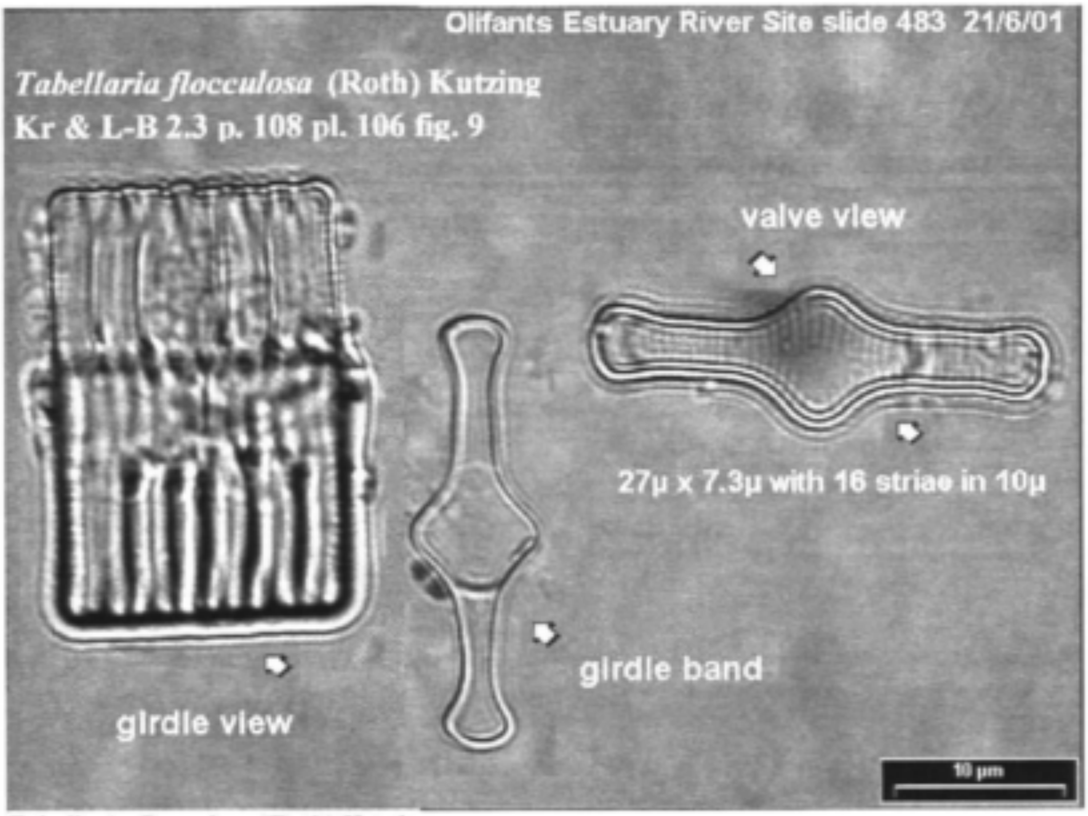
Surirella brebissonii Krammer & Lange-Bertalot

Ref. used for identification: Krammer & Lange-Bertalot 1986. 2.2 Page 179. Plate 126. Figure 9.

Locations - Dominant in epipelon – Great Fish Estuary Subtidal Site 4.

<u>NOTES</u>	<u>NOTES</u>
Found at salinity: 26 ppt. Sims (1996): Fresh water. Lange-Bertalot (2000): Fresh water – Brak.	

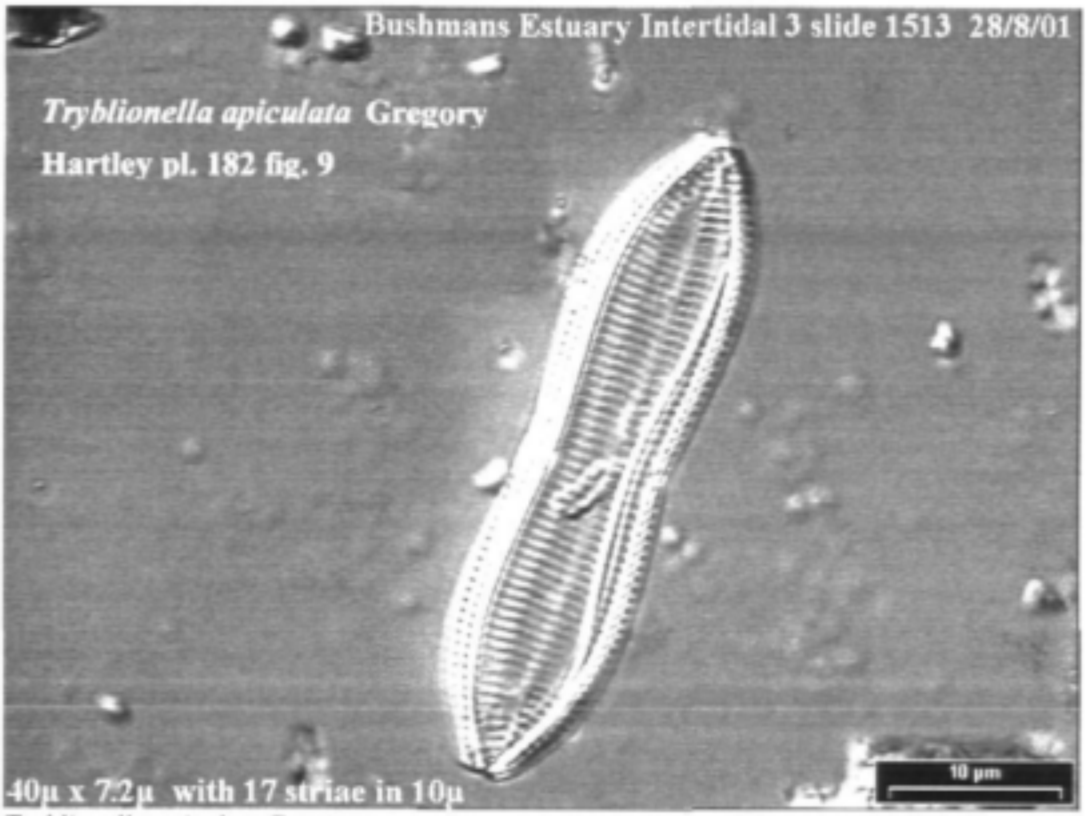
TABEFLOC



Tabellaria flocculosa (Roth) Kutzing
Ref. used for identification: Krammer & Lange-Bertalot 1986. 2.3 Page 108. Plate 106. Figure 9.
Locations -Dominant in epipelon – Olifants Estuary River Site.

NOTES	NOTES
This fresh water genus was present at the fresh water site in the Olifants Estuary.	

TRYBAPIC



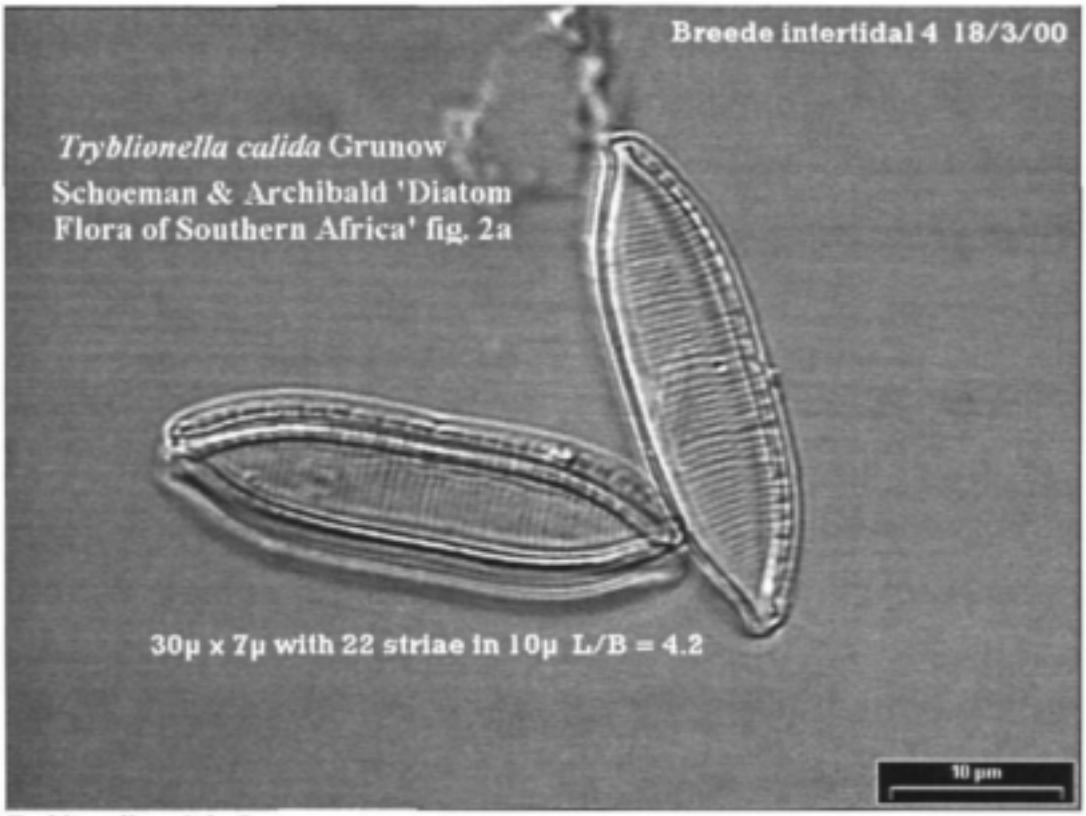
Tryblionella apiculata Gregory

Reference used for identification: Hartley 1996. Plate 182. Figure 9

Locations - Dominant in epipelon – Bushmans Estuary Intertidal Site 4.

NOTES	NOTES
Found at salinity: 33 ppt. Sims (1996): Brak.	

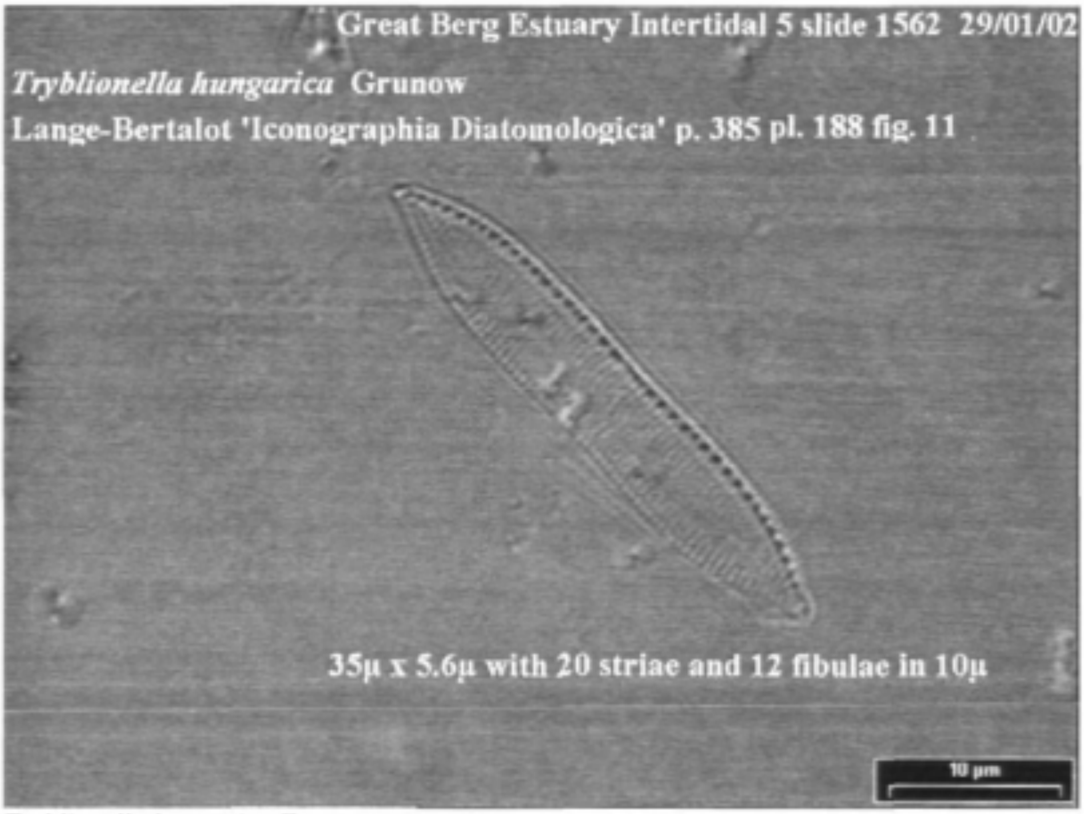
TRYBCALI



Tryblionella calida Grunow
Reference used for identification: Schoeman & Archibald 1976. Figure 2a.
Locations - Dominant in epipelon – Breede Estuary 1 Intertidal Site 5.

NOTES	NOTES
Found at salinity: 0 ppt. Sims (1996): Fresh water.	

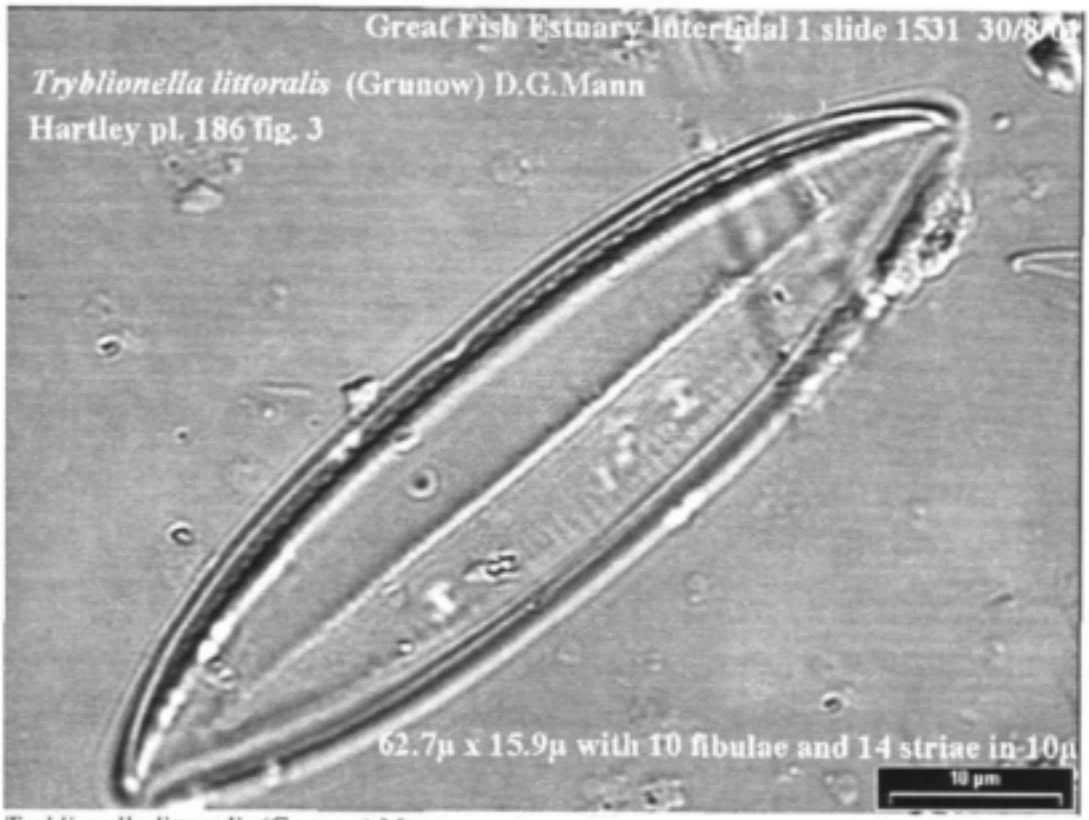
TRYBHUNG



Tryblionella hungarica Grunow
Reference used for identification: Lange-Bertalot 2000. Page 385. Plate 188. Figure 11.
Locations – Sub-dominant in epipelon – Great Berg Estuary Intertidal Site 5.

NOTES	NOTES
Found at salinity: 20 ppt. Sims (1996): Brak.	

TRYBLITT

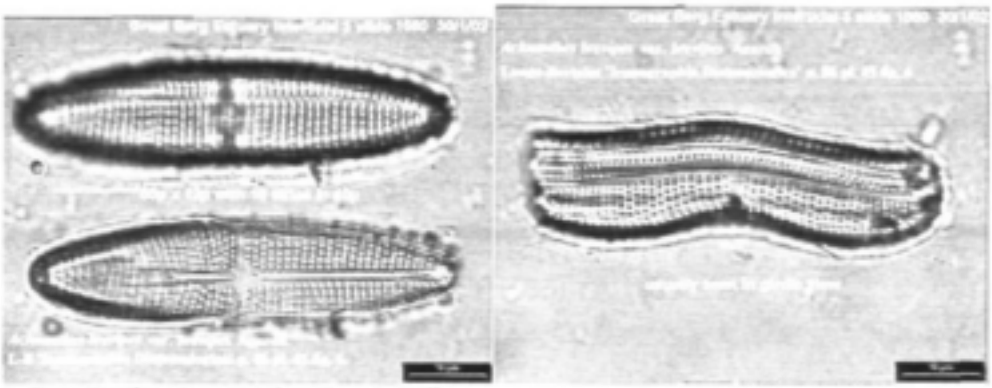


Tryblionella littoralis (Grunow) Mann
Reference used for identification: Hartley 1996. Plate 186. Figure 3.
Locations - Dominant in epipelon – Great Fish Estuary Intertidal Site 3.

NOTES	NOTES
Found at salinity: 10 ppt. Sims (1996): Marine.	

ESTUARINE SUB-DOMINANTS

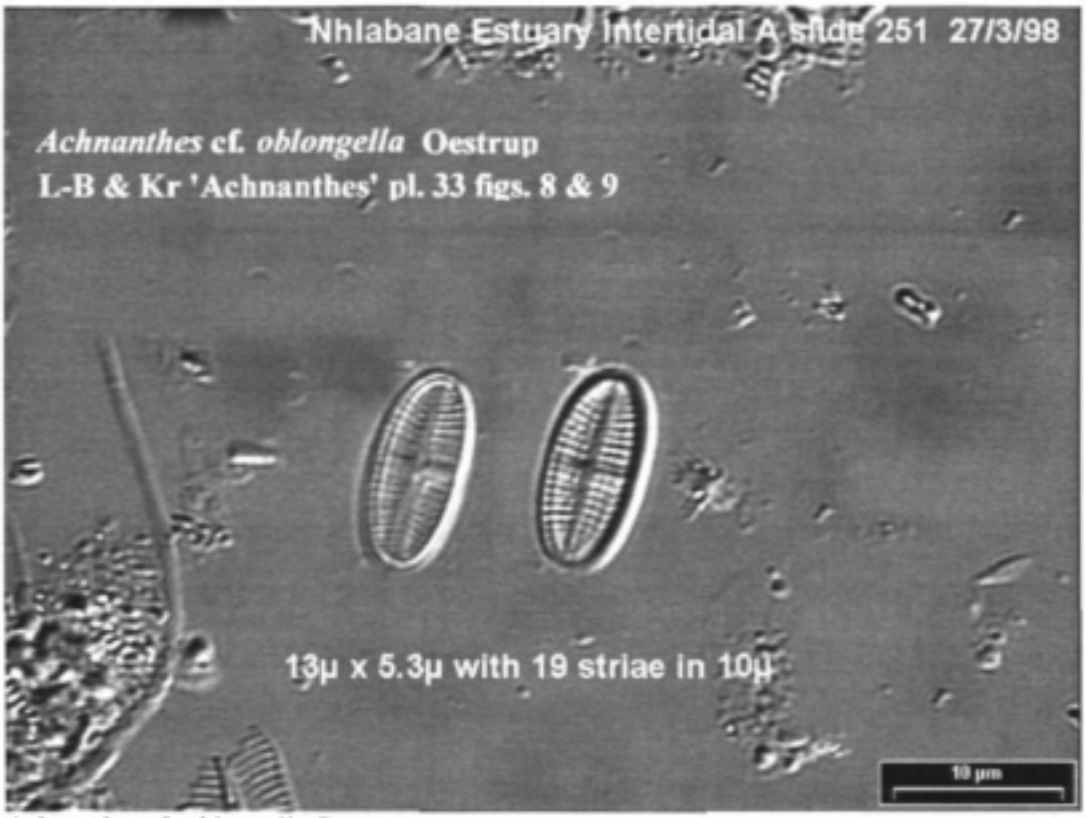
ACHNBRbr



Achnanthes brevipes var. *brevipes* Agardh
Reference used for identification: Lange-Bertalot 2000. Page 86. Plate 45. Figure 6.
Locations – Sub-dominant in epipelon – Great Berg Estuary Intertidal Site 3.

NOTES	NOTES
Found at salinity: 38 ppt. Lange-Bertalot (2000): Brak – Marine. Hustedt (1976): Brak. Sims (1996): Brak.	This is a heterovalvar genus having one raphid and one rapheless valve.

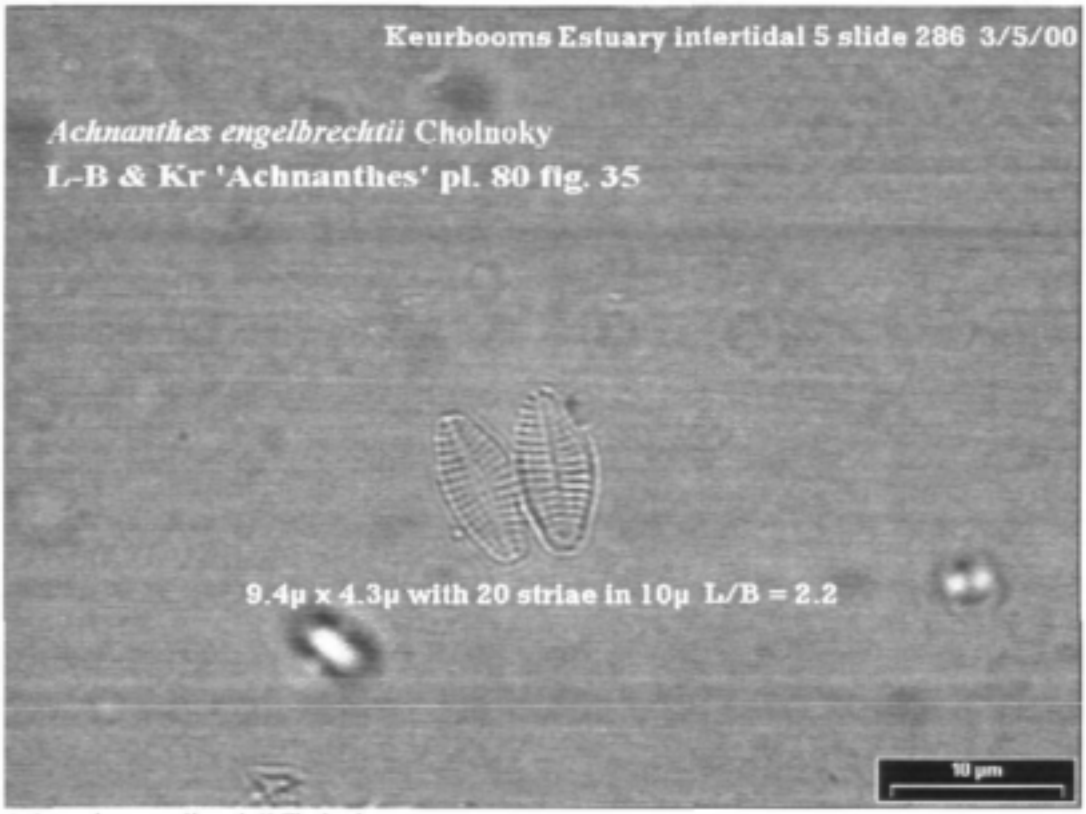
ACHNcfOB



Achnanthes cf. *oblongella* Oestrup
Reference used for identification: Lange-Bertalot & Krammer 1989. Plate 33. Figure 5.
Locations – Sub-dominant in epipelon – Nhlabane Estuary Intertidal Site A - fresh water lake.

NOTES	NOTES
Note: Found in fresh water. Lange-Bertalot & Krammer (1989): Fresh water.	This is a heterovalvar genus having one raphid and one rapheless valve.

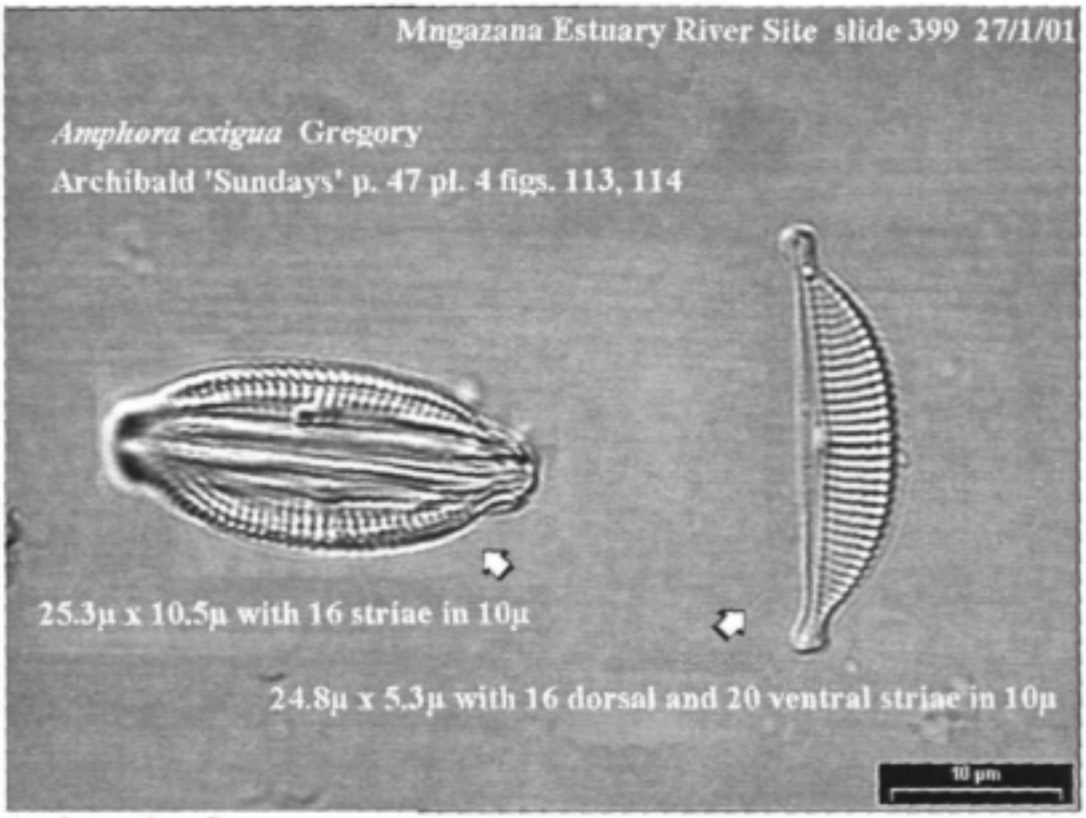
ACHNENGE



Achnanthes engelbrechtii Cholnoky
Reference used for identification: Lange-Bertalot and Krammer 1989. Plate 80. Figure 35.
Locations – Sub-dominant in epipelon - Keurbooms Estuary Intertidal Site 5.

NOTES	NOTES
Found at salinity: 2 ppt.	This is a heterovalvar genus having one raphid and one rapheless valve.

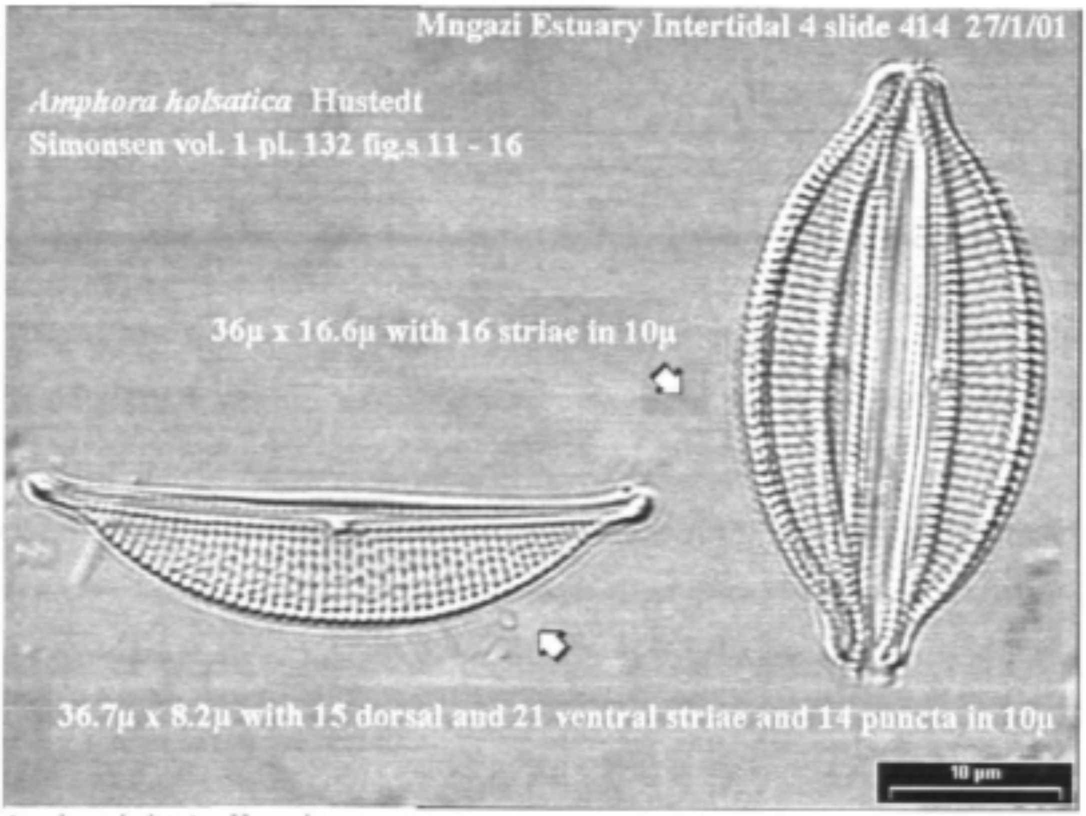
AMPHEXIG



Amphora exigua Gregory
Reference used for identification: Archibald 1983. Page 47. Plate 4. Figure 113.
Locations – Sub-dominant in epipelon - Zinkwazi Estuary Intertidal Sites 3 & 5.

NOTES	NOTES
Found at salinity: 13 – 14 ppt. Lange-Bertalot (2000): Brak. Patrick & Reimer (1975): Fresh – Brak.	

AMPHHOLS



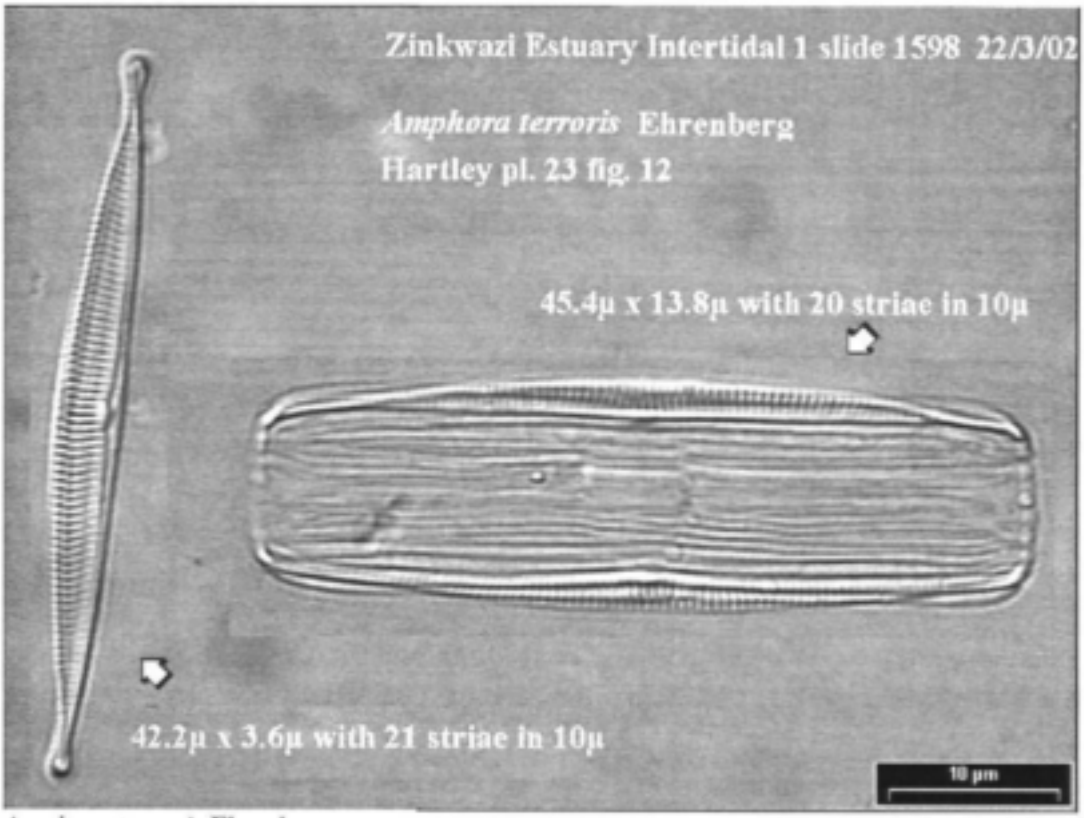
Amphora holsatica Hustedt

Reference used for identification: Simonsen 1987. Volume 1. Plate 132. Figures 11 – 16. Hartley 1996. Plate 19. Figure 5.

Locations – Sub-dominant in epipelon – Mngazi Estuary River Site & Intertidal Site 4.

NOTES	NOTES
Found at salinity: 0 – 8 ppt. Hustedt (1976): Brak. Sims (1996): Marine.	

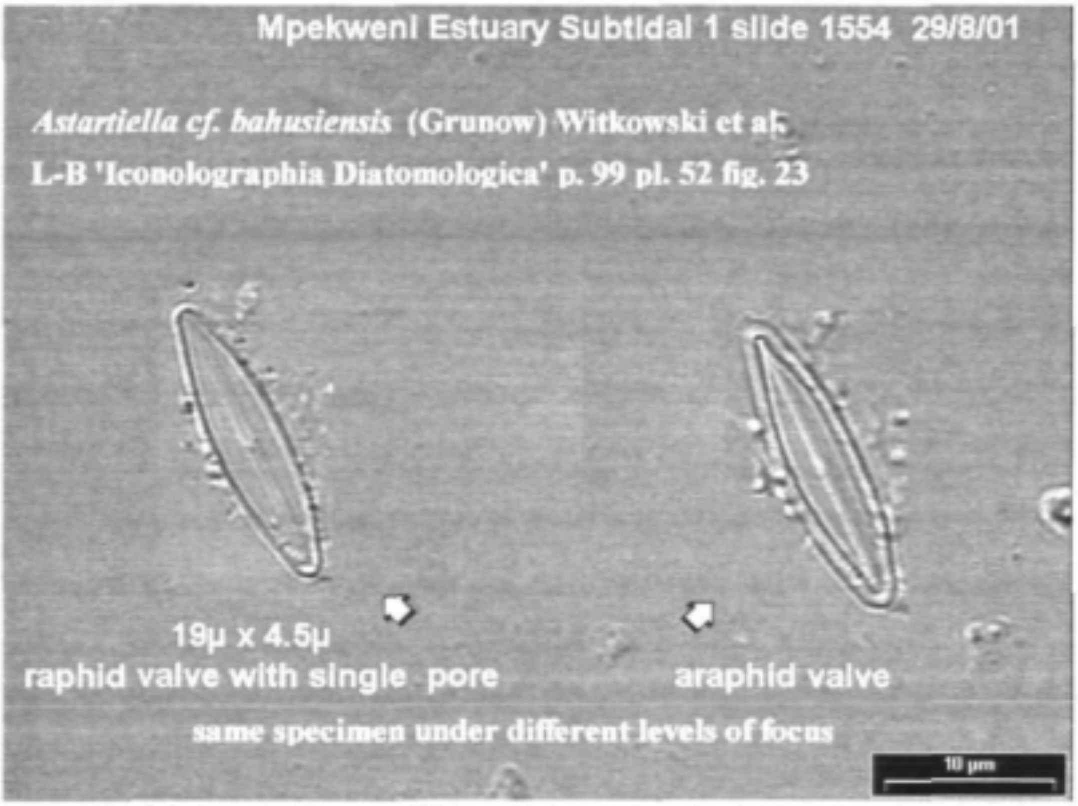
AMPHTERR



Amphora terroris Ehrenberg
Reference used for identification: Hartley 1996. Plate 23. Figure 12.
Locations – Sub-dominant in epipelon – Zinkwazi Estuary Intertidal Site 1.

<u>NOTES</u>	<u>NOTES</u>
Found at salinity: 15 ppt. Sims (1996): Brak – Marine.	

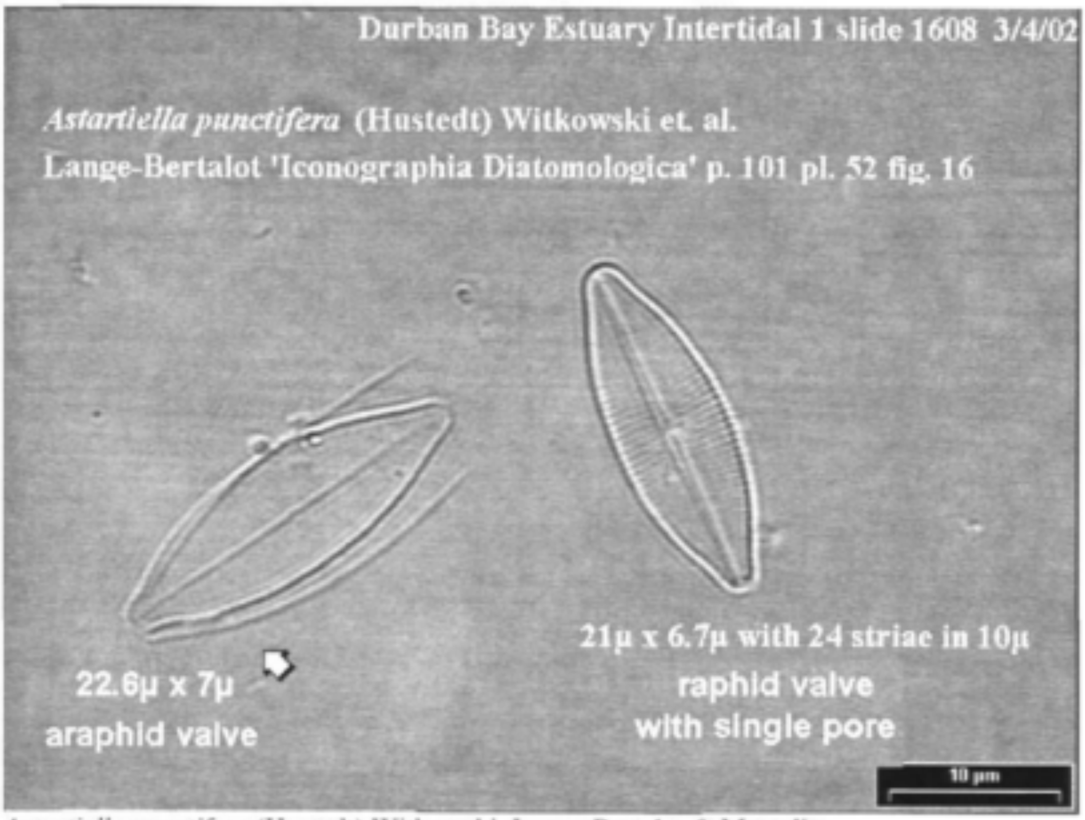
ASTAcfBA



Astartiella cf. *bahuensis* (Grunow) Witkowski, Lange-Bertalot & Metzelin
Reference used for identification: Lange-Bertalot 2000. Page 99. Plate 52. Figure 24.
Locations – Sub-dominant in epipelon – Mpekweni Estuary Subtidal Site 1.

NOTES	NOTES
Found at salinity: 35 ppt. Lange-Bertalot (2000): Brak – Marine.	This is a heterovalvar genus having one raphid and one rapheless valve. Look for stigmata in the centre of raphid valve.

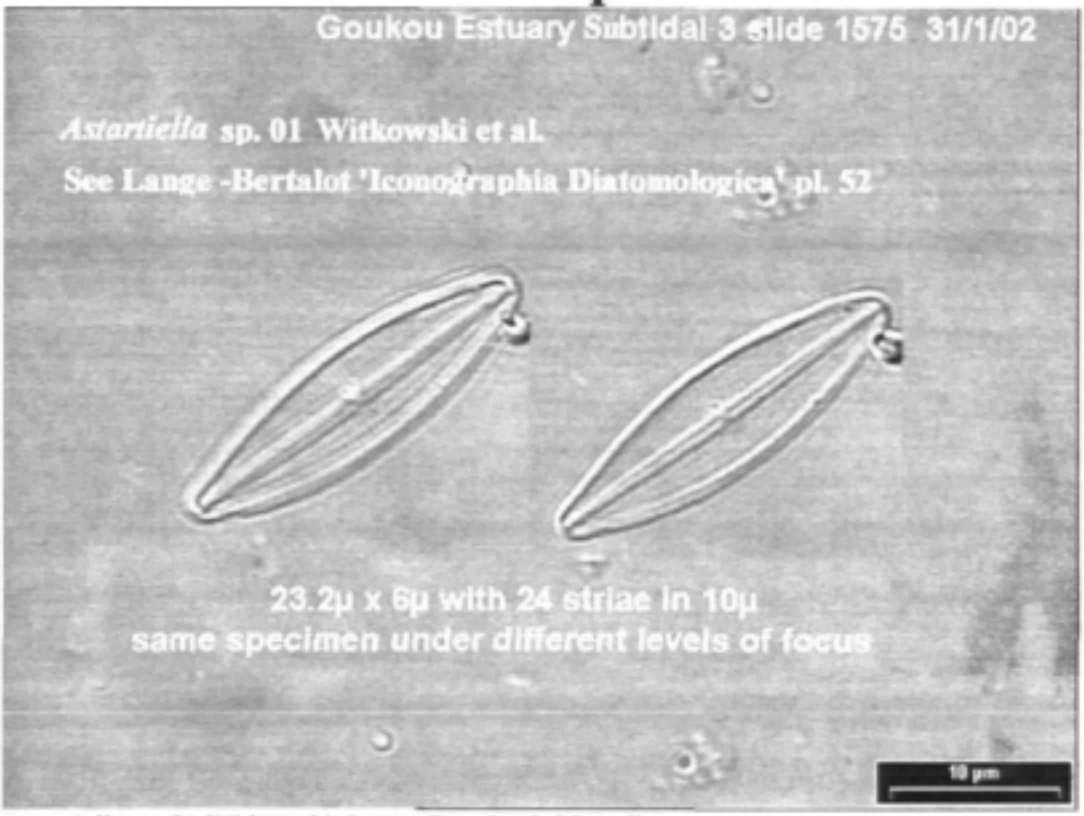
ASTAPUNC



Astartiella punctifera (Hustedt) Witkowski, Lange-Bertalot & Metzelin
Reference used for identification: Lange-Bertalot 2000. Page 101. Plate 52. Figure 16.
Locations – Sub-dominant in epipelon – Durban Bay Estuary Intertidal Site 1.

NOTES	NOTES
Found at salinity: 35 ppt. Lange-Bertalot (2000): Marine.	This is a heterovalvar genus having one raphid and one rapheless valve. Look for stigmata in the centre of raphid valve.

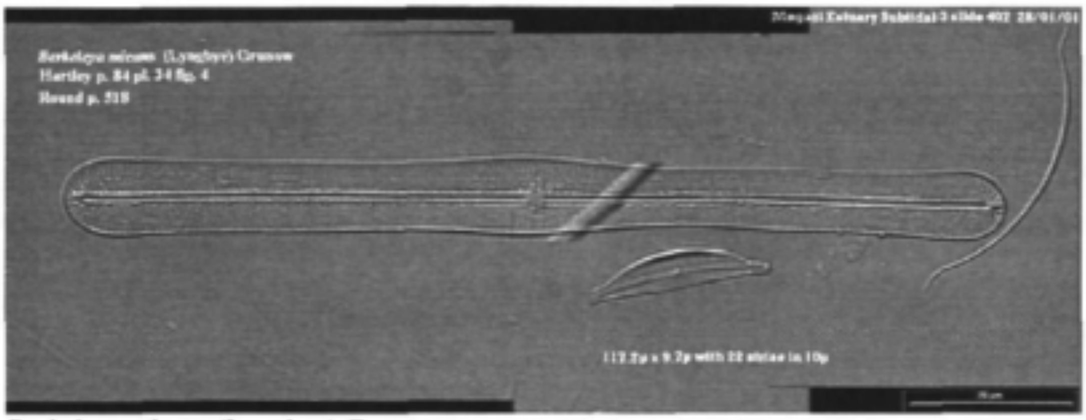
ASTAsp01



Astartiella sp. 01 Witkowski, Lange-Bertalot & Metzelin
Reference used for identification: Lange-Bertalot 2000.
Locations – Sub-dominant in epipelon – Gourits Estuary Intertidal & Subtidal Site 3 & Subtidal Site 4; Goukou Subtidal Site 3.

NOTES	NOTES
Found at salinity: 14 – 34 ppt.	This is a heterovalvar genus having one raphid and one rapheless valve. Look for stigmata in the centre of raphid valve.

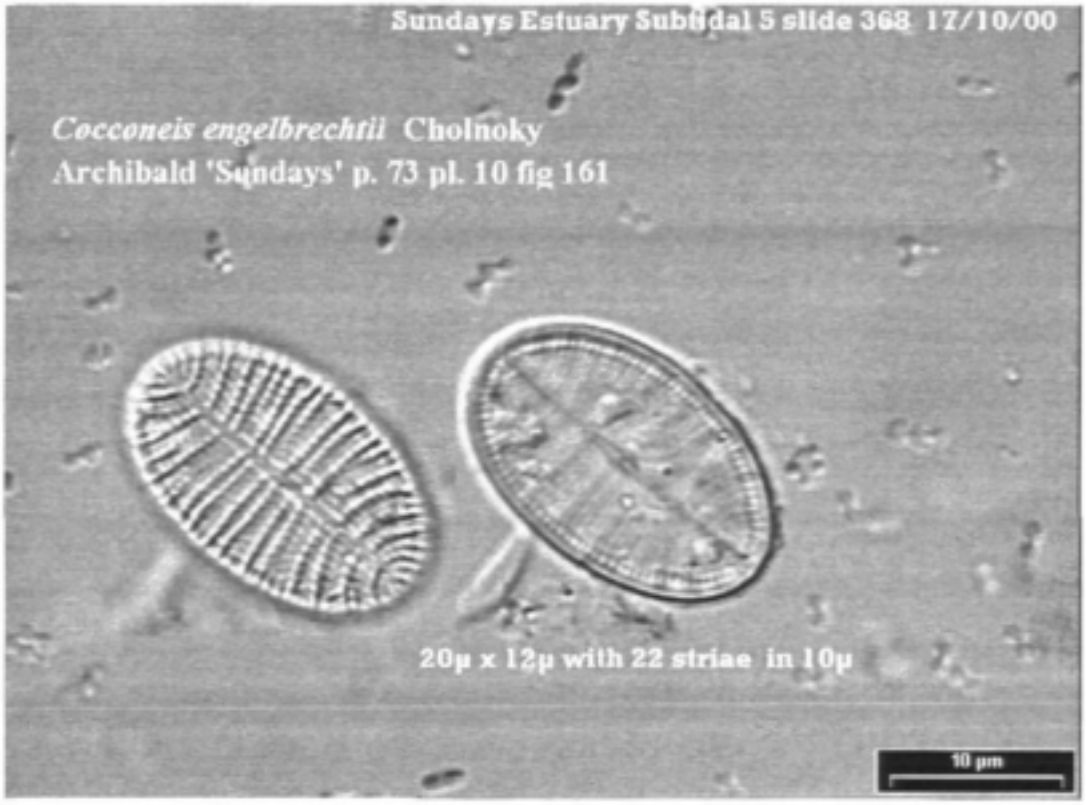
BERKMICA



Berkeleya micans (Lyngbye) Grunow
Reference used for identification: Hartley 1996. Plate 34. Figure 4.
Locations – Sub-dominant in epipelon – Mngazi Estuary Subtidal Site 3; Breede Estuary 3 Intertidal Site 3.

NOTES	NOTES
Found at salinity: 15 –33 ppt. Sims (1996): Marine.	

COCCENGE



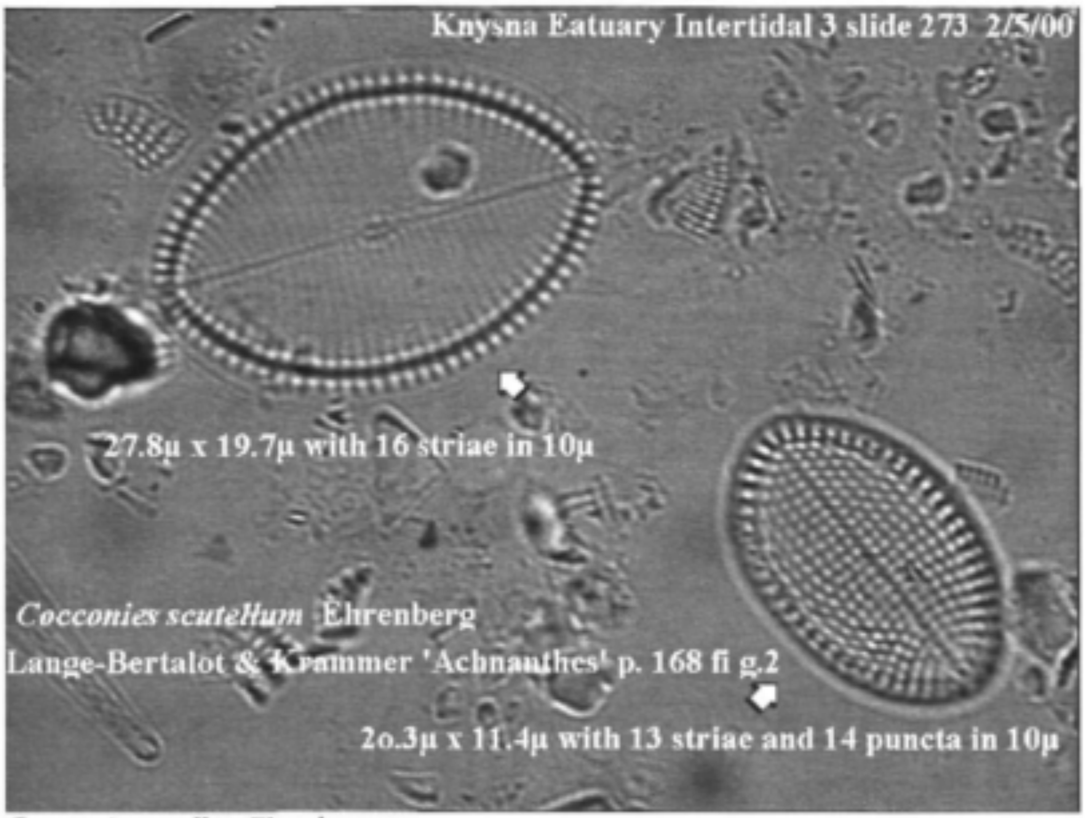
Cocconeis engelbrechtii Cholnoky

Reference used for identification: Archibald 1983. Page 73. Plate 10. Figure 161.

Locations – Sub-dominant in epipelon – Breede Estuary Intertidal Site 5.

NOTES	NOTES
Found at salinity: 1 ppt. Archibald (1983): Brak.	This is a heterovalvar genus having one valve with a raphe-sternum and the other lacking the raphe, but having a corresponding sternum.

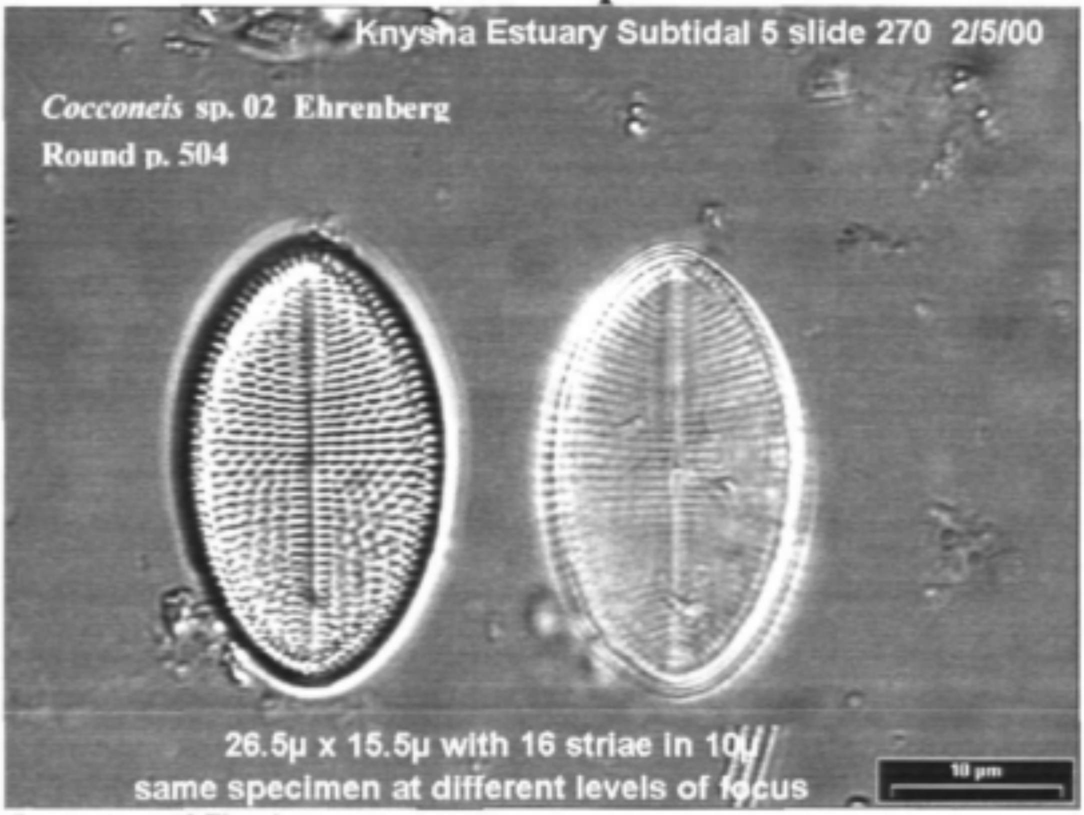
COCCSCUT



Cocconeis scutellum Ehrenberg
Reference used for identification: Lange-Bertalot & Krammer 1989. Plate 168. Figure 2.
Locations – Sub-dominant in epipelon – Knysna Estuary Intertidal Site 3.

NOTES	NOTES
Found at salinity: 36 ppt. Hustedt (1976): Marine. Sims (1996): Marine. Lange-Bertalot (2000): Brak – Marine.	This is a heterovalvar genus having one valve with a raphe-sternum and the other lacking the raphe, but having a corresponding sternum.

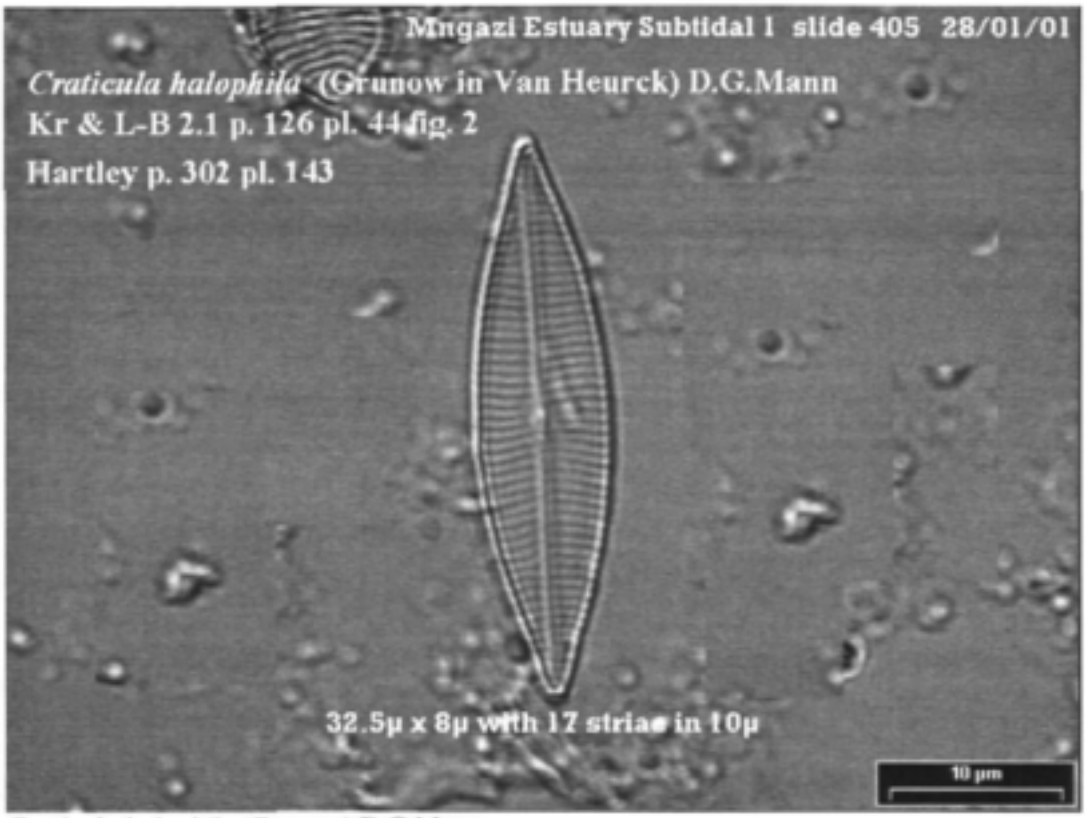
COCCsp02



Cocconeis sp. 02 Ehrenberg
Reference used for identification: Round, Crawford & Mann 1990. Page 504.
Locations – Sub-dominant in epipelon – Knysna Estuary Subtidal Site 5.

NOTES	NOTES
Found at salinity: 28 ppt.	This is a heterovalvar genus having one valve with a raphe-sternum and the other lacking the raphe, but having a corresponding sternum

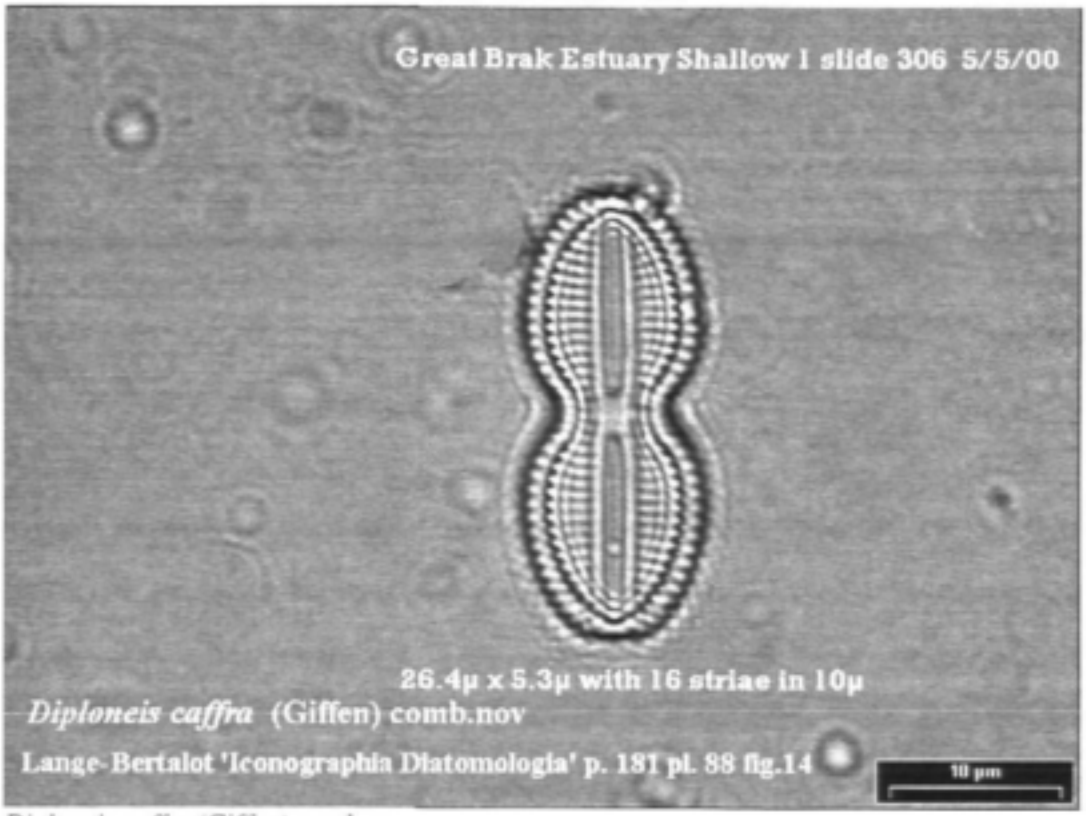
CRATHALO



Craticula halophila (Grunow) D.G.Mann
Reference used for identification: Hartley 1996. Page 302. Plate 143. Figure 12.
Locations – Sub-dominant in epipelon – Mngazi Estuary Subtidal Site 1.

NOTES	NOTES
Found at salinity: 30 ppt.	

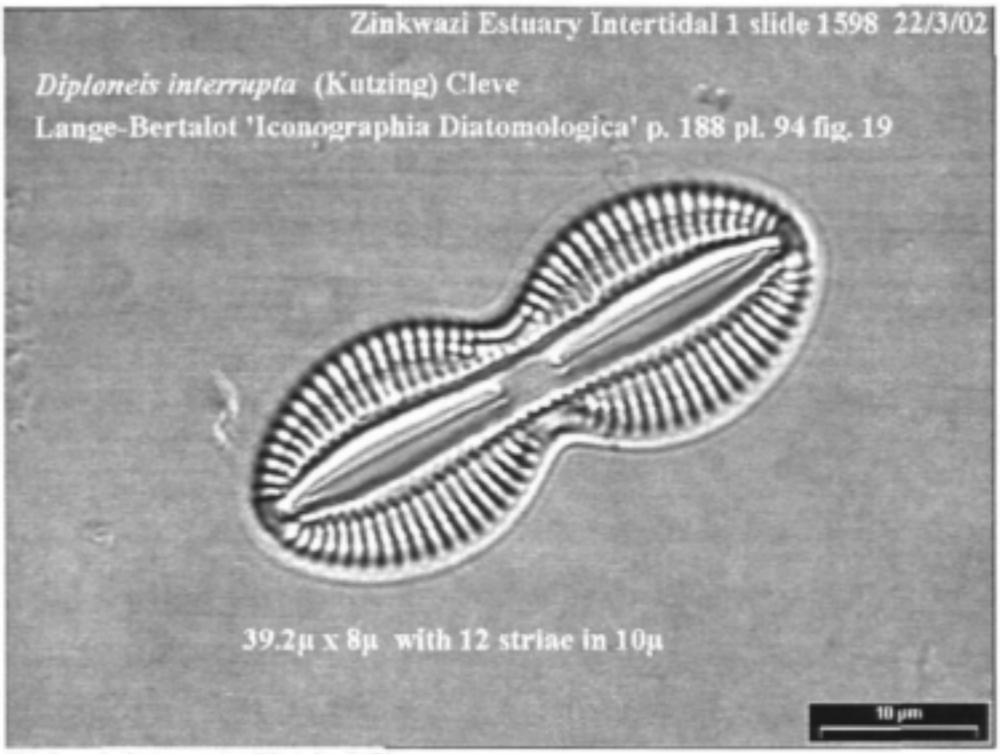
DIPLCAFF



Diploneis caffra (Giffen) comb. nov.
Reference used for identification: Lange-Bertalot 2000. Page 181. Plate 88. Figure 14.
Locations – Sub-dominant in epipelon – Great Brak Estuary Intertidal Site 1.

NOTES	NOTES
Found at salinity: 29 ppt. Lange-Bertalot (2000): Marine.	

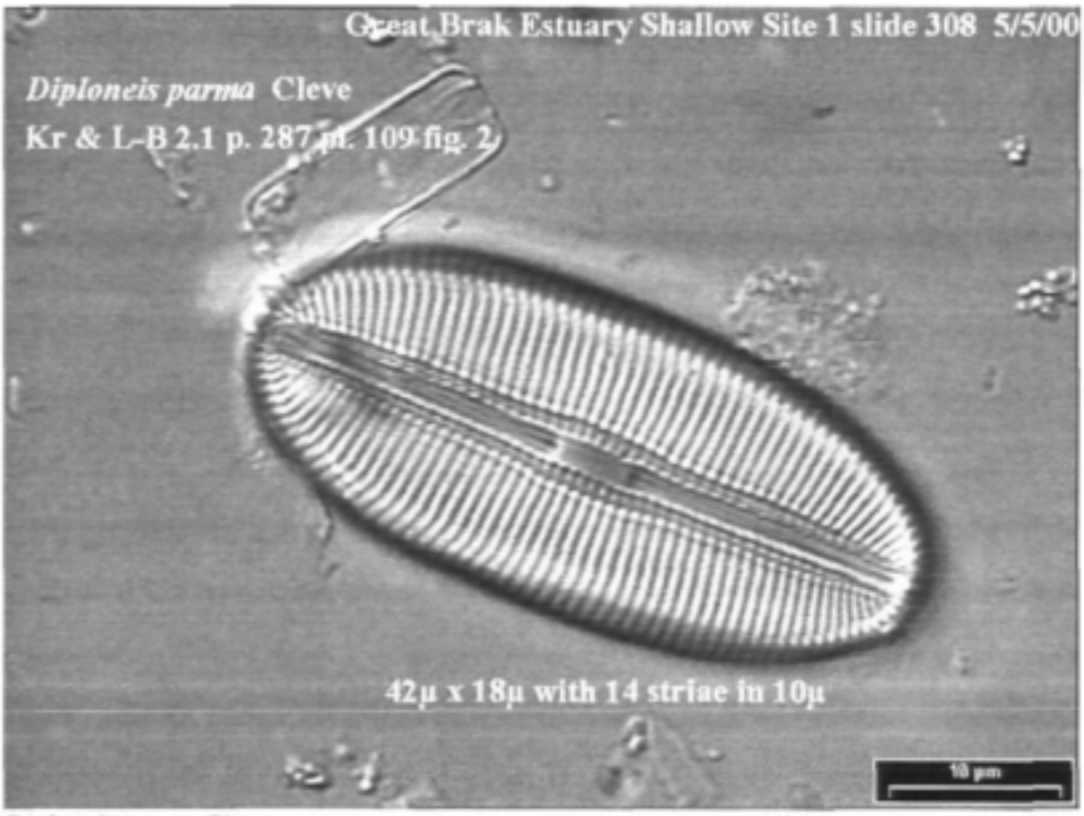
DIPLINTE



Diploneis interrupta (Kutzing) Cleve
Reference used for identification: Lange-Bertalot 2000.
Locations – Sub-dominant in epipelon – Mlalazi Estuary Intertidal Site 4; Zinkwazi Estuary Intertidal Site 1.

NOTES	NOTES
Found at salinity 15 – 33 ppt.	

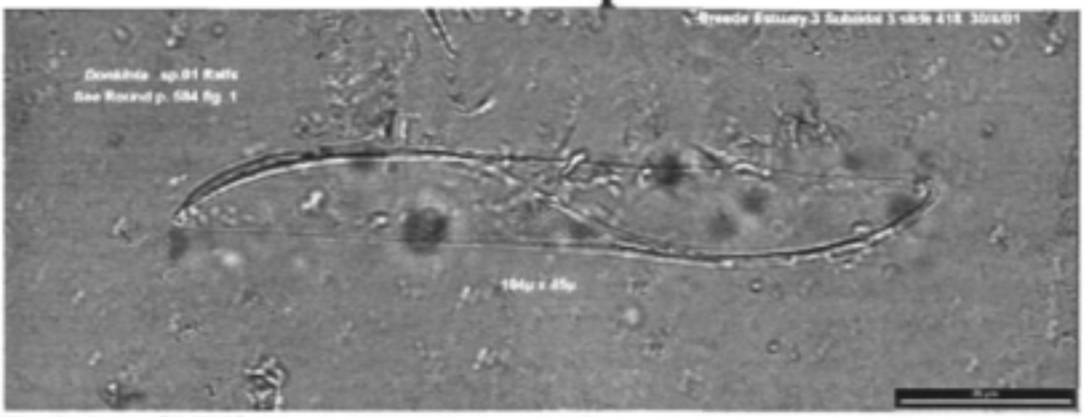
DIPLPARM



Diploneis parma Cleve
Reference used for identification: Krammer & Lange-Bertalot 1986. 2.1 Page 287. Plate 109. Figure 2.
Locations – Sub-dominant in epipelon – Great Brak Estuary Intertidal Site 1.

NOTES	NOTES
Found at salinity: 29 ppt. Sims (1996): Fresh – Brak.	

DONKsp01



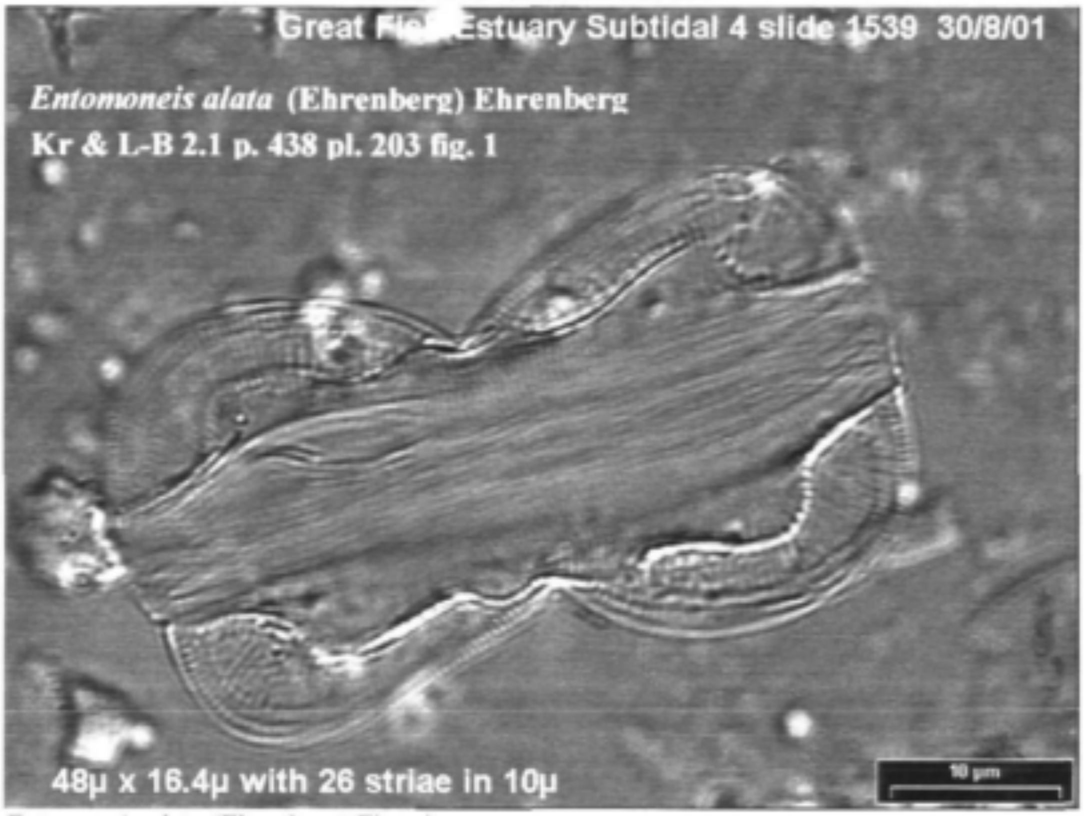
Donkinia sp. 01 Ralfs

Reference used for identification: Round, Crawford & Mann 1990. Page 584. Figure a.

Locations – Sub-dominant in epipelon – Breede Estuary 3 Subtidal Site 4.

<u>NOTES</u>	<u>NOTES</u>
Found at salinity: 14 ppt. Round *et al* (1990): Marine genus.	

ENTOALAT



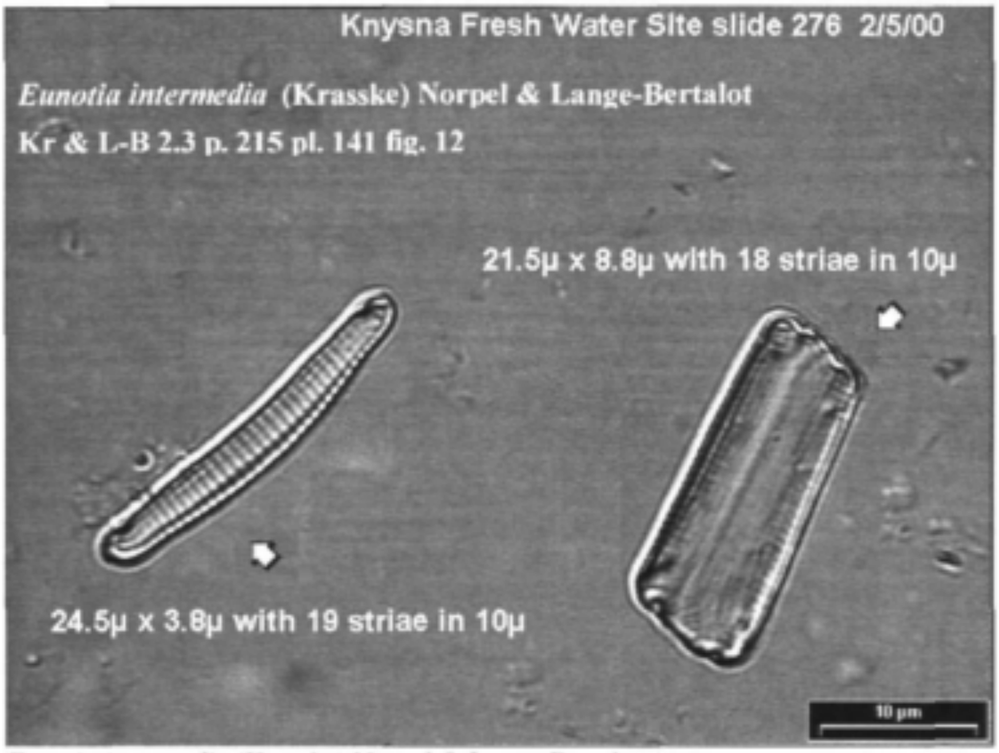
Entomoneis alata (Ehrenberg) Ehrenberg

Reference used for identification: Krammer & Lange-Bertalot 1986. 2.1 Page 438. Plate 203. Figure 1.

Locations – Sub-dominant in epipelon – Great Fish Estuary Subtidal Site 4.

NOTES	NOTES
Found at salinity: 26 ppt. Sims (1996): Marine. Lange-Bertalot (2000): Brak.	

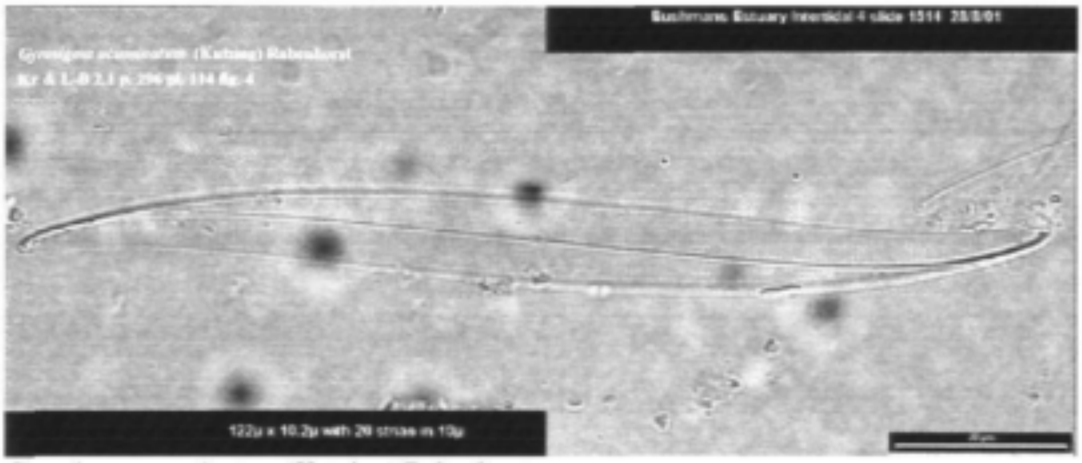
EUNOINTE



Eunotia intermedia (Krasske) Norpel & Lange-Bertalot
Reference used for identification: Krammer & Lange-Bertalot 1986.
Locations – Sub-dominant in epipelon – Knysna Fresh Water Site.

NOTES	NOTES
Found at salinity 0 ppt at the fresh water site of the Knysna Estuary. *Eunotia* is a fresh water genus, present at this fresh water site in the estuary.	

GYROACUM



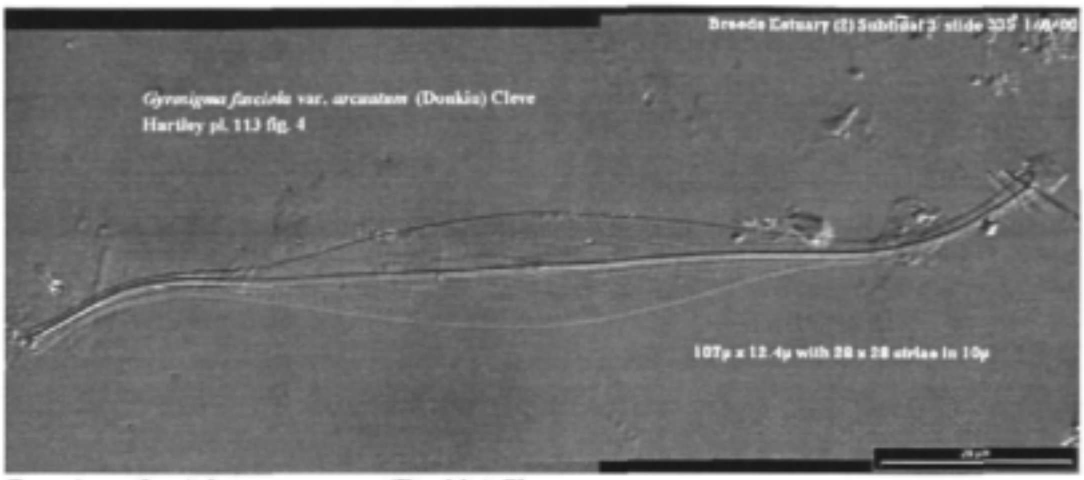
Gyrosigma acuminatum (Kutzing) Rabenhorst

Reference used for identification: Krammer & Lange-Bertalot 1986. 2.1 Page296. Plate 114. Figure 4.

Locations – Sub-dominant in epipelon – Bushmans Estuary Intertidal 3 & Subtidal Site 5.

NOTES	NOTES
Found at salinity: 33 ppt. Hustedt (1976): Brak. Lange-Bertalot (2000): Fresh – Brak.	

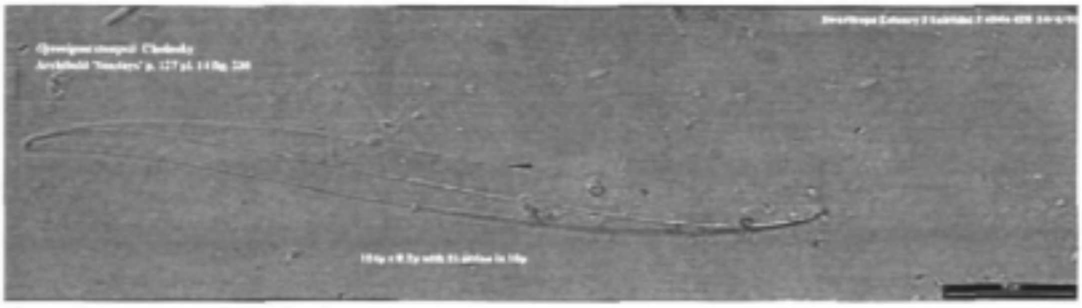
GYROFAar



Gyrosigma fasciola var. *arcutum* (Donkin) Cleve
Reference used for identification: Hartley 1996. Plate 113. Figure 4.
Locations – Sub-dominant in epipelon – Olifants Estuary Intertidal Sites 2 & 3; Great Berg Estuary Subtidal Site 1.

<u>NOTES</u>	<u>NOTES</u>
Found at salinity: 12 - 34 ppt. Sims (1996): Brak – Marine. Patrick & Reimer (1975): Brak – Marine.	

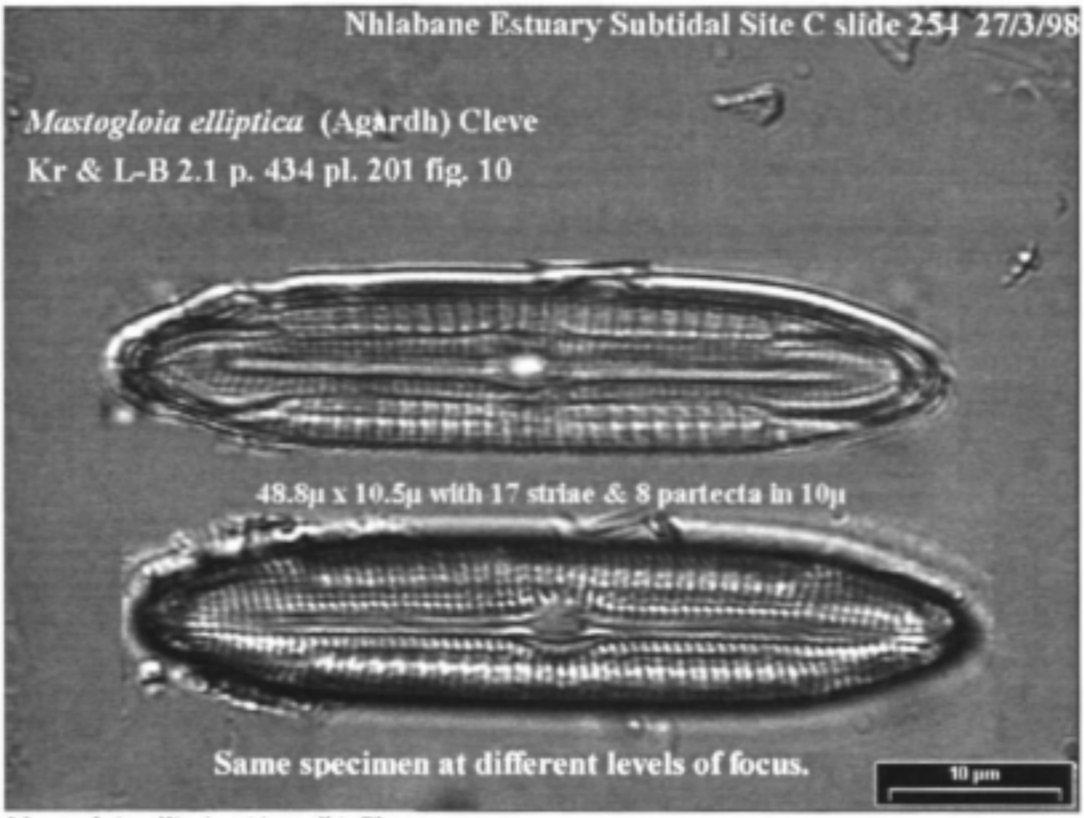
GYROSTOM



Gyrosigma stompsii Cholnoky
Reference used for identification: Archibald 1983. Page 127. Plate 14. Figure 230.
Locations – Sub-dominant in epipelon – Swartkops Estuary 2 Subtidal Site 2.

NOTES	NOTES
Found at salinity: 26 ppt.	

MASTELLI



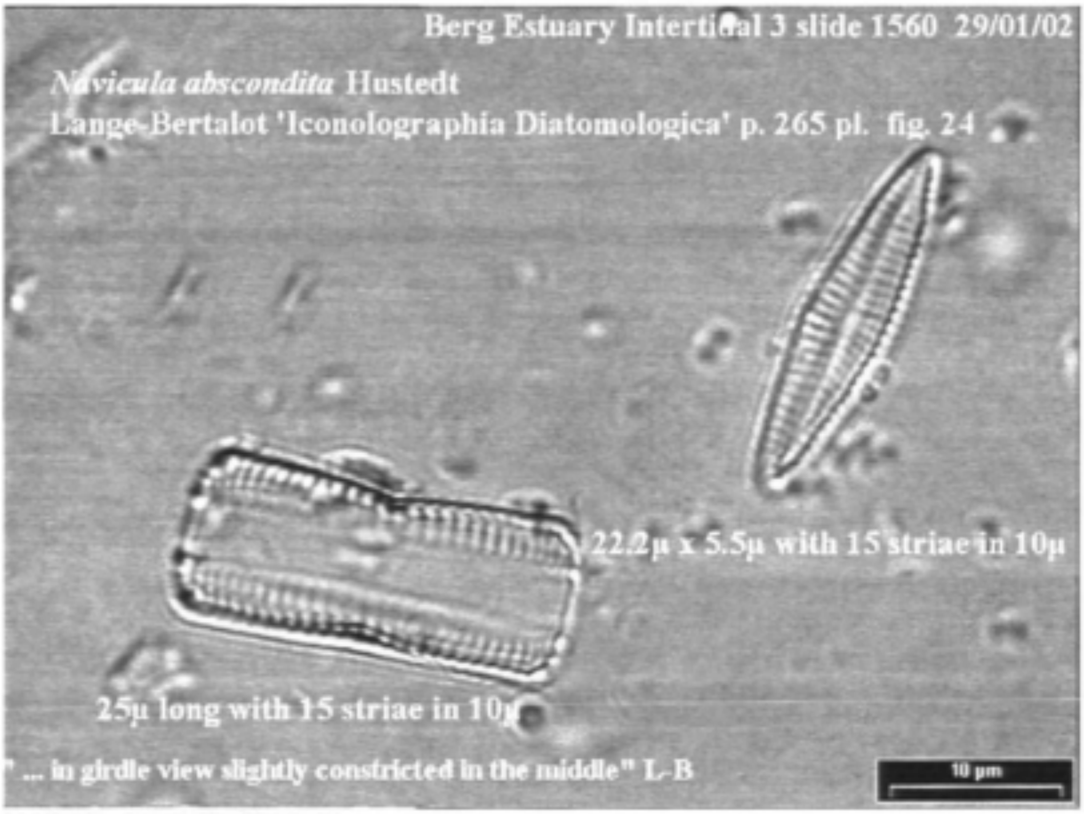
Mastogloia elliptica (Agardh) Cleve

Reference used for identification: Krammer & Lange-Bertalot 1986. 2.1 Page 434. Plate 201. Figure 10.

Locations – Sub-dominant in epipelon – Nhlabane Estuary Subtidal Site B.

NOTES	NOTES
Found at salinity: Fresh water. Sims (1996): Fresh. Lange-Bertalot (2000): Fresh – Brak. Krammer & Lange-Bertalot (1986): Brak. Patrick & Reimer (1975): Brak.	

NAVIABSC



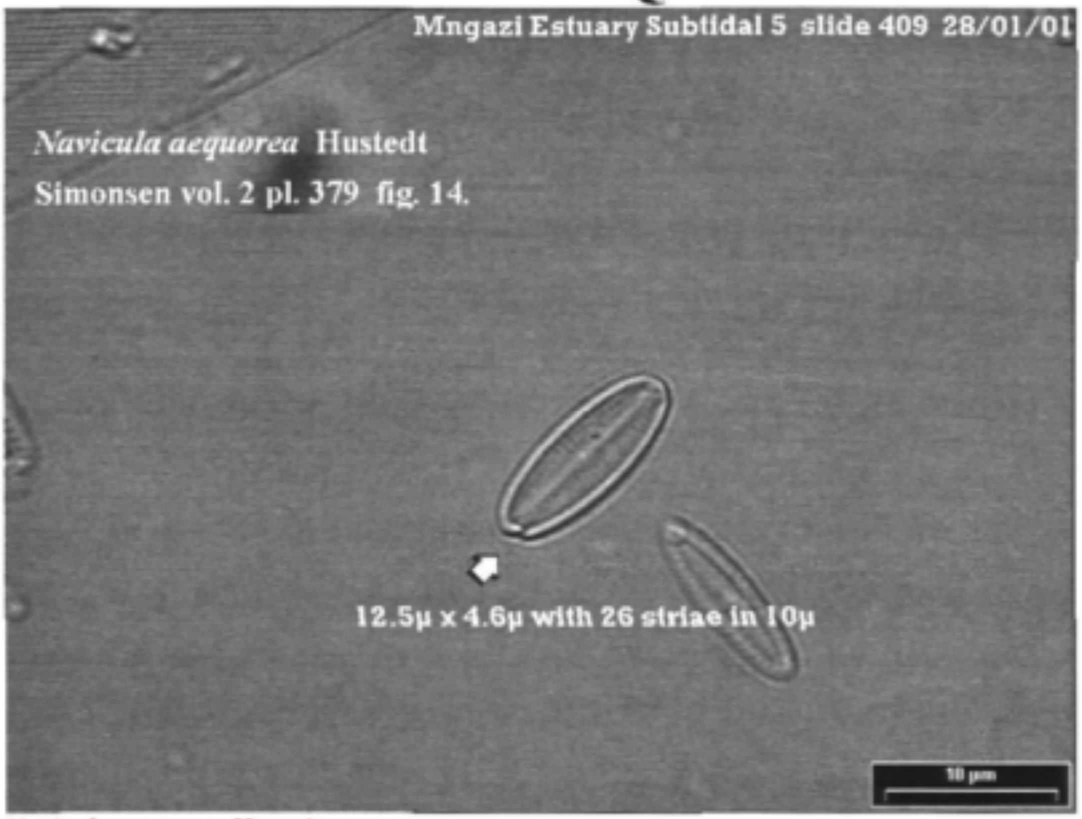
Navicula abscondita Hustedt

Reference used for identification: Lange-Bertalot 2000. Page 265. Plate 130. Figure 24.

Locations – Sub-dominant in epipelon – Great Berg Estuary Intertidal Site 3.

NOTES	NOTES
Found at salinity: 38 ppt. Lange-Bertalot (2000): Marine.	

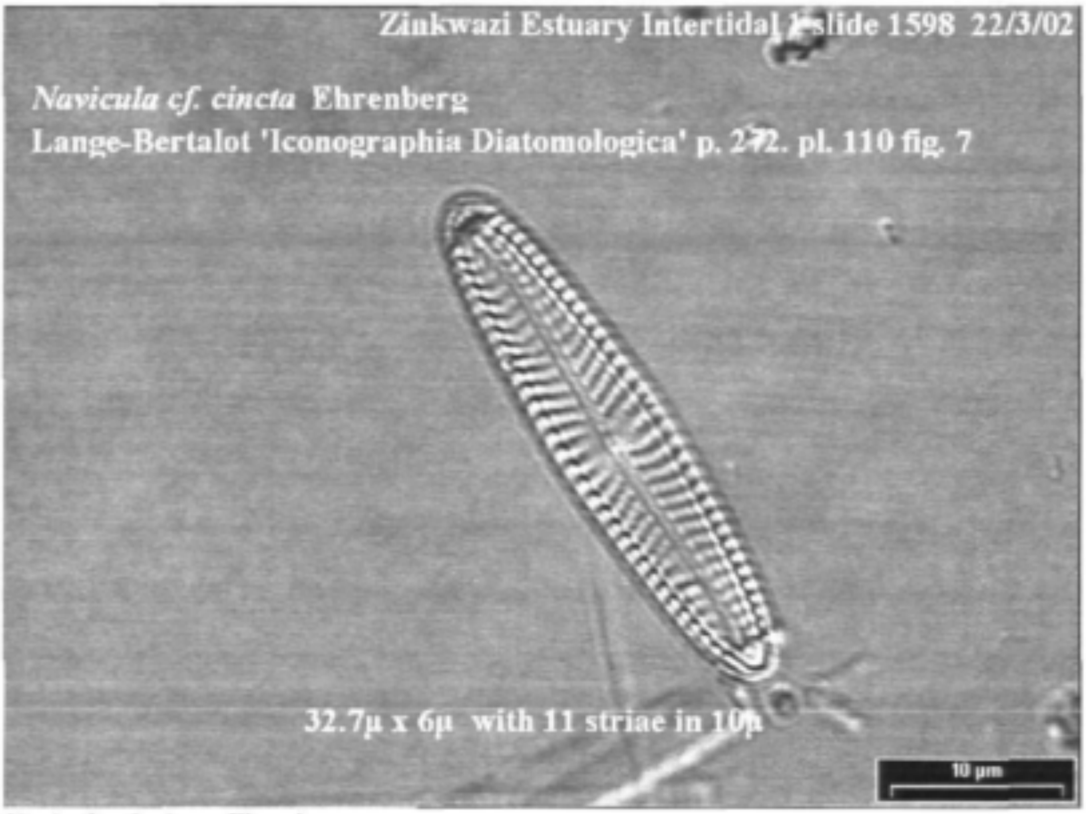
NAVIAEQU



Navicula aequorea Hustedt
Reference used for identification: Simonsen 1987. Volume 2. Plate 379. Figure 14.
Locations – Sub-dominant in epipelon – Mngazi Estuary Subtidal Site 5.

<u>NOTES</u>	<u>NOTES</u>
Found at salinity: 29 ppt.	

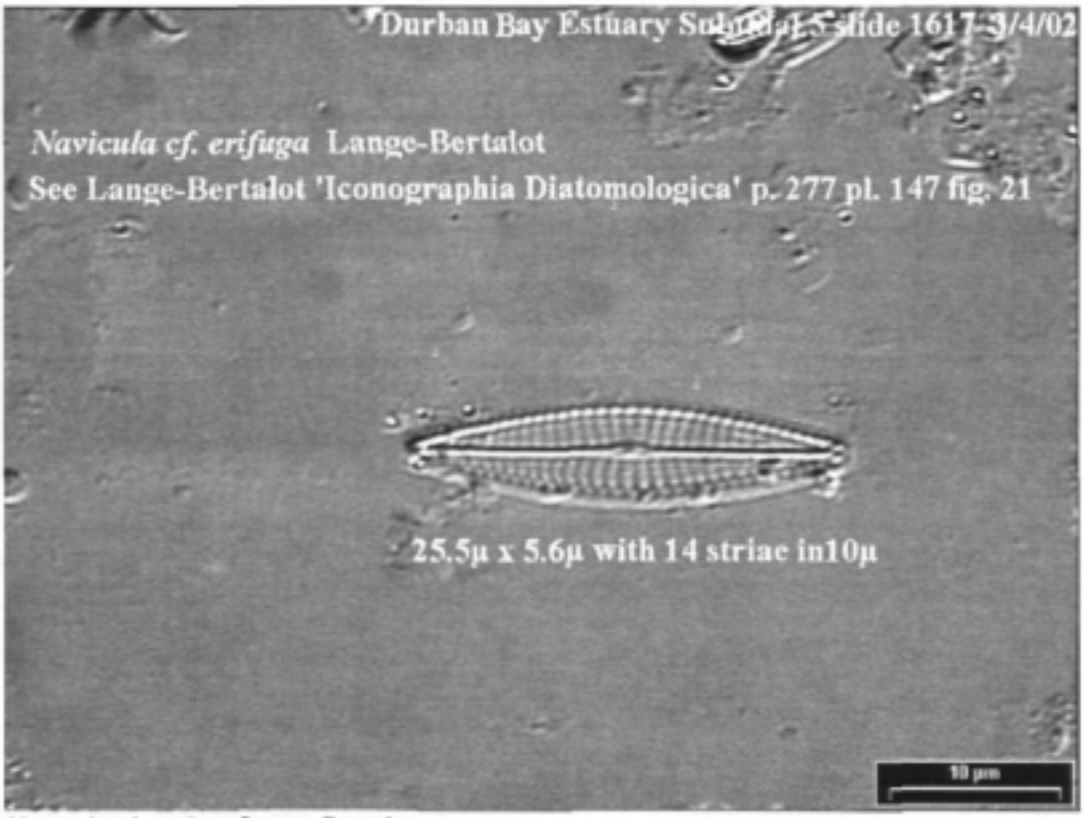
NAVIcfCI



Navicula cf. *cincta* Ehrenberg
Reference used for identification: Lange-Bertalot 2000. See Plate 110. Figures 1-29.
Locations – Sub-dominant in epipelon – Zinkwazi Estuary Intertidal Site 1.

NOTES	NOTES
Found at salinity: 15 ppt.	

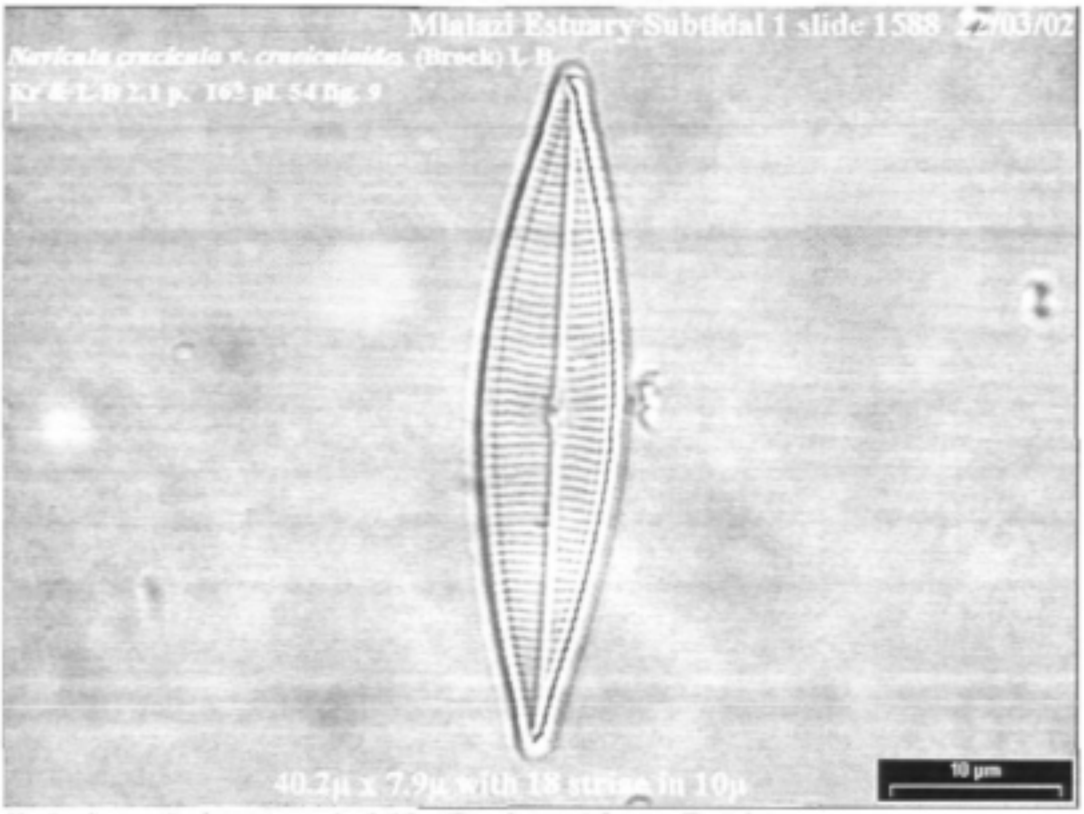
NAVIcfER



Navicula cf. *erifuga* Lange-Bertalot
Reference used for identification: Lange-Bertalot 2000. Page 277. Plate 147. Figure 21.
Locations – Sub-dominant in epipelon – Durban Bay Estuary Subtidal Site 5.

<u>NOTES</u>	<u>NOTES</u>
Found at salinity: 34 ppt.	

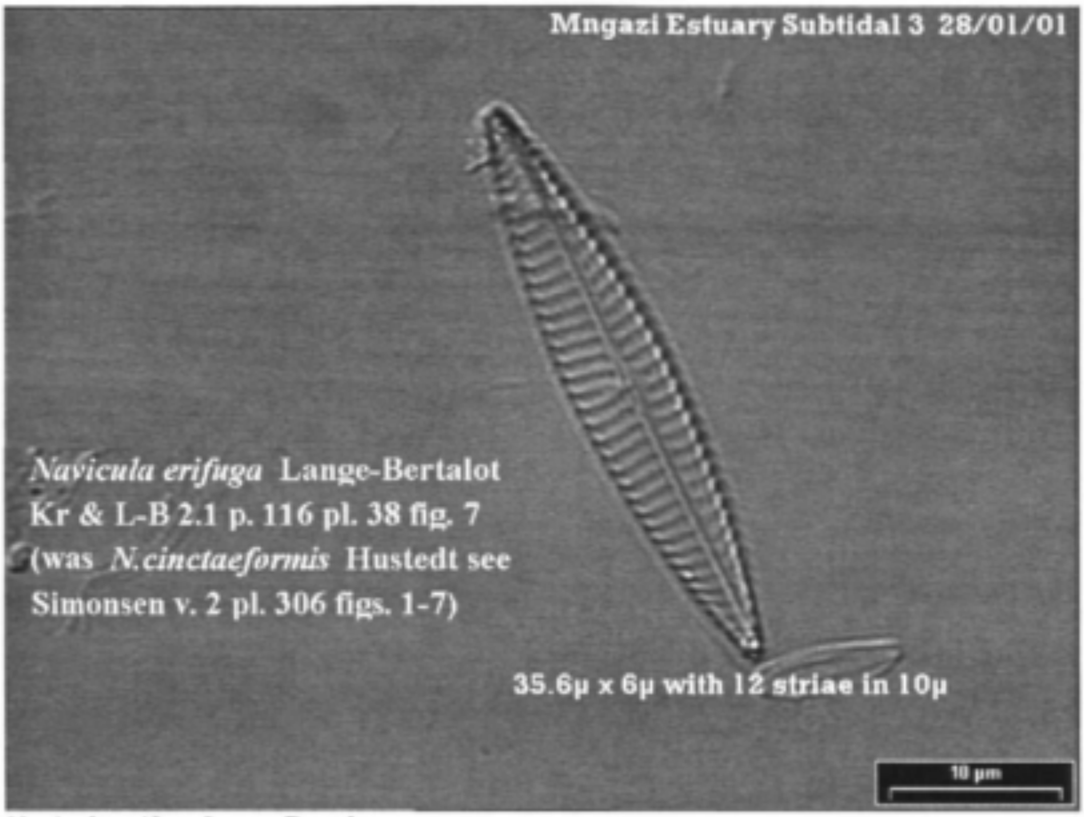
NAVICRcr



Navicula crucicula var. *cruciculoides* (Brockmann) Lange-Bertalot
Reference used for identification: Krammer & Lange-Bertalot 1986. 2.1 Page 162. Plate 54. Figure 9.
Locations – Sub-dominant in epipelon – Mlalazi Estuary Subtidal Site 1.

NOTES	NOTES
Found at salinity: 34 ppt. Sims (1996): Marine. Patrick & Reimer (1975): Fresh – Brak.	

NAVIERIF



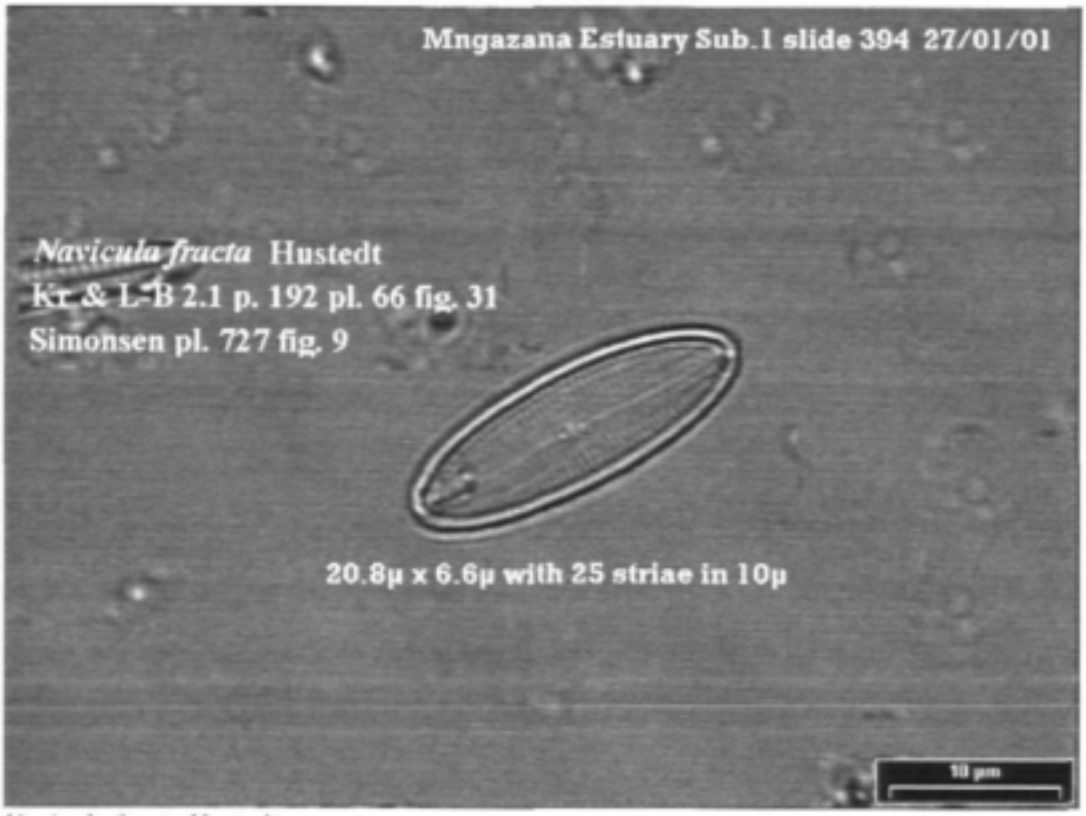
Navicula erifuga Lange-Bertalot

Reference used for identification: Krammer & Lange-Bertalot 1986. 2.1 Page 116. Plate 38. Figure 7.

Locations Sub-dominant in epipelon – Mngazi Estuary Subtidal Site 3.

NOTES	NOTES
Found at salinity 33 ppt. Krammer & Lange-Bertalot (1986): Brak. Lange-Bertalot (2000): Fresh – Brak. Sims (1996): Brak.	

NAVIFRAC



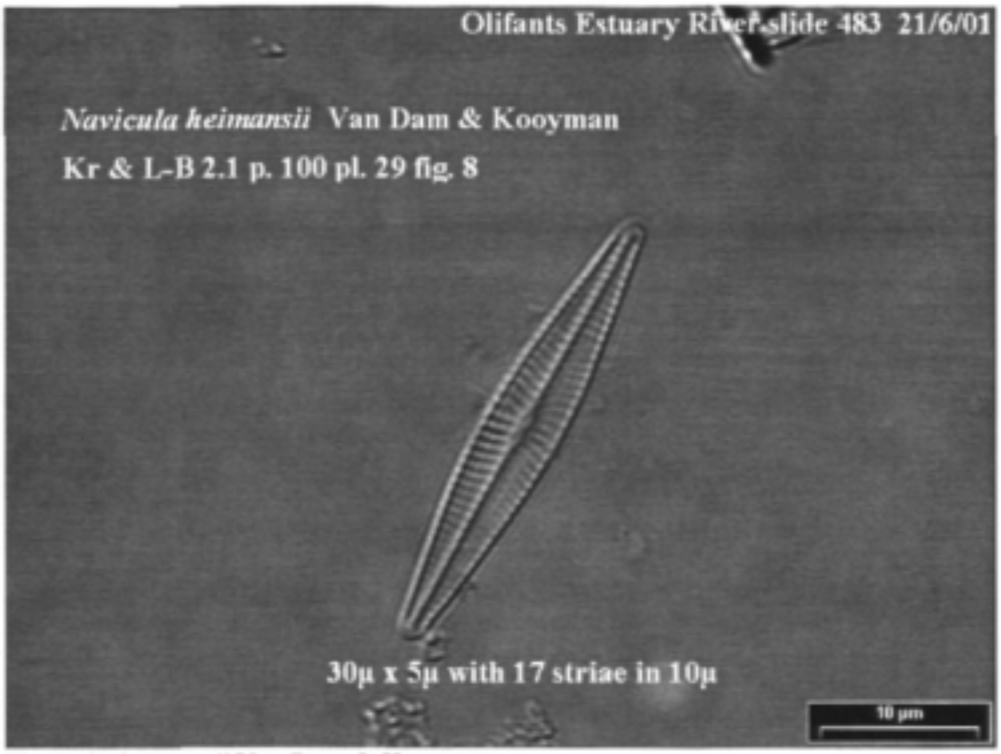
Navicula fracta Hustedt

Reference used for identification: Krammer & Lange-Bertalot 1986. 2.1 Page 192. Plate 66. Figure 31.

Locations – Sub-dominant in epipelon – Mngazana Estuary Subtidal Site 1.

NOTES	NOTES
Found at salinity: 35 ppt.	

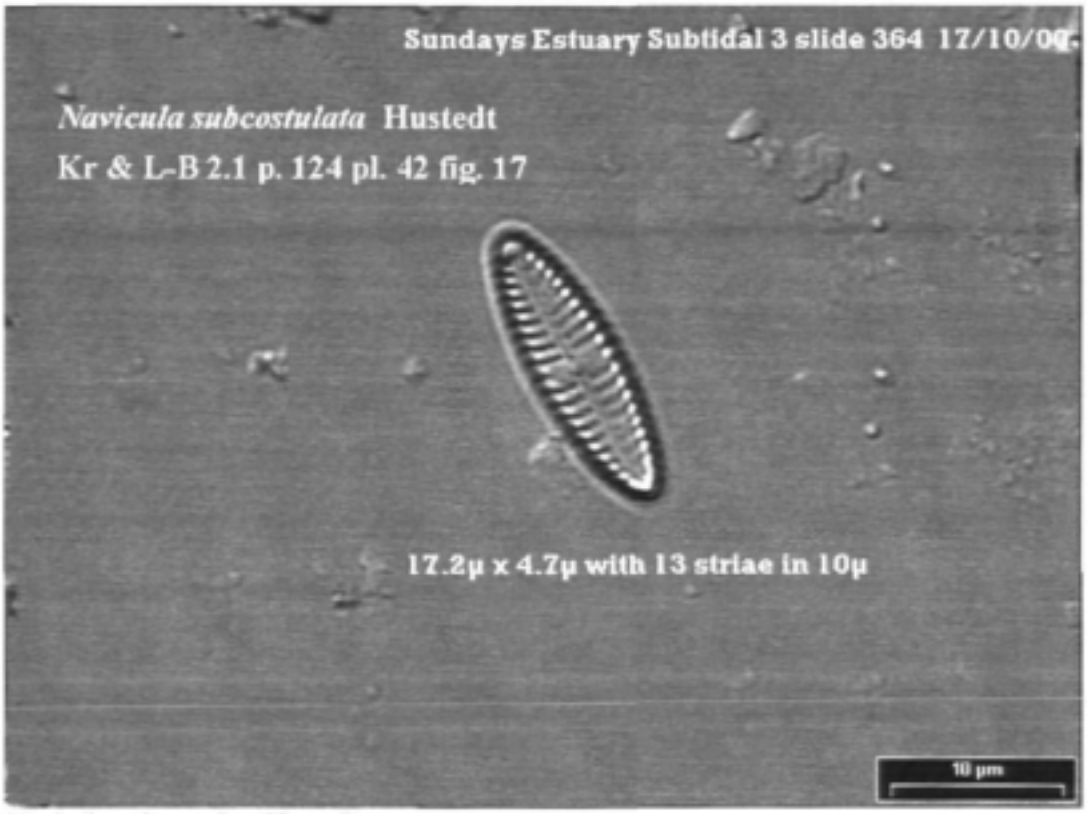
NAVIHEIM



Navicula heimansii Van Dam & Kooyman
Reference used for identification: Krammer & Lange-Bertalot 1986. 2.1 Page 100. Plate 29. Figure 11.
Locations – Sub-dominant in epipelon – Olifants Estuary River Site.

NOTES	NOTES
Found at salinity: 0 ppt.	

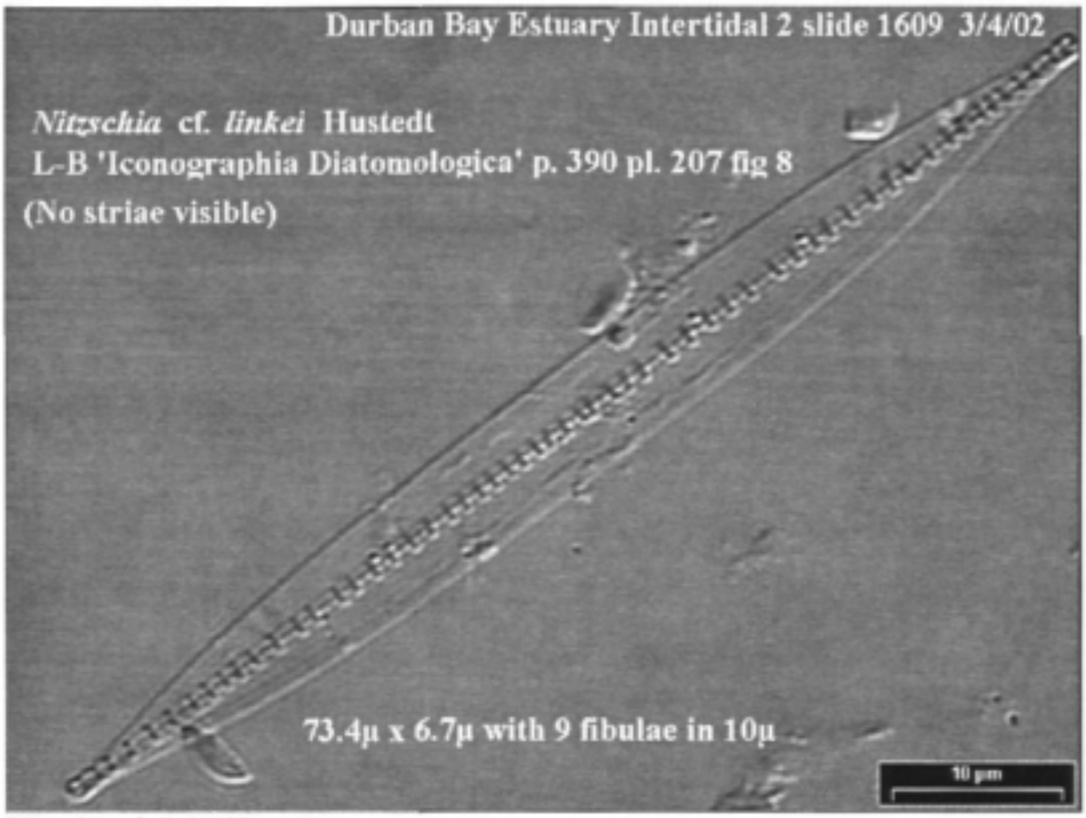
NAVISUBC



Navicula subcostulata Hustedt
Reference used for identification: Krammer & Lange-Bertalot 1986. 2.1 Page 124. Plate 42. Figure 17.
Locations – Sub-dominant in epipelon – Sundays Estuary Subtidal Site 3; Goukou Estuary Intertidal Site 3.

NOTES	NOTES
Found at salinity: 10 – 15 ppt. Sims (1996): Fresh water.	

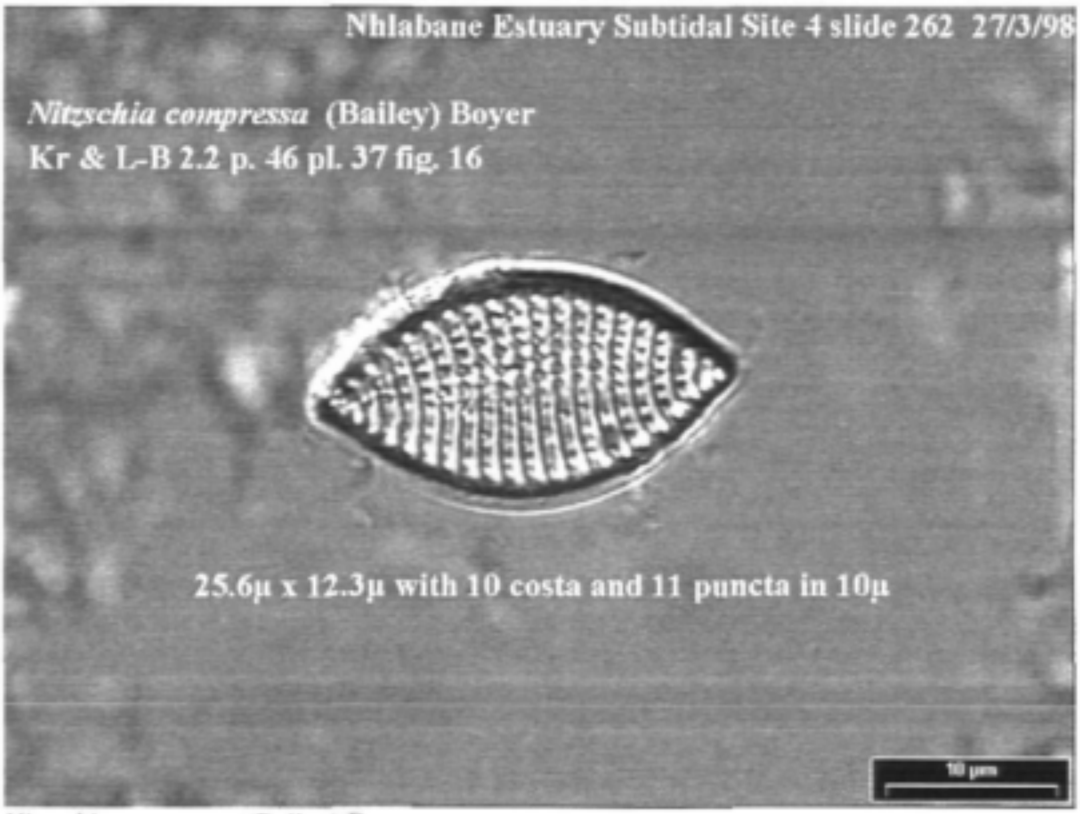
NITZcfLI



Nitzschia cf. *linkei* Hustedt
Reference used for identification: Lange-Bertalot 2000. Page 390. Plate 207. Figure 8.
Locations – Sub-dominant in epipelon – Durban Bay Estuary Intertidal Sites 2 & 3.

NOTES	NOTES
Found at salinity: 26 – 35 ppt.	

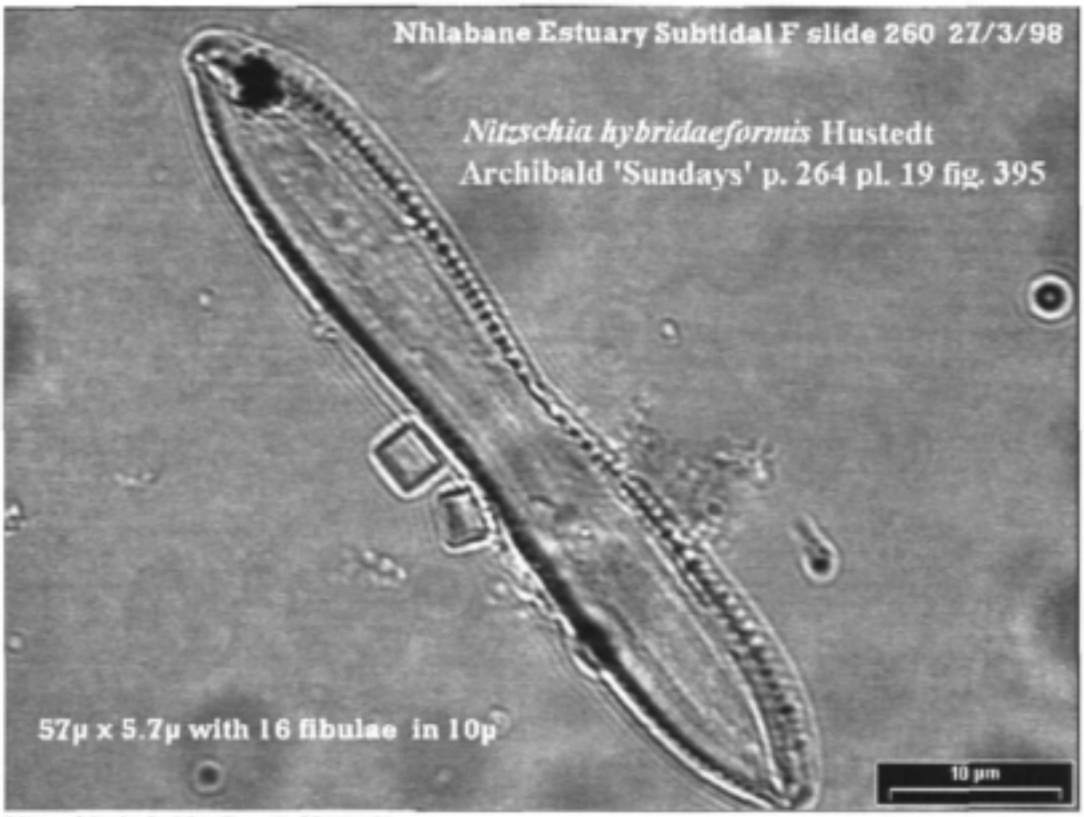
NITZCOMP



Nitzschia compressa (Bailey) Boyer
Reference used for identification: Krammer & Lange-Bertalot 1986. 2.2 Page 46. Plate 37. Figure 16.
Locations – Sub-dominant in epipelon – Nhlabane Estuary Subtidal Site G.

NOTES	NOTES
Found at salinity: 23 ppt. Lange-Bertalot (2000): Brak – Marine.	

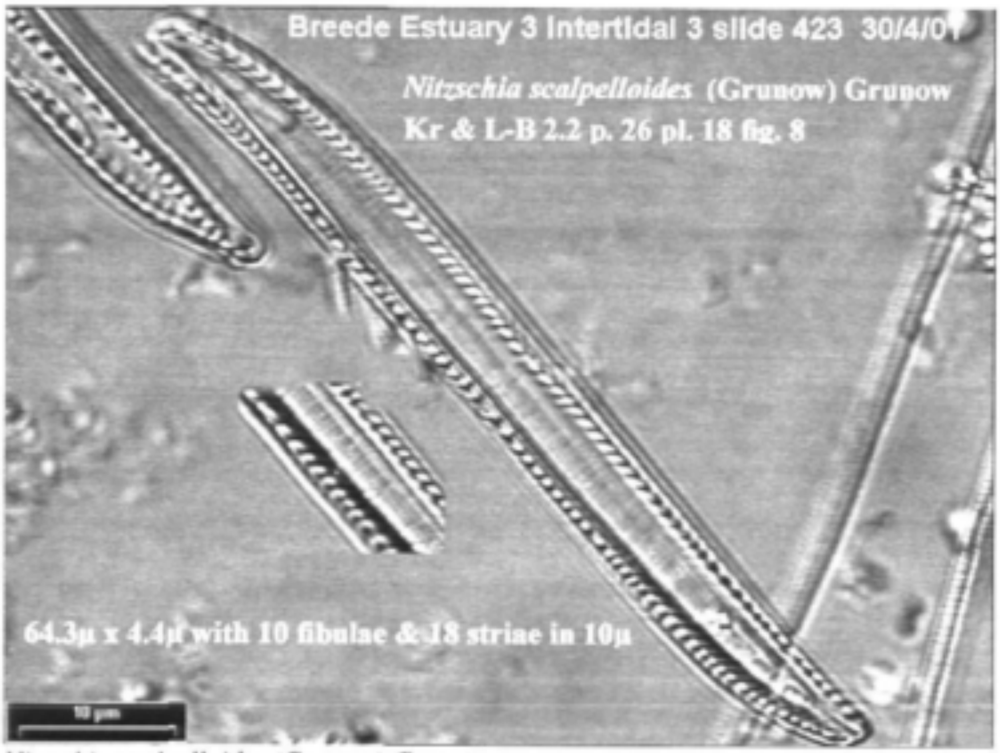
NITZHYBR



Nitzschia hybridaeformis Hustedt
Reference used for identification: Archibald 1983. Page 264. Plate 19. Figure 395.
Locations – Sub-dominant in epipelon – Nhlabane Estuary Subtidal Sites F & G.

NOTES	NOTES
Found at salinity: 23 ppt.	

NITZSCES



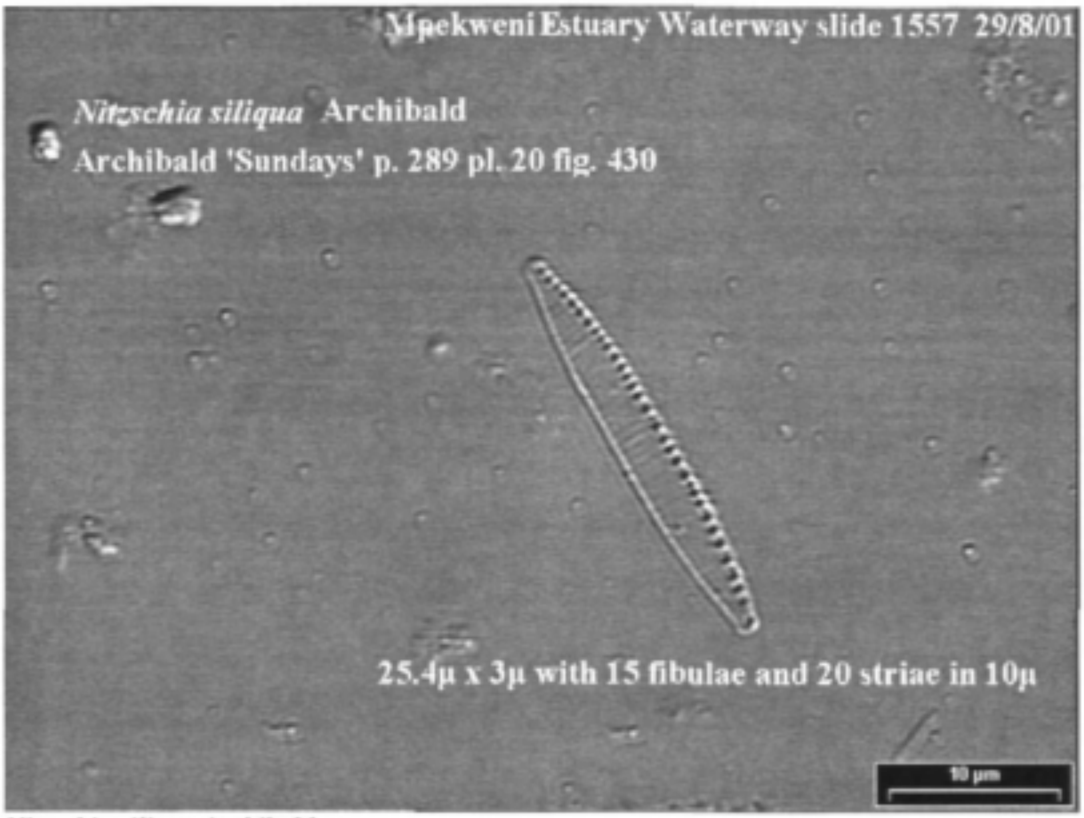
Nitzschia scalpelloides (Grunow) Grunow

Reference used for identification: Krammer & Lange-Bertalot 1986. 2.2 Page 26. Plate 18. Figure 8.

Locations – Sub-dominant in epipelon – Breede Estuary 3 Intertidal Site 3.

NOTES	NOTES
Found at salinity: 15 ppt.	

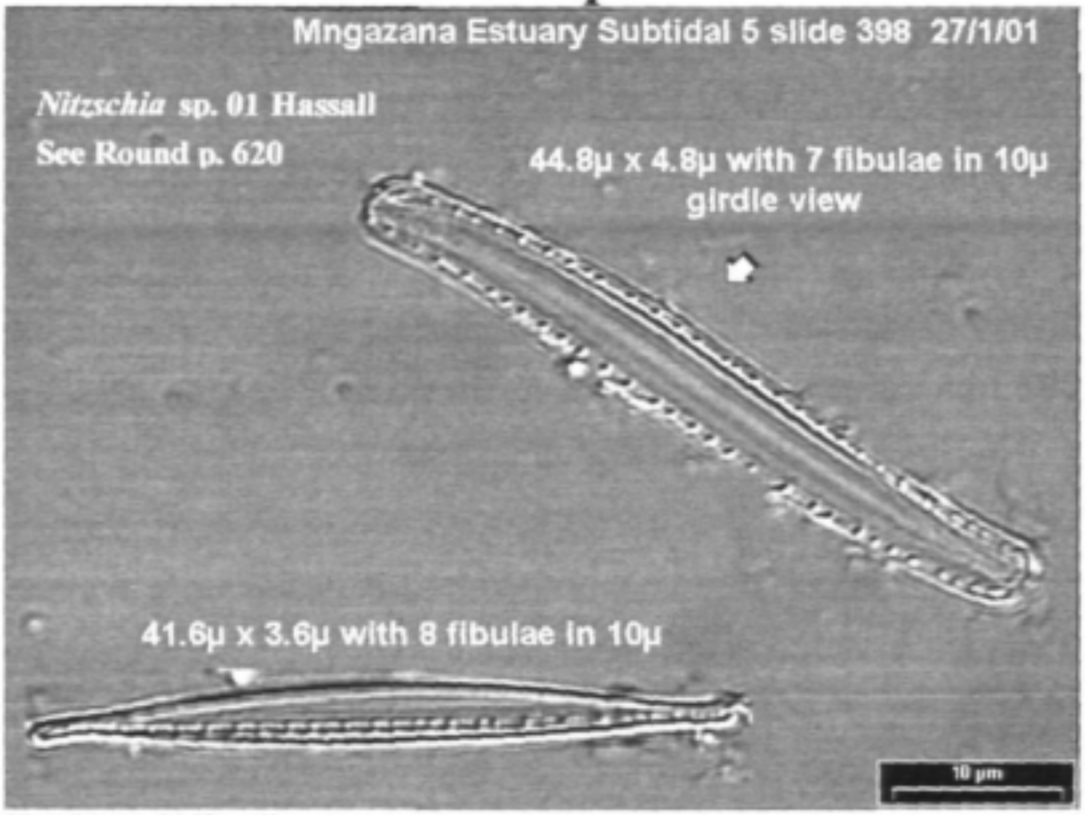
NITZSILI



Nitzschia siliqua Archibald
Reference used for identification: Archibald 1983. Page 298. Plate 20. Figure 430.
Locations – Sub-dominant in epipelon – Mpekweni Estuary Waterway Site.

<u>NOTES</u>	<u>NOTES</u>
Found at salinity: 4 ppt.	

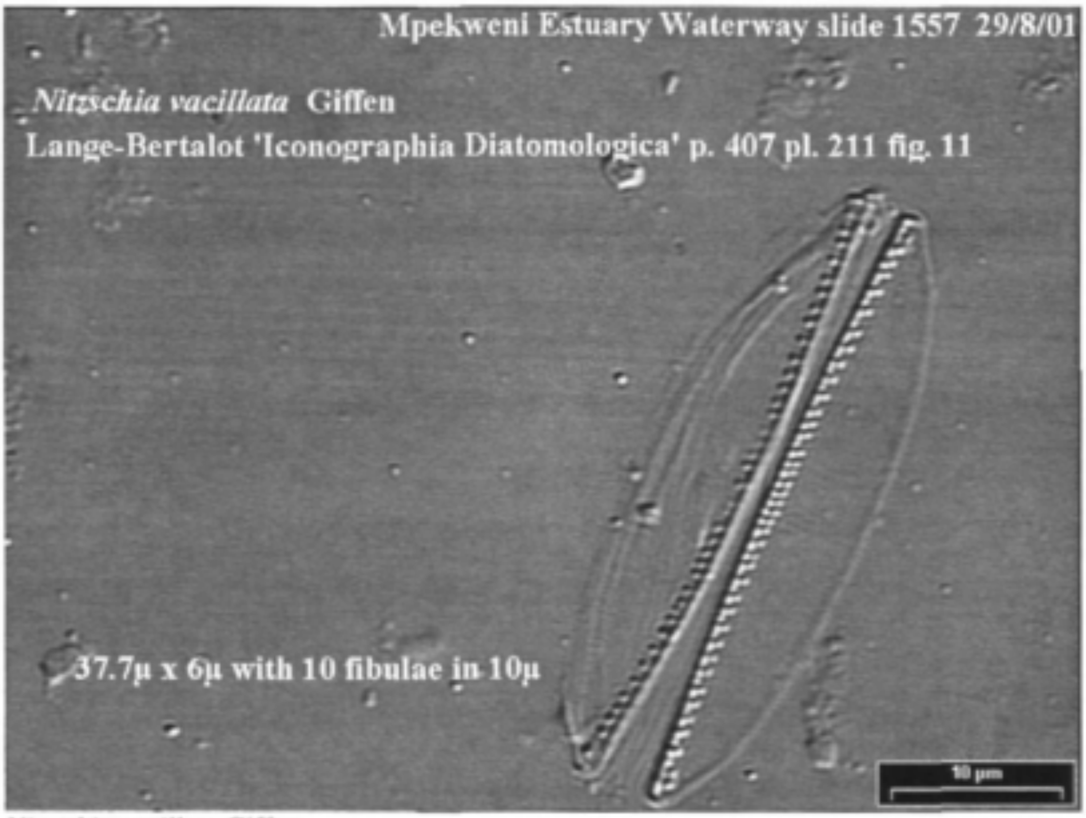
NITZsp01



Nitzschia sp. 01 Hassall
Reference used for identification: Round, Crawford & Mann 1990. Page 620.
Locations – Sub-dominant in epipelon – Mngazana Estuary Subtidal Site 5.

NOTES	NOTES
Found at salinity: 27 ppt.	Note: Similar to *Nitzschia dissipata* in valve view, this is distinctly sigmoid in girdle. Although similar to *N. fasciculata*, the ends of the girdle view are blunt whereas those of *N. fasciculata* are 'towards the apices strongly narrowed' Lange-Bertalot 2000 p. 380.

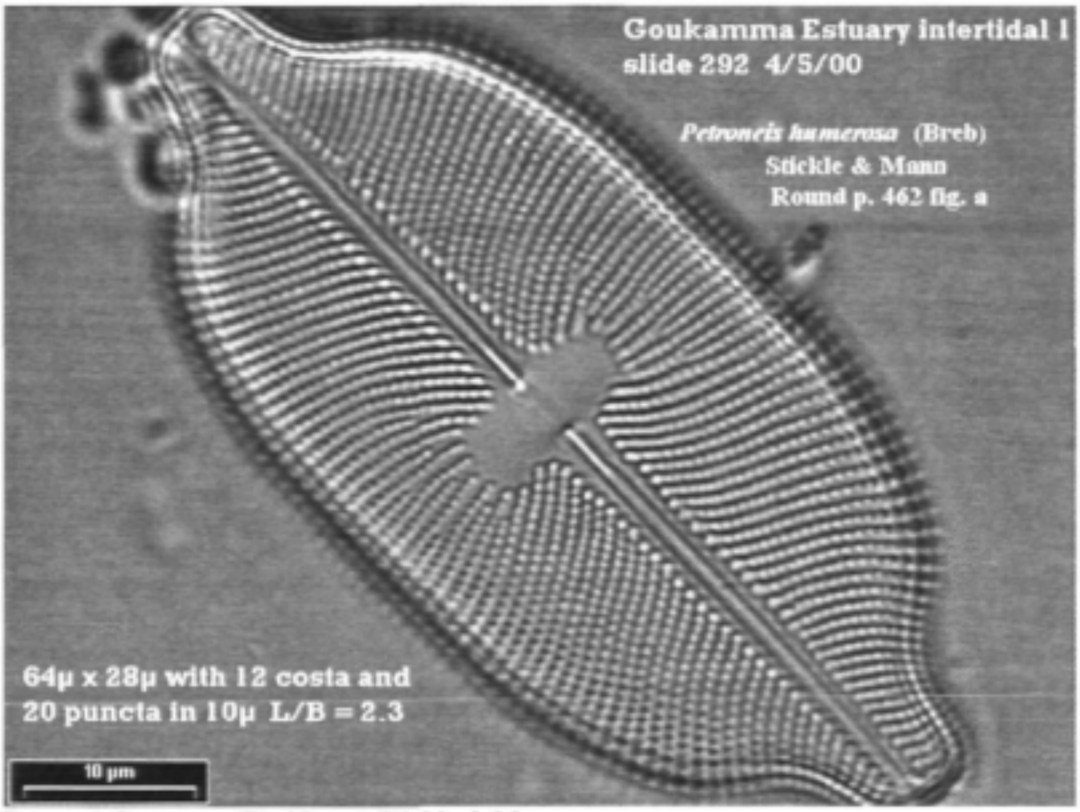
NITZVACI



Nitzschia vacillata Giffen
Reference used for identification: Lange-Bertalot 2000. Page 407. Plate 211. Figure 11.
Locations – Sub-dominant in epipelon – Mpekweni Estuary Waterway Site.

NOTES	NOTES
Found at salinity: 4 ppt. Lange-Bertalot (2000): Marine.	

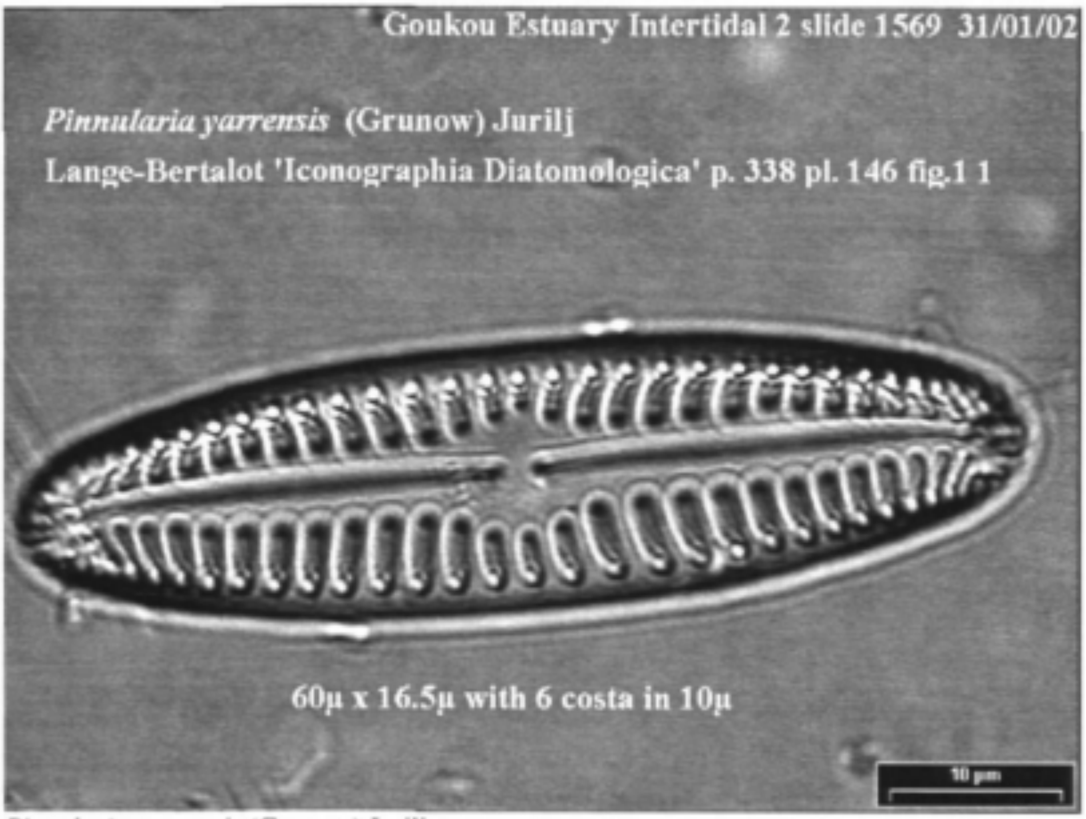
PETRHUME



Petroneis humerosa (Brebisson) Stickle & Mann
Reference used for identification: Round, Crawford & Mann 1990. Plate 462. Figure a. Also Lange-Bertalot 2000. Page 327. Plate 101. Figure 3.
Locations – Sub-dominant in epipelon – Goukamma Estuary Intertidal Site 1.

NOTES	NOTES
Found at salinity: 29 ppt. Hustedt (1976): Brak. Sims (1996): Marine. Lange-Bertalot (2000): Brak – Marine.	

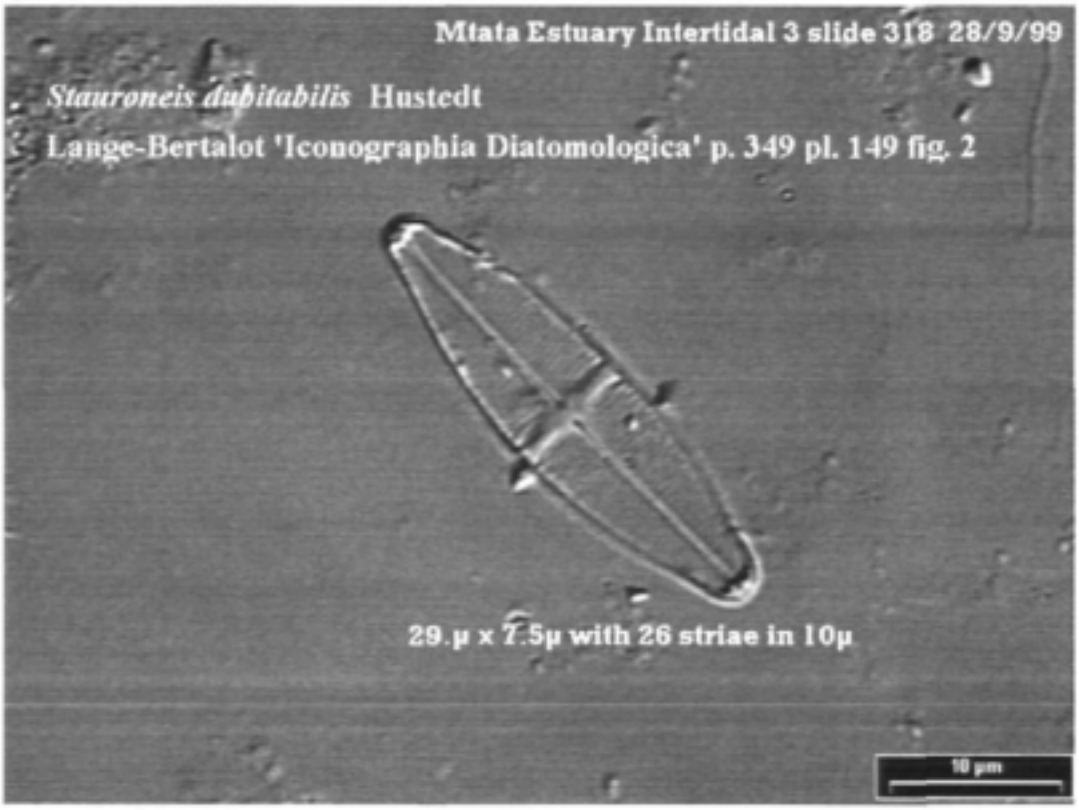
PINNYARR



Pinnularia yarrensis (Grunow) Jurilj
Reference used for identification: Lange-Bertalot 2000. Page 338. Plate 146. Figure 11.
Locations – Sub-dominant in epipelon – Goukou Estuary Intertidal Site 2.

NOTES	NOTES
Found at salinity: 19 ppt. Lange-Bertalot (2000): Brak – Marine.	

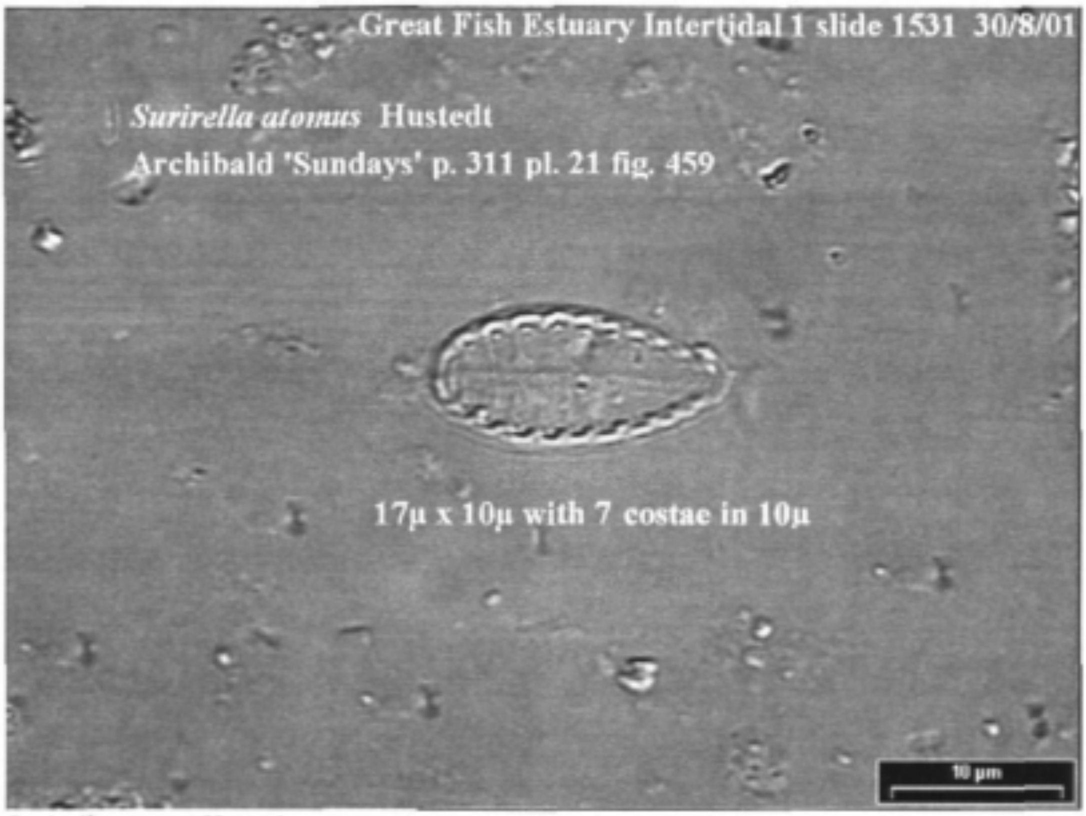
STAUDUBI



Stauroneis dubitabilis Hustedt
Reference used for identification: Lange-Bertalot 2000. Page 349. Plate 149. Figure 2.
Locations – Sub-dominant in epipelon – Mtata Estuary Intertidal Site 3.

NOTES	NOTES
Found at salinity: 3 ppt. Lange-Bertalot (2000): Brak.	

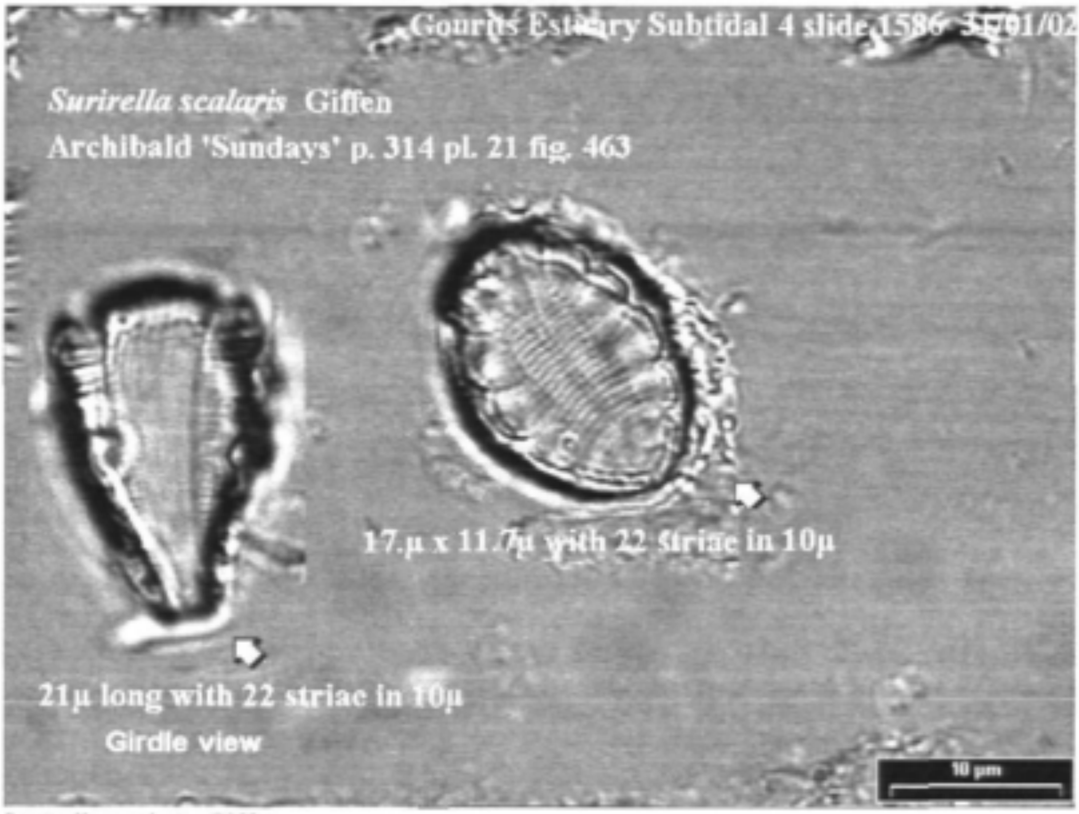
SURIATOM



Surirella atomus Hustedt
Reference used for identification: Archibald 1983. Page 311. Plate 21. Figure 459.
Locations – Sub-dominant in epipelon- Great Fish Estuary Intertidal Sites 1 & 2.

NOTES	NOTES
Found at salinity: 13 – 18 ppt.	

SURISCAL



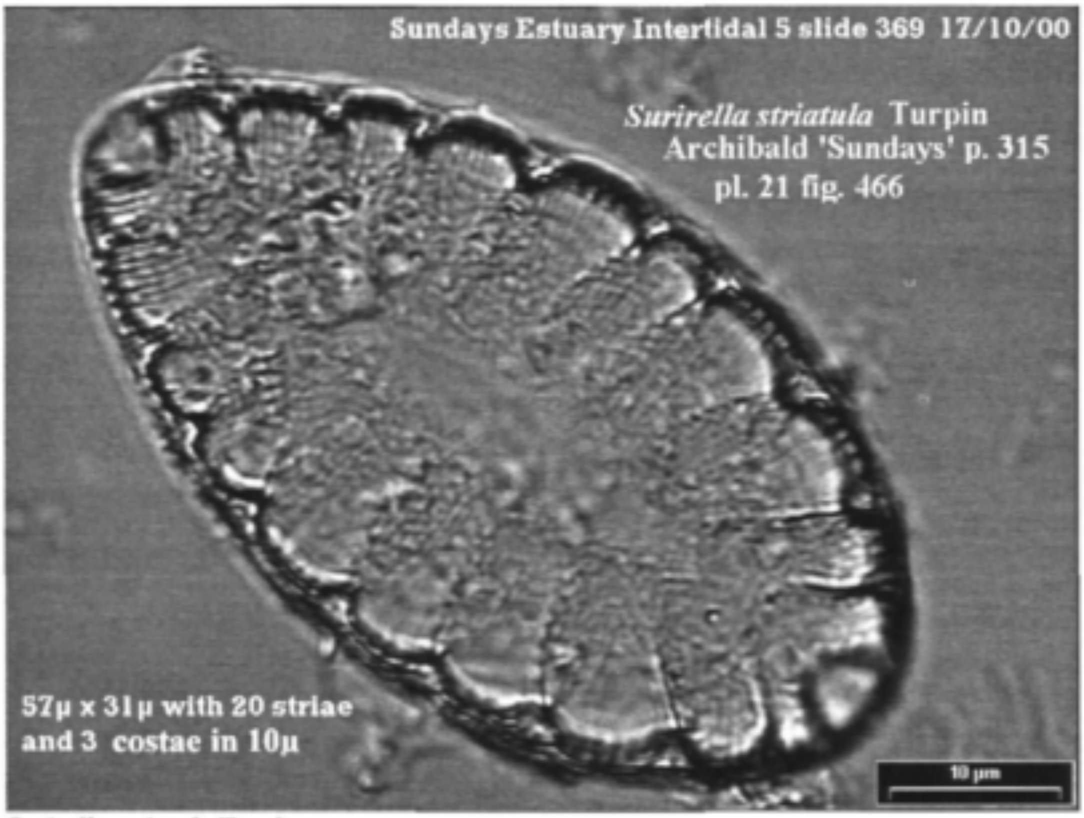
Surirella scalaris Giffen

Reference used for identification: Archibald 1983. Page 314. Plate 21. Figure 463.

Locations – Sub-dominant in epipelon – Gourits Estuary Subtidal Site 3.

NOTES	NOTES
Found at salinity: 34 ppt.	

SURISTRI



Surirella striatula Turpin
Reference used for identification: Archibald 1983. Page 315. Plate 21. Figure 466.
Locations – Sub-dominant in epipelon – Sundays Estuary Intertidal Sites 4 & 5.

NOTES	NOTES
Found at salinity: 3 – 4 ppt. Hustedt (1976): Brak. Krammer & Lange-Bertalot (1986): Brak. Lange-Bertalot (2000): Brak. Sims (1996): Brak. .	

ESTUARINE DOMINANTS THAT WERE ALSO SUB-DOMINANTS

Achnanthes kuelbsii sub-dominant at: Mngazana Estuary Intertidal Site 1.

Amphora acutiuscula sub-dominant at: Mngazana Estuary Intertidal Site 4; Mhlathuze Estuary Site 2; Sundays Estuary Subtidal Site 4; Bushmans Estuary Intertidal Site 3; Great Berg Estuary Intertidal Sites 1 & 4 & Subtidal Site 4; Goukou Estuary Intertidal Site 1.
Amphora arcus sub-dominant at: Swartkops Estuary 3 Intertidal Site 5 & Subtidal Sites 2 & 5.
Amphora castellata sub-dominant at: Nhlabane Estuary Intertidal Site G.
Amphora cf. strigosa sub-dominant at: Mlalazi Estuary Subtidal Site 4.
Amphora coffeaeformis sub-dominant at: Goukamma Estuary Intertidal Site 4; Mngazi Estuary Intertidal Site 1 & Subtidal Sites 4 & 5; Swartkops Estuary 3 Intertidal Site 2 & Subtidal Site 5; Swartkops Estuary 4 Subtidal Site 2; Great Berg Estuary Subtidal Site 4; Goukou Estuary Intertidal Sites 3 & 5, Subtidal Sites 3; Gourits Estuary Subtidal Site 5; Mlalazi Estuary Intertidal Site 5.
Amphora helenensis sub-dominant at: Swartkops Estuary 2 Intertidal site 3; Swartkops Estuary 4 Subtidal Site 4; Mngazi Estuary River Site, Intertidal Site 4 & Subtidal Site 2; Nhlabane Estuary Intertidal Site D.
Amphora proteoides sub-dominant at: Sundays Estuary Intertidal Site 1; Mtata Estuary Subtidal Site 1.
Amphora subacutiuscula sub-dominant at: Breede Estuary 2 Intertidal Site 4 & Subtidal Site 3; Goukou Estuary Intertidal Site 5; Mngazana Estuary Subtidal Sites 2 & 4; Swartkops Estuary 1 Intertidal site 4; Swartkops Estuary 3 Subtidal Site 3; Gourits Estuary Subtidal Site 4; Mtata Estuary Subtidal Site 3; Bushmans Estuary Intertidal Site 3 & Subtidal Site 4; Kowie Estuary Subtidal Site 5; Great Berg Estuary Intertidal Site 3.
Amphora helenensis sub-dominant at: Swartkops Estuary 2 Intertidal site 3; Swartkops Estuary 4 Subtidal Site 4; Mngazi Estuary River Site, Intertidal Site 4 & Subtidal Site 2; Nhlabane Estuary Intertidal Site D.
Amphora sublaevis sub-dominant at: Swartkops Estuary Intertidal Site 2; Swartkops Estuary 4 Intertidal Site 3, Subtidal Sites 1 & 2.

Bacillaria paxillifer sub-dominant at: Nhlabane Estuary Intertidal Sites F & H; Olifants Estuary Intertidal Sites 4 & 5; Zinkwazi Estuary Intertidal Site 3, Subtidal Sites 3,4 & 5.

Berkeleya rutilans sub-dominant at: Swartkops Estuary 4 Intertidal Site 5.

Cocconeis placentula sub-dominant at: Breede Estuary Subtidal Site 4; Great Berg Estuary Intertidal Site 5.

Cylindrotheca closterium sub-dominant at: Swartkops Estuary 3 Intertidal & Subtidal Site 3; Swartkops Estuary 4 Intertidal Site 4; Bushmans Estuary Intertidal Site 5 & Subtidal Site 1.
Cylindrotheca gracilis sub-dominant at: Mngazana Estuary Intertidal Site 5; Mzimkulu Estuary Intertidal Site 4.

Cymbella turgidula sub-dominant at: Mzimkulu Estuary Subtidal Site 5.

Diploneis elliptica sub-dominant at: Olifants Estuary Intertidal Sites 2,3 & 5; Sundays Estuary Subtidal Site 3; Breede Estuary 1 Subtidal Site 2; Breede Estuary 3 Intertidal Sites 2 & 4, Subtidal Site 2.
Diploneis puella sub-dominant at: Mtata Estuary Intertidal Site 2; Mhlathuze Estuary Bridge Site; Mlalazi Estuary Intertidal site 2; Zinkwazi Estuary Subtidal Site 5.

Entomoneis paludosa var. ***paludosa*** sub-dominant at: Kowie Estuary Intertidal Site 2; Mpekweni Estuary Beach Site.

Fragilaria elliptica sub-dominant at: Keurbooms Estuary Intertidal Site 2; Swartkops Estuary 1 Subtidal Site 5.

Gyrosigma prolongatum var. ***closteroides*** sub-dominant at: Kowie Estuary Subtidal Site 5; Mpekweni Estuary Intertidal Site 3; Goukou Estuary Intertidal Site 2.
Gyrosigma scalproides sub-dominant at: Gourits Estuary Subtidal Site 4; Mkomazi Estuary Intertidal Site 2; Mzimkulu Estuary Intertidal Site 2.

Hantzschia distinctepunctata sub-dominant at: Nhlabane Estuary Intertidal Site D.

Haslea crucigera sub-dominant at: Bushmans Estuary Subtidal Site 3; Kowie Estuary Subtidal Site 1.
Haslea spiculata sub-dominant at: Swartkops Estuary 3 Subtidal Site 3; Swartkops Estuary 4 Subtidal Sites 2 & 3; Kowie Estuary Intertidal Site 3; Mpekweni Estuary Subtidal Site 1.

Navicula arenaria vr. ***rostellata*** sub-dominant at: Goukamma Estuary Subtidal Site 5.
Navicula besarensis sub-dominant at: Mlalazi Intertidal Site 4.
Navicula cincta var. ***leptocephala*** sub-dominant at: Mngazi Estuary River Site.
Navicula gregaria sub-dominant at: Mngazana Estuary Subtidal Sites 3 & 5; Mngazi Estuary Intertidal Site 2; Mtata Estuary Intertidal Site 3; Olifants Estuary Intertidal Site 5, Subtidal Site 4; Swartkops Estuary 1 Intertidal Sites 1 & 3; Swartkops Estuary 2 Subtidal Site 4; Swartkops Estuary 3 Intertidal Site 5; Bushmans Estuary Subtidal Sites 2 & 4; Mpekweni Estuary Subtidal Site 5; Great Fish Estuary Intertidal Sites 4 & 5, Subtidal Site 1; Mkomazi Estuary Intertidal Site 2; Mzimkulu Estuary Intertidal Sties 3 & 5; Sundays Estuary Intertidal Site 1; Mzimkulu Estuary Intertidal Site 5.
Navicula normaloides sub-tidal at: Zinkwazi Estuary Intertidal Site 5, Subtidal Site 4.
Navicula perminuta sub-dominant at: Mpekweni estuary Subtidal Site3.
Navicula phyllepta sub-dominant at: Sundays Estuary Intertidal Site 5; Mzimkulu Estuary Intertidal Site 2 & Subtidal Site 1.
Navicula salinicola sub-dominant at: Sundays Estuary Subtidal Site 2; Breede Estuary 1 Intertidal & Subtidal Site 2, Groenpunt Subtidal; Kowie Estuary Intertidal Site 3; Mngazana Estuary Intertidal Site 4.
***Navicula* sp. 01** sub-dominant at: Mlalazi Subtidal Site 3.

***Navicula* sp. 03** sub-dominant at: Goukou Estuary Intertidal & Subtidal Site5; Gourits Estuary Subtidal Site 1; Breede Estuary Intertidal Site 2.
Navicula tenelloides sub-dominant at: Mngazana Estuary Intertidal Site 5; Mngazi Estuary Intertidal Site 4; Kowie Estuary Intertidal Site 5.

Nitzschia* aff. *perindistincta sub-dominant at: Great Fish Estuary Subtidal Site 4.
Nitzschia angularis var. (?) sub-dominant at: Bushmans Estuary Intertidal & Subtidal Site 4; Knysna Estuary Subtidal Site 1; Swartkops Estuary 2 Intertidal Sites 1 & 5; Kowie estuary Subtidal Site 2.
Nitzschia aremonica sub-dominant at: Gourits Estuary Subtidal Site 1.
Nitzschia fontifuga sub-dominant at: Mtata Estuary Intertidal Site 1.
Nitzschia frustulum sub-dominant at: Durban Bay Intertidal Site 5.
Nitzschia linkei sub-dominant at: Mlalazi Subtidal Site 1.
Nitzschia palea sub-dominant at: Goukamma Estuary Intertidal Site 3.
Nitzschia pellucida sub-dominant at: Breede Estuary 3 Intertidal Site 3.
Nitzschia sigma sub-dominant at: Breede Estuary Intertidal Site 5; Great Berg Estuary Intertidal Site 5.

Opephora horstiana sub-dominant at: Keurbooms Estuary Subtidal Site 1; Knysna Estuary Intertidal Site 1; Great Berg Estuary Subtidal Site 1.
Opephora minuta sub-dominant at: Kowie Estuary Intertidal Site 2.

Parlibellus berkeleyi sub-dominant at: Sundays Estuary Intertidal Site 2; Breede Estuary Intertidal Site 2; Great Berg Estuary Intertidal Site 1.
Parlibellus delognei sub-dominant at: Goukou Estuary Intertidal Site 4; Mzimkulu Estuary Intertidal Site 1.

Plagiotropis tayrecta sub-dominant at: Bushmans Estuary Subtidal Sites 3 & 4.

Pleurasigma delicatulum sub-dominant at: Keurbooms Estuary Subtidal Site 5; Sundays Estuary Subtidal Site 4; Zinkwazi Estuary Subtidal Site 3.

***Seminavis* sp. 01** sub-dominant at: Breede Estuary Intertidal Site 3; Mngazi Estuary Subtidal Site 3.
***Seminavis* sp. 02** sub-dominant at: Swartkops Estuary Subtidal Sites 2 & 4.
***Seminavis* sp. 03** sub-dominant at: Mlalazi Estuary Subtidal Site 3.

Tryblionella calida sub-dominant at: Breede Estuary 1 Intertidal Site 1.

ESTUARY SAMPLING SITES

Great Berg : 29 January 2002

Site	GPS co-ordinates	Salinity (ppt)	Number of taxa
Subtidal 1	32°46'42''S 18°09'00''E	34	41
Subtidal 2	32°47'24''S 18°09'20''E	24	25
Subtidal 3	32°47'38''S 18°10'24''E	25	Empty
Subtidal 4	32°47'15''S 18°11'20''E	26	24
Subtidal 5	32°48'03''S 18°11'46''E	23	34
Intertidal 1	32°46'42''S 18°09'00''E	35	47
Intertidal 2	32°47'24''S 18°09'20''E	34	35
Intertidal 3	32°47'38''S 18°10'24''E	38	56
Intertidal 4	32°47'15''S 18°11'20''E	26	45
Intertidal 5	32°48'03''S 18°11'46''E	N/D	40

Breede (1): 18 March 2000

Site	GPS co-ordinates	Salinity (ppt)	Number of taxa
Subtidal 1	34°23'59"S 20°46'27" E	30	24
Subtidal 2	32°23'32''S 20°45'07'E	20	40
Subtidal 3	34°21'25"S 20°41'26"E	0	Empty
Subtidal 4	34°21'13"S 20°38' 13"E	0	19
Subtidal 5	34°20'55"S 20°38' 13"E	0	30
GPSub	34°24'22"S 20°47 48"E	20	32
Intertidal 1	34°23'59"S 20°46'27" E	20	40
Intertidal 2	32°23'32''S 20°45'07'E	16	33
Intertidal 3	34°21'25"S 20°41'26"E	0	Empty
Intertidal 4	34°21'13"S 20°38' 13"E	0	24
Intertidal 5	34°20'55"S 20°38' 13"E	0	17
GPInt	34°24'22"S 20°47 48"E	30	28

Breede (2): 11 August 2000

Site	GPS co-ordinates	Salinity (ppt)	Number of taxa
Subtidal 1	34°23'54.6''S 20°49'40.5''E	7.2	36
Subtidal 2	34°24'08.2''S 27°47'16.8''E	5	Nil
Subtidal 3	34°24'13.1''S 20°49'06.2''E	3.5	22
Subtidal 4	34°23'33.9''S 20°45'13.5''E	2	19
Subtidal 5	34°23'04.4''S 20°43'49.6''E	0.2	13
Intertidal 1	34°23'54.6''S 20°49'40.5''E	5	Nil
Intertidal 2	34°24'08.2''S 27°47'16.8''E	4.2	24
Intertidal 3	34°24'13.1''S 20°49'06.2''E	3.4	8
Intertidal 4	34°23'33.9''S 20°45'13.5''E	2	20
Intertidal 5	34°23'04.4''S 20°43'49.6''E	0.2	32

Breede (3): 3 April 2001

Site	GPS co-ordinates	Salinity (ppt)	Number of taxa
Subtidal 1	34°23'49''S 20°49'36''E	28	70+
Subtidal 2	34°23'50''S 20°45'11''E	25	44
Subtidal 3	34°22'46''S 20°43'10''E	14	36
Subtidal 4	34°20'44''S 20°41'00''E	7	28
Subtidal 5	34°20'45''S 20°36'45''E	1	43
Intertidal 1	34°23'49''S 20°49'36''E	29	70+
Intertidal 2	34°23'50''S 20°45'11''E	24	30
Intertidal 3	34°22'46''S 20°43'10''E	15	36
Intertidal 4	34°20'44''S 20°41'00''E	7	27
Intertidal 5	34°20'45''S 20°36'45''E	1	17
River	34°18'08''S 20°25'27''E	0	27

Bushmans: 28 August 2001

Site	GPS co-ordinates	Salinity (ppt)	Number of taxa
Subtidal 1	33°41'17''S 26°38'40''E	34	73
Subtidal 2	33°40'39''S 26°39'08''E	34	60
Subtidal 3	33°40'09''S 26°38'39''E	33	74
Subtidal 4	33°39'13''S 26°37'16''E	33	48
Subtidal 5	33°39'36''S 26°36'26''E	32	50
Intertidal 1	33°41'17''S 26°38'40''E	36	60
Intertidal 2	33°40'39''S 26°39'08''E	34	65
Intertidal 3	33°40'09''S 26°38'39''E	34	60
Intertidal 4	33°39'13''S 26°37'16''E	34	60
Intertidal 5	33°39'36''S 26°36'26''E	33	60

Durban Bay: 27 March 2002

Site	GPS co-ordinates	Salinity (ppt)	Number of taxa
Subtidal 1	29°52'14''S 31°01'09''E	35	24
Subtidal 2	29°52'51''S 31°00'39''E	35	15
Subtidal 3	29°53'18''S 31°00'39''E	26	26
Subtidal 4	29°53'08''S 31°00'19''E	26	0
Subtidal 5	29°54'10''S 31°00'31''E	20	36
Intertidal 1	29°52'14''S 31°01'09''E	34	24
Intertidal 2	29°52'51''S 31°00'39''E	35	52
Intertidal 3	29°53'18''S 31°00'39''E	34	0
Intertidal 4	29°53'08''S 31°00'19''E	26	21
Intertidal 5	29°54'10''S 31°00'31''E	34	47

Goukamma: 5 May 2000

Site	GPS co-ordinates	Salinity (ppt)	Number of taxa
Deep 1	34°04'S 22°56'E	25	28
Deep 2	34°04'S 22°56'E	31	16
Deep 3	34°03'S 22°56'E	33	28
Deep 4	34°03'S 22°56'E	30	21
Deep 5	34°03'S 22°56'E	10	11
Shallow 1	34°04'S 22°56'E	29	20
Shallow 2	34°04'S 22°56'E	18	11
Shallow 3	34°03'S 22°56'E	22	14
Shallow 4	34°03'S 22°56'E	14	25
Shallow 5	34°03'S 22°56'E	5	30
River	34°03'S 22°56'E	1	20

Great Brak: 5 May 2000

Site	GPS co-ordinates	Salinity (ppt)	Number of taxa
Subtidal 1	34°03'2.3''S 22°14'10.8''E	35	22
Subtidal 2	34°03'0.8''S 22°13'52.2''E	30	20
Subtidal 3	34°03'15.5''S 22°13'10.7''E	29	32
Subtidal 4	34°02'23.2''S 22°13'16.9''E	25	22
Subtidal 5	34°02'13.4''S 22°13'13.1''E	25	22
Intertidal 1	34°03'2.3''S 22°14'10.8''E	29	16
Intertidal 2	34°03'0.8''S 22°13'52.2''E	26	9
Intertidal 3	34°03'15.5''S 22°13'10.7''E	26	10
Intertidal 4	34°02'23.2''S 22°13'16.9''E	24	13
Intertidal 5	34°02'13.4''S 22°13'13.1''E	26	15

Great Fish: 30 August 2001

Site	GPS co-ordinates	Salinity (ppt)	Number of taxa
Subtidal 1	33°29'21''S 27°07'33''E	33	21
Subtidal 2	33°29'03''S 27°06'57''E	35	27
Subtidal 3	33°28'40''S 27°06'08''E	30	15
Subtidal 4	33°28'36''S 27°05'20''E	26	21
Subtidal 5	33°28'01''S 27°04'30''E	0	Empty
Intertidal 1	33°29'21''S 27°07'33''E	18	34
Intertidal 2	33°29'03''S 27°06'57''E	13	23
Intertidal 3	33°28'40''S 27°06'08''E	10	17
Intertidal 4	33°28'36''S 27°05'20''E	5	30
Intertidal 5	33°28'01''S 27°04'30''E	0	20

Keurbooms: 3 May 2000

Site	GPS co-ordinates	Salinity (ppt)	Number of taxa
Subtidal 1	34°02'35.2''S 23°22'35.2''E	31	47
Subtidal 2	34°02'04.8''S 23°22'58.1''E	32	50
Subtidal 3	34°00'07.4''S 23°24'03.7''E	27	21
Subtidal 4	33°59'??''S 23°24'??''E	9	35
Subtidal 5	33°59'??''S 23°24'??''E	2	21
Intertidal 1	34°02'35.2''S 23°22'35.2''E	34	24
Intertidal 2	34°02'04.8''S 23°22'58.1''E	38	60+
Intertidal 3	34°00'07.4''S 23°24'03.7''E	19	26
Intertidal 4	33°59'??''S 23°24'??''E	5	10
Intertidal 5	33°59'??''S 23°24'??''E	2	22

Knysna: 2 May 2000

Site	GPS co-ordinates	Salinity (ppt)	Number of taxa
Subtidal 1	34°03'21.3'S 22°14'10.8''E	37	27
Subtidal 2	34°03'00.8'S 22°13'52.2''E	34	32
Subtidal 3	34°03'15.5'S 22°13'10.7''E	36	27
Subtidal 4	34°02'23.2'S 22°13'16.9''E	31	10
Subtidal 5	34°02'13.4'S 22°13'13.1''E	28	20
Intertidal 1	34°03'21.3'S 22°14'10.8''E	30	28
Intertidal 2	34°03'00.8'S 22°13'52.2''E	30	44+
Intertidal 3	34°03'15.5'S 22°13'10.7''E	36	30
Intertidal 4	34°02'23.2'S 22°13'16.9''E	31	36
Intertidal 5	34°02'13.4'S 22°13'13.1''E	28	30
Weir		Fresh	14

Mhlathuze: 24 June 1998

Site	GPS co-ordinates	Salinity (ppt)	Number of taxa
Bridge	Not measured	Estuary	45+
Tidal gate		Estuary	40
Boat launch		Estuary	65+
Site 1		Estuary	36
Site 2		Estuary	30
Mouth		Estuary	30

Mtata: 28 September 1999

Site	GPS co-ordinates	Salinity (ppt)	Number of taxa
Subtidal 1	31°57'S 29°12'E	35	14
Subtidal 2	31°57'S 29°11'E	35	Empty
Subtidal 3	31°57'S 29°11'E	26.5	13
Subtidal 4	31°56'S 29°11'E	28	14
Subtidal 5	31°56'S 29°11'E	18	11
Intertidal 1	31°57'S 29°12'E	35	14
Intertidal 2	31°57'S 29°11'E	12.1	12
Intertidal 3	31°57'S 29°11'E	2.6	18
Intertidal 4	31°56'S 29°11'E	1.2	1
Intertidal 5	31°56'S 29°11'E	0.1	14

Nhlabane: 27 March 1998

Site	GPS co-ordinates	Salinity (ppt)	Number of taxa
Subtidal A	28°37'09''S 32°16'50''E	F/W lake	32
Subtidal B	28°37'17''S 32°16'43''E	F/W lake	50
Subtidal C	28°38'06''S 32°16'15''E	13.3	46
Subtidal D	28°38'20''S 32°16'15''E	18.3	30
Subtidal E	28°38'39'S 32°16'10''E	19.7	38
Subtidal F	28°38'58''S 32°15'56''E	23.4	40
Subtidal G	28°39'20''S 32°15'42''E	23.4	40
Subtidal H	28°39'41''S 32°15'18''E	25.4	24
Intertidal A	28°37'09''S 32°16'50''E	F/W lake	36
Intertidal B	28°37'17''S 32°16'43''E	F/W lake	No slide
Intertidal C	28°38'06''S 32°16'15''E	3.3	18
Intertidal D	28°38'20''S 32°16'15''E	5.4	18
Intertidal E	28°38'39'S 32°16'10''E	6.7	27
Intertidal F	28°38'58''S 32°15'56''E	10	40
Intertidal G	28°39'20''S 32°15'42''E	16	40
Intertidal H	28°39'41''S 32°15'18''E	17.4	35

Olifants: 21 June 2001

Site	GPS co-ordinates	Salinity (ppt)	Number of taxa
Subtidal 1	32°41'30''S 18°11'51''E	25	25
Subtidal 2	31°40'02''S 18°11'53''E	20	10
Subtidal 3	31°38'48''S 18°11'54''E	14	10
Subtidal 4	31°37'50''S 18°11'55''E	9	11
Subtidal 5	31°36'44''S 18°12'07''E	1	16
Intertidal 1	32°41'30''S 18°11'51''E	24	31
Intertidal 2	31°40'02''S 18°11'53''E	16	21
Intertidal 3	31°38'48''S 18°11'54''E	12	16
Intertidal 4	31°37'50''S 18°11'55''E	5	20
Intertidal 5	31°36'44''S 18°12'07''E	1	22
River	32°36'07''S 19°00'09''E	0	33

Sundays: 17 October 2000

Site	GPS co-ordinates	Salinity (ppt)	Number of taxa
Subtidal 1	33°46'11.4''S 25°50'01.7''E	24	30
Subtidal 2	33°42'41.4''S 25°47'50.3''E	15	24
Subtidal 3	33°41'48.5''S 25°47'42.4''E	10	36
Subtidal 4	34°10'09.8''S 25°46'22.2''E	4	19
Subtidal 5	33°58'54''S 25°45'18.6''E	2	20
Intertidal 1	33°46'11.4''S 25°50'01.7''E	23	45
Intertidal 2	33°42'41.4''S 25°47'50.3''E	16	30
Intertidal 3	33°41'48.5''S 25°47'42.4''E	11	28
Intertidal 4	34°10'09.8''S 25°46'22.2''E	4	18
Intertidal 5	33°58'54''S 25°45'18.6''E	3	36
River	33°37'14.2''S 25°42'51.1''E	0	20

Swartkops 1: 19 September 2000

Site	GPS co-ordinates	Salinity (ppt)	Number of taxa
Subtidal 1	33°51'43.3''S 25°37'40.6''E	37	11
Subtidal 2	33°52'04.7''S 25°33'33.2''E	36	16
Subtidal 3	33°51'35.7''S 25°36'02.5''E	35	30
Subtidal 4	33°50'29.9''S 25°34'35.4''E	28	22
Subtidal 5	33°48'37.7''S 25°32'03.7''E		12
Intertidal 1	33°51'43.3''S 25°37'40.6''E	37	17
Intertidal 2	33°52'04.7''S 25°33'33.2''E	36	32
Intertidal 3	33°51'35.7''S 25°36'02.5''E	33	30
Intertidal 4	33°50'29.9''S 25°34'35.4''E	28	20
Intertidal 5	33°48'37.7''S 25°32'03.7''E		12

Swartkops 2: 23 April 2001

Site	GPS co-ordinates	Salinity (ppt)	Number of taxa
Subtidal 1	33°51'43.3''S 25°37'40.6''E	33	30
Subtidal 2	33°52'04.7''S 25°33'33.2''E	26	45
Subtidal 3	33°51'35.7''S 25°36'02.5''E	24	34
Subtidal 4	33°50'29.9''S 25°34'35.4''E	21	42
Subtidal 5	33°48'37.7''S 25°32'03.7''E	18	15
Intertidal 1	33°51'43.3''S 25°37'40.6''E	32	22
Intertidal 2	33°52'04.7''S 25°33'33.2''E	24	24
Intertidal 3	33°51'35.7''S 25°36'02.5''E	21	36
Intertidal 4	33°50'29.9''S 25°34'35.4''E	18	36
Intertidal 5	33°48'37.7''S 25°32'03.7''E	17	27

Swartkops 3: 25 June 2001

Site	GPS co-ordinates	Salinity (ppt)	Number of taxa
Subtidal 1	33°51'43.3''S 25°37'40.6''E	33	34
Subtidal 2	33°52'04.7''S 25°33'33.2''E	26	25
Subtidal 3	33°51'35.7''S 25°36'02.5''E	24	66
Subtidal 4	33°50'29.9''S 25°34'35.4''E	21	58
Subtidal 5	33°48'37.7''S 25°32'03.7''E	18	37
Intertidal 1	33°51'43.3''S 25°37'40.6''E	32	19
Intertidal 2	33°52'04.7''S 25°33'33.2''E	24	40
Intertidal 3	33°51'35.7''S 25°36'02.5''E	21	50
Intertidal 4	33°50'29.9''S 25°34'35.4''E	18	42
Intertidal 5	33°48'37.7''S 25°32'03.7''E	17	38

Swartkops 4: 27 August 2001

Site	GPS co-ordinates	Salinity (ppt)	Number of taxa
Subtidal 1	33°51'43.3''S 25°37'40.6''E	38	42
Subtidal 2	33°52'04.7''S 25°33'33.2''E	36	65
Subtidal 3	33°51'35.7''S 25°36'02.5''E	31	64
Subtidal 4	33°50'29.9''S 25°34'35.4''E	33	41
Subtidal 5	33°48'37.7''S 25°32'03.7''E	27	36
Intertidal 1	33°51'43.3''S 25°37'40.6''E	38	51
Intertidal 2	33°52'04.7''S 25°33'33.2''E	35	37
Intertidal 3	33°51'35.7''S 25°36'02.5''E	29	58
Intertidal 4	33°50'29.9''S 25°34'35.4''E	25	54
Intertidal 5	33°48'37.7''S 25°32'03.7''E	21	51

Mngazi: 27 January 2001

Site	GPS co-ordinates	Salinity (ppt)	Number of taxa
Subtidal 1	31°40'32''S 29°27'20''E	30	20
Subtidal 2	31°40'14'S 29°27'14''E	24	33
Subtidal 3	31°39'54'S 29°27'15''E	27	22
Subtidal 4	31°29'24'S 29°27'21''E	8	26
Subtidal 5	31°39'10'S 29°27'59''E	2	26
Intertidal 1	31°40'32''S 29°27'20''E	30	45
Intertidal 2	31°40'14'S 29°27'14''E	28	30
Intertidal 3	31°39'54'S 29°27'15''E	33	26
Intertidal 4	31°29'24'S 29°27'21''E	32	46
Intertidal 5	31°39'10'S 29°27'59''E	29	30

Mngazana : 27 January 2001

Site	GPS co-ordinates	Salinity (ppt)	Number of taxa
Subtidal 1	31°41'29''S 29°24'55''E	35	60+
Subtidal 2	31°41'43''S 29°24'18''E	27	40
Subtidal 3	31°41'45''S 29°23'51''E	30	40
Subtidal 4	31°41'19''S 29°23'24''E	25	40
Subtidal 5	31°40'54''S 29°23'26''E	23	24
Intertidal 1	31°41'29''S 29°24'55''E	35	60+
Intertidal 2	31°41'43''S 29°24'18''E	32	-
Intertidal 3	31°41'45''S 29°23'51''E	34	40
Intertidal 4	31°41'19''S 29°23'24''E	29	40
Intertidal 5	31°40'54''S 29°23'26''E	27	20

Mkomazi: 4 March 2002

Site	GPS co-ordinates	Salinity (ppt)	Number of taxa
Subtidal 1	30°12'03''S 30°48'04''E	0.6	0
Subtidal 2	30°11'58''S 30°47'52''E	0.2	23
Intertidal 1	30°12'03''S 30°48'04''E	1.6	0
Intertidal 2	30°11'58''S 30°47'52''E	0.3	13

Mzimkulu : 3 April 2002

Site	GPS co-ordinates	Salinity (ppt)	Number of taxa
Subtidal 1	30°44'15''S 30°27'23''E	5	15
Subtidal 2	30°43'54''S 30°27'10''E	5	23
Subtidal 3	30°43'28''S 30°26'04''E	4	36
Subtidal 4	30°43'15''S 30°26'54''E	5	34
Subtidal 5	30°42'53''S 30°26'46''E	11	40
Intertidal 1	30°43'15''S 30°26'54''E	6	52
Intertidal 2	30°43'15''S 30°26'54''E	33	14
Intertidal 3	30°43'15''S 30°26'54''E	30	48
Intertidal 4	30°43'15''S 30°26'54''E	14	47
Intertidal 5	30°43'15''S 30°26'54''E	8	56

Mlalazi: 22 March 2002

Site	GPS co-ordinates	Salinity (ppt)	Number of taxa
Intertidal 1	28°56'36''S 31°48'51''E	28	42
Intertidal 2	28°56'39''S 31°48'14''E	24	32
Intertidal 3	28°56'57''S 31°47'12''E	24	16
Intertidal 4	28°56'55''S 31°46'26''E	33	19
Intertidal 5	28°56'52''S 31°46'58''E	0	30
Subtidal 1	28°56'36''S 31°48'51''E	34	24
Subtidal 2	28°56'39''S 31°48'14''E	34	41
Subtidal 3	28°56'57''S 31°47'12''E	33	26
Subtidal 4	28°56'55''S 31°46'26''E	33	32
Subtidal 5	28°56'52''S 31°46'58''E	0	28

Zinkwazi : 22 March 2002

Site	GPS co-ordinates	Salinity (ppt)	Number of taxa
Intertidal 1	29°16'44''S 31°26'23''E	15	11
Intertidal 2	29°16'31''S 31°26'19''E	14	19
Intertidal 3	29°15'58'S 31°26'18''E	14	21
Intertidal 4	29°15'27'S 31°26'21''E	12	10
Intertidal 5	28°56'52'S 31°25'28''E	13	22
Subtidal 1	29°15'27'S 31°26'21''E	15	18
Subtidal 2	29°15'27'S 31°26'21''E	14	33
Subtidal 3	29°15'27'S 31°26'21''E	14	36
Subtidal 4	29°15'27'S 31°26'21''E	12	38
Subtidal 5	29°15'27'S 31°26'21''E	13	28

Goukou: 31 January 2002

Site	GPS co-ordinates	Salinity (ppt)	Number of taxa
Intertidal 1	32°47'15''S 18°11'20''E	20	32
Intertidal 2	34°21'53''S 21°24'44''E	19	54
Intertidal 3	34°21'27''S 21°25'00''E	15	17
Intertidal 4	34°20'59''S 21°24'28''E	14	15
Intertidal 5	34°20'32''S 21°24'21''E	5	33
Subtidal 1	32°47'15''S 18°11'20''E	25	48
Subtidal 2	34°21'53''S 21°24'44''E	27	43
Subtidal 3	34°21'27''S 21°25'00''E	14	34
Subtidal 4	34°20'59''S 21°24'28''E	14	25
Subtidal 5	34°20'32''S 21°24'21''E	10	25

Gourits: 31 January 2002

Site	GPS co-ordinates	Salinity (ppt)	Number of taxa
Intertidal 1	34°20'14''S 21°23'56''E	39	12
Intertidal 2	34°20'35''S 21°52'45''E	38	17
Intertidal 3	34°20'05''S 21°51'20''E	35	16
Intertidal 4	34°19'30''S 21°50'32''E	34	12
Intertidal 5	34°18'34''S 21°19'34''E	27	42
Subtidal 1	34°20'14''S 21°23'56''E	39	23
Subtidal 2	34°20'35''S 21°52'45''E	39	30
Subtidal 3	34°20'05''S 21°51'20''E	34	29
Subtidal 4	34°19'30''S 21°50'32''E	34	24
Subtidal 5	34°18'34''S 21°19'34''E	27	53

Kowie: 29 August 2001

Site	GPS co-ordinates	Salinity (ppt)	Number of taxa
Intertidal 1	No slide		
Intertidal 2	33°35'27''S 26°52'39''E	32	56
Intertidal 3	33°35'06''S 26°51'39''E	29	61
Intertidal 4	33°34'29''S 26°51'13''E	25	42
Intertidal 5	33°33'45''S 26°50'35''E	20	60
Subtidal 1	33°35'48''S 26°53'35''E	35	61
Subtidal 2	33°35'27''S 26°52'39''E	35	57
Subtidal 3	33°35'06''S 26°51'39''E	30	53
Subtidal 4	33°34'29''S 26°51'13''E	29	71
Subtidal 5	33°33'45''S 26°50'35''E	26	47

Mpekweni: 29 August 2001

Site	GPS co-ordinates	Salinity (ppt)	Number of taxa
Beach	33°26'28''S 27°13'34''E	17	27
Intertidal 3	33°26'01''S 27°13'41''E	35	27
Subtidal 1	33°26'28''S 27°13'34''E	35	49
Subtidal 3	33°26'01''S 27°13'41''E	35	25
Subtidal 5	33°26'52''S 27°13'34''E	?	20

REFERENCES

Archibald, R.E.M. 1983. The Diatoms of the Sundays and Great Fish Rivers in the Eastern Cape Province of South Africa. *Bibliotheca Diamotologica*. J Cramer. 431 pp.

Hustedt, F. 1976. Die Süsswasser- flora Mitteleeuropas. Otto Koeltz Science Publishers. Koenigstein, Germany. 466 pp.

Krammer, K. and Lange-Bertalot, H. 1986. Süsswasser von Mitteleuropa. Bacillariophyceae. Teil 1: Naviculaceae. Gustav Fischer Verlag. Stuttgart. 440 pp.

Lange-Bertalot, H. (Ed.) 2000. Iconographia Diatomologica. Volume 7. Koeltz Scientific Books, Germany. 925 pp.

Lange-Bertalot, H. and Krammer, K. 1989. *Achnanthes* Eine Monographie der Gattung. *Bibliotheca Diatomologica*. Band 18. J Cramer. Berlin. 393 pp.

Patrick, R. and C.W. Reimer. 1975. The Diatoms of the United States Exclusive of Alaska and Hawaii. Monographic Series of Academy of Natural Sciences of Philadelphia # 13. Volume 2. Part 1.

Round, F.E.; Crawford, R.M. and D.G. Mann 1990. The Diatoms. Biology and Morphology of the Genera. Cambridge University Press. Cambridge. 747 pp.

Schoeman, F.R. and Archibald, R.E.M 1976. The Diatom Flora of Southern Africa. *Special Report WAT 50*. CSIR, South Africa.

Simonsen, R. 1987. Atlas and Catalogue of the Diatom Types of Friedrich Hustedt. Vol 1:Catalogue. J. Cramer, Stuttgart. 525 pp.

Simonsen, R. 1987. Atlas and catalogue of the diatom types of Friedrich Hustedt. Vol 2: Atlas, Plates 1-395. 395 pp. J. Cramer, Stuttgart

Simonsen, R. 1987. Atlas and catalogue of the diatom types of Friedrich Hustedt. Vol 3: Atlas, Plates 396 -772. J. Cramer, Stuttgart. 772 pp.

Sims, P.A. 1996. An Atlas of British Diatoms. Arranged by B. Hartley and based on illustrations by H. G. Barbour and J. R. Carter.[Ed. P.A. Sims]. Biopress Ltd. Bristol. 601 pp.