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Diatom analysis of a core from La Grande Mare, Guernsey

N. Cameron

Report to R.L. Jones, School of Natural & Environmental Sciences,
Coventry University

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**Environmental Change Research Centre
University College London
26 Bedford Way
London
WC1H 0AP**

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N.G. Cameron, Environmental Change Research Centre, University College London, 26 Bedford Way, London. WC1H 0AP

Introduction

Diatom analysis was carried out on a sediment sequence from La Grande Mare, Guernsey (49° 27' 58" N 2° 36' 20" W). The technique was used to determine the conditions under which the sediments accumulated and, in particular, the salinity regime of the water. A diatom assemblage examined in an earlier study of a *Phragmites* peat sampled at La Grande Mare had a brackish water flora (Churchill 1964). This was believed to indicate a rise in sea level and the contact of the peat with overlying grey silty clay, at +6 ft OD, was dated to 3180±110 BP. In the present study the suggestion that the sediments contain evidence for a marine transgression is examined.

Methods

Diatom preparation and analysis followed standard techniques (Battarbee 1986). For assessment and counting, slides were examined at a magnification of x1250 under phase contrast illumination. For diatom counting, a total of approximately 200-250 valves was counted on the slides. Where necessary diatom identifications were confirmed using diatom floras and taxonomic publications held in the collection of the Environmental Change Research Centre (ECRC), UCL and in the authors own collection. The floras most commonly consulted were: Cleve-Euler (1951-1955), Hendeby (1964), Hustedt (1930-1966), Werff & Huls (1957-1974). A number of taxa were of uncertain identity, usually being close in morphology to one or more taxa of known ecology. In a few cases it was possible to assign the taxon to the halobian group appropriate for the taxon or taxa which the diatom closely matches. Otherwise these taxa were assigned to the 'unknown' halobian category. The principle source of data on species ecology used was Denys (1992).

Data were entered into the AMPHORA diatom database at the ECRC, where these data, slides and cleaned valve suspensions are available for examination. The programs TRAN (Juggins 1993) and TILIA 2.00 (Grimm 1991) were used for data manipulation and diagrams were plotted using TILIAGRAPH 1.25 (Grimm 1991). A cluster analysis, constrained by stratigraphic order, was carried out on the diatom assemblages using the CONISS program (Grimm 1987). The results of cluster analysis were used to produce a diatom-based zonation.

Diatom species' salinity preferences were classified using the halobian groups of Hustedt (1953, 1957: 199) summarised below:

1. Polyhalobian: >30 g l⁻¹
2. Mesohalobian: 0.2-30 g l⁻¹
3. Oligohalobian - Halophilous: optimum in slightly brackish water
4. Oligohalobian - Indifferent: optimum in freshwater but tolerant of slightly brackish water
5. Halophobous: exclusively freshwater

6. Unknown: taxa of unknown salinity preference.

Diatom halobian groups are indicated above the diatom species percentage and summary percentage diagrams (Figures 1 & 2)

Results

The site location, survey and stratigraphy were detailed by Jim Campbell, Department of Geography, Coventry University. The investigation forms part of his PhD. research. The mastercore selected for diatom analysis has also been analysed for pollen (J. Campbell unpubl. results).

A total of 127 samples from the master corer were prepared and screened for diatom analysis. These samples ranged in altitude from -0.81 m (Sample 1, depth from core surface 385 cm) to +2.55 m (Sample 127, 49 cm in the core) relative to the Guernsey Datum (GD). Slides were scanned and the concentration, preservation, diversity and type of diatom assemblage noted along with the potential for further analysis. The conclusions of this assessment stage (unpubl. results) were:

1. Diatoms are fairly well preserved in a range of samples 22-127. For *most* of these percentage counting is possible.
2. Assemblages are dominated by freshwater diatom taxa throughout, with some more brackish species appearing. From scanning of the slides, there appeared to be *no marine species* in the sequence.
3. Diatoms are absent, or present only at very low abundances in samples 1-21. Percentage counts cannot be made on these levels.

It was therefore decided to carry out percentage diatom counts across the range of samples in which the assessment had shown that diatom counting was possible. These samples ranged in altitude from +0.71 m GD to 2.55 m GD (287 cm to 49 cm depth in the core)

Diatom stratigraphy (Figures 1 & 2)

A total of 27 samples were analysed for diatoms. Using the results of the cluster analysis the diagram was divided into five zones (D-1 to D-5).

Zone D-1 (251-287 cm)

The diatom assemblage zone D-1 corresponds with the period of maximum abundances (>30%), succeeded by a decline, of mesohalobous to halophilous diatoms. Most of these are benthic diatoms such as *Navicula slesvicensis* and *Navicula digitoradiata* and, exceptionally, the planktonic species *Cyclotella meneghiniana*. The abundance of these diatoms indicates that the water conductivity was relatively high, but the absence of polyhalobous (marine) taxa shows that there was not an open channel connecting the basin with the sea. The high percentages of brackish water taxa and halophilous species, having growth optima at high conductivities, is probably related to the incursion of marine water into groundwater, and is

not derived from salts leached from the surrounding bedrock, since conductivity is not constantly high. In addition, because of the basin's proximity to the sea, it is likely that salt water spray would increase the conductivity of the water or that salts were concentrated by evaporation.

In the upper part of D-1 there is a decline in the percentage of halophilous taxa, for example *Navicula slesvicensis*. *Cyclotella meneghiniana* declines, the abundances of *Fragilaria brevistriata* and *Fragilaria pinnata* increase as does the percentage of *Achnanthes lanceolata*. The *Fragilaria* species are typical of shallow water environments, subject to instability, and despite their "oligohalobous indifferent" classification they are tolerant of brackish water (Denys 1988). The increasing abundance of *Achnanthes lanceolata*, also growing on submerged surfaces, indicates increasingly fresh water conditions.

Zone D-2 (243-251 cm)

This zone, enclosing a single sample, is characterised by a marked maximum in the abundance of *Eunotia pectinalis*, a freshwater, and halophobic taxon, according to some ecological literature (see Denys 1992). There is also a peak in the percentage of the halophilous, freshwater species *Melosira varians*. There are also maxima in other oligoalobous taxa, such as *Achnanthes minutissima* and *Fragilaria vaucheriae*. These species are typical of shallow, freshwater environments, often with dense growth of macrophyte vegetation. During this period it appears that freshwater conditions are prevalent, but freshwater to brackish taxa continue to be present at relatively low abundances.

Zone D-3 (105-243 cm)

The abundance of *Eunotia pectinalis* declines whilst percentages of oligoalobous indifferent (freshwater) taxa such as *Achnanthes lanceolata* and *Fragilaria* sp. continue to be high or increase further. Other taxa become established; these include the benthic taxa freshwater taxa *Amphora pediculus*, *Cymbella sinuata*, *Cocconeis diminuta*, *Cocconeis placentula* var. *euglypta* and *Achnanthes conspicua*. The continuing influence of brackish water is shown by the maxima of mesoalobous to halophilous taxa, for example *Navicula digitoradiata*, *Achnanthes haukiana* and *Navicula cincta* which occur throughout the zone. In general the diatoms appear to indicate a decrease in salinity with freshwater taxa dominant.

Zone D-4 (81-105 cm)

Zone D-4 is characterised by maximum abundances of the benthic, freshwater diatom *Achnanthes lanceolata* and a small, but significant rise in the percentage of *Eunotia pectinalis*. Both suggest a period of relatively stable freshwater conditions and are accompanied by decreased percentages of brackish and halophilous species.

Zone D-5 (49-81 cm)

In Zone D-5 there are declining percentages of some freshwater taxa, for example *Fragilaria pinnata* and *Achnanthes lanceolata*. However, these and other freshwater taxa continue to be abundant. The percentage of *Fragilaria brevistriata* increases towards the top of this zone and may indicate increasingly variable or rising salinity. There are also slight increases in the percentages of some mesohalobous to halophilous taxa in this zone, notably the reappearance of a low percentage of *Cyclotella meneghiniana*.

Discussion & Conclusions

The results of diatom analysis largely support the conclusions of the initial assessment and also provide some more detail of the sequence. The main features of the diatom diagram are:

1. The sequence is dominated throughout by oligohalobous indifferent (freshwater) diatoms. However, at the base of zone D-1 the most brackish conditions occur and the diatom assemblage is composed of over 30% halophilous (salinity tolerant freshwater) or mesohalobous taxa. There are also peaks of about 20% halophilous or mesohalobous (brackish) taxa at depths of approximately 210 cm and 110 cm in the sequence.
2. Throughout the sequence, occurrences of true marine (polyhalobous) species are sporadic and where these are present valve numbers are very low. The infrequent occurrence and rarity of polyhalobous taxa can be accounted for by aerial contamination. There is therefore no evidence for marine transgression *directly* affecting the basin. However, a salinisation of groundwater by seawater, or an increase in salt spray could account for increases in the salinity of freshwater.
3. Zone D-2 is distinguished by an increase in *Eunotia pectinalis* which has a halobian classification of oligohalobous indifferent to halophobous (freshwater species less tolerant of higher salinities). The expansion of this taxon, following the more saline conditions recorded at the base of zone D-1 and succeeded by the increased percentage of oligohalobous indifferent (freshwater) diatoms at the top of zone D-1 is consistent with a sequence of increasingly freshwater conditions. The expansion of this benthic species might also be related to the availability of a new substrate or substrates for colonisation, for example increased growth of aquatic macrophytes associated with a change in water quality. The establishment of other benthic taxa associated with epiphytic habitats such as *Cocconeis placentula* var. *euglypta* and *Cocconeis diminuta* for example in D-3 and D-4 may also be related to further increases in aquatic macrophyte growth.

The diatom sequence from La Grande Mare has been compared with the diatom record from Le Marais de St. Pierre (Goose Green Marsh), Jersey (Jones *et.al.* 1990). Radiocarbon dates indicate that the top of La Grande Mare core overlaps in time with the basal section of the core investigated from Goose Green Marsh. Comparison of the zones recognised at Goose Green (GG) and their ages with those from La Grande Mare is useful.

In zone GG1 (mid date 4660 ± 60) the freshwater diatom *Fragilaria pinnata* is dominant. In age, this is equivalent to the section of the La Grande Mare core lying between the upper date of lgm 4 to lgm 5 (pollen zonation scheme) or in zone D-3 of the diatom zonation scheme. The diatoms at both sites indicate a dominantly freshwater assemblage. However, a significant percentage of the marine species *Paralia sulcata* occurs in zone GG1 of the Goose Green core.

In zone GG2 (which has a mid-zone date of 4710 ± 80 , and therefore appears to be earlier than underlying sediment) there is an expansion of *Achnanthes lanceolata* and other freshwater species. Again this is consistent with the sequence of La Grande Mare pollen zones lgm 4 to lgm 5 (diatom zone D-3) although there are indications of brackish water influence within lgm 4 and lgm 5.

At La Grande Mare pollen zone lgm 6 shows a very slight indication of increasingly brackish conditions and perhaps disturbed conditions indicated by the rising percentage of *Fragilaria brevistriata*. In contrast at Goose Green Marsh there is clear evidence of a marine transgression with a sudden shift to marine species in zone GG3. At this point of the Goose Green Marsh sequence there is no phase with a transitional brackish water diatom flora. It is suggested that this was the result of a rapid change from freshwater to marine conditions. It is also possible that there was loss of sediment in the transition from freshwater to marine conditions and loss of the facies representing brackish water environments.

A diatom core has also been studied from a coastal lake, St.Ouen's Pond, Jersey (Chambers 1993). The sequence shows similar diatom assemblages to the La Grande Mare core with fluctuations from freshwater to slightly brackish conditions. There is, however, no evidence for full marine conditions and this is not unexpected given the probable Recent age (1000-1500 BP) of the oldest sediment in this sequence. Radiocarbon ages are, however, not available for this core.

The absence or poor preservation of diatom valves in the samples from the base of La Grande Mare core probably reflects an unsuitable preservational environment for diatoms, rather than an initial absence of diatoms from the sediments. For example in alkaline environments (pH > 9) silica dissolution is rapid and even in alkaline environments below this pH, silica dissolution occurs gradually. Drying of the sediment in a shallow water environment would also be unfavourable for diatom preservation. In general the taphonomic problems of interpreting diatom assemblages from this site are relatively small compared with many coastal sites (eg. Vos & de Wolf 1988, 1993). It seems that the basin was enclosed and the diatom flora is therefore largely allochthonous.

Acknowledgements

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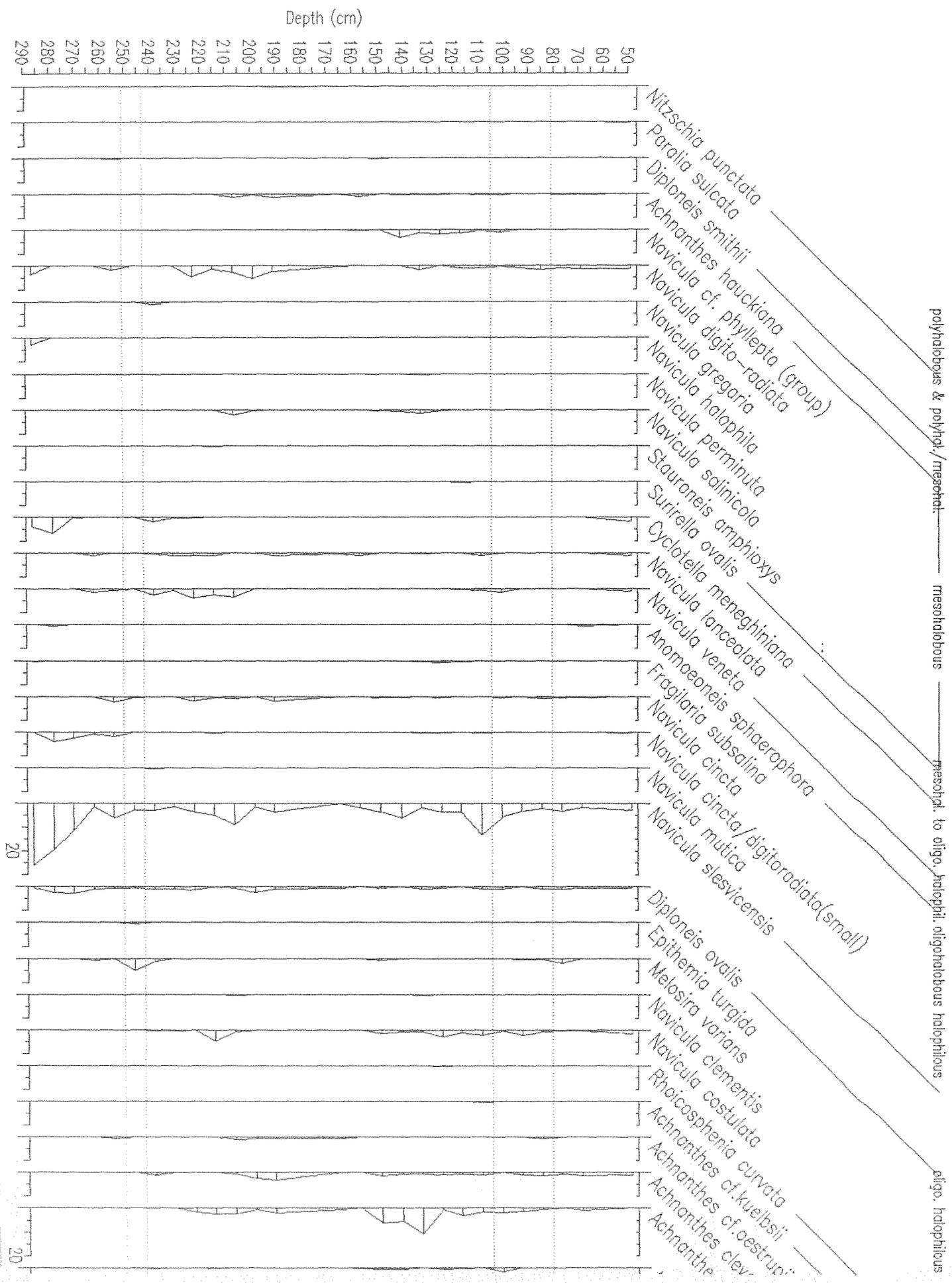
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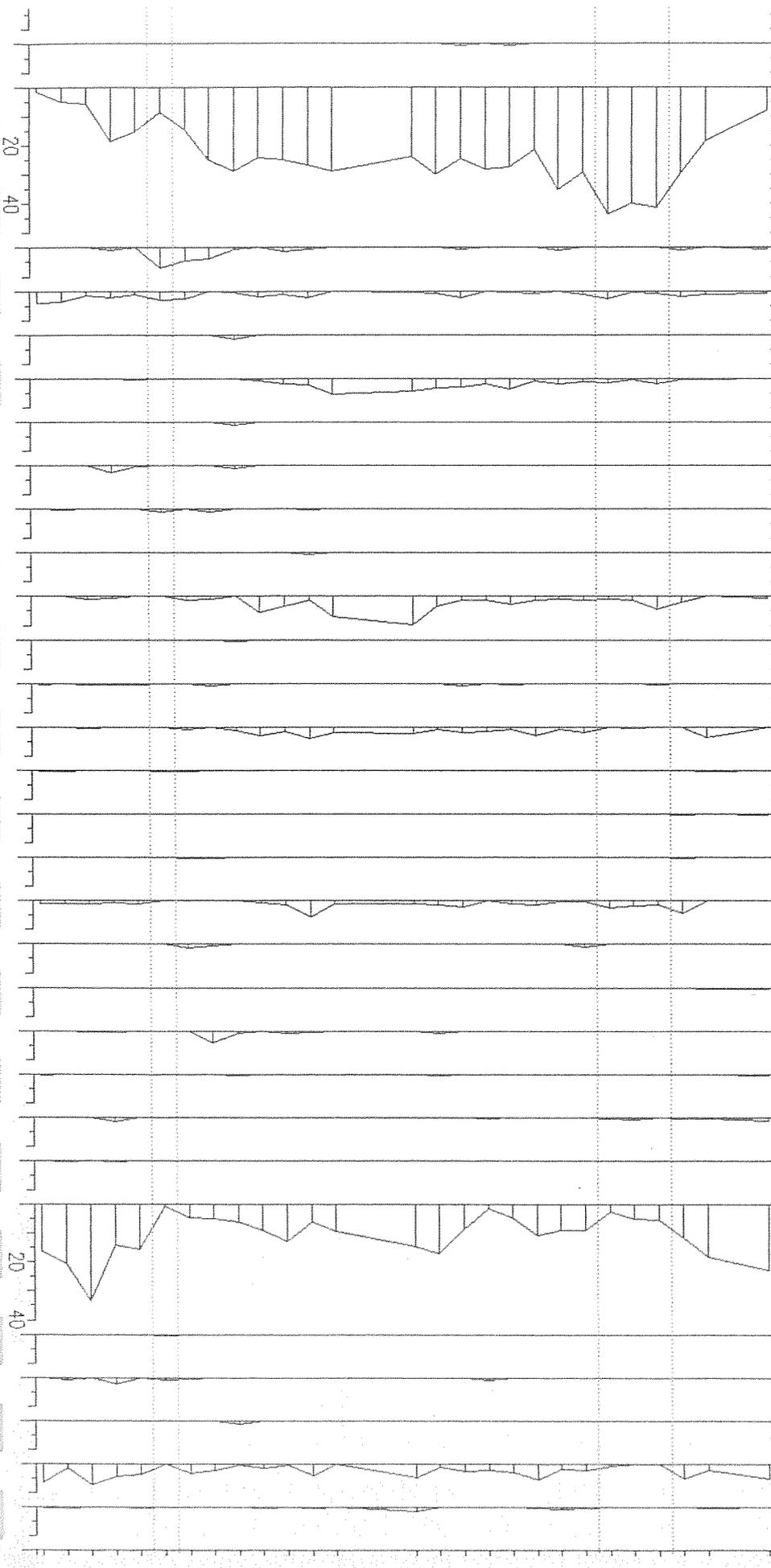
N.G. Cameron,
Environmental Change Research Centre,
University College London,
26, Bedford Way,
London WC1H 0AP

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Figure 1. La Grande Mare, Guernsey



to indifferent

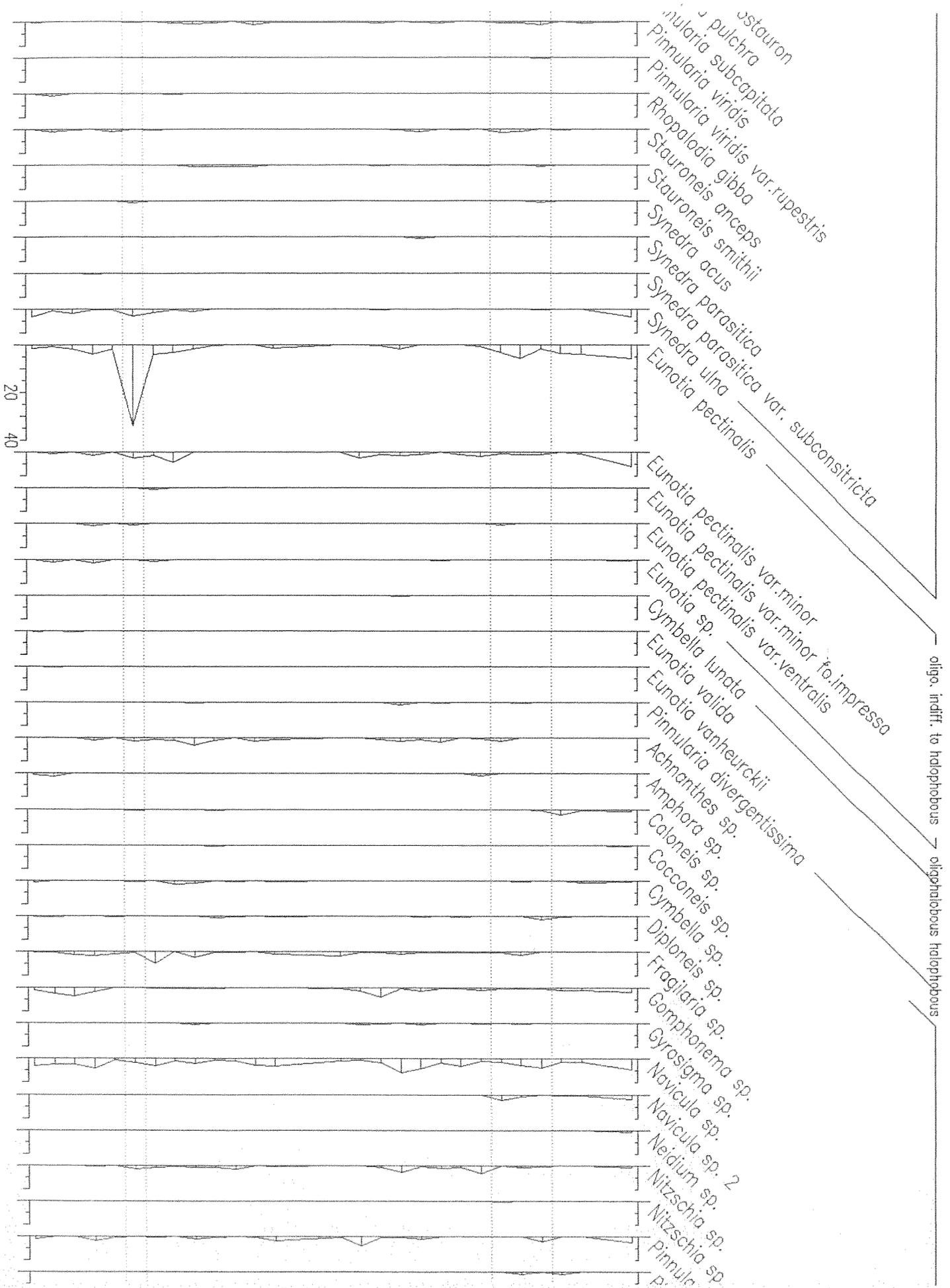


- Achnanthes constricta*
- Achnanthes conspicua*
- Achnanthes exigua*
- Achnanthes hungarica*
- Achnanthes lanceolata*
- Achnanthes minutissima*
- Amphora libyca*
- Amphora ovalis*
- Brachysira pediculus*
- Caloneis brebissonii*
- Caloneis bacillum*
- Campylodiscus cf. noricus*
- Cocconeis diminuta*
- Cocconeis disculus*
- Cocconeis placentula*
- Cocconeis placentula var. euglypta*
- Cymbella aspera*
- Cymbella minuta*
- Cymbella naviculiformis*
- Cymbella sinuata*
- Diploneis ventricosa*
- Ellerbeckia elliptica*
- Epithemia arenaria*
- Eunotia sp.*
- Eunotia curvata*
- Eunotia flexuosa*
- Fragilaria brevisirata*
- Fragilaria capucina*
- Fragilaria capucina var. ruficornis*
- Fragilaria construens*
- Fragilaria cf. construens*

20
40

- Fragilaria leptostauron*
- Fragilaria pinnata*
- Fragilaria vaucheriae*
- Fragilaria virescens* var. *exigua*
- Gomphonema acuminatum*
- Gomphonema angustatum*
- Gomphonema angustatum* var. *productum*
- Gomphonema gracile*
- Gomphonema intricatum*
- Hantzschia parvulum*
- Meridion amphioxys*
- Navicula circularis*
- Navicula capitata*
- Navicula contenta*
- Navicula cuspidata*
- Navicula elginensis*
- Navicula laevissima*
- Navicula perpusilla*
- Navicula pupula*
- Navicula radiosa*
- Navicula radiosa* var. *tenella*
- Navicula seminulum*
- Navicula tantula*
- Nitzschia variostrata*
- Nitzschia amphibia*
- Opephora recta*
- Pinnularia martyi*
- Pinnularia cbaujensis*
- Pinnularia borealis*
- Pinnularia major*
- Pinnularia mesolepta*
- Pinnularia micro*

oligohalobous indifferent



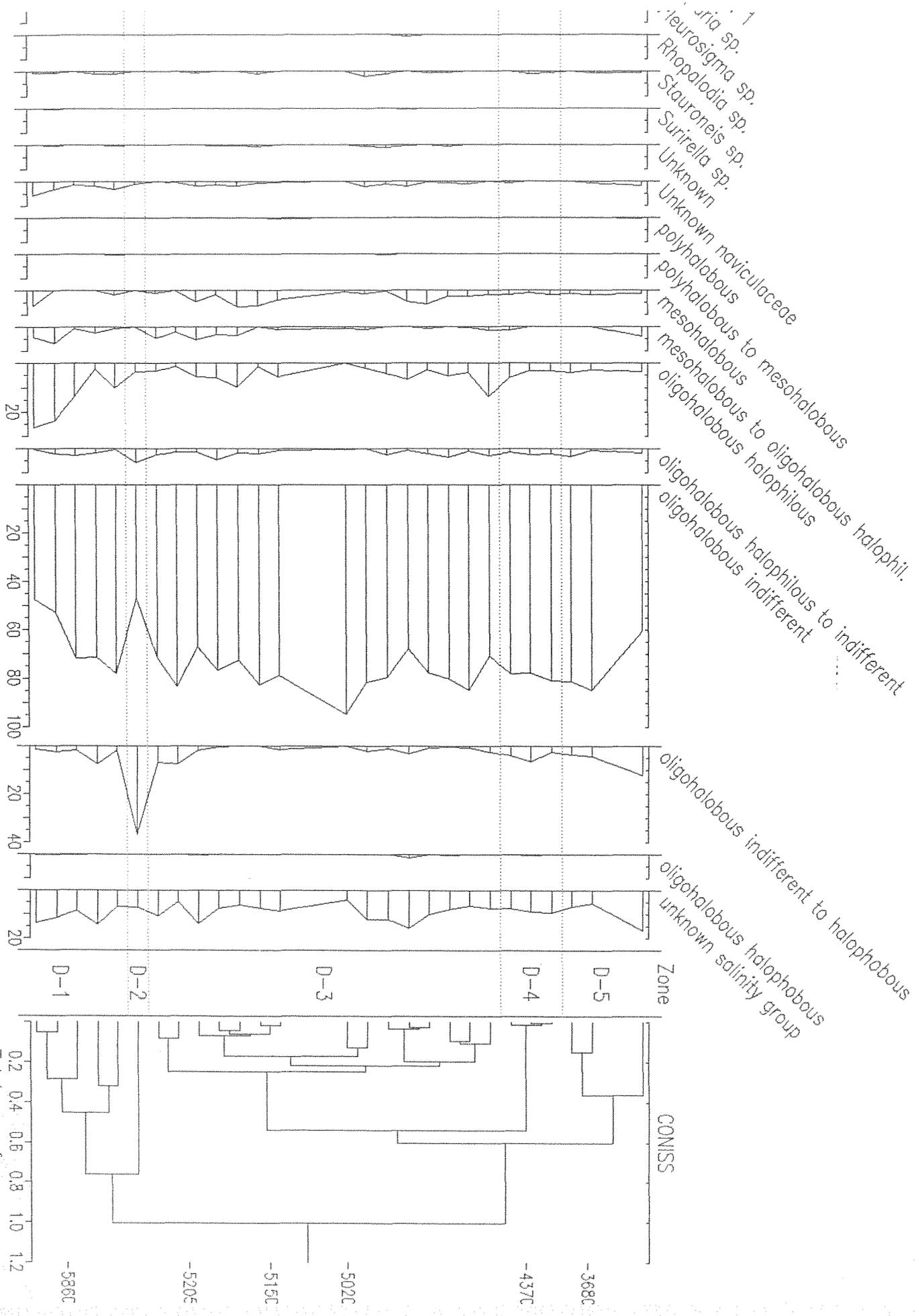
- Stauron*
- Stauron pulchra*
- Pinnularia subcapitata*
- Pinnularia viridis*
- Pinnularia viridis* var. *rupestris*
- Rhopalodia gibba*
- Stauroneis anceps*
- Stauroneis smithii*
- Synedra acus*
- Synedra parasitica*
- Synedra parasitica* var. *subconstricta*
- Eunotia ulna*
- Eunotia pectinalis*
- Eunotia pectinalis* var. *minor*
- Eunotia pectinalis* var. *minor* fo. *impressa*
- Eunotia pectinalis* var. *ventralis*
- Cymbella* sp.
- Eunotia lunata*
- Eunotia valida*
- Pinnularia vanheurckii*
- Achnanthes divergentissima*
- Amphora* sp.
- Coloneis* sp.
- Cocconeis* sp.
- Cymbella* sp.
- Diploneis* sp.
- Fragilaria* sp.
- Gomphonema* sp.
- Gyrasigma* sp.
- Navicula* sp.
- Navicula* sp.
- Neidium* sp. 2
- Nitzschia* sp.
- Nitzschia* sp.
- Pinnularia* sp.

oligo-indiff. to halophobous

oligohalobous halophobous

20
40

— unknown salinity group



1455

1450

1470

Radiocarbon age

1410

1445

1450

