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Diatom analysis of sediments from Barland's Farm, Magor (Severn Estuary)

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DIATOM ANALYSIS OF SEDIMENTS FROM BARLAND'S FARM, MAGOR, GWENT

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Introduction

The site details and rationale of the archaeological excavation are discussed in Lawler & Nayling (1994), Nayling *et.al.* (1994) and Nayling & McGrail (1995). In October 1993, a diatom assessment was carried out on selected samples from 3 locations at the site, these were: Open Trench 050 (including a sample from a Point Bar formation in the palaeochannel); Coffer Dam 051; and Coffer Dam 053. Its aim was to determine the potential use of diatom analysis in further investigations of these sediments, and in particular the value of diatom analysis in reconstructing the salinity conditions under which the sediments formed. The relatively good preservation of diatoms in the samples assessed indicated that diatom analysis would be a valuable tool in characterising the environment of deposition. A programme of diatom analyses was therefore implemented.

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 prepared from Context 1030 and Trenches 053 and 051, whilst approximately 100-150 valves were counted from samples from Trench 050 and from the Point Bar formation. The lower counting sums for the latter features was considered adequate, given the relatively low species diversity and usefulness of counting a larger number of samples at closer intervals in the time available. 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), Hendey (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 program TRAN (Juggins 1993) was used for data manipulation and diagrams were plotted using TILIA and TILIAGRAPH (Grimm 1991).

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 percentage diatom diagrams (Appendix Figures 1-4) and these groups are the basis of the classification presented in the composite diatom diagrams (Figures 1-5).

Results

1993 Diatom Assessment

Results from the assessment are presented as brief species lists showing only the most commonly encountered taxa in each sample, (very abundant species are indicated by a '+'). The concentration of diatom valves, their state of preservation, the probable (broad) salinity conditions and potential for further work are commented upon.

TRENCH 050

CONTEXT 2003, SAMPLE 1080

Single valve cf. *Diatoma vulgare*
Single valve *Cocconeis placentula*

Diatom concentration very low, poor preservation, both valves are freshwater taxa, little potential for percentage counting.

CONTEXT 2006, SAMPLE 1090

Single fragment cf. *Pseudopodosira westii*

Diatom concentration very low, poor preservation, the fragment observed is of a marine taxon, little potential for percentage counting.

CONTEXT 2008, SAMPLE 1100

Paralia sulcata+, Cymatosira belgica+, Rhaphoneis surirella, R.minutissima, Thalassiosira decipiens, Actinoptychus undulatus, Podosira stelligera, Nitzschia spp., *Aulacoseira* sp.

Diatom valves in countable concentrations, well preserved, a marine species assemblage, percentage counting worthwhile.

CONTEXT 2309, SAMPLE 1118

P.sulcata, T.decipiens, R.minutissima, Campylosira cymbelliformis, Diploneis interrupta, C.belgica, Navicula cincta, Nitzchia punctata (fo.), *P. stelligera, Navicula* (lyrate species).

Diatom valves in countable concentrations, well preserved, a marine species assemblage with some estuarine taxa, percentage counting worthwhile.

CONTEXT 2348, SAMPLE 1125

R.minutissima++, C.belgica+, R.surirella, P.sulcata+, N.apiculata, T.decipiens, Gyrosigma sp., *N.cincta, Achnanthes minutissima, D.interrupta/bombus*

Diatom valves in countable concentrations, well preserved, predominantly marine spp., percentage counting worthwhile.

CONTEXT 2306, SAMPLE 1132

C.belgica++, R.minutissima, P.sulcata++, Cyclotella striata, T.decipiens, R.amphiceros, P.stelligera, Psuedopodosira westii

Diatom valves in countable concentrations, well preserved, predominantly marine spp. some estuarine, percentage counting worthwhile.

CONTEXT 2307, SAMPLE 1139

2 valves *Nitzschia* sp., 2 *Navicula* sp., 1 fragment *Surirella*, 1 fragment *Gyrosigma*, 2 valves *Achnanthes lanceolata, T.decipiens*, fragment *P.sulcata*, 3 Naviculaceae

Diatom valves in low concentrations (peat-like sediment), poorly preserved, mixed assemblage of fresh to marine taxa.

(POINT BAR FORMATION) CONTEXT 2337, SAMPLE 1155

C.belgica, P.stelligera, P.sulcata, Navicula peregrina, cf.*Bacillaria paradoxa*

Diatom valves in low concentrations, poorly preserved but countable, marine with and brackish.

COFFER DAM 051

CONTEXT 2100/2101, SAMPLE 1209

Nitzschia apiculata, Navicula gregaria, P.sulcata, R.minutissima, N.cincta, N.peregrina, Navicula (lyrate sp.)++, *T.decipiens, Nitzschia punctata, Amphora* sp., *C.belgica, Actinoptychus undulatus, C.cymbelliformis, Navicula flannatica, R.amphiceros*

High concentration, well preserved, marine and estuarine taxa.

COFFER DAM 053

CONTEXT 2203, SAMPLE 1192

C.belgica++, *P.sulcata*++, *T.decipiens, C.cymbelliformis, A.undulatus, N.cincta, Nitzschia punctata, R.minutissima, Navicula* (lyrate species), *Nitzschia* sp., *N.peregrina, Rhopalodia gibberula*

High concentration, well preserved, marine and estuarine taxa.

Diatom counting

Although the qualitative diatom assessment was useful in indicating the potential value of diatom analysis in the study of the sediments, without species counts it is difficult to compare the relative changes and trends within diatom composition within and between sections. Therefore diatom counts were made on selected samples.

A total of 46 samples were counted and 158 diatom taxa were identified from 5 locations. These were: a section of the 'core' 1029/30, which was also analysed for pollen, plant macrofossils etc. (Walker *et.al*.in prep.); the battered face and vertical section exposed in Trench 050; the Point Bar Formation; samples from Coffer Dam 051; samples from Coffer Dam 053.

Trench 050 (Figure 1, Appendix Figure 1)

For the assessment, a total of 7 diatom slides was examined from the battered face and vertical sections of Trench 050. Samples from the upper part of the battered face (1080, 1090) and the basal sample of the vertical column (1139) had poorly preserved diatom assemblages, for which it is not possible to carry out percentage counting. Further slides for diatom analysis were prepared from samples from the battered trench face (1094, 1098, 1102, 1106). Samples 1094 and 1098 were found to contain no diatoms or very low concentrations of valves, however, percentage counts were made from the samples from lower down the face (1102, 1106).

A total of 25 samples was counted from Trench 050. Slides were additionally prepared from samples 1080, 1090 and 1094 in the upper part of the sequence (battered trench face) and sample 1139 the basal sample from the vertical column through the basal channel fills.

Diatom analysis confirms the results of the assessment in that assemblages between +2.28 m and +3.58 m OD are dominated by polyhalobous taxa, which have abundances from c.60-80% in this section of the core. The dominant taxa are planktonic or tychoplanktonic species (Round 1981), such as *Paralia sulcata*, *Cymatosira belgica* and *Rhaphoneis minutissima*. The diatom assemblages associated with tidal mudflats & creeks in the Severn Estuary (Underwood 1994). The repeatability of diatom analysis is illustrated by the similar abundances of halobian groups (Figure 1) and component taxa (Appendix Figure 1) where 2 samples have been analysed for the same level (BF1110 & BF1117, 0.4 m in section and +3.18 m OD) However, in the basal part of the core 1.45 to 1.35 m (+2.13 to +2.23 m OD), although a significant proportion of the polyhalobous species remain, the diatom assemblages are dominated by mesohalobous and halophilous taxa. These brackish water taxa are entirely of benthic origin and included diatoms such as *Navicula cincta*, *Navicula cincta/digitoradiata*, *Stauroneis* cf. *amphoxys*, *Diploneis interupta*, *Navicula peregrina* and *Caloneis westii*. It is reasonable to interpret these diatom assemblages as representing a predominantly brackish water regime with a tidal input of planktonic estuarine (polyhalobous) taxa. Despite re-preparation of the slide made from the basal sample (1139) from the vertical section, diatom counting was not possible. Diatom valves were found only in very low concentrations in this sample. Those valves present were poorly preserved, but appear to be a mixed assemblage of freshwater to marine taxa.

Point Bar Formation (Figure 2, Appendix Figure 2)

At the assessment stage a single sample (1155) was evaluated from the Point Bar formation on the east side of the palaeochannel. Although diatom valves were in low concentrations, diatom counting was considered to be possible and an assemblage dominated by marine taxa with some brackish water diatoms was reported from scanning of the slide. Diatom counting shows that polyhalobous taxa are dominant in four samples (1144, 1147, 1146, 1154), comprising c.75-90% of the diatom assemblages. The polyhalobous taxa are tychoplanktonic diatoms and include *Paralia sulcata*, *Cymatosira belgica* and *Rhaphoneis* spp., including *Rhaphoneis minutissima*. Three samples (1155, 1156, 1145) also had relatively high percentages of polyhalobous taxa (c.25-60%) but with larger numbers of brackish water taxa, mainly from benthic habitats. NB. The uppermost samples (1155/1156) were sampled at the same height (+3.02 m OD, corresponding with 0.00 m in the section), however, in order that their compositions can be distinguished 1156 has been drawn at 0.05 m on the diagram. The brackish water species include *Navicula peregrina*, *Navicula cincta* and *Nitzschia navicularis*. These are non-planktonic species and their increased abundances in these samples suggest that the environment of deposition was a brackish one. The marine tychoplanktonic diatom component in the same samples is more likely to be allochthonous, being easily transported by tidal currents.

Coffer Dam 053 (Figure 3, Appendix Figure 3)

Sample 1192 was assessed from Coffer Dam 053 and was found to contain a high concentration of well preserved, marine and estuarine diatom taxa. Four samples were counted from Coffer Dam 053 (1191, 1192, 1222, 1241). Diatom assemblages were composed of c.60-85% polyhalobous taxa, with a significant trend towards higher percentages of mesohalobous and halophilous taxa in the two uppermost samples (these halobian groups have a combined maximum of c.25% in the top sample). The polyhalobous component of the assemblages consists of estuarine, tychoplanktonic taxa such as *Paralia sulcata*, *Cymatosira belgica* and *Rhaphoneis minutissima*. The brackish water diatoms in the uppermost samples include *Navicula cincta* and *Navicula cincta/digitoradiata*. Again this suggests that the local environment was becoming a predominantly brackish one with the periodic introduction of planktonic marine taxa possibly from spring tides. Such an environment would be found in parts of a salt marsh.

The section of increasing brackish water diatom content matches well with the elevation (207 cm depth, +0.47 m OD) of the marine regression recorded in the 'core'[1030/1029] and radiocarbon dated to 5920+/-60 BP. However, this cross-correlation is tentative and is based only on the sample elevations and the consistent environmental reconstructions.

Coffer Dam 051 (Table 1)

Sample 1209 was assessed from Coffer Dam 051 and was found to contain a high concentration of well preserved estuarine and marine taxa, therefore diatom counting was carried out on this single sample (Table 1). The diatom assemblage is dominated by mesohalobous taxa (39%) which includes such species as those of the *Navicula phyllepta* group and *Nitzschia apiculata*. There is a significant component of polyhalobous taxa (22%) for example *Cymatosira belgica* and *Paralia sulcata* and polyhalobous to mesohalobous taxa (11%) which indicates the influence of tides on the site of deposition. Alternatively sediment mixing has resulted in a mixed diatom assemblage of disparate diatom salinity types. The elevation and dominantly brackish water assemblage of this sample is consistent with the onset of the marine transgressive phase seen at the base of the 1030 diatom section.

Monolith 1029/1030 (Figure 4, Appendix Figure 4)

The monolith analysed for diatoms was taken parallel to that analysed by Walker *et.al.* (in prep.) and represents the top 40 cm of that section. From the archaeological section drawing, the level of the core top is +2.54 m OD. The basal section of the core 20-40 cm is dominated by mesohalobous and polyhalobous to mesohalobous diatoms with a significant, decreasing, component of freshwater diatoms, notably tolerant (oligohalobous indifferent) species such as *Fragilaria pinnata* and *Fragilaria construens* var. *venter*. There are also significant numbers of planktonic, polyhalobous taxa. The dominance of brackish water benthic diatoms such as *Navicula phyllepta, Navicula cincta, Nitzschia hungarica, Diploneis aesturii* and *Navicula forcipata* suggests that the locality was predominantly of brackish water with a small input of marine tychoplankton (*Cymatosira belgica, Paralia sulcata, Rhaphoneis minutissima*) perhaps on spring tides or alternatively from sediment mixing processes. However, in the upper part of the core the brackish water component declines and these polyhalobous taxa become dominant. This shift from brackish to marine conditions accords with the marine transgression (contact dated to 2900+/-60BP described by Walker *et.al*. from the same sequence.

Discussion

Diatom assemblages across the contexts analysed show consistent patterns. It therefore appears useful to present a composite diatom diagram showing the proportions of each of the diatom halobian groups in all samples, with altitudes standardised against the Newlyn datum. Clearly this approach is open to pitfalls, if for example a barrier forms between the site of deposition of the diatom assemblage and the estuary (see for example Palmer & Abbott 1986). However, the close proximity of the sampling locations and consistency of the results seems to justify the attempt in this case (Figure 5)

The samples of lowest altitude are from the section of the Coffer Dam 053, ranging from -1.42 m OD to +0.52 m OD. The diatom assemblages represent predominantly polyhalobous taxa, but with a significant trend towards higher percentages of brackish water taxa in the top two samples. Tentatively, the section of increasing brackish water diatom content matches well with the elevation (207 cm depth, +0.47 m OD) of the marine regression recorded in the section 1030/1029 and radiocarbon dated, at 3.11 m to 5920+/-60 BP (Walker *et.al.* in prep)

Diatom assemblages were absent between elevations of +0.52 m OD and +2.09 m OD. Sediments from between these heights seem to represent a marine transgressive phase with peat formation (Walker *et.al.*in prep). Predominantly brackish water diatom assemblages reappear at +2.09 m OD, with a significant freshwater (oligohalobous indifferent) component in some samples indicating a return to brackish/freshwater conditions. The onset of this phase, coincident with the marine transgression recorded in 1030/1029 has been dated to 2900 +/- 60BP. A small, but significant polyhalobous diatom component indicates the periodic influence of tides, or alternatively the effects of sediment mixing processes (bioturbation, physical mixing) introducing marine diatom taxa from overlying sediment. In the levels at +2.28m OD and above the polyhalobous diatom component becomes dominant, oligohalobous indifferent taxa decline to low percentages and brackish water (mesohalobous) taxa generally decrease to values of approximately 10% or lower. Exceptionally maxima in the percentages of freshwater and brackish water diatom species are found at 3.02 m OD in a Sample 1156 from the Point Bar formation. Sample 1155 from the same elevation and the same feature has increased abundances of brackish water taxa compared with other samples from high elevations, but relatively low percentages of freshwater species compared with sample 1156. Both these samples from the Point Bar feature appear to indicate an environment with relatively low salinity compared with other samples from similar elevations in other features. The location of the Point Bar formation makes the transport of alluvium and diatoms from freshwater and brackish water environments upstream a more probable explanation of these species occurrences.

The taphonomic complexity of estuarine diatom assemblages with particular reference to the Severn has been discussed elsewhere (Cameron 1993, 1994). It seems probable that the hypertidal nature of the Estuary and resulting transport of marine or estuarine taxa into periodically inundated freshwater or brackish habitats results in a particularly large marine allochthonous (Vos & De Wolf 1988, 1993, Sherrod *et.al.*1989) component in assemblages deposited under essentially brackish to freshwater conditions. This factor has been taken into account in the interpretation of the Barlands Farm diatom assemblages. However, as has been suggested elsewhere (Cameron 1995), that the use of multivariate analysis in a study of contemporary diatom surface sediment assemblages in relation to environmental gradients,(for example such features as salinity, site elevation, substrate, and habitat) may be a means of improving the information available from diatom-based environmental reconstructions in the Severn and other coastal environments. Studies of contemporary diatom communities (eg. Oppenheim 1991, Underwood 1994) are useful in this area, however, the development of a transfer function (Juggins 1992) or an analogue matching technique to compare fossil assemblages from archaeological contexts directly with diatom death assemblages are promising approaches. It is hoped that such techniques will be piloted in the near future using fossil and modern diatom material from the Severn Estuary.

Conclusions

1. A diatom assessment of samples from Trench 050 and Coffer Dams 051 and 053 indicated the potential value of diatom analysis in environmental reconstruction.

2. Diatom analysis of material from the vertical section and battered face of Trench 050 indicates a marine regressive phase.

3. A single sample (1209) from Coffer Dam 051 has a mixed diatom assemblage with abundant brackish and marine taxa. However, the dominance of mesohalobous, benthic taxa is consistent with local brackish water conditions.

4. Samples from Coffer Dam 053 are dominated by estuarine, polyhalobous taxa. However, an increasing component of brackish water species towards the top of the section is consistent with a marine transgressive phase.

5. The diatom assemblages in Monolith 1029/1030 indicate an initial brackish-freshwater environment followed by a marine phase, consistent with a marine transgression.

6. A composite diatom diagram (Figure 5) shows some coherence between locations in the types of diatom assemblage present at similar elevations. However, this correlation is tentative and requires confirmation with archaeological and other stratigraphic analyses.

Acknowledgements

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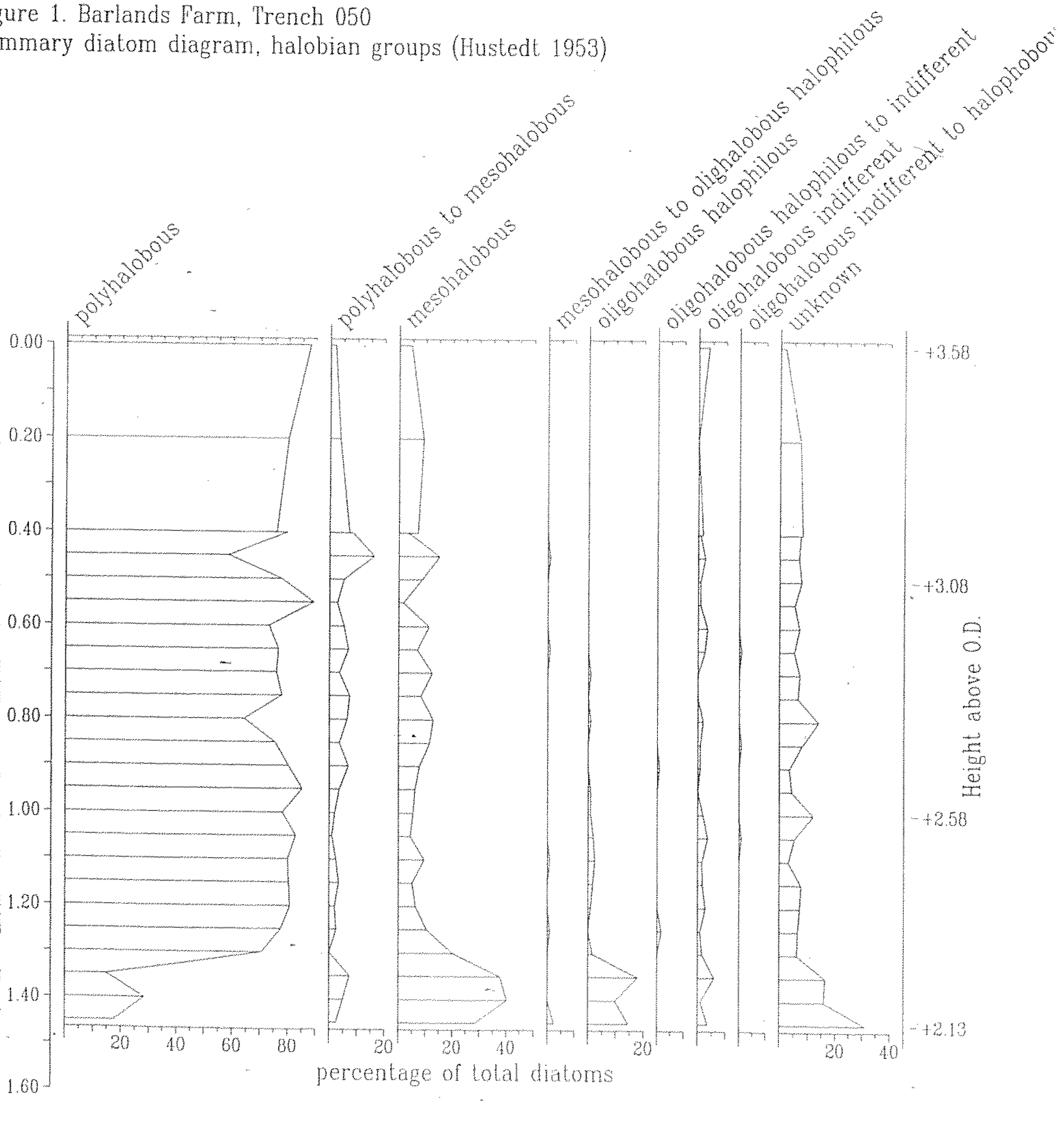
Appendix Table 1

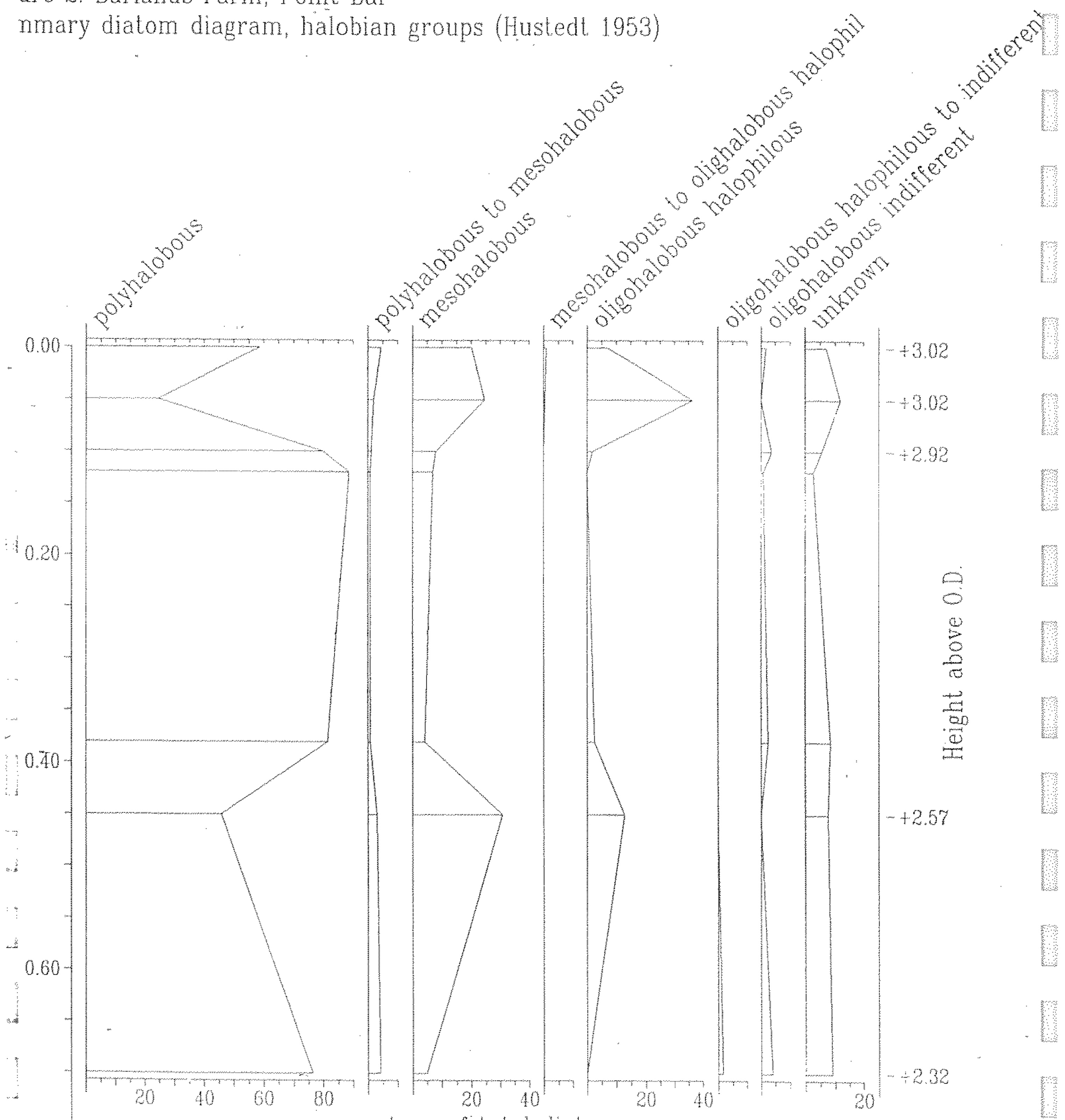
Barlands Farm, Coffer Dam 051, diatom taxa & percentages

	Sample 1209
Amphora sp.	1.5
Aulacoseira sp.	0.4
Cymbellonitzschia diluviana Hust.	0.4
Diploneis sp.	0.4
Gyrosigma sp.	0.4
Navicula sp.	4.2
Nitzschia sp.	3.0
Pinnularia sp.	0.4
Pleurosigma sp.	0.4
Stauroneis producta Grun.	0.4
Unknown naviculaceae	2.6
Actinoptychus undulatus (J.W.	0.4
Campylosira cymbelliformis (A.	0.8
Cymatosira belgica Grun.	7.9
Navicula palpebralis var.palpebralis	0.8
Paralia sulcata f.sulcata	6.0
Rhaphoneis minutissima Hust.	6.0
Rhaphoneis surirella (Ehrenb.)	0.4
Navicula flanatica var.flanatica	3.0
Temporary sp. 1	0.4
Temporary sp. 18	0.4
Temporary sp. 6	5.3
Thalassiosira sp.	1.9
Achnanthes amoena Hustedt	1.5
Achnanthes hauckiana Grun.	1.5
Amphora coffeaeformis var.coffeaeformis	0.4
Bacillaria paradoxa Gmelin	0.4
Cyclotella striata var.striata	0.4
Diploneis aestuari Hust.	0.8
Diploneis didyma (Ehrenb.)	0.4
Diploneis interrupta var.interrupta	0.4
Navicula crucicula var.crucicula	0.8
Navicula gregaria Donk.	1.9
Navicula peregrina var.peregrina	0.8
Nitzschia apiculata (Greg.)	6.4
Nitzschia granulata Grun.	0.8
Nitzschia hungarica Grun.	0.4
Nitzschia navicularis (Breb.	1.1
Nitzschia punctata var.punctata	2.3
Nitzschia sigma var.sigma	0.8
Temporary sp. 13	1.5
Temporary sp. 19	14.0
Temporary sp. 2	0.4
Temporary sp. 20	1.9
Nitzschia tryblionella var.tryblionella	2.6
Navicula cincta (Ehrenb.)	3.0
Surirella ovata var.ovata	0.4
Cocconeis placentula var.euglypta	1.5
Fragilaria construens var.venter	1.9
Fragilaria pinnata var.pinnata	3.8
Navicula cryptocephala var.cryptocephala	0.8
Opephora martyi Herib.	0.4

gure 1. Barlands Farm, Trench 050
ummary diatom diagram, halobian groups (Hustedt 1953)



ure 2. Barlands Farm, Point Bar
nmary diatom diagram, halobian groups (Hustedt 1953)



ɡure 3. Barlands Farms Coffer Dam 053
ummary diatom diagram, halobian groups (Hustedt 1953)

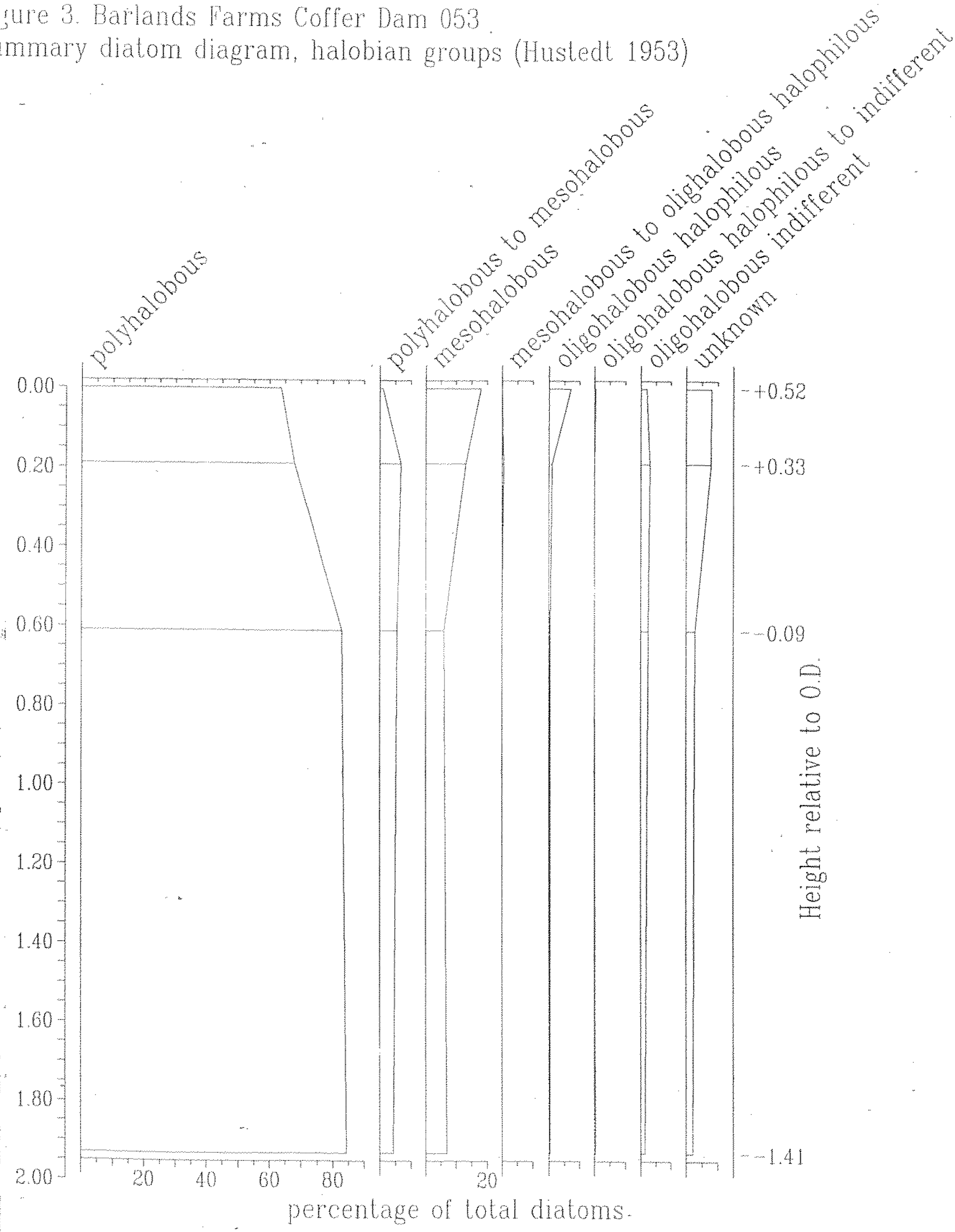
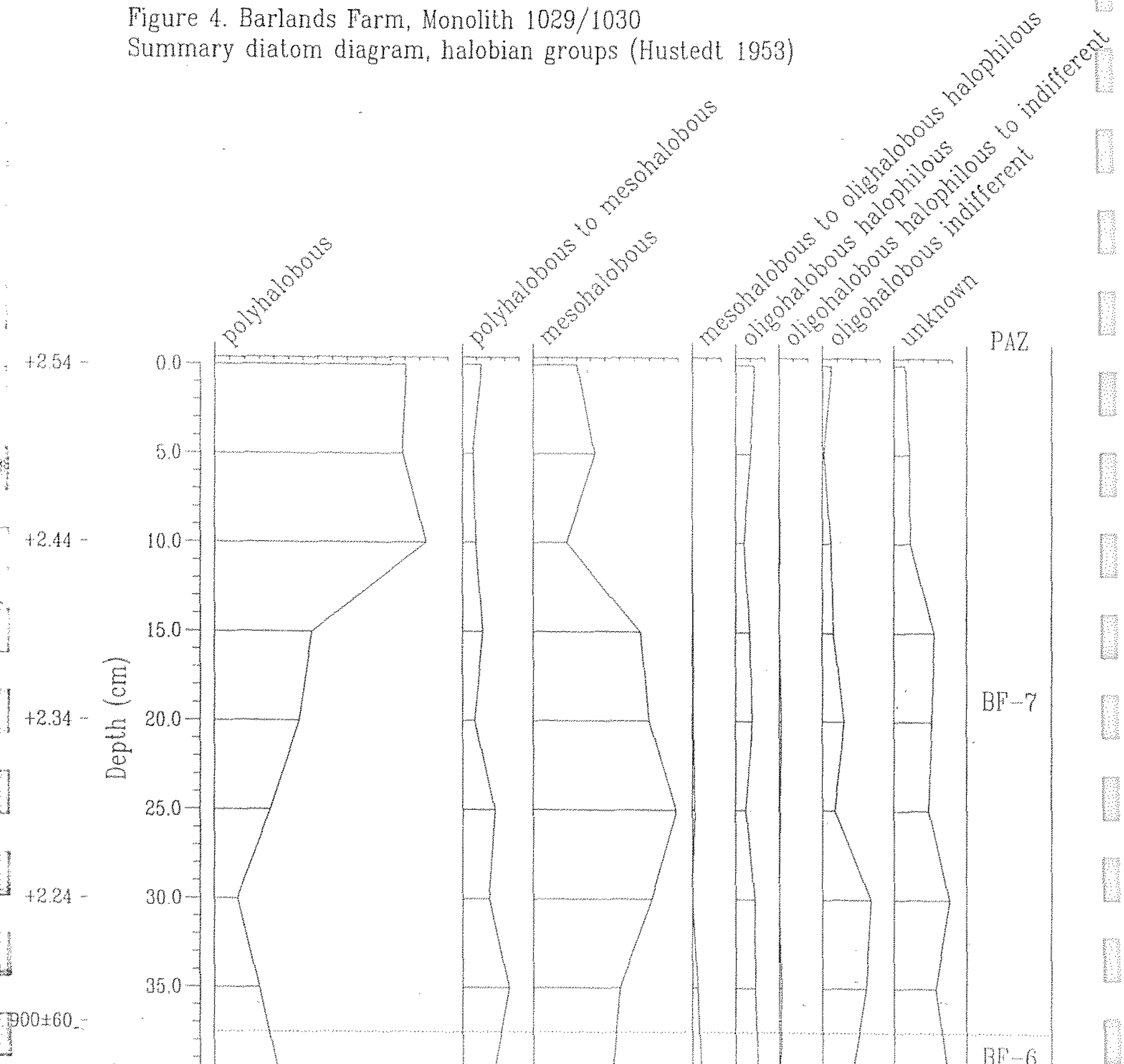
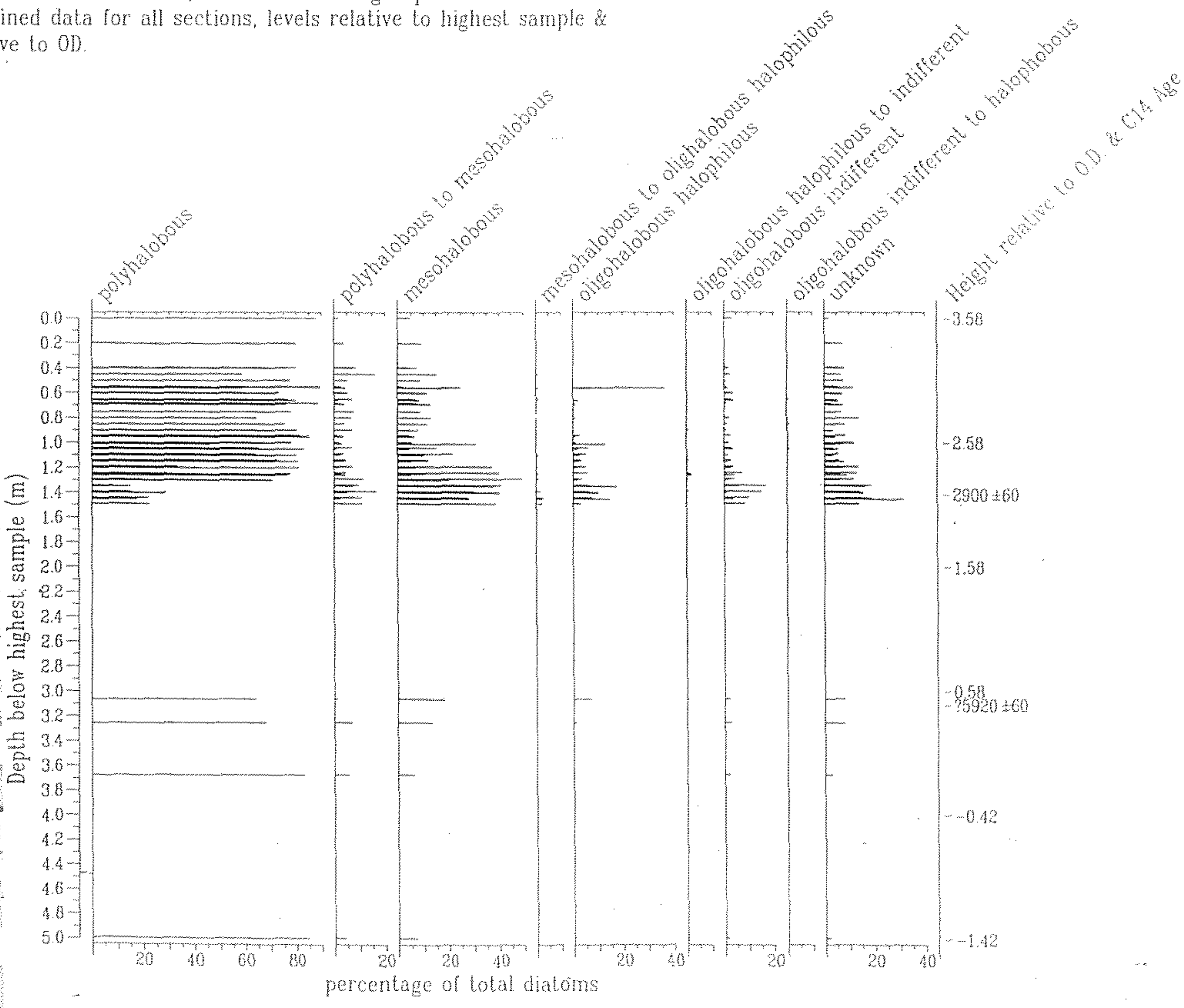


Figure 4. Barlands Farm, Monolith 1029/1030
Summary diatom diagram, halobian groups (Hustedt 1953)



'e 5. Barlands Farm, diatom halobian groups.
)ined data for all sections, levels relative to highest sample &
tive to OD.

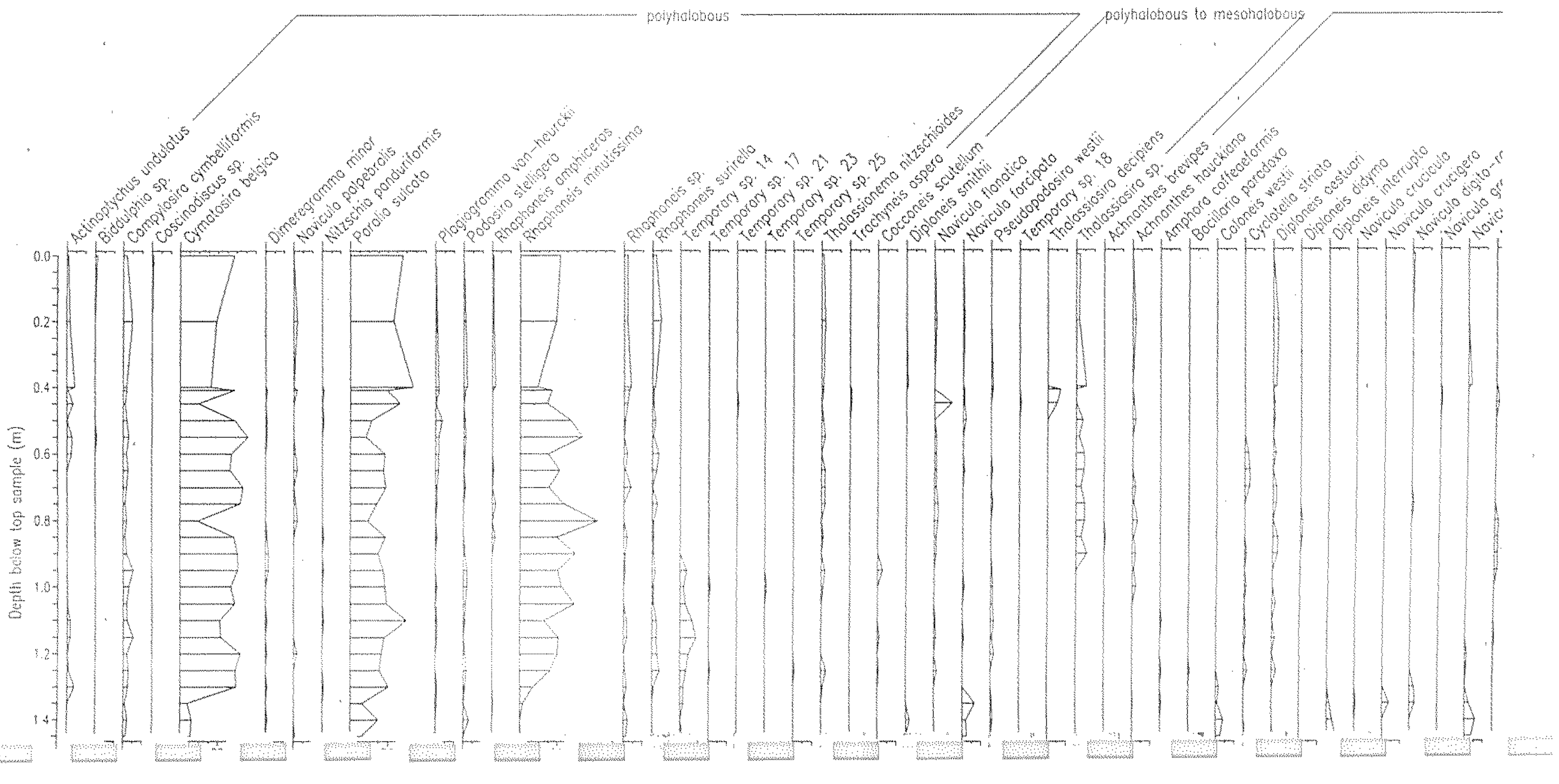


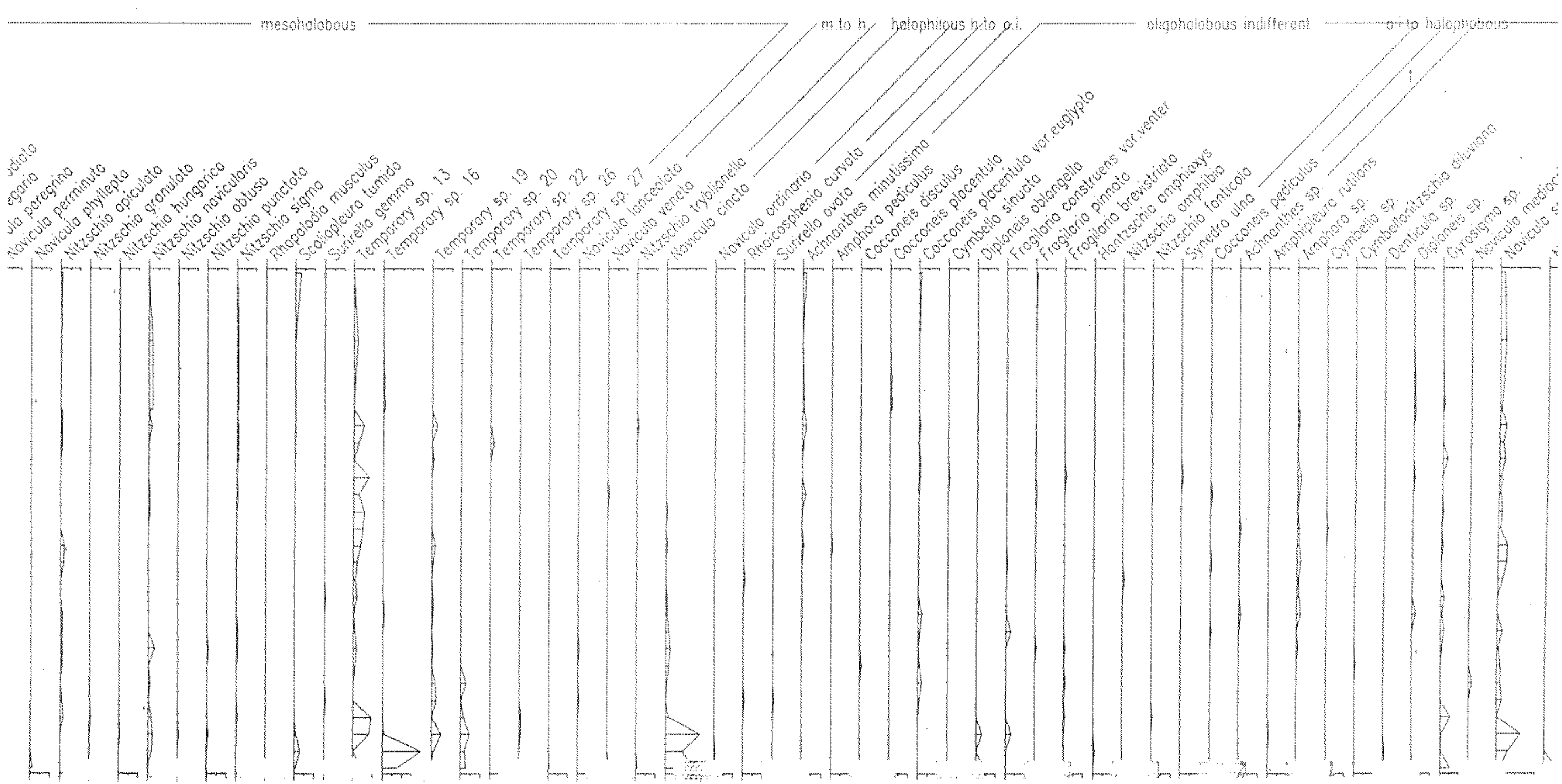
le 1. Barlands Farm, Coffer Dam 051, Sample 1209, Context 2100/2101

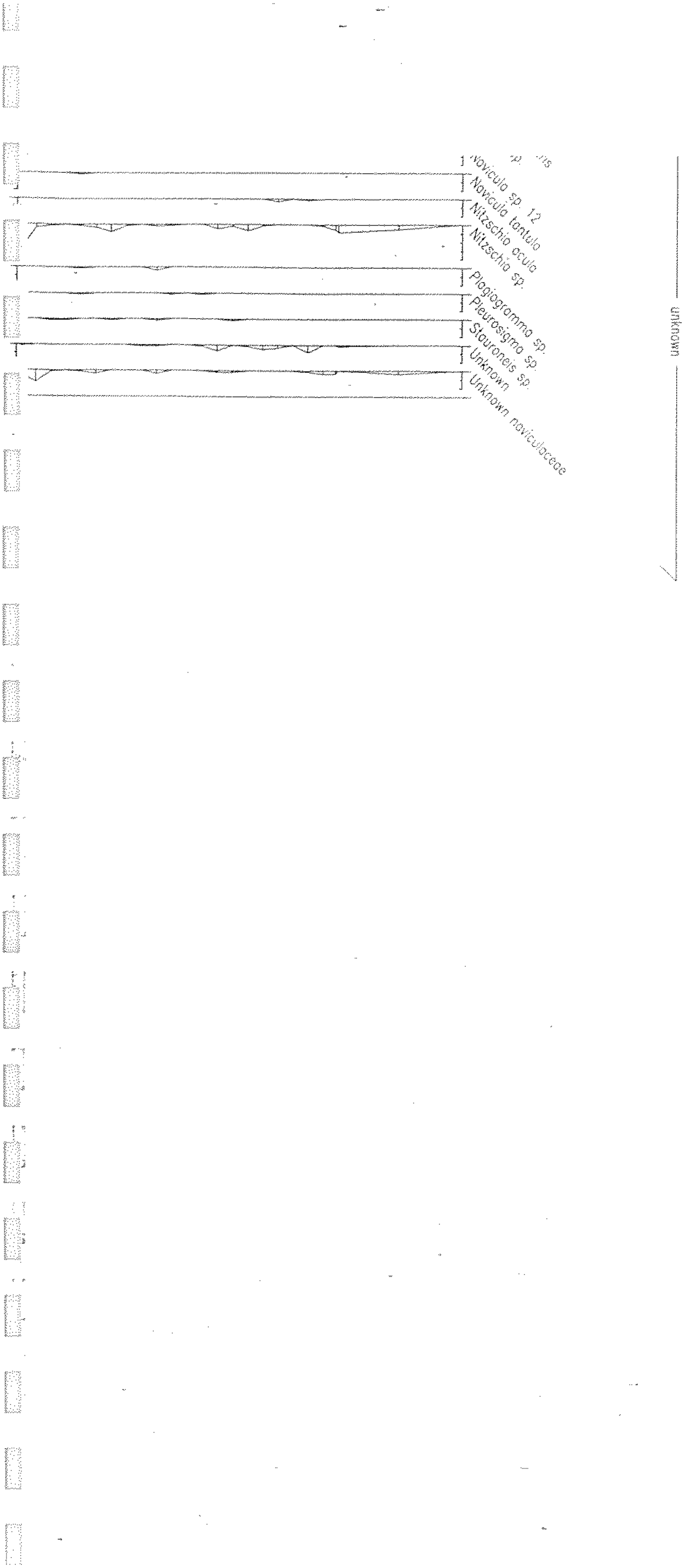
rcentage of total diatoms at: +2.09 m OD

obian group	
lyhalobous	22.3
yhalobous to mesohalobous	10.9
ohalobous	38.5
sohalobous to olighalobous halophilous	2.6
gohalobous halophilous	3.0
gohalobous halophilous to indifferent	0.4
igohalobous indifferent	8.3
nown	14.0

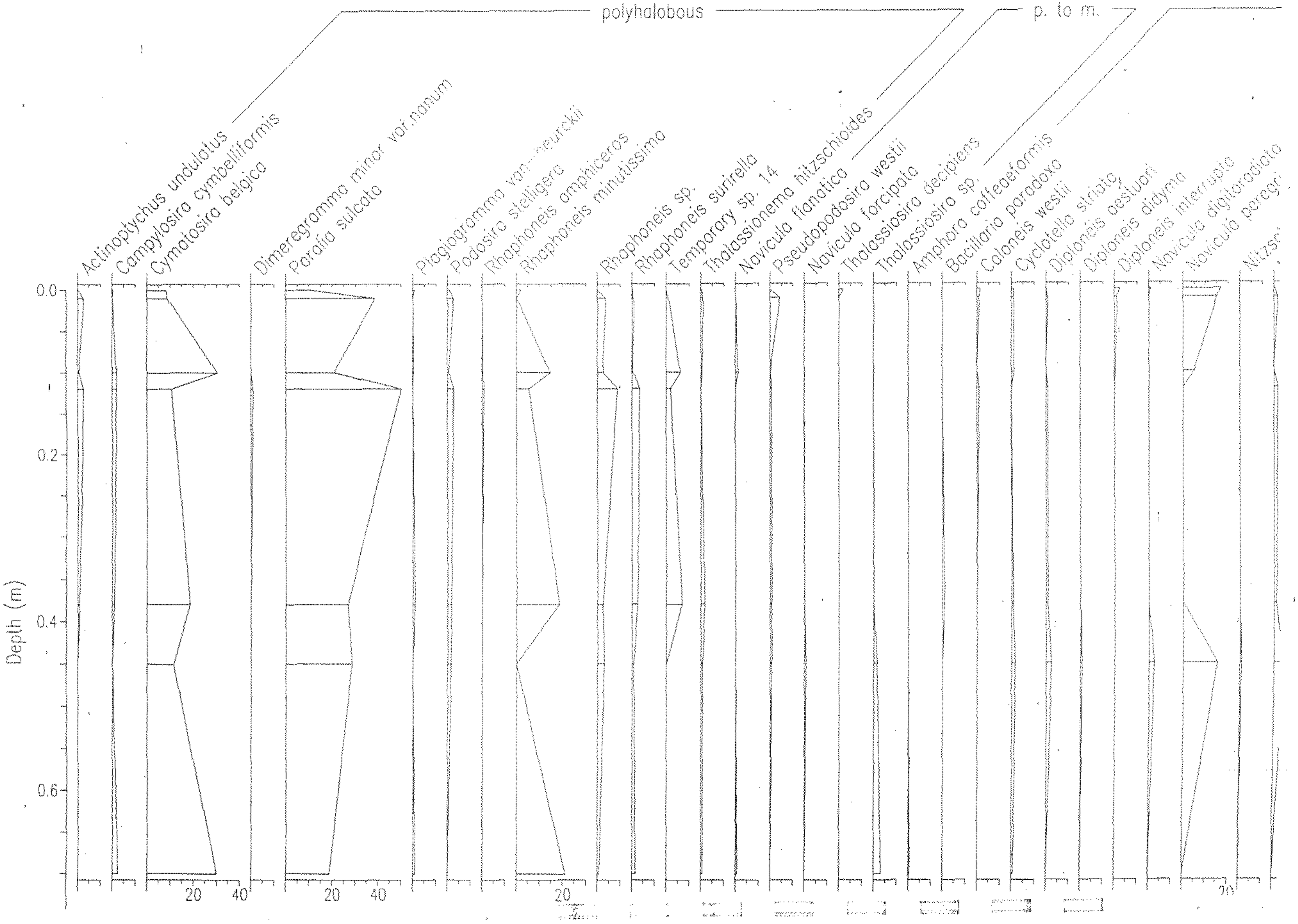
Appendix Figure 1. Barlands Farm, Trench 050, all diatom taxa with halobian groups

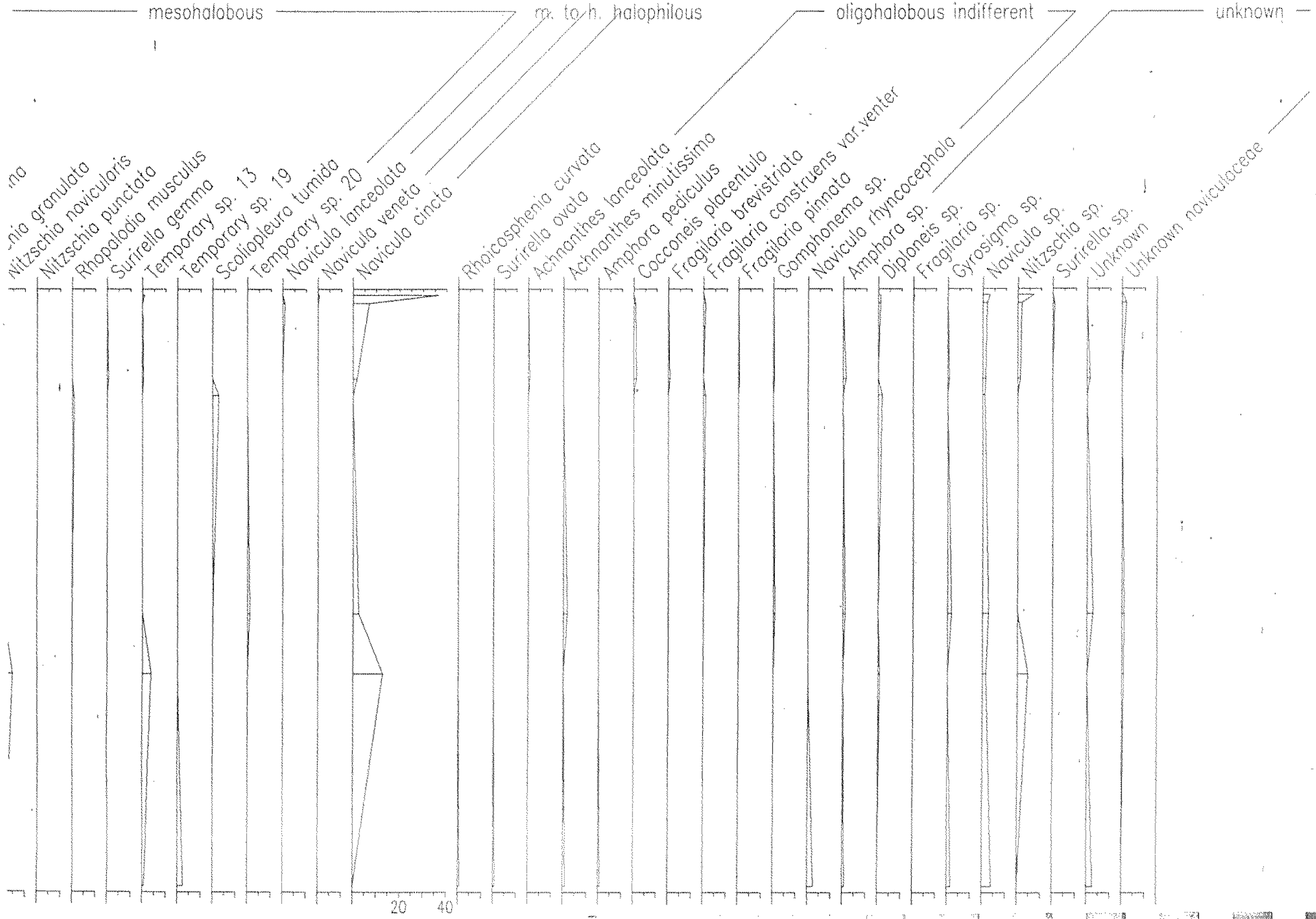



mesohalobous
m.to h.
halophilous h.to o.i.
oligohalobous indifferent
o-i to halophobous
Navicula perminuta
Navicula phyllepta
Nitzschia apiculata
Nitzschia granulata
Nitzschia hungarica
Nitzschia navicularis
Nitzschia obtusa
Nitzschia punctata
Nitzschia sigma
Rhopalodia musculus
Scoliopleura tumida
Surirella gemma
Temporary sp. 13
Temporary sp. 16
Temporary sp. 19
Temporary sp. 20
Temporary sp. 22
Temporary sp. 26
Temporary sp. 27
Navicula lanceolata
Navicula veneta
Nitzschia tryblionella
Navicula cincta
Navicula ordinaria
Rhoicosphenia curvata
Surirella ovata
Achnanthes minutissima
Amphora pediculus
Cocconeis disculus
Cocconeis placentula
Cocconeis placentula var. euglypta
Cymbella sinuata
Diploneis oblongella
Fragilaria construens var. venter
Fragilaria pinnata
Fragilaria brevistriata
Hantzschia amphioxys
Nitzschia amphibia
Nitzschia fonticola
Synedra ulna
Cocconeis pediculus
Achnanthes sp.
Amphipleura rutilans
Amphora sp.
Cymbella sp.
Cymbellonitzschia diluviana
Denticula sp.
Diploneis sp.
Gyrosigma sp.

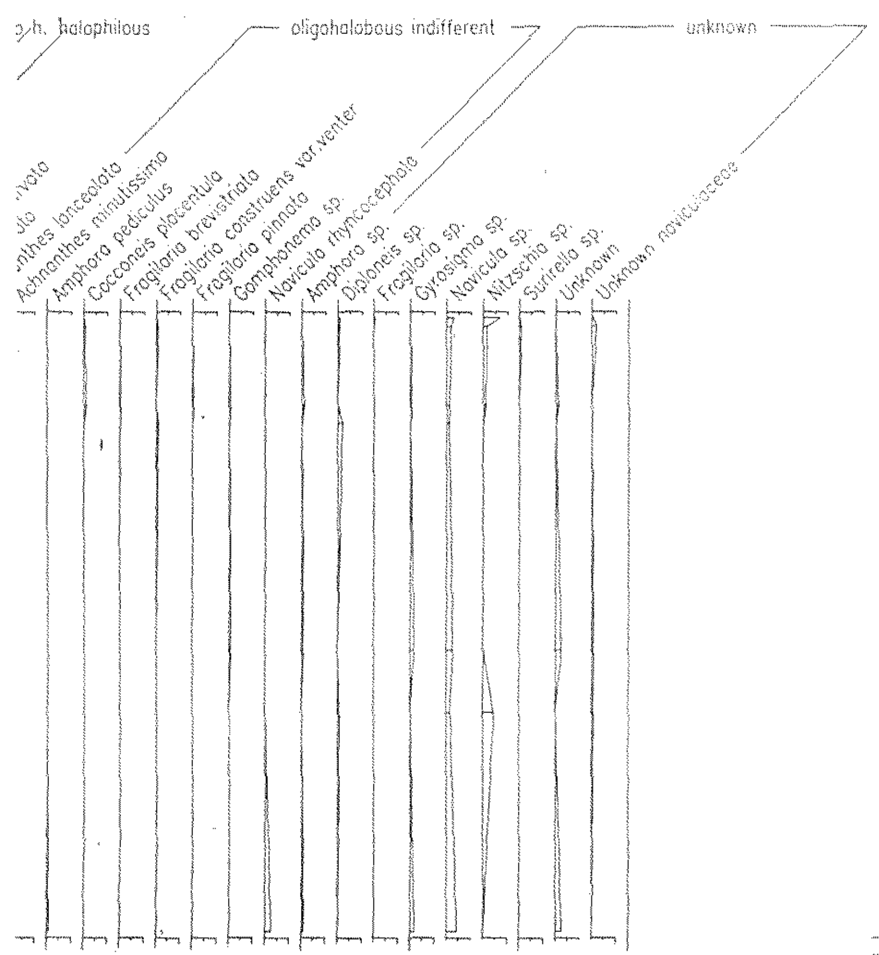

Navicula sp. 12
Navicula tantula
Nitzschia acula
Nitzschia sp.
Plagiogramma sp.
Pleurosigma sp.
Stauroneis sp.
Unknown
Unknown naviculaceae
unknown

Appendix Figure 2, Barlands Farm, Point Bar Formation, all diatom taxa with halobian groups



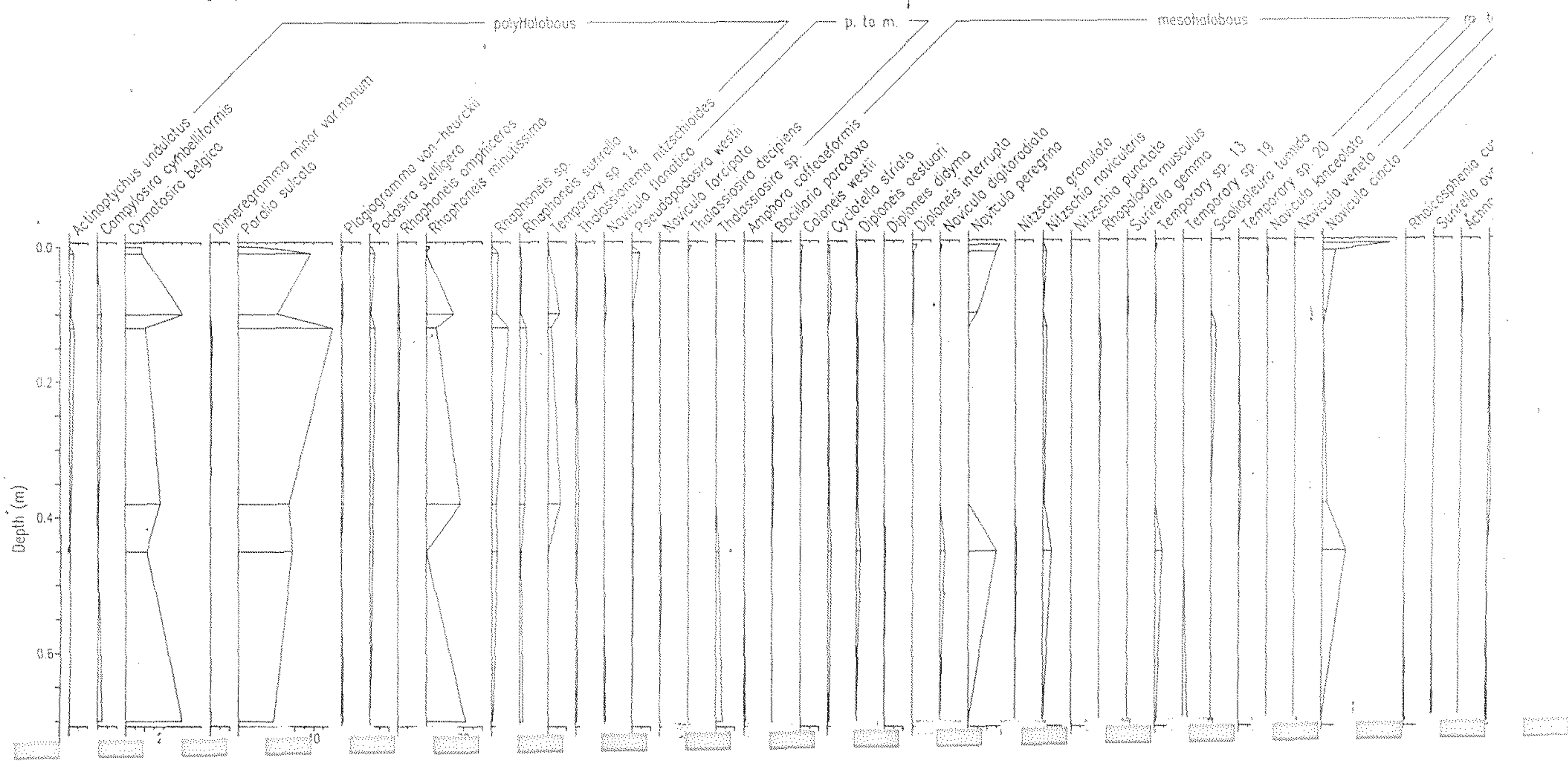


mesohalobous
m. to h. halophilous
oligohalobous indifferent
unknown
Nitzschia granulata
Nitzschia navicularis
Nitzschia punctata
Rhopalodia musculus
Surirella gemma
Temporary sp. 13
Temporary sp. 19
Scoliopleura tumida
Temporary sp. 20
Navicula lanceolata
Navicula veneta
Navicula cincta
Rhoicosphenia curvata
Surirella ovata
Achnanthes lanceolata
Achnanthes minutissima
Amphora pediculus
Cocconeis placentula
Fragilaria brevistriata
Fragilaria construens var.venter
Fragilaria pinnata
Gomphonema sp.
Navicula rhyncocephala
Amphora sp.
Diploneis sp.
Fragilaria sp.
Gyrosigma sp.
Navicula sp.
Nitzschia sp.
Surirella sp.
Unknown
Unknown naviculaceae
20
40

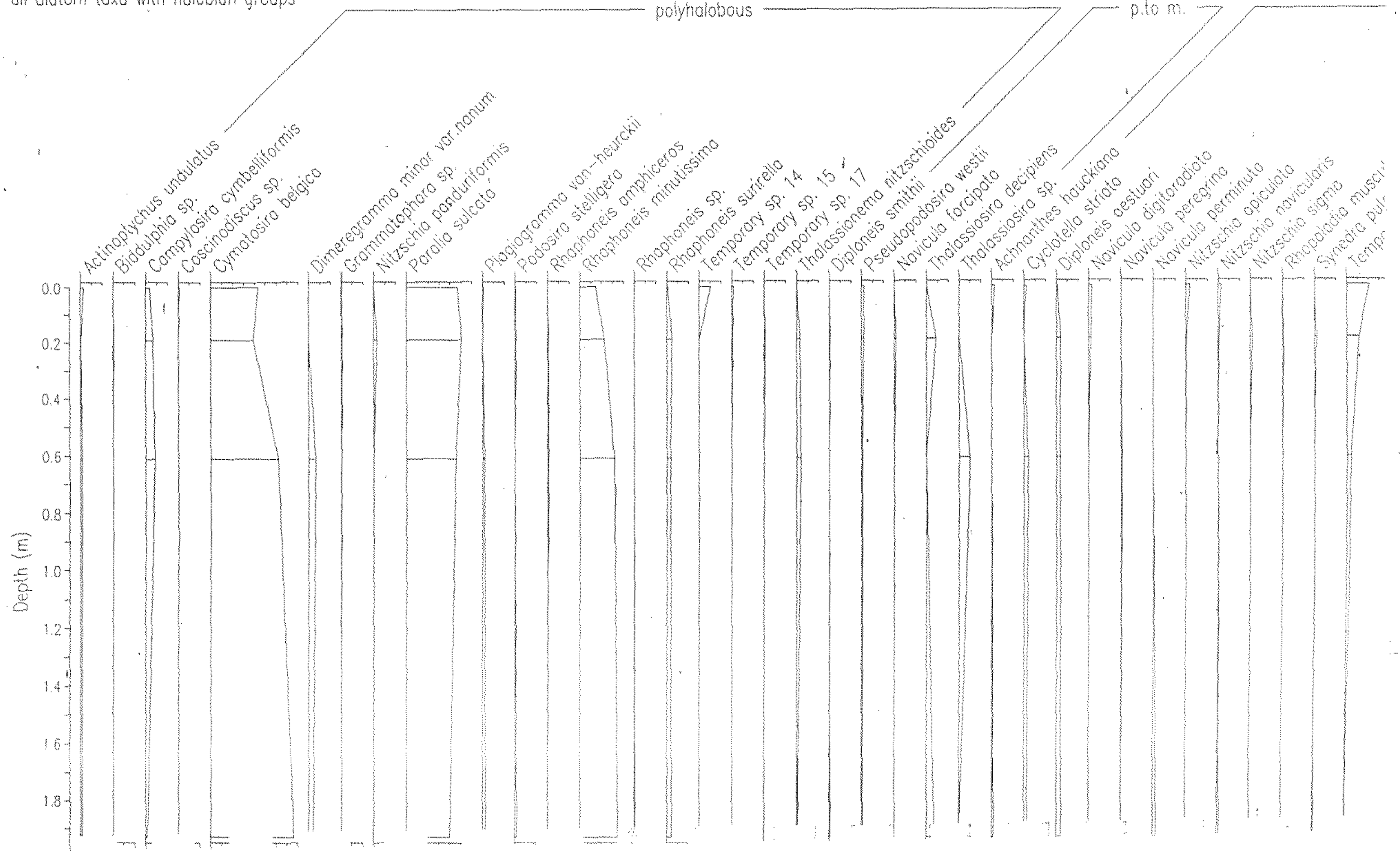


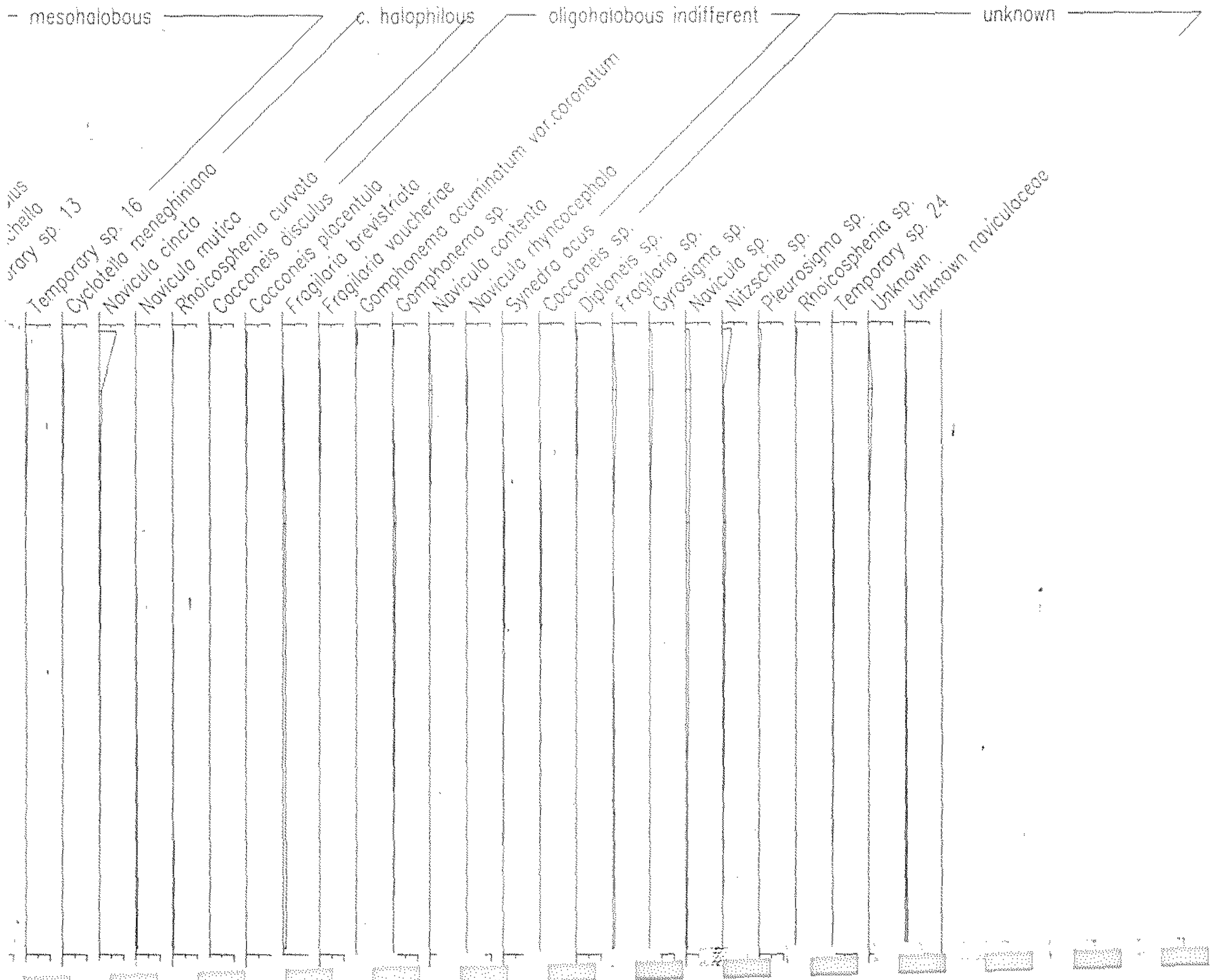
halophilous
oligohalobous indifferent
unknown
Achnanthes lanceolata
Achnanthes minutissima
Amphora pediculus
Cocconeis placentula
Fragilaria brevistriata
Fragilaria construens var. venter
Fragilaria pinnata
Gomphonema sp.
Navicula rhyncocephala
Amphora sp.
Diploneis sp.
Fragilaria sp.
Gyrosigma sp.
Navicula sp.
Nitzschia sp.
Surirella sp.
Unknown
Unknown naviculaceae

Appendix Figure 2, Barlands Form, Point Bar Formation, all diatom taxa with halobian groups



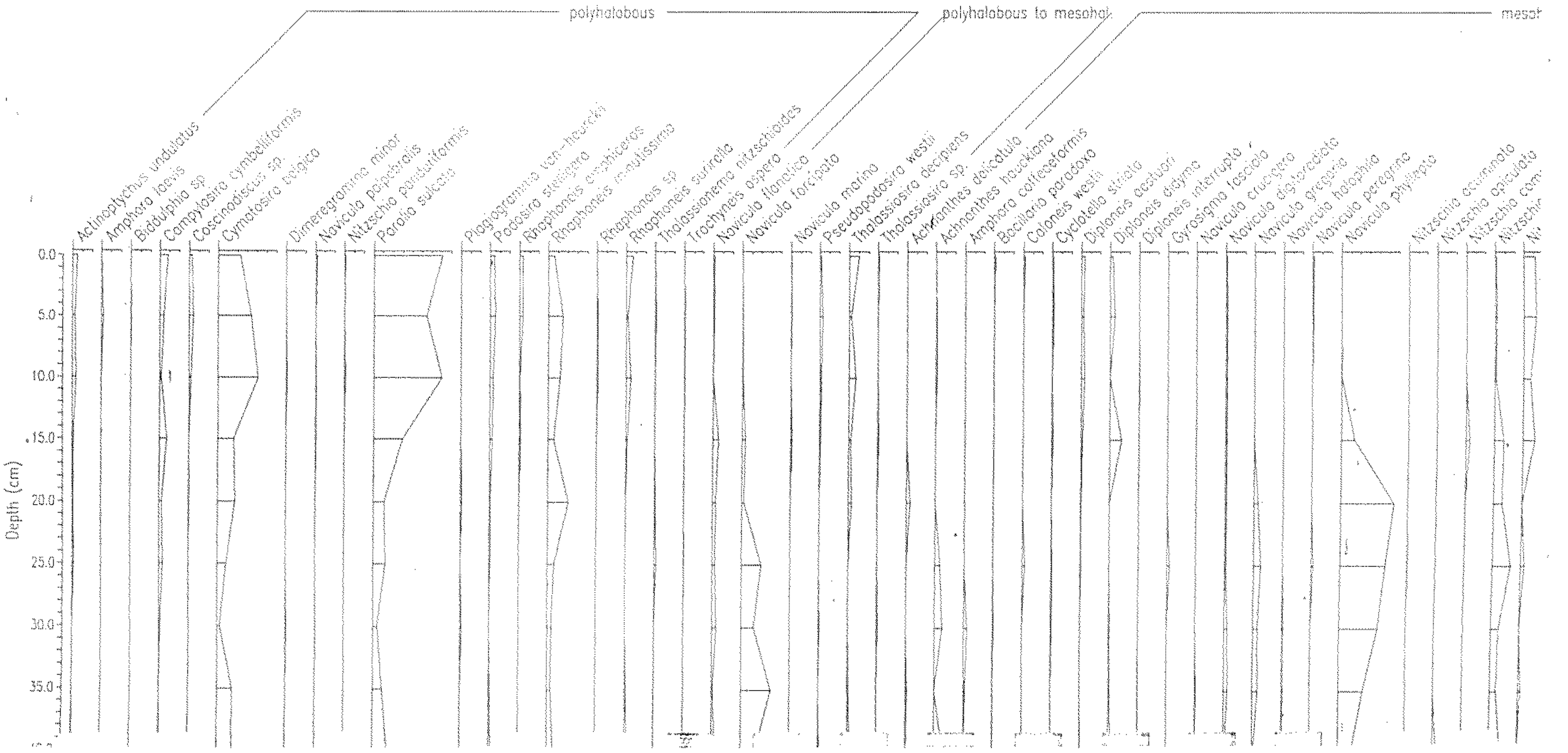
Appendix Figure 3. Barlands Farm, Coffer Dam 053, all diatom taxa with halobian groups

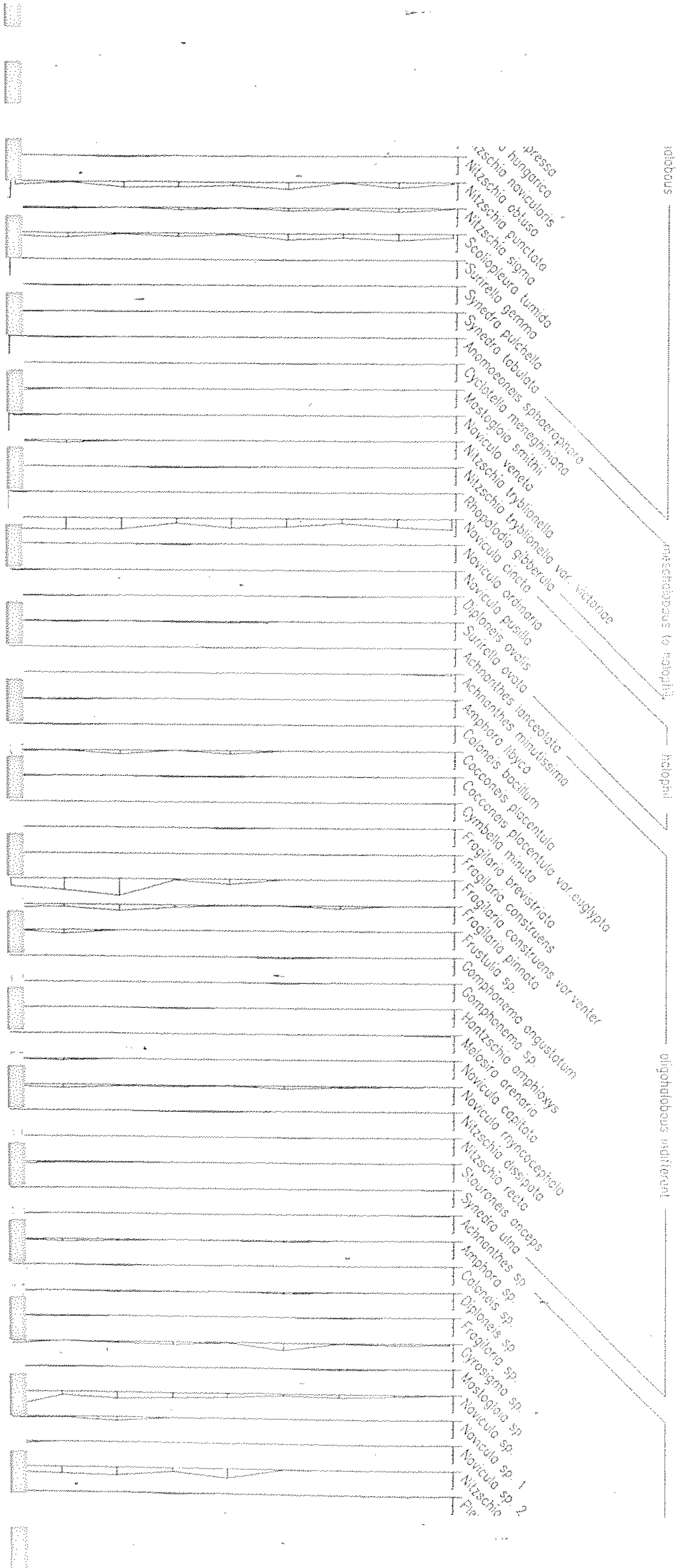




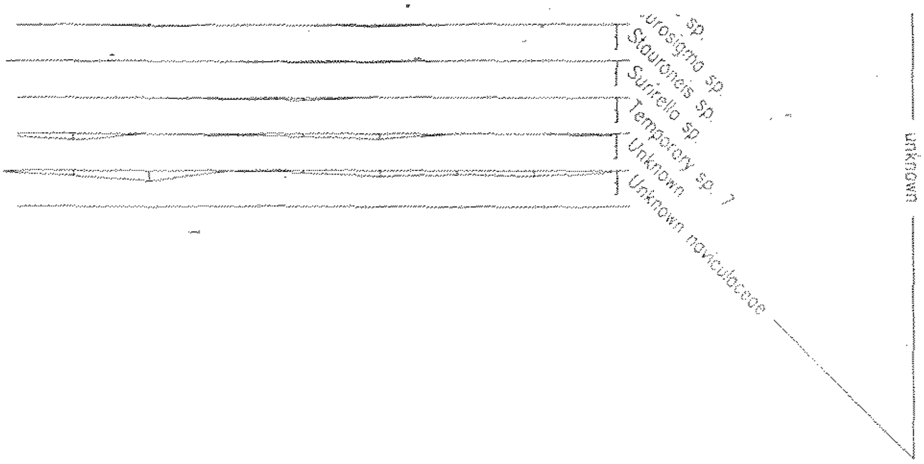
mesohalobous
c. halophilous
oligohalobous indifferent
unknown
Temporary sp. 16
Cyclotella meneghiniana
Navicula cincta
Navicula mutica
Rhoicosphenia curvata
Cocconeis disculus
Cocconeis placentula
Fragilaria brevistriata
Fragilaria vaucheriae
Gomphonema acuminatum var.coronatum
Gomphonema sp.
Navicula contenta
Navicula rhyncocephala
Synedra acus
Cocconeis sp.
Diploneis sp.
Fragilaria sp.
Gyrosigma sp.
Navicula sp.
Nitzschia sp.
Pleurosigma sp.
Rhoicosphenia sp.
Temporary sp. 24
Unknown
Unknown naviculaceae

Appendix Figure 4. Barlands Farm, Area 051,
Monolith 1029/1030
all diatom taxa with halobian groups





Nitzschia navicularis
Nitzschia obtusa
Nitzschia punctata
Nitzschia sigma
Scoliopleura tumida
Surirella gemma
Synedra pulchella
Synedra tabulata
Anomoeoneis sphaerophora
Cyclotella meneghiniana
Mastogloia smithii
Navicula veneta
Nitzschia tryblionella
Nitzschia tryblionella var. victoriae
Rhopalodia gibberula
Navicula cincta
Navicula ordinaria
Navicula pusilla
Diploneis ovalis
Surirella ovata
Achnanthes lanceolata
Achnanthes minutissima
Amphora libyca
Caloneis bacillum
Cocconeis placentula
Cocconeis placentula var. euglypta
Cymbella minuta
Fragilaria brevistriata
Fragilaria construens
Fragilaria construens var. venter
Fragilaria pinnata
Frustulia sp.
Gomphonema angustatum
Gomphonema sp.
Hantzschia amphioxys
Melosira arenaria
Navicula capitata
Navicula rhyncocephala
Nitzschia dissipata
Nitzschia recta
Stauroneis anceps
Synedra ulna
Achnanthes sp.
Amphora sp.
Caloneis sp.
Diploneis sp.
Fragilaria sp.
Gyrosigma sp.
Mastogloia sp.
Navicula sp. 1
Navicula sp. 2


Stauroneis sp.
Surirella sp.
Temporary sp. 7
Unknown
Unknown naviculaceae
Unknown