London Gateway

Iron Age and Roman Salt Making in the Thames Estuary

Excavation at Stanford Wharf Nature Reserve, Essex

Specialist Report 21

Diatoms

by Nigel Cameron

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Introduction

Forty-five sediment sub-samples, taken from three areas of Stanford Wharf Nature Reserve, were prepared and assessed for diatoms (Cameron 2010). The purpose of the diatom evaluation was to assess the potential to use diatom analysis of the Stanford Wharf sequences for environmental reconstruction. The diatom assessment considered the numbers of diatoms, the state of diatom preservation, species diversity and diatom species environmental preferences.

Following a meeting of archaeologists and palaeoenvironmental specialists at Oxford Archaeology in January 2011 it was decided to carry out further analysis and reporting of samples from site. An additional 21 samples (Table 21.2) have therefore been prepared and assessed or analysed for diatoms. Five samples (Table 21.1) that were found to have potential for diatom analysis in the first diatom assessment (Cameron 2010) have also been analysed for diatoms.

Methods

Diatom preparation, counting and analysis followed standard techniques (Battarbee *et al.* 2001). Diatom floras and taxonomic publications were consulted to assist with diatom identification; these include Hendey (1964), Werff and Huls (1957-1974), Hartley *et al.* (1996), Krammer and Lange-Bertalot (1986-1991) and Witkowski *et al.* (2000). Diatom species' salinity preferences are discussed in part using the classification data in Denys (1992), Vos and de Wolf (1988, 1993) and the halobian groups of Hustedt (1953, 1957: 199), these salinity groups are summarised as follows:

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 data were plotted using the 'C2' program (Juggins 2003).

Results and discussion

The samples evaluated previously and identified as having some potential for diatom analysis are shown in Table 21.1. Diatom analysis has therefore been carried out on these five samples. Slides from an additional twenty-one samples were prepared and assessed and, where possible, analysed for diatoms (Table 21.2).

The results of the diatom evaluation for the twenty-one additional samples from Stanford Wharf are summarised in Table 21.3 and the diatom species recorded are shown in Table 21.4, along with their halobian classifications. Figures 21.1 and 21.2 present diatom species and summary halobian group diagrams for those samples from the original selection of samples that were assessed (Cameron 2010) and for the additional new samples for which percentage diatom counting is possible.

A total of five samples from the original diatom assessment that were identified as having potential for diatom analysis, and a further three samples from the new group of samples, have been analysed for diatoms and the results of these percentage analyses are presented in Figures 21.1 and 21.2. The samples are shown on the y-axis of the diatom diagrams by their respective site sample and context numbers and, for the new samples, depth in the relevant sequence or, for the original samples, the UCL diatom sample number.

For the twenty-one additional samples, it was found that diatoms are absent from five samples (Table 21.3) (diatom samples 1, 2, 7, 12, 16). Diatom assemblages suitable for percentage diatom analysis were present in three samples (Table 21.3) (diatom samples 4, 5, 19). However, diatom assemblages that provide some useful palaeoenvironmental information, but as a result of poor preservation, or very low diatom numbers, are unsuitable for percentage analysis, are present in the remaining thirteen samples (Table 21.3) (diatom samples 3, 6, 8, 9, 10, 11 13, 14, 15, 17, 18, 20, 21). The species results for the analysis of these thirteen new samples are presented in Table 21.4. The new diatom analyses that have been carried out for each of the sequences are discussed below.

Area A

Area A Sequence 1

Four sub-samples from Sample 1002 and four from Sample 1004 were selected and reported on in the original assessment from Sequence 1 (Cameron 2010). This was identified as a key sequence of an anthrosol over alluvium. The lower part of the sequence contains a pre-Roman, possibly Bronze Age, palaeosol (Chris Carey pers. comm).

The top diatom sample D1 from context 1132 (Table 21.1) is from the upper alluvial layer, a flood deposit sealing the archaeology in Area A. Exceptionally, among the samples assessed from Sequence 1, this sample (D1) was identified as having moderately good potential for percentage diatom counting, and diatom analysis has therefore been carried out here (Figs. 21.1 and 21.2). The analysis confirms that the diatom assemblage is dominated by coastal marine and estuarine brackish water diatoms, such as the marine planktonic species *Paralia sulcata* (5%), *Rhaphoneis minutissima* (21%), *Rhaphoneis surirella* (5%), *Cymatosira belgica* (16%); the estuarine planktonic species *Cyclotella striata* (12%), with a smaller component of benthic and attached estuarine diatoms such as *Nitzschia navicularis* (5%), *Nitzschia hungarica* (2%), *Achnanthes delicatula* (1%) and *Diploneis didyma* (1%). This diatom assemblage is consistent with the lithological interpretation of the context as an alluvial, outer estuary, flood deposit. Oligohalobous indifferent, freshwater diatoms are restricted to low percentages of non-planktonic species, comprising a total of 11% of the diatom assemblage, the most common being *Fragilaria taxa* (eg *Fragilaria pinnata*, *Fragilaria construens* var. *venter*) that have freshwater salinity optima but are species with broad salinity tolerance. The dominant polyhalobous, marine, diatom component of the D1 diatom assemblage comprises 53% of the total diatoms and the estuarine, mesohalobous group 24%.

As stated above, diatoms are absent from both of the new samples (1, 2) (see Tables 21.2 and 21.3) prepared for diatom analysis from Sequence 1, Early Holocene sequence (Sample 1007) .

Area A Sequence 6

In the initial assessment (Cameron 2010), one sub-sample from 1380 and four sub-samples from 1381 were assessed for diatoms. The sequence comprises three sequential anthrosols, separated by alluvium (Chris Carey pers.comm.). Although diatoms are present in all of the five slides there is little or no potential to make percentage diatom counts for these slides. The diatom composition and interpretation of the samples is described in Cameron (2010).

One new diatom sample (3) (Table 21.2) has been prepared from Sample 1380. In sample 3 there are low numbers of poorly preserved diatoms and there is low potential for percentage counting. However, the results of a low sum diatom count for sample 3 are presented in Table 21.4. The dominant taxa are estuarine mesohalobous diatoms (*Cyclotella striata, Nitzschia navicularis, Diploneis interrupta, Diploneis didyma, Scoliopleura brunkseiensis, Achnanthes brevipes, Nitzschia brevissima*) but with significant numbers of halophilous and oligohalobous indifferent aerophilous taxa (see Cameron 2010) such as *Navicula cincta, Navicula mutica* and *Hantzschia amphioxys*. Polyhalobous taxa are present in lower numbers (*Rhaphoneis minutissima, Diploneis smithii*). The mesohalobous (with mesohalobous, benthic aerophiles such as *Diploneis interrupta*) component and small component of polyhalobous taxa in sample 3 is comparable with the underlying sample assessed previously (D9, Sample 1380, Context 1747, 16-18 cm) (Cameron 2010). However, the increased elements of halophilous and oligohalobous indifferent aerophilous taxa indicates increasing periods of drying out or erosion from ephemeral freshwater environments. The diatom composition of sample 3 is consistent with a marginal habitat and the dominance of mesohalobous estuarine taxa, the lack of marine diatoms in any numbers and the presence of freshwater and halophilous aerophiles suggests a sedimentary environment such as high salt marsh.

Area A Sequence 8

Sequence 8 comprises post-Roman alluvium which lies below a post medieval boundary or drainage ditch (Chris Carey pers.comm.).

Four samples have now been analysed for diatoms (Figs 21.1 and 21.2): two samples from the original assessment (Table 21.1, D14 and D17) and two new samples from site sample 1133 (Table 21.2) (new samples 4 and 5). In addition, a new sample (6) (see Table 21.2) with a very poorly preserved diatom assemblage was evaluated (Table 21.3) and semi-quantitative results of diatom analysis are presented for sample 6 in Table 21.4.

The diatom assemblage of sample 6 is dominated by polyhalobous species such as *Paralia sulcata* and *Rhaphoneis surirella*, there are also high numbers of mesohalobous estuarine taxa such as *Cyclotella striata* and *Nitzschia navicularis*. Halophilous and oligohalobous indifferent diatoms are absent. The diatom composition of the new sample 6 indicates a fully tidal habitat such as a mudflat.

In sample D14 marine and brackish water diatoms are present, comprising about 15% and 10% of the assemblage respectively (Figs 21.1 and 21.2). However, the aerophilous halophile *Navicula cincta* comprises almost 70% of the D14 assemblage and indicates a high shore habitat subject to long periods of drying-out. Sample D17 also has a high proportion of *Navicula cincta* (25%), but approximately 37% of the diatom assemblage is comprised of oligohalobous indifferent diatom taxa and these are mainly aerophilous (see Cameron 2010) freshwater species, such as *Hantzschia amphioxys, Navicula contenta, Pinnularia borealis* and *Pinnularia subcapitata*. Again this high proportion of desiccation tolerant diatoms, with relatively low percentages of polyhalobous (eg *Cymatosira belgica, Paralia sulcata Rhaphoneis minutissima*), and polyhalobous to mesohalobous taxa (total 15%) and mesohalobous groups (eg *Cyclotella striata, Nitzschia navicularis, Actinocyclus normanii, Tryblionella levidensis*) (total 10%) suggests a high shore, marginal habitat subject to occasional flooding from the estuary.

In the new samples 4 and 5, diatoms are in relatively low numbers and the valves are poorly preserved. However, species diversity is moderately high and it has been possible to carry out percentage diatom counting for these slides. The poor quality of preservation in contexts 5000 and 1999 is partly reflected in the dominance of the robust, heavily silicified oligohalobous indifferent diatom *Navicula rhyncocephala* which comprises almost 25-30% of the total diatoms. The relatively high proportion (15-20%) of taxa identified to the generic level is also a reflection of the poor quality of preservation. Freshwater aerophiles are also present in sample 4 (*Hantzschia amphioxys, Pinnularia borealis*) and indicate periods of drying-out. Other freshwater taxa in samples 4 and 5 include the attached species *Achnanthes lanceolata, Cocconeis placentula* and *Gomphonema angustatum*. Polyhalobous taxa are absent in sample 5 and there is a low percentage of *Paralia sulcata* (5%) in sample 4, which might indicate occasional flooding. The non-planktonic diatoms, *Lyrella pygmaea* and *Nitzschia hungarica*, comprise a high proportion of the mesohalobous group in sample 5. The diatom assemblages of both samples 4 and 5 suggest a shallow freshwater to brackish sedimentary environment subject to drying-out and with only occasional flooding from the estuary.

Area A Sequence 12

Sequence 12 was taken through the outer enclosure ditch. Three slides taken from two monolith samples, 1026 and 1027, were assessed previously for diatoms. The quality of diatom preservation was poor and there was little or no potential for percentage counting. However, the slides contained brackish marine diatom assemblages, with a freshwater aerophilous component in the slide from sample 1027.

Six further slides (Table 21.2, diatom samples 7-12) from Sequence 12 have been prepared for diatom analysis. Diatoms are absent from the top and bottom samples (diatom samples 7 and 12) and very poorly preserved in diatom samples 10 and 11 which contain only fragments of benthic mesohalobous taxa (cf. *Campylodiscus clypeus, Nitzschia navicularis*). Diatom samples 8 and 9 from sample 1025 have very low concentrations of poorly preserved diatoms. The diatom assemblages from samples 8 and 9 are shown in Table 21.4. These samples contain brackish marine diatom assemblages. There is a greater component of marine species (*Paralia sulcata, Rhaphoneis* spp., *Thalassionema nitzschiodes*) and planktonic estuarine diatoms (*Cyclotella striata*) in sample 8 from context 1198 than in sample 9 (context 1283). Both samples contain benthic mesohalobous species (eg *Diploneis didyma, Diploneis interrupta, Nitzschia granulata, Nitzschia navicularis*), while halophilous and oligohalobous indifferent diatoms are absent. Therefore, despite the poor quality of diatom preservation, the samples from sequence 12 all represent estuarine conditions, with a greater input of open water and coastal planktonic species in diatom sample 8.

Area A Sequence 14

Three diatom slides were prepared previously from Sample 1203 in Sequence 14 which was taken from the roundhouse outer ditch. Brackish marine diatom assemblages are present with some aerophilous taxa in the basal sample.

Four further slides have been prepared from sample 1198 (diatom samples 13-15) and sample 1203 (diatom sample 16). Diatoms are absent from sample 16 and poorly preserved in samples 13-15. However, the diatom assemblages preserved in the three slides from Sample <1198> do provide some information about the sedimentary environment.

The basal sample (15) has a benthic, brackish water diatom assemblage (*Caloneis westii, Diploneis interrupta, Nitzschia granulata, Nitzschia navicularis*) with some halophilous and oligohalobous indifferent aerophiles (*Navicula mutica, Hantzschia amphioxys, Pinnularia borealis*) which suggest that the sedimentary environment dried out and would also be a cause of poor preservation. Diatom sample 14 is dominated by benthic (*Diploneis interrupta, Diploneis didyma, Nitzschia navicularis, Nitzschia hungarica, Nitzschia granulata, Navicula peregrina*) and planktonic (*Cyclotella striata*) mesohalobous diatoms. The polyhalobous, planktonic species *Paralia sulcata* is present, but no other marine diatoms were recorded in the species count, and freshwater and halophilous diatoms are absent from sample 14. The diatom assemblage of sample 13 is dominated by a similar, benthic mesohalobous species assemblage, but with a higher proportion of the aerophilous benthic species *Diploneis interrupta*. In addition sample 13 has a greater diversity of polyhalobous taxa than sample 14 (*Paralia sulcata, Podosira stelligera, Rhaphoneis* sp., *Diploneis smithii*). The halophilous and oligohalobous indifferent aerophiles *Navicula mutica, Hantzschia amphioxys* and *Pinnularia borealis* are also common or present in sample 13. Overall then the diatom sequence found in the roundhouse outer ditch sequence 14, sample 1198 seems to represent increasing water levels and salinity as oligohalobous, aerophilous taxa decline and subsequently brackish water diatoms and allochthonous marine plankton increase in importance.

Area A Sequence 16

A single sample (D27) from sample 1366, context 6376, was evaluated previously for diatoms (Cameron 2010) and found to have a brackish marine, aerophilous diatom assemblage with some potential for percentage diatom analysis. Percentage diatom counting has been carried out on sample D27; the sample is of particular interest because of its location in a roundhouse brine settling tank.

Diatom analysis confirms that the diatom assemblage is dominated by the mesohalobous benthic diatom, *Diploneis interrupta*, which comprises over 75% of the total diatom assemblage. *Diploneis interrupta* has been classified as a marine-brackish aerophilous diatom that is associated in natural environments, when occurring at very high abundances, with salt marshes above Mean High Water (Vos and de Wolf 1993). It is thus able to grow at sites with high salinity levels and with prolonged periods of desiccation. The dominance of *Diploneis interrupta* in sediments from the roundhouse settling tank is consistent with high salinity levels and prolonged dry periods, perhaps as a result of evaporation during salt-production. A number of other polyhalobous (*Paralia sulcata, Pseudopodosira westii*), mesohalobous (*Navicula peregrina, Nitzschia navicularis, Lyrella pygmaea, Nitzschia hungarica, Nitzschia sigma, Caloneis westii, Cyclotella striata*) and halophilous aerophilic (*Navicula cincta*) species are present in relatively low abundances. In total mesohalobous (mainly benthic) diatoms compose 85% of the diatom assemblage whilst oligohalobous indifferent, freshwater, diatoms are absent.

Area B

Area B Sequence 25

In the initial diatom evaluation, seven diatom samples were assessed from sequence 25, a salt making sequence at the edge of the platform, with alluvium interspersing salt making detritus. Diatoms were found to be generally poorly preserved, but partial assemblages were present in five samples with potential for percentage counting of one sample, D32.

Five further diatom slides (Table 21.2, diatom samples 17-21) have been prepared for diatom analysis. It has been possible to carry out percentage diatom counting for sample 19 from sample 4093. In the remaining four samples, diatom preservation is poor but low sum counts have been used to characterise the diatom assemblages of these samples (Table 21.4).

The diatom assemblage of diatom sample D32 (Context 4437) is composed of a mixture of marine taxa, which represent about 40% of the total diatoms (eg *Paralia sulcata, Cymatosira belgica, Rhaphoneis* sp., *Podosira stelligera*), and brackish water taxa (eg *Cyclotella striata, Nitzschia navicularis, Nitzschia sigma, Nitzschia granulata, Actinocyclus normanii*) which comprise about 35% of the assemblage. Oligohalobous indifferent diatoms represent less than 5% of the total diatom assemblage. Similarly in sample 19 polyhalobous (40%) and mesohalobous (20%) diatom groups and intermediate salinity groups represent a high proportion of the diatom assemblage, but in sample 19 halophilous and oligohalobous indifferent diatoms comprise about 30% of the diatom assemblage. These latter groups of oligohalobous diatoms include species such as the halophilous aerophiles *Navicula* *cincta* and *Navicula mutica*. Freshwater diatoms include Fragilaria spp. with wide salinity tolerances, but also freshwater epiphytes with narrower salinity tolerance such as *Cocconeis placentula*. The new samples from sequence 25 for which low sum counts were carried out (Table 21.4) show a similar dominance of brackish and marine taxa (although only single species were identified in D18 and D21). In sample 20 there is a mixture of mesohalobous (eg *Cyclotella striata, Diploneis interrupta, Nitzschia navicularis*) with polyhalobous (eg *Rhaphoneis minutissima*) halophilous (*Navicula cincta*) and oligohalobous indifferent (*Cocconeis placentula*) diatoms. In the top sample, sample 17, the most common diatom is *Nitzschia navicularis* with polyhalobous taxa (eg *Rhaphoneis* spp., *Paralia sulcata, Dimeregramma minor*) and halophiles (*Actinocyclus normanii, Navicula mutica*) also present.

Conclusions

1. Diatoms have been analysed from five samples identified in the original diatom assessment of forty-five samples from Stanford Wharf Nature Reserve as having diatom assemblages suitable for percentage counting.

2. A further twenty-one slides have been prepared from a new group of samples selected from the site. Diatom assemblages suitable for percentage counting are present in three of the additional samples and diatom analysis has been carried out for these. A further thirteen samples have relatively poorly preserved diatoms assemblages or very low numbers of diatoms and are therefore unsuitable for diatom counting. However, semi-quantitative diatom analysis has been carried out for these thirteen samples which can provide some useful palaeoenvironmental information. Diatoms are absent from five of the new slides that were prepared for analysis.

3. Analysis of the original sample (D1) from the layer sealing the archaeology supports other palaeoenvironmental evidence that this alluvium is deposited from the outer estuary. The diatom assemblage is dominated by coastal marine and estuarine brackish water taxa. Diatoms are absent from the two new slides prepared from sample 1007 in Area A Sequence 1.

4. Analysis of one new sample (3) from alluvium in Sequence 6 is consistent with a

high shore environment. Here mesohalobous taxa dominate the assemblage, along with halophilous and oligohalobous aerophiles, while polyhalobous, marine taxa form only a small component of the diatom assemblage.

5. The samples analysed from the post-Roman alluvium of Sequence 8 indicate respectively (sample 6) a fully tidal estuarine environment and in the remaining samples (samples 4 and 5; D14 and D17) for which percentage diatom analysis has been carried out, high shore marginal habitats subject to relatively infrequent estuarine flooding. The latter sedimentary environments appear to have been affected by drying out of the habitat resulting in the preferential preservation of robust diatoms and the occurrence of aerophilous taxa.

6. Where diatom assemblages are present in the new samples evaluated from Sequence 12 of the outer enclosure ditch they represent marine brackish conditions, with varying amounts of allochthonous coastal marine species and estuarine plankton. However, the quality of diatom preservation is very poor and it was not possible to make diatom percentage counts for these samples.

7. Diatoms are poorly preserved in the roundhouse outer ditch. However, the diatom sequence found in the roundhouse outer ditch sequence 14, sample 1198 seems to represent increasing water levels and salinity as oligohalobous, aerophilous taxa decline and subsequently brackish water diatoms and allochthonous marine plankton increase in importance.

8. Diatom analysis of sample D27 from sequence 16, the roundhouse settling tank confirms that the mesohalobous, aerophilous diatom *Diploneis interrupta* is dominant. The ecology of this diatom taxon is consistent with a sedimentary environment with high salinity levels and prolonged dry periods.

9. The evaluation of further samples from Area B sequence 25 (the salt-making sequence at the edge of the platform) and analysis of two samples supports the inferences made in the previous diatom assessment. Mixtures dominated by brackish water and marine diatoms were recorded, with significant halophilous and freshwater elements in the assemblages, particularly sample 19. The quality of diatom

preservation is poor. However, the diatom assemblages are not dominated by a single mesohalobous, aerophilous species as was found in the sample analysed from Area A, sequence 16, the Roundhouse settling tank.

10. As indicated in the original assessment, the poor preservation, absence or low numbers of diatoms from many of the sediment samples here can be attributed to taphonomic processes in marginal, often ephemeral aquatic habitats (or the extreme environment that would be created for example in a brine settling tank). The loss of diatom assemblages may be the result of silica dissolution caused by factors such as high sediment alkalinity, very high acidity, the under-saturation of sediment pore water with dissolved silica, cycles of prolonged drying and rehydration exposure of sediment to the air, or physical damage to diatom valves from abrasion or wave action (eg Flower 1993; Ryves *et al.* 2001).

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Diatom Tables

TABLE 21.1. ORIGINAL SAMPLES FROM STANFORD WHARF NATURE RESERVE (COMPA 09) SITE (CAMERON 2010) SELECTED FOR DIATOM ANALYSIS.

Area	Seq.	Section	Cont.	Sample	Diatom Sample Number
A	1	1027	1132	1004	D1
A	8	1319	5980	1289	D14
A	8	1167	1995	1133	D17
A	16	1050	1365	1225	D27
B	25	4093	4437	4031(2)	D32

TABLE 21.2: ADDITIONAL SAMPLES PREPARED FOR DIATOM ANALYSIS FROM STANFORD WHARF NATURE RESERVE

Sequence	Sample	Context	Depth	Diatom Sample
Sequence 1 Early Holocene sequence	<1007>	1143	25 - 29cm	**1**
		1077 (8503) G4a	32 - 35cm	**2**
Sequence 6 Sequential anthrosols	1380	1588	0-4cm	**3**
Sequence 8 - Post Roman alluvium	<1133>	5000	0-5cm	**4**
		1999	14 - 16cm	**5**
		1997	30 - 33cm	**6**
12 Outer enclosure ditch	<1024>	1220	5-10cm	**7**
	<1025>	1198	5-10cm	**8**
		1283	25-30cm	**9**
	<1026>	1352	5-10cm	**10**
	<1056>	1612	25-30cm	**11**
		1381	45-50cm	**12**
14 Roundhouse outer ditch	<1198>	5365	2 - 6cm	**13**
		5414	15 - 20cm	**14**
		5418	35 - 40cm	**15**
	<1203>	5429	12-15cm	**16**
Sequence 25 Area B salt making sequence	<4091>	4630	15-20cm	**17**
		4639	30-35cm	**18**
	<4093>	4648	45-50cm	**19**
		4645	15-20cm	**20**
		4647	35-40cm	**21**

TABLE 21.3. SUMMARY OF DIATOM EVALUATION RESULTS FOR TWENTY-ONE ADDITIONAL SAMPLES (+ PRESENT, - ABSENT, MOD – MODERATELY HIGH, EX.LOW- EXTREMELY LOW, FW – FRESHWATER, AERO- AEROPHILOUS, BK – BRACKISH, MAR – MARINE, HAL – HALOPHILOUS, INDET – INDETERMINATE)

Diatom Sample No.	Diatoms present or absent	Diatom numbers	Quality of preservation	Diversity	Assemblage type	Potential for % count
1	-	-	-	-	-	none
2	-	-	-	-	-	none
3	+	low	poor	low	bk hal fw aero	low
4	+	low	poor	mod	see diagrams	count
5	+	low	poor	mod	see diagrams	count
6	+	v low	v poor	low	mar bk	low
7	-	-	-	-	-	none
8	+	v low	v poor	low	mar bk	v low
9	+	v low	v poor	low	bk mar	v low
10	+	ex low	ex poor	1 sp.	bk?	none
11	+	ex low	ex poor	1 sp.	bk	none
12	-	-	-	-	-	none
13	+	low	poor	mod	mar bk hal aero	v low
14	+	v low	v poor	low	bk	none
15	+	v low	v poor	low	bk aero	none
16	-	-	-	-	-	none
17	+	v low	v poor	v low	bk mar hal	none
18	+	v low	v poor	v low	mar	none
19	+	mod	mod	mod	mar bk fw	count
20	+	low	poor	low/mod	bk hal fw mar	none
21	+	ex low	ex poor	v low	bk	none

TABLE 21.4. DIATOM SPECIES RECORDED IN TWENTY-ONE ADDITIONAL SAMPLES

Diatom Taxon/Laboratory Sample Number	**D3**	**D6**	**D8**	**D9**	**D10**	**D11**	**D13**	**D14**	**D15**	**D17**	**D18**	**D20**	**D21**
Polyhalobous													
Cymatosira belgica												1	
Dimmeregramma minor										1			
Paralia sulcata		3	2	1			1	1		1	1	1	
Podosira stelligera		1					1						
Rhaphoneis amphiceros		1	1										
Rhaphoneis minutissima	1											2	
Rhaphoneis sp.		1	1				1			1			
Rhaphoneis surirella		2								1			
Thalassionema nitzschiodes			1										
Trachyneis aspera		1								cf			
Polyhalobous to Mesohalobous													
Diploneis smithii	1	1					1						
Synedra gaillonii										1			
Mesohalobous													
Achnanthes brevipes	1						1						
Bacillaria paradoxa				1									
Caloneis westii									1				
Campylodiscus clypeus					cf								
Cyclotella striata	2	2	2				1	2				2	1
Diploneis interrupta	1			2			2	1	1			2	
Diploneis didyma	1	1	1	1			1	2				1	
Navicula peregrina				1				1					
Nitzschia punctata							1	1					
Nitzschia granulata		1	1					1	1				
Nitzschia hungarica							1						
Nitzschia navicularis	2	2	2	1		1	2	2	1	2		2	
Nitzschia sigma												1	
Scoliopleura brunkseiensis	1												
Mesohalobous to Oligohalobous Halophil													
Actinocyclus normanii										1			
Mesohalobous to Oligohalobous Indifferent													
Nitzschia brevissima	2												
Oligohalobous Halophilous													
Navicula cincta	2											3	
Navicula mutica	1						2		1	1			
Oligohalobous Indifferent													
Cocconeis placentula & var.												2	
Hantzschia amphioxys	2						1		1				
Pinnularia borealis							1		1				
Unknown Salinity Group													
Cocconeis sp.							1						
Denticula sp.	1												
Diploneis sp.			1				1	1	1				
Inderminate pennate sp.	1			1									1
Navicula sp.	1							1				1	
Nitzschia sp.				1			1		1	1		1	
Unknown naviculaceae			1	1			1			1	1	1	

Figure 21.1: Diatom species and summary halobian group diagram (a)

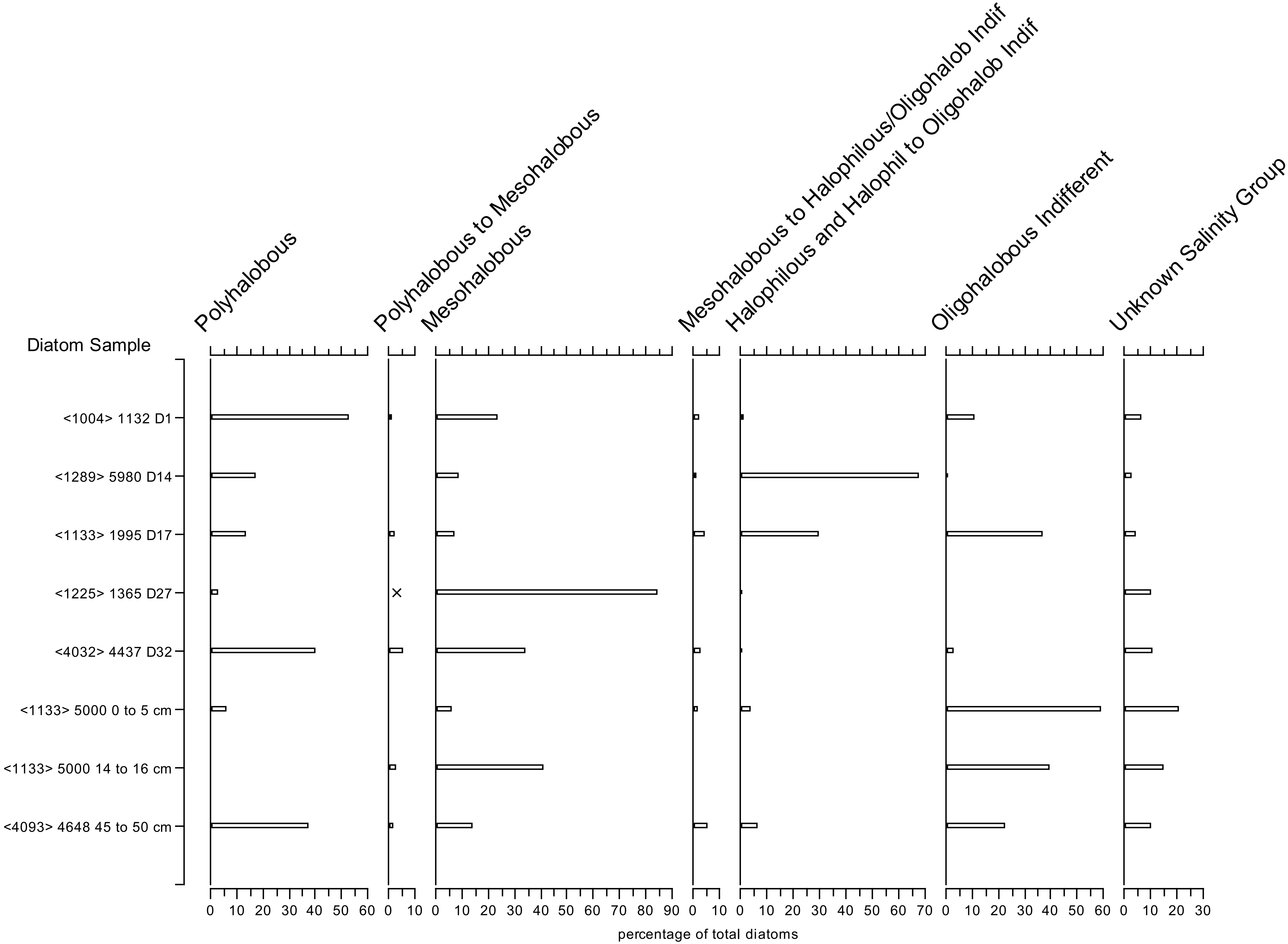

Figure 21.2: Diatom species and summary halobian group diagram (b)

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