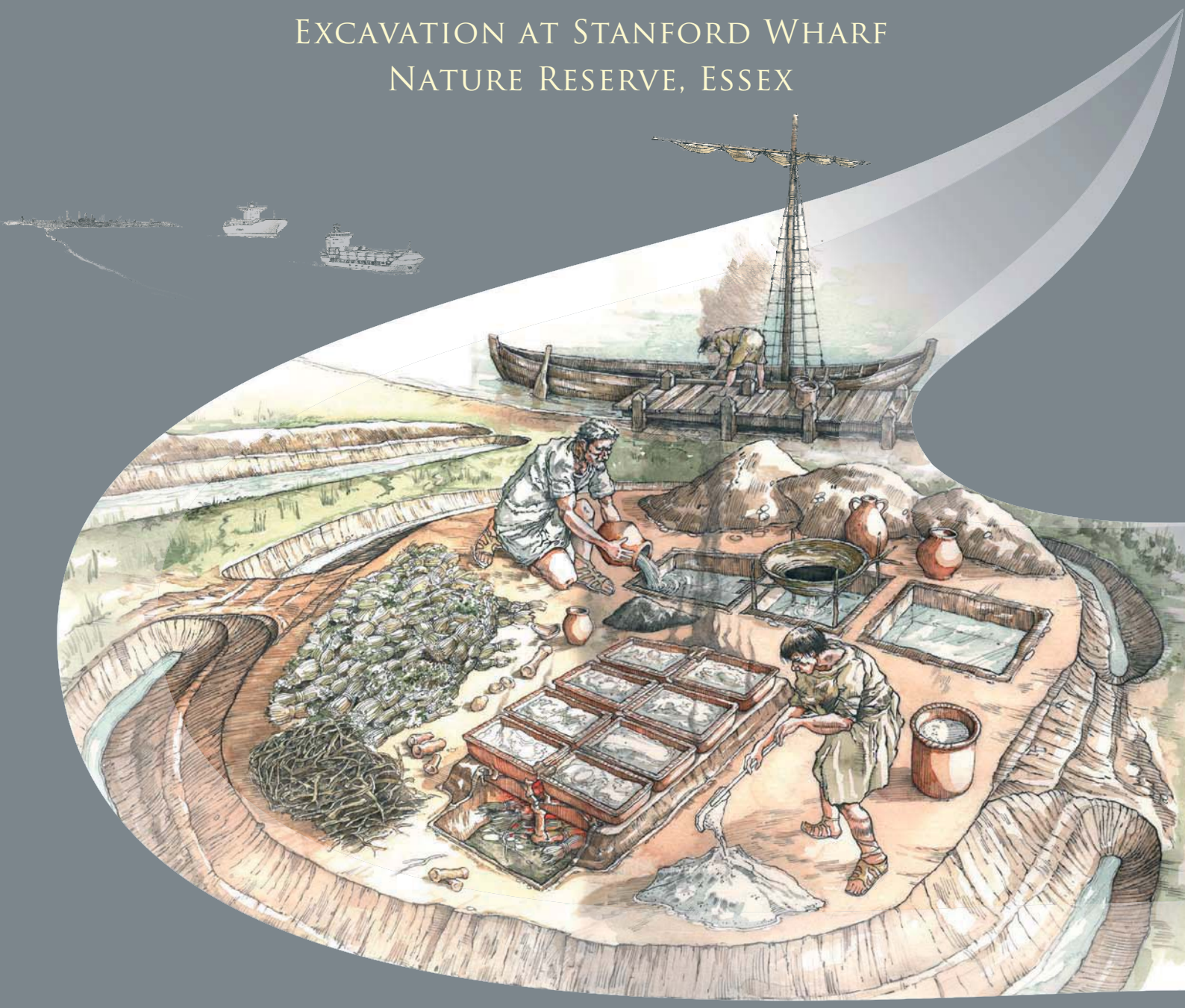
London Gateway

Iron Age and Roman Salt Making in the Thames Estuary

Excavation at Stanford Wharf Nature Reserve, Essex



Specialist Report 22

Microfauna

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Introduction

In 2010 a total of 45 samples formed the basis of my microfossil assessment report of Stanford Wharf Nature Reserve, Stanford-le-Hope, Essex (Whittaker 2010). Using any foraminifera and ostracods that might occur in the samples, the aim had been to further the palaeoenvironmental reconstruction of several important sequences that had been found. In a meeting of members of OA South, addressed by Edward Biddulph (Project Manager) and Chris Carey, and attended by various specialists, at Oxford in January 2011, several ways forward were discussed to bring the project to a completion and to achieve a final publication report. Subsequently, guidance notes were issued and I was given 37 samples from various sequences to follow up on the findings of the assessment phase, and in some cases where the initial samples were barren or showed future potential, to achieve better results. The sequences chosen for further work on the microfauna (foraminifera and ostracods) were sequences 2, 6, 8, 12, 14 and 19 in Area A (23 samples in total), and Sequence 25 in Area B (5 samples). In addition, I was given nine samples through an almost 3m section of OA Borehole 3, drilled through a large palaeochannel, which from a single sample had shown some useful initial results in the Assessment.

At the January 2011 meeting in Oxford a staged approach to reporting for the final publication report phase was also agreed, in that “aspects of the specialist work could be staggered allowing the results of certain categories to inform on the level of recording required for others”, with recommendations that “the diatoms and foraminifera/ostracods should go ahead as planned, while a staged approach for pollen might be necessary as the specialists await the diatom and foraminifera/ostracod results”.

Some reference is also made here to the post-excavation assessment report, produced by Oxford Archaeology (Anker *et al*. 2010) in describing the various sequences and what was hoped might be achieved from the new analyses.

Material and methods

Area A

Sample no.	Context	Depth	Weight processed
SEQUENCE 1			
1005	1132	5-10cm	5+135g
1007	1143	25-29cm (G5)	20g
1007	1144	29-31cm (G4)	25g
1007	1077	32-35cm (G4a)	25g
1007	1145	35-40cm (G3)	25g
SEQUENCE 6			
1380	1588	0-4cm	30g
SEQUENCE 8			
1133	1997	30-33cm	45g
SEQUENCE 12			
1024	1220	5-10cm	50g
1025	1198	5-10cm	30g
1025	1283	25-30cm	25g
1026	1352	5-10cm	40g
1056	1612	5-10cm	40g
1056	1381	25-30cm	40g
SEQUENCE 14			
1198	5365	2-6cm	20g
1198	5414	15-20cm	30g
1198	5418	35-40cm	40g
SEQUENCE 19			
1298	5651	10-15cm	30g

1298	5654	35-40cm	30g
1364	6236	20-25cm	20g
1364	6238	35-40cm	20g
1365	6375	0-5cm	20g
1366	6373B	21-25cm	20g
1366	6379	36-42cm	45g

Area B

Sample no.	Context	Depth	Weight processed
SEQUENCE 25			
4091	4630	15-20cm	30g
4091	4639	30-35cm	20g
4093	4645	15-20cm	25g
4093	4647	35-40cm	40g
4093	4648	45-50cm	25g

Palaeochannel: OA Borehole 3

Depth	Weight processed
1.05cm [1-2m 5cm]	25g
1.50cm [1-2m 50cm]	30g
1.85cm [1-2m 85cm]	40g
2.05cm [2-3m 5cm]	25g
2.32cm [2-3m 32cm]	40g
2.64cm [2-3m 64cm]	30g
3.05cm [3-4m 5cm]	40g
3.53cm [3-4m 53cm]	50g
3.97cm [3-4m 97cm]	50g

Processing was undertaken as follows: each sample was placed in a ceramic bowl and first, dried in an oven, then soaked in hot water with a little sodium carbonate added to help remove the clay fraction. It was then washed through a 75 micron sieve with

hot water. The resultant residue was returned to the bowl and dried again in the oven. All the samples, even those with some organic content, broke down quite readily.

The residues were finally placed in labelled plastic bags for storage and subsequent examination. For analysis of the residues from areas A and B, each dry sample was put through a nest of sieves (>500, >250, >150 microns and pan) and a little of each residue at a time was sprinkled onto a picking tray. For the most part, each sample was merely observed under a microscope and notes made on its content. The "organic remains" were recorded on a presence/absence basis, while the abundance of each foraminiferal and ostracod species (where present) was estimated semi-quantitatively by experience and by eye on a present/common/abundant basis and this information is included on the tables accompanying this report.

For the OA 3 Borehole, on the other hand, a fully quantitative analysis was undertaken. This concentrated on the >150 micron fraction, as it was found that the microfauna smaller than this was comprised of very small juveniles and invariably difficult to attribute to a species. At first all the foraminifera and ostracods from the >500, >250 and >150 micron fractions were picked out into a slide and counted, but this was very time-consuming. It was found more practicable to scan each picking tray under the microscope, square by square, and make counts of several species at a time, undertaking several passes before all the species were accounted for. For each species in Table 22.7, therefore, the full counts are listed with their percentage of the total microfauna next to this figure (in italics, in brackets). Additionally the "organic remains" are included, on a presence/absence basis as before.

Results

Area A

The results of the new microfaunal analysis of the 23 samples from Area A are shown in Tables 22.1-3. The "organic remains" are merely recorded on a presence (x)/absence basis, whereas the foraminiferal species (lowest column) are recorded semi-quantitatively as explained in Table 22.1.

Sequence 1: Anthosol over alluvium; lower part contains pre-Roman palaeosol

According to Anker *et al.* (2010) this is a key sequence for the early to mid Holocene environment. Disappointingly, none of the five samples examined contained any

foraminifera or ostracods at all. Sample 1005, 5-10cm (context 1132) had only iron mineral and is probably weathered; sample 1007, 25-29cm G5 (context 1143) was completely barren. The samples below, all from 1007, 29-40cm, G4, G4a and G3 (contexts 1144, 1077 and 1145, respectively), contained plant debris and seeds, charcoal and burnt organics, and in one case, insect remains. The sequence may be freshwater, but the diatom and pollen survey, to come, will be the key to a better elucidation of the ecology.

Sequence 6: Anthosols separated by alluvium

According to Anker *et al.* (2010) this is a key sequence to address the formation of these anthosols and their use. In the guidance notes issued by Oxford Archaeology to the various specialists ("Notes about the sequences for analysis") it is suggested that "probably all the sequence is inter-tidal at this point". Only one sample (1380, 0-4cm, context 1588) was examined, but this contained no foraminifera (or ostracods for that matter), which ought to have been expected, from evidence elsewhere on the site, if the ecology was indeed brackish. Only plant debris and charcoal/burnt organics were found. Again, pollen and/or diatom analysis should provide the best evidence for the environment of deposition in this sequence.

Sequence 8: Medieval alluvium

The one sample examined (1133, 30-33cm, context 1997) provided plant debris and seeds, diatoms (>75µ), insect remains and a rich brackish foraminiferal fauna. However, unlike my previous analysis of Sequence 8 (Whittaker, 2010), especially of samples 1133 and 1136 (contexts 1195 and 1196, respectively), there were no ostracods. The foraminiferal fauna contains many specimens of *Trochammina inflata* and *Jadammina macrescens*, both species being herbivores and detrivores, typical of mid-high saltmarsh. They are also joined by two other agglutinating foraminiferal species – *Tiphotrocha comprimata* and *Miliammina fusca* – again detrivores, the former being found previously (Whittaker 2010) only in Sequence 25 (Area B), the latter being new to the Stanford Wharf site. This is the only occurrence of *Tiphotrocha comprimata* in the present survey. Rare and sporadic in its distribution in north-west Europe, its occurrence is not without interest as it has been claimed to be due to human introduction with American shellfish in recent times. It was originally described from the Caribbean and the eastern United States (Murray 2006), but clearly

it is native to this country since at least Roman times. The occurrence of two calcareous foraminifera (*Haynesina germanica* and a brackish species of Ammonia), in association, attest to the presence of mudflats either fronting the saltmarsh or of creeks within the saltmarsh. Large circular diatoms were also seen in great abundance in this sample (Table 22.1). Their occurrence in this and the previous survey (Whittaker 2009) with benthic calcareous foraminifera indicates a healthy fauna – there is a known symbiotic relationship between the two.

Sequence 12: Roman-period outer enclosure ditches

Six samples were analysed. Four of them, samples 1025 (contexts 1198 and 1283) and 1056 (contexts 1612 and 1381) produced good faunas of agglutinating foraminifera indicative of mid-high saltmarsh and for the first time in sequence 12, one (sample 1025, 5-10cm, context 1198) containing a calcareous foraminifer (*Haynesina germanica*) indicative of low-mid saltmarsh and tidal mud. Foraminifera were absent in the other two: one (1026, 5-10cm, context 1352) was completely barren (?weathered), the other (1024, 5-10cm, context 1220) merely contained plant debris.

In Oxford Archaeology's "Notes about the sequences for analysis", the statement is made that there is a "clear sequence to the phasing of the ditches", which "can almost be separated into depo[sitional] environments based on assessment", and that "analysis of 1381 is key, possibly FW [freshwater]". Hopefully my assessment will now help in this characterization. However, context 1381, is clearly indicative of brackish mid-high saltmarsh and is certainly not freshwater! Large diatoms were seen in one sample (Table 22.1) and plant debris and seeds were seen in five.

Sequence 14: Roman-period roundhouse outer ditch

Three samples were analysed. All contained brackish saltmarsh agglutinating foraminifera, as well as plant debris, charcoal/burnt organics and fish/amphibian remains. One (1198, 2-6cm, context 5365, contained red clay. As in my previous analysis (Whittaker 2010), the question remains are the foraminifera *in situ* or are they introduced or washed in from clays used in salt-making nearby, or accumulated when the site was cleared from time to time?

Sequence 19: red hill site 5664

Seven samples from seven different contexts were analysed. In the one sample

examined in the assessment phase (Whittaker 2010), the agglutinating foraminifer *Trochammina inflata* was found preserved, albeit burnt and recrystallized through the salt-making process. More contexts have now been examined to see if the pattern is repeated throughout. In the new material the sediment was almost entirely composed of red clay, often in large lumps. In two of the samples there was also charcoal/burnt organics and in one (1366, 21-25cm, context 6373B), a great deal of what looked like fragments of straw and these, curiously, were not burnt. In the new survey, moreover, all the samples contained examples of *Trochammina inflata*, again often burnt (and red in colour) or otherwise recrystallized. In one sample there were also, for the first time, a few *Miliammina fusca*. Both these species of agglutinating foraminifera have very robust shells of mineral grains with organic cement and an inner and outer organic layer; it is interesting to see how they have survived. They undoubtedly come from the clay used in the salt-making process. Moreover, it indicates that the clay must have been excavated from the nearby saltmarsh.

Area B

The results of the microfaunal analysis of the five samples from Area B are shown in Tables 22.4-6.

Sequence 25: Salt making sequence at edge of platform; alluvium interspersing salt-making detritus

Two different sequences appear to occur. First, there is sample 4093 in which three different contexts are represented between 15 and 50cm in the monolith. The basal two, 4647 and 4648, on both foraminiferal and ostracod evidence, attest to a brackish mid-high saltmarsh interspersed or fronted by tidal mudflat, giving way to tidal mudflat alone in context 4645 at the top. The specimens of *Trochammina inflata* are common, brown (ie in their “natural” state), in marked contrast to those which are found in sample 4091 (which we shall see described below). There is a great deal of plant debris and seeds, which also augurs well for pollen analysis. There are also molluscs (“planorbid” gastropods) in context 4648, which would warrant attention from a bulk sample; these are indeed the only molluscs found in either Area A or B. They are not common but might be freshwater/terrestrial. Burnt organics are quite rare and might be due to natural fire, perhaps initiated by burning for salt extraction nearby, but not yet at this actual site.

The second sequence, that of sample 4091 (above 4093) is represented by two contexts 4639 (30-35cm) and 4630 (15-20cm) and contains some interesting microfossil data. Both of the residues contain red clay and much burnt organics/charcoal. It is clear salt making is now taking place here, but it is the nature of the microfossils that might shed some light on the situation at the site and the process. The foraminifera and ostracods, although mainly brackish and indicative of tidal mudflats, now include a number of essentially marine foraminifera for the first time, which are very small (eg *Nonion depressulus*) and have probably come in, in suspension with the tide. It looks as though the salt workers were actively channelling in the water on a rising tide, then trapping it, to initially evaporate the salt. This "marine" foraminiferal component was not found in Area A at all and may partly reflect the nearer proximity of Area B, in the east, to the main tidal channel, and/or a different method of salt extraction. In the top sample examined of 4091, 15-20cm (context 4630), there are also a number of *Trochammina inflata* which have been burnt and recrystallized by the heat during the final phase of salt making process, where clay from the saltmarsh was being used. This was particularly noticeable in Sequence 19 in Area A, but is in marked contrast to the situation in Sample 4093, found below 4091 (described above).

Borehole OA3: Palaeochannel (Table 22.7)

In my assessment report (Whittaker 2010), only one sample was analysed for microfossils from this borehole (from 3.83-3.85m depth), which had been drilled through a large palaeochannel to the south of the western part of Area A. This time, nine samples from nearly 3m of sediment were provided from the borehole covering the interval 1.05m and 3.97m. Whereas my microfaunal analysis of the 28 samples from Area A and B are semi-quantitative (the abundance of the foraminiferal and ostracod species being assessed merely as present, common or abundant. Each species of foraminifera and ostracod are listed with full counts; a foraminiferal test and an ostracod valve being counted as 1, while an ostracod carapace is counted as 2. Next to this figure, on the right of each column, numbers in brackets (and in italics) indicate the percentage of each foraminiferal and ostracod species in terms of the total microfossil assemblage. Nearly 4,700 specimens were counted in total from the nine samples.

The topmost column in Table 22.7, first lists the "organic remains", but merely

on a presence (x)/absence basis. Those listed are plant debris (and seeds), insect remains, large diatoms (>75 microns in diameter), foraminifera and ostracods separated into by ecological groups and finally, molluscs. All those listed, except the molluscs, occurred in all nine samples, the molluscs only occurred in 6 and these for the most part appeared to be juveniles.

The microfauna are then listed in detail in five sets of columns, from top to bottom: brackish foraminifera of saltmarsh and tidal flats; outer estuarine and marine foraminifera; brackish foraminifera of tidal flats and creeks; outer estuarine and marine ostracods; and finally, freshwater ostracods.

Within the nine samples of Borehole OA3 two species of mid-high saltmarsh foraminifera occur throughout the borehole. *Jadanmmina macrescens* was the commonest, varying between 16% of the total fauna at 2.05m to 2% at 1.05m; it usually attains 6-8%. *Trochammina inflata*, on the other hand, never achieves more than 2% in any one sample. The calcareous foraminifera of low-mid saltmarsh and tidal flats comprise three species and all three occur throughout. *Haynesina germanica* was by far the commonest making up 21% of the total fauna at the base (3.97m) generally gradually increasing in numbers to achieve 65% at the top (1.05m). The brackish species of Ammonia varies between 6% at the top (1.05m) and 21%, recorded at 2.05m, whereas *Elphidium williamsoni* was the least common, only achieving between 2 and 6% of the total microfaunal population.

Of the ostracods indicative of brackish mudflats, two species of *Leptocythere* dominate the assemblage, *L lacertosa and L porcellanea* being the commonest, the former particularly so, forming 19% of the total microfossil population at 2.32m (it is never less than 5%, and in these samples ostracods are generally rare). The latter makes up 11-12% of the total population in the two lowest samples (3.53m and 3.97m), but is generally below 4% elsewhere. This evidence, in association with the other species found (none of them making up more than 5%), seems to indicate tidal mudflats prevailed throughout within the proximity of the channel, rather than any indication of a protected creek being formed, as its would-be key species, *Cyprideis torosa*, is always extremely rare (<1%).

Probably because of its situation to the south of Area A and being cut into by a large palaeochannel from the main river, the site provides the best evidence at Stanford Wharf of marine influence. All the samples contain foraminifera (at least eight species) and ostracods (at least nine species) that are essentially marine or can

penetrate outer estuaries. Most are quite small and probably have been washed in, in suspension with the spring tides or by tidal surges (eg the foraminifer *Nonion depressulus*, which can appear in quite large numbers, forming 9% of the total population at 3.05m). Many of the benthonic ostracods (eg *Pontocythere elongata* and *Hemicythere villosa*) are also only represented by small juveniles and again appear to be washed in. Others within this component are phytal species which are associated with marine algae (eg the ostracod *Paradoxostoma*), or cling to seaweeds and sea-grasses (eg the miliolids). It would be generally true to say that this marine component is strongest in the lower part of the borehole, diminishing especially near the top. This may give an indication that the channel was more prominent initially and perhaps more prone to tidal surges and the like. Over time, it gradually silted up with the dominance of the adjacent mudflats becoming more apparent.

Finally, the freshwater component of the palaeochannel is surprisingly low throughout. Clearly it does not represent the course of even a small river. Only a few species of non-marine ostracods are found, the only one of any significance being *Limnocythere inopinata*, which usually inhabits coastal ditches, and therefore may have been washed out by an overtopping spring tide.

In conclusion, the palaeochannel was surrounded by extensive tidal mudflats backed by saltmarsh. Initially, it was prone to strong tidal influences and surges bringing in the outer estuarine/marine component. One such catastrophic event may have formed the channel in the first place. Probably due to silting, this influence diminished over time. Any freshwater component was always at a minimum.

References

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Murray, J W, 2006 *Ecology and Application of Benthic Foraminifera*, Cambridge University Press, Cambridge

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Microfauna Tables

TABLE 22.1. MICROFAUNA FROM AREA A (RECORDED ON A PRESENCE (X)/ASBENCE BASIS)

SEQUENCE	1					6	8	12						14			19						
CONTEXT	1132	1143	1144	1077	1145	1588	1997	1220	1198	1283	1352	1612	1381	5365	5414	5418	5651	5654	6236	6238	6375	6373B	6379
SAMPLE	1005	1007	1007	1007	1007	1380	1133	1024	1025	1025	1026	1056	1056	1198	1198	1198	1298	1298	1364	1364	1365	1366	1366
Depth	5-10cm	G5 25-29cm	G4 29-31cm	G4a 32-35cm	G3 35-40cm	0-4cm	30-33cm	5-10cm	5-10cm	25-30cm	5-10cm	5-10cm	25-30cm	2-6cm	15-20cm	35-40cm	10-15cm	35-40cm	20-25cm	35-40cm	0-5cm	21-25cm	36-42cm
iron minerals	x										x												
red clay						x				x				x			x	x	x	x	x	x	x

TABLE 22.2. MICROFAUNA FROM AREA A: ORGANIC REMAINS (RECORDED ON A PRESENCE (X)/ASBENCE BASIS)

SEQUENCE	1					6	8	12						14			19						
CONTEXT	1132	1143	1144	1077	1145	1588	1997	1220	1198	1283	1352	1612	1381	5365	5414	5418	5651	5654	6236	6238	6375	6373B	6379
SAMPLE	1005	1007	1007	1007	1007	1380	1133	1024	1025	1025	1026	1056	1056	1198	1198	1198	1298	1298	1364	1364	1365	1366	1366
Depth	5-10cm	G5 25-29cm	G4 29-31cm	G4a 32-35cm	G3 35-40cm	0-4cm	30-33cm	5-10cm	5-10cm	25-30cm	5-10cm	5-10cm	25-30cm	2-6cm	15-20cm	35-40cm	10-15cm	35-40cm	20-25cm	35-40cm	0-5cm	21-25cm	36-42cm
plant debris + seeds			x	x	x	x	x	x	x	x		x	x	x	x	x						x	
charcoal/burnt organics			x	x		x				x				x	x	x						x	x
insect remains			x				x		x	x													
brackish foraminifera							x		x	x		x	x	x	x	x	x	x	x	x	x	x	x
diatoms (>75µ)							x		x														
fish/amphibian remains														x	x	x							

TABLE 22.3. MICROFAUNA FROM AREA A: BRACKISH FORAMINIFERA (X = SEVERAL SPECIMENS, XX = COMMON). ECOLOGY: TIDAL ACCESS. ESTUARINE BRACKISH SALTMARSH OR MUDFLAT FAUNA (OR NEARBY SALTMARSH COMPONENT, REWORKED VIA SALT EXTRACTION INDUSTRY)

SEQUENCE		1					6	8	12						14			19						
CONTEXT		1132	1143	1144	1077	1145	1588	1997	1220	1198	1283	1352	1612	1381	5365	5414	5418	5651	5654	6236	6238	6375	6373 B	6379
SAMPLE		1005	1007	1007	1007	1007	1380	1133	1024	1025	1025	1026	1056	1056	1198	1198	1198	1298	1298	1364	1364	1365	1366	1366
Depth		5-10cm	G5 25-29cm	G4 29-31cm	G4a 32-35cm	G3 35-40cm	0-4cm	30-33cm	5-10cm	5-10cm	25-30cm	5-10cm	5-10cm	25-30cm	2-6cm	15-20cm	35-40cm	10-15cm	35-40cm	20-25cm	35-40cm	0-5cm	21-25cm	36-42cm
Agglutinating foraminifera of mid-high saltmarsh	***Jadammina macrescens***							xx		x			xx	xx		x	x							
	Trochammina inflata							xx		x	x		xx	xx	x			x	x	x	x	x	x	x
	Tiphotrocha comprimata							x																
	Miliammina fusca							x									x						x	
Calcareous foraminifera of low-mid saltmarsh and tidal flats	***Haynesina germanica***							xx		x														
	Ammonia (brackish) sp.							x																

TABLE 22.4. MICROFAUNA FROM AREA B (ORGANIC REMAINS RECORDED ON A PRESENCE (X)/ABSENCE BASIS)

SEQUENCE	25				
CONTEXT	4630	4639	4645	4647	4648
SAMPLE	4091	4091	4093	4093	4093
Depth	15-20cm	30-35cm	15-20cm	30-35cm	45-50cm
red clay	x	x			
charcoal/burnt organics	x	x	x	x	
brackish foraminifera	x	x	x	x	x
brackish ostracods	x		x		x
open estuarine/marine foraminifera	x	x			
fish/amphibian remains		x	x		
plant debris + seeds			x	x	x
insect remains			x	x	
molluscs			x		

TABLE 22.5: MICROFAUNA FROM AREA B. FORAMINIFERA (X = SEVERAL SPECIMENS, XX = COMMON).

	SEQUENCE	25				
	CONTEXT	4630	4639	4645	4647	4648
	SAMPLE	4091	4091	4093	4093	4093
	Depth	15-20cm	30-35cm	15-20cm	30-35cm	45-50cm
Agglutinating foraminifera of mid-high saltmarsh	***Trochammina inflata***	x			xx	xx
	Jadammina macrescens				x	x
Calcareous foraminifera of low-mid saltmarsh and tidal flats	***Haynesina germanica***	xx	x	x	x	x
	Ammonia (brackish) sp.	xx	x	x	x	x
	Elphidium williamsoni	x	x	x	x	
Essentially marine foraminifera, but able to penetrate outer estuaries	***Nonion depressulus***	xx	x			
	Elphidium gerthi	x				
	Lagena spp.	x				

TABLE 22.6: MICROFAUNA FROM AREA B. OSTRACODS (X = SEVERAL SPECIMENS, XX = COMMON).

SEQUENCE		25				
CONTEXT		4630	4639	4645	4647	4648
SAMPLE		4091	4091	4093	4093	4093
Depth		15-20cm	30-35cm	15-20cm	30-35cm	45-50cm
Brackish ostracods of tidal flats and creeks	***Cyprideis torosa***	x		x		
	Loxoconcha elliptica	x				
	Leptocythere porcellanea	x				x
Ecology		Tidal; saltmarsh and mudflats with outer estuarine component washed in		Tidal; brackish saltmarsh and mudflats		

TABLE 22.7: MICROFAUNA FROM PALAEOCHANNEL BOREHOLE OA3

	DEPTH	1-2m 5cm	1-2m 50cm	1-2m 85cm	2-3m 5cm	2-3m 32cm	2-3cm 64cm	3-4m 5cm	3-4m 53cm	3-4m 97cm
		1.05m	1.50m	1.85m	2.05m	2.32m	2.64m	3.05m	3.53m	3.97m
plant debris + seeds		x	x	x	x	x	x	x	x	x
insect remains		x	x	x	x	x	x	x	x	x
large diatoms (>75µ)		x	x	x	x	x	x	x	x	x
brackish foraminifera		x	x	x	x	x	x	x	x	x
brackish ostracods		x	x	x	x	x	x	x	x	x
outer estuarine/marine foraminifera		x	x	x	x	x	x	x	x	x
outer estuarine/marine ostracods		x	x	x	x	x	x	x	x	x
freshwater ostracods		x	x	x	x	x	x	x	x	x
molluscs				x		x	x	x	x	x
BRACKISH FORAMINIFERA										
	DEPTH	1-2m 5cm	1-2m 50cm	1-2m 85cm	2-3m 5cm	2-3m 32cm	2-3cm 64cm	3-4m 5cm	3-4m 53cm	3-4m 97cm
		1.05m	1.50m	1.85m	2.05m	2.32m	2.64m	3.05m	3.53m	3.97m
Agglutinating foraminifera of mid-high saltmarsh	***Jadammina macrescens***	*5 (2%)*	*21 (7%)*	*37 (8%)*	*19 (16%)*	*32 (5%)*	*65 (9%)*	*47 (6%)*	*50 (6%)*	*27 (4%)*
	Trochammina inflata	*4 (2%)*	*4 (1%)*	*8 (2%)*	*2 (2%)*	*7 (1%)*	*11 (2%)*	*11 (1%)*	*9 (1%)*	*12 (2%)*
Calcareous foraminifera of low-mid saltmarsh and tidal flats	***Haynesina germanica***	*163 (65%)*	*171 (58%)*	*119 (27%)*	*46 (38%)*	*318 (45%)*	*165 (24%)*	*231 (31%)*	*174 (22%)*	*128 (21%)*
	Ammonia (brackish) sp.	*15 (6%)*	*33 (11%)*	*70 (16%)*	*26 (21%)*	*79 (11%)*	*114 (17%)*	*87 (12%)*	*75 (9%)*	*70 (11%)*
	Elphidium williamsoni	*10 (4%)*	*12 (4%)*	*25 (6%)*	*6 (5%)*	*13 (2%)*	*13 (2%)*	*19 (3%)*	*29 (4%)*	*29 (5%)*
OUTER ESTUARINE & MARINE FORAMINIFERA										
	DEPTH	1-2m 5cm	1-2m 50cm	1-2m 85cm	2-3m 5cm	2-3m 32cm	2-3cm 64cm	3-4m 5cm	3-4m 53cm	3-4m 97cm
		1.05m	1.50m	1.85m	2.05m	2.32m	2.64m	3.05m	3.53m	3.97m
Essentially marine foraminifera, but able to penetrate outer estuaries	***Nonion depressulus***	*5 (2%)*	*8 (3%)*	*16 (4%)*	*3 (2%)*	*14 (2%)*	*34 (5%)*	*65 (9%)*	*39 (5%)*	*29 (5%)*
	Elphidium margaritaceum	*4 (2%)*	*3 (1%)*	*2 (<1%)*	*1 (<1%)*	*5 (<1%)*	*5 (<1%)*	*9 (1%)*	*8 (1%)*	*5 (<1%)*
	Lagena spp.	*1 (<1%)*		*4 (1%)*		*8 (1%)*	*10 (1%)*	*8 (1%)*	*6 (<1%)*	*6 (1%)*
	Elphidium gerthi			*9 (2%)*		*8 (1%)*	*12 (2%)*	*11 (1%)*	*8 (1%)*	*12 (2%)*
	miliolids			*5 (1%)*		*8 (1%)*	*12 (2%)*	*18 (2%)*	*21 (3%)*	*26 (4%)*
	Cyclogyra involvens			*2 (<1%)*		*3 (<1%)*	*2 (<1%)*	*2 (<1%)*	*2 (<1%)*	*9 (1%)*
	discorbids							*6 (<1%)*	*2 (<1%)*	*2 (<1%)*
	bolivinids							*4 (<1%)*		
BRACKISH OSTRACODS										
	DEPTH	1-2m 5cm	1-2m 50cm	1-2m 85cm	2-3m 5cm	2-3m 32cm	2-3cm 64cm	3-4m 5cm	3-4m 53cm	3-4m 97cm

		1.05m	1.50m	1.85m	2.05m	2.32m	2.64m	3.05m	3.53m	3.97m
Brackish ostracods of tidal flats and creeks	***Leptocythere lacertosa***	*32 (13%)*	*18 (5%)*	*98 (22%)*	*6 (5%)*	*132 (19%)*	*91 (13%)*	*98 (13%)*	*135 (17%)*	*73 (12%)*
	Loxoconcha elliptica	*3 (1%)*	*6 (2%)*	*7 (2%)*	*2 (2%)*	*12 (2%)*	*16 (2%)*	*7 (1%)*	*23 (3%)*	*8 (1%)*
	Leptocythere porcellanea	*2 (<1%)*	*2 (<1%)*	*10 (2%)*	*2 (2%)*	*27 (4%)*	*18 (3%)*	*26 (3%)*	*92 (11%)*	*77 (12%)*
	Cyprideis torosa		*2 (<1%)*	*2 (<1%)*		*4 (<1%)*	*3 (<1%)*	*5 (<1%)*	*3 (>1%)*	*4 (<1%)*
	Leptocythere psammophila			*5 (1%)*		*2 (<1%)*	*11 (2%)*	*9 (1%)*	*22 (3%)*	*16 (3%)*
	Leptocythere castanea			*4 (1%)*		*15 (2%)*	*20 (3%)*	*2 (<1%)*	*10 (1%)*	*11 (2%)*
OUTER ESTUARINE & MARINE OSTRACODS										
	DEPTH	1-2m 5cm	1-2m 50cm	1-2m 85cm	2-3m 5cm	2-3m 32cm	2-3cm 64cm	3-4m 5cm	3-4m 53cm	3-4m 97cm
		1.05m	1.50m	1.85m	2.05m	2.32m	2.64m	3.05m	3.53m	3.97m
Essentially marine ostracods, but able to penetrate outer estuaries	***Hirschmannia viridis***	*3 (1%)*	*5 (2%)*	*4 (1%)*	*4 (3%)*	*9 (1%)*	*12 (2%)*	*18 (2%)*	*17 (2%)*	*15 (2%)*
	Pontocythere elongata		*3 (1%)*	*4 (1%)*	*1 (<1%)*	*2 (<1%)*	*18 (3%)*	*10 (1%)*	*20 (2%)*	*4 (<1%)*
	Paradoxostoma spp.		*2 (<1%)*	*2 (<1%)*	*1 (<1%)*		*17 (2%)*	*6 (<1%)*	*6 (<1%)*	*20 (3%)*
	Hemicythere villosa		*2 (<1%)*	*2 (<1%)*	*1 (<1%)*		*5 (<1%)*	*5 (<1%)*	*5 (<1%)*	*4 (<1%)*
	Semicytherura spp.						*12 (2%)*	*16 (2%)*	*14 (2%)*	*13 (2%)*
	Carinocythereis whitei						*2 (<1%)*		*3 (>1%)*	
	Leptocythere tenera							*6 (<1%)*	*2 (<1%)*	
	Loxoconcha rhomboidea							*4 (<1%)*	*3 (>1%)*	*5 (<1%)*
	Heterocythereis albomaculata							*2 (<1%)*		*2 (<1%)*
FRESHWATER OSTRACODS										
	DEPTH	1-2m 5cm	1-2m 50cm	1-2m 85cm	2-3m 5cm	2-3m 32cm	2-3cm 64cm	3-4m 5cm	3-4m 53cm	3-4m 97cm
		1.05m	1.50m	1.85m	2.05m	2.32m	2.64m	3.05m	3.53m	3.97m
Freshwater ostracods	***Limnocythere inopinata***	*2 (<1%)*	*4 (1%)*	*1 (<1%)*	*2 (2%)*	*5 (<1%)*	*16 (2%)*	*19 (3%)*	*21 (3%)*	*9 (1%)*
	Ilyocypris sp.						*4 (<1%)*	*3 (<1%)*	*2 (<1%)*	*2 (<1%)*
	Cyclocypris ovum (RV>LV)								*3 (>1%)*	
	Pseudocandona sp. (juvs)								*3 (>1%)*	
COUNTS		[252]	[296]	[436]	[122]	[703]	[688]	[754]	[807]	[618]

Organic remains are recorded on a presence (x)/absence basis.

Foraminifera and ostracods are represented by full counts; an ostracod carapace is counted as 2

(Numbers in brackets indicate percentages of each foraminiferal and ostracod species within the total microfossil assemblage)

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