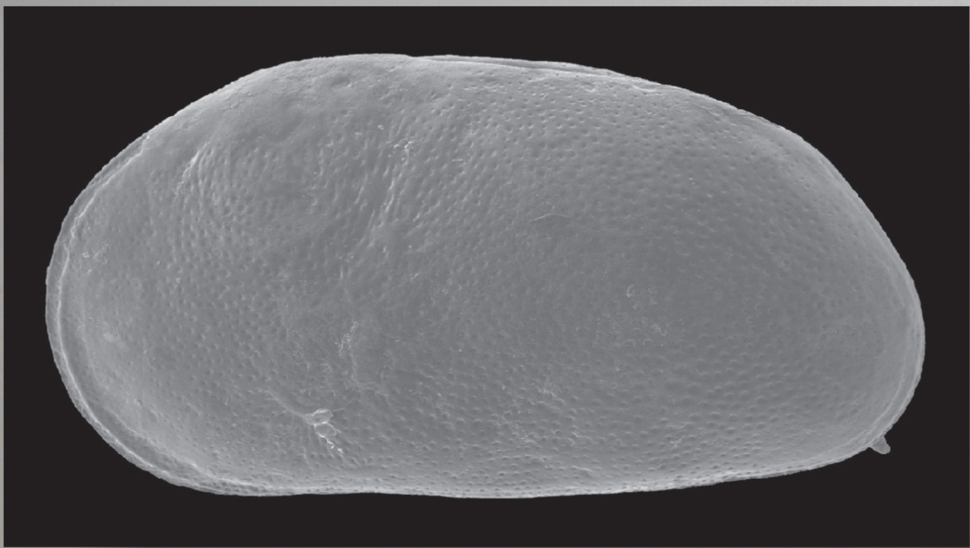
Wessex Archaeology

Project Nemo
UK-Belgium Electrical Interconnector
Richborough to West-Zeebrugge

Archaeological Stage 3 Sample Assessment



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October 2011

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UK-BELGIUM ELECTRICAL INTERCONNECTOR
RICHBOROUGH TO WEST-ZEEBRUGGE

ARCHAEOLOGICAL STAGE 3 SAMPLE ASSESSMENT

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The palaeoenvironmental sample assessments were carried out by Nigel Cameron, Michael Grant, Jack Russell, Chris Stevens and Sarah Wyles. The radiocarbon dating was undertaken at the Scottish Universities Environmental Research Centre (SUERC), East Kilbride under the supervision of Gordon Cook.

This report was written by Jack Russell and figures were produced by Kitty Brandon. The project was managed for Wessex Archaeology by Euan McNeill and quality assurance was provided by Nikki Cook and Euan McNeill.

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Summary

A series of samples have been assessed from vibrocore **VC7**. This vibrocore is located *c*.12km east of Ramsgate along the proposed route of the Project NEMO UK-Belgium Electrical Interconnector on the margins of a palaeochannel feature visible on geophysical data. The vibrocore has been chosen for archaeological Stage 3 assessment as it contained probable prehistoric terrestrial deposits, lying on the route of the proposed interconnector which had the potential to provide information as to the timing on marine transgression and the nature of the environment at that time.

The Stage 3 palaeoenvironmental assessment of the recovered core material was undertaken following a Stage 1 review of core logs to select a suitable sample and Stage 2 detailed logging and sub-sampling of the core. Stage 3 includes radiocarbon dating of samples and palaeoenvironmental assessment of suitable material for recovering floral (plants, charcoal, pollen and diatoms) and faunal (insects, molluscs, ostracods and foraminifera) remains.

The results of the palaeoenvironmental assessments show successive environments including an early Holocene freshwater channel and freshwater pool within a wooded river valley that has become progressively choked with vegetation. This woodland comprised pine and hazel with a possible highly significant and if confirmed internationally important record of beech. The increasing amounts of vegetation has lead to peat formation, with the two radiocarbon dates from the peat deposit indicating that this terrestrial environment dates from around *c*.10,000 years ago, equivalent the early Mesolithic archaeological period, a period of known human occupation on both sides of the North Sea where people were following a predominantly hunter gatherer lifestyle. Potential evidence of human activity in the form of charcoal which may have formed as a result of forest clearance by burning and/or the use of wood for fuel has been recovered from the sediments. The well preserved remains of pollen, ostracods, molluscs and foraminifera are considered to be highly significant in the understanding of this early Mesolithic environment. This peat deposit has been truncated by sea level rise with subsequent deposition evident of possibly late Mesolithic date within outer estuarine and shallow marine environments.

It is recommended that further Stage 4 analysis work on the molluscs, ostracods and pollen is undertaken. This should be supported by further radiocarbon dating of the sediments to discover the timing of deposition of significant sediments pertinent to understanding the potentially significant deposits within this vibrocore and the chronology of transgressive deposits in this area.

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1. INTRODUCTION

1.1.1. Wessex Archaeology was commissioned by PMSS to undertake a Stage 3 archaeological assessment of samples taken from vibrocore **VC7** (**Figure 1**), recovered during a programme of geotechnical investigations on the site of the proposed Project NEMO, UK-Belgium Electrical Interconnector. The proposed NEMO electrical interconnector cable will extend approximately 130 km between Pegwell Bay in Kent to the West-Zeebrugge in Belgium.

1.1.2. This work forms part of a staged process of mitigation proposals; Stage 1 and 2 were previously reported on within the archaeological desk based assessment (DBA) (Wessex Archaeology 2011).

1.1.3. The Stage 1 and 2 work comprised a review of core data which included a Stage 1 review of on-board sampling logs of 92 geotechnical vibrocores. 10 additional vibrocores were collected for Stage 2 recording which was undertaken at Wessex Archaeology during 2010 (Wessex Archaeology 2011).

1.1.4. Of these 10 vibrocores, vibrocore **VC7** was selected for this Stage 3 archaeological assessment as it contained deposits that were thought to relate to former, now submerged terrestrial environments. The presence of peat within the vibrocore highlighted the time when this area was dry land and suitable for human occupation, and its survival suggested high potential for the survival of other archaeological material. The deposits were thought to have the potential to contain both *in situ* and derived archaeological material, alongside preserved organic remains of potential importance to palaeoenvironmental studies (Wessex Archaeology 2011).

1.1.5. Vibrocore **VC7** is located *c*.12km east of Ramsgate within a palaeovalley feature identified within the geophysical survey work (Wessex Archaeology 2011). The corrected water depth below Lowest Astronomical Tide recorded on the vibrocore log was 26.2m below LAT. This depth has been converted to 28.78m below OD using the published figure of Chart Datum being 2.58 metres below Ordnance Datum (m below OD) at the port of Ramsgate (Admiralty Chart 1828). The location of the vibrocore is shown in **Figure 1** and in the table below:

Vibrocore	**WGS84 UTM Zone 31N**		**Depth**	
	Easting	Northing	mbLAT	mbOD
VC7	404296	5686691	26.2	28.78

1.1.6. This Stage 3 work comprises scientific (radiocarbon) dating and palaeoenvironmental assessment of selected samples from vibrocore **VC7**.

2. BACKGROUND

2.1. ARCHAEOLOGICAL WORK AND STAGES

2.1.1. The Desk Based Assessment (DBA) of the Project NEMO, UK-Belgium Electrical Interconnector contained a detailed archaeological background of the scheme area (Wessex Archaeology 2011) and is not repeated here. The DBA also detailed the results of the Stage 1 review of geotechnical data and a Stage 2 recording of 10 vibrocores. Sampling for this Stage 3 work was undertaken subsequent to the Stage 2 geoarchaeological recording. The stages of archaeological mitigation completed so far are outlined below:

- Stage 1: archaeological assessment of geotechnical logs – a review of all the vibrocore fieldwork logs (102) upon completion of the geotechnical ground investigation. Of these, ten were positioned specifically to assess sediments identified as having archaeological potential. The sediments described within the vibrocores were then correlated to the sedimentary units observed within the geophysical data;
- Stage 2: archaeological recording of available vibrocores (10) – detailed description of the sediments contained within the cores; identification of sediments with archaeological potential; interpretation of sedimentary descriptions to place them within a stratigraphic framework. The sediments described within the vibrocores were then assigned to sedimentary units based on the observed sedimentary characteristics and compared with the sub-bottom profiler geophysical survey data
- Stage 3: subsampling of vibrocores to retain material of archaeological interest for potential further assessment.

2.2. GEOLOGY AND GEOARCHAEOLOGY

2.2.1. The broad geological sequence across the entire Project NEMO, UK-Belgium Electrical Interconnector route from Pegwell Bay in Kent to the West-Zeebrugge in Belgium has been interpreted from the scheme geophysical and geotechnical survey data (Wessex Archaeology 2011) and with reference to the work of the British Geological Survey (Cameron *et al*. 1992). The interpreted geological sequence has been grouped (Wessex Archaeology 2011) into five units summarised in the table below.

Unit	Description
1	Recent (Holocene) seabed sediments, gravelly shelly sand.
2	Post-Devensian terrestrial and estuarine clay, silt and fine sand with organic inclusions and peat layers
3	Eocene clay (**London Clay Formation**)
4	Palaeocene sand and sandy clay (**Thanet Formation**)
5	Campanian (Upper Cretaceous) chalk

2.2.2. Not all of the sequence described above is present across the entire survey area, with some units being only sporadically present.

2.2.3. Vibrocore **VC7** is located within and on the eastern edge of a palaeochannel feature, numbered **WA7500** on the multibeam bathymetric data and on the sub-bottom profiler data (Wessex Archaeology 2011). The palaeochannel is delineated in a northwest to southeast direction and is approximately 250m in width. The channel can be traced for approximately 500 metres, the width of the multibeam bathymetric survey corridor at this location (**Figure 1**).

2.2.4. As the palaeochannel feature is visible on the multibeam bathymetric survey data, this indicates that the upper part of it (*c*.4m in depth) remains unfilled. The sub bottom profiler data indicates that up to 8m of sediment infill exists within the feature at its deepest point. The total depth of the feature (filled and unfilled) is approximately 12 metres.

2.2.5. At location **VC7** geaoarchaeological recording has recorded a sedimentary sequence comprising Chalk putty (**Unit 5/2**) overlain by channel edge alluvial and peat deposits (**Unit 2**) which are in turn overlain by recent (Holocene) seabed sediments (**Unit 1**). The recorded sediments and their depths below OD within vibrocore **VC7** are shown in **Figure 1** (photographic record), **Figure 2** (interpreted sedimentary log) and **Appendix 7** (detailed sedimentary descriptions). This sequence is summarised below with reference to the unitary interpretation in the table above.

Unit 5/2: Chalk putty (34.80 to 34.68m below OD)

2.2.6. This unit, recorded at the base of the sequence comprised a grey and white chalk mix with occasional flint inclusions. The unit was 0.18m in thickness, although was recorded at the base of the vibrocore and was not fully penetrated. The unit is interpreted as Upper Createaceous Chalk bedrock which has been periglacially weathered into “Chalk putty” probably during the last glacial period (Marine Isotope Stage 2 (MIS 2)), the Devensian.

Unit 2: Peat and Alluvium (34.68 to 31.19m below OD)

2.2.7. This unit can broadly be split into two subunits. From 34.68 to 34.08m below OD a 0.6m thick sequence of freshwater channel edge and peat deposits is recorded. The alluvial deposits are recorded from 34.68 to 34.48m below OD comprising organic and peaty silts indicative of relatively slow flowing, channel edge alluvial deposition. Above this from 34.38 to 34.08m below ODthere is a dark brown peat containing visible remains of *Phragmites* reeds and numerous molluscs. The peat is 0.3m in thickness and has been truncated with vertical molluscan burrows frequent upon its surface. These deposits have been interpreted as possible early post glacial/ early Holocene alluvium and peat.

2.2.8. The outer estuarine and shallow marine deposits overlying the peat are recorded from 34.08 to 31.19m below OD and comprise a 2.89 m thick sequence of grey silty sands and gravels. This part of the unit has been interpreted as indicative of Holocene outer estuarine and shallow marine deposition.

Unit 1. Sand and Gravel (31.19 to 28.78m below OD).

2.2.9. This unit, the uppermost deposit, comprised shelly sand and gravels and was 1.43m in thickness. Frequent marine molluscs were recorded within the sediment. The unit was interpreted as Holocene seabed sediment.

3. METHOD

3.1.1. Samples for palaeoenvironmental assessment (radiocarbon dating, pollen, diatoms, foraminifera, ostracods, plant macrofossils, charcoal, insects and molluscs) were taken from vibrocore **VC7**. This was undertaken subsequent to the Stage 2 recording.

3.1.2. Samples taken from vibrocore **VC7** were targeted at layers and depths thought to be of geoarchaeological and palaeoenvironmental interest. The positions of the samples are given on **Figure 2** and in **Appendix 7**. During the sampling for the Stage 3 work some extra sedimentary details were noted and these have been collated with the original sedimentary description (Wessex Archaeology 2011) and presented in **Appendix 7**.

3.1.3. The method of subsampling and processing of each sample is given in **Appendices 1-6**. The depth of each assessed sample is also given in **Appendices 1-6** and shown in **Figure 1**.

3.1.4. Radiocarbon dating samples were taken by carefully examining sediment under a microscope for suitable organic remains. Once identified the remains were carefully removed from the sediment, cleaned, identified and stored in glass tubes for delivery to the Radiocarbon dating facility at the at the Scottish Universities Environmental Research Centre (SUERC), East Kilbride, Scotland (**Appendix 1**).

3.1.5. Four samples of approximately 250 to 500cm^3 were taken for assessment of plant macrofossils, molluscs, charcoal and insects. The four samples were prepared at Wessex Archaeology, the details of which are given in **Appendices 3** and **5**.

3.1.6. Eight sediment samples for pollen assessment from approximately 4cm^3 were taken for pollen assessment. These were sent to the University of Reading for preparation, the details of which are given in **Appendix 2**.

3.1.7. Eight sediment samples for diatom assessment of approximately 4cm^3 were taken from the vibrocore. These were prepared for assessment at the Environmental Change Research Centre (ECRC), University College London, details of which are given in **Appendix 4**.

3.1.8. Eight samples for foraminifera and ostracod assessment approximately 10cm^3 were taken from the vibrocore. The samples were prepared for assessment at Wessex Archaeology, the details of which are given in **Appendix 6**.

4. RESULTS

4.1.1. This section summarises the results of the sample assessments. The full reports of the individual assessments, containing more detailed methodologies, discussions of results and recommendations, can be found in **Appendices 1-6**.

Radiocarbon Dating

4.1.2. Two samples were submitted for radiocarbon dating, from 34.13m and 34.38m below OD. The lower sample at 34.38m below OD comprised plant stems and returned a date of 8915±30 SUERC-36006 (8240-7960 cal. BC). The upper sample at 34.13m below OD dating returned a date of 8855±35 SUERC-36005 (8210-7820 cal. BC). These dates are equivalent to the early Mesolithic archaeological period. (**Appendix 1**).

Pollen

4.1.3. Eight samples were assessed for their pollen content (**Appendix 2, Figure 4**). Pollen was present in all eight samples

4.1.4. The base of the sampled sequence at 35.63m below OD contained evidence of dryland vegetation dominated by *Pinus sylvestris* (pine) and *Corylus avellana*-type (hazel) with *Betula* (birch) and *Salix* (willow) also important components. More localised wetland vegetation was represented by high percentages of Cyperaceae (sedges) and Poaceae (grasses) with aquatic pollen types such as *Potamogeton natans* (pondweed), *Sparganium erectum* (branched bur-reed) and *Sparganium emersum*-type (unbranched bur-reed) noted.

4.1.5. Above this (34.48m below OD to 34.13m below OD) a change was noted within the woodland taxa, with increases in *Ulmus* (elm) and *Quercus* (oak) recorded, along with a large increase in *Corylus avellana*-type (hazel). The unusual presence of *Fagus sylvatica* (beech) in the sample at 34.13m below OD was noted. Other species included *Thelypteris palustris* (marsh fern) and Chenopodiaceae (fat hen).

4.1.6. The samples from the overlying estuarine alluvial and shallow marine deposits contained higher percentages of *Quercus* (oak) and lower *Pinus sylvestris* (pine) and *Salix* (willow) (at 33.98m below OD) and at 33.00 and 31.58m below OD high percentages of *Corylus avellana*-type (hazel) with *Quercus* (oak) with *Ulmus* (elm) and *Betula* (birch) consistently present. At these levels Chenopodiaceae (fat hen), Cyperaceae (sedges) and Poaceae (grasses) are well represented, probably indicating local open salt marsh.

Waterlogged Plant Remains, Charcoal and Insects

4.1.7. Four samples (at 34.23 to 34.28m; 34.13 to 34.18m; 32.89 to 32.99m and 31.38 to 31.48m below OD) were assessed for their plant macrofossil, insect and charcoal content (**Appendix 3**). The sample at the base of the sequence contained numerous unidentified stem and root fragments and a single hazelnut (*Corylus*). Above this at 34.13 to 34.18m below OD some remains of reeds (*Phragmites*) and seeds of mint (*Mentha* spp.) were recovered. At 32.89 to 32.99m below OD no plant remains were recovered.

4.1.8. The uppermost sample at 31.38 to 31.48m below OD contained some plant root and stem fragments; additionally in this sample charcoal was recovered in small quantities, although the specimens were too small for identification purposes. No insect remains were recovered from any of the four samples. Insect remains are typically fragile and sometimes sparse within deposits thus reducing the possibility of their recovery within a vibrocore sample.

Diatoms

4.1.9. Eight samples (taken at 34.63m, 34.48m, 34.38m, 34.28m, 34.13m, 33.98m, 33.00m and 31.58m below OD) were assessed for their diatom content (**Appendix 4**). All eight samples were barren of diatoms except for a single valve of a freshwater diatom species *Synedra rumpens*, at 33.00m below OD which was though to be possibly contaminant within the sample as it was a singular occurrence of a fragile taxon.

Molluscs

4.1.10. Four samples (at 34.23 to 34.28m, 34.13 to 34.18m, 32.89 to 32.99m and 31.38 to 31.48m below OD) were assessed for their molluscan content (**Appendix 5**). The sample at the base of the sequence from 34.23 to 34.28m below OD contained no molluscs. At 34.13 to 34.18m below OD a range of shells of terrestrial and freshwater gastropod molluscs were recorded including *Bithynia tentaculata*, *Valvata cristata* and *Lymnaea truncatula.*

4.1.11. The assemblage from the upper samples at 31.38 to 31.48m and 32.89 to 32.99m below OD produced shell assemblages of marine and brackish water species including gastropods and bivalves including *Hydrobia* spp., cockle (*Cerastoderma* spp.), mussel (*Mytilus edulis*), *Bithynia* spp., Rissoidae, Scrobicularia/Tellina, top shell (*Gibbula* spp.) and barnacles.

Foraminifera and Ostracods

4.1.12. Eight samples (taken at 34.63m, 34.48m, 34.38m, 34.28m, 34.13m, 33.98m, 33.00m and 31.58m below OD) were assessed for their microfaunal content, predominantly foraminifera and ostracods (**Appendix 6**).

4.1.13. Foraminifera were present in the upper three of the eight samples, at (33.98m, 33.00m and 31.58m below OD). The foraminifera were abundant and well preserved in these samples and were dominated by shallow marine and outer estuarine forms including species of the genera *Ammonia*, *Elphidium* and Miliolids. Fossilised (Upper Cretaceous Chalk) foraminifera were present in the samples at 34.63m, 34.48m, 34.38m, and 34.13m below OD).

4.1.14. Ostracods were present in five of the eight samples (at 34.63m, 34.13m, 33.98m, 33.00m and 31.58m below OD). At 34.63m below OD a singular occurrence of the freshwater ostracod *Limnocythere* sp. was recorded. At 34.13m below OD an interesting and well preserved ostracod assemblage was recovered. The ostracods comprised freshwater Candoniid forms and also included the species *Notodromas monacha* and *Metacypris cordata*. The preservation of ostracods within peat deposits is unusual, with this fauna possibly indicative of a Holocene “cordata” fauna, suggesting environmental changes from oligotrophic to trophic conditions as noted in other North Western European lake deposits (Meisch 2000).

4.1.15. The upper three samples at (at 33.98m, 33.00m and 31.58m below OD) contained abundant and well preserved brackish and marine ostracod taxa including *Cyprideis torosa* (smooth form), *Hirschmannia viridis*, *Leptocythere* sp., *Loxoconcha* sp, *Semicytherura* sp., *Heterocythereis albumaculata*, *Leptocythere pellucida, Loxoconcha elliptica* and *Loxoconcha rhomboidea.*

5. DISCUSSION

5.1.1. The sedimentary descriptions, paleoenvironmental assessment, scientific and geophysical data at the location of vibrocore **VC7**, when viewed together, indicate an interesting sequence of deposition. It is not known when incision of the palaeochannel feature (**WA7000**) occurred. The base of the channel is elevated at around 36m below OD. Assuming that the channel is a terrestrial fluvial feature, as the palaeoenvironmental assessments suggest then incision must have occurred when relative sea level was at *c*. 40m below OD or lower. It is likely that the feature has been formed during a glacial period.

5.1.2. Whilst it is tempting to view the multibeam bathymetric data showing palaeochannel **7500** (**Figure 1**) as a relict terrestrial landscape it should be noted that the effects of sea level rise and marine processes may have had a significant effect on the morphology of the feature.

5.1.3. Vibrocore **VC7** is located on the eastern side of the channel where approximately 6 metres of sediment have accumulated. The Chalk bedrock at the base of the sequence has been periglacially frost weathered to form “chalk putty”. It is likely that this has occurred during the last, Devensian, glacial period (Marine Isotope Stage (MIS) 2). At the Devensian glacial maximum, sea levels were up to 120m below that of the present day (Siddal *et al*. 2003), see **Figure 3**. Britain at this time is thought to be uninhabited, with the earliest known reoccupation of Britain occurring at *c*.14,700BP (Jacobi and Higham 2009).

5.1.4. Subsequent deposition of, probably, early Holocene channel edge alluvial deposits are recorded within **VC7**. Faunal remains were generally sparse within the sample (although the occurrence of the ostracod *Limnocythere and* occasional molluscan remains including Planorbids and opercula of *Bithynia* (from within the foraminifera and ostracod samples) at 35.63m below OD indicate a slow moving, probably channel edge freshwater environment. The pollen from these levels was indicative of a fairly open surrounding environment containing some *Pinus sylvestris* (pine) and *Corylus avellana*-type (hazel) with *Betula* (birch) woodland, these taxa being typical of an early Holocene pollen assemblage. Poaceae (grasses), Cyperaceae (sedges), *Salix* (willow) and aquatic pollen and spores were recovered from the more localised wetland environment.

5.1.5. Increasing vegetation is recorded within the sedimentary sequence with the initiation of peat deposition. The radiocarbon dating of the peat at 34.38m (8240-7960 cal. BC) and at 34.13m below OD (8210-7820 cal. BC) indicates an early Mesolithic date for the peat which is corroborated by the woodland pollen taxa recovered (*Ulmus* (elm), *Quercus* (oak) and *Corylus avellana* (hazel)) which is typical for the period (Waller 1993, Birks 1989). A hazelnut was also recovered from these levels. The ostracods (*Notodromas monacha* and *Metacypris cordata*) and molluscs clearly indicate the on site environment evolving into a small, warm shallow, vegetated freshwater body, indicative of deposition within a warm, shallow, vegetated, still, freshwater body, possibly an ox-bow lake within a wider alluvial floodplain. The on site vegetation recorded at these levels included remains of *Phragmites australis* (common reed). An unusual occurrence of *Fagus sylvatica* (beech) was recorded from the sample at 34.13m below OD which is significant as it is at present not known in this period at these latitudes and is potentially of internationalimportance.

5.1.6. The two radiocarbon dates from the peat have been plotted against a relative sea level rise curve based upon Shennan and Horton (2002) and Siddal *et al*. (2003) (**Figure 3**). The elevation and dates are very close to the interpreted mean sea level for the period. It is noted that the peat has probably suffered from post depositional compaction which is likely to have reduced its elevation by up to 2 metres (Allen 2000).

5.1.7. The rapid sea level rise noted during the Mesolithic archaeological period is shown on **Figure 3**. This is recorded in the truncation of the freshwater peat deposit and subsequent deposition of outer estuarine and shallow marine deposits recorded within vibrocore **VC7** from 34.08m to 31.19m below OD. The molluscs, foraminfera and ostracods are together indicative of deposition in an outer estuarine environment of near to normal marine salinities at these levels. The pollen remains at these levels, whilst they differ from the underlying peat, are characteristically Mesolithic in date including *Corylus avellana* (hazel), *Quercus* (oak), *Ulmus* (elm) and *Betula* (birch). Some indication of surrounding saltmarsh was indicated by the presence of Chenopodiaceae (fat hen), Cyperaceae (sedges) and Poaceae (grasses) at these levels.

5.1.8. Other examples of offshore peat deposits include the submerged forest recorded at Cockleshell Hard on the eastern tip of the Isle of Grain (Devoy 1979, 1980 and 1982). More recent work on these deposits in advance of the BritNed High Voltage interconnecting electricity cable indicated a submerged forest at *c*.28.5 m below OD (Russell *et al*. 2011) This sequence contained pollen, diatoms, foraminifera, ostracods, molluscs, charcoal and waterlogged plants indicative of a submerged

Quercus (oak) and *Corylus avellana* (hazel forest) with the development of brackish creeks. Radiocarbon dating was undertaken on an oak (*Quercus* sp.) acorn cup, which returned a result of 8,018 ± 45 BP which calibrates to 9030-8720 cal. BP; 7080-6770 cal. BC, which is within the Early Mesolithic period (see **Figure 3**).

5.1.9. Work in advance of the electrical cable route for the London Array Offshore Windfarm has also recovered Mesolithic terrestrial environments in the form of saltmarsh peats at 15.08m below OD dated to 7680±35BP; (6600-6460 cal. BC; 8550 to 8400 cal. BP) and at 8.12m below OD dated to 6925±35 BP (5890-5730 cal. BC; 7840 to 7689 cal. BP) (Wessex Archaeology 2009). These dates are equivalent to the late Mesolithic period and are plotted on **Figure 3**) These offshore sequences from may correlate with the estuarine alluvial deposits overlying the peat within vibrocore **VC7**.

5.1.10. Although dating has not been undertaken on these sediments, it is conjectured that a wide embayment was present in the area during the later Mesolithic period (Coles 1998; Perkins 1998; Moody 2008) of which **VC7** would be located in the northern part.

5.1.11. The shallow marine deposits at the top of the core, whilst more recent in origin, are of note as they may have been originally part of shallow marine and or beach deposits.

5.1.12. The presence of charcoal (at 34.48m, 33.98m, 33.00m, 31.58m and at 31.38 to 31.48m below OD) is of note as it is possibly the result of anthropogenic burning in the area. The utilisation of fire during the Mesolithic is well known (Moore 2000) and charcoal thought to have been formed as the result of deliberate burning has been recovered in other offshore environments (Russell *et al*. 2011). The possibility however that the charcoal has formed as a result of natural processes such as lightning strikes is also noted.

5.1.13. Archaeological remains typical of the Mesolithic period have been recovered from offshore locations including Mesolithic tranchet axes from the Outer Thames Estuary and the North Kent Coast. These tranchet axes or adzes are known as Thames picks as many have been found in the Thames. Offshore finds of Thames picks listed in the Kent Historic Environment Register include one recovered by dredging 1.5km north east of Herne Bay pier (HER no.TR16 NE4) and one is thought to have been dredged up off Reculver in 1897 (HER TR26 NW22).

5.1.14. To set this most interesting sedimentary sequence into its regional and national archaeological context, it is worth noting that archaeological material becomes more frequent in Kent after *c*.8000BP and it is postulated that this may be either due to a real increase in population or a loss of lower-lying land (as is represented at the site of vibrocore **VC7** c.12km east of Ramsgate) due to sea level rise (Williams 2007). It is also at this time that Britain becomes and island and the uniquely British lithic industry (geometric microliths) appears.

6. RECOMMENDATIONS

6.1.1. The sequence recorded within vibrocore **VC7** is considered significant in the understanding of the drowned Mesolithic landscapes of the Southern North Sea and English Channel across which the proposed NEMO cable route traverses. For some elements of the assessment further work may be warranted. The proposed work constitutes a Stage 4 analysis. Typically this level of analysis would represent compensatory works as mitigation and would occur post development consent, subject to the view of the curator.

6.1.2. This recommended Stage 4 analysis of the sampled sequence is based upon standards and guidance set out regarding environmental archaeology (English Heritage 2011), geoarchaeology (English Heritage 2007), management of archaeological projects (English Heritage 2006) and the guidance for the renewable energy sector produced for COWRIE (Collaborative Offshore Wind Research into the Environment) entitled: "Offshore Geotechnical Investigations and Historic Environmental Analysis" (Gribble and Leather 2011).

6.1.3. The well preserved remains of pollen, ostracods, molluscs and foraminifera would benefit from Stage 4 analysis to fully understand the palaeoenvironment and in turn their archaeological significance. Stage 4 work including analysis (full counts) of selected assessed samples and further samples from specific depths is recommended for pollen, ostracods, foraminifera and molluscs. The specific analysis requirements are set out in the individual appendices.

6.1.4. Further radicarbon dating would support the analysis. Whilst the pollen data from the estuarine alluvial deposits suggests they were deposited during the Mesolithic period, pollen is not a suitable dating method and this inference should be supported by further scientific dating.

6.1.5. Stage 4 will produce an account of the successive environments within the coring area, a model of environmental change over time, and an outline of the archaeological implications of the analysis. It is envisaged that the Stage 4 analysis will specifically provide information on past landscapes, possible prehistoric activity (charcoal and microcharcoal), the chronology of marine inundation of the area (radiocarbon dating, molluscs, ostracods and foraminifera), the local ecology (pollen, molluscs, ostracods and foraminifera) and the composition of the surrounding woodland plants (pollen) including the potentially internationally significant early record of *Fagus sylvatica* (beech).

6.1.6. It is recommended that these Stage 4 analytical results should then be disseminated for consumption by the public, stakeholders and heritage professionals. If warranted, the results should be worked up into a publication within a suitable academic journal. This publication should take into account the geotechnical investigations on site and the subsequent dating and environmental analyses. Documentary research and comparison with available data in order to enhance the understanding of the site on the basis of analytical results within its local and national context should be undertaken as part of this process.

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APPENDIX 1: RADIOCARBON DATING

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Introduction

Two samples of suitable material from waterlogged sub-samples within vibrocore **VC7** were extracted for radiocarbon dating. In the case of the upper sample from 5.35m, the material comprised fragments of common reed (*Phragmites australis*) stems. In the lower sample the material was of unidentified stem material.

The samples were identified and submitted to the Scottish Universities Environmental Research Centre, East Kilbride (SUERC) for radiocarbon dating.

Results

The radiocarbon determinations were calibrated using OxCal 4.1.7 (Bronk Ramsey 2001; 2009) and the IntCal09 calibration curve (Reimer et al. 2009) and are quoted in the form recommended by Mook (1986) with the end points rounded outward to 10 years (**Table 1; Figure 4**).

The results were broadly similar and although the slightly older date was in the sample below the dates are statistically consistent (χ^2 Test: T'=1.7; T' (5%) = 3.8; df-1; Ward and Wilson 1978).

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Depth	Identification	Laboratory Code	δ^{13}C	Date BP	calibration (2 sig. 95.4%)
Vibrocore VC7					
34.13m below OD (5.35m)	Stem of *Phragmites australis*	SUERC-36005	-25.0 (assumed)‰	8855±35	8210-7820 cal. BC 10160-9770 cal. BP
34.38m below OD (5.60m)	Indet. waterlogged stem	SUERC-36006	-28.7‰	8915±30	8240-7960 cal. BC 10190-9910 cal. BP

Table 1 Radiocarbon determinations from Vibrocore VC7

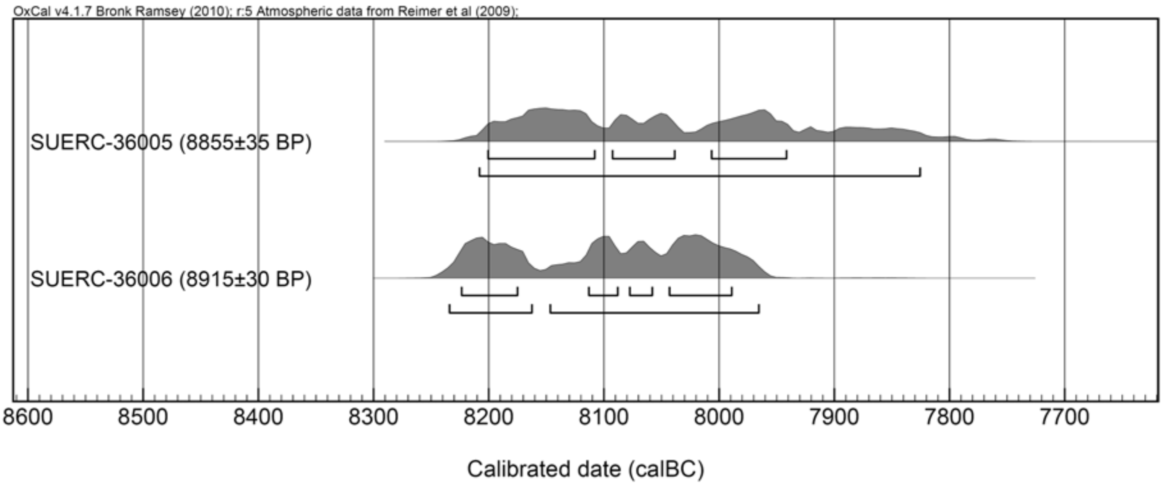

Figure 1 Probability distribution for dates from Vibrocore VC7

APPENDIX 2: POLLEN ASSESSMENT

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Introduction

A pollen assessment has been undertaken upon pollen samples from vibrocore **VC7**, a sediment core taken during geotechnical investigations in the area of the NEMO UK to Belgium interconnecting cable route in the English Channel off East Kent. This report contains the results of the assessment upon these samples and provides recommendations for future work.

Methods

Pollen assessment is used to provide information on pollen assemblages from past environments. When a stratified sequence of sediment is investigated, pollen analysis can show how the pollen arriving at the site of deposition has varied over a given time period, and therefore allow interpretations relating to climate change, vegetation history, human activity and the modification of the local environment. Pollen can be preserved in a range of environments, but preservation is principally determined by whether they are anoxic, such as sediments deposited in lakes, fens, mires and buried soils.

Standard preparation procedures were used (Moore *et al*. 1991). 2cm^3 of sediment was sampled, with a *Lycopodium* spike (2 tablets from batch 1031) added to allow the calculation of pollen concentrations. All samples received the following treatment: 20 mls of 10% KOH (80°C for 30 minutes); 20mls of 60% HF (80°C for 120 minutes); 15 mls of acetolysis mix (80°C for 3 minutes); stained in 0.2% aqueous solution of safranin and mounted in silicone oil following dehydration with tert-butyl alcohol.

Pollen counting was done at a magnification of x400 using a Nikon SE transmitted light microscope. Determinable pollen and spore types were identified to the lowest possible taxonomic level with the aid of a reference collection kept at Wessex Archaeology. The pollen and spore types used are those defined by Bennett (1994; Bennett *et al*., 1994) with the exceptions given below, with plant nomenclature following Stace (1997). A total land pollen (TLP) sum has been adopted in this study excluding obligate aquatics, pteridophytes (includes club moss, horsetails and ferns) and bryophyta (mosses). The desired TLP sum during assessment was a minimum of 100 grains. The pollen diagram was drawn using Tilia v 1.7.16 (Grimm, 1991) (**Figure 4**).

Results

Results of the assessment are described below and shown in **Figure 4**. Pollen samples were obtained through a range of different sediment types (organic and inorganic) which originated from both freshwater and brackish / marine environments.

The base of the pollen diagram show a dryland vegetation dominated by *Pinus sylvestris* (pine) and *Corylus avellana*-type (hazel) with *Betula* (birch) and *Salix* (willow) also important components. High percentages of Cyperaceae (sedges; up to 24%) and Poaceae (grasses; up to 19%) suggest that the local area is fairly open and, in combination with the presence of aquatic pollen types *Potamogeton natans* (pondweed), *Sparganium erectum* (branched bur-reed) and *Sparganium emersum*-type (unbranched bur-reed), these are likely to be derived from the local wetland vegetation, of which *Salix* may also be a component.

Above 34.48m below OD there is a change in the woodland taxa, with increases in *Ulmus* (elm) and *Quercus* (oak) recorded, along with a large increase in *Corylus avellana*-type. This marks the arrival of these taxa into the UK during the early Mesolithic, collaborated by the radiocarbon dates at 34.38 and 34.13m below OD (**Appendix 1**) of *c.* 10,000 cal. BP. This date is comparable with dated terrestrial sequences from south east England such as Pannel Bridge, East Sussex (Waller 1993) and shown in Birks (1989). Pollen concentrations are highest at 34.38 m below OD coinciding with the base of the peat, and decrease above this as the minerogenic component increases in the overlying sediments.

At 34.13m below OD there is a peak in Pteropsida (monolete) indet. spores (41% TLP + Pteridophytes) which coincides with a peak in *Thelypteris palustris* (marsh fern; 27% TLP + Pteridophytes). The preservation of the outer perine coating on the later allowed their identification and it is likely that most of the Pteropsida (monolete) indet. also originate from *Thelypteris palustris*. Increases in Chenopodiaceae (fat hen) from this level may be related to the influence of local brackish conditions.

Of notable interest in this sample was the presence of two grains of *Fagus sylvatica* (beech). Pollen-based reconstructions of the *Fagus sylvatica* distribution at that time indicate that it was only present in south east Europe close to its glacial refugia and often do not arrive in the UK until *c.* 3000 cal. BP. However, studies in southern Britain (Grant *et al.* 2009a) have suggested that it might have arrived in the Hampshire Basin by 8500 cal. BP. Giesecke *et al.* (2007) simulated the European distributions of *Fagus* for 6000 years ago using a physiologically-based bioclimatic model driven by different atmospheric general circulation models and found that *Fagus sylvatica* had the potential to be as widespread 6000 years ago as it is today, which gives a profound mismatch with pollen-based reconstructions of the *Fagus* distribution at that time. Therefore the presence of this taxon at this time is worthy of further investigation to check whether it is simply a chance occurrence (long distance transport, contamination, *etc*) or represented throughout these samples which would be extremely significant.

A truncation of the sedimentary sequence occurs at 34.08m below OD where the upper peat contact has been eroded by wave action and estuarine alluvium has been deposited over it. The pollen assemblage at 33.98m below OD is notably different to those underlying, with higher percentages of *Quercus* and lower *Pinus sylvestris* and *Salix*. The pollen sequence looks to be characteristic of one from the Mesolithic though without any independent chronological data it is uncertain the exact date or indeed the extent of the truncation. Overlying pollen samples show a high presence of *Corylus avellana*-type and *Quercus* with *Ulmus* and *Betula* consistently present. *Alnus glutinosa* (alder) also increases, though the date for the expansion of *Alnus* is highly variable throughout the UK (Chambers and Elliott 1989; Tallantire 1992), but locally is known to range from *c.* 9500 cal. BP at Tilbury, Essex (Devoy 1979) to 7000 cal. BP at Bramcote Green, Central London (Thomas and Rackham 1996). There is little diversity in the herb taxa, with Chenopodiaceae, Cyperaceae and Poaceae well represented probably indicating local open salt marsh. The continuation of high amounts of woodland taxa is surprising given the thick estuarine alluvium deposits from which these samples were derived, possibly indicating that little of this pollen is locally derived but instead transported from further afield, which is consistent with the low pollen concentrations throughout the top three pollen samples. However, the tree taxa represented are likely to suggest that the alluvium is also Mesolithic in date.

Potential

The pollen sequence assessed from this vibrocore is potentially of great significance. The expansion of *Ulmus* and *Quercus* within the peat provides a key pollen-stratigraphic marker for the arrival of these taxa in the UK after the last glaciation which is poorly represented and dated in many terrestrial records from south east England (see Waller 2002, 15). The early appearance of *Fagus sylvatica* accompanying the expansion of *Quercus* is also of great international interest as it would show much faster migration rates of this taxon from its glacial refugia during the last glaciation and have implications for understanding early Holocene woodland dynamics.

The succession from *Pinus-Corylus* to *Corylus-Quercus-Ulmus* woodland is also likely to be associated with a charcoal signal as has been recognised in other southern Britain sequences where investigated – *e.g*. Cranes Moor, New Forest (Grant *et al.* 2009b) and Romney Marsh, East Sussex (Grant and Waller 2010) which may be indicative of either natural fire regimes or human activity, the later implied elsewhere in the Thames (*e.g*. Russell *et al.* 2011).

Without any chronological control, the samples above the eroded peat contact (34.08mbOD) are of little potential.

Recommendations

The basal part of the sequence (the bottom 6 samples) are of both local and international importance archaeologically and may warrant being taken to full analysis, including closer sampling intervals. It is recommended that these 6 samples are supplemented with a further 8 samples and also analysed for micro-charcoal concentrations to assess any fire activity which might be occurring in conjunction with the changing vegetation. Closer sampling should be focused predominantly within the peat unit (34.08 - 34.38m below OD) where the main changes are occurring and to also ascertain whether the appearance of *Fagus sylvatica* pollen was an isolated occurrence or not. An additional radiocarbon date should also be obtained from the peat to date more firmly the vegetational changes.

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APPENDIX 3: WATERLOGGED PLANT, CHARCOAL AND INSECT ASSESSMENT

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Introduction

Four samples were selected from Project NEMO for the assessment of waterlogged plant remains, charcoal and insect remains from vibrocore **VC7**.

Samples of 250 to 500ml were taken from four points within vibrocore **VC7** (see **Table 1**). The samples were processed for the recovery of mollusca, plant remains insects and charcoal.

Methods

The samples were processed by wet-sieving using a 0.25mm mesh size. The samples were visually inspected under a x10 to x40 stereo-binocular microscope to determine if waterlogged plant remains, charcoal or insects were preserved.

Results

Organic material comprising fragments of stems and rootlets, possibly of brackish or estuarine plants, but equally within at least that from 31.38-31.48m below OD may come from marine algae (seaweed), were recorded from three of the samples.

A single hazelnut (*Corylus avellana*) shell was recovered from 34.23-34.28 m below OD, while a few seeds of mint (*Mentha* spp.) were recorded at 34.13-34.18m below OD. The hazelnut is of some interest as it is likely to come from local plants growing near the source area. Hazel becomes a common component of Early Mesolithic mixed pine woodland and in wetter areas may have been the dominant tree species. Many species of mint (*Mentha* sp.) are found in wetland environments and seeds of this species are a common component of more open riverine environments, although it can be found also on open riverbanks growing adjacent to scrub or woodland.

A small quantity of charcoal fragments were observed at 31.38-31.48m below OD.

No remains of insects were seen within the samples.

Recommendations

No further recommendations are proposed for this material.

Vibrocore	VC7	VC7	VC7	VC7
mbOD	31.38 - 31.48	32.89 - 32.99	34.13 - 34.18	34.23 - 34.28
Depth in core	2.60 -2.70	4.11-4.21	5.35-5.40	5.45-5.50
Volume	0.5l	0.4l	0.25l	0.25l
Processed sample size	175 ml	175 ml	100 ml	50 ml
Seeds				
small frags of *Phragmites* stem/root			+	
small stem/root frags	+			++
Mentha spp.			3	
Corylus avellana				1
Charcoal	+			

Table 1 Plant remains and Charcoal from VC7

APPENDIX 4 DIATOM ASSESSMENT

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Introduction

Eight sediment sub-samples from 73391 Project NEMO have been prepared and assessed for diatoms. The eight samples for diatom evaluation were taken from one vibrocore, **VC7**. The location of **VC7** was in The Dover Strait approximately 12km east of Ramsgate. The sediments in the **VC7** sequence comprise peat, alluvium and shallow marine sediments (Jack Russell pers. comm.)

The purpose of the diatom assessment of the NEMO **VC7** sequence is to understand the presence or absence of diatoms within the sequence and the potential of the sediments for further diatom analysis. It is hoped that, if present, the diatoms will inform upon sea level and local environment along with possible comment on chronology, climate and hydrology (Jack Russell pers. comm.). The diatom assessment of each sample takes into account the numbers of diatoms, the state of preservation of the diatom assemblages, species diversity and diatom species environmental preferences.

Methods

Diatom preparation followed standard techniques (Battarbee 1986, Battarbee *et al.* 2001). Two coverslips were made from each sample and fixed in Naphrax for diatom microscopy. A large area of the coverslips on each slide was scanned for diatoms at magnifications of x400 and x1000 under phase contrast illumination.

Results & Discussion

The laboratory diatom sample numbers and sample depth below the seabed are shown in **Table 1**. The results of the diatom evaluation for the **VC7** sequence are summarised in **Table 2.**

Vibrocore	**Diatom Sample Number**	**Sample Depth (m) below seabed**
VC7		
	D1	2.80
	D2	4.22
	D3	5.20
	D4	5.35
	D5	5.50
	D6	5.60
	D7	5.70
	D8	5.85

Table 1. Samples selected for diatom evaluation from 73391 Project NEMO VC7

Diatom Sample No.	Diatoms	Diatom numbers	Quality of preservation	Diversity	Assemblage type	Potential for % count
D1	-	-	-	-	-	none
D2	- *	-	-	-	-	none
D3	-	-	-	-	-	none
D4	-	-	-	-	-	none
D5	-	-	-	-	-	none
D6	-	-	-	-	-	none
D7	-	-	-	-	-	none
D8	-	-	-	-	-	none

Table 2. Summary of diatom evaluation results for 73391 Project NEMO VC7 (- absent, * see text)

Vibrocore VC7

Diatoms are absent from all of the eight sub samples (D1-D8) assessed from VC7. The exception is in sample D2 (4.22 m) where a single valve of a freshwater diatom species *Synedra rumpens*, was recorded. However the unique occurrence of this relatively lightly silicified species suggests that the valve is a contaminant on the slide.

The absence of diatoms may reflect unfavourable conditions for diatom silica preservation (Flower 1993, Ryves *et al.* 2001). Given the ubiquity of diatoms in natural water bodies, the poor preservation, absence or low numbers of their remains from the sediment samples assessed here can be attributed to taphonomic processes. This may be the result of diatom silica dissolution and breakage caused by factors such as high sediment alkalinity, high acidity, the under-saturation of sediment pore water with dissolved silica, cycles of prolonged drying and rehydration, or physical damage to diatom valves from abrasion or wave action.

It is not therefore possible to comment on the salinity or other aspects of the aquatic environment. There is no further potential for diatom analysis of these samples.

Conclusions

1. Diatoms are absent from the eight samples assessed from VC7. There is therefore no further potential for diatom analysis of these samples.
2. The absence of diatom assemblages from water-lain sediments is attributed to taphonomic processes.

Acknowledgements

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APPENDIX 5: MOLLUSC ASSSESSMENT

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Wessex Archaeology

Introduction

Four samples were selected for the assessment of the preserved molluscan remains from vibrocore **VC7** from Project NEMO.

The samples of between 250 and 500 ml were taken from four points within the vibracore (see Table 1). The samples were processed for the recovery of mollusca and plant remains.

Methods

The samples were processed through wet-sieving through a sieve of 0.25mm mesh sizes. The samples were visually inspected under a x10 to x40 stereo-binocular microscope to determine if molluscs were preserved. Where molluscs were present, preliminary identifications and quantifications of dominant taxa were conducted and are presented below. Habitat preferences follow those described by Kerney (1999) and Barrett and Yonge (1958).

Results

The sample from **VC7** at 34.23 - 34.28m below OD contained no shells.

The mollusc assemblage observed in the sample from **VC7** at 34.13 – 34.18m below OD contained a range of fresh-water species together with a few land snails. No marine or brackish shells were recorded. The land snails were all species which can be found in marshy/ damp grassland environments.

The freshwater species included species which favour well vegetated, slowly flowing aquatic environments with muddy substrates, such as *Bithynia tentaculata* and *Valvata cristata. Lymnaea truncatula* is more reflective of areas of temporary flooding and marshy grassland.

The samples obtained from **VC7** at 31.38 to 31.48m and 32.89 to 32.99m below OD produced shell assemblages of marine and brackish water species. The predominant shells recovered within the samples were those of *Hydrobia*, including those of *ulvae*. There were also a number of shells of cockle (*Cerastoderma* spp.), of the Rissoidae family, of Scrobicularia/Tellina type, mussel (*Mytilus edulis*), top shells (*Gibbula* spp.) and barnacles. There was also a small scallop (*Chlamys* type) recorded in the upper sample and a dog whelk (*Nassarius* sp.) in the lower sample.

Hydrobia ulvae is typically found on muddy or silty surfaces in estuaries, intertidal mudflats and saltmarshes and is restricted to brackish or salt water. *Scrobicularia* and *Tellina* can inhabit thick mud and muddy sand in estuarine and intertidal conditions, whereas mussels tend to inhabit rocky open shores or rocks within sheltered harbours and estuaries. Small scallops can be recovered from the middle shore or below while cockles can be found in sandy mud on the middle shore or below. Rissoidae can favour shallow marine environments.

Discussion

The habitats of the molluscs within the assemblages from **VC7** may be indicative of a muddy outer estuarine and shallow marine environment at 31.38-32.99m below OD.

There is a marked transition from this environment to a fresh-water environment reflected in the sample from 34.13 to 34.18 m below OD. In this sample, the mollusc assemblage may be indicative of a slowly flowing well vegetated body of fresh-water possibly with a muddy substrate with an area of marshy grassland in the vicinity. There is no indication of any tidal influences within the aquatic environment at this depth. There is the potential that analysis of the mollusc assemblage from 34.13-34.18 m below OD would assist in defining the nature of the fresh-water environment to a greater extent.

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Vibrocore	VC7	VC7	VC7	VC7
Metres below OD	31.38 - 31.48	32.89 - 32.99	34.13 - 34.18	34.23 - 34.28
Depth in core	2.60 -2.70	4.11-4.21	5.35-5.40	5.45-5.50
Volume	0.5l	0.4l	0.25l	0.25l
Processed sample size	175 ml	175 ml	100 ml	50 ml
Land Snails				
Carychium sp.			C	
Succinea/Oxyloma sp.			C	
Vertigo sp.			C	
Fresh Water Snails				
Valvata cristata			A	
Bithynia tentaculata			A	
Bithynia leachii			C	
Bithynia operculum			A	
Lymnaea truncatula			A	
Lymnaea peregra			A	
Lymnaea spp.			A	
Planorbis planorbis			A	
Anisus spp.			A	
Bathyomphalus contortus			B	
Gyraulus crista			A	
Hippeutis complanatus/ Segmentina nitida			B	
Planorbids			A	
Pisidium spp.			B	
Marine and Brackish- Water Shells				
Hydrobia ulvae	+	+		
Hydrobia spp.	++	+		
Tellina/Scrobicularia type	+	+		
Cockle (*Cerastoderma* spp.)	+	+		
Barnacle	+	+		
Mussel (*Mytilus edulis*)	+	+		
Rissoidae	+	+		
Small scallop (*Chlamys* type)	+			
Dog whelk (*Nassarius* sp.)		+		
Top shell (*Gibbula* spp.)	+	+		
Total shells	+ 100	+50	+ 100	0

Key A = 10+ shells, B = 5-9 shells, C = <5 shells, + = low shell numbers, ++ moderate shell numbers

Table 1 Molluscs from VC7

APPENDIX 6: FORAMIFERA AND OSTRACOD ASSESSMENT

Jack Russell
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Introduction

Eight sediment subsamples from vibrocore **VC7** taken during geotechnical investigations in the area of the NEMO UK to Belgium interconnecting cable route in the English Channel off East Kent have been assessed for the presence and environmental significance of their microfaunal contents, predominantly foraminifera and ostracods. The samples consisted of clay, silt, sand and peat deposits elevated at 33.63m, 34.48m, 34.38m, 34.38m, 34.13m, 33.98m, 33.00m and 31.58 m below OD.

Ostracods occurred in 5 of the 8 samples and foraminifera occurred in 6 of the 8 samples. Both ostracods and foraminifera, where present, were generally well preserved. Other plant and animal remains were also recovered from the samples and note has been made of their occurrence.

Method

Sediment samples of *c*.25g were diaggregated in a weak solution of Hydrogen Peroxide and water, then wet sieved through a 63µm sieve. The sediment was dried and sieved through 500µm, 250µm, 125µm sieves. Microfossils were picked out under 10-60x magnification and transmitted and incident light using a Vickers binocular microscope. Specimens were extracted and placed in card slides for identification. Identification and environmental interpretation of ostracods follows Athersuch *et al*. (1989) and Meisch (2000); and that of foraminifera of Murray (1979; 1991).

Results

Abundance and presence/absence of microfaunal remains within the samples is summarised below and in **Table 1**.

At 33.63m below OD a few ostracods were recovered although these were predominantly fossilised forms. One specimen of the genus *Limnocythere* was recovered. Foraminifera were also recovered and these were also (Upper Cretaceous) fossilised forms. Other remains within the sample included plants and molluscs (Planorbids and one opercula of *Bythinia*).

At 34.48m below OD no ostracods were recovered. A few fossilised Upper Cretaceous foraminifera were recovered. Other remains within this sample included Planorbid molluscs and a small animal bone.

At 34.38m below OD no ostracods were recovered. A few fossilised Upper Cretaceous foraminifera were recovered. Other remains with the sample included molluscs (Planorbids and *Bithynia*) a small bone and plants including an oognium of the freshwater plant *Chara.*

At 34.38m below OD no ostracods or foraminfera were recovered. Other remains within the samples included frequent plant remains (including a small piece of wood) and some small, fragmented possible insect parts.

At 34.13m below OD an interesting and well preserved ostracod assemblage was recovered. The ostracods comprised Candoniid forms and the species *Notodromas monacha* and *Metacypris cordata*. These were often represented by united carapaces. One fossilised (Upper Creatceous?) ostracod was recovered. Other remains within the sample included highly abundant plant remains and frequent occurrence of Planorbid molluscs. Some opercula of *Bithynia* were also recovered.

At 33.98m below OD ostracods were relatively abundant and well preserved. Taxa recovered included *Cyprideis torosa* (smooth form), *Hirschmannia viridis*, *Leptocythere* sp., *Loxoconcha* sp and *Semicytherura* sp. Foraminifera were abundant and well preserved within the sample and included species of the genera *Ammonia* and *Elphidium*, *Astergerinata mamilla*, *Haynesina germanica*, *Jadammina macrescens* and Miliolids. Other remains within the sample included molluscs (*Cerastoderma edule*, Hydrobids and *Gibbula* sp.), sponge spicules and charcoal.

At 33.00m below OD ostracods were relatively abundant and well preserved. The fauna was dominated by *Cyprideis torosa* (smooth form) with other species present including *Hemicythere villosa*, *Heterocythereis albumaculata*, *Leptocythere pellucida, Loxoconcha elliptica* and *Loxoconcha rhomboidea*. Foraminifera were highly abundant within the sample and well preserved. Taxa recovered included species of the genera *Ammonia* and *Elphidium*, *Lagena semistriata*, *Haynesina germanica*, *Jadammina macrescens* and Miliolids. Other remains within the sample included molluscs (*Cerastoderma edule*, Hydrobids, *Ostrea edulis* and ?*Pholas* sp..) and charcoal.

At 31.58m below OD ostracods were relatively abundant and well preserved. Taxa recovered included *Cyprideis torosa* (smooth form), *Loxoconcha rhomboidea* and specied of the genera *Heterocythereis*, *Leptocythere* and *Propontocypris*.
Foraminifera were highly abundant within the sample and well preserved. Taxa recovered included species of the genera *Ammonia* and *Elphidium*, *Haynesina germanica*, *Jadammina macrescens, Lagena* sp. and Miliolids. Other remains within the sample included molluscs (*Cerastoderma edule* and Hydrobids) and plants (including charcoal and a seed).

Discussion
Of the samples at the base of the sequence from 33.63 to 34.28m below OD little can be said regarding their ostracod and foraminiferal content. The foraminifera and ostracods recovered were predominantly Upper Cretaceous forms, no doubt reworked from the underlying Chalk bedrock. One singular occurrence of the ostracod *Limnocythere* sp. at 33.63m below OD hints at the non marine “freshwater” depositional environment indicated by the other remains such as Planorbid molluscs and the opercula and apices of the mollusc *Bithynia*. The presence of *Bithynia* at (at 33.63 and 34.38m below OD) is of interest as *Bithynia* is generally confined to temperate environments. Plant remains were noted to become more frequent up profile. A shallow, vegetated, channel edge, backwater possibly periodically cut-off freshwater environment is tentatively interpreted at these levels.

At 34.13m below OD the sample contained a most interesting ostracod fauna. The presence of the ostracods*, Notodromas monacha* and *Metacypris cordata* indicate deposition within a warm, shallow, vegetated, still, freshwater body. This assemblage is likely to relate to a post-glacial/early Holocene “cordata” fauna inidcative of environmental changes from oligotrophic to trophic conditions noted in North Western Europe lake deposits (Meisch 2000 p.452).

The upper three samples at 33.98m, 33.00m and 31.58m below OD contain similar assemblages indicative of a marine transgression at these levels. The foraminifera are dominated by Rotaliid forms such as *Ammonia* and *Elphidium* with significant numbers of Miliolids (*Miliolinella* and *Quinqueloculina*). Some specimens of the ecophenotypical variant of *Ammonia beccarrii* with the distinctive umbilical boss, (*Ammonia batavus*) indicate a marine connection and together the foraminifera indicate an estuary mouth depositional environment at near to normal marine salinities. The ostracods at these levels are dominated by the smooth form of *Cyprideis torosa* including adult and instar stages and some united carapaces. This ostracod is known as an indicator of estuarine environments capable of withstanding extreme fluctuations in salinity. *Cyprideis torosa* is a euryhaline taxon that can occur in freshwater to hypersaline conditions (60‰) (Meisch 2000). Other ostracods (mostly represented by a few valves) indicative of a range of environments including shallow marine *(Loxoconcha rhomboidea* and *Leptocythere pellucida*), estuarine (*Loxoconcha elliptica* and *Hirschmannia viridis*) and shallow sublittoral and intertidal (*Hemicythere villosa*) together support the interpretation of an estuary mouth.

Recommendations

Stage 4 analysis of the samples is recommended. Further investigation of the assessed samples including taxonomic work should be undertaken. Further samples at closer intervals and analysis of these including identification and abundances of species of both foraminifera and ostracods is recommended in order to further refine the environmental interpretations given here.

Further samples should be taken between 33.98m and *c*.34.00m below OD in order to identifiy any of the changes associated with the freshwater and estuarine environments at these levels.

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Ostracods / m below OD	33.63	34.48	34.38	34.28	34.13	33.98	33.00	31.58
Candona sp.						o		
Candoniids					x			
Cyprideis torosa smooth						x	xx	xx
Hemicythere villosa							x	
Heterocythereis albumaculata							x	
Heterocythereis sp.								o
Hirschmannia viridis						x		
Leptocythere spp.						x		o
Leptocythere pellucida							x	
Limnocythere sp.	o							
Loxoconcha elliptica							x	
Loxoconcha rhomboidea							o	x
Loxoconcha sp.						x		
Metacypris cordata					x			
Notodromas monacha					x			
Palmoconcha sp.							x	
Propontocypris spp.							o	o
Semicytherura sp.						x	x	
Broken/Unidentified					x	x	x	
Fossilised ostracods	x							
Foraminfera								
Ammonia sp.						x	xx	xx
Ammonia batavus						xx	xx	xx
Ammonia beccarii						xx	xx	xx
Astergerinata mamilla						x		
Elphidiumsp.						xx	x	xx
Elphidium crispum						x		
Elphidium gerthi							x	
Elphidium macellum						x	x	x
Fursenkoiina fuseiformis								
Haynesina germanica						xx	xx	xx
Jadammina macrescens						xx	xx	xx
Lagena semistriata							x	
Lagena sp.								o
Miliolids						xx	xx	xxx
Miliolinella subrotundata						x	x	xx
Patella corrugata								
Quinqueloculina sp.						x	x	xx
Rosalina sp.								o
Rotaliid							xx	xx
Fossil foraminifera	xx	x	x		o			
Unidentified						x		
Molluscs								
Broken/Unid	xxx					xxxx	xxx	xxxx
Hydrobids						xxx	x	xx
Planorbid	xx	o	x		xxx			
Bithynia opercula	o				x			
Bithinia			x					

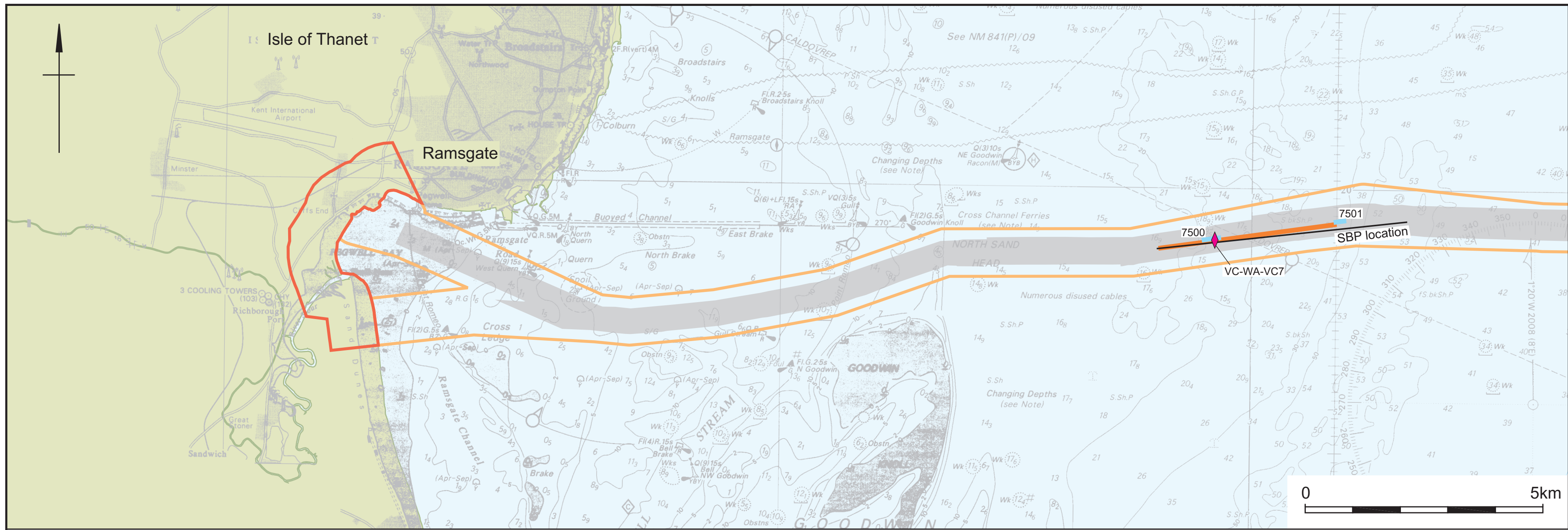
Molluscs								
Cerastoderma edule						xxx	xx	xx
Gibbula sp.						x		
?Ostrea edulis							x	
?Pholas							x	
Animal remains								
Bone		o	o					
Insects parts				?x				
Sponge spicules						x		xx
Plant remains								
Charcoal		?o				?o	?o	?x
Charophyte oogonia			o					
peat lumps				x				
plants unid	xx		xxx	xxxx	xxxx			xx
wood				o				
Seed unidentified								o

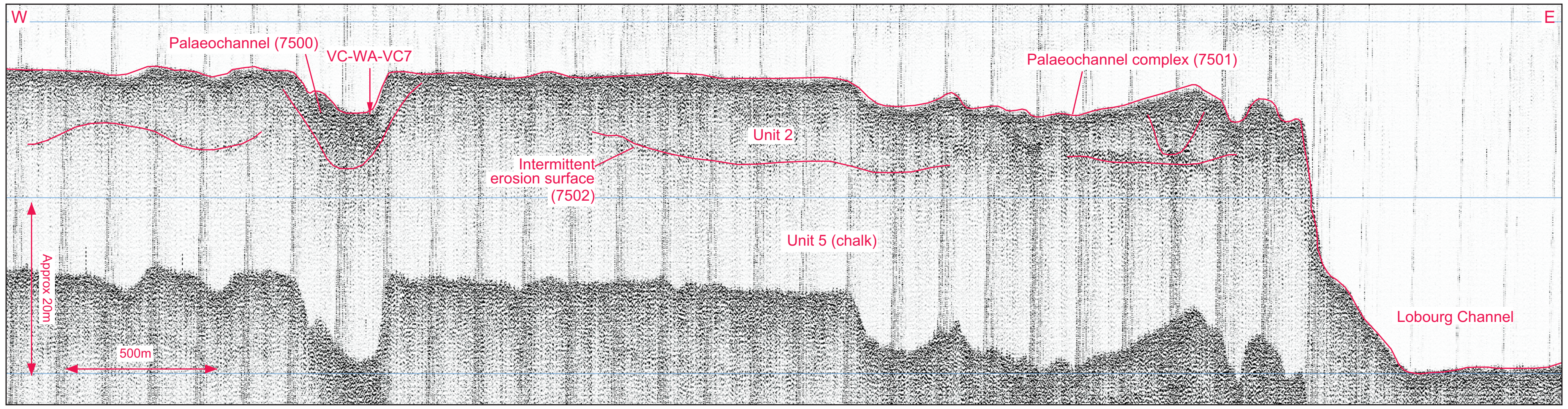
Table 1. Number of taxa assessed from samples within vibrocore WA_VC7.
Abundance:
o - present
x – 2-9 specimens
xx – 9-50 specimens
xxx – greater than 50 specimens
xxxx – greater than 100 specimens

APPENDIX 7: VC7 SEDIMENTARY DESCRIPTION AND SAMPLE DEPTHS

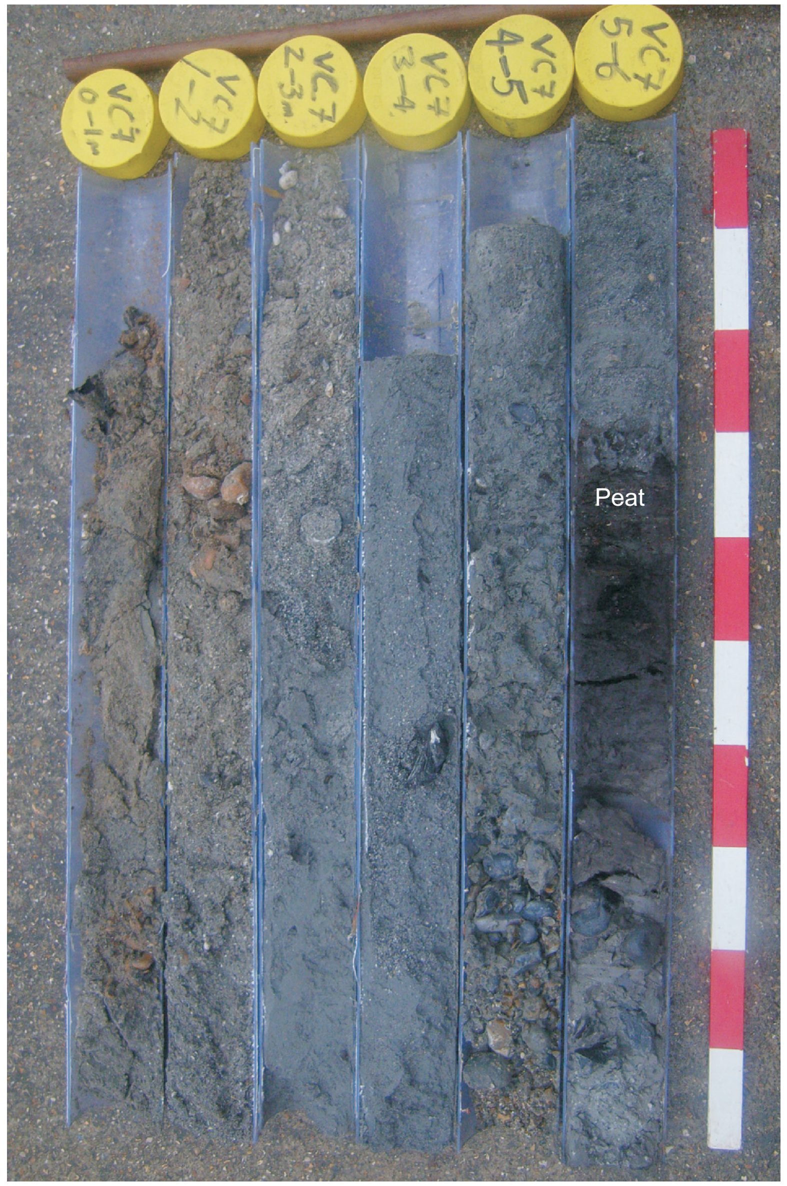
J. Russell
Wessex Archaeology

Depth below seabed (m)	Depth below OD (m)	Sedimentary Description	Unit	Plant, mollusc, charcoal and insect samples	Pollen, diatoms, forams and ostracod samples	14C sample
0 to 1.43	28.78 to 30.21	2.5Y 4/3 Olive brown sand medium to coarse grain, moderately well sorted, abundant flint pebble inclusions up to 50mm in diameter. Sharp boundary. **Recent seabed sediment**	1			
1.43 to 2.41	30.21 to 31.19	2.5Y 4/1 Dark grey sand and gravel, coarse to medium grain, poorly sorted, abundant marine mollusc inclusions and flint pebbles up to 20mm in diameter. Sharp boundary. **Recent seabed sediment**	1			
2.41 to 4.25	31.19 to 33.03	2.5Y 3/1 Very dark grey gravelly sand, well sorted, occasional marine mollusc (including *Ostrea edulis* at 3.60m) inclusions up to 50mm in diameter. Hard/cemented between 4.20 and 4.25m. Occasional wood inclusions up to 60mm in length. Grdaual boundary. **Outer estuarine alluvium/ shallow marine sediment**	2	31.38 to 31.48 32.89 to 32.99	31.58 33.00	
4.25 to 5.00	33.03 to 33.78	2.5Y 5/2 greyish brown silty gravel. Slightly sorted. fining upwards Very gravelly from 4.70 to 5.00m. Sharp boundary **Outer estuarine alluvium/ shallow marine sediment**.	2			
5.00 – 5.30	33.78 to 34.08	2.5Y 5/2 greyish brown gravelly sand. Moderate molluscan inclusions including *Cerastoderma edule*.Hiatus/erosive, sharp boundary. **Outer estuarine alluvium/ shallow marine sediment**	2		33.98	
5.30 to 5.34	34.08 to 34.12	10YR 2/2 very dark brown peat, with abundant reed and root remains,. Frequent molluscan burrows, vertical with the remains of the burrowing mollusc *Pholas dactylu*s. Mollusc burrows filled with grey silty sand. **Wave cut platform surface on peat**	2			
5.34 to 5.60	34.12 to 34.38	10YR 2/2 very dark brown peat, with abundant reed and root remains, horizontally bedded and abundant *in situ* fresh water molluscs including Planorbids and *Lymnaea*. Filled in mollusc burrows on the upper boundary. Gradual horizon. **Small vegetated freshwaterbody ?channel cut-off?**	2	34.13 to 34.18 34.23 to 34.28	34.13 34.28	34.13
5.6 to 5.73	34.38 to 34.51	10YR 5/2 Greyish brown peaty silt. (5.64 to 5.70 some disturbance. (sediment has slipped in tube) Occasional palnorbid molluscs. **Small freshwaterbody ?channel cut-off?**	2		34.38 34.48	34.38
5.73 to 5.9	34.51 to 34.68	2.5Y 5/1 Grey gravelly organic silt. Moderate black angular non patinated flint up to 50mm diameter. **Channel edge alluvium**	2		34.63	
5.90 to 6.02	34.68 to 34.80	2.5Y 5/1 Grey chalk putty (silty soft clay) with large black rounded to angular flint pebble inclusions up to 60mm in diameter. **Chalk putty**	5 and 2			

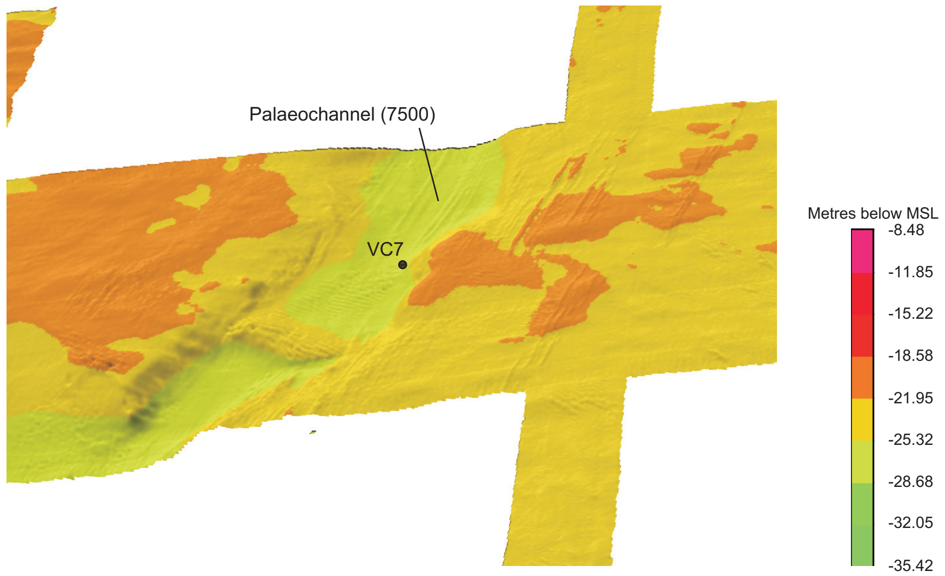




Sub-bottom profiler data example



VC-WA-VC7



Multibeam bathymetry (facing north at x10 vertical exaggeration)

Drawing Projection: UTM WGS84 Z31N
Admiralty Chart 323 (dated 2008)

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- Kent Landfall Study Area
- English Waters Study Area
- 12 nautical mile limit (approximate location)
- Geophysical Extents
- Palaeochannel at surface
- Erosion surface
- Boreholes assessed by Wessex Archaeology

Date:	10/10/11	Revision Number:	0
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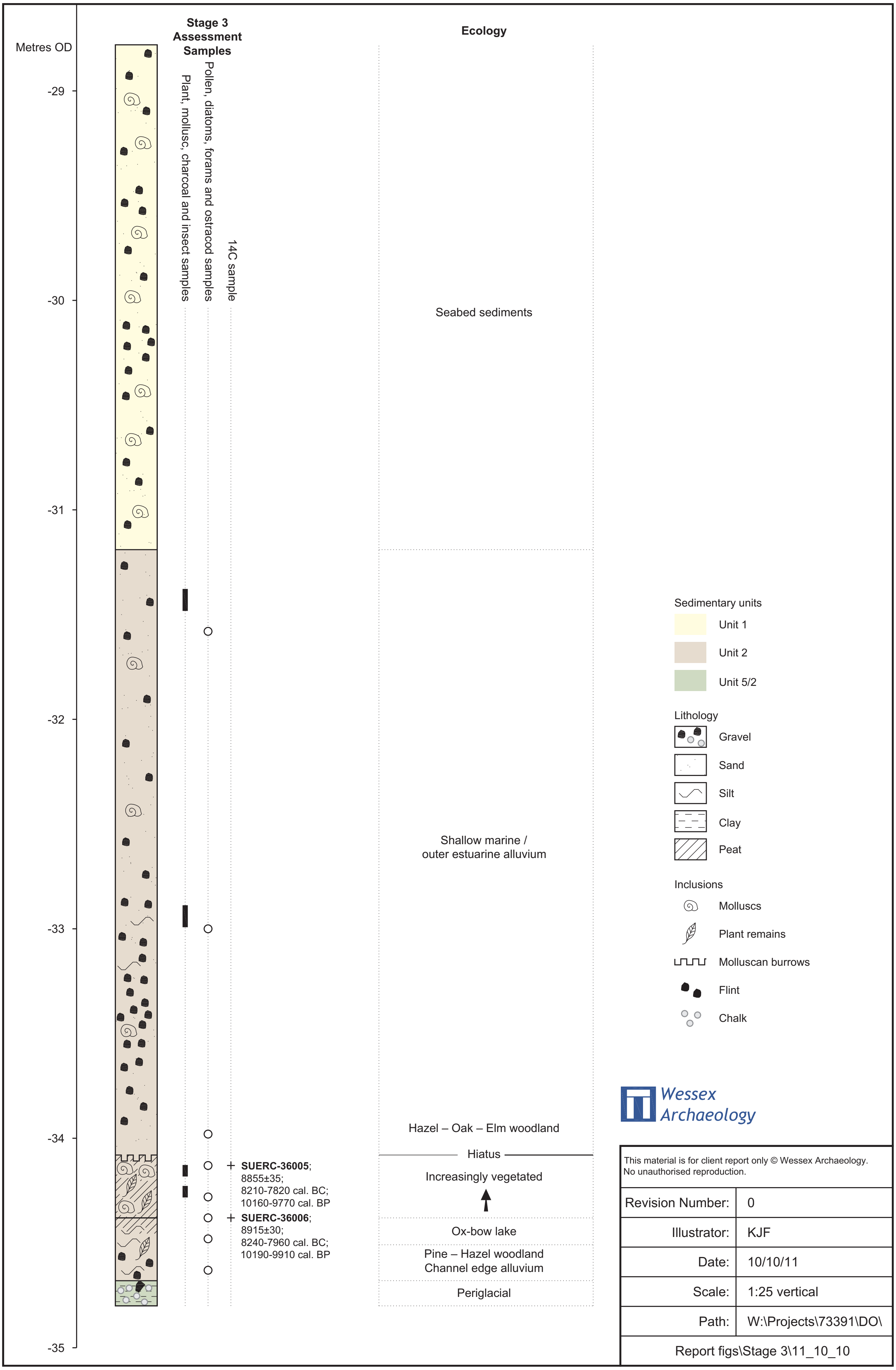
Site vibrocore location, photographic log and geophysical data

Figure 1



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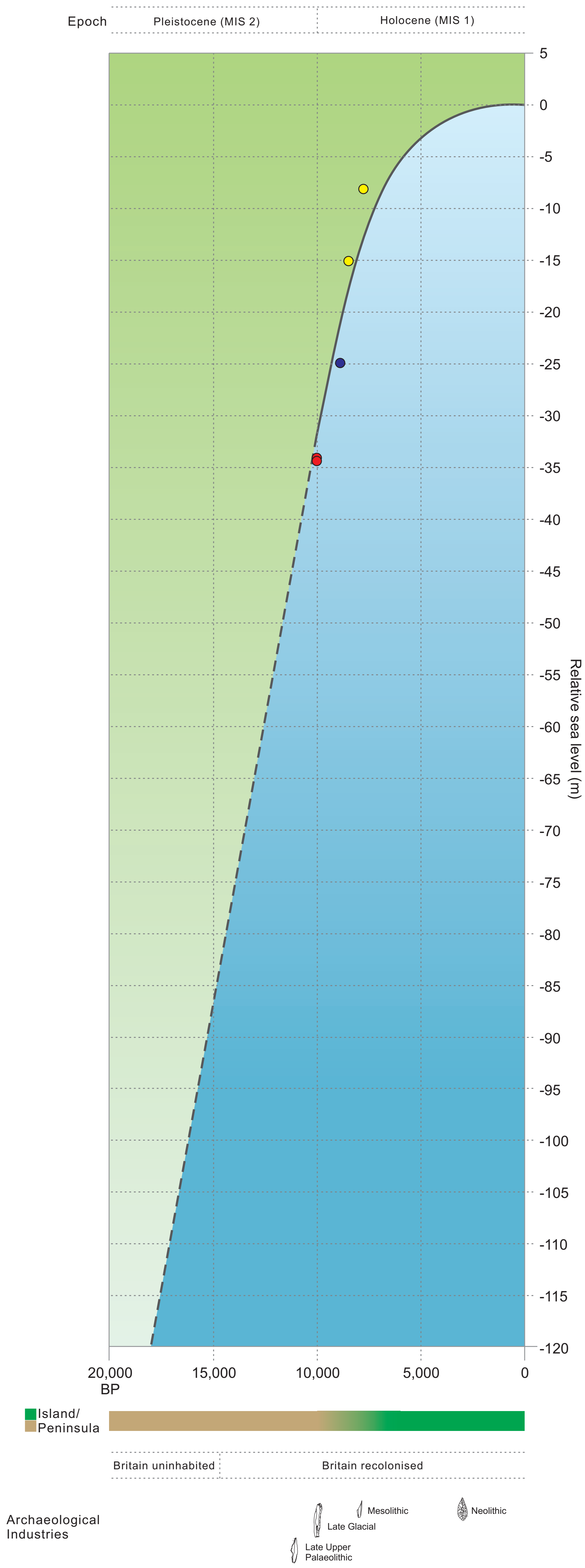
Vibrocore VC7, sediments and samples

Figure 2



—— Relative sea level from Shennan and Horton, 2002
– – Relative sea level extrapolated from Siddal *et al.*, 2003
● Project NEMO ^{14}C dates
● London Array OWF ^{14}C dates (WA, 2009)
● Britned Interconnector ^{14}C dates (Russell, 2011)

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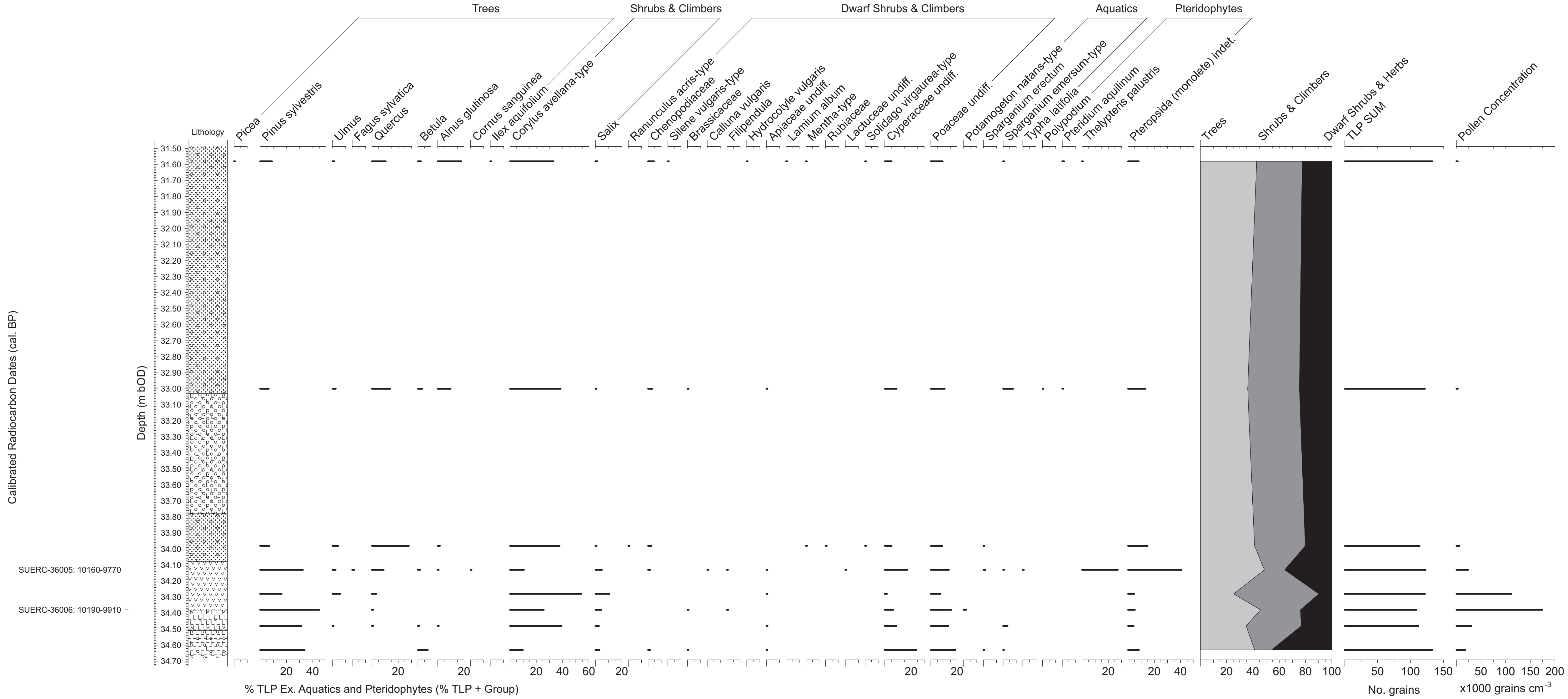
Sea level curve and radiocarbon dates

Figure 3



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Pollen diagram

Figure 4

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