Natural England

Biological Survey of the Intertidal Sediments of the Essex Estuaries SAC and Swale SSSI: Survey Report

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1. Introduction

Precision Marine Survey Ltd (PMSL) was commissioned by Natural England to undertake a biological survey of the intertidal sediments of the Essex Estuaries SAC and The Swale SSSI. The principal aim of the study was to characterise the communities of these important estuarine and coastal habitats in order to provide baseline data on the condition of the intertidal mudflats and sandflats of the Essex Estuaries SAC and The Swale SSSI to support Natural England's programme of monitoring and surveillance of these intertidal features. Specifically, the project aim is to provide standardised faunal and infaunal information for the littoral sediment habitats across a series of sampling areas. This was to include mapping the main sediment types and their associated communities (biotopes) along a series of transects within these areas. This information will act as a baseline for future management and condition monitoring of the Essex Estuaries SAC and The Swale SSSI (according to JNCC common standards guidance).

Intertidal mudflats and sandflats are one of several interest features of the site and Natural England has a duty to monitor and assess the condition of the intertidal features in order to report on the conservation status of mudflats and sandflats habitats once every six years. This project will provide baseline data to support Natural England's overall programme of monitoring and surveillance of the sites into the future and ultimately the data will inform Natural England's condition assessment for the site.

The survey aimed to provide suitable information on the following key attributes of the intertidal mudflats and sandflats of the Essex Estuaries SAC and The Swale SSSI;

- Geographical extent of the littoral sediment feature and its sub-features and notable biotopes present
- Biotope composition and the spatial distribution of biotopes across the feature
- Species composition of both representative and notable biotopes of the mid and lower shore
- Sediment character: sediment grain size by infield assessment and the depth of the redox layer

The survey was divided into a series of components to fulfil these objectives namely:

1. Pre-survey deskwork: Consultation with Natural England and assessment of any available historical survey data of the area in order to derive a sampling methodology and transect layout within budgetary constraints;
2. Phase 1 mapping: a Phase 1 biotope mapping exercise along each transect recoding notable biotopes up to 200-400m either side of each transect; and
3. Phase 2 sampling: sampling of infaunal communities and sediments at representative or key biotopes across the survey area.

1.1 Survey Area

The survey area covers intertidal habitats within the Essex Estuaries Special Area of Conservation (SAC) and the Swale SSSI as shown in Figure 1.

The Essex Estuaries Special Area of Conservation (SAC) is the second largest estuarine site on the east coast of England covering an area of 472 square kilometres. It contributes to the range and variation of estuaries in the UK as the best example of a coastal plain estuary system on the British North Sea Coast. The Essex SAC is part of a low-lying sedimentary coastline and includes the major estuaries of the Blackwater, Colne, and Crouch/Roach complex, with open coast and offshore elements including extensive open coast tidal flats at Foulness, Maplin and Dengie creating an extensive area of continuous marine habitat. These estuaries have formed from pre-existing valleys, which were flooded at the end of the last ice age. The estuary floors have a large width to depth ratio and are typically shallow (less than 30 metres deep) and have been infilled with post-glacial sediments sourced by deposits trapped in the southern North Sea.

Surfical sediments range from muds in the upper reaches and becoming increasingly sandy towards the mouth. The range in tidal heights, which has an average tidal range of 4.8 metres, means that extremely large extents of intertidal sediment flats are exposed (approximately 169 square kilometres). In sheltered areas these may become stabilised by microscopic algae (diatoms) and saltmarsh plants and the intertidal mudflats and sandflats within the European Marine Site support a wide range of typical estuarine and marine communities on sediments ranging from the finer estuarine muds and muddy sands to coarser sands and gravels (English Nature, 2000). The infaunal communities consequently provide an important food resource for both wildfowl and wading bird populations and fish communities. Furthermore this estuary system is of high importance to larger-scale regional sediment circulation of the southern North Sea as a whole, including the East Anglian coastline.

The Swale SSSI includes the largest remaining areas of freshwater grazing marsh in Kent and is representative of the estuarine habitats found on the north Kent coast. The habitats within the Swale are primarily mudflats, saltmarsh, and freshwater grazing marsh, the latter being intersected by extensive dykes and fleets and associated with the various constituent habitats of the site are a diverse assemblage of plant and invertebrate communities. The mudflats of the Swale are very rich in invertebrates with in excess of 350 species having been recorded and includes species which have not been recorded elsewhere in the UK such as the polychaete worm *Clymenella torquata*. Other more widespread species are typically present in high densities and provide an important food resource for the extremely large and varied bird assemblage present in the Swale (particularly waders) and the area is notable for the internationally important numbers of wintering and passage wildfowl and waders in addition to important breeding populations of a number of bird species.

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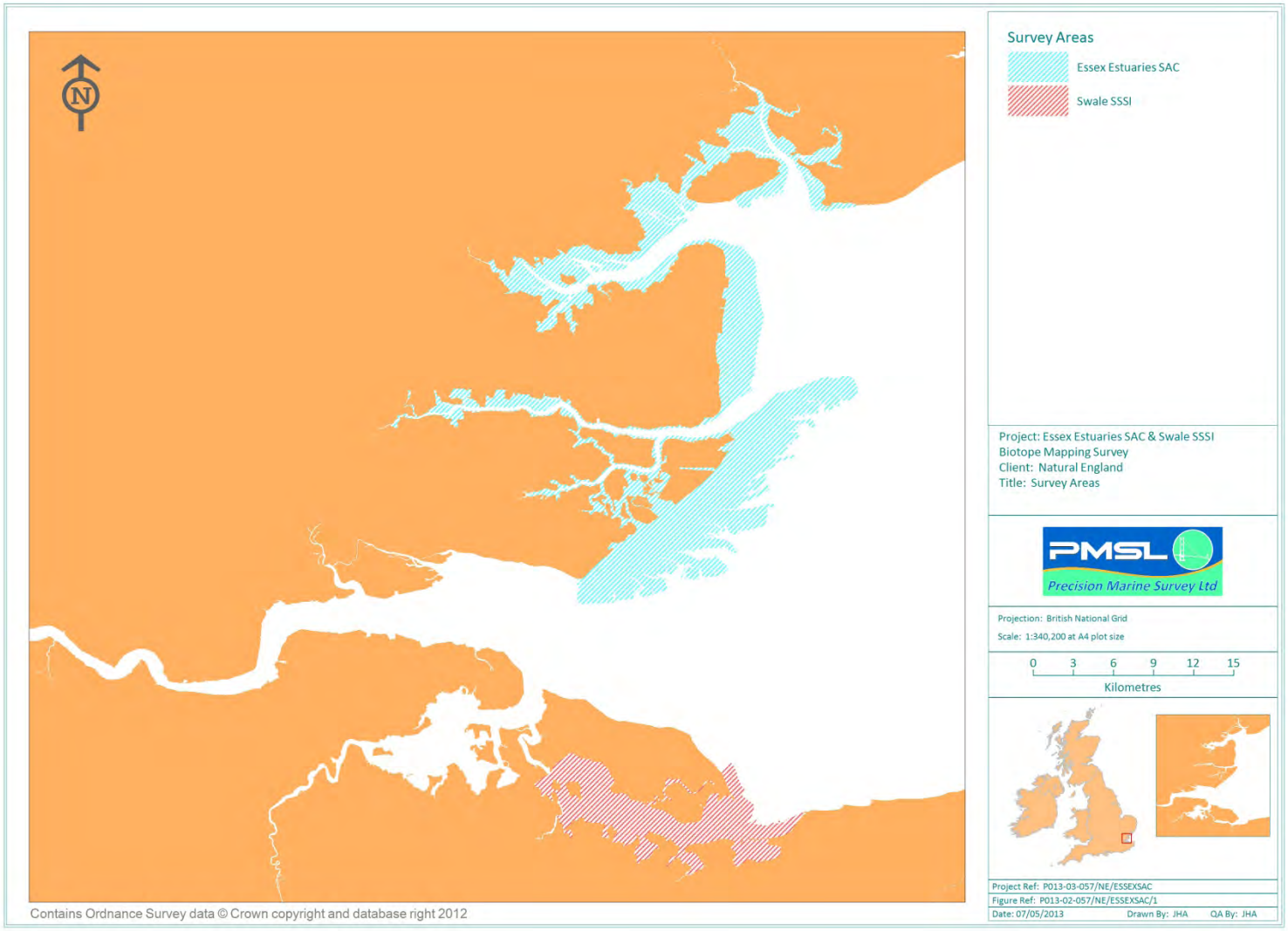

Figure 1. Project survey area.

2. Methodology

2.1 Start Up Meeting

A start up meeting was held with Natural England on the 23rd November 2011 to finalise the scope of the survey work where it was agreed that biotope data would be collected along 15 transects within the estuary.

2.2 Survey Methodology

Following discussions with Natural England a series of 15 transects were provisionally identified in order to provide coverage of the area within budgetary constraints and to complement existing recent survey data. Transect sites were based on existing intertidal habitat information including historical survey data, admiralty charts and aerial photographs. Natural England's provisional transects were then reviewed with regard to sensitive or key habitats and issues regarding access or permissions were assessed, prior to deciding on the final site positions (Figure 2). In particular consideration was given to the scale of the survey area and feasible survey coverage (within budgeted survey time) with regard to access, spatial separation of transects and health and safety issues in relation to extensive soft muddy habitats. Given the restricted access to much of the intertidal and wide spatial separation of transects (which significantly increases survey time required to transit from one transect to another) in addition to inherent difficulties in safely traversing large expanses of soft sediments following a trial visit to the survey site it was decided to utilise a hovercraft platform to undertake the survey.

Optimum survey periods for this type of work are on spring tides during late spring or summer periods as during these periods maximum daylight is available and low water times allow access to the intertidal before and after low water. However, given the time constraints of the project the surveys were originally commissioned to be carried out in late autumn 2011. Following the decision to utilise hovercraft for the survey further consultation was required including completion of the Appropriate Assessment by Natural England which delayed the project till autumn 2012. A combination of weather constraints and hovercraft availability meant the biotope survey commenced in October 2012 with surveys undertaken from the 8th October to the 11th October and the 25th October during which the majority of sites were completed. However, during much of October strong winds and limited daylight hampered survey work on suitable tides and as such surveys were carried out on the best tide available with adequate weather. The transects on Maplin Sands (transects 5 and 6) are within the MOD firing range at Shoeburyness which has restricted access to the intertidal and this in conjunction with extremely strong winds during the survey period in this extensive and exposed coastal habitat meant that survey in this area was postponed to 2013 with the hovercraft survey undertaken on the 3rd March.

As per the tender specification Phase 1 biotope mapping of the littoral sediment biotopes was undertaken across the shore within the designated survey areas on a transect basis. Surveys were carried out by PMSL and methods for survey followed the standardised Phase 1 mapping methodology (Marine Monitoring Handbook, procedural guidance No 3-1 – Wyn & Brazier, 2001 and Wyn et al, 2000).

A systematic route was covered along the transects within each survey area from high water (or the seaward extent of saltmarsh) to mean low water along which the distribution of biotopes were recorded. Boundaries between the main habitats/biotopes were recorded along each transect along with other information such as species composition, sediment type and the extent of sub-features and biotopes of conservation importance. The boundaries of key habitats or biotopes within 200m either side of the transect lines were also noted and the presence of any biotopes of particular interest (e.g. cockle beds, sea grass beds) were recorded within 400m of the transect as time allowed. The survey work was undertaken by a team of two surveyors using a hovercraft as a platform. A hovercraft was used in order to increase the safety of the survey and to maximise transect coverage in a short survey window, particularly given the wide spacing of transects.

To assist in mapping, each transect was located in the field using a Thales MobileMapper WAAS/EGNOSS enabled GPS logger which had transects and site maps/boundaries stored in memory and viewable on screen. A biotope recoding database was derived using PC software and input into the GPS loggers to assist in data entry which was backed up by hand written notes. A back-up GPS logger was also used on each survey to prevent possible data loss. Each transect followed an approximate bearing down the shore (allowing for positions of creeks or other obstacles) and extended to the lowest level exposed at low tide for a given tide. Starting at the top of the shore the upper and lower extents of each distinct biotope or habitat along each transect was recorded using the GPS from a hovercraft platform. This involved running the hovercraft at low speed down each transect and stopping periodically within each biotope and at the boundaries between biotopes to record positions and site characterisation data.

Within each distinct habitat, the substratum and dominant/characteristic species were identified using a surface inspection to assess sediment type, geomorphological features and biological features (e.g. worm tubes/casts or burrows) and sub-surface infaunal sediment sampling with sediment sieved through a 0.5mm mesh sieve and identification of species retained. In areas where sieving in-situ was problematic due to limited standing water or high levels of detritus a voucher collection of surface sediment was collected and bagged for rapid assessment in the laboratory. In order to facilitate identification, a representative sample of fauna from sieved sediment was collected in sample pots for subsequent laboratory identification and future reference purposes. For each transect MNCR site record forms including target notes were completed and geo-referenced photographs of characteristic biotopes/habitats within each sector were taken.

Sedimentary characteristics were described using a rapid in-field assessment technique which included an assessment of sediment type, water content, presence and depth of anoxic layer and any other relevant features. Sediment grain size was assessed in-situ using standardised Wentworth scale sediment comparison guides. Photographs of the wider area, individual habitats and characteristic species (where visible) were taken at each survey transect and cross-referenced with the survey notes and GPS positions. Supplementary information was also recorded such as any indication of natural or anthropogenic impacts (i.e. movement of drainage channels, vehicle tracks, diggings, saltmarsh encroachment, localised erosion and sediment accretion).

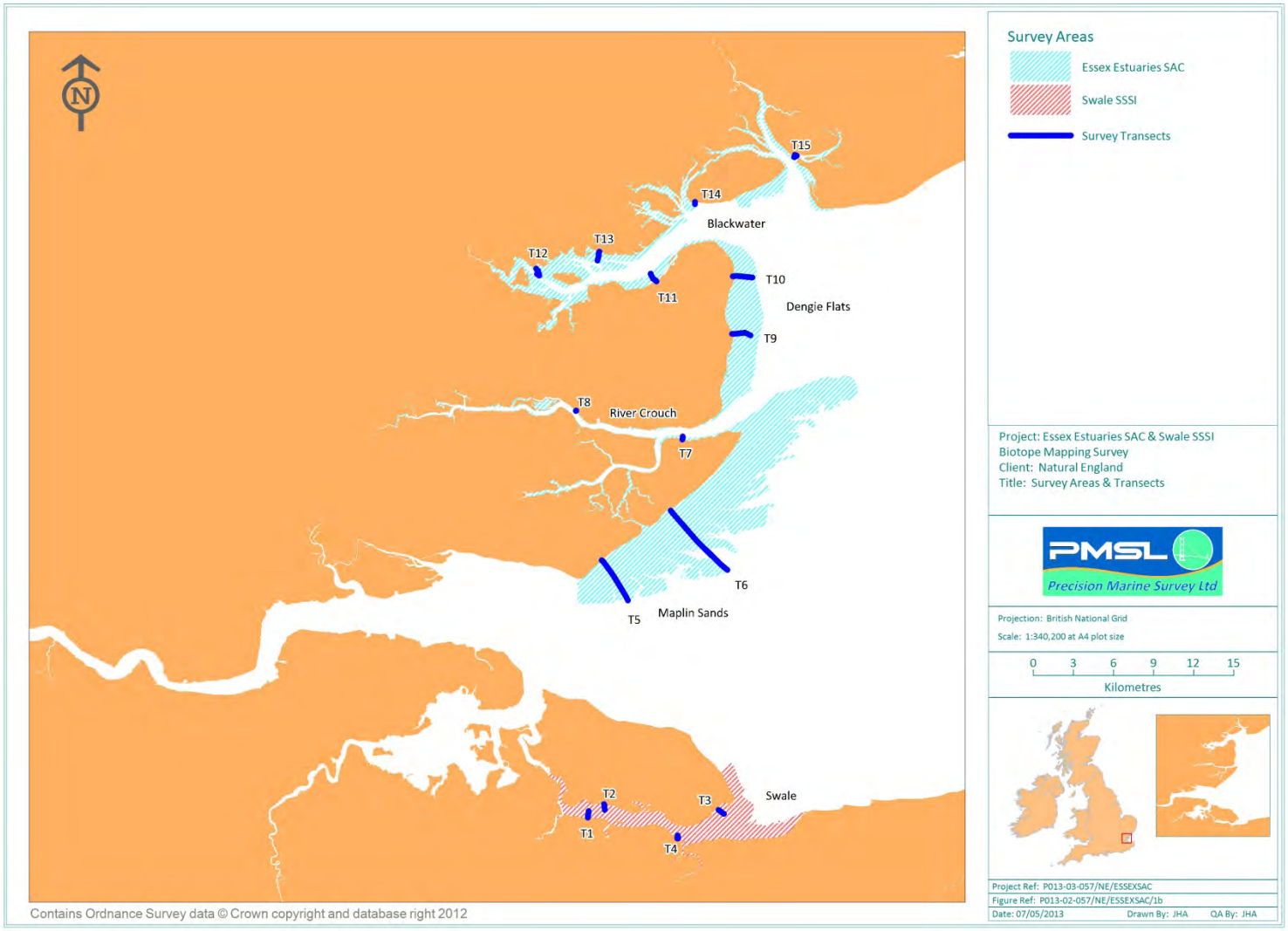

Figure 2. Location of survey transects.

This survey information was used to provide an assessment of biotope classification in the field for the main habitats along each transect. Biotope and biotope complex designations were based on the most recent (2004) Marine Habitat Classification for Britain and Ireland – Version 04.05. Mapping and biotope assignations were coordinated by Dr. James Allen at PMSL who was one of the principal authors of the current classification (Connor *et al*., 2004). As the 2004 version of the biotope scheme was heavily dependent on quantitative data from core samples a number of biotopes or sub-biotopes are based on taxa which may be difficult to identify in the field. As a consequence the field biotope assessment was supplemented and refined where necessary following assessments of voucher specimens in the laboratory to provide additional species data on the biotopes and to assist in biotope descriptions (or used to form a reference collection). This approach assists subsequent analysis and interpretation of field biotope data and also provides a more detailed species list with minimal additional effort in the field. This information along with field notes was subsequently used to derive a full biotope code for each habitat which was then further refined as required following processing of the core samples from phase 2 survey.

2.3 Access

All survey staff had extensive experience of using the standard Phase 1 mapping methodologies and, following standard PMSL Health & Safety policy, carried auto inflation lifejackets, waders or wellingtons, suitable weatherproof clothing, navigation instruments (compass/GPS), whistle, mobile phone and VHF radio. Each survey team comprised experienced marine biologists/surveyors, with extensive knowledge of surveying in muddy intertidal areas and extensive tidal flats. Following risk assessment prior to the survey all staff were made aware of tidal constraints within the survey area and operation windows identified. Surveys were predominantly undertaken during ebb conditions with any work carried out on the flood tide restricted to the mid-upper shore although as the transects were covered using hovercraft this allowed less restrictive survey periods. Appropriate permissions were obtained prior to access and Thames coastguard notified prior to and after survey. The access points used for the survey are summarised in Table 1.

Table 1. Access points utilised for the survey

Transect	Location	Coordinates (WGS84)
Transects 1 to 4 (Swale)	Oare Slipway	51.346533° N, 0.889200° E
Transect 5 & 6 (Maplin Sands)	Thorpe Bay Yacht Club	51.526453° N, 0.764770° E
Transects 7 & 8 (Crouch)	Burnham Marina	51.629790° N, 0.802948° E
Transects 9 & 10 (Dengie Flats)	Bradwell Outdoor Centre Slipway	51.734510° N, 0.886454° E
Transects 11 to 13 (Blackwater)	Bradwell Outdoor Centre Slipway	51.734510° N, 0.886454° E
Transect 14 (Mersea Island)	Coast Road, West Mersea	51.778619° N, 0.898731° E
Transect 15 (Brightlingsea)	The Hard, Copperas Road, Brightlingsea	51.805404° N, 1.024028° E

2.4 Phase 2 Sampling

In addition to Phase 1 biotope mapping, Phase 2 sampling of infaunal communities was also carried out at representative sampling stations on the middle and lower shore along each transect centre line. The phase 2 survey aimed to look in depth at the composition of the recorded biotopes, or a selection of key biotopes mapped in the phase 1 survey. This will ensure a suitable baseline at a relevant spatial scale for looking at changes over time. Usually such surveys would identify most representative biotopes, and (for example) take 5 replicates at random from four transect/biotope combinations over a nominal range of biotopes – usually three as a minimum. However, given the scale of the survey area and separation of transects the full range of biotopes would not be known till completion of survey which would not allow time to revisit representative sites for phase 2 sampling. During the current survey a wide range of biotopes were recorded and as such phase 2 sampling was undertaken at a spatially representative biotope on the mid or low shore at each transect and a subset of these were processed within the allotted budgetry constraints which allowed for 12 core stations of 5 replicates. The remaining samples were held by PMSL should they be required for future monitoring/assessment. In addition to the phase 2 sampling a representative sample of approx $0.1m^2$ was taken at each of the main habitats/biotopes recorded and whilst these were utilised for in-situ biotope assessment (and not collected for quantitative analysis) the residue from these samples were brought back to the laboratory as they provide a useful resource for species distribution and future assessment.

Methodologies for phase 2 sampling followed Procedural Guideline No. 3-6: Quantitative sampling of intertidal sediment species using cores (from the Marine Monitoring Handbook - Davies et al, 2001) in addition to supplementary Environment Agency procedures provided in the tender specification. At representative sites on the mid and low shore, five replicate $0.01m^2$ cores were taken from the sediment and placed into sealable plastic bags, each carrying a unique code for the station. Cores were taken to a depth no less than 15cm to ensure adequate recovery of burrowing invertebrates and an additional sample at each sampling station was collected for Particle Size Analysis.

The samples collected were kept cool until laboratory processing which took place the following day in which samples were sieved through a 0.5mm mesh sieve and stored in 10% buffered saline formalin solution. A complete survey log was maintained throughout the survey detailing time, position and physical characteristics of the sediment (e.g. depth of redox layer).

2.5 Laboratory Analysis

All laboratory methodologies were based on best practice and followed tried and tested method statements widely acknowledged within the industry (Rees et al, 1990, Barnett 1993, Turner 1999, Cooper & Rees 2002, Boyd et al, 2002, Prior et al, 2004 & Proudfoot et al, 2003). PMSL are members of the National Marine Biological and Analytical Quality Control scheme (NMBAQC).

Two experienced members of PMSL undertook the sample sorting, conducting all the sieving, sorting work and sample description with a further member of staff carrying out standard sorting quality control. Experienced taxonomists carried out the identification of the sorted fauna, with an additional member of staff carrying out quality control for faunal identification. A standard sample tracking procedure was followed throughout the analysis period.

2.6 Sorting

Each sample was sieved in freshwater water and then rinsed with running tap water through a 0.5mm stainless steel sieve with a nest of 20cm diameter 5mm and 1mm sieves used as required for coarser material. The sieve contents were backwashed over a white tray to catch any potential spillage, into pre-labelled plastic storage buckets. A borax buffered 10% saline formalin solution was then added to the samples. The samples were then well mixed and stored at a constant temperature of around 10°C for at least 48 hours to ensure adequate preservation and shaken once during the period.

Prior to identification each sample was washed through a nest of sieves, with the smallest mesh aperture of 0.5mm, to remove the preservative and partition the sample for ease of sorting. The residue from each sieve was then gently washed into separate white trays. Water was added to the trays and the contents agitated. Immediately after agitation, the light fraction was decanted to another tray. This procedure was repeated up to 3 times, and each tray of light fractions examined as a sub-sample of the heavy fraction. The trays were marked with the appropriate sample code (relating to the client, date, specific site, sample and replicate number). All fractions were then decanted into separate 100mm Petri dishes and examined under a stereoscopic microscope with 20x eyepieces giving a maximum magnification of up to 80x. The fauna derived was added to the retained containers, preserved and stored ready for identification. Each petri dish was checked for a final time by another member of staff.

2.7 Taxonomic Identification

Identification was carried out using Olympus SZ40 zoom microscopes with 10X and 20X eyepieces, giving a maximum magnification of up to 80X. An additional 2X objective was occasionally used to increase the potential magnification to 160X. Olympus BX41 compound microscopes were used for further magnification, up to 800X.

Identification of infaunal samples was to the lowest possible taxonomic level (i.e. species), and during identification, all individuals were initially separated into families, with part animals being assigned to families where possible. The macrofaunal specimens were identified to species level using standard taxonomic keys, low and high power stereoscopic microscopes and dissection when necessary, for identification. Incomplete animals without anterior ends are not recorded as individuals to be included in the quantitative dataset. However, they were identified where possible and recorded as present. Similarly, motile and colonial sessile epibenthic taxa and meiofauna were only recorded as present and not included within the infaunal quantitative data set.

As part of the standard quality assessment (QA) procedure, regular cross-reference identification was carried out. Each sample residue was described textually with the residue retained for possible further analysis and Analytical Quality Control (AQC). All fauna will be retained under the standard codes for 2 years or returned to the clients representative for further analysis and AQC should this be required.

The taxonomic literature used is essentially as given in Rees et al (1990) and reporting nomenclature was based on that of the Species Directory of the Marine Fauna and Flora of the British Isles and Surrounding Seas (Howson & Picton, 1997), with updated nomenclature as required following WoRMS standards (Appletans *et al*., 2010).

2.8 Biomass

Biomass analysis was performed by wet weight (tissue blotted) and carried out for individual species in each sample. Each taxa was placed on blotting paper for 30 seconds to allow absorption of preservative into the blotting paper. Following this time period the individuals were placed on the microbalance and the reading taken. The macrofaunal organisms were then placed back in their respective pots and stored. Biomass calculations include all identifiable fragments and calculated to ± 0.0001g, all biomass data was recorded in grams or fractions thereof. Following analysis each specimen was returned to its sample pot and stored in 70% IMS (Industrial Methylated Spirits).

2.9 Data Analysis

All data obtained from the phase 2 CORE survey was tabulated as a full species list for each sample to be provided electronically on excel spreadsheet. The univariate community parameters species richness (S and Margalef's d), species evenness (Pielou's index J) and diversity (Shannon Weiner index H') were also calculated using PRIMER v6.

2.10 Particle Size Analysis (PSA)

The particle size analysis was carried out by a combination of dry sieving and laser particle size analysis (for the fraction <1mm) using a Malvern Mastersizer 2000. Prior to analysis, photographs were taken of all samples. The sediment samples were then split with one sub-sample being passed through a 1mm sieve to remove the larger size classes of sediment if required. The <1mm fraction of the sample was then analysed using the Malvern Mastersizer 2000 and the >1mm fraction discarded. The second sub-sample was passed through a nest of sieves at 0.5 phi intervals. Each fraction, including the <1mm fraction, was then oven dried at 85°C for 24 hours and weighed. Data generated from these methods was analysed separately but for visualisation purposes the finer fractions were also merged to the coarse fraction (if present) to provide an overall grain size distribution for each sample – although it is acknowledged that merging of such datasets can be problematic due to differing techniques. The data derived from PSA was then used to derive statistics such as mean grain size, bulk sediment classes (% silt, sand & gravel), skewness and sorting coefficient using the program Gradistat. These methods are consistent with the procedures identified at the NMBAQC PSA workshop on laboratory methods, which was held at the Cefas Lowestoft laboratory in July 2009.

Total organic carbon was determined by a 480ºC loss on ignition methodology. Each sample was oven dried at 105ºC until the weight stabilises (± 0.001g). The weight of the sample was recorded and the sample was then placed into a kiln at 600ºC for four hours. Once the sample has cooled the sample is then re-weighed and the difference between the two weights expressed as the percentage loss on ignition.

3. Results

3.1 Transect 1

Transect 1 was located in the upper Swale on the south bank and backed onto hard sea defences with a very narrow band of *Enteromorpha* covered rock at the top of the shore (LR.FLR.Eph.Ent - *Enteromorpha* spp. on freshwater-influenced and/or unstable upper eulittoral rock) followed by a narrow band of fucoids (approximately 1m wide) notably including *Fucus ceranoides* (LR.LLR.FVS.Fcer - *Fucus ceranoides* on reduced salinity eulittoral rock) and occasional other upper shore fucoids (e.g. *F. Spiralis*). Immediately below this was an area approximately 10m wide at the base of the sea wall and adjacent rocks characterised by abundant *Ascophyllum nodosum* which was joined at the lower end by frequent *Fucus vesiculosus* (LR.LLR.FVS.AscVS - *Ascophyllum nodosum* and *Fucus vesiculosus* on variable salinity mid eulittoral rock). Beyond this on upper shore anoxic mud was an area characterised by frequent *Hediste diversicolor* and abundant oligochaetes (primarily *Tubificoides benedii*) whilst *Macoma balthica* and *Hydrobia ulvae* were common. Other taxa included frequent *Streblospio sp.* and occasional cirratulid polychaetes along with low numbers of *Polydora* spp. and occasional patches of *Ulva* sp. This habitat appears to be somewhat transitional example of LS.LMu.UEst.Hed (*Hediste diversicolor* in littoral mud).

This habitat graded into a wider area of mud or sandy mud with patches of *Enteromorpha* and other algal debris which included abundant tubificid oligochaetes and *Hydrobia* along with frequent *Streblospio sp.*, cirratulid polychaetes and *Macoma balthica*, occasional to frequent *Nephtys hombergii*, occasional cockle and *Littorina* sp. and occasional *Carcinus maenas*. Low numbers of Ampharetidae polychaetes (potentially *Melinna* sp.) were also recorded and very occasional patches of *Zostera noltii* were noted which increased downshore as this area graded into a proper seagrass bed. As such this habitat is somewhat transitional and classified as LS.LMu.MEst (Polychaete / bivalve dominated mid estuarine mud shores) but is potentially a transitional upper shore (seasonal) extension of the biotope LS.LMp.LSgr.Znol (*Zostera noltii* beds in littoral muddy sand) recorded slightly lower down the shore. Surveys undertaken in late spring/summer in this area may therefore record an increased dominance of the *Zostera noltii* biotope in this area.

This habitat graded into the main mid shore habitat which was 250 to 300m wide and comprised of sandy mud with varying amounts of shell debris and had a broadly similar infaunal community but was characterised by seagrass (*Zostera noltii*) which had a relatively high coverage particularly on the mid to upper shore section with coverage decreasing or becoming patchy at the upper and lower extremities. The seagrass bed appeared to cover an extensive area along the estuary and there were also examples of larger seagrass specimens in more waterlogged areas (often of a paler colour) which may include *Zostera angustifolia* (the intertidal variant of *Zostera marina*) and the two forms of seagrass may in some areas form a mosaic across the midshore relating to exposure and water content. Infaunal species here included abundant *Tubificoides benedii* or other oligochaetes and *Hydrobia ulvae*, frequent cockles, *Littorina* sp., *Streblospio sp.* and amphipods, common Cirratulidae polychaetes, occasional *Nephtys hombergii*, *Macoma balthica* and clumps of *Mytilus edulis*, occasional fucoids and lower numbers of other taxa such as *Scrobicularia*

plana, juvenile *Tapes* sp. bivalves, Polyplacophora sp. (chitons), Ampharetidae polychaetes and *Carcinus maenas*. Given the location of the seagrass bed on the mid to upper shore this habitat has been classified as LS.LMp.LSgr.Znol (*Zostera noltii* beds in littoral muddy sand). The lower section of this habitat showed a decrease in seagrass coverage which became somewhat patchy with increased shell debris/stones/gravel and patches of mussel (or cockle) often with attached fucoids *(Fucus vesiculosus*). The infaunal community was broadly similar to the main seagrass bed but with lower numbers of oligochaetes and higher numbers of *Macoma balthica*, amphipods and with Phyllodocidae polychaetes such as *Eteone* sp. and is a somewhat transitional habitat including LS.LMu.MEst (Polychaete / bivalve dominated mid estuarine mud shores) with patchy LS.LBR.LMus.Myt (*Mytilus edulis* beds on littoral sediments).

At the low shore was a band of mud/sandy mud approximately 80m wide which extended to low water which was characterised by occasional to frequent juvenile *Hediste diversicolor*, frequent *Macoma balthica* and Cirratulidae polychaetes whilst oligochaetes (primarily *Tubificoides benedii*) and spionid polychaetes (*Streblospio sp.* and *Pygospio elegans*) were common along with occasional *Hydrobia ulvae* and is likely to be a somewhat impoverished variant of LS.LMu.MEst.HedMac - *Hediste diversicolor* and *Macoma balthica* in littoral sandy mud. This habitat included increased quantities of stones at the very edge of the channel (1 to 2m wide). A selection of representative photographs from transect 1 is provided in Figures 3 to 5 and a map showing the distribution of biotopes is provided in Figure 6.

Figure 3. Upper shore habitats on transect 1.

Figure 4. Mid shore habitats on transect 1.

Figure 5. Low shore habitats on transect 1.

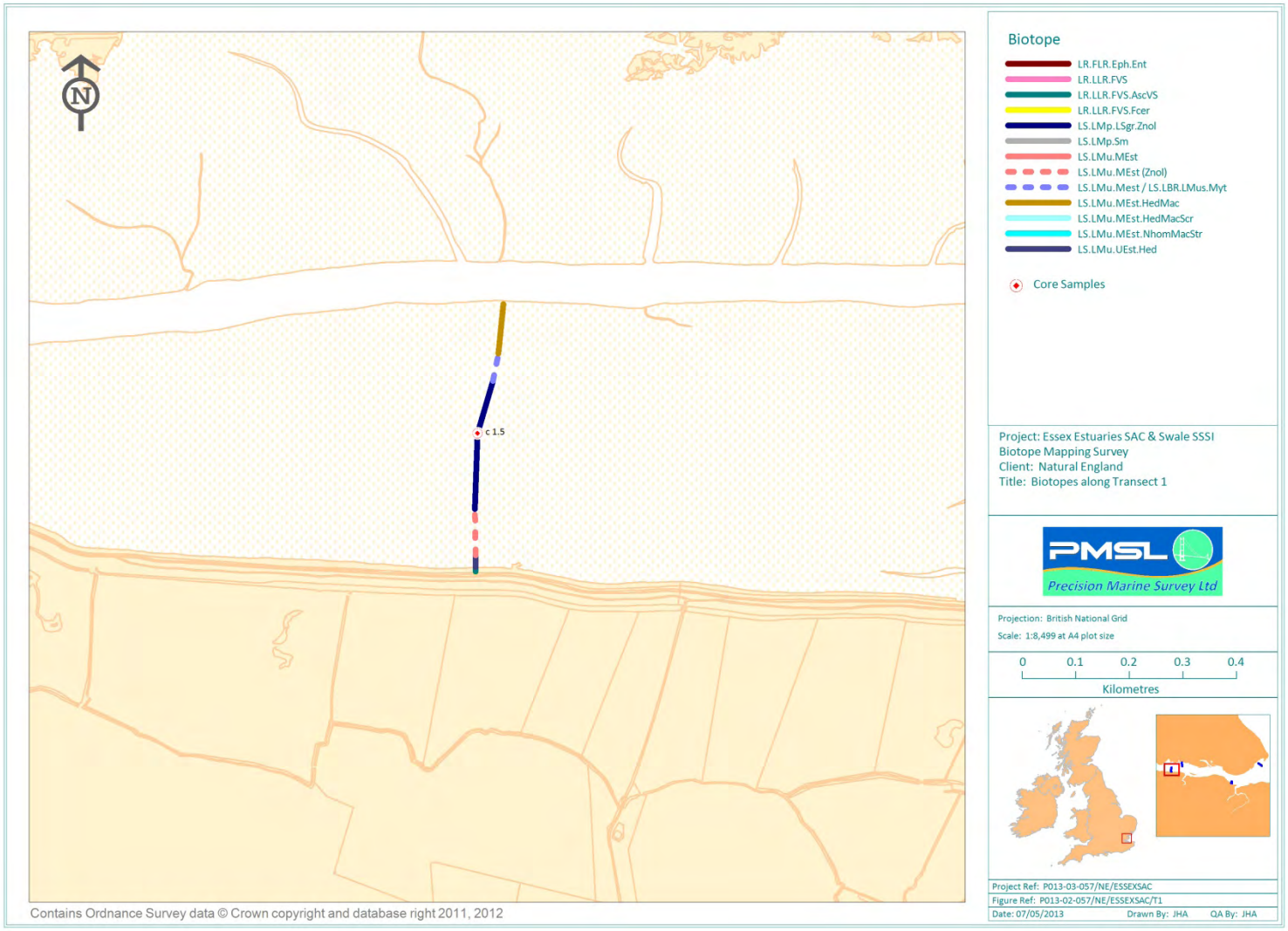

Figure 6. Biotopes along transect 1.

3.2 Transect 2

Transect 2 was located further downstream on the north bank of the Swale in the upper/middle estuary and as described for transect 1 backed onto hard sea defence with a narrow Enteromorpha covered rock at the base of the sea defence (LR.FLR.Eph.Ent - Enteromorpha spp. on freshwater-influenced and/or unstable upper eulittoral rock).

Below this was a band of cobble/small boulder with abundant *Ascophyllum nodosum* and *Fucus vesiculosus* overlaying barnacle covered cobbles (LR.LLR.FVS.AscVS - *Ascophyllum nodosum* and *Fucus vesiculosus* on variable salinity mid eulittoral rock) which graded into a narrow band of stones and mud at the base adjacent to the mud flat. In small pools at the top of the shore adjacent to the fucoid zone were very occasional Pacific oysters (*Crassostrea gigas*). The main upper shore area was some 60m in width with mud or sandy mud and occasional cockle shell debris and algal debris (*Ulva* and *Enteromorpha*). This area was characterised by abundant oligochaetes (primarily *Tubificoides benedii*) along with frequent *Nephtys hombergii*, *Streblospio sp.* and *Macoma balthica*. Occasional Ampharetidae polychaetes (potentially *Melinna* sp.), *Hydrobia ulvae* and Phyllodocidae polychaetes such as *Eteone* sp. were also present. This habitat is somewhat transitional between biotopes such as LS.LMu.MEst.HedMac or LS.LSa.MuSa.HedMacEte and has been classified as LS.LMu.MEst (Polychaete / bivalve dominated mid estuarine mud shores).

The midshore habitat comprised of an area of sandy mud with occasional/patchy clumps of cockle or mussel with occasional fucoids which was characterised by patchy *Enteromorpha*, abundant oligochaetes, frequent *Nephtys hombergii*, *Macoma balthica* and cirratulid polychaetes along with frequent *Streblospio sp.*, *Hydrobia ulvae* and occasional *Hediste diversicolor* or *Scrobicularia plana*. This habitat continued through the midshore to low water but with slightly higher numbers of cockle (occasional to frequent) and small patches of mussel with tubificid oligochaetes and cirratulid polychaetes common and occasional *Nephtys hombergii*, *Macoma balthica*, *Streblospio sp.* and other spionid worms such as *Polydora* sp. This community is representative of LS.LMu.MEst.HedMac (*Hediste diversicolor* and *Macoma balthica* in littoral sandy mud) but also includes some patchy elements of LS.LBR.LMus.Myt or LS.LSa.MuSa.CerPo and may be a somewhat transitional environment as larger patches of mussel bed for example were noted further downstream on transit to transect 3.

A selection of representative photographs from transect 2 is provided in Figures 7 to 9 and a map showing the distribution of biotopes is provided in Figure 10.

Figure 7. Upper shore habitats on transect 2.

Figure 8. Mid shore habitats on transect 2

Figure 9. Low shore habitats on transect 2.

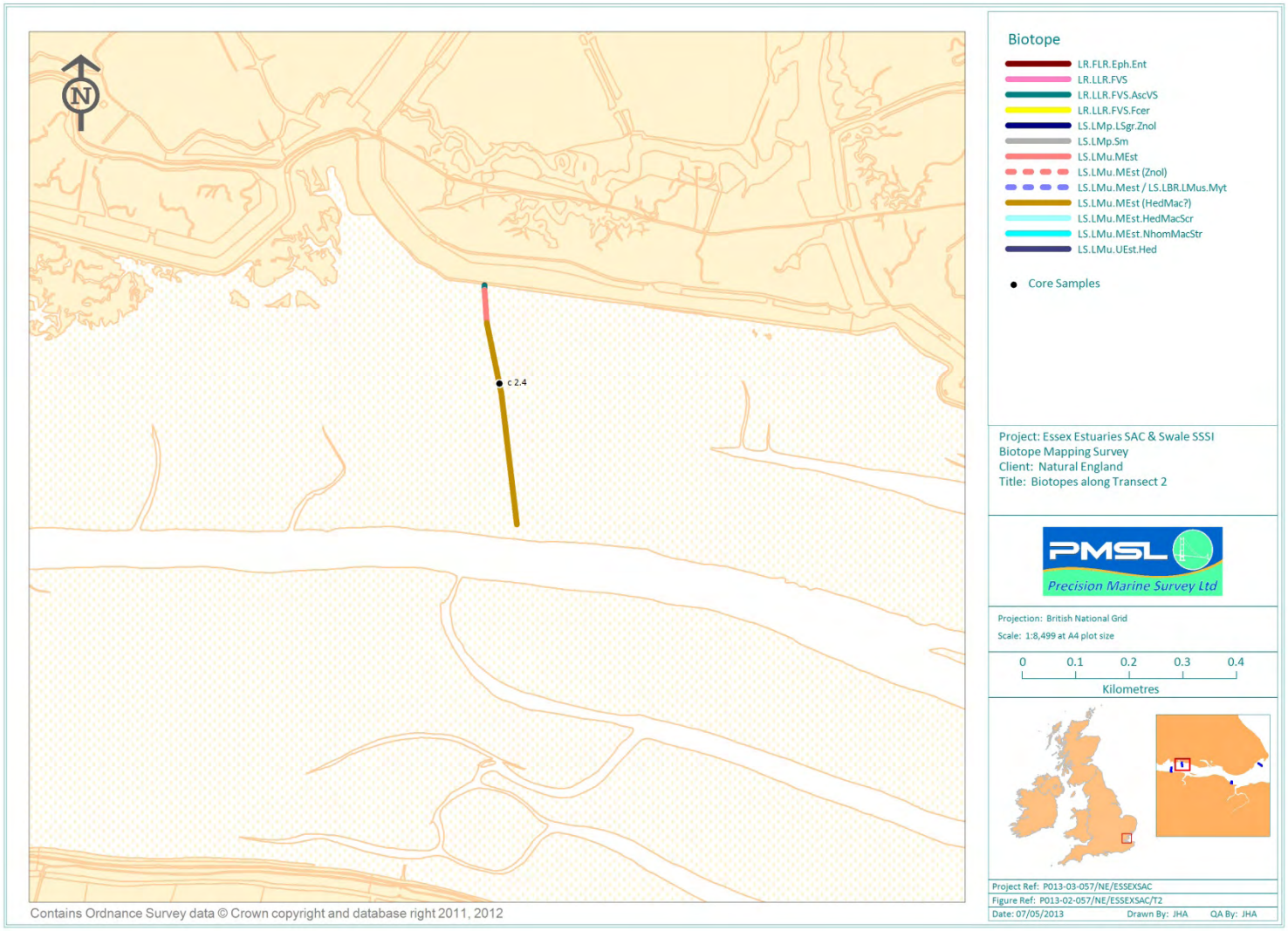

Figure 10. Biotopes along transect 2.

3.3 Transect 3

Transect 3 was situated in the outer Swale on the north bank and backed onto *Spartina* dominated saltmarsh which was fringed by an area of sandy mud with occasional clumps of *Spartina*, juvenile *Hediste diversicolor* (common), occasional oligochaetes (including Enchytraeidae), *Hydrobia ulvae* and juvenile *Macoma balthica* along with diptera larvae and may be an impoverished form of LS.LMu.MEst.HedMac (*Hediste diversicolor* and *Macoma balthica* in littoral sandy mud). This habitat graded into the main midshore habitat of lumpy sandy mud which was somewhat anoxic and generally similar to habitat 1 with frequent or common *Hediste diversicolor*, occasional oligochaetes (*Tubificoides benedii* and possibly Enchytraeidae sp.), frequent *Hydrobia ulvae* and frequent or common *Scrobicularia plana* (LS.LMu.MEst.HedMacScr - *Hediste diversicolor*, *Macoma balthica* and *Scrobicularia plana* in littoral sandy mud shores). This habitat ended toward the lower shore where the mudflat gently sloped down into a narrower area of flatter sandy mud with frequent/common oligochaetes (primarily *Tubificoides benedii*), occasional or frequent *Nephtys hombergii* and *Streblospio sp.* with occasional *Macoma balthica* and Cirratulidae polychaetes (LS.LMu.MEst.NhomMacStr - *Nephtys hombergii*, *Macoma balthica* and *Streblospio shrubsolii* in littoral sandy mud). A selection of representative photographs from transect 3 is provided in Figures 11 to 13 and a map showing the distribution of biotopes is provided in Figure 14.

Figure 11. Upper shore habitats on transect 3.

Figure 12. Mid shore habitats on transect 3.

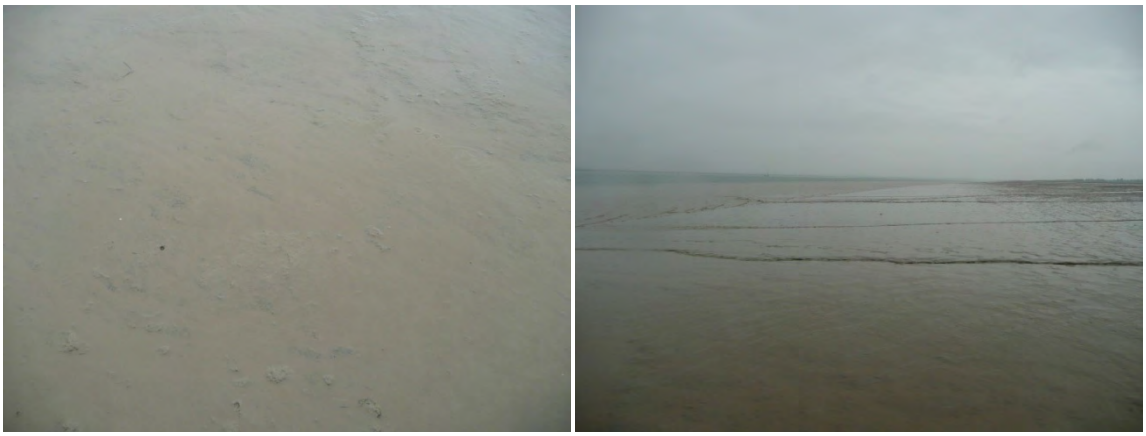

Figure 13. Low shore habitats on transect 3.

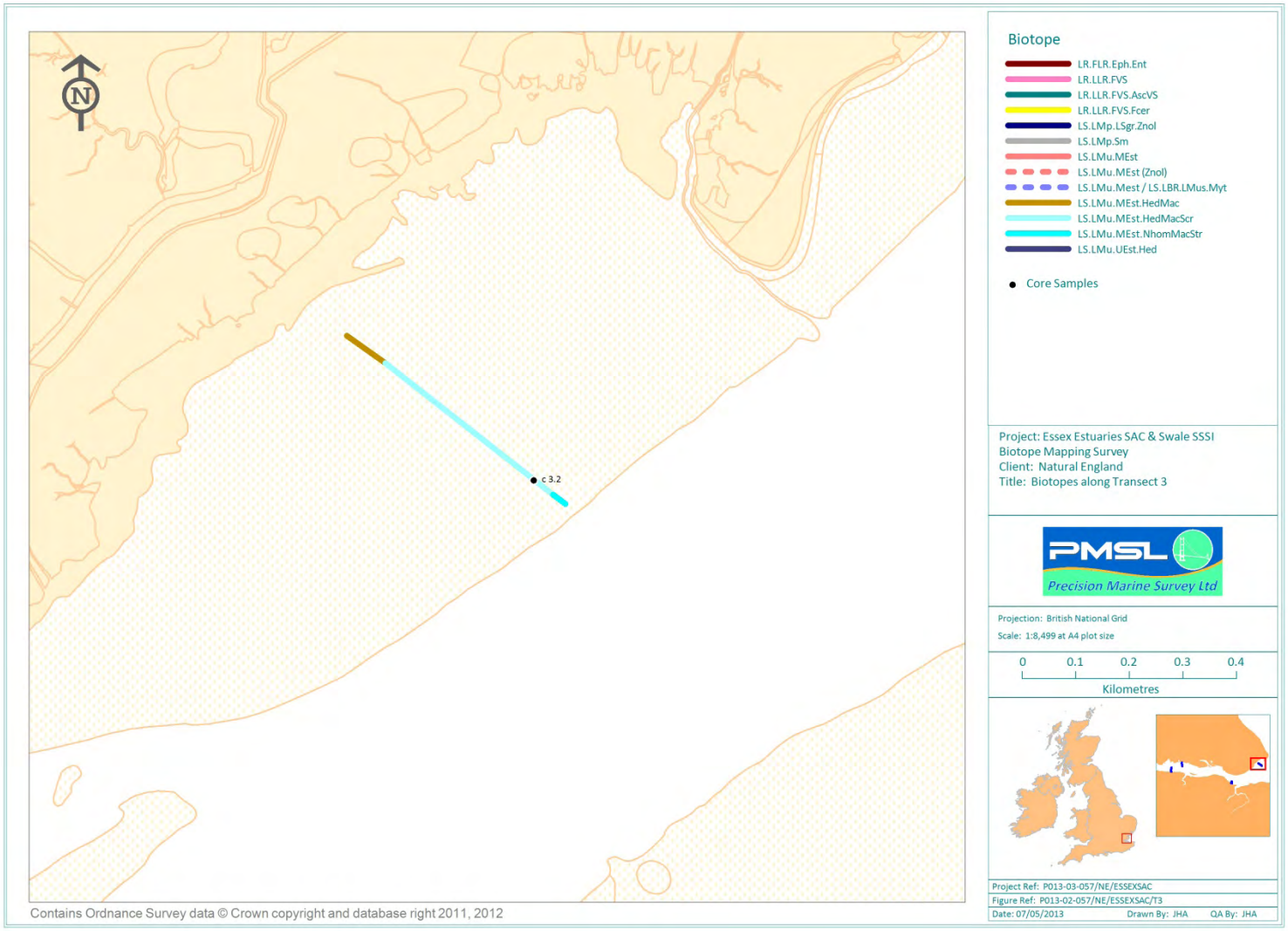

Figure 14. Biotopes along transect 3.

3.4 Transect 4

Transect 4 was located on the south bank of the Swale toward the outer estuary adjacent to a slipway utilised by small pleasure craft or for fishing activity. The intertidal here was relatively narrow (<200m) and backed onto a narrow area of Spartina saltmarsh to the west of the slipway which increased in coverage further upstream. The mudflat was relatively homogenous with the main upper shore and mid shore area comprising of anoxic mud/sandy mud characterised by *Hediste diversicolor* (common), frequent oligochaetes (primarily tubificid worms such as *Tubificoides benedii* and possibly others such as Enchytraeidae sp.) and occasional *Nephtys hombergii*, *Macoma balthica* and Hydrobia ulvae with low numbers of *Scrobicularia plana* or tellinid bivalves (LS.LMu.MEst.HedMac - *Hediste diversicolor* and *Macoma balthica* in littoral sandy mud.

This habitat covered the majority of the intertidal and then graded into a narrow band (approximately 10 to 15m in width) of anoxic sandy mud on the low shore which was characterised by an infaunal community comprising of frequent or common *Streblospio sp.* (along with occasional other spionids worms such as *Pygospio elegans)* and *Tubificoides benedii* with *Macoma balthica* and *Hediste diversicolor* or Nephtys hombergii and low numbers of Cirratulidae polychaetes, Eteone sp. or other Phyllodocidae polychaetes and some weed debris (*Ulva* sp.) and is perhaps transitional between LS.LMu.MEst.NhomMacStr and LS.LMu.MEst.HedMac or LS.LSa.MuSa.HedMacEte.

Along the edge of the lower slipway were patches of fucoids such as *Fucus vesiculosus* (LR.LLR.FVS - Fucoids in variable salinity) other whilst on harder sea defence adjacent to the top of the slipway and backing open mud adjacent to the saltmarsh were bands of *Fucus ceranoides* (LR.LLR.FVS.Fcer - *Fucus ceranoides* on reduced salinity eulittoral rock) above *Ascophyllum nodosum* and *Fucus vesiculosus* with *Enteromorpha* sp. (LR.LLR.FVS.AscVS - *Ascophyllum nodosum* and *Fucus vesiculosus* on variable salinity mid eulittoral rock).

A selection of representative photographs from transect 4 is provided in Figures 15 to 17 and a map showing the distribution of biotopes is provided in Figure 18.

Figure 15. Upper shore habitats on transect 4.

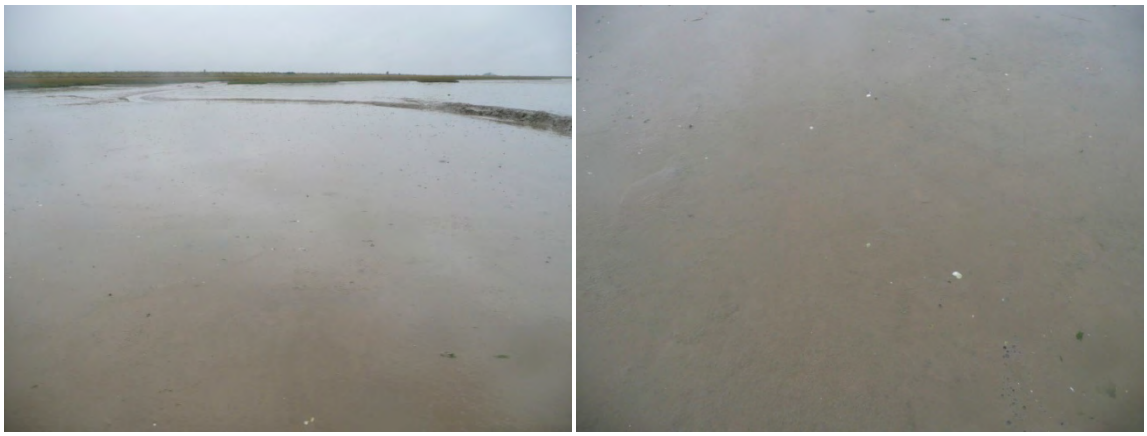

Figure 16. Mid shore habitats on transect 4.

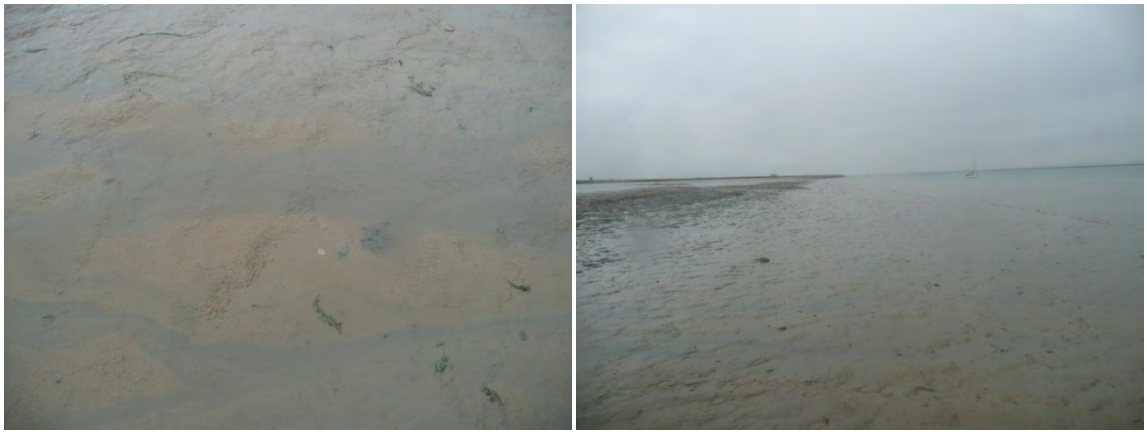

Figure 17. Low shore habitats on transect 4.

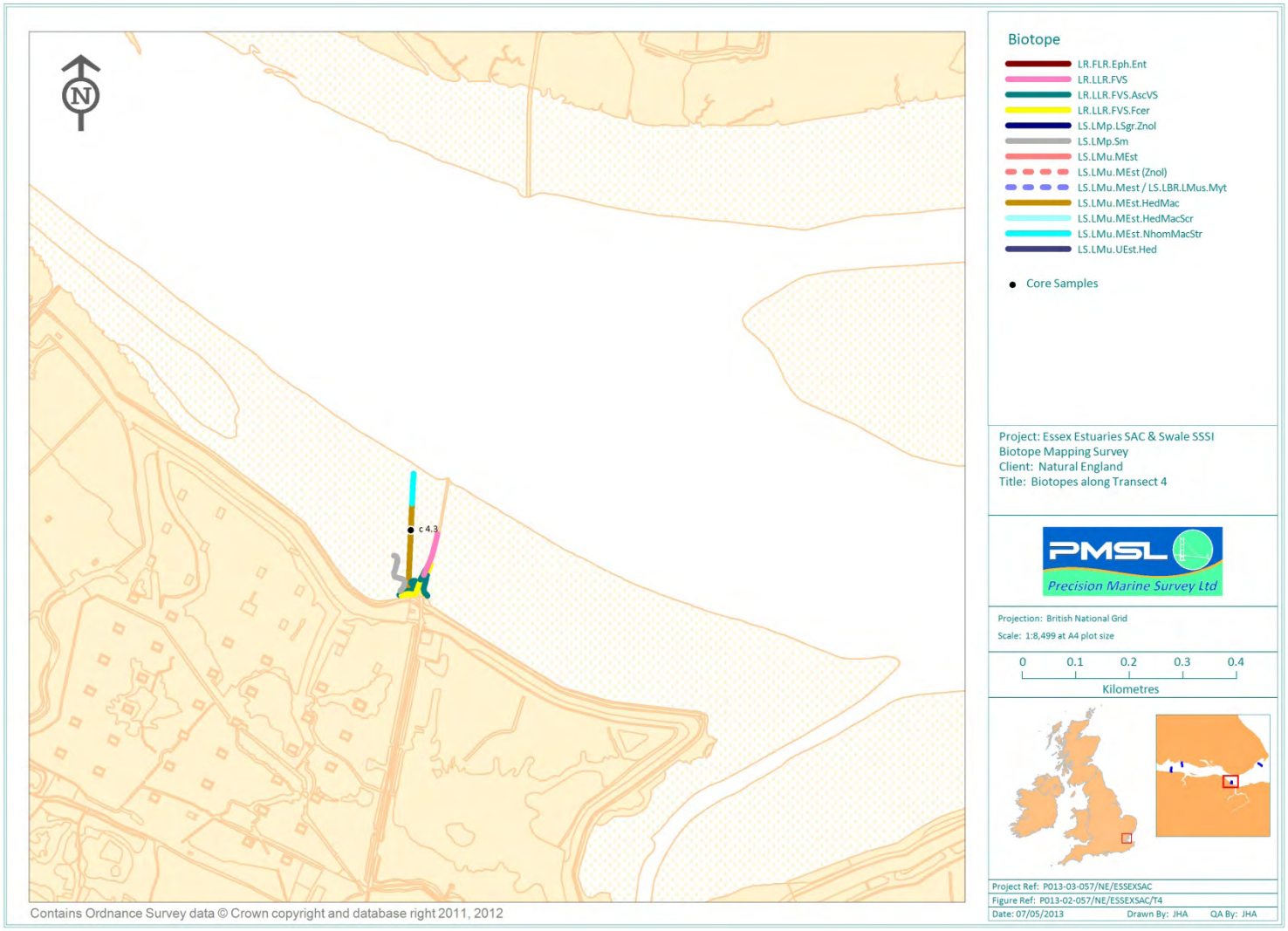

Figure 18. Biotopes along transect 4.

3.5 Transect 5

Transect 5 is situated to the southern end of Maplin Sands just inside the MOD range at Shoeburyness. At the top of the shore is a narrow band of barren gravelly sand/shingle (LS.LCS.Sh.BarSh - Barren littoral shingle) which is followed by an area of rippled muddy sand approximately 100m wide which is characterised by sparse to moderate coverage of *Zostera noltii* (LS.LMp.LSgr.Znol - *Zostera noltii* beds in littoral muddy sand). In this area infaunal species includes common or abundant *Hydrobia ulvae*, frequent *Macoma balthica*, *Nephtys* spp., and *Tubificoides* spp. (mainly T. *benedii*) and occasional other taxa including *cockles*, cumacean crustacea, spionids such as *Pygospio elegans*, *Corophium* sp., *Scoloplos armiger*, *Glycera* sp., Phyllodocidae polychaetes and low numbers of *Arenicola marina*.

Beyond this is an extensive area (over 2km) of somewhat variable rippled sand or slightly muddy sand which is characterised by occasional to frequent cockles and frequent *Arenicola marina* (1-3m^2), occasional or frequent amphipods (*Bathyporeia* sp.) along with *Nephtys* sp. *Macoma balthica* and *Hydrobia ulvae* which were also recorded frequently although their distribution was somewhat variable. This habitat was somewhat transitional between LS.LSa.MuSa.MacAre - *Macoma balthica* and *Arenicola marina* in littoral muddy sand and LS.LSa.FiSa.Po.Ncir (*Nephtys cirrosa* dominated littoral fine sand).

This habitat graded into a similar rippled sand or slightly muddy sand further down shore which extended almost to low water which had a higher level of cockle shell debris and greater numbers of cockles (frequent to common) along with frequent amphipods (*Bathyporeia* sp.), occasional *Nephtys* sp., spionids and Phyllodocidae polychaetes along with low numbers of other polychaetes such as *Scoloplos armiger* and *Glycera* sp. *Arenicola marina* was also present sporadically in low numbers (<1m^2). This area was also crossed by a number of run-off channels running north to south, the edges of which had slightly muddier sands with high levels of cockle debris. This habitat formed a somewhat transitional community with elements of LS.LSa.MuSa.CerPo - *Cerastoderma edule* and polychaetes in littoral muddy sand and LS.LSa.FiSa.Po.Ncir (*Nephtys cirrosa* dominated littoral fine sand).

At the low shore was an area some 200m wide which comprised of flat slightly rippled medium/fine sand which was characterised by *Bathyporeia* sp. and nematode worms (common) with occasional *Nephtys cirrosa*, *Diastylis* sp. and spionid polychaetes (LS.LSa.FiSa.Po.Ncir - *Nephtys cirrosa* dominated littoral fine sand). Adjacent to this transect the MOD firing range fence extends some distance down shore and whilst this extensive structure was not part of the survey transect on the midshore it was typically colonised by barnacles and *Mytlius edulis* at the base of the fence posts with *Ulva* and *Porphyra* higher up. One shell of Pacific oyster (*Crossastrea gigas*) was also recorded here with others occasionally noted on the upper shore adjacent to the fence.

A selection of representative photographs from transect 5 is provided in Figures 19 to 21 and a map showing the distribution of biotopes is provided in Figure 22.

Figure 19. Upper shore habitats on transect 5.

Figure 20. Mid shore habitats on transect 5.

Figure 21. Low shore habitats on transect 5.

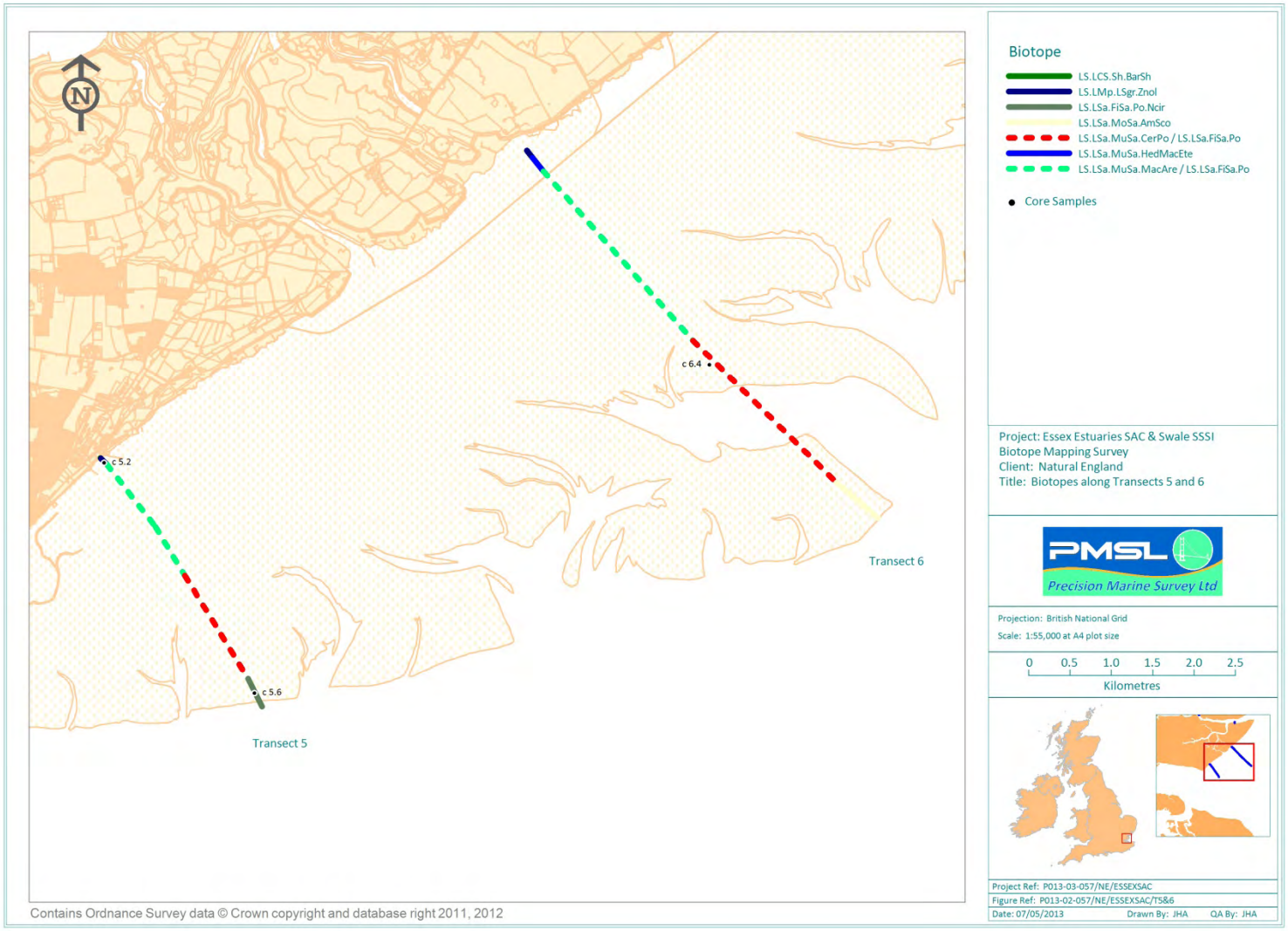

Figure 22. Biotopes along transects 5 and 6.

3.6 Transect 6

Transect 6 was located on Maplin Sands within the MOD range north of Shoeburyness and covered a particularly extensive area of relatively homogenous sand flats approximately 6km wide. At the top of the intertidal adjacent to *Spartina* dominated saltmarsh was a band of rippled muddy sand or sandy mud approximately 200-300m wide characterised by the seagrass *Zostera noltii* which varied in coverage from relatively sparse to moderate (LS.LMp.LSgr.Znol - *Zostera noltii* beds in littoral muddy sand). This habitat was characterised by abundant *Hydrobia ulvae* and common *Macoma balthica* along with frequent oligochaetes (primarily *Tubificoides benedii*). Other infauna included occasional *Nephtys hombergii*, Phyllodocidae polychaetes (including *Eteone* sp.) and also low numbers of Ampharetidae worms (*Melinna* sp.?) and *Arenicola marina*. Toward the lower end of this area was a band of uneven somewhat transitional muddy sand which had very sparse or occasional small patches *Zostera* but also higher numbers of *Corophium* sp. along with occasional *Arenicola marina*, *Hydrobia ulvae*, juvenile *Hediste* and *Scoloplos armiger* which is possibly LS.LSa.MuSa.HedMacEte (*Hediste diversicolor*, Macoma balthica and *Eteone longa* in littoral muddy sand) or a seasonal lower shore extension of the seagrass bed.

This habitat graded into a very extensive area of rippled sand or slightly muddy sand (approx 2km wide) often with variable coverage (frequent to common) of *Arenicola marina* (up to 5m^2) along with occasional *Macoma balthica*, *Nephtys* sp., amphipods and spionid polychaetes and forms a somewhat transitional variant of LS.LSa.MuSa.MacAre (*Macoma balthica* and *Arenicola marina* in littoral muddy sand) with LS.LSa.FiSa.Po.Ncir (*Nephtys cirrosa* dominated littoral fine sand). On the midshore this habitat included a quite wide area of similar character with frequent *Arenicola* which was covered in shallow standing water a few cm deep.

This area then graded into an extensive area of rippled sand (>3km) with varying cockle shell debris on the surface and variable abundances of live cockle in the sand (generally ranging from frequent to common). Other infaunal species showed a somewhat variable distribution and included occasional or frequent *Scoloplos armiger*, occasional to common *Bathyporeia* sp. and Tanaidacea crustacea (*Tanaissus lilljeborgi*) with occasional *Corophium* sp., *Macoma balthica* and spionid polychaetes such as *Spiophanes bombyx* or *Pygospio elegans* with *Arenicola marina* rarely recorded. Tubificidae oligochaetes and Nephtys hombergii were also often present in low numbers. This habitat was generally fairly homogenous but varied considerably in numbers of cockles and also included extensive areas covered by standing water and in such areas there were occasionally small clumps of hydroids or algae such as *Plocamium cartilagineum* attached to surface shell or live cockle. As described for transect 5 this region formed a transitional habitat with elements of both LS.LSa.MuSa.CerPo - *Cerastoderma edule* and polychaetes in littoral muddy sand and LS.LSa.FiSa.Po.Ncir (*Nephtys cirrosa* dominated littoral fine sand).

On the very low shore was a relatively narrow area of rippled fine to medium sand with some shell grit characterised by relatively sparse infauna including occasional amphipods such as *Bathyporeia* sp. and cumaceans (LS.LSa.MoSa.AmSco - Amphipods and *Scolelepis* spp. in littoral medium-fine sand).

A selection of representative photographs from transect 6 is provided in Figures 23 to 25 and a map showing the distribution of biotopes is provided in Figure 22.

Figure 23. Upper shore habitats on transect 6.

Figure 24. Mid shore habitats on transect 6.

Figure 25. Low shore habitats on transect 6.

3.7 Transect 7

Transect 7 was located in the outer Crouch Estuary on the south Bank to the east of Wallasey island. The top of the shore was backed by an area of raised mud punctuated by numerous small gullies colonised by *Salicornia* and *Enteromorpha* and the upper shore adjacent to the saltmarsh was characterised by an area approximately 30m wide with a similar habitat comprising of slightly elevated sandy mud with numerous shallow gullies. The surface of the more elevated mud was characterised by occasional *Salicornia* and patches of *Enteromorpha* with softer mud or sandy mud between with high levels of detritus colonised by abundant Tubificidae oligochaetes (primarily *Tubificoides benedii*), frequent *Hediste diversicolor* and *Hydrobia ulvae*, occasional *Scrobicularia plana*, *Macoma balthica*, *Eteone longa* and Cirratulidae polychaetes (transitional saltmarsh with LS.LMu.MEst.HedMac (*Hediste diversicolor* and *Macoma balthica* in littoral sandy mud).

Beyond this area on the main mudflat on the midshore was an area of somewhat lumpy sandy mud which was anoxic a few cm below surface with patches of *Enteromorpha* or *Ulva* and algal debris/detritus characterised by frequent to common *Tubificoides* sp. (*T. benedii*) and *Hydrobia ulvae*, occasional *Hediste diversicolor*, *Macoma balthica*, juvenile tellinid bivalves, *Pygospio elegans* or *Eteone* sp. Diptera larvae were also occasionally recorded in this area which forms a somewhat impoverished form of LS.LMu.MEst.HedMac (*Hediste diversicolor* and *Macoma balthica* in littoral sandy mud) or possibly transitional with LS.LSa.MuSa.HedMacEte (*Hediste diversicolor*, *Macoma balthica* and *Eteone longa* in littoral muddy sand).

From the mid to low shore a similar sandy mud habitat was present with less *Enteromorpha*/algal debris which had similar species but also included frequent or common *Scrobicularia plana* along with *Hediste diversicolor*, *Tubificoides benedii* and occasional *Macoma balthica* and spionid polychaetes including *Pygospio elegans* (LS.LMu.MEst.HedMacScr - *Hediste diversicolor*, *Macoma balthica* and *Scrobicularia plana* in littoral sandy mud shores). On the low shore was a narrow area (<40m) of smoother (and slightly sandier) muddy sand/sandy mud which had no *Scrobicularia plana* but high numbers of oligochaetes (*Tubificoides* spp.), frequent Macoma balthica and juvenile *Nephtys hombergii* and occasional spionid polychaetes (LS.LMu.MEst.NhomMacStr - *Nephtys hombergii*, *Macoma balthica* and *Streblospio shrubsolii* in littoral sandy mud).

A selection of representative photographs from transect 7 is provided in Figures 26 to 28 and a map showing the distribution of biotopes is provided in Figure 29.

Figure 26. Upper shore habitats on transect 7.

Figure 27. Mid shore habitats on transect 7.

Figure 28. Low shore habitats on transect 7.

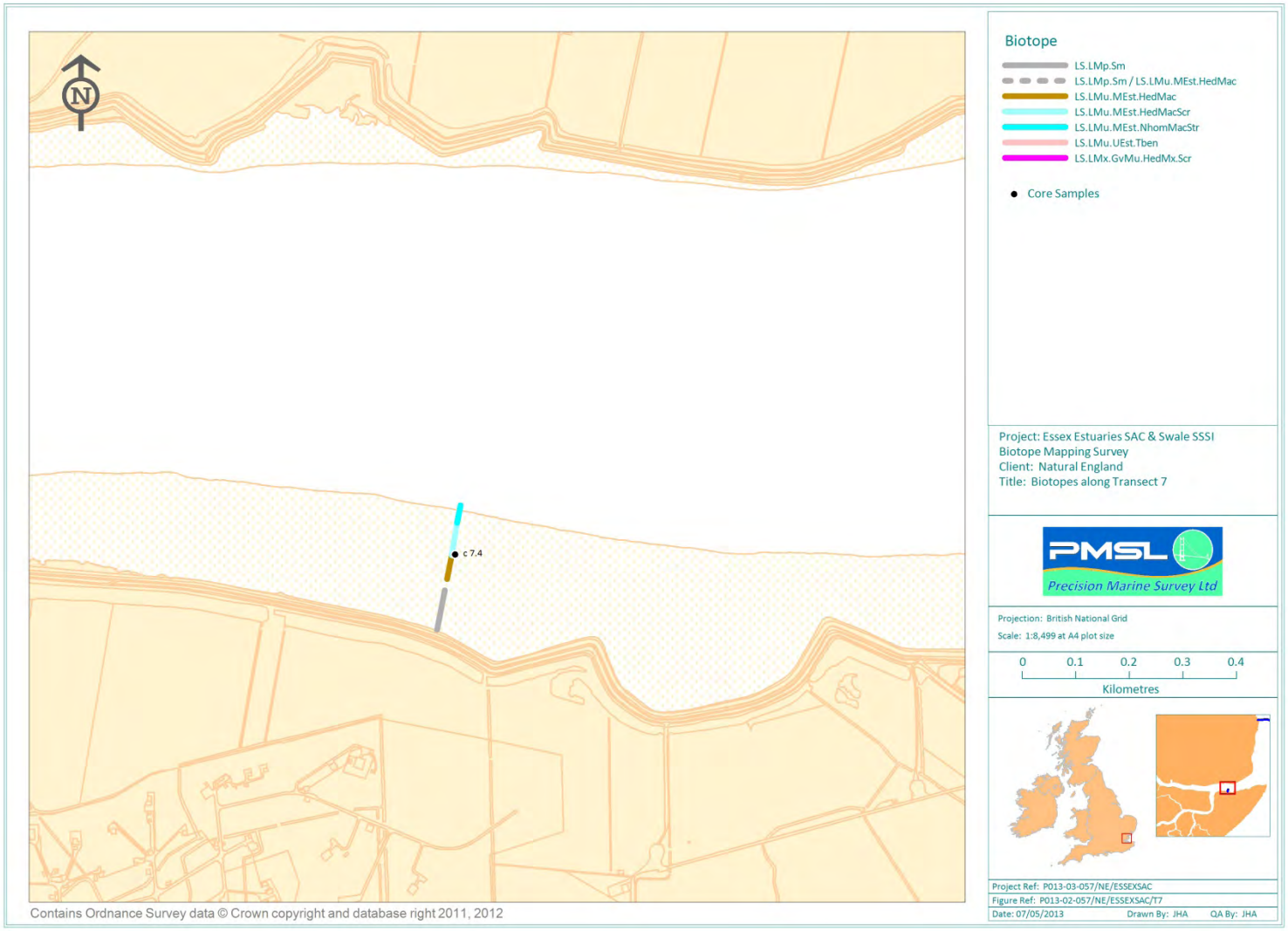

Figure 29. Biotopes along transect 7.

3.8 Transect 8

Transect 8 was a narrow area of intertidal located on the north bank of the Crouch upstream of Burnham. This area was backed by an eroded mud/clay bank with *Enteromorpha* which graded into mixed stony/gravelly sand or mud at its base. Muds at the base of the clay bank were characterised by oligochaetes (common) which included *Tubificoides benedii* or other *Tubificoides* sp. and possibly Enchytraeidae spp (LS.LMu.UEst.Tben - *Tubificoides benedii* and other oligochaetes in littoral mud). This area was fronted by an area of gravelly mud or sandy mud with stones/shell which was somewhat patchy with variable gravel/pebble content which included barnacles (*Elminius modestus*) and *Littorina* on the stones/pebbles with very occasional Pacific oyster (*Crassostrea gigas*) and muddier patches with frequent or common *Hediste diversicolor*, *Scrobicularia plana* and oligochaetes (primarily *Tubificoides benedii*) along with lower numbers of *Eteone* sp., Spionidae polychaetes, *Macoma balthica*, *Abra tenuis* and *Cyathura carinata* (LS.LMx.GvMu.HedMx.Scr - *Hediste diversicolor* and *Scrobicularia plana* in littoral gravelly mud). This habitat extended to the lower shore which was characterised by slightly rough sandy mud (with a diatom film) and included frequent *Nephtys hombergii*, *Streblospio sp.*, occasional juvenile *Hediste diversicolor*, frequent *Macoma balthica* and common or abundant *Tubificoides benedii* with very low numbers of *Scrobicularia plana* (LS.LMu.MEst.NhomMacStr - *Nephtys hombergii*, *Macoma balthica* and *Streblospio shrubsolii* in littoral sandy mud).

A selection of representative photographs from transect 8 is provided in Figures 30 to 32 and a map showing the distribution of biotopes is provided in Figure 33.

Figure 30. Upper shore habitats on transect 8.

Figure 31. Mid shore habitats on transect 8.

Figure 32. Low shore habitats on transect 8.

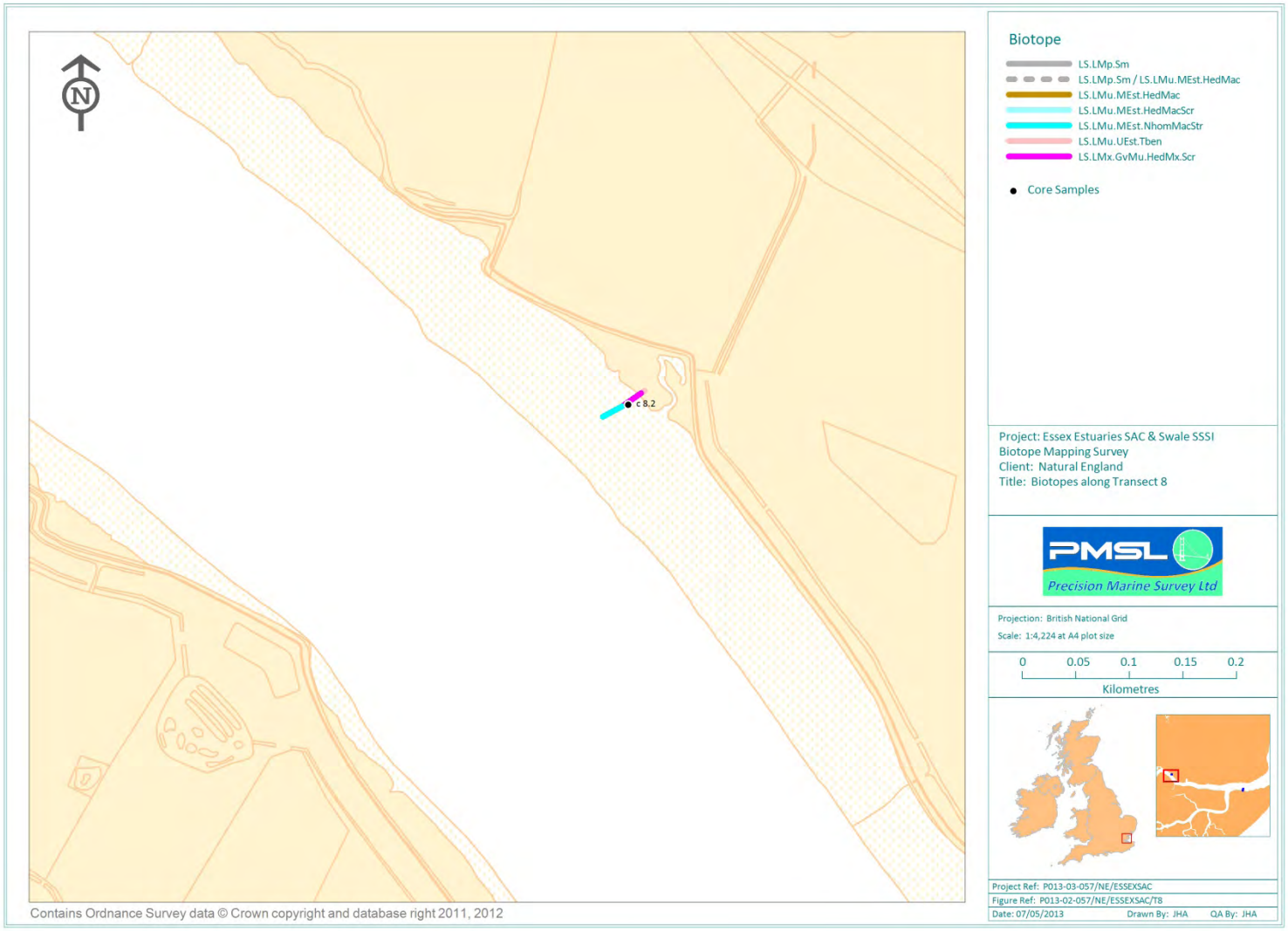

Figure 33. Biotopes along transect 8.

3.9 Transect 9

Transect 9 was located on the Dengie Flats off Tillingham marshes and was backed by a shallow eroded clay cliff with the upper shore characterised by an area some 150m wide with uneven sandy mud/muddy sand with numerous shallow run-off channels and areas of standing water. This habitat included softer mud over firmer anoxic, sandy mud/muddy sand with frequent or common *Streblospio sp.* or other spionids, occasional to frequent *Macoma balthica*, frequent juvenile *Hediste diversicolor*, occasional or frequent juvenile Tellinidae bivalves and Phyllodocidae polychaetes and frequent *Hydrobia ulvae* and as such may form an unusual sheltered coastal example of LS.LMu.MEst.HedMac (*Hediste diversicolor* and *Macoma balthica* in littoral sandy mud) which is presumably subject to some freshwater influence from runoff from the adjacent saltmarsh via the numerous channels present in this area.

A broadly similar habitat continued down the shore over an extensive area of sandy mud with shallow runoff channels with standing water running perpendicular to the shore. This area was characterised by common or frequent *Macoma balthica* and abundant *Hydrobia ulvae* with frequent or common *Streblospio sp.* (and other spionids), variable densities of cockle (occasional to common) and occasional to frequent *Nephtys hombergii* or *Hediste diversicolor*, juvenile Tellinidae bivalves and occasional *Tubificoides* oligochaetes with low numbers of *Arenicola marina*. Towards the lower midshore to low water was another extensive area some 500m in width which was characterised by uneven sandy mud with standing water characterised by frequent spionids such as *Pygospio elegans* or *Streblospio* sp., *Hydrobia ulvae, Macoma balthica* and cockles with occasional *Tubificoides* spp. *Nephtys hombergii* and juvenile *Hediste diversicolor* and *Abra* sp.

These habitats form somewhat unusual examples of open coast sandy mud and exhibit strong similarities to more typically outer estuarine biotopes such as LS.LMu.MEst.HedMac (*Hediste diversicolor* and *Macoma balthica* in littoral sandy mud) along with muddy sand biotopes such as LS.LSa.MuSa.HedMacEte - *Hediste diversicolor*, *Macoma balthica* and *Eteone longa* in littoral muddy sand). The moderately high cockle density in this area may not qualify as a full cockle bed but shows some resemblance (and is perhaps a transitional form) with the cockle biotope (LS.LSa.MuSa.CerPo (*Cerastoderma edule* and polychaetes in littoral muddy sand).

A selection of representative photographs from transect 9 is provided in Figures 34 to 36 and a map showing the distribution of biotopes is provided in Figure 37.

Figure 34. Upper shore habitats on transect 9.

Figure 35. Mid shore habitats on transect 9.

Figure 36. Low shore habitats on transect 9.

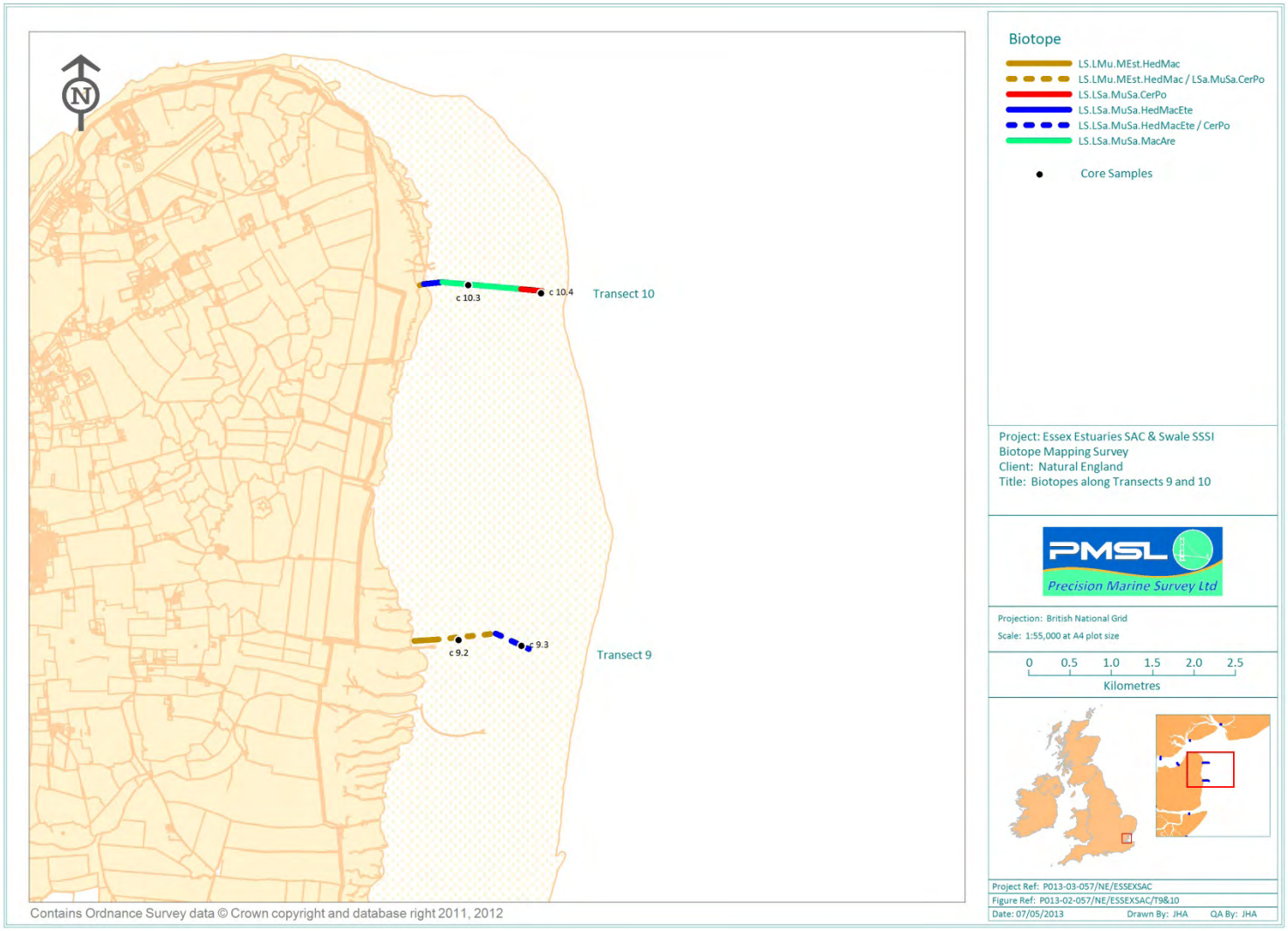

Figure 37. Biotopes along transect 9.

3.10 Transect 10

Transect 10 was located off Bradwell marshes on the Dengie flats and as recorded for transect 9 was backed by a shallow eroded clay cliff with *Enteromorpha*. This was fronted by an area of soft uneven sandy mud characterised by common or abundant Tubificidae oligochaetes (*T. benedii* primarily), frequent *Hediste diversicolor* and frequent or common *Macoma balthica* with occasional *Streblospio sp.*, *Hydrobia ulvae* and Cirratulidae polychaetes. As described for transect 9 this may form an unusual sheltered coastal example of LS.LMu.MEst.HedMac (*Hediste diversicolor* and *Macoma balthica* in littoral sandy mud) which is presumably subject to some freshwater influence from runoff from the adjacent saltmarsh. This habitat graded into a similar habitat of slightly ridged sandy mud/muddy sand with perpendicular runoff channels which was characterised by frequent juvenile *Hediste diversicolor*, frequent *Pygospio elegans* and other spionids, occasional *Nephtys hombergii* and *Macoma balthica* with *Eteone* sp. and occasional Diptera larvae which may be a somewhat muddier variant of LS.LSa.MuSa.HedMacEte (*Hediste diversicolor*, *Macoma balthica* and *Eteone longa* in littoral muddy sand).

Beyond this habitat the sediment become progressively sandier down shore and to the north to an extensive area of rippled muddy sand with common *Arenicola marina* (up to 5m^2), occasional *Macoma balthica*, *Nephtys* sp., *Scoloplos armiger* and *Pygospio elegans* (LS.LSa.MuSa.MacAre - *Macoma balthica* and *Arenicola marina* in littoral muddy sand) but also had occasional Maldanidae polychaetes (bamboo worms) namely *Euclymene oerstedi* and *Corophium* sp. This habitat continued for approximately 1km to somewhat sandier sediments with fewer *Arenicola marina* (occasional) and increasing amounts of cockle shell debris often with attached hydroids or red/green filamentous algae. This habitat continued to low water and was characterised by frequent to occasional cockles, occasional patches of *Lanice conchilega*, frequent *Macoma balthica* along with occasional *Nephtys* spp., Spionidae and Maldanidae polychaetes and Nuculidae bivalves. This may comprise a somewhat low density example of LS.LSa.MuSa.CerPo - *Cerastoderma edule* and polychaetes in littoral muddy sand with increased contribution from other sandy communities.

A selection of representative photographs from transect 10 is provided in Figures 38 to 40 and a map showing the distribution of biotopes is provided in Figure 41.

Figure 38. Upper shore habitats on transect 10.

Figure 39. Mid shore habitats on transect 10.

Figure 40. Low shore habitats on transect 10.

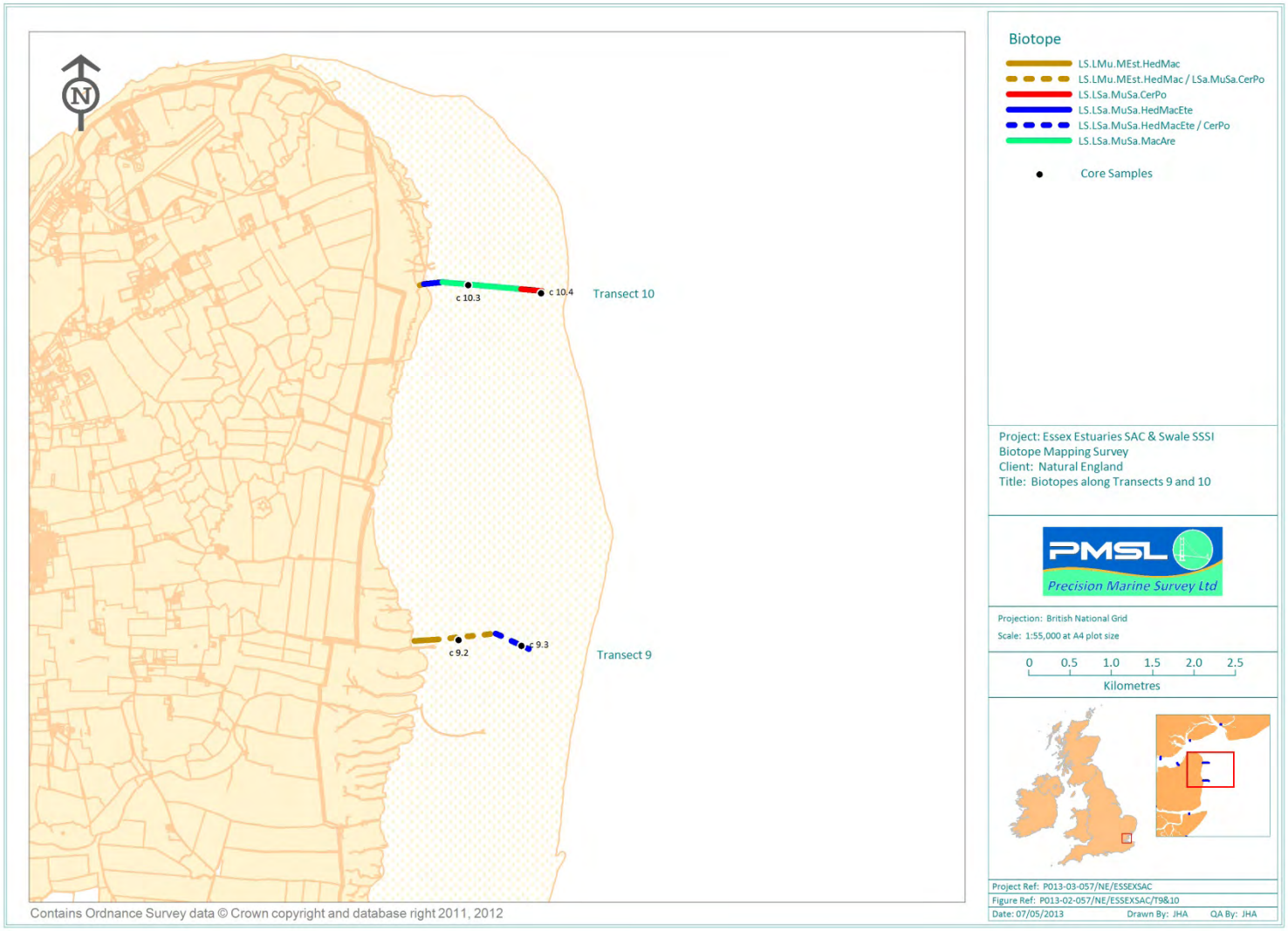

Figure 41. Biotopes along transect 10.

3.11 Transect 11

Transect 11 was located in Saint Lawrence bay in the outer Blackwater and was backed by hard sea defence colonised at its upper limit by a narrow band of *Enteromorpha* interspersed with a very thin band of patchy fucoids including *Fucus ceranoides* and/or occasional *Fucus spiralis* which is somewhat variable across the wider area but likely to include the biotopes LR.LLR.FVS.Fcer – (*Fucus ceranoides* on reduced salinity eulittoral rock) or LR.FLR.Eph.Ent (*Enteromorpha* spp. on freshwater-influenced and/or unstable upper eulittoral rock). Immediately below this was a wider area of dense *Ascophyllum nodosum* over rocks with abundant barnacles (*Elminius modestus*) and occasional/patchy *Fucus vesiculosus* which corresponds to the biotope LR.LLR.FVS.AscVS (*Ascophyllum nodosum* and *Fucus vesiculosus* on variable salinity mid eulittoral rock).

Beyond this was an area of soft anoxic upper shore mud with a diatom film characterised by abundant *Tubificoides benedii*, frequent *Macoma balthica* (juveniles) and Spionidae such as *Pygospio elegans* or *Streblospio sp.* along with occasional *Hediste diversicolor*, *Nephtys hombergii* and Cirratulidae polychaetes.

This habitat extends 300m to a narrow channel beyond which is an elevated area of uneven, very soft anoxic mud with a surface diatom film and a similar infaunal community to that described for the upper/mid shore and characterised by abundant/common oligochaetes (primarily *Tubificoides benedii*), frequent Spionidae polychaetes, *Macoma balthica* and *Nephtys hombergii* with occasional *Hediste diversicolor* and Cirratulidae polychaetes and frequent *Hydrobia ulvae*. Whilst somewhat variable the main intertidal section in this area broadly corresponds to LS.LMu.MEst.NhomMacStr (*Nephtys hombergii*, *Macoma balthica* and *Streblospio shrubsolii* in littoral sandy mud) albeit with a slightly richer infaunal community which perhaps indicates a somewhat transitional LS.LMu.MEst community.

At low water was a narrow band of firmer mud with patches or clumps of mussels (LS.LBR.LMus.Myt.Mu - *Mytilus edulis* beds on littoral mud). A selection of representative photographs from transect 11 is provided in Figures 42 to 44 and a map showing the distribution of biotopes is provided in Figure 45.

Figure 42. Upper shore habitats on transect 11.

Figure 43. Mid shore habitats on transect 11.

Figure 44. Low shore habitats on transect 11.

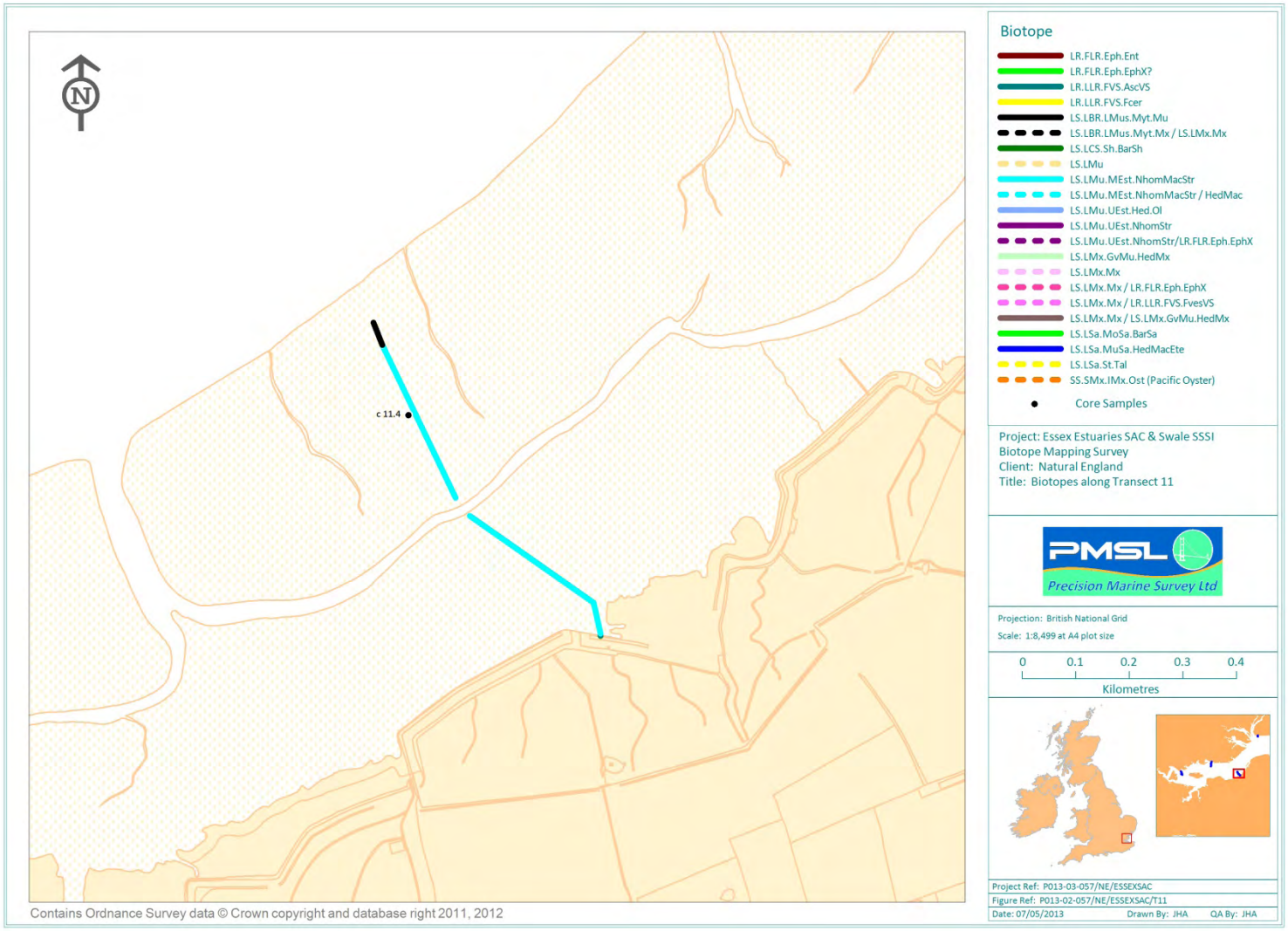

Figure 45. Biotopes along transect 11.

3.12 Transect 12

Transect 12 was located in the upper reaches of the Blackwater and backed onto hard sea defences characterised by a narrow fringe of Enteromorpha (LR.FLR.Eph.Ent - *Enteromorpha* spp. on freshwater-influenced and/or unstable upper eulittoral rock) on the sea wall above a band of LR.LLR.FVS.AscVS (Ascophyllum nodosum and Fucus vesiculosus on variable salinity mid eulittoral rock) which included dense *Ascophyllum nodosum* and occasional *Fucus vesiculosus* on silted cobble/boulder with occasional/frequent *Elminius modestus* and limpets (*Patella)*. This area was fronted by an area of muddy sand covered with *Enteromorpha* and filamentous red algae and occasional *Arenicola marina* (tentatively classified as LR.FLR.Eph.EphX - Ephemeral green and red seaweeds on variable salinity and/or disturbed eulittoral mixed substrata). This habitat graded into a wider area of anoxic muddy sand with 60% *Enteromorpha* coverage, occasional *Arenicola marina* and high numbers of *Tubificoides* oligochaetes with frequent/occasional spionid worms, Cirratulidae and Phyllodocidae polychaetes (such as *Eteone* sp.), *Nephtys hombergii, Hydrobia ulvae* and *Macoma balthica*. Lower numbers of Ampharetidae polychaetes (possibly *Melinna* sp.), *Hediste diversicolor,* juvenile Tellinidae bivalves and *Cyathura carinata* were also present. This habitat did not fit particularly well into the biotope classification but has been assigned LS.LSa.MuSa and possibly a variant of LS.LSa.MuSa.HedMacEte - *Hediste diversicolor*, *Macoma balthica* and *Eteone longa* in littoral muddy sand) albeit with a much reduced contribution by *Hediste diversicolor*.

This habitat was separated from the lower shore by an area of muddy mixed sediment with a variety of taxa including some green and red filamentous algae, a variety of amphipod species, common or abundant *Tubificoides* sp. oligochaetes and frequent Cirratulidae polychaetes. Other taxa included *Carcinus maenas*, chitons, occasional Phyllodocidae polychaetes, *Nephtys hombergii*, *Hydrobia ulvae*, Ampharetidae polychaetes, cockles and patches of *Mytilus edulis* often with *Fucus vesiculosus* and *Elminius modestus* and *Littorina* sp. which form a patchy/variable example of LS.LMx.Mx and/or LR.LLR.FVS.FvesVS. Beyond this extending to low water was an area of soft mud/sandy mud with a diatom cover and variable *Enteromorpha* along with occasional *Hediste diversicolor*, *Nephtys hombergii*, *Macoma balthica* and Spionidae polychaetes. Oligochaetes (primarily *Tubificoides benedii* and other Tubificidae) were common to abundant along with frequent *Hydrobia* and low numbers of Ampharetidae polychaetes and juvenile Tellinidae bivalves. This habitat appears to be a somewhat transitional example of LS.LMu.MEst.NhomMacStr (*Nephtys hombergii*, *Macoma balthica* and *Streblospio shrubsolii* in littoral sandy mud) with elements of LS.LMu.MEst.HedMac (*Hediste diversicolor* and *Macoma balthica* in littoral sandy mud but with a lower than usual contribution by *Hediste diversicolor* and a slightly wider complement of other infauna. To the north west of the transect at low water was another area of patchy mussels and *Fucus vesiculosus* in muddy mixed sediment (LS.LBR.LMus.Myt.Mx / LS.LMx.Mx - *Mytilus edulis* beds on littoral mixed substrata).

A selection of representative photographs from transect 12 is provided in Figures 46 to 48 and a map showing the distribution of biotopes is provided in Figure 49.

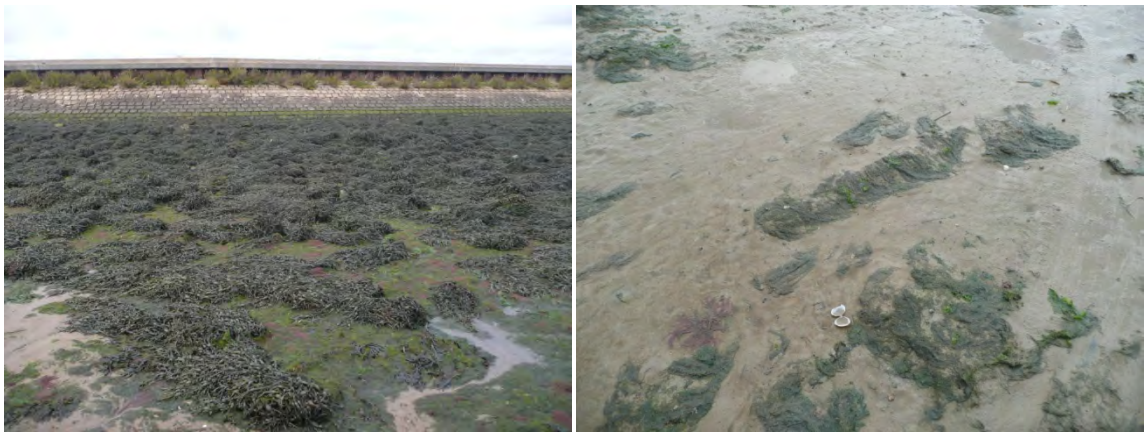

Figure 46. Upper shore habitats on transect 12.

Figure 47. Mid shore habitats on transect 12.

Figure 48. Low shore habitats on transect 12.

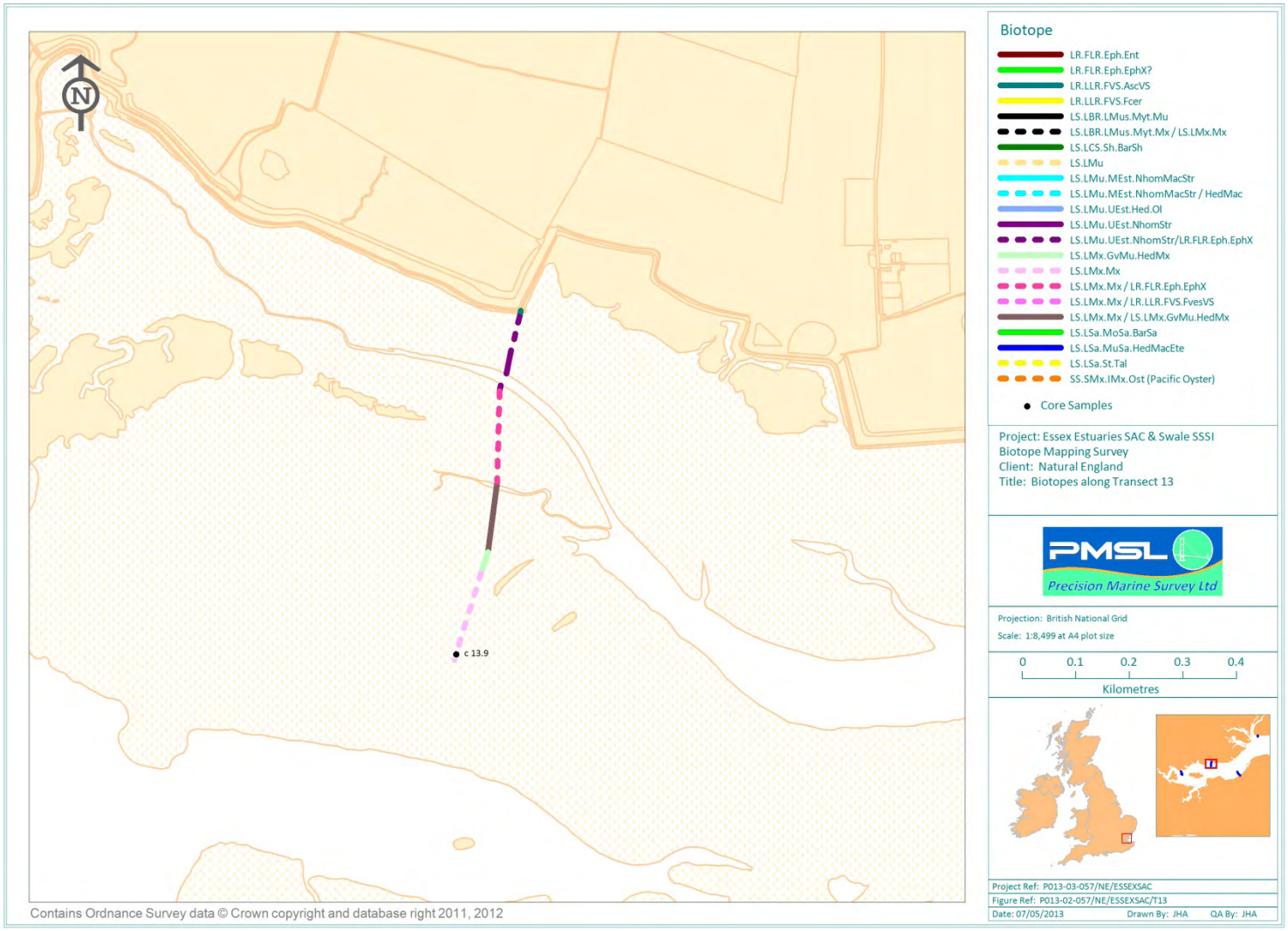

Figure 49. Biotopes along transect 12.

3.13 Transect 13

Transect 13 was situated in the Blackwater to the east of Osea Island and backed onto hard sea defences colonised by a narrow band of fucoids (including *Fucus ceranoides* - LR.LLR.FVS.Fcer - *Fucus ceranoides* on reduced salinity eulittoral rock) above a band of *Ascophyllum nodosum* and *Fucus vesiculosus* (LR.LLR.FVS.AscVS - *Ascophyllum nodosum* and *Fucus vesiculosus* on variable salinity mid eulittoral rock). Fringing this area was an area of mud/muddy sand and stones with filamentous green and red algae with *Ulva* and *Enteromorpha* sp. (LR.FLR.Eph.EphX - Ephemeral green and red seaweeds on variable salinity and/or disturbed eulittoral mixed substrata) which graded into a wider upper shore habitat of sandy mud and patchy stones/cobble colonised by dense patches of *Enteromorpha* and filamentous algae with frequent *Nephtys hombergii* and *Tubificoides* sp (*T. benedii* primarily) and occasional spionids including *Pygospio elegans* and occasional *Idotea* sp. isopods associated with the algae. This habitat forms a mosaic of patchy or transitional examples of LS.LMu.UEst.NhomStr (*Nephtys hombergii* and *Streblospio shrubsolii* in littoral mud) and LR.FLR.Eph.EphX (Ephemeral green and red seaweeds on variable salinity and/or disturbed eulittoral mixed substrata). This muddy mixed sediment habitat graded into sandy mud either side of a narrow upper shore channel with a similar infaunal assemblage but less algal coverage (LS.LMu.UEst.NhomStr - *Nephtys hombergii* and *Streblospio shrubsolii* in littoral mud).

Beyond the channel the remaining mid and low shore comprised of a heterogeneous mixed sediment habitat of stone and gravel/shell overlaying or mixed with sandy mud. This habitat was water logged and often covered by shallow water a few cm deep and on the low shore was colonised by a variety of species including patches of red and green filamentous algae, occasional *Corallina* spp., calcareous red algae and *Mastocarpus stellatus* on large stones along with barnacles such as *Elminius modestus*, *Littorina* sp. occasional *Mytilus*, cockle and both *Crepidula fornicata* and Pacific oyster (*Crassostrea gigas*) along with low numbers of brittlestars and anemones. Within the sediment was a variety of amphipods, frequent *Hediste diversicolor*, frequent Ampharetidae polychaetes (*Ampharete acutifrons*) occasional *Nephtys hombergii*, Cirratulidae polychaetes, spionids such as *Pygospio elegans* (and occasionally *Streblospio sp.)*, *Tubificoides benedii* and a range of other polychaetes.

This mixed sediment habitat continued up the shore to the upper mid shore channel with a broadly similar range of species but with species diversity and numbers of Pacific oyster tending to decrease up the shore whilst coverage by *Enteromorpha* or other filamentous algae increased. On the midshore and band of dryer mixed sandy mud and stones/gravel was present with a lower diversity of epibiota (primarily *Littorina* spp. and barnacles such as *Elminius modestus*) although the infauna was broadly similar to that lower down the shore albeit with a reduced range of species. Above this was a similar habitat to that recorded on the mid/low shore i.e. wetter mixed sediments with patchy drier areas of mixed sediment but with lower species diversity and higher coverage by *Enteromorpha*. This habitat then graded into anoxic sandy mud with *Enteromorpha* and green/ red filamentous algae with stones/shell on the surface which were colonised by barnacles, *Littorina* spp. and occasional *Mytilus*, cockle or Pacific oyster and an infaunal community characterised by frequent *Nephtys hombergii* and *Pygospio elegans* or other spionids, common Tubificidae oligochaetes and occasional amphipods and Phyllodocidae polychaetes. This habitat was

similar to that recorded on the lower shore but less diverse and continued to the channel on the upper shore and overall the mid to low shore area forms a mosaic of LS.LMx.Mx (Species-rich mixed sediment shores) on the lower shore and less well drained midshore areas interspersed with areas LS.LMx.GvMu.HedMx (Hediste diversicolor in littoral gravelly muddy sand and gravelly sandy mud).

A selection of representative photographs from transect 13 is provided in Figures 50 to 52 and a map showing the distribution of biotopes is provided in Figure 53.

Figure 50. Upper shore habitats on transect 13.

Figure 51. Mid shore habitats on transect 13.

Figure 52. Low shore habitats on transect 13.

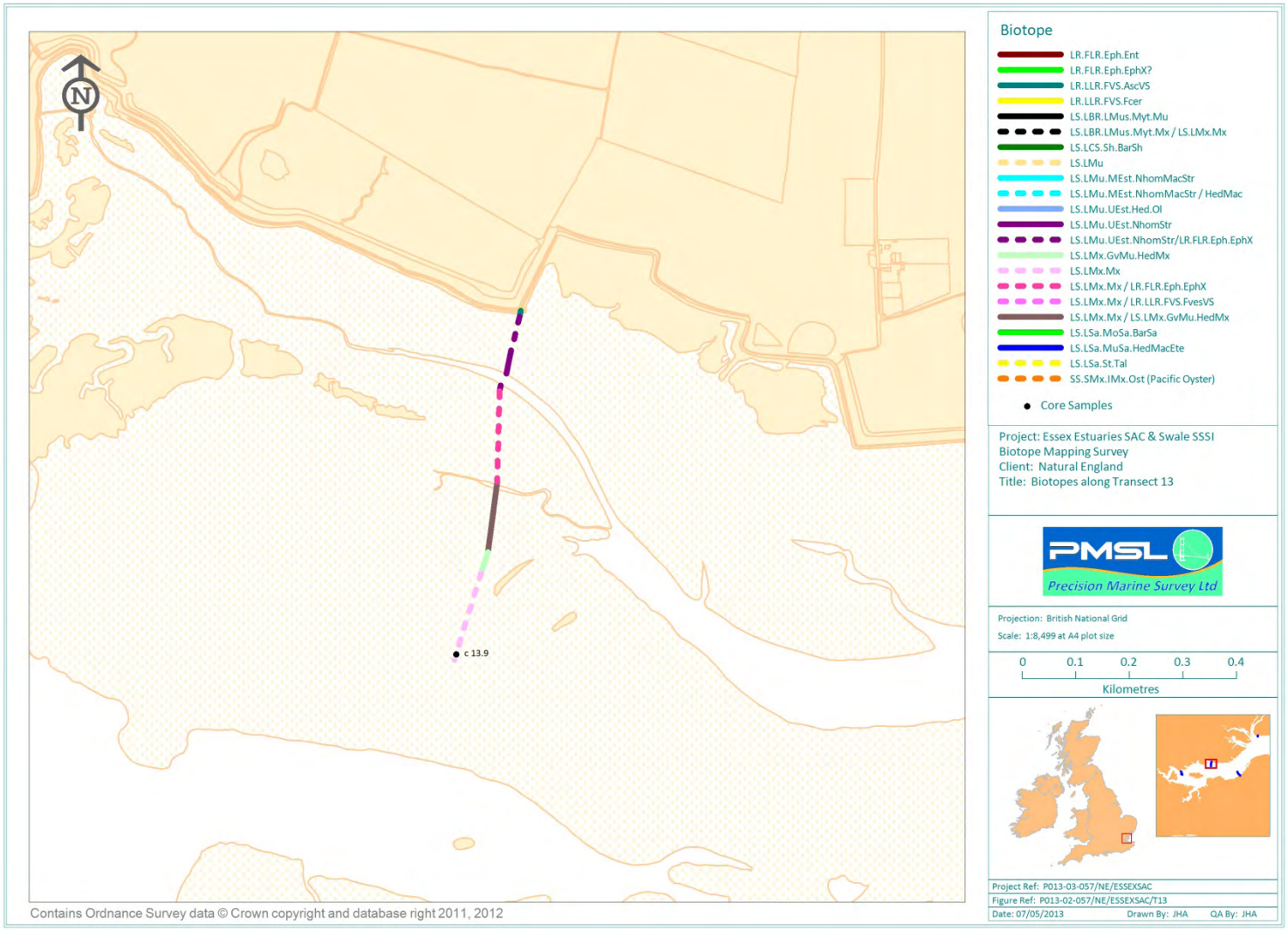

Figure 53. Biotopes along transect 13.

3.14 Transect 14

Transect 14 was located at the western end of Mersea Island and covered a relatively narrow area of intertidal although given the tidal regime and flooding tide during survey there was less exposed intertidal than likely on a big spring tide. This area was characterised by bands of barren sand (LS.LSa.MoSa.BarSa - Barren littoral coarse sand) or gravel/shingle (LS.LCS.Sh.BarSh - Barren littoral shingle) with occasional Gammaridae amphipod at the top of the beach with the strandline area colonised by little aside from amphipods such as *Talitrus saltator* (LS.LSa.St.Tal - Talitrids on the upper shore and strandline). Below this was an area of muddy sand/sandy mud with stones, cobble and shell with patches of *Ulva*, occasional mussel and cockle or one or two Pacific oyster, frequent *Littorina* sp. and occasional *Patella* and amphipod spp. with *Elminius modestus* encrusting larger stones/cobble. The infauna here was characterised by frequent *Hediste diversicolor* and Tubificoides oligochaetes with occasional *Nephtys hombergii*, Spionidae, Phyllodocidae polychaetes and isopod crustacea (LS.LMx.GvMu.HedMx - *Hediste diversicolor* in littoral gravelly muddy sand and gravelly sandy mud).

This habitat grades into a similar mixed sediment habitat which continued down to low water comprising of stones, shell over sandy mud with occasional *Mytilus edulis* and cockle and patchy coverage by barnacles (*Elminius modestus*) or red/green filamentous algae and frequent or common Pacific oyster. Infauna included frequent Tubificidae oligochaetes (primarily *T. benedii*) and occasional *Nephtys hombergii* or *Hediste diversicolor* along with Cirratuludae polychaetes and occasional Capitellidae worms and a variety of othe polychaetes including *Melinna palmata*. This habitat appears to include transitional/variable examples of LS.LMx.Mx and LS.LMx.GvMu.HedMx but with reduced diversity in comparison to mixed sediments on transect 13 perhaps reflecting the nature of the sediments (which comprised a veneer of coarser mixed sediment over mud) and the limited tidal exposure possible during survey. The epibiota in this area were somewhat patchily distributed and given the subsurface muddy sediment it is likely that cores collected in this area will be more representative of muddy sediments. In addition, the low shore area had numerous marks or trails across the sediment possibly indicating fishing activity or from movement of boats across the area. A selection of representative photographs from transect 11 is provided in Figures 54 to 56 and a map showing the distribution of biotopes is provided in Figure 57.

Figure 54. Upper shore habitats on transect 14.

Figure 55. Mid shore habitats on transect 14.

Figure 56. Low shore habitats on transect 14.

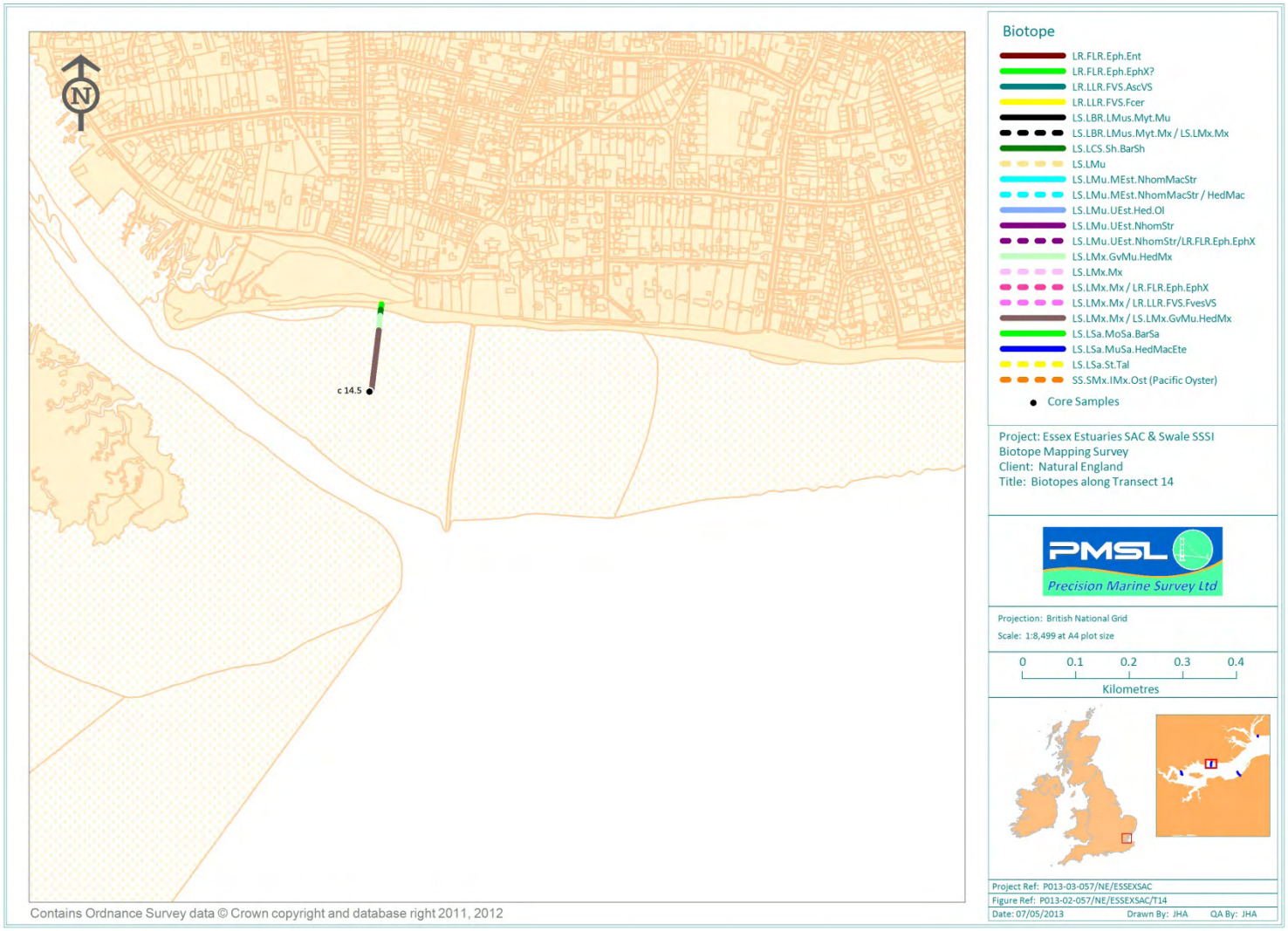

Figure 57. Biotopes along transect 14.

3.15 Transect 15

Transect 15 was a short transect located to the west of Brightlingsea and backed onto the sea wall which had a series of steps colonised by a very narrow band of Enteromorpha (LR.FLR.Eph.Ent - *Enteromorpha* spp. on freshwater-influenced and/or unstable upper eulittoral rock) above a band of *Fucus ceranoides* (LR.LLR.FVS.Fcer - *Fucus ceranoides* on reduced salinity eulittoral rock). Below this was an area of *Ascophyllum nodosum* and *Fucus vesiculosus* with abundant *Elminius modestus*, *Littorina* spp. and *Patella vulgata* underneath the weed (LR.LLR.FVS.AscVS - *Ascophyllum nodosum* and *Fucus vesiculosus* on variable salinity mid eulittoral rock). Frequent Pacific oyster were also recorded within the lower edge of the *Ascophyllum* zone on areas of exposed rock which had reduced coverage by *Ascophyllum* along with slightly higher coverage by *Fucus vesiculosus* at the base of the steps.

A narrow band (<1m wide) of mud with stones was present at the base of the steps which graded into an area of anoxic mud/sandy mud which covered the remaining intertidal area down to low water. This muddy habitat was colonised relatively few species primarily oligochaetes (including *Tubificoides benedii*) which were common or abundant and occasional to frequent *Hediste diversicolor* and *Nephtys hombergii* along with occasional spionids such as *Streblospio sp..* This habitat has been classified as LS.LMu.UEst.Hed.Ol (*Hediste diversicolor* and oligochaetes in littoral mud) albeit with a slightly wider range of infauna perhaps reflecting the position of the site in the estuary. The extreme low shore was covered by shallow water during the prevailing tides but the muddy habitat appeared to continue another 30-40m down shore to an oyster bed at or around the low water mark and running 250m along the edge of the main channel. This has been classified as a variant of the biotope SS.SMx.IMx.Ost characterised by abundant Pacific oyster (*Crassostrea gigas*) with patches of *Ulva lactuca*, *Fucus vesiculosus*, and *Porphyra* with occasional *Mytilus* and common barnacles (*Elminius modestus*) along with occasional/frequent *Littorina* spp. A selection of representative photographs from transect 11 is provided in Figures 58 to 60 and a map showing the distribution of biotopes is provided in Figure 61.

Figure 58. Upper shore habitats on transect 15.

Figure 59. Mid shore habitats on transect 15.

Figure 60. Low shore habitats on transect 15.

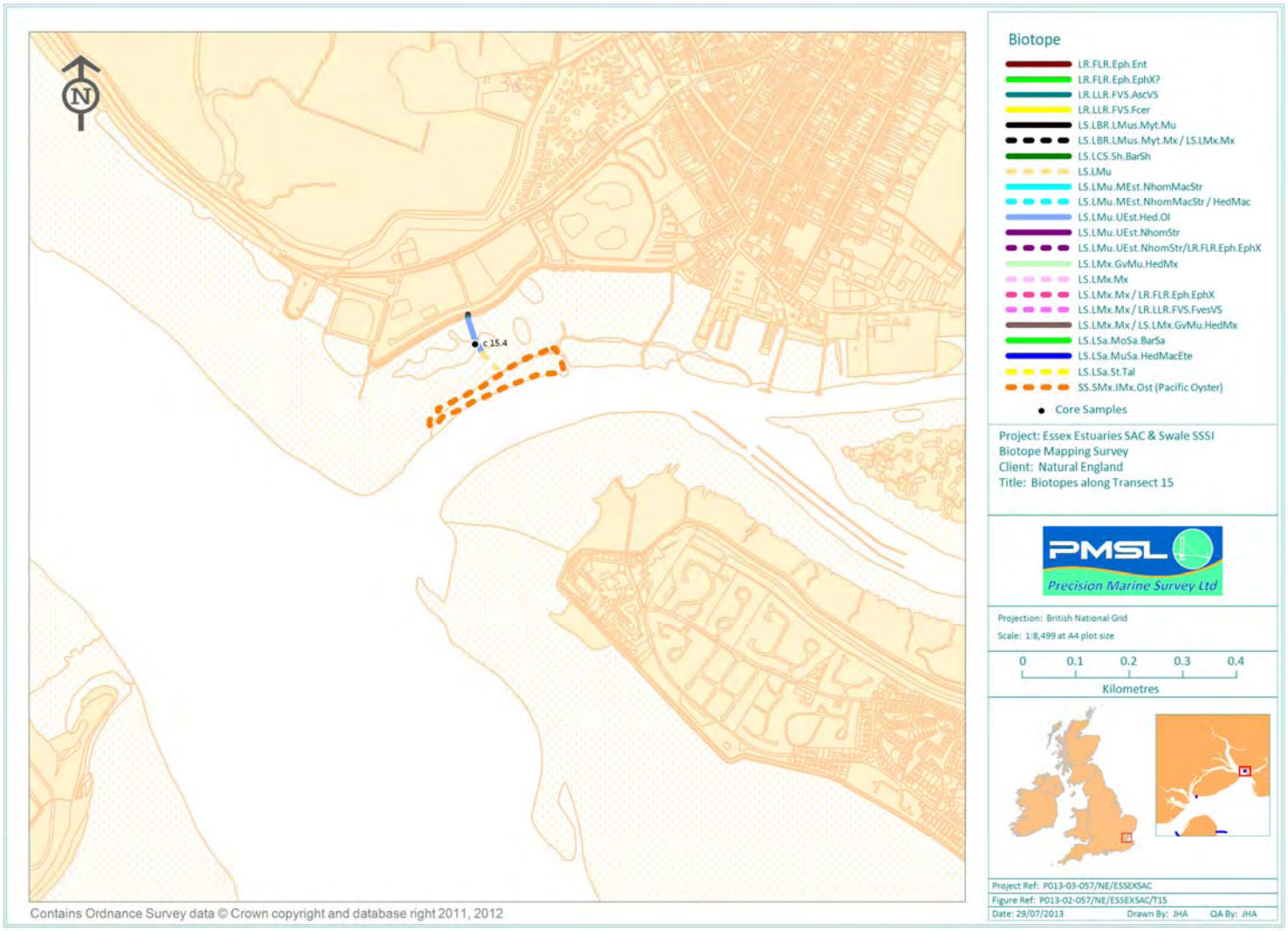

Figure 61. Biotopes along transect 15.

4. Summary

A total of 15 transects have been sampled from throughout the Essex Estuaries SAC and Swale SSSI. These were selected to provide representative examples of the main intertidal habitats/biotopes and how they are linked to the varying physical conditions that occur throughout the survey area. Given the scale of the area they do not, however, allow the derivation of a full biotope map of the entire estuary system but are merely representative of the areas targeted during survey. As such the data collected within this study represents a snapshot in time and does not capture any degree of natural variability.

A range of habitat types were recorded whilst undertaking the surveys including extensive areas of intertidal mudflats and sandflats (often backed by saltmarsh) and limited amounts of hard substratum – primarily hard sea defences. Localised but often quite extensive areas of mixed substrata were also recorded – notably in the Blackwater estuary. The intertidal areas of the Swale estuary were predominantly mudflats primarily comprising of sandy muds. A range of biotopes were recorded in this area including littoral rock biotopes on sea defences or other hard structures such as slipways (LR.FLR.Eph.Ent, LR.LLR.FVS, LR.LLR.FVS.AscVS and LR.LLR.FVS.Fcer). Soft sediments were characterised by littoral mud biotopes including LS.LMu.MEst, LS.LMu.MEst.HedMac, LS.LMu.MEst.HedMacScr, LS.LMu.MEst.NhomMacStr, and LS.LMu.UEst.Hed. Some areas of mussel beds (LS.LBR.LMus.Myt) were also noted and of particular interest was an extensive area of seagrass (including the biotope LS.LMp.LSgr.Znol) in the upper Swale which was also characterised by a diverse collection of infauna. Overall the infaunal communities in the Swale were moderately diverse (9 to 16 taxa per 0.01m^2) but often included high abundances (108 to 772 animals per 0.01m^2) which reflects the importance of the area for waders and wildfowl. Saltmarsh was found at the upper shore margins of a number of transects, particularly in the middle to outer reaches of the estuary and at transect 3 the seaward margin of the saltmarsh appears to be expanding (based on historic aerial photography).

Areas of coastal sand and muds are present within the SAC across the extensive intertidal flats at Maplin sands and Dengie Flats. The survey areas covered on Maplin Sands (transects 5 and 6) are characterised by extensive areas of moderately exposed sand and muddy sand with biotopes such as LS.LSa.MuSa.MacAre and LS.LSa.FiSa.Po which often form broad transitional habitats which in some areas on the mid to low shore grade into areas with higher numbers of cockle (LS.LSa.MuSa.CerPo). More dynamic/mobile sands are present on the lower shore with biotopes including LS.LSa.FiSa.Po.Ncir and LS.LSa.MoSa.AmSco whilst muddier sands are present torward the upper shore with examples of the biotope LS.LSa.MuSa.HedMacEte on transect 6. Both transects include a band of seagrass (LS.LMp.LSgr.Znol) on the upper shore and this habitat appears to be relatively widely distributed and appears to be a persistent feature of the site with a number of historic records (Boorman and Ranwell, 1977). Transects on Dengie flats (transects 9 and 10) indicate extensive areas of muddy sand often with muddier sediment toward the upper shore. These include coastal variants of biotopes such as LS.LMu.MEst.HedMac and LS.LSa.MuSa.HedMacEte along with LS.LSa.MuSa.MacAre and extensive areas cockle dominated sediments LS.LSa.MuSa.CerPo which often form wide transition zones. Sandier

habitats on Maplin sands tend to have relatively low species richness (2 to 8 taxa per 0.01m^2) and numbers of individuals (<30 per 0.01m2) whilst the seagrass beds on the upper shore include more diverse communities (8 to 12 taxa per 0.01m^2 and 176 to 507 individuals per 0.01m^2). Core samples from Dengie flat indicate moderate numbers of taxa (7 to 11 taxa per 0.01m^2) and moderate to low numbers of individuals (15 to 59 individuals per 0.01m^2).

Habitats surveyed in the Crouch estuary (transects 7 and 8) were predominantly muds or sandy muds which often formed relatively narrow intertidal areas. These were typically characterised by biotopes such as LS.LMu.UEst.Tben, LS.LMu.MEst.NhomMacStr, LS.LMu.MEst.HedMac and LS.LMu.MEst.HedMacScr whilst on transect 8 areas of mid to low shore mixed sediments were present characterised by the biotope LS.LMx.GvMu.HedMx.Scr. Core samples from the latter indicated moderate numbers of taxa and individuals (8 to 14 taxa per 0.01m^2 and 33 to 114 individuals per 0.01m^2).

Within the Blackwater a wide range of biotopes were recorded often accompanied by a relatively diverse estuarine invertebrate assemblage and highlights the physical complexity of this area. A wide range of habitats/biotopes were recorded in the Blackwater including fresh water influenced (variable salinity) algal communities (LR.FLR.Eph.Ent, LR.FLR.Eph.EphX, LR.LLR.FVS.AscVS and LR.LLR.FVS.Fcer) and muddy estuarine habitats characterised by biotopes such as such as LS.LSa.MuSa.HedMacEte, LS.LMu.MEst.NhomMacStr, LS.LMu.MEst.HedMac, LS.LMu.UEst.Hed.Ol and LS.LMu.UEst.NhomStr. Other important communities included mussel beds (LS.LBR.LMus.Myt.Mu and LS.LBR.LMus.Myt.Mx) and mixed sediment communities with biotopes such as LS.LMx.GvMu.HedMx and LS.LMx.Mx which often included a diverse invertebrate assemblage. These mixed sediments were often characterised by beds of Pacific Oyster in varying densities. No native oysters were recorded during the surveys although these are known to be present in many areas in the Blackwater (usually in subtidal areas or on the low shore) and form a key fishery along with Pacific Oyster within the region. Whilst not as widespread as in the Blackwater, Pacific Oyster were also recorded on a number of occasions throughout the Essex estuary SAC and also in the Swale SSSI including open coast habitats. The intertidal habitats surveyed within the Blackwater were characterised by variable levels of invertebrate species richness and density including some areas (usually in mixed sediments) with quite high values and numbers from core samples ranged from 6 to 17 taxa per 0.01m^2 and 31 to 879 individuals per 0.01m^2.

Overall the range of communities and biotopes recorded in the Swale SSSI and Essex Estuaries SAC appear to be typical for muddy estuarine habitats and open coast intertidal sands and muddy sands along the east coast with many habitats/biotopes recorded corresponding to those identified from previous studies (e.g. Boorman and Ranwell, 1977; English Nature, 1998; English Nature, 2000; Chesman *et al*., 2006; Unicomarine, 2009) and historic survey data compiled by JNCC contributing to the Marine Habitat Classification for Britain & Ireland (Connor *et al*., 2004). A relatively wide range of biotopes has been recorded within these areas with their distributions regulated by the physical characteristics of the estuaries and adjoining open coast. Estuaries tend to have a lower biodiversity than bordering marine and freshwater systems reflecting the high level of variability of environmental parameters such as salinity and sediment stability (Nybakken, 2001) in

conjunction to physiological and biological stresses caused by exposure to air (Peterson, 1991). However, within the Swale SSSI and Essex Estuary SAC areas of intertidal habitat with relatively high species richness and density were present highlighting the importance of these areas for avifaunal and fish communities. In addition, a number of habitats of conservation and commercial importance (e.g. seagrass beds, mixed sediments, mussel beds, oyster beds) are present in the area. Some of the habitats covered by the survey also included examples of ongoing environmental change or modification such as expanding (transect 3) or eroding saltmarsh (transects 9 and 10) and moderately high ephemeral algal growth possibly reflecting nutrient levels in conjunction with freshwater influences (upper Swale and Blackwater). Evidence of localised sediment disruption either in relation to commercial or recreational vessel movement (adjacent to slips, moorings etc) or fishing activity was also noted in both the Swale and the Blackwater.

In summary this study has served to provide a baseline description of the intertidal habitats and biotope types that occur along the 15 representative transects from around the Swale SSSI and Essex Estuary SAC. This data will contribute to the assessment of the condition of the intertidal mudflats and sandflats in these areas and support Natural England's ongoing programme of monitoring and surveillance of these intertidal features.

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Appendix 1: Abundance Data from Core Samples

	c 1.5A	c 1.5B	c 1.5C	c 1.5D	c 1.5E	c 2.4A	c 2.4B	c 2.4C	c 2.4D	c 2.4E
Sertulariidae sp. indet.										
Actiniaria sp. indet										
Nemertea sp.								1		
Nematoda sp. indet	12	7	2	3		3				
Eteone longa agg.			1		1			7	1	
Phyllodoce mucosa										
Eumida sanguinea										
Glycera alba										
Sphaerodoropsis minuta										
Nereididae sp. (juvenile)						1			1	1
Hediste diversicolor							2			
Alitta virens										
Nephtys sp. (juvenile)				1						
Nephtys cirrosa										
Nephtys hombergii	1	2	3	2	1	4	5	5	3	3
Scoloplos armiger										
Polydora cornuta				1		1	2	1	1	1
Pygospio elegans					3	12	20	20	7	14
Spiophanes bombyx										
Streblospio benedicti	8	1	3	3		53	50	52	29	43
Magelona johnstoni										
Caulleriella killariensis	178	111	117	156	231	17	28	15	18	24
Cossura longocirrata		5							1	1
Capitella sp. indet										
Euclymene oerstedi										
Melinna palmata										
Ampharete acutifrons										
Lanice conchilega										
Manayunkia aestuarina						1				
Paranais littoralis							1			1
Tubificoides benedii	27	27	21	36	56	131	150	118	131	90
Tubificoides pseudogaster						40	39	54	64	69
Anoplodactylus petiolatus										
Elminius modestus										P
Eusarsiella zostericola										
Dexamine spinosa										
Bathyporeia sarsi										
Gammarus sp. indet (damaged)										
Melita palmata										
Aoridae sp. (female)										
Corophium arenarium										
Corophium volutator										
Pariambus typicus										
Cyathura carinata										
Idotea pelagica										
Tanaissus lilljeborgi										
Cumopsis goodsiri										
Crangon crangon										
Carcinus maenas		1			1					
Leptochiton asellus			1							
Littorina littorea										1
Littorina saxatilis	1									
Hydrobia ulvae	492	395	416	384	467	30	78	46	16	42
Crepidula fornicata										
Nucula nitidosa										
Mytilus edulis (juvenile)					1					
Cerastoderma edule	6	9	8	4	8		2			
Angulus fabula										
Macoma balthica	3	4	6	3	2	13	18	13	17	15
Macoma balthica (juvenile)										
Abra nitida										
Abra tenuis										
Scrobicularia plana		1	1	1	1	1	2	1		1
Rhodophyta sp. indet										
Mastocarpus stellatus										
Ceramium sp.										
Ulva sp. indet										
Cladophora sp. indet										
Dolichopodidae sp. larvae										

Number of Taxa	9	11	11	11	11	13	13	12	12	15
Number of Individuals	728	563	579	594	772	307	397	333	289	306
Biomass (g wet weight)	13.8533	6.1831	13.6915	8.8143	11.9152	0.6541	5.9273	0.749	0.3565	2.7581
Margalef's d	1.21	1.58	1.57	1.57	1.50	2.10	2.01	1.89	1.94	2.27
Pielou's Evenness J	0.42	0.40	0.37	0.40	0.41	0.68	0.71	0.75	0.66	0.72
Shannon's Diversity H'(log 2)	1.34	1.39	1.29	1.40	1.42	2.53	2.64	2.68	2.36	2.73

	c 3.2A	c 3.2B	c 3.2C	c 3.2D	c 3.2E	c 5.2A	c 5.2B	c 5.2C	c 5.2D	c 5.2E
Sertulariidae sp. indet.										
Actiniaria sp. indet						1				
Nemertea sp.	1	1		1						
Nematoda sp. indet		7		3						
Eteone longa agg.	4	2	3	3	2			1	3	
Phyllodoce mucosa										
Eumida sanguinea										
Glycera alba										
Sphaerodoropsis minuta										
Nereididae sp. (juvenile)	16	37	36	9	7					
Hediste diversicolor	18	12	5	10	7					
Alitta virens										
Nephtys sp. (juvenile)					1					
Nephtys cirrosa										
Nephtys hombergii	1	3	4	2	3		1		1	1
Scoloplos armiger						1	1		1	P
Polydora cornuta										
Pygospio elegans	3	12	5		1	6	17	22	10	15
Spiophanes bombyx										
Streblospio benedicti	1	22	20	5	3			1		
Magelona johnstoni										
Caulleriella killariensis	1	3	9	5	2		2	2	1	3
Cossura longocirrata										
Capitella sp. indet									1	
Euclymene oerstedi										
Melinna palmata										
Ampharete acutifrons										
Lanice conchilega										
Manayunkia aestuarina										
Paranais littoralis										
Tubificoides benedii	25	19	49	42	16	34	15	16	9	12
Tubificoides pseudogaster	13	8	8	10	3	11	4	8	7	
Anoplodactylus petiolatus										
Elminius modestus										
Eusarsiella zostericola										
Dexamine spinosa										
Bathyporeia sarsi										
Gammarus sp. indet (damaged)										
Melita palmata										
Aoridae sp. (female)										
Corophium arenarium										
Corophium volutator										
Pariambus typicus										
Cyathura carinata										
Idotea pelagica						1				
Tanaissus lilljeborgi										
Cumopsis goodsiri						5				
Crangon crangon										
Carcinus maenas										
Leptochiton asellus										
Littorina littorea										
Littorina saxatilis									1	
Hydrobia ulvae	30	24	53	25	33	425	213	184	182	138
Crepidula fornicata										
Nucula nitidosa										
Mytilus edulis (juvenile)										
Cerastoderma edule						4				
Angulus fabula										
Macoma balthica	2	9	16	5	11	9	6	2	2	6
Macoma balthica (juvenile)						10	20	9	7	
Abra nitida										
Abra tenuis	6	11	13	4	10					1
Scrobicularia plana	12	12	6	13	9					
Rhodophyta sp. indet										
Mastocarpus stellatus										
Ceramium sp.										
Ulva sp. indet										
Cladophora sp. indet										
Dolichopodidae sp. larvae		1								

Number of Taxa	14	16	13	14	14	11	9	9	12	8
Number of Individuals	133	183	227	137	108	507	279	245	225	176
Biomass (g wet weight)	3.4674	9.1801	7.6075	2.8291	13.9215	6.7077	3.1292	1.9756	1.9154	2.3471
Margalef's d	2.66	2.88	2.21	2.64	2.78	1.61	1.42	1.45	2.03	1.16
Pielou's Evenness J	0.82	0.88	0.84	0.83	0.83	0.31	0.43	0.44	0.35	0.43
Shannon's Diversity H'(log 2)	3.12	3.51	3.12	3.16	3.16	1.06	1.36	1.39	1.26	1.19

	c 5.6A	c 5.6B	c 5.6C	c 5.6D	c 5.6E	c 6.4A	c 6.4B	c 6.4C	c 6.4D	c 6.4E
Sertulariidae sp. indet.										
Actiniaria sp. indet										
Nemertea sp.										
Nematoda sp. indet										
Eteone longa agg.							1			1
Phyllodoce mucosa										
Eumida sanguinea										
Glycera alba										
Sphaerodoropsis minuta										
Nereididae sp. (juvenile)										
Hediste diversicolor										
Alitta virens										
Nephtys sp. (juvenile)										
Nephtys cirrosa	2	1								
Nephtys hombergii					1	2				P
Scoloplos armiger										
Polydora cornuta										
Pygospio elegans									1	
Spiophanes bombyx						1	1	1		
Streblospio benedicti										
Magelona johnstoni			1							
Caulleriella killariensis								1		
Cossura longocirrata										
Capitella sp. indet										3
Euclymene oerstedi									1	
Melinna palmata										
Ampharete acutifrons										
Lanice conchilega										
Manayunkia aestuarina										
Paranais littoralis										
Tubificoides benedii							2	1	1	1
Tubificoides pseudogaster										
Anoplodactylus petiolatus										
Elminius modestus										
Eusarsiella zostericola										
Dexamine spinosa										
Bathyporeia sarsi	2			1		3	17	6	10	12
Gammarus sp. indet (damaged)										
Melita palmata										
Aoridae sp. (female)										
Corophium arenarium										
Corophium volutator										
Pariambus typicus										
Cyathura carinata										
Idotea pelagica										
Tanaissus lilljeborgi	1	1		3			2	2	4	6
Cumopsis goodsiri				1						
Crangon crangon					1					
Carcinus maenas										
Leptochiton asellus							1			
Littorina littorea										
Littorina saxatilis										
Hydrobia ulvae			1							
Crepidula fornicata										
Nucula nitidosa										
Mytilus edulis (juvenile)										
Cerastoderma edule						2	2			1
Angulus fabula										1
Macoma balthica							1			
Macoma balthica (juvenile)										
Abra nitida										
Abra tenuis										
Scrobicularia plana										
Rhodophyta sp. indet										
Mastocarpus stellatus										
Ceramium sp.										
Ulva sp. indet										
Cladophora sp. indet										
Dolichopodidae sp. larvae										

Number of Taxa	3	2	2	3	2	4	8	5	5	8
Number of Individuals	5	2	2	5	2	8	27	11	17	25
Biomass (g wet weight)	0.0148	0.2274	0.0005	0.0023	0.1873	3.3867	3.4195	0.0194	0.0353	1.2739
Margalef's d	1.24	1.44	1.44	1.24	1.44	1.44	2.12	1.67	1.41	1.86
Pielou's Evenness J	0.96	1.00	1.00	0.86	1.00	0.95	0.65	0.80	0.72	0.75
Shannon's Diversity H'(log 2)	1.52	1.00	1.00	1.37	1.00	1.91	1.96	1.87	1.66	2.11

	c 8.2A	c 8.2B	c 8.2C	c 8.2D	c 8.2E	c 9.3A	c 9.3B	c 9.3C	c 9.3D	c 9.3E
Sertulariidae sp. indet.										
Actiniaria sp. indet										
Nemertea sp.			1							1
Nematoda sp. indet										
Eteone longa agg.	3		2		2					
Phyllodoce mucosa										
Eumida sanguinea										
Glycera alba										
Sphaerodoropsis minuta										
Nereididae sp. (juvenile)	7	4	2	6	3					1
Hediste diversicolor	5	10	7	13	6					1
Alitta virens										
Nephtys sp. (juvenile)						1	1	1		2
Nephtys cirrosa										
Nephtys hombergii						1	1	3	1	2
Scoloplos armiger										
Polydora cornuta	1									
Pygospio elegans	12	2	1	4	2	10	14	11	5	5
Spiophanes bombyx										
Streblospio benedicti				3	9	5	3	11	4	7
Magelona johnstoni										
Caulleriella killariensis					2		2			
Cossura longocirrata										
Capitella sp. indet										
Euclymene oerstedi										
Melinna palmata										
Ampharete acutifrons						1				
Lanice conchilega										
Manayunkia aestuarina										
Paranais littoralis										
Tubificoides benedii	34	12	23	73	45	7				
Tubificoides pseudogaster	1		4			1				
Anoplodactylus petiolatus										
Elminius modestus	P	P	P	P	P					
Eusarsiella zostericola										
Dexamine spinosa										
Bathyporeia sarsi										
Gammarus sp. indet (damaged)										
Melita palmata										
Aoridae sp. (female)										
Corophium arenarium										
Corophium volutator										
Pariambus typicus										
Cyathura carinata	4	3	3	6	6					
Idotea pelagica										
Tanaissus lilljeborgi										
Cumopsis goodsiri										
Crangon crangon										
Carcinus maenas										
Leptochiton asellus										
Littorina littorea										
Littorina saxatilis										
Hydrobia ulvae	5	1	3	3	10	16	3	14	4	8
Crepidula fornicata										
Nucula nitidosa						1				1
Mytilus edulis (juvenile)										
Cerastoderma edule						14	7	6	8	10
Angulus fabula										
Macoma balthica	2		1		2	2	6	5	5	1
Macoma balthica (juvenile)										
Abra nitida									1	
Abra tenuis	1		4	4				1		
Scrobicularia plana	1	1	3	2	3					
Rhodophyta sp. indet										
Mastocarpus stellatus										
Ceramium sp.										
Ulva sp. indet										
Cladophora sp. indet										
Dolichopodidae sp. larvae	1									

Number of Taxa	14	8	13	10	12	11	8	8	7	11
Number of Individuals	77	33	54	114	90	59	37	52	28	39
Biomass (g wet weight)	0.0913	0.2653	0.952	0.559	2.5152	6.7712	6.0727	4.4012	4.2659	3.7237
Margalef's d	2.76	1.72	2.76	1.69	2.22	2.45	1.94	1.77	1.80	2.73
Pielou's Evenness J	0.73	0.81	0.79	0.61	0.73	0.80	0.84	0.87	0.91	0.84
Shannon's Diversity H'(log 2)	2.71	2.29	2.83	1.93	2.52	2.77	2.51	2.60	2.55	2.91

	c 10.3A	c 10.3B	c 10.3C	c 10.3D	c 10.3E	c 11.4A	c 11.4B	c 11.4C	c 11.4D	c 11.4E
Sertulariidae sp. indet.										
Actiniaria sp. indet										
Nemertea sp.										
Nematoda sp. indet										
Eteone longa agg.						3	1	3		1
Phyllodoce mucosa										
Eumida sanguinea										
Glycera alba										
Sphaerodoropsis minuta										
Nereididae sp. (juvenile)						5	11	24	14	16
Hediste diversicolor										
Alitta virens										
Nephtys sp. (juvenile)					1					1
Nephtys cirrosa										
Nephtys hombergii	1	1		1		4	2	2	1	2
Scoloplos armiger	1	4	1	5	4					
Polydora cornuta										
Pygospio elegans	3	1	6	1	3	127	39	120	52	96
Spiophanes bombyx										
Streblospio benedicti	1				1	45	32	96	22	84
Magelona johnstoni										
Caulleriella killariensis						2		2	1	
Cossura longocirrata										
Capitella sp. indet										
Euclymene oerstedi	3	6	2	3	P					
Melinna palmata										
Ampharete acutifrons										
Lanice conchilega										
Manayunkia aestuarina							1			
Paranais littoralis										
Tubificoides benedii	4					575	343	592	261	484
Tubificoides pseudogaster						5		4	3	4
Anoplodactylus petiolatus										
Elminius modestus										
Eusarsiella zostericola										
Dexamine spinosa										
Bathyporeia sarsi										
Gammarus sp. indet (damaged)										
Melita palmata										1
Aoridae sp. (female)										
Corophium arenarium		2			1					
Corophium volutator				1						
Pariambus typicus										
Cyathura carinata										
Idotea pelagica										
Tanaissus lilljeborgi										
Cumopsis goodsiri										
Crangon crangon										
Carcinus maenas										
Leptochiton asellus										
Littorina littorea										
Littorina saxatilis										
Hydrobia ulvae	5	4	8	2	7	34	12	13	13	12
Crepidula fornicata										
Nucula nitidosa			1	1	1					
Mytilus edulis (juvenile)										
Cerastoderma edule		1	2	1	2					
Angulus fabula										
Macoma balthica	5	4	5		6	44	33	23	20	25
Macoma balthica (juvenile)										
Abra nitida										
Abra tenuis										
Scrobicularia plana										
Rhodophyta sp. indet										
Mastocarpus stellatus										
Ceramium sp.										
Ulva sp. indet										
Cladophora sp. indet										
Dolichopodidae sp. larvae										

Number of Taxa	8	8	7	8	10	10	9	10	9	11
Number of Individuals	23	23	25	15	26	844	474	879	387	726
Biomass (g wet weight)	1.4776	2.269	6.3103	0.2416	2.5475	0.5982	0.5472	0.458	0.6145	0.6209
Margalef's d	2.23	2.23	1.86	2.58	2.46	1.34	1.30	1.33	1.34	1.52
Pielou's Evenness J	0.92	0.91	0.87	0.89	0.88	0.48	0.47	0.48	0.53	0.47
Shannon's Diversity H'(log 2)	2.75	2.72	2.44	2.68	2.78	1.60	1.50	1.60	1.66	1.63

	c 13.9A	c 13.9B	c 13.9C	c 13.9D	c 13.9E	c 14.5A	c 14.5B	c 14.5C	c 14.5D	c 14.5E
Sertulariidae sp. indet.				P						
Actiniaria sp. indet		1								
Nemertea sp.										
Nematoda sp. indet										
Eteone longa agg.				1						
Phyllodoce mucosa	2	1			1		1		1	
Eumida sanguinea					1					
Glycera alba	1									
Sphaerodoropsis minuta				2		1		1		
Nereididae sp. (juvenile)		1	5		9			2		5
Hediste diversicolor		2	2	1			1			
Alitta virens								P	1	
Nephtys sp. (juvenile)	1	2	2	4	6	2	7	9	11	4
Nephtys cirrosa										
Nephtys hombergii		2			1					
Scoloplos armiger										
Polydora cornuta			1							
Pygospio elegans	1	5	6	7	8		4	22	2	8
Spiophanes bombyx										
Streblospio benedicti		1	1			1	17	144	13	9
Magelona johnstoni										
Caulleriella killariensis	11	24	33	11	38	1	1	7	6	4
Cossura longocirrata								2		
Capitella sp. indet					1		1			
Euclymene oerstedi										
Melinna palmata				1				1	1	
Ampharete acutifrons	18	10	1	7	6					
Lanice conchilega				1						
Manayunkia aestuarina										
Paranais littoralis										
Tubificoides benedii	24	35	24	40	38	3	14	21	23	6
Tubificoides pseudogaster					11	23	45	71	60	51
Anoplodactylus petiolatus					1					
Elminius modestus	P		P		P					
Eusarsiella zostericola	1									
Dexamine spinosa					4					
Bathyporeia sarsi										
Gammarus sp. indet (damaged)					5					
Melita palmata	2		14		11					
Aoridae sp. (female)					3					
Corophium arenarium										
Corophium volutator								1		
Pariambus typicus										1
Cyathura carinata										
Idotea pelagica										
Tanaissus lilljeborgi										
Cumopsis goodsiri										
Crangon crangon										
Carcinus maenas	1		3		1					
Leptochiton asellus	4		4							
Littorina littorea										
Littorina saxatilis										
Hydrobia ulvae	1									
Crepidula fornicata	2		1		5					
Nucula nitidosa										
Mytilus edulis (juvenile)			1		1					
Cerastoderma edule	1			1						
Angulus fabula										
Macoma balthica										
Macoma balthica (juvenile)										
Abra nitida										
Abra tenuis				1				1		
Scrobicularia plana										
Rhodophyta sp. indet		P	P		P					
Mastocarpus stellatus					P					
Ceramium sp.		P	P							
Ulva sp. indet					P					P
Cladophora sp. indet	P									
Dolichopodidae sp. larvae										

Number of Taxa	16	13	17	13	23	6	9	13	9	9
Number of Individuals	70	84	98	77	151	31	91	282	118	88
Biomass (g wet weight)	0.5957	0.2137	3.1524	8.3237	19.3347	0.0191	0.9137	0.1672	2.1923	0.0323
Margalef's d	3.06	2.26	2.84	2.53	3.59	1.46	1.77	1.95	1.68	1.56
Pielou's Evenness J	0.72	0.68	0.74	0.66	0.78	0.53	0.67	0.58	0.67	0.70
Shannon's Diversity H'(log 2)	2.74	2.34	2.80	2.37	3.30	1.38	2.14	2.07	2.12	2.09

Appendix 2: Biomass Data from Core Samples

	c 1.5A	c 1.5B	c 1.5C	c 1.5D	c 1.5E	c 2.4A	c 2.4B	c 2.4C	c 2.4D	c 2.4E	c 3.2A	c 3.2B	c 3.2C	c 3.2D	c 3.2E
Sertulariidae sp. indet.															
Nemertea sp.								0.0003			0.0005	0.0003		0.0025	
Nematoda sp. indet	0.0001	0.0001	0.0001	0.0001		0.0001						0.0001		0.0001	
Eteone longa agg.			0.0006		0.0002			0.002	0.0007		0.0057	0.0011	0.0035	0.0081	0.0024
Phyllodoce mucosa															
Eumida sanguinea															
Glycera alba															
Sphaerodoropsis minuta															
Nereididae sp. (juvenile)						0.0002			0.0002	0.0004	0.01	0.0113	0.0137	0.0042	0.0051
Hediste diversicolor							0.0015				0.4262	0.5339	0.3455	0.2863	0.3884
Alitta virens															
Nephtys sp. (juvenile)				0.3318											0.0013
Nephtys cirrosa															
Nephtys hombergii	0.1267	0.168	0.4232	0.0068	0.0552	0.1621	0.1436	0.2485	0.0498	0.0703	0.0069	0.1218	0.2136	0.3375	0.1083
Scoloplos armiger															
Polydora cornuta				0.0004		0.0004	0.0014	0.0009	0.0016	0.0018					
Pygospio elegans					0.0008	0.0058	0.0155	0.0078	0.0063	0.0122	0.0005	0.0019	0.0018		0.0001
Spiophanes bombyx															
Streblospio benedicti	0.0015	0.0002	0.0003	0.0009		0.0117	0.0139	0.0188	0.0107	0.0114	0.0001	0.0031	0.0041	0.0008	0.0004
Magelona johnstoni															
Caulleriella killariensis	0.1605	0.0986	0.0875	0.1111	0.1804	0.007	0.0088	0.0108	0.0124	0.0024	0.001	0.0021	0.0042	0.004	0.0003
Cossura longocirrata		0.0005							0.0001	0.0001					
Capitella sp. indet															
Euclymene oerstedi															
Melinna palmata															
Ampharete acutifrons															
Lanice conchilega															
Manayunkia aestuarina						0.0001									
Paranais littoralis							0.0001			0.0001					
Tubificoides benedii	0.0103	0.0138	0.0109	0.0179	0.0252	0.0448	0.068	0.0415	0.0658	0.035	0.0109	0.0071	0.0247	0.0159	0.0084
Tubificoides pseudogaster						0.0079	0.0078	0.0113	0.0175	0.0186	0.0011	0.0011	0.0016	0.0011	0.0008
Anoplodactylus petiolatus															
Elminius modestus															
Eusarsiella zostericola															
Dexamine spinosa															
Bathyporeia sarsi															
Gammarus sp. indet (damaged)															
Melita palmata															
Aoridae sp. (female)															
Corophium arenarium															
Corophium volutator															
Pariambus typicus															
Cyathura carinata															
Idotea pelagica															
Tanaissus lilljeborgi															
Cumopsis goodsir															
Crangon crangon															
Carcinus maenas		0.0112			0.0213										
Leptochiton asellus			0.0032												
Littorina littorea										2.0376					
Littorina saxatilis	0.0539														
Hydrobia ulvae	2.812	1.8748	1.9193	2.3093	2.7027	0.1132	0.3191	0.1784	0.0745	0.1748	0.0785	0.0446	0.1366	0.0517	0.1083
Crepidula fornicata															
Nucula nitidosa															
Mytilus edulis (juvenile)					0.0337										
Cerastoderma edule	10.6413	3.4539	11.0553	5.8303	8.0056		4.598								
Angulus fabula															
Macoma balthica	0.047	0.5244	0.1039	0.128	0.7754	0.0866	0.0852	0.1385	0.1169	0.0701	0.0026	0.1303	0.1553	0.2302	0.3249
Macoma balthica (juvenile)															
Abra nitida															
Abra tenuis											0.0241	0.0529	0.0668	0.0149	0.0227
Scrobicularia plana		0.0376	0.0872	0.0777	0.1147	0.2142	0.6644	0.0902		0.3233	2.8993	8.268	6.6361	1.8718	12.9501
Dolichopodidae sp. larvae												0.0005			

	c 5.2A	c 5.2B	c 5.2C	c 5.2D	c 5.2E	c 5.6A	c 5.6B	c 5.6C	c 5.6D	c 5.6E	c 6.4A	c 6.4B	c 6.4C	c 6.4D	c 6.4E
Sertulariidae sp. indet.															
Nemertea sp.															
Nematoda sp. indet															
Eteone longa agg.			0.0017	0.0046								0.0099			0.0028
Phyllodoce mucosa															
Eumida sanguinea															
Glycera alba															
Sphaerodoropsis minuta															
Nereididae sp. (juvenile)															
Hediste diversicolor															
Alitta virens															
Nephtys sp. (juvenile)															
Nephtys cirrosa						0.0134	0.2273								
Nephtys hombergii		0.0139		0.1166	0.0101					0.1308	0.0237				0.0494
Scoloplos armiger	0.0269	0.0043		0.0138	0.0038										
Polydora cornuta															
Pygospio elegans	0.0057	0.0398	0.0189	0.0188	0.0174									0.0008	
Spiophanes bombyx											0.0294	0.0011	0.0055		
Streblospio benedicti			0.0008												
Magelona johnstoni								0.0004							
Caulleriella killariensis		0.0008	0.0007	0.0013	0.0007								0.0003		
Cossura longocirrata															
Capitella sp. indet				0.0004											0.0012
Euclymene oerstedi														0.0117	
Melinna palmata															
Ampharete acutifrons															
Lanice conchilega															
Manayunkia aestuarina															
Paranais littoralis															
Tubificoides benedii	0.0115	0.0092	0.0087	0.0038	0.0027							0.0007	0.0006	0.0004	0.0001
Tubificoides pseudogaster	0.001	0.0004	0.0033	0.0009											
Anoplodactylus petiolatus															
Elminius modestus															
Eusarsiella zostericola															
Dexamine spinosa															
Bathyporeia sarsi						0.0013			0.0021		0.0024	0.0341	0.0129	0.0221	0.0231
Gammarus sp. indet (damaged)															
Melita palmata															
Aoridae sp. (female)															
Corophium arenarium															
Corophium volutator															
Pariambus typicus															
Cyathura carinata															
Idotea pelagica	0.0016														
Tanaissus lilljeborgi						0.0001	0.0001		0.0001			0.0001	0.0001	0.0003	0.0003
Cumopsis goodsiri	0.0013								0.0001						
Crangon crangon										0.0565					
Carcinus maenas															
Leptochiton asellus												0.0234			
Littorina littorea															
Littorina saxatilis				0.0407											
Hydrobia ulvae	3.117	1.399	1.2849	1.2813	0.8689			0.0001							
Crepidula fornicata															
Nucula nitidosa															
Mytilus edulis (juvenile)															
Cerastoderma edule	0.6049										3.3312	3.3469			0.9681
Angulus fabula															0.2289
Macoma balthica	2.9358	1.6592	0.655	0.4319	1.4427							0.0033			
Macoma balthica (juvenile)	0.002	0.0026	0.0016	0.0013											
Abra nitida															
Abra tenuis					0.0008										
Scrobicularia plana															
Dolichopodidae sp. larvae															

	c 8.2A	c 8.2B	c 8.2C	c 8.2D	c 8.2E	c 9.3A	c 9.3B	c 9.3C	c 9.3D	c 9.3E	c 10.3A	c 10.3B	c 10.3C	c 10.3D	c 10.3E
Sertulariidae sp. indet.															
Nemertea sp.			0.0156							0.0003					
Nematoda sp. indet															
Eteone longa agg.	0.0029		0.0038		0.0053										
Phyllodoce mucosa															
Eumida sanguinea															
Glycera alba															
Sphaerodoropsis minuta															
Nereididae sp. (juvenile)	0.0027	0.0012	0.0008	0.0046	0.0012					0.0012					
Hediste diversicolor	0.0439	0.2075	0.3559	0.4193	0.0973					0.002					
Alitta virens															
Nephtys sp. (juvenile)						0.0032	0.0021	0.0042		0.0082					0.0031
Nephtys cirrosa															
Nephtys hombergii						0.0646	0.0461	0.149	0.0536	0.2112	0.062	0.0785		0.0205	
Scoloplos armiger											0.0072	0.0246	0.0004	0.0104	0.0402
Polydora cornuta	0.0003														
Pygospio elegans	0.0021	0.0005	0.0001	0.0016	0.0005	0.0047	0.0062	0.0038	0.0025	0.0012	0.0012	0.0002	0.0021	0.0006	0.0013
Spiophanes bombyx															
Streblospio benedicti				0.0001	0.0013	0.0025	0.0005	0.0023	0.0012	0.0013	0.0002				0.0001
Magelona johnstoni															
Caulleriella killariensis					0.0005		0.0006								
Cossura longocirrata															
Capitella sp. indet															
Euclymene oerstedi											0.1729	0.0438	0.0136	0.037	0.0074
Melinna palmata															
Ampharete acutifrons						0.0765									
Lanice conchilega															
Manayunkia aestuarina															
Paranais littoralis															
Tubificoides benedii	0.0067	0.0032	0.006	0.0267	0.0157	0.0024					0.0003				
Tubificoides pseudogaster	0.0001		0.0014			0.0006									
Anoplodactylus petiolatus															
Elminius modestus															
Eusarsiella zostericola															
Dexamine spinosa															
Bathyporeia sarsi															
Gammarus sp. indet (damaged)															
Melita palmata															
Aoridae sp. (female)															
Corophium arenarium												0.0005			0.0003
Corophium volutator														0.0001	
Pariambus typicus															
Cyathura carinata	0.0064	0.0076	0.0077	0.0096	0.0065										
Idotea pelagica															
Tanaissus lilljeborgi															
Cumopsis goodsiri															
Crangon crangon															
Carcinus maenas															
Leptochiton asellus															
Littorina littorea															
Littorina saxatilis															
Hydrobia ulvae	0.0086	0.0006	0.0037	0.0064	0.0132	0.0656	0.0203	0.0521	0.0521	0.0711	0.0137	0.0297	0.0378	0.0098	0.0326
Crepidula fornicata															
Nucula nitidosa						0.1258				0.1472			0.0948	0.063	0.0547
Mytilus edulis (juvenile)															
Cerastoderma edule						6.3327	5.2901	2.0761	2.9772	2.1044		0.4609	4.3062	0.1002	0.5778
Angulus fabula															
Macoma balthica	0.0031		0.0009		0.0009	0.0926	0.7068	2.1134	1.1376	1.1756	1.2201	1.6308	1.8554		1.83
Macoma balthica (juvenile)															
Abra nitida									0.0417						
Abra tenuis	0.0039		0.006	0.0167				0.0003							
Scrobicularia plana	0.006	0.0447	0.5501	0.074	2.3728										
Dolichopodidae sp. larvae	0.0046														

	c 11.4A	c 11.4B	c 11.4C	c 11.4D	c 11.4E	c 13.9A	c 13.9B	c 13.9C	c 13.9D	c 13.9E	c 14.5A	c 14.5B	c 14.5C	c 14.5D	c 14.5E
Sertulariidae sp. indet.															
Nemertea sp.															
Nematoda sp. indet															
Eteone longa agg.	0.0019	0.0011	0.0034		0.0004				0.0099						
Phyllodoce mucosa						0.0043	0.0022			0.0005		0.0026		0.0009	
Eumida sanguinea										0.0003					
Glycera alba						0.0108									
Sphaerodoropsis minuta									0.0006		0.0001		0.0001		
Nereididae sp. (juvenile)	0.0014	0.0032	0.0081	0.0118	0.0066		0.0013	0.004		0.0022			0.0023		0.0013
Hediste diversicolor							0.0159	0.0176	0.0051			0.8563			
Alitta virens													0.026	2.0928	
Nephtys sp. (juvenile)					0.0049	0.0019	0.0013	0.0116	0.0247	0.0243	0.008	0.0357	0.0391	0.0657	0.0105
Nephtys cirrosa															
Nephtys hombergii	0.0155	0.1532	0.0472	0.275	0.3276		0.0523			0.0412					
Scoloplos armiger															
Polydora cornuta								0.0004							
Pygospio elegans	0.0561	0.0098	0.0436	0.0217	0.0236	0.0005	0.0078	0.0019	0.0102	0.0093		0.0017	0.0235	0.0021	0.0031
Spiophanes bombyx															
Streblospio benedicti	0.0157	0.0054	0.024	0.0064	0.0164		0.0001	0.0007			0.0001	0.0022	0.0261	0.0016	0.0017
Magelona johnstoni															
Caulleriella killariensis	0.0004		0.0011	0.0019		0.0065	0.0115	0.0133	0.0122	0.0078	0.0011	0.0003	0.0015	0.0029	0.0015
Cossura longocirrata													0.0001		
Capitella sp. indet										0.0002		0.0001			
Euclymene oerstedi															
Melinna palmata									0.0028				0.0213	0.0005	
Ampharete acutifrons						0.2304	0.102	0.0062	0.0605	0.081					
Lanice conchilega									0.0527						
Manayunkia aestuarina		0.0001													
Paranais littoralis															
Tubificoides benedii	0.236	0.1865	0.1476	0.1509	0.0471	0.013	0.0193	0.0152	0.0287	0.0078	0.0006	0.0058	0.0054	0.0054	0.0023
Tubificoides pseudogaster	0.0018		0.0008	0.001	0.0016					0.0006	0.0092	0.009	0.0137	0.0204	0.0117
Anoplodactylus petiolatus										0.0001					
Elminius modestus															
Eusarsiella zostericola						0.0005									
Dexamine spinosa										0.0028					
Bathyporeia sarsi															
Gammarus sp. indet (damaged)										0.0737					
Melita palmata					0.0165	0.002		0.0123		0.0109					
Aoridae sp. (female)										0.0001					
Corophium arenarium															
Corophium volutator													0.0076		
Pariambus typicus															0.0002
Cyathura carinata															
Idotea pelagica															
Tanaissus lilljeborgi															
Cumopsis goodsiri															
Crangon crangon															
Carcinus maenas						0.0381		0.3592		0.2323					
Leptochiton asellus						0.0304		0.0358							
Littorina littorea															
Littorina saxatilis															
Hydrobia ulvae	0.0673	0.0297	0.0357	0.0371	0.0313	0.0018									
Crepidula fornicata						0.0177		0.006		11.486					
Nucula nitidosa															
Mytilus edulis (juvenile)								2.6682		7.3536					
Cerastoderma edule						0.2378			8.1086						
Angulus fabula															
Macoma balthica	0.2021	0.1582	0.1465	0.1087	0.1449										
Macoma balthica (juvenile)															
Abra nitida															
Abra tenuis									0.0077				0.0005		
Scrobicularia plana															
Dolichopodidae sp. larvae															

Appendix 3: Sediment data

SAMPLE	PARAMETER	c 1.5	c 2.4	c 3.2	c 4.3	c 5.2
COORDINATES (WGS84)	LATITUDE	51.362823	51.368106	51.363465	51.347670	51.533575
	LONGITUDE	0.792480	0.810265	0.938106	0.888966	0.807929
SAMPLE TYPE:		Bimodal, Very Poorly Sorted	Trimodal, Very Poorly Sorted	Bimodal, Very Poorly Sorted	Unimodal, Very Poorly Sorted	Unimodal, Moderately Sorted
TEXTURAL GROUP:		Slightly Gravelly Sandy Mud	Slightly Gravelly Sandy Mud	Sandy Mud	Slightly Gravelly Sandy Mud	Sand
SEDIMENT NAME:		Slightly Medium Gravelly Very Fine Sandy Medium Silt	Slightly Medium Gravelly Very Fine Sandy Very Coarse Silt	Very Fine Sandy Fine Silt	Slightly Fine Gravelly Very Fine Sandy Very Coarse Silt	Moderately Sorted Fine Sand
FOLK AND WARD METHOD (μm)	MEDIAN GRAIN SIZE D_{50} (μm)	30.9	30.7	21.3	35.2	130.4
	MEAN GRAIN SIZE (μm)	30.4	30.88	20.8	33.04	127.5
	SORTING	4.849	4.705	4.453	4.641	1.981
	SKEWNESS	0.016	0.034	-0.001	-0.035	-0.321
	KURTOSIS	0.828	0.888	0.769	0.886	2.050
FOLK AND WARD METHOD (ϕ)	MEDIAN GRAIN SIZE D_{50} (ϕ):	5.019	5.026	5.552	4.830	2.939
	MEAN GRAIN SIZE (ϕ):	5.039	5.017	5.590	4.919	2.971
	SORTING	2.278	2.234	2.155	2.214	0.986
	SKEWNESS	-0.016	-0.034	0.001	0.035	0.321
	KURTOSIS	0.828	0.888	0.769	0.886	2.050
FOLK AND WARD METHOD (Description)	MEAN:	Coarse Silt	Coarse Silt	Coarse Silt	Very Coarse Silt	Fine Sand
	SORTING:	Very Poorly Sorted	Very Poorly Sorted	Very Poorly Sorted	Very Poorly Sorted	Moderately Sorted
	SKEWNESS:	Symmetrical	Symmetrical	Symmetrical	Symmetrical	Very Fine Skewed
	KURTOSIS:	Platykurtic	Platykurtic	Platykurtic	Platykurtic	Very Leptokurtic
BULK GRAIN SIZE	% GRAVEL:	1.50	1.94	0.00	0.23	0.00
	% SAND:	34.55	31.81	27.80	35.41	91.53
	% MUD:	63.95	66.26	72.20	64.36	8.47
	% V COARSE GRAVEL:	0.00	0.00	0.00	0.00	0.00
	% COARSE GRAVEL:	0.00	0.00	0.00	0.00	0.00
	% MEDIUM GRAVEL:	0.98	1.85	0.00	0.00	0.00
	% FINE GRAVEL:	0.08	0.02	0.00	0.18	0.00
	% V FINE GRAVEL:	0.43	0.07	0.00	0.05	0.00
	% V COARSE SAND:	0.65	0.13	0.24	0.01	0.00
	% COARSE SAND:	1.68	1.76	0.98	2.47	0.00
	% MEDIUM SAND:	5.20	5.63	2.83	6.88	4.44
	% FINE SAND:	11.57	9.92	7.52	10.45	49.38
	% V FINE SAND:	15.46	14.37	16.22	15.61	37.71
	% V COARSE SILT:	13.71	15.86	15.68	17.19	1.33
	% COARSE SILT:	13.32	15.02	11.67	14.49	1.17
	% MEDIUM SILT:	14.64	14.87	13.83	13.24	2.96
	% FINE SILT:	13.27	12.52	16.39	11.51	1.89
	% V FINE SILT:	7.58	6.74	11.72	6.59	1.01
	% CLAY:	1.43	1.25	2.91	1.34	0.11
% LOI (ORGANIC CARBON)		5.77	6.26	5.32	5.65	0.96

SAMPLE	PARAMETER	c 5.6	c 6.4	c 7.4	c DR004	c 8.2
COORDINATES (WGS84)	LATITUDE	51.508579	51.544209	51.616254	51.622604	51.634352
	LONGITUDE	0.834057	0.913320	0.894584	0.839712	0.779499
SAMPLE TYPE:		Unimodal, Well Sorted	Unimodal, Moderately Well Sorted	Bimodal, Very Poorly Sorted	Bimodal, Very Poorly Sorted	Trimodal, Very Poorly Sorted
TEXTURAL GROUP:		Sand	Sand	Sandy Mud	Sandy Mud	Gravelly Mud
SEDIMENT NAME:		Well Sorted Fine Sand	Moderately Well Sorted Fine Sand	Very Fine Sandy Very Coarse Silt	Very Fine Sandy Fine Silt	Medium Gravelly Very Coarse Silt
FOLK AND WARD METHOD (μm)	MEDIAN GRAIN SIZE D_{50} (μm)	144.0	144.1	55.2	21.5	56.0
	MEAN GRAIN SIZE (μm)	143.9	143.5	36.3	22.4	65.2
	SORTING	1.410	1.476	4.415	4.691	11.617
	SKEWNESS	-0.013	-0.067	-0.332	0.076	0.180
	KURTOSIS	0.940	0.981	0.918	0.842	1.420
FOLK AND WARD METHOD (ϕ)	MEDIAN GRAIN SIZE D_{50} (ϕ):	2.796	2.795	4.178	5.538	4.158
	MEAN GRAIN SIZE (ϕ):	2.797	2.801	4.785	5.481	3.940
	SORTING	0.496	0.562	2.142	2.230	3.538
	SKEWNESS	0.013	0.067	0.332	-0.076	-0.180
	KURTOSIS	0.940	0.981	0.918	0.842	1.420
FOLK AND WARD METHOD (Description)	MEAN:	Fine Sand	Fine Sand	Very Coarse Silt	Coarse Silt	Very Fine Sand
	SORTING:	Well Sorted	Moderately Well Sorted	Very Poorly Sorted	Very Poorly Sorted	Very Poorly Sorted
	SKEWNESS:	Symmetrical	Symmetrical	Very Fine Skewed	Symmetrical	Coarse Skewed
	KURTOSIS:	Mesokurtic	Mesokurtic	Mesokurtic	Platykurtic	Leptokurtic
BULK GRAIN SIZE	% GRAVEL:	0.00	0.00	0.00	0.00	13.46
	% SAND:	99.93	97.45	45.71	28.18	33.05
	% MUD:	0.07	2.55	54.29	71.82	53.50
	% V COARSE GRAVEL:	0.00	0.00	0.00	0.00	0.00
	% COARSE GRAVEL:	0.00	0.00	0.00	0.00	0.00
	% MEDIUM GRAVEL:	0.00	0.00	0.00	0.00	7.59
	% FINE GRAVEL:	0.00	0.00	0.00	0.00	3.65
	% V FINE GRAVEL:	0.00	0.00	0.00	0.00	2.22
	% V COARSE SAND:	0.00	0.00	0.43	0.23	2.30
	% COARSE SAND:	0.00	0.00	2.53	2.20	1.48
	% MEDIUM SAND:	3.43	5.11	3.40	4.47	2.11
	% FINE SAND:	63.11	59.96	11.56	7.50	5.81
	% V FINE SAND:	33.39	32.38	27.79	13.79	21.35
	% V COARSE SILT:	0.07	0.27	19.39	14.77	18.34
	% COARSE SILT:	0.00	0.82	7.38	13.18	7.26
	% MEDIUM SILT:	0.00	1.06	8.47	15.24	8.41
	% FINE SILT:	0.00	0.20	10.12	16.09	10.34
	% V FINE SILT:	0.00	0.19	7.09	10.32	7.24
	% CLAY:	0.00	0.00	1.83	2.21	1.90
% LOI (ORGANIC CARBON)		0.43	0.58	3.80	6.35	2.98

SAMPLE	PARAMETER	c 9.2	c 9.3	c 10.3	c 10.4	c 11.4
COORDINATES (WGS84)	LATITUDE	51.686081	51.685437	51.724444	51.723565	51.724620
	LONGITUDE	0.955406	0.966361	0.957057	0.969788	0.860907
SAMPLE TYPE:		Bimodal, Poorly Sorted	Bimodal, Very Poorly Sorted	Unimodal, Moderately Sorted	Unimodal, Poorly Sorted	Bimodal, Very Poorly Sorted
TEXTURAL GROUP:		Sandy Mud	Slightly Gravelly Sandy Mud	Muddy Sand	Gravelly Muddy Sand	Sandy Mud
SEDIMENT NAME:		Very Fine Sandy Very Coarse Silt	Slightly Medium Gravelly Very Fine Sandy Very Coarse Silt	Very Coarse Silty Very Fine Sand	Very Fine Gravelly Very Coarse Silty Very Fine Sand	Very Fine Sandy Very Coarse Silt
FOLK AND WARD METHOD (μm)	MEDIAN GRAIN SIZE D_{50} (μm)	35.4	36.1	97.22	99.27	22.60
	MEAN GRAIN SIZE (μm)	25.1	27.55	96.058	97.520	22.556
	SORTING	3.88	4.031	1.787	3.233	4.453
	SKEWNESS	-0.330	-0.240	-0.311	0.047	0.052
	KURTOSIS	0.729	0.780	2.118	3.403	0.921
FOLK AND WARD METHOD (ϕ)	MEDIAN GRAIN SIZE D_{50} (ϕ):	4.821	4.793	3.363	3.333	5.467
	MEAN GRAIN SIZE (ϕ):	5.314	5.182	3.380	3.358	5.470
	SORTING	1.955	2.011	0.838	1.693	2.155
	SKEWNESS	0.330	0.240	0.311	-0.047	-0.052
	KURTOSIS	0.729	0.780	2.118	3.403	0.921
FOLK AND WARD METHOD (Description)	MEAN:	Coarse Silt	Coarse Silt	Very Fine Sand	Very Fine Sand	Coarse Silt
	SORTING:	Poorly Sorted	Very Poorly Sorted	Moderately Sorted	Poorly Sorted	Very Poorly Sorted
	SKEWNESS:	Very Fine Skewed	Fine Skewed	Very Fine Skewed	Symmetrical	Symmetrical
	KURTOSIS:	Platykurtic	Platykurtic	Very Leptokurtic	Extremely Leptokurtic	Mesokurtic
BULK GRAIN SIZE	% GRAVEL:	0.00	1.81	0.00	6.27	0.00
	% SAND:	31.70	32.42	87.82	75.03	25.35
	% MUD:	68.30	65.77	12.18	18.70	74.65
	% V COARSE GRAVEL:	0.00	0.00	0.00	0.00	0.00
	% COARSE GRAVEL:	0.00	0.00	0.00	0.00	0.00
	% MEDIUM GRAVEL:	0.00	0.89	0.00	1.79	0.00
	% FINE GRAVEL:	0.00	0.63	0.00	1.89	0.00
	% V FINE GRAVEL:	0.00	0.29	0.00	2.59	0.00
	% V COARSE SAND:	0.00	0.11	0.00	1.69	0.26
	% COARSE SAND:	0.05	0.46	0.00	0.00	2.22
	% MEDIUM SAND:	0.11	1.06	0.00	0.16	4.34
	% FINE SAND:	6.79	8.03	21.92	23.25	6.32
	% V FINE SAND:	24.74	22.76	65.90	49.93	12.20
	% V COARSE SILT:	21.42	19.07	5.96	9.20	17.01
	% COARSE SILT:	9.85	10.99	0.29	0.68	15.89
	% MEDIUM SILT:	11.38	12.48	3.13	3.82	15.51
	% FINE SILT:	13.72	13.11	1.76	2.88	15.00
	% V FINE SILT:	9.55	8.26	0.81	1.65	9.25
	% CLAY:	2.38	1.86	0.23	0.46	1.99
% LOI (ORGANIC CARBON)		3.78	5.32	1.14	1.28	6.63

SAMPLE	PARAMETER	c 12.6	c 13.9	c 14.5	c 15.4
COORDINATES (WGS84)	LATITUDE	51.726382	51.735085	51.772631	51.805205
	LONGITUDE	0.739392	0.802787	0.907595	1.015574
SAMPLE TYPE:		Bimodal, Very Poorly Sorted	Polymodal, Very Poorly Sorted	Trimodal, Extremely Poorly Sorted	Unimodal, Very Poorly Sorted
TEXTURAL GROUP:		Sandy Mud	Gravelly Mud	Gravelly Mud	Sandy Mud
SEDIMENT NAME:		Very Fine Sandy Very Coarse Silt	Coarse Gravelly Very Coarse Silt	Coarse Gravelly Very Coarse Silt	Very Fine Sandy Medium Silt
FOLK AND WARD METHOD (μm)	MEDIAN GRAIN SIZE D_{50} (μm)	34.23	75.4	53.6	15.5
	MEAN GRAIN SIZE (μm)	28.776	131.953	120.516	18.060
	SORTING	4.403	15.830	18.461	4.257
	SKEWNESS	-0.116	0.284	0.367	0.193
	KURTOSIS	0.835	1.329	1.266	0.981
FOLK AND WARD METHOD (ϕ)	MEDIAN GRAIN SIZE D_{50} (ϕ):	4.868	3.730	4.223	6.011
	MEAN GRAIN SIZE (ϕ):	5.119	2.922	3.053	5.791
	SORTING	2.138	3.985	4.206	2.090
	SKEWNESS	0.116	-0.284	-0.367	-0.193
	KURTOSIS	0.835	1.329	1.266	0.981
FOLK AND WARD METHOD (Description)	MEAN:	Coarse Silt	Fine Sand	Very Fine Sand	Coarse Silt
	SORTING:	Very Poorly Sorted	Very Poorly Sorted	Extremely Poorly Sorted	Very Poorly Sorted
	SKEWNESS:	Fine Skewed	Coarse Skewed	Very Coarse Skewed	Coarse Skewed
	KURTOSIS:	Platykurtic	Leptokurtic	Leptokurtic	Mesokurtic
BULK GRAIN SIZE	% GRAVEL:	0.00	17.43	17.34	0.00
	% SAND:	34.82	38.73	28.96	19.98
	% MUD:	65.18	43.84	53.70	80.02
	% V COARSE GRAVEL:	0.00	0.00	0.00	0.00
	% COARSE GRAVEL:	0.00	8.29	10.44	0.00
	% MEDIUM GRAVEL:	0.00	4.64	4.16	0.00
	% FINE GRAVEL:	0.00	2.50	1.65	0.00
	% V FINE GRAVEL:	0.00	2.01	1.09	0.00
	% V COARSE SAND:	0.29	2.82	0.47	0.17
	% COARSE SAND:	2.01	2.28	1.86	1.64
	% MEDIUM SAND:	4.02	3.66	4.57	4.04
	% FINE SAND:	9.47	8.74	7.60	5.78
	% V FINE SAND:	19.03	21.22	14.45	8.36
	% V COARSE SILT:	17.18	15.33	15.56	12.70
	% COARSE SILT:	11.97	6.79	11.13	17.10
	% MEDIUM SILT:	13.36	7.90	10.36	19.67
	% FINE SILT:	13.25	7.82	9.56	18.02
	% V FINE SILT:	7.87	4.76	5.72	10.42
	% CLAY:	1.54	1.25	1.38	2.10
% LOI (ORGANIC CARBON)		6.62	2.24	3.61	7.80