Natural England Commissioned Report NECR354

Otter Estuary rMCZ Intertidal Rock and Sediment Verification Survey 2013

First published May 2021

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Foreword

Natural England commission a range of reports from external contractors to provide evidence and advice to assist us in delivering our duties. The views in this report are those of the authors and do not necessarily represent those of Natural England.

Background

The Otter estuary rMCZ is a small estuarine site on the south coast of Devon 19km to the south east of Exeter. The site is being considered for designation because of its extensive intertidal mud flats which harbour a diverse range of fauna making the estuary an ecologically important site for both bird populations and as a nursery area for juvenile fish including bass.

Surveys commissioned by Natural England were undertaken by Ecospan Enivronmental Ltd during the spring low tides in October 2013 and March 2014. These surveys were designed to provide additional data and a partial baseline data set on the extent and presence of certain features within the Otter estuary rMCZ.

This report should be cited as: Lingard, B. 2013. Otter Estuary rMCZ Intertidal Rock and Sediment Verification Survey (2013). A report to Natural England from Ecospan Environmental Ltd.

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Keywords –

Further information
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ISBN 978-1-78354-751-7

Otter Estuary rMCZ Intertidal Rock and Sediment Verification Survey 2013

Report Number: ER14-233

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Framework Agreement No. 22643/04
Ecospan Project No: 13-287/288

SUMMARY REPORT CARD: The Otter estuary recommended Marine Conservation Zone (rMCZ)

The purpose of this 'Report Card' is to provide a summary comparison of the Broadscale habitat (BSH) characteristics predicted in the original Finding Sanctuary Regional MCZ Project Report Site Assessment Document (SAD) with revised estimates based on analysis of new data from the Natural England intertidal verification survey of the Otter estuary rMCZ conducted by Ecospan Environmental Ltd between October 2013 and March 2014.

In order to meet conservation objectives under the Marine and Coastal Access Act 2009, the Otter estuary rMCZ is being considered for inclusion in a network of marine protected areas (MPAs) within UK waters. Prior to the current survey, the SAD was largely based on 'best available evidence' drawn from historical data, stakeholder knowledge and modelled habitat maps. The key purpose of the current survey is to provide direct evidence of the presence and extent of the BSH and Habitats of Conservation Importance (HOCI) and the presence and distribution of Species of Conservation Importance (SOCI).

Table A. *Intertidal features [Broadscale habitat (BSH); Habitats of Conservation Importance (HOCI); Species of Conservation Importance (SOCI); and those habitats or species which are not listed in the Ecological Network Guidance (Non_ENG)] proposed in the Finding Sanctuary Regional MCZ Project SAD for inclusion within the MCZ designation*

Feature Code / Name	Regional MCZ Project SAD: Extent (km^2)*	Current Survey: Extent (km^2)	Accordance between Regional MCZ Project SAD and current survey	
			Presence (Y/N)	Extent (km^2)
BSH				
Littoral coarse sediment (A2.1)	<0.01	<0.01	Y	0
Littoral mud (A2.3)	0.05	0.04	Y	-0.01
Coastal saltmarsh and saline reedbeds*	0.07	-	Y	-
SOCI				
Anguilla anguilla (European eel)**	-	-	Y	-

**This BSH was not within the remit of this study; however it was noted as present during the surveys.*
*** This fish species and was therefore unlikely to be observed during this inter tidal survey.*

Table B. *Intertidal features [Broadscale habitat (BSH); Habitats of Conservation Importance (HOCI); Species of Conservation Importance (SOCI); and those habitats or species which are not listed in the Ecological Network Guidance (Non_ENG)] present but not currently proposed in the Otter estuary Regional MCZ Project SAD for inclusion within the MCZ designation*

Feature Code / Name	Regional MCZ Project SAD: Extent (km^2)*	Current Survey: Extent (km^2)	Accordance between Regional MCZ Project SAD and current survey	
			Presence (Y/N)	Extent (km^2)
BSH				
Littoral sand and muddy sand (A2.2)	-	0.01	Y	+0.01
Littoral mixed sediments (A2.4)	-	0.01	Y	+0.01
Littoral low energy rock (A1.3)	-	0.03	Y	+0.01

***Summary of major differences in presence and extent of intertidal features between the Regional Project SAD and current survey**:*

The main differences observed are the inclusion of low energy littoral rock (A1.3) and littoral sand and muddy sand (A2.2). The area of littoral mud (A2.3) has changed slightly due to the addition of littoral mixed sediments (A2.4) which have similar species compositions but different sediment granulometry.

Summary of anthropogenic activity within the rMCZ:

Slightly raised levels of PAHs were found in the sediment near the car park at the mouth of the estuary. This was probably a result of rain water run-off from this car park. It is highly unlikely that these levels of contamination pose a significant threat to communities within the rMCZ.

Some metal contamination was found at all sampling stations. However, this is most likely the result of erosion of local geology of the river catchment area. The total digest used during the analysis may also have contributed to these raised levels as this method extracts all metals not just those which are bio-available.

Other anthropogenic influences were very limited but included a land drain discharging from a drainage ditch into the estuary and two littered tyres lodged into the sediment.

Summary of Invasive Non-Native Species (INNS) present within the rMCZ:

No INNS were found within the sediment core samples taken in the estuary.

EXECUTIVE SUMMARY

The Otter estuary rMCZ is a small estuarine site on the south coast of Devon 19km to the south east of Exeter. The site is being considered for designation because of its extensive intertidal mud flats which harbour a diverse range of fauna making the estuary an ecologially important site for both bird populations and as a nursery area for juvenile fish including bass.

Surveys commissioned by Natural England were undertaken by Ecospan Enivronmental Ltd during the spring low tides in October 2013 and March 2014. These surveys were designed to provide additional data and a partial baseline data set on the extent and presence of certain features within the Otter estuary rMCZ.

Due to the extensive mud flats in the estuary rock habitat types were limited to a single small area near the mouth of the river. This area was mapped and a habitat type was assingned.

A total of seven sediment habitat types were identified and mapped during the course of the surveys; three littoral mud, one littoral sand and muddy sand, two mixed sediment and one coarse sediment. The majority of the sediment area was composed of mud habitat types dominated by the polychaete *Hediste diversicolor* along with various other species That varied with the geographical location within the estuary.

Very few anthropogenic impacts were noted during the surveys. Those that were observed were at a low intensity. Consequently it is unlikley that they have any significant impact on the faunal communities in the estuary.

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1. INTRODUCTION

Natural England, in partnership with the Environment Agency, CEFAS, and DEFRA, has commissioned a number of surveys to add to the current information available for recommended Marine Conservation Zones (rMCZ) throughout England. More specifically, the data collected is intended to add to the knowledge on the extent and presence of certain features at intertidal sites where more evidence is required.

The surveys are required to determine the presence and extent of Broadscale habitats (BSHs) and Habitats of Conservation Importance (HOCI), as well as the presence of Species of Conservation Importance (SOCI). In addition they will provide a partial baseline data set to inform a future assessment of condition.

The JNCC finding sanctuary report[1] recommended the Otter estuary for addition into the MCZ network. The inclusion of this estuary and other estuarine rMCZs in the network was in recognition of the ecological importance of estuaries in terms of productivity and their function as nursery areas for fish including Bass.

1.1 Otter Estuary rMCZ Features of Conservation Importance

The following Features of Conservation Interest (FOCI) have been proposed for this site:

- A1.3 Low Energy Intertidal Rock
- A2.1 Littoral Coarse Sediments
- A2.3 Littoral mud

The European eel (*Anguilla anguilla)* has been proposed as a Species of Conservation Importance (SOCI) for this rMCZ. Over-harvesting of the eel has contributed to an 80% decline in the numbers of adults in the past 60 years. Consequently, the species is also a UKBAP priority species and is listed as critically endangered on the IUCN Red List[2].

1.2 Otter Estuary rMCZ Site Description

The Otter estuary rMCZ boundary extends less than 2km inland from the mouth of the river which is surrounded mainly by farmland. There is a large shingle bar sheltering the mouth of the estuary east of Budleigh salterton, with the River Otter passing through a narrow passage at the eastern end of the bar. A map of the site is shown in Figure 1.

The inland extent of the rMCZ boundary is just south east of the village of East Budleigh, here the water is almost unaffected by the tidal influence of the sea. When the river reaches a point just east of Budleigh Salterton the banks widen forming large areas of saltmarsh, showing the increased tidal influence. From here the river bed is composed of coarse gravelly substrate whilst the littoral banks are made up of muddy sand. The majority of the estuary is salt marsh raised above the littoral sediment on steep eroding banks and bounded by sea defence embankment to the west and sandstone cliffs to the east. Between the areas of marsh a well-defined network of creeks and pans provide multiple sheltered inlets with soft muddy sediments.

Nearer the mouth, the river completes a sharp turn to the east where it meets the shingle bar at Budleigh Salterton. in this area the river bed is composed of cobbles and shingle washed over from the bank. There is a muddy creek running parallel to the bank which also contains large numbers of pebbles and cobbles from the shingle bank. From here the river makes a

final turn south to run briefly along the base of the sandstone cliffs before passing through the narrow channel at the end of the shingle bar and into the sea.

The entirety of the rMCZ lies within the Otter estuary SSSI which was primarily designated based on the particularly well developed salt marsh features of the estuary[3].

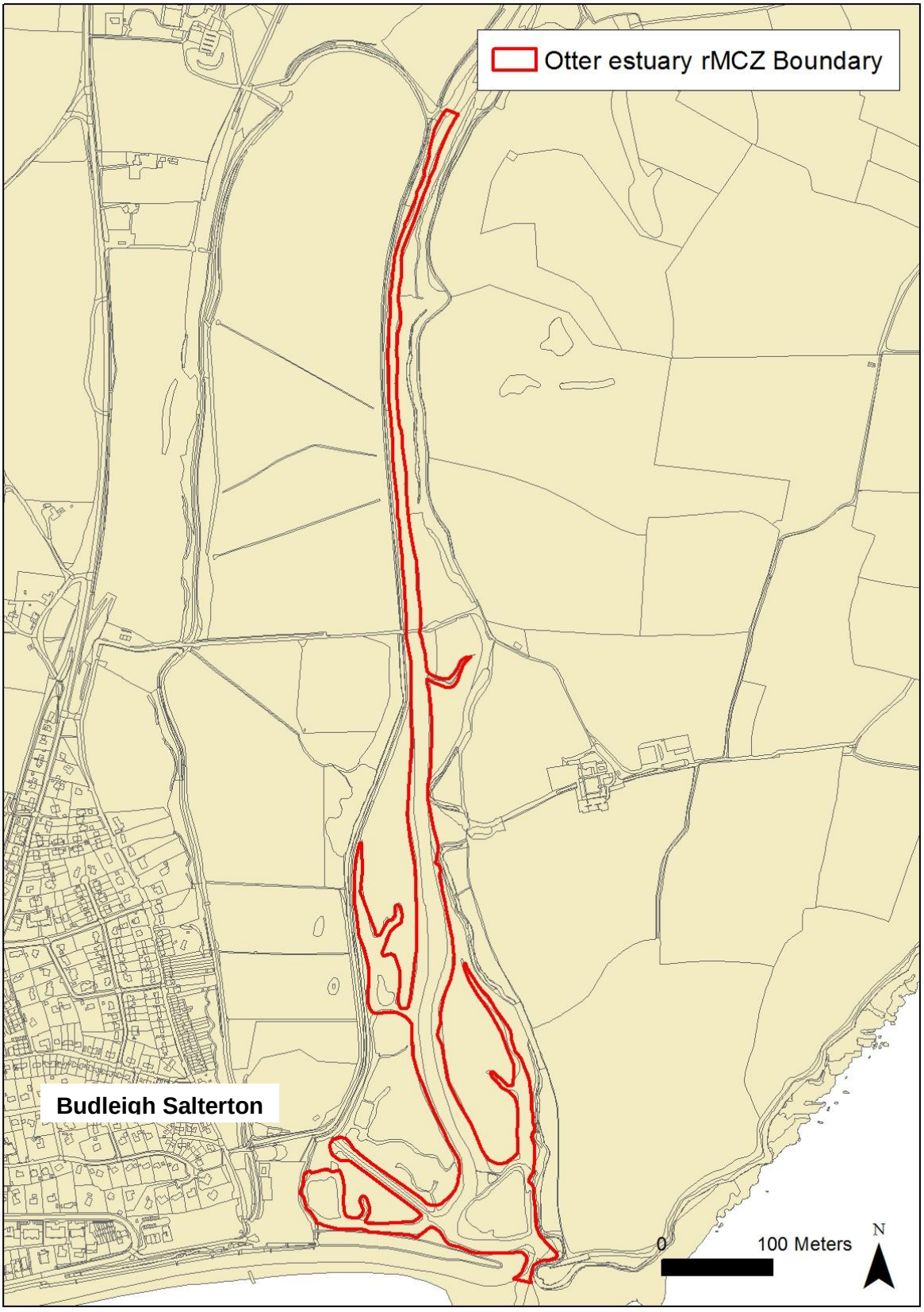

Figure 1. Boundaries of the Otter Estuary rMCZ.

1.3 AIMS

The aims of the study were to:

- Carry out a Phase I habitat type survey to obtain standardised information on the presence and extent of littoral rock and littoral sediment habitat types focusing on the BSHs identified for the rMCZ.
- Within the littoral habitats, map the extent and distribution of habitat types identified during the Phase I to the highest level of classification possible under the EUNIS classification system.
- Identify and map the extent and distribution of the rMCZ Habitats of Conservation Importance (HOCI), as well as the extent and abundance of Species of Conservation Importance (SOCI).
- Carry out Phase II surveys to provide a partial baseline of the species composition of the different habitat types in order to facilitate future condition assessment should the rMCZ area be designated as an MCZ in the future.
- Record anthropogenic influences that might impact on identified features.

2. METHODS

2.1 Access

All of the necessary land access permissions were gained prior to the survey by Natural England. Low tides were required to ensure that the lower shore littoral habitat types were exposed sufficiently to study. Throughout the study area access was achieved on foot.

2.2 Survey Strategy

A two phased approach was adopted to gather data on the sediment habitat types. Phase I was carried out in order to provide a preliminary habitat type map and to note any features of interest. This information was then used to design the Phase II sampling strategy.

Due to the very small area of littoral rock a Phase I survey only was used for these habitat types.

The presence of features of conservation interest (as listed in Section 1.1) and of potential anthropogenic influences (e.g. sewers, land drains, dredging etc.) were recorded where encountered during all surveys.

2.3 Phase I

The Phase I rock and sediment components of the study were carried out during the low tides on the 1st of October 2013 (Low water was 1.8m above chart datum at Lyme Regis).

The aim of the Phase I survey was to map the distribution and extent of littoral rock and littoral sediment habitat types and FOCI, focusing on BSHs identified by Natural England for primary survey within the rMCZ. This was achieved by examining geo-referenced aerial photography and subsequently ground-truthing defined habitats via field survey in order to establish the habitat types present (as per Procedural Guidelines 1-1 and 3-1 in the Marine Monitoring Handbook[4]).

Pre-determined transects were established at a maximum of 500m intervals throughout the rMCZ. These transects were added to the aerial photographs and loaded into hand held dGPS sets which were used for all position fixing during the course of the survey. The Phase I target locations are shown in Figure 2.

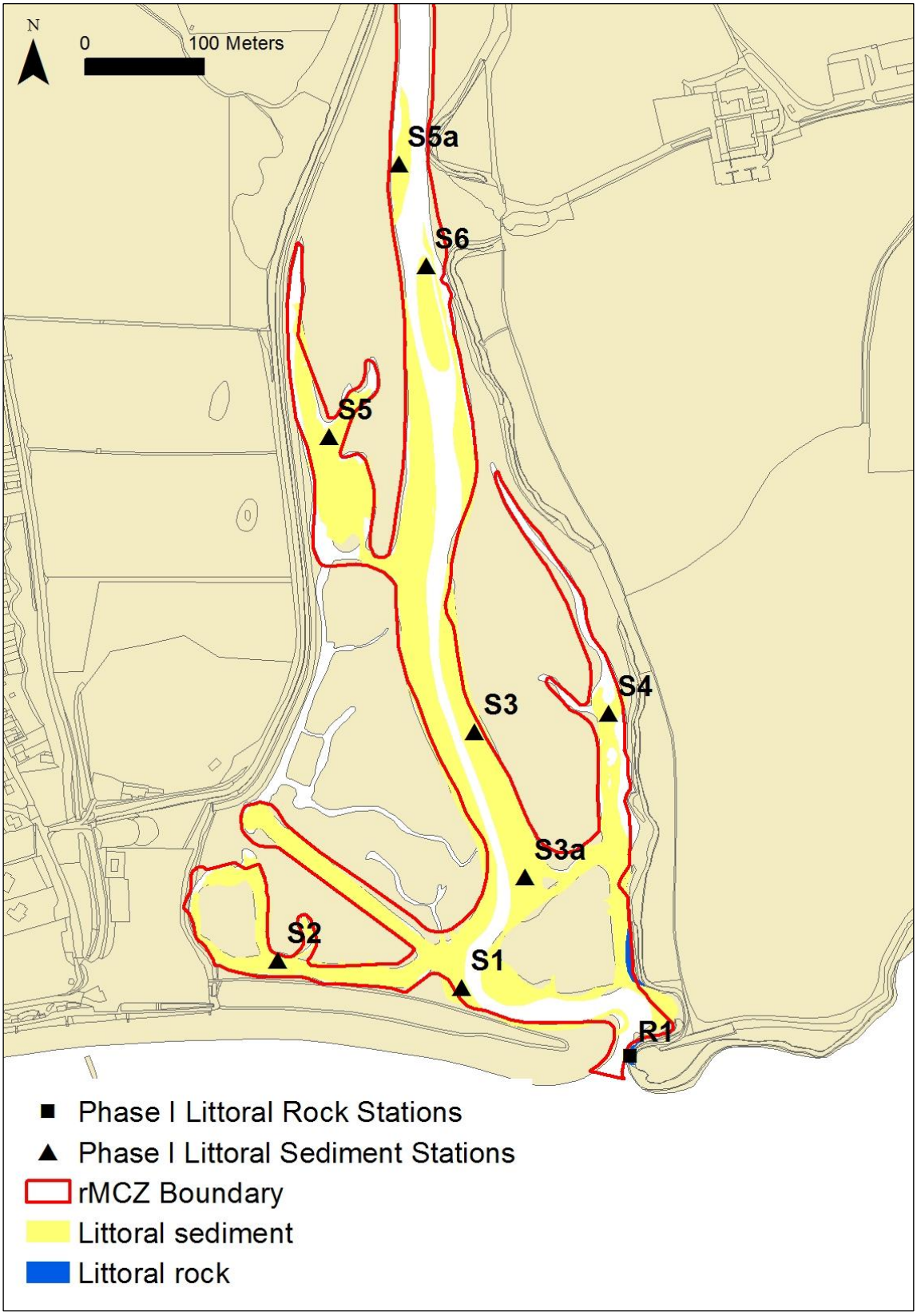

Figure 2. Map of Phase I sampled locations and transects in the Otter Estuary rMCZ.

The survey technique was to cover all the littoral habitat types within the study area by walking from one transect to another. When traversing broad expanses of sediment a 'zig zag' route was taken to maximise coverage. Where changes in habitat type were observed, the perceived boundaries of the changes were marked on the aerial map and dGPS where necessary.

2.3.1 Littoral Rock

All sampling was undertaken using the relevant guidelines[4,5,6]. Upon arrival at a target transect all habitat types within were identified and recorded using the highest EUNIS classification[7] level possible. The vertical extent of each habitat type was gauged and recorded using a combination of dGPS and the aerial photography. A photograph of each habitat type within each transect was taken with additional photographs of up-shore, down-shore and along-shore aspects to record zonation patterns with adjacent Habitat types. A photograph of each habitat type was taken along with waypoints indicating the extent, width and the abundance of the dominant species (using the SACFOR scale). Having habitat mapped the immediate area around each transect, the survey team then walked to the next target station. Whilst traversing between target stations the survey team investigated any areas of rock that were potentially different habitat types, and where necessary, different habitat types were assigned. The boundaries of all habitat types were annotated on aerial photographs.

2.3.2 Littoral Sediment

Littoral sediment habitat mapping was carried out following national guidelines[4,6,8] The position of all sediment stations on target transects was recorded using dGPS. At each station photographs were taken of the sediment surface, together with up-shore, down-shore and along-shore aspects. The time and date, sediment type, depth of the redox discontinuity (assessed visually), interstitial salinity (determined using a refractometer), tidal height, presumptive biotope, conspicuous species observed, and beach topography were also recorded in the field note book.

Habitat types were assigned in the field by direct observation wherever possible (e.g. spade sample inspection and species field signs). Where the species present and resulting habitat type was not obvious (e.g. in those biotopes harbouring only sparse fauna), a 0.01m^2 core of sediment was taken. The faunal sampling and preservation was carried out in accordance with the ISO guidelines[9] and according to Ecospan Environmental Ltd's Standard Operating Procedures (SOP) (ES-01, ES-02, ES-07 and ES-08). The samples were sieved using a BS410 standard 0.5mm sieve, and the <0.5mm fraction was rejected. The >0.5mm fractions were fixed with 10% (borax buffered) formaldehyde solution containing the vital stain Rose Bengal for microscopic analysis at the Ecospan laboratory. In order to keep the costs to a minimum, these samples were only processed to a level at which the biotope could be determined (rapid assessment) rather than full faunal enumeration and identification.

2.4 Phase II

2.4.1 Littoral Sediment

The Phase II littoral sediment survey was carried out on the 17th of March 2014 (low water was 0.6m above chart datum). All sampling was undertaken following the appropriate guidelines[4,8,9]. A total of 15 stations were sampled. At three of the stations (1, 5, and 10) additional samples were taken for metals and organic contaminant analysis. The positions of all sediment stations were determined by Natural England, having taken into consideration the results of the Phase I preliminary habitat type map.

At each station detailed habitat descriptions were recorded using habitat survey forms that included aspects such as substrate characteristics, interstitial salinity, features and modifiers. For the faunal analysis, three replicate 0.01m^2 cores were taken to a depth of 15cm using a hand-held box corer. Each replicate was sieved and preserved in the same manner as detailed in section 2.4.2. A fourth 0.01m^2 core was taken for particle size analysis (PSA); a sub-sample of which was placed into a one litre plastic pot. All cores for both fauna and PSA were taken within an area of 1m^2 at each station. At the relevant stations contaminant samples were taken by scraping the first 1cm of sediment (avoiding any anoxic layer) using a clean plastic scoop for the metal contaminant samples, and a metal scoop for organic contamination samples.

All preserved fauna samples were delivered to APEM Ltd for full faunal identification and enumeration. PSA and contaminant samples were delivered to the NLS laboratory at Starcross for analysis.

2.5 Anthropogenic Influences and Negative Indicators

Throughout both Phases of survey the presence of any anthropogenic inputs or activities with the potential to cause impacts at any scale were recorded where encountered in the survey area.

2.6 Univariate and Multivariate Analysis of Faunal Data

Two statistical approaches have been applied during the analysis of the data in order to assess the spatial differences in community structure within sediment habitat types.

Simple univariate statistics, such as the number of taxa and mean abundance per sample were calculated, as well as diversity/equitability indices such as Margalef's species richness, Pielou's eveness, the Shannon Weiner diversity index, and Simpson's diversity index.

Community analysis was carried out in PRIMER[10] using techniques incorporating multivariate statistics such as the Bray Curtis similarity measure, multidimensional scaling (MDS), and SIMPER (species contributions to the similarities in percentages). These analyses were used to compare the samples and provide a measurement of the overall similarity between the stations. Comparisons were made between stations both in terms of the abundance of their constituent taxa and, for the littoral sediment data, the composition of their sediments as determined by the particle size analysis. In order to reduce the influence of very abundant taxa on the analysis, data sets were subjected to a single square root transformation prior to multivariate analysis.

2.7 Quality Assurance

Ecospan Environmental Ltd has an ISO 9001 accredited quality management system to ensure that we work to the highest standards expected by our customers. We undertake all work in accordance with standard operating procedures and recognised national and international guidelines.

Identification of the marine benthic macrofauna from the rapid assessment cores was carried out in house by Ecospan Environmental Ltd which is a NMBAQCS accredited laboratory.

3. RESULTS

3.1 Littoral Rock habitat types in Otter Estuary rMCZ

A single littoral rock habitat type was identified in the Otter rMCZ, along with one feature of littoral rock. The distribution of this habitat type is shown in Figure 3.

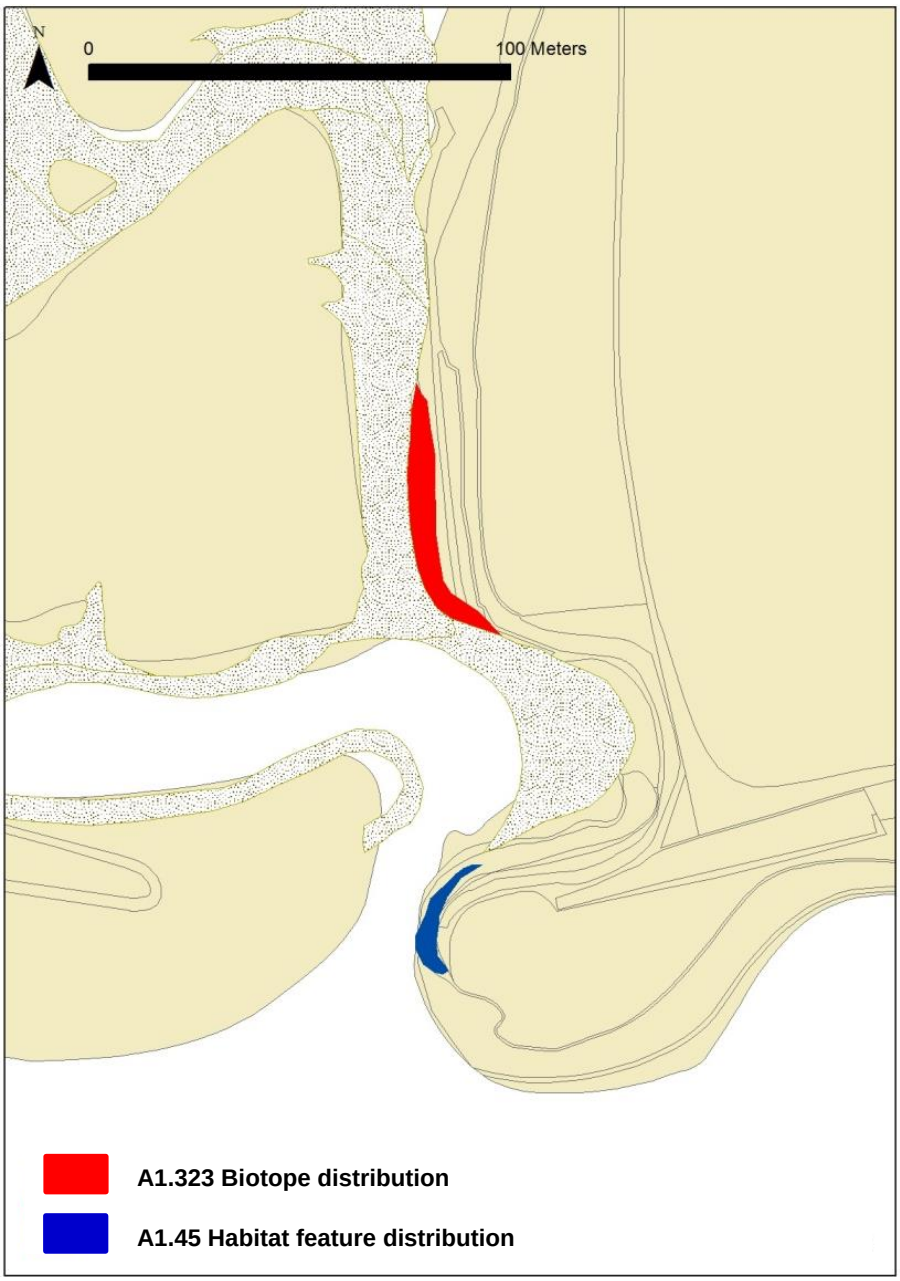

Figure 3. Rock habitat type in the Otter estuary, this map is zoomed in on the mouth.

A1.323 *Fucus vesiculosus* on variable salinity mid eulittoral boulders and stable mixed substrata

This Biotope was found growing on a small area of large cobbles at the base of the sandstone cliffs just north of the mouth. The distribution is shown in Figure 3.

This Biotope was found as sparse growth of bladder wrack (*Fucus vesiculosus*) growing on pebbles and cobbles lodged within the mud in a channel close to the mouth of the estuary. This species was also found on certain strata in the sandstone cliff. This Biotope was relatively species poor, with only occasional growths of the main characterising species, as can be seen in Plate 1.

Plate 1. A1.323 Biotope, and A1.45 feature in Otter estuary.

As well as the single rock Biotope, one feature of littoral rock was also identified; A1.45 ephemeral green or red seaweeds (freshwater or sand influenced) on non-mobile substrata. This feature was found at the base of some of the sand stone cliffs near the mouth, where it formed a short green turf over the rock. A single species, *Ulva intestinalis*, constituted habitat type in this area. The exposed nature of the cliffs results in backwash which causes scouring which prevents the settlement of any other algal species and also faunal species such as barnacles and limpets. The single species has led to a very homogenous habitat type (Plate 1).

This very small area of a single Biotope constitutes the only rock BSH in the entire estuary. Because of this it was decided not to carry out Phase II surveys.

3.2 Littoral sediment habitat types

A total of seven sediment habitat types were identified and mapped during the course of the survey: one littoral coarse sediment (A2.1), one littoral sand and muddy sand (A2.2), three littoral mud (A2.3) and two littoral mixed sediments (A2.4). The extent and distribution of each sediment habitat type is mapped in Figure 4.

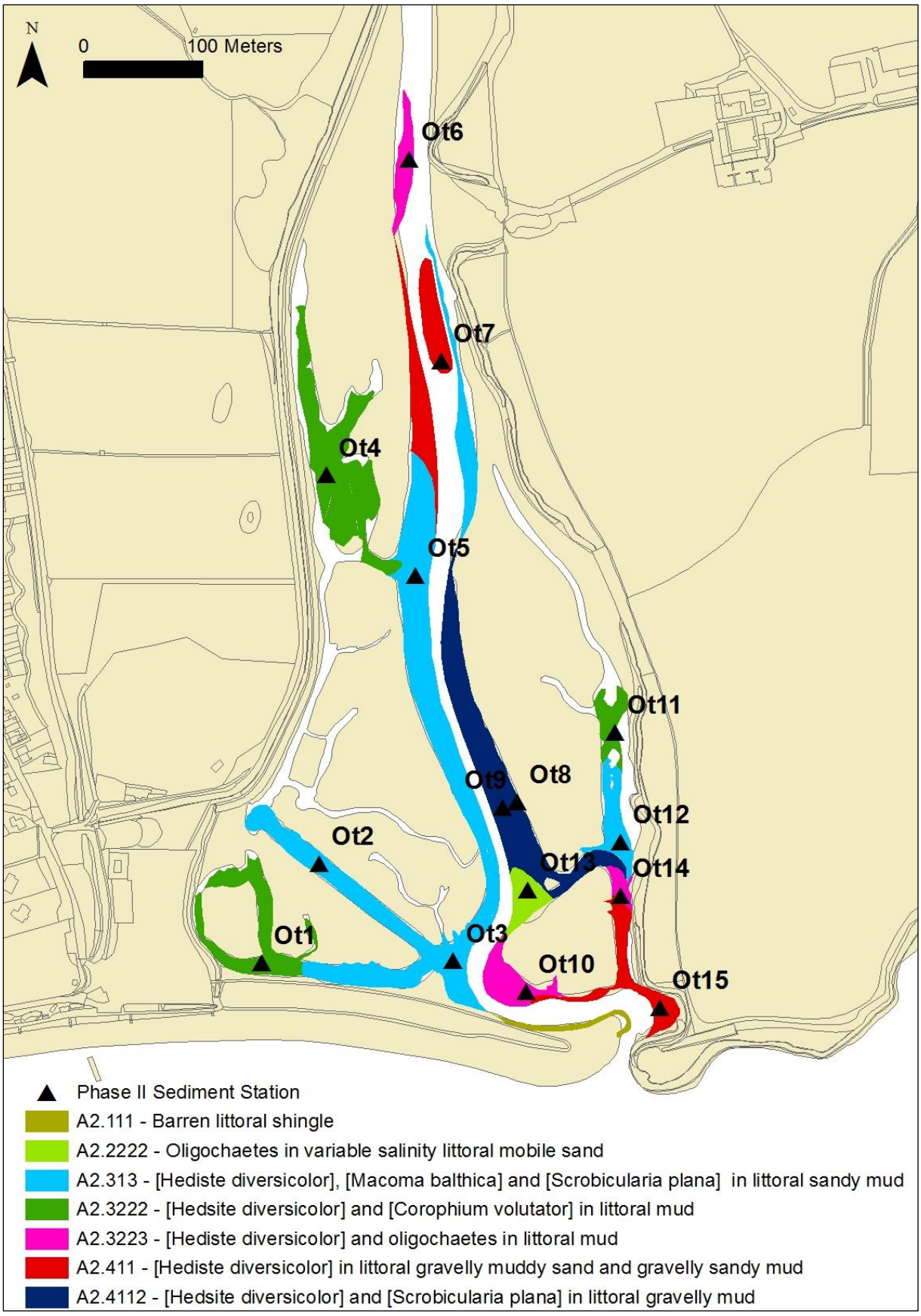

Figure 4. Extent and distribution of littoral sediment habitat types within the Otter rMCZ.

A2.111 Barren littoral shingle

This habitat type was confined entirely to the inland side of the shingle bank at the mouth of the estuary (Figure 4). Where the river runs past the bank there is no opportunity for fine sediment to settle out. No fauna cores were taken in this habitat type as it was assumed that, due to the mobile nature of the shingle and the highly varied salinity, the species composition would be highly impoverished. Therefore survey effort and time was dedicated to other habitat types.

A2.2222 Oligochaetes in variable salinity mobile sand

This sub-biotope was found in the mid-section of the estuary adjacent to the main channel of the river. The extent and distribution are shown in Figure 5.

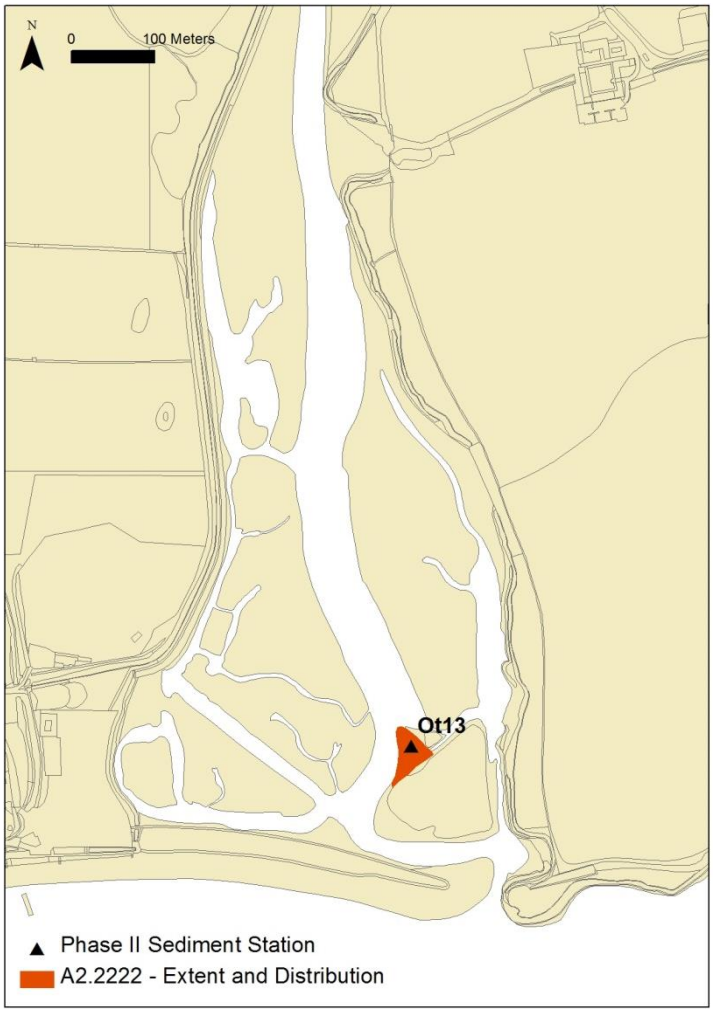

Figure 5. Map of A2.2222 Sub-biotope extent and distribution within the Otter estuary rMCZ.

Just north of the area of salt marsh opposite the mouth of the estuary this habitat type formed a bank of firm sand. Salinity measurements were not possible since the sandy sediment drains freely. However, the main channel of the river is adjacent to this area and the presence of significant numbers of enchytraeid oligochaetes in the faunal analysis indicates a reduced salinity habitat type (Table 1). The species composition, sediment granulometry and location of this habitat type match very well with the description in the EUNIS classification.

The EUNIS classification system describes this habitat type as "*A species-poor community of oligochaetes occurring in estuarine conditions where sands and gravel are associated with the lower shore river channel in estuaries. The sediment is relatively coarse and mobile*

due to strong river flow and subject to variable salinity. There is usually very little mud in the sediment. Oligochaetes, including enchytraeid oligochaetes, constitute the infaunal assemblage. Nemerteans may be present, and nematodes may be frequent."

Table 1. A2.2222 Sub-biotope mean species abundances per 0.01m^2 core.

Species	Sample station Ot13
Baltidrilus costatus	1.7
Enchytraeidae	28
Corophium volutator	0.7

A2.313 *Hediste diversicolor, Macoma balthica,* and *Scrobicularia plana* in littoral sandy mud

This Biotope accounted for a large proportion of the littoral sediment area in the rMCZ, as can be seen in Figure 6.

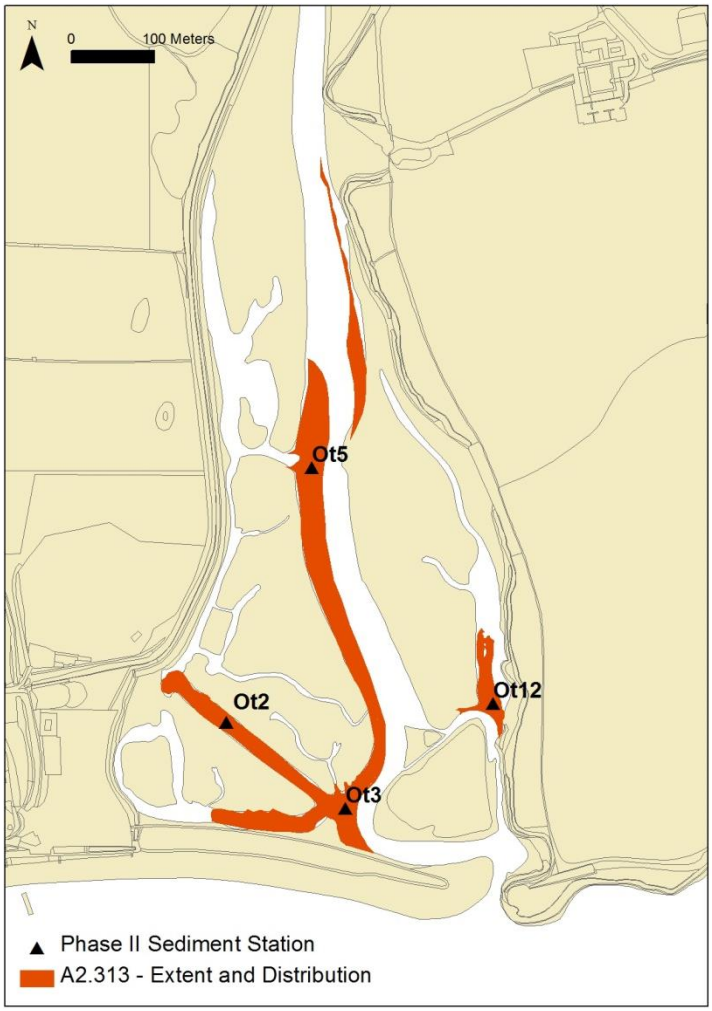

Figure 6. Map of A2.313 Biotope extent and distribution in the Otter estuary rMCZ.

Soft mud banks on the low to mid shores of the estuary were found with abundant populations of the ragworm *Hediste diversicolor*, as well as large numbers of the conspicuous 'birds feet' markings left by *Scrobicularia plana* on the sediment surface.

The species composition seen in Table 2 shows relatively low numbers of one of the main characterising species *Scrobicularia plana*. This is not unusual as this species frequently burrows below the 15cm depth of these core samples. Therefore the designation of this habitat type was based on the often abundant surface markings left by this species.

Table 2. A2.313 Biotope mean species abundance per 0.01m^2 core.

Species	Sample station			
	Ot2	Ot3	Ot5	Ot12
Nematoda				1.0
Hediste diversicolor	30.3	23.3	11.3	24.7
Streblospio spp.	11.3	9.0	1.7	6.3
Manayunkia aestuarina	3.3			
Baltidrilus costatus	30.3	121.7	57.7	51.0
Tubificoides pseudogaster agg	4.3	5.7	0.3	
Enchytraeidae	0.7	0.7	0.7	0.3
Gammaridae juv			0.7	
Corophium volutator	25.7	0.3	1.3	7.3
Cyathura carinata	2.3	0.3		0.7
Scrobicularia plana	3.7	0.3		0.3
Scrobicularia plana juv				0.3

The EUNIS classification system describes this Biotope as "*Mainly mid shore mud or sandy mud subject to variable salinity on sheltered estuarine shores. Typically, the sediment is wet in appearance and has an anoxic layer below 1 cm depth. The surface of the mud has the distinctive 'birds foot' pattern formed by the peppery furrow shell [Scrobicularia plana]. The infauna is additionally characterised by a range of polychaete and bivalve species, including the ragworm [Hediste diversicolor], [Pygospio elegans], [Streblospio shrubsolii], [Tharyx killariensis] and the baltic tellin [Macoma balthica]. Oligochaetes, most notably [Tubificoides benedii], and the spire shell [Hydrobia ulvae] may be abundant. Other species that sometimes occur in this biotope are the cockle [Cerastoderma edule], the sand gaper [Mya arenaria] and the polychaetes [Eteone longa] and [Nephtys hombergii].*"

Many of the species mentioned in the EUNIS classification description of this Biotope were present in the core samples from this habitat type (Table 2). This gives a high level of confidence in the designation of this habitat type.

A2.3222 *Hediste diversicolor* and *Corophium volutator* in littoral mud.

This habitat type was typically found in very sheltered upper shore inlets and creeks, above the A2.313 *Hediste, Macoma,* and *Scrobicularia* mud Biotope. The extent and distribution of this Sub-biotope are shown in Figure 7.

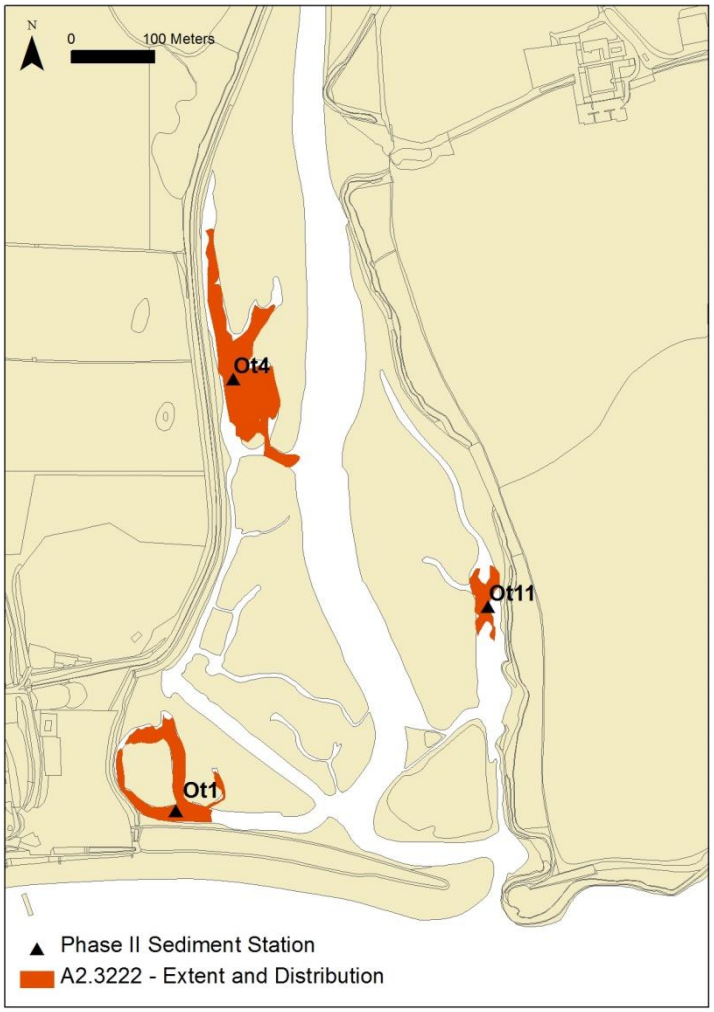

Figure 7. Map of A2.3222 extent and distribution within the Otter estuary rMCZ.

It can be seen from Table 3 that the main characterising species, *Hediste diversicolor* and *Corophium volutator*, were found in significant numbers at all three stations within this habitat type. The peppery furrow shell *Scrobicularia plana* was found in cores at sample station Ot11. This is unusual in this habitat type and is probably the result of the cores being taken in the transitional zone between this and the A2.313 Biotope on the lower shore.

Table 3. A2.3222 Sub-biotope mean abundance per 0.01m^2 core.

Species	Sample station		
	Ot1	Ot4	Ot11
Turbellaria			1.0
Nematoda	4.0	0.3	5.7
Hediste diversicolor	43.7	10.3	6.0
Streblospio spp.			0.3
Manayunkia aestuarina	26.7		1.7
Baltidrilus costatus	28.7		0.3
Tubificoides pseudogaster agg		0.3	0.3
Enchytraeidae	1.0	0.3	1.0
Corophium volutator	58.3	13.0	20.3
Cyathura carinata		14.7	4.3
Scrobicularia plana			0.3
Scrobicularia plana juv			0.3

The EUNIS classification describes this Sub-biotope as "*Sheltered estuarine shores of sandy mud, which may become firm and compacted if present in the upper shore where there is more time for drainage between high tides. An anoxic layer is usually present within the first 5 cm of the sediment. The infauna is very sparse, usually only the ragworm [Hediste diversicolor] and the amphipod [Corophium volutator] are present in any abundance. Occasionally, oligochaetes or the spire shell [Hydrobia ulvae] may be present. [Corophium multisetosum] may also be found. There may be organic pollution of the sediment.*"

This description matches well with the observations made during the survey, as well as the species composition.

A2.3223 *Hediste diversicolor* and oligochaetes in littoral mud

This habitat type was found in several areas of the estuary, primarily where there is a constant flow of fresh water adjacent to the habitat type. The extent and distribution of this Sub-biotope are mapped in Figure 8

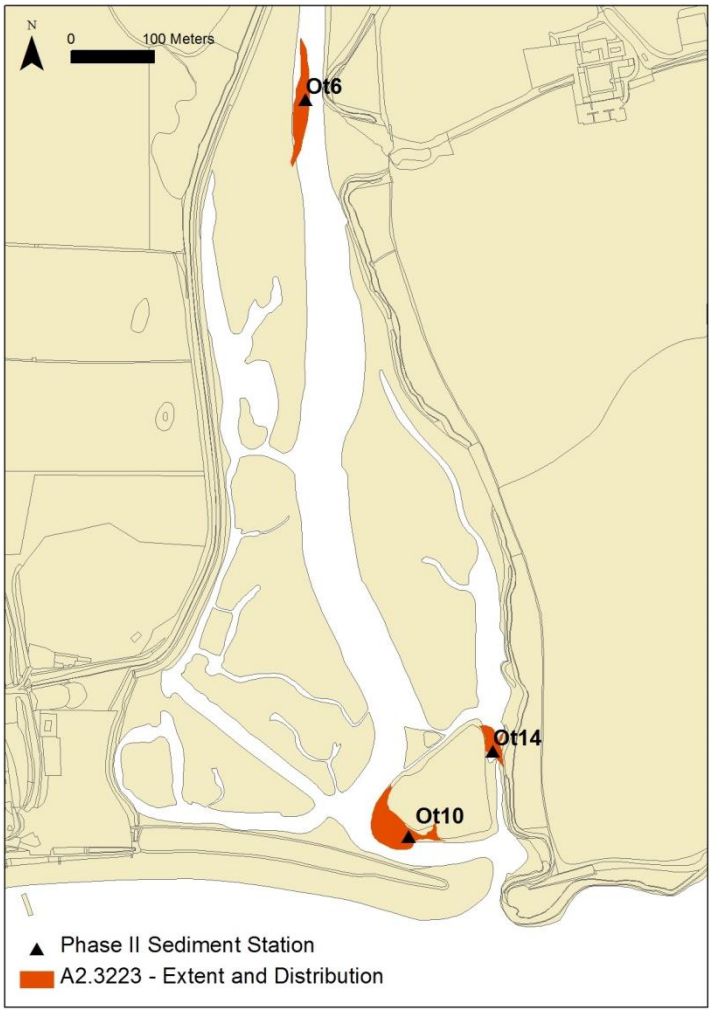

Figure 8. Map of A2.3223 extent and distribution.

It can be seen from Table 4 that, as well as the main characterising species *Hediste diversicolor,* there was a wide variety of oligochaetes with five species recorded at sample station Ot14. The species present are typical of a variable salinity habitats, which coincides with salinity of between 15 and 23 ppt measured in this habitat type during the survey.

Table 4. A2.3223 Sub-biotope mean abundance per 0.01m^2 core.

Species	Sample site		
	Ot6	Ot10	Ot14
Hediste diversicolor	7.0	4.3	39.7
Streblospio		0.3	8.7
Manayunkia aestuarina			2.0
Paranais litoralis	0.3		
Baltidrilus costatus	59.7	7.0	204.7
Tubificoides benedii			0.3
Tubificoides pseudogaster agg			2.0
Enchytraeidae	1.0	10.7	5.7
Corophium volutator	0.3		3.0
Cyathura carinata	0.3		
Mytilus edulis juv		0.3	

The EUNNIS classification describes this Sub-biotope as "*A species-poor community found in mud or slightly sandy mud in low salinity conditions, typically at the head of estuaries. The infauna is dominated by the ragworm [Hediste diversicolor] which is typically superabundant. Oligochaetes, including tubificids and [Baltidrilus costatus], can be abundant, as well as spionids. The peppery furrow shell [Scrobicularia plana] may be present in low abundances. The mud is often very soft and fluid, with a 'wet' surface appearance, or it may be compacted and form steep banks in the upper parts of macro-tidal estuaries and along saltmarsh creeks.*"

The wide variety and high abundance of oligochaetes, as well as the presence of the ragowrm *H. diversicolor* make a good match with the description provided in the EUNIS classification.

A2.411 *Hediste diversicolor* in littoral gravelly muddy sand and gravelly sandy mud.

This habitat type was found in areas on the low shore and usually in close proximity to the strong flow of the main river channel. The extent and distribution of this Biotope are mapped in Figure 9.

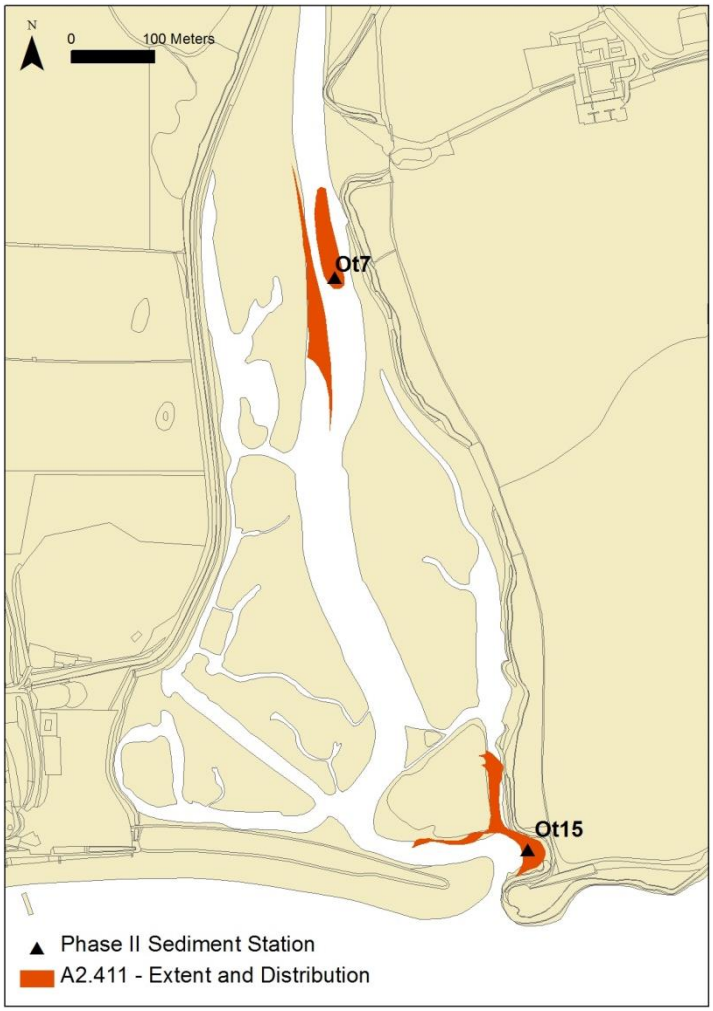

Figure 9. Map of A2.411 extent and distribution.

It can be seen from Table 5 that this Biotope has a relatively poor species composition. At sample station Ot7 the benthic fauna was dominated by large numbers of oligochaetes. This station was located on a gravel bar in the main channel of the river with a salinity of 16 ppt, which has allowed the domination of oligochaete species which thrive in reduced salinity conditions. The sampling position at Ot15 was located further towards the mid shore, the coarse sediment drains freely here which is probably the cause of the impoverished species community found at this location.

Table 5. A2.411 Biotope mean abundance per 0.01m^2 core.

Species	Sample station	
	Ot7	Ot15
Nematoda		0.3
Hediste diversicolor	8.0	4.0
Streblospio		1.3
Baltidrilus costatus	347.0	6.0
Enchytraeidae	140.0	4.3
Gammaridae juv	29.7	
Gammarus zaddachi	4.0	

The EUNIS classification describes this Biotope as "*Sheltered gravelly sandy mud, subject to reduced salinity, mainly on the mid and lower shore. The infaunal community is dominated by abundant ragworms [Hediste diversicolor]. Other species of the infauna vary for the sub-biotopes described. They include polychaetes such as [Pygospio elegans], [Streblospio shrubsolii], and [Manayunkia aestuarina], oligochaetes such as [Baltidrilus costatus] and [Tubificoides] spp., the mud shrimp [Corophium volutator], the spire shell [Hydrobia ulvae], the baltic tellin [Macoma balthica] and the peppery furrow shell [Scrobicularia plana]. Sub-biotopes described in HedMx have equivalent communities in soft muddy sediments, but the sediment here is much firmer due to the gravel component.*"

This Biotope has a similar species composition to the A2.3223 *Hediste* and oligochaetes in mud Sub-biotope. The differentiating feature is the much larger gravel component in the sediment granulometry. This species composition combined with the gravelly mixed sediment and the reduced salinity match well with the description provided in the EUNIS classification.

A2.4112 *Hediste diversicolor* and *Scrobicularia plana* in littoral gravelly mud

This habitat type occupied the eastern shore of the main river channel in the middle reaches of the estuary. The extent of this Sub-biotope is shown in Figure 10.

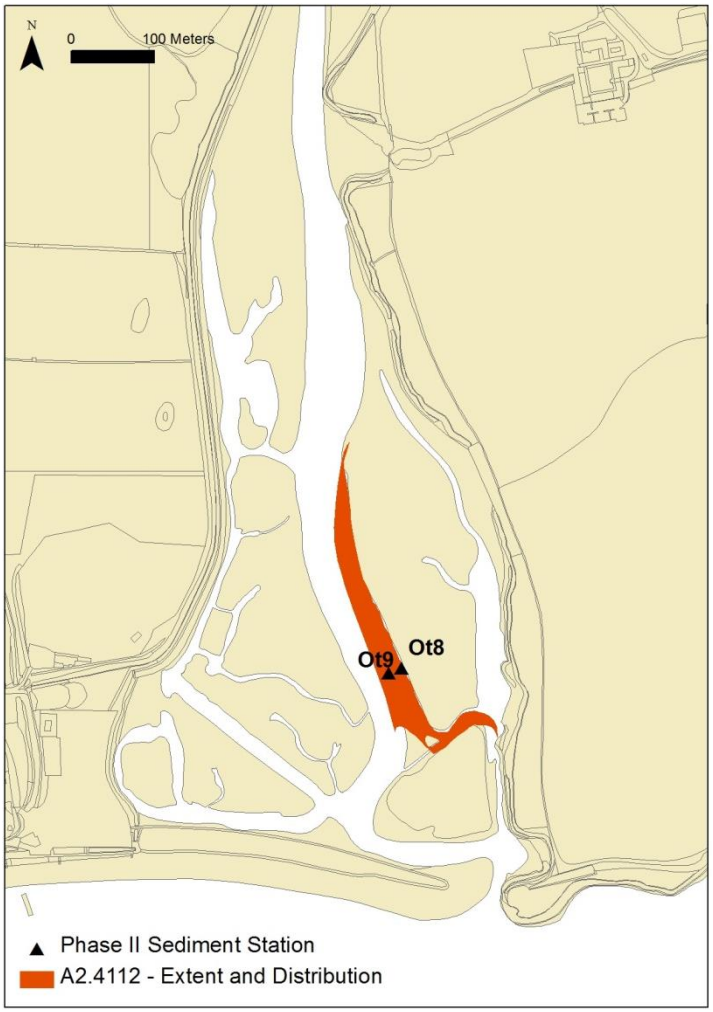

Figure 10. Map of A2.4112 extent and distribution within the Otter estuary rMCZ.

Despite being taken in close proximity to each other (Figure 10) it can be seen from Table 6 that the species composition of the two sampling stations is fairly different. The presence of oligochaete species such as Nais and Enchytraeidae are probably a function of the lower shore station (Ot9) being subject to a more varied salinity than the mid shore station (Ot8).

At both Ot8 and Ot9 the distinctive 'birds foot' pattern of *S. plana* on the sediment surface were visible, as well as this species being present in the core samples. The other characterising species for this Sub-biotope is *Hediste diversicolor*, which was also found in cores from both stations.

Table 6. A2.4112 mean abundance per 0.01m^2 core.

Species	Sample station	
	Ot8	Ot9
Nematoda		0.7
Hediste diversicolor	39.0	3.0
Streblospio	19.0	0.3
Manayunkia aestuarina	6.0	0.3
Nais		0.3
Paranais litoralis		1.3
Baltidrilus costatus	101.0	5.0
Tubificoides benedii	3.0	
Tubificoides pseudogaster agg	2.0	
Enchytraeidae		2.3
Gammaridae juv		0.3
Corophium volutator	1.7	0.3
Cyathura carinata	1.3	
Peringia ulvae		0.3
Scrobicularia plana	1.7	
Scrobicularia plana juv	0.3	

The EUNIS classification system describes this Sub-biotope as "*Extremely sheltered gravelly mud on the mid and lower shore, containing little sand with occasional cobbles. The infaunal community includes the ragworm [Hediste diversicolor] and the peppery furrow shell [Scrobicularia plana], as well as a range of polychaetes, oligochaetes, and molluscs.*"

The species composition matches relatively well with the description proved in the EUNIS classification with both main characterising species present.

3.3 Comparison of community composition between sample stations

Multi-dimensional scaling (MDS) was used in PRIMER, along with the Bray Curtis similarity index, to analyse the communities at each sampling station. The MDS plot in Figure 11 represents the similarity between benthic communities at each station and between each habitat type in two dimensions. The distances between the points represents the similarities between communities (i.e. the closer together to points the more similar the communities).

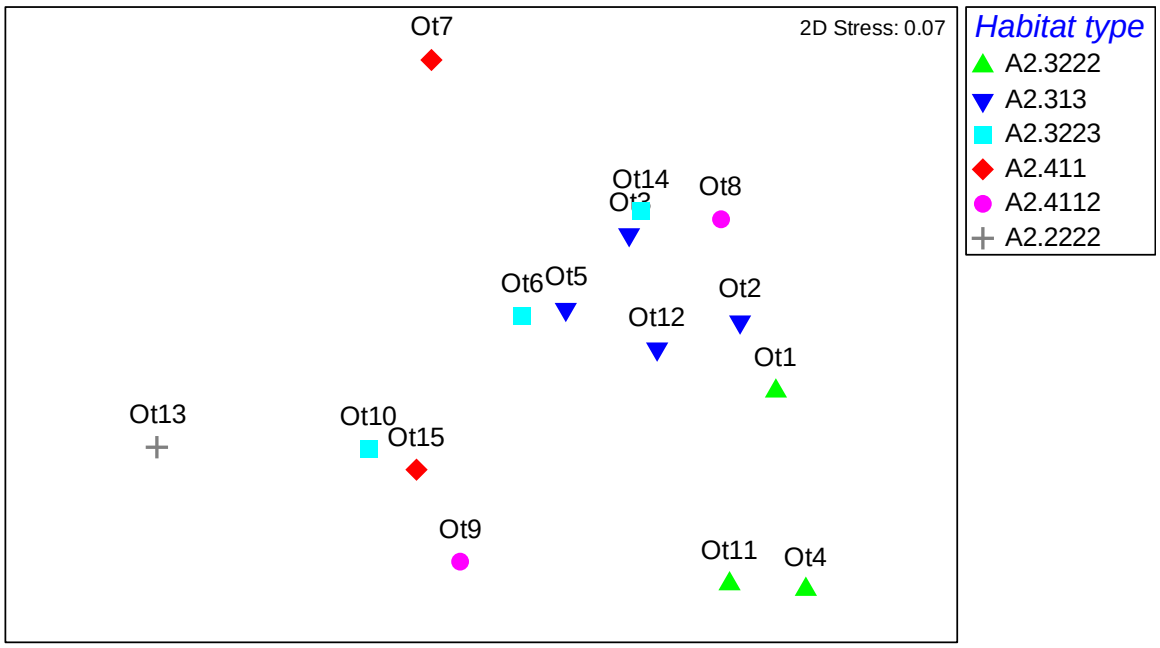

Figure 11. MDS plot of community similarity between samples and habitat types

The plot in Figure 11 exhibits reasonably close grouping in some habitat types e.g. A2.313 and A2.3222. This corresponds to greater levels of similarity between the sampling stations within these habitat types. The grouping is especially close in the A2.313 Biotope, which shows mean similarity of 71% in the community structure of samples within this habitat type (Table 7).

The two points representing the A2.4112 habitat type are widely separated, showing very low similarity despite the fact that these points were in close proximity to each other. This difference can be further seen in Table 7 where the similarity between these samples is just 27%. This significant difference may be a result of more variable salinity found on the low shore.

Sample station Ot13 is situated on the far left of the plot, this is most likely due to the low species diversity in this habitat type, with only three species being found in core samples taken. Conversely, the position of station Ot7 towards the top of the plot is due to very high numbers of oligochaete species, notably *Baltidrilus costatus*.

Table 7. Bray Curtis similarity between samples within each habitat type.

Habitat type	% Similarity
A2.3222	53
A2.313	71
A2.3223	48
A2.411	27
A2.4112	27

Univariate analysis was carried out to produce indices for species diversity and richness, the results are shown in Table 8 along with the number of taxa and average abundance for each sample.

The results in Table 8 are show a range of diversity and richness values with some stations, such as Ot9, showing quite high values. The lowest diversity and richness values were found at Ot13 which was located on a firm sandy bar in close proximity to the main river channel, this location and the quick draining sandy sediment probably cause a highly variable salinity which may fluctuate between almost fresh and fully marine depending on the state of the tide. Despite the seemingly low numbers of in-fauna at this station, the highest diversity and richness values were found only a small distance up stream at Ot9. The sediment at this station was a gravelly mud with large amounts of organic detritus, which may be a factor in the diverse range of species present in the cores in this location.

Table 8. Univariate statistical analysis for all stations with mean values for habitat types with more than one sample station.

Habitat type	Sample	Total No. Taxa per Station	Mean Abundance per Station	Margalef's Species Richness	Pielou's evenness	Shannon Wiener Index	Simpson Diversity Index
		S	N	d	J'	H'(loge)	1-Lambda'
A2.2222	Ot13	**3**	**31**	**0.6**	**0.3**	**0.3**	**0.2**
A2.313	Ot2	9	112	1.7	0.8	1.7	0.8
A2.313	Ot3	8	161	1.4	0.4	0.8	0.4
A2.313	Ot5	7	74	1.4	0.4	0.7	0.4
A2.313	Ot12	9	92	1.8	0.6	1.2	0.6
Mean		**8**	**110**	**1.6**	**0.5**	**1.1**	**0.5**
A2.3222	Ot1	6	162	1.0	0.8	1.4	0.7
A2.3222	Ot4	6	39	1.4	0.7	1.2	0.7
A2.3222	Ot11	12	42	2.9	0.7	1.6	0.7
Mean		**8**	**81**	**1.8**	**0.7**	**1.4**	**0.7**
A2.3223	Ot6	6	69	1.2	0.3	0.5	0.2
A2.3223	Ot10	5	23	1.3	0.7	1.2	0.7
A2.3223	Ot14	8	266	1.3	0.4	0.8	0.4
Mean		**6**	**119**	**1.2**	**0.5**	**0.8**	**0.4**
A2.411	Ot7	5	529	0.6	0.6	0.9	0.5
A2.411	Ot15	5	16	1.4	0.8	1.4	0.8
Mean		**5**	**273**	**1.0**	**0.7**	**1.1**	**0.6**
A2.4112	Ot8	10	175	1.7	0.6	1.3	0.6
A2.4112	Ot9	11	14	3.8	0.8	1.9	0.9
Mean		**11**	**95**	**2.7**	**0.7**	**1.6**	**0.7**

3.4 Particle size analysis

The particle size distributions (percentage distributions of sediment by weight) at each sampling station have been summarised in Table 9 following the Wentworth scale (though the silt fractions have been amalgamated here).

Table 9. Percentage of each particle size fraction by weight for each station using the Wentworth scale.

Habitat type	Sample station	Clay <3.91µm	Silt 3.91-62.5µm	Very fine sand 62.5-125µm	Fine sand 125-250µm	Medium sand 250-500µm	Coarse sand 500-1000µm	Very coarse sand 1000-2000µm	Granules 2000-4000µm	Peebbles >4000µm
A2.2222	Ot13	0.6	5.4	3.4	33.5	44.2	9.7	1.1	0.8	1.2
A2.313	Ot2	9.3	55.2	18.6	8.5	5.3	3.5	0.3	0.6	2.7
A2.313	Ot3	4.8	28.6	23.2	30.2	12.2	0.5	0.0	0.0	0.5
A2.313	Ot5	4.0	31.5	12.1	19.4	18.6	5.3	1.0	1.0	7.1
A2.313	Ot12	4.9	26.3	22.1	32.0	13.7	1.0	0.0	0.0	0.0
A2.3222	Ot1	4.9	29.4	6.3	2.6	1.3	0.0	0.0	0.1	55.5
A2.3222	Ot4	10.1	53.0	24.1	9.2	3.4	0.2	0.0	0.0	0.0
A2.3222	Ot11	9.9	47.0	24.7	13.6	3.5	1.4	0.0	0.0	0.0
A2.3223	Ot6	0.9	6.4	17.9	50.7	23.8	0.2	0.0	0.0	0.0
A2.3223	Ot10	5.6	33.0	19.6	27.3	12.5	2.0	0.0	0.0	0.0
A2.3223	Ot14	3.5	18.9	11.1	29.4	32.5	4.2	0.0	0.0	0.4
A2.411	Ot7	0.0	1.3	0.5	0.4	10.3	17.1	5.1	6.2	59.0
A2.411	Ot15	2.3	10.2	6.1	22.3	29.7	7.8	2.3	2.4	17.0
A2.4112	Ot8	7.2	40.3	21.1	17.5	9.4	1.3	0.1	0.1	2.9
A2.4112	Ot9	1.2	11.6	2.7	22.9	40.7	8.3	1.1	1.8	9.7

It is well documented that the particle size distribution of the sediment has an effect on the structure of benthic communities [11]. The overall degree of similarity in the mean sediment particle size between each station has been determined using PRIMER and is illustrated by the Principle Component Analysis (PCA) plot in Figure 12.

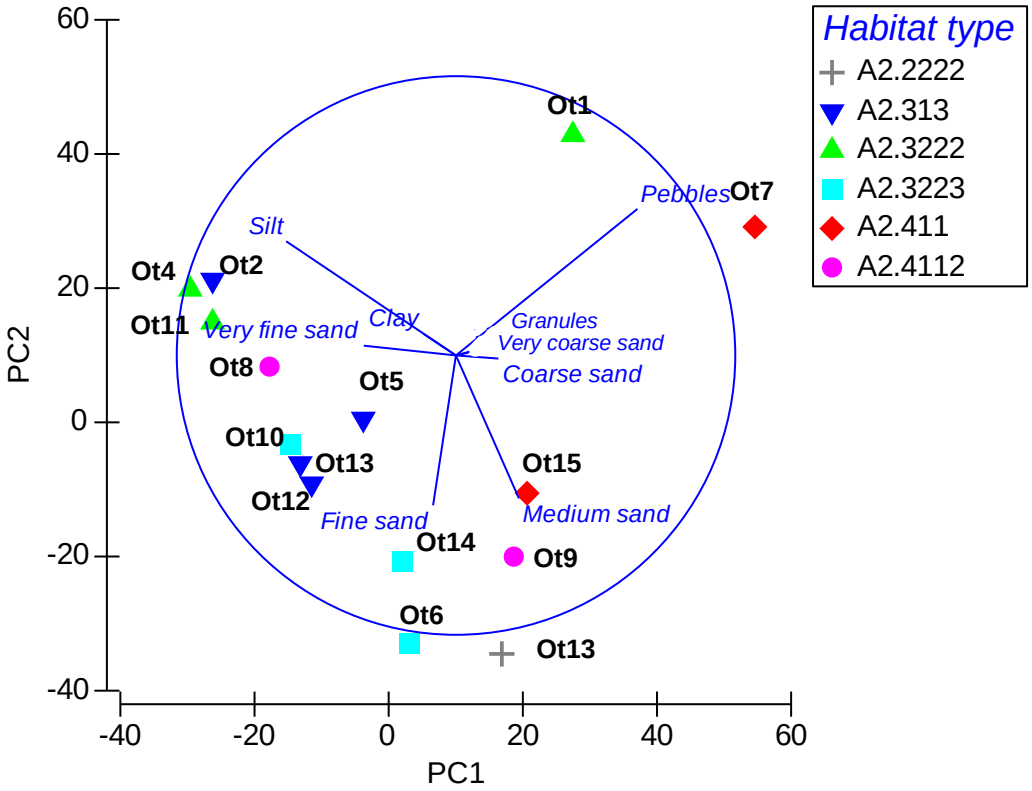

Figure 12. Principle Component Analysis (PCA) of station sediment granulometry similarities

The PCA plot in Figure 12 does not show a strong distinction between the sediment granulometry in different habitat types. This is partially because there are several other factors that influence the species composition in an estuary. As well as sediment granulometry, variables such as salinity, drainage, and current all have significant effects on the community structure.

Although station Ot1 is in a mud habitat type, a large gravel proportion can be seen in the PCA plot. The pebble component is entirely accounted for by large rounded stones (approximately 6cm) which have been transported from the large shingle bank at the estuary mouth which is adjacent to this sample station. The break-down of individual fractions in Table 9 shows that without the large fraction the sediment at Ot1 was composed of silt, clay, and very fine sand. Because of this, this area was designated at the A2.3222 mud habitat type.

Sample station Ot8 is situated with many samples designated as mud habitat types to the left of the plot. Despite this, observations taken by field recorders noted a significant gravel component at this sampling station. It is likely that the distribution of gravel in this area is not uniform and that by chance the PSA sample was simply taken in a section with less gravel.

3.5 Sediment contamination analysis

Additional samples were taken at stations Ot1, Ot5, and Ot10 for contaminant analysis, the locations of these samples are shown in Figure 13.

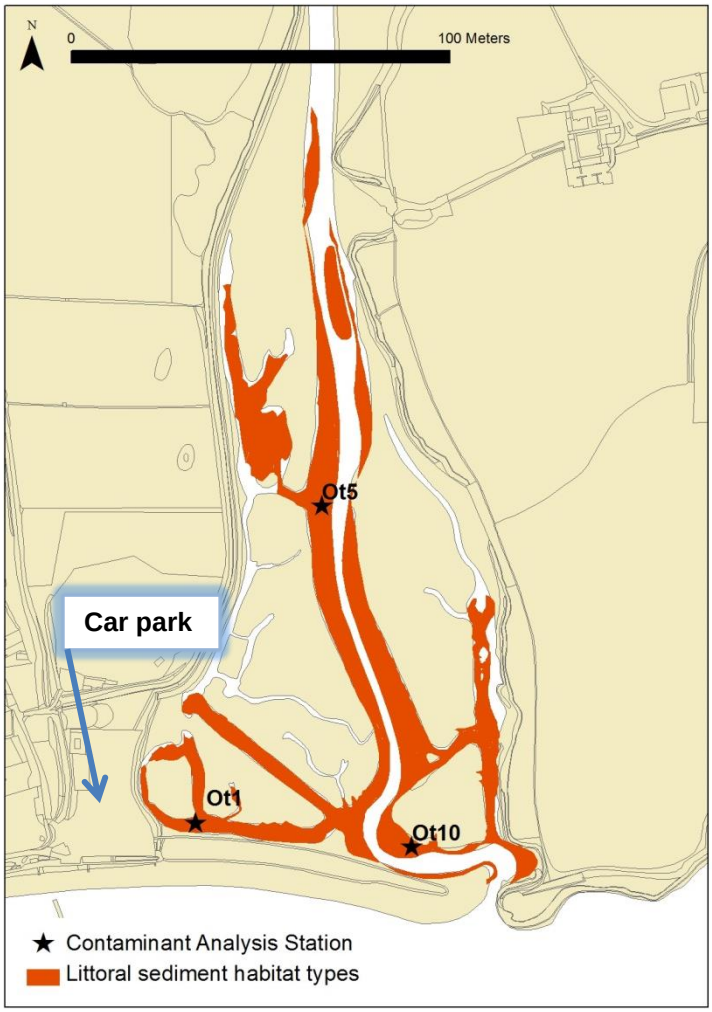

Figure 13. Map of sediment contamination sample locations

The results of the analysis of contamination samples are summarised in Table 10. Guideline limits given in Table 12 have been taken from both the CEFAS action levels[12] and from the CCME Interim Sediment Quality Guidelines (ISQG) and Probable Effect Levels (PEL)[13]. CEFAS action levels were designed to assess the potential impact contamination in dredged sediment on marine life. The CCME ISQG level is the level at which certain sensitive species may be affected, whilst the PEL is the level above which adverse effects to aquatic life are likely to occur frequently.

The ISQG level for both arsenic and chromium was exceeded at all three stations. Slightly elevated levels of metal contamination such as this are most likely a result of the local geology of the river catchment. Furthermore, the complete hydrofluoric digest used to analyse the samples releases metals found inside each particle of the sediment, not just those which are available.

Table 10 shows that at sample station Ot1 there were several relatively small breaches of the ISQG levels by Poly-Aromatic Hydrocarbons (PAHs). These pollutants are found in several sources such as fuels, coal tar and fumes from engines and fires. The most likely source of these low levels in this case is run off from the nearby car park (Figure 13).

Table 10. Sediment contamination analysis results from the Otter estuary rMCZ, with relevant guideline limits where available.

Analyte	Units	Ot 1	Ot 5	Ot 10	CEFAS Action Level 1	CEFAS Action Level 2	CCME Guidelines ISQG Level	CCME Guidelines PEL Level
Mercury	mg/kg	0.0462	0.0497	0.0281	0.3	3	0.13	0.7
Aluminium, HF Digest		49300	45100	31300	-	-	-	-
Iron, HF Digest		25100	23600	18800	-	-	-	-
Arsenic, HF Digest		20.5	19.5	12.3	20	100	7.24	41.6
Cadmium, HF Digest		0.18	0.274	0.228	0.4	5	0.7	4.2
Chromium, HF Digest		61	66.5	69.5	40	400	52.3	160
Copper, HF Digest		17.3	18.5	11.4	40	400	18.7	108
Lead, HF Digest		24.9	28.7	17.9	50	500	30.2	112
Lithium, HF Digest		57.8	49.9	35.8	-	-	-	-
Manganese, HF Digest		744	546	463	-	-	-	-
Nickel, HF Digest		25.8	22.7	15.8	20	200	-	-
Zinc : HF Digest		84.4	94.2	59.1	130	800	124	271
Hexachlorobenzene	ug/kg	<1	<1	<1	-	-	-	-
Hexachlorobutadiene		<1	<1	<1	-	-	-	-
Anthracene		15	6.2	3.72	-	-	46.9	245
Benzo(a)anthracene		102	43.2	33.7	-	-	74.8	693
Benzo(a)pyrene		145	63.9	40.7	-	-	88.8	763
Benzo(ghi)perylene		114	50	24.7	-	-	-	-
Chrysene + Triphenylene		118	50.2	36.3	-	-	108	846
Fluoranthene		226	92.9	52.5	-	-	113	1494
Indeno(1,2,3-c,d)pyrene		111	44.5	25.7	-	-	-	-
Naphthalene		<30	<30	<30	-	-	34.6	391
Phenanthrene		63.1	29.7	16.3	-	-	86.7	544
Pyrene		199	79.9	44.4	-	-	153	1398
2,2,4,4,5,5-Hexabromodiphenyl ether		<0.02	<0.02	<0.02	-	-	-	-
2,2,4,4,5,6-Hexabromodiphenyl ether		<0.02	<0.02	<0.02	-	-	-	-
2,2,4,4,5-Pentabromodiphenyl ether		0.074	<0.05	<0.05	-	-	-	-
2,2,4,4,6-Pentabromodiphenyl ether		<0.02	<0.02	<0.02	-	-	-	-
2,2,4,4-Tetrabromodiphenyl ether		<0.07	<0.07	<0.07	-	-	-	-
2,4,4-Tribromodiphenyl ether		<0.02	<0.02	<0.02	-	-	-	-
PCB - 028		<0.1	<0.1	<0.1	-	-	-	-
PCB - 052		<0.1	<0.1	<0.1	-	-	-	-
PCB - 101		<0.1	<0.1	<0.1	-	-	-	-
PCB - 118		<0.1	<0.1	<0.1	-	-	-	-
PCB - 138		<0.1	<0.1	<0.1	-	-	-	-
PCB - 153		<0.1	<0.1	<0.1	-	-	-	-
PCB - 180		<0.1	<0.1	<0.1	-	-	-	-
PCB Total		<0.1	<0.1	<0.1	10	10	21.5	189
Tributyl Tin as Cation		<6	<4	<4	100	100	-	-

Levels within ISQG and CEFAS Action Level 1

Levels over the ISQG or CEFAS Action Level 1

Levels over the PEL or CEFAS Action Level 2

No CCME or CEFAS Action Levels available

3.6 Anthropogenic impacts

There were very few anthropogenic influences on the estuary, and it is highly unlikely that any of these is having a significant influence on the community structure of the rMCZ. The following possible influences were noted;

- Low level PAH contamination at Ot1.
- Discarded tyres embedded in the sediment.
- A land drain discharging at the top of the channel where Ot2 is located.

The low levels of contamination at Ot1 were discussed in section 3.5.

Two discarded tyres were found partially embedded in the sediment of the estuary; it is unlikely that this has any impact other than visual

At the top of the channel where sample station Ot2 is located there is a sluice gate which releases water from the drainage ditch on the other side of the bank. This has the potential to introduce low level contamination caused by urban run-off into the estuary. However, any contamination introduced is highly unlikely to be at such a concentration as to have a significant effect.

4. DISCUSSION

In order to meet conservation objectives under the Marine and Coastal Access Act 2009, the Otter rMCZ is to be included in a network of marine protected areas (MPAs) within UK waters. Prior to the current survey, the Finding Sanctuary Project Report Site Assessment Document (SAD)[1] was largely based on 'best available evidence' drawn from historical data, stakeholder knowledge and modelled habitat maps. The key purpose of the current survey was to provide direct evidence of the presence and extent of the BSH and HOCI and the presence and distribution of SOCI.

All three of the BSHs outlined as FOCI for this study were found and mapped accordingly. Three additional BSHs were also identified and mapped. Table 11 provides a summary comparison of the BSH characteristics predicted by the finding sanctuary Site Assessment Document (SAD) along with revised estimates based on the new data provided by these verification surveys.

Table 11. Area of BSHs found in the Otter rMCZ, compared to data provided by the finding sanctuary report SAD.

Feature code/ Name BSH	Regional MCZ Project SAD: Extent km^2	Current Survey Extent km^2	Accordance between Regional MCZ Project SAD Presence (Y/N)	Extent (km2)
A2.1 Littoral coarse sediment	<0.01	<0.01	Y	0
A2.2 Littoral sand and muddy sand	-	<0.01	Y	+0.01
A2.3 Littoral mud	0.05	0.04	Y	-0.01
A2.4 Littoral mixed sediments	-	0.01	Y	+0.01
A2.5 Coastal saltmarsh and esturine reedbeds*	<0.01	-	Y	0
A1.3 Low energy littoral rock	-	<0.01	Y	+0.01
HOCI **SOCI**	**Records**	**Records**		**Records**
Anguilla anguilla (European eel)**	-	-	?	-

*This BSH was not within the remit of this study and was therefore not accurately mapped.

**This SOCI is a fish and is usually only found in intertidal areas when the tide is in. It was therefore unlikely to be found during this survey.

The main difference between the SAD and the current survey data is the inclusion of the A2.4 mixed sediment BSH which aptly describes the gravelly sediment habitat types in the estuary. Low energy littoral rock (A1.3) was also added due to the very small area (approximately $10m^2$) of a single rock Biotope. One littoral sand and muddy sand (A2.2) habitat type was found and mapped. There was a small reduction in the area of littoral mud predicted by the SAD. This is accounted for by the addition of the A2.4 mixed sediment habitat types which are similar in terms of species composition by with a coarse sediment component.

The SOCI Anguilla anguilla is a fish species and as such lives underwater. It was therefore unlikely to be seen during this intertidal survey. A 2001 Environment agency report recorded relatively high densities of eels found in the river Otter[14]. It is reasonable to expect this species is still present in the estuary. However further targeted survey work would be required to ascertain current population levels of this species in the Axe rMCZ.

A small area of littoral rock habitat type, A1.323 *Fucus vesiculosus* on variable salinity mid eulittoral boulders and stable mixed substrata, was found towards the mouth of the estuary. This area was mapped, but due to its very small size, a Phase II survey was deemed unnecessary.

The data and information collected within the littoral sediment habitat types in the Otter estuary is sufficiently detailed to enable at least some statistical comparison with compatible future data. There are opportunities to imporove the potential for stronger statistical comparisons in future however. The power to detect change in the least widespread littoral sediment habitat types may be constrained by the fact that less than three samples were taken in each one. Conversely, the higher level of replication in the most widespread habitat type (A2.313) will provide a reasonable basis of data from which any temporal change in community structure will be detectable with greater power in future. Such comparisons will enable Natural England to fulfil their statutory duty to monitor and report on a range of features and attributes for the site should it be designated as an MCZ in the future.

5. RECOMMENDATIONS

Whilst the level of sampling in the A2.313 habitat type may be adequate, many of the other habitat types in the estuary have only one or two samples taken. This level of sampling may not be sufficient to detect future impacts unless they are of a significant size. Therefore, depending on the value that Natural England place on these less widespread habitat types (A2.2222 and A2.411) the sampling effort in these communities should be increased to three and preferably five sampling stations. This will greatly increase the likelihood that factors affecting these habitat types are detected. A larger number of samples would also increase the power of statistical analysis and comparison between habitat types within the estuary.

The same sampling stations should be revisited during subsequent surveys which should be undertaken at the same time of year. This will enable direct comparison and give the ability to detect both directional and temporal change over time. Furthermore this will also reduce the potential for detecting erroneous change caused by different sampling locations or from seasonal recruitment of benthic species.

GLOSSARY

Abundance	Total number of all animals (individuals) in a sample
Bray Curtis similarity	Statistic that compares fauna samples in terms of abundance and number of taxa
BSH	Broad scale habitat
CCME	Canadian Council of Ministers of the Environment
Community	A collection of fauna (or flora) cohabiting in and characteristic of an area of the environment
Community analysis	Statistical technique used to identify areas with a similar biological community
Diversity	The range of animals (taxa) in a sample
FOCI	Feature of Conservation Importance
HOCI	Habitat of Conservation Importance
Infauna	Animals that live within the sediment
MDS	Multi-Dimensional Scaling, a statistical manipulation used to identify groups of distinct fauna (communities).
Multi-variate	Statistics which can be applied to a complete taxa abundance data matrix without any loss of information i.e. not requiring reduction of the data to a single number or index
Margalef's species richness	A measure of the variety of species present.
Pielou's evenness	A measure of the relative abundance of each species
Shannon Wiener diversity index	An index (single number) of fauna diversity, increases with fauna diversity
Simpson's diversity index	An index of fauna diversity, increases with fauna diversity
SOCI	Species of Conservation Importance
Taxon	A grouping of the fauna, may be a species or, if different species are indistinguishable, it may be based on a higher taxonomic group such as the genus, family or phylum
Uni-variate	Statistics that describe the fauna in terms of a single number
Wentworth scale	Recognised 12 band scale of sediment particle size
A1.323	*Fucus vesiculosus* on variable salinity mid eulittoral boulders and stable mixed substrata
A1.45	Ephemeral green or red seaweeds (fresh water or sand influenced) on non-mobile substrata

A2.111	Barren littoral shingle
A2.2222	Oligochaetes in variable salinity littoral mobile sand
A2.313	*Hediste diversicolor*, *Macoma balthica* and *Scrobicularia plana* in littoral sandy mud
A2.3222	*Hediste diversicolor* and *Corophium volutator* in littoral mud
A2.3223	*Hediste diversicolor* and oligochaetes in littoral mud
A2.411	*Hediste diversicolor* in littoral gravelly muddy sand and gravelly sandy mud
A2.4112	*Hediste diversicolor* and *Scrobicularia plana* in littoral gravelly mud

REFERENCES

[1] Lieberknecht, L., Hooper, T., Mullier, T., Murphy, A., Neilly, M., Carr, H., Haines, R., Lewin, S., and Hughes, E. (2011) Finding Sanctuary final report and recommendations. A report submitted by the Finding Sanctuary stakeholder project to Defra, the Joint Nature Conservation Committee, and Natural England (online). URL: www.finding-sanctuary.org (Accessed January 2013).

[2] Natural England Marine conservation zones features catalogue, European eel URL: http://www.naturalengland.org.uk/ourwork/marine/mpa/mcz/features/species/europeaneel.aspx (Accessed May 2014)

[3] Natural England SSSI designation Citation, URL: http://www.sssi.naturalengland.org.uk/citation/citation_photo/1001733.pdf (Accessed September 2014)

[4] Davies, J., Baxter, J., Bradley, M., Connor, D., Khan, J., Murray, E., Sanderson, W., Turnbull, C. & Vincent, M., (2001), Marine Monitoring Handbook, 40 pp, ISBN 1 85716 550 0 (online). URL: http://jncc.defra.gov.uk/page-2240 (accessed January 2014).

[5] JNCC (2004). Common Standards Monitoring Guidance for Littoral Rock and Inshore Sublittoral Rock Habitats (Reefs). Version August 2004, Updated from (February 2004). JNCC. ISSN 1743-8160 (online). URL: http://jncc.defra.gov.uk/page-2236 (Accessed January 2013)

[6] Wyn, G., Brazier, P., Jones, M., Roberts, S., Cooke, A., Lough, N. & Uttley, C. (2000). CCW Handbook for Marine Intertidal Phase 1 Survey and Mapping, 107 pp. Marine Science Report No. 00/06/01, February 2000, Countryside Council for Wales, UK.

[7] European Environment Agency. EUNIS Habitat types [Online]. Available: http://eunis.eea.europa.eu/habitats.jsp [Accessed 10 July 2013]

[8] JNCC (2004). Common Standards Monitoring Guidance for Littoral Sediment Flats (Sand/mud flats). Version August 2004, Updated from (February 2004). JNCC. ISSN 1743-8160 (online). URL: http://jncc.defra.gov.uk/page-2236 (Accessed January 2013)

[9] ISO 16665:2014 Water quality – Guidelines for quantitative sampling and sample processing of marine soft bottom macrofauna.

[10] Clarke, K., and Warwick, R.M., (1994). Change in marine communities: an approach to statistical analysis and interpretation. 2nd edition, NERC, UK.

[11] Rhoads D C (1974). Organism-sediment relations on the muddy sea floor. Annual Reviews. Oceanogr. & Mar. Biol., 12, 263-300.

[12] CEFAS (1994). Guideline Action Levels for the disposal of dredged materials at sea. [Online] Available: www.pla.co.uk/display_fixedpage.cfm/id/2467/site/environment [Accessed 10 July 2013].

[13] CCME (1999). Canadian sediment quality guidelines for the protection of aquatic life. Summary tables. In Canadian environmental quality guidelines 1999. Canadian Council of Ministers for the Environment. Winnipeg.

[14] Knights, B., Bark, A., Ball, M., Williams, F., Winter, E., Dunn, S. (2001), Eel and Elver stocks in England and Wales – Status and management options, Environment Agency ISBN 18507054008, (Online) URL: http://www.freshwaterlife.org/projects/media/projects/images/5/29483_ca_object_representations_media_569_original.pdf, (Accessed September 2014).