Condition Monitoring of the Intertidal Mudflats and Sandflats Feature at Fal and Helford Marine Sites 2011

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1. Introduction

The Fal and Helford sits on the southern coast of Cornwall. The Fal and Helford Rivers are both ria systems (drowned river valleys) with a low freshwater input opening into Falmouth Bay, with marine communities ranging from those exposed to wave action at the entrance to ones which are extremely sheltered within the inlets. Most of the shores of the Fal and Helford rias, and their upper reaches, are fringed by sheltered intertidal sandflats and mudflats representative of the south-west of England and recognised for the importance of the species living in the sediments. The mudflats and sandflats support a wide range of invertebrate and bird communities and make a vital dynamic contribution to the structure and function of the Fal and Helford system. Consequently, the Malpas Estuary; Upper Fal Estuary and Woods; and the Lower Fal & Helford Intertidal have all been designated as Sites of Special Scientific Interest (SSSI) notified under Section 28 of the Wildlife and Countryside Act 1981 (as amended).

As well as the intertidal mudflats and sandflats being features of the SSSIs, they are also features of the Fal and Helford Special Area of Conservation (SAC). Intertidal mudflats and sandflats are one of several interest features of the site.

1.1 Reasons for Notification

1.1.1 The Malpas Estuary SSSI Mudflats and Sand Flats

This estuarine site extends across Lambe Creek, Calenick Creek and the Truro River at the northwestern limits of the Fal Estuary complex. The major habitat feature of the site is tidal mudflats which are feeding grounds for wildfowl and wading birds, including nationally important numbers of a rare wader. The site also includes saltmarsh, adjoining ancient semi-natural woodland and a heronry.

The site is primarily important for wildfowl and wading birds. The Truro River section regularly supports nationally important numbers of Black-tailed Godwit *Limosa limosa* during autumn and winter. The site is also used for feeding by up to 500 Dunlin *Calidris alpina*, 200 Shelduck *Tadorna tadorna*, 300 Teal *Anas crecca*, and smaller numbers of other waders including Redshank *Tringa totanus*, Greenshank *T. nebularia*, Curlew *Numenius arquata*, Whimbrel *N. phaeopus* and Oystercatcher *Haematopus ostralegus*. The birds make use of different parts of the site and the wider complex of Fal estuaries depending on the time of year, weather and tidal conditions.

Relatively undisturbed agriculturally improved pastureland to the south of Calenick Creek outside of the SSSI boundary is used by roosting waders during high spring tides. Saltmarsh communities have developed in a number of localities within the site, most notably at Calenick Creek where species within the turf include Reflexed Saltmarsh-grass *Puccinellia distans* subsp. *distans*, Sea Couch *Elymus pycnanthus*, Sea Aster *Aster tripolium*, Sea Arrow-grass *Triglochin maritima*, Sea Club-rush *Scirpus maritimus* and Sea Rush *Juncus maritimus*. At Calenick Creek the saltmarsh is immediately continuous with a semi-natural ancient wood. A heronry at Kea Wood, one of the three largest heronries in Cornwall, contains about 13 nests, and Herons *Ardea cinerea* regularly feed along the estuary.

1.1.2 The Upper Fal Estuary and Woods SSSI Mudflats and Sand Flats

The Fal Estuary is a ria system. The lower section of the estuary is an important natural deep-water harbour, which opens to the sea near Falmouth on the south coast of west Cornwall. The upper reaches of the estuary are, for the most part, sediment-filled, with mudflats backed by low rocky cliffs. Of particular importance and rarity are the relatively undisturbed transitions from tidal mud through saltmarsh and scrub to woodland at the upper limits of tidal influence.

The mudflats within the SSSI boundary support nationally important numbers of wintering birds including the Black-tailed Godwit *Limosa limosa*, Curlew *Numenius arquata*, Dunlin *Calidris alpina*, Shelduck *Tadorna tadorna*, Redshank *Tringa totanus* and Golden Plover *Pluvialis apricaria*. On the Tresillian River there are habitats which support Greenshank *Tringa nebularia*, Spotted Redshank *Tringa erythropus*, Little Grebe *Tachybaptus ruficollis* and Kingfisher *Alcedo atthis*. Small but growing numbers of Little Egret *Egretta garzetta* also now occur within the complex. The site is important for Grey Herons *Ardea cinerea* and there is a major heronry.

Saltmarsh communities have developed in a number of localities within the complex, most notably near the limit of tidal influence at Ruan Lanihorne and on the Tresillian River. In addition extensive beds of Common Reed *Phragmites australis* have developed in some places. Typically the saltmarshes in these upper reaches are characterised by Sea Clubrush *Scirpus maritimus* and Creeping Bent *Agrostis stolonifera*, Common Saltmarsh-grass *Puccinellia maritima*, Red Fescue *Festuca rubra* and Sea Rush *Juncus maritimus*.

This transition zone supports over 100 species of flowering plants and ferns, many not normally associated with maritime situations. On the drier areas on the estuary sides there is a transition to oak-dominated woodland. The upper estuaries and these transitional zones are important for Otters *Lutra lutra*.

The site is also of high marine interest. On the extensive area of coarse intertidal sediment at Turnaware Point, a number of interesting communities have developed largely associated with beds of Seagrass *Zostera marina*. A rich algal flora includes *Cladosiphon zosterae*, *Gracilaria verrucosa* and *Chorda filum*. Further communities of particular interest occur at Toms Rock within the King Harry Reaches where the steep rocky shores are dominated by *Ascophyllum nodosum*. On the lower shores a particularly luxuriant growth of sponges has developed which includes *Hymeniacidon perleve* and *Halichondria panicea*.

1.1.3 The Lower Fal and Helford Intertidal SSSI Mudflats and Sand Flats

The site encompasses sections of the shores of the Fal estuary, most of the Percuil estuary and most of the tidal portion of the Helford River. The Fal Estuary and Helford River together form an example of a ria system. Rias have only a low freshwater input; the area therefore contains a diversity of fully marine habitats, including communities representative of those occurring in enclosed marine waters in south-western Britain. A range of wave exposures, variations in geology, tidal streams and aspect gives variety to the shore communities which occur in the three areas.

The steep-sided ria of the Fal has extensive areas of shallow sediment banks either side of a sinuous main channel. It is characterised by very slow tidal currents in most areas. Downstream of

Turnaware Point the ria opens out into the Carrick Roads which is a wide largely subtidal inlet fringed by rocky shores. Areas of intertidal flats are found predominantly within tributaries, particularly the Percuil River, where a number of species more typical of open coasts are able to penetrate into the lower reaches contributing to the richness of intertidal communities.

The Helford is fairly narrow, widening at the entrance, with a number of relatively short, narrow and steeply-sided branches and creeks. Sediments vary from open shore coarse mixed mud and sands to fine soft muds which are typical of upper estuarine conditions. Within the range of sediment types rich communities of burrowing polychaete worms, bivalve molluscs and echinoderms are present.

Percuil River:

This is the most significant inlet of interest in the Fal, grading from rocky shores in the outer section to extensive areas of sediment in the upper sections. Within a small distance (around 2 km) a great change in wave exposure occurs.

The sediment shore communities exhibit distinct zonation in relation to the various environmental factors. In fully marine conditions at the mouth of the Fal the sheltered sand habitat is very rich. A number of species are only found on the shores of the Fal at Amsterdam Point including species of amphipods, polychaete worms, bivalves and sea cucumber *Trachythyone elongata*. Other species characterising this area include the sand mason worm *Lanice conchilega*, the razor shell *Ensis arcuatus* and the burrowing heart urchin *Echinocardium cordatum*. Many other species are only found around St Mawes within the Fal system and include those with a preference for sand subject to high salinity, for example the brittle stars *Ophiura ophiura* and *Amphiura brachiata*. Those in the muddier sediments of Place Cove include polychaete worms such as *Myxicola infundibulum* and *Sabella pavonina* and bivalves such as the carpet shell *Venerupis senegalensis* and the razor shell *Ensis arcuatus*. West of Amsterdam Point the presence of sheltered rocky platform and boulders, as well as sand, adds to the diversity of intertidal habitats in St Mawes inlet. Further variety is given by the transition upstream of sediment communities which are more typical of reduced salinity, including muddy shores characterised by polychaete worms and the peppery furrow shell *Scrobicularia plana* and, towards the extreme upper reaches, by the ragworm *Hediste diversicolor* and oligochaete worms.

Helford River and Gillan Creek:

The Helford is notable as a natural physiographic feature, representing the range of communities which are present in an estuary from the limit of saline influence out to the open coast at the mouth. There are extensive areas of intertidal sediment, predominantly mudflats in the upper estuary and muddy sands in the lower reaches.

Major areas of sandier sediment are present at Gillan Harbour, Flushing Cove, Treath, Helford Point and Helford Passage. These flats are extremely rich in both burrowing and surface fauna including the peacock worm *Sabella pavonina* and other polychaetes, and the cockle *Cerastoderma edule*.

Extensive areas of sediment flats occur at the Bar round to Passage Cove, and on the opposite shore around Helford Point. At the Bar these range from sandy mud to coarse gravel and pebbles. A wide variety of seaweeds occur attached to the pebbles including *Gracilaria verrucosa*, *Ceramium rubrum* and *Polysiphonia elongata* whilst the fauna is less diverse and dominated by polychaete worms such as the sand mason *Lanice conchilega*, and hermit crabs.

In Passage Cove there is an equally high diversity of seaweeds but with some fauna associated with the more abundant pebbles including the chinamans hat *Calyptraea chinensis* and the brittle star *Ophiothrix fragilis*. Burrowing animals are limited and include capitellid worms and the mollusc *Lucinoma borealis*.

Shale and shingle shores are present up the river, often replaced by deep mud towards low water, including at Merthen Wood, Groyne Point, Frenchmans Creek and Calmansack. There is seaweed cover on these shores including *Pelvetia canaliculata*, *Fucus spiralis* and *F. vesiculosus* and *Ascophyllum nodosum*. The fauna on such shores is often limited with only the shore crab *Carcinus maenas*, mussels *Mytilus edulis* and the barnacle *Elminius modestus* being widespread. Downstream of Merthen Wood the fauna also includes gastropods such as *Littorina littorea* and *L. obtusata*, the barnacle *Semibalanoides balanoides*. Of note is an area of mixed shale shingle with mud on the lower shore between Helford Point and Frenchmans Creek with a rich community of massive sponges *Hymeniacidon perleve* and the tube worm *Sabella pavonina*.

1.2 Condition Monitoring of the Intertidal Mudflats and Sandflats Feature at Fal and Helford Marine Sites

Site Condition Monitoring is (SCM) undertaken to determine whether the status of the special interest features which underpin the designation of habitats or areas are being maintained, and to guide site management action where appropriate. Natural England has a duty to monitor and assess the condition of the intertidal features in order to report on the conservation status of mudflat and sandflat habitats once every six years.

Natural England in association with other countryside agencies has established a series of common standards for the monitoring of sites of nature conservation interest. These common standards apply to a number of statutory designated sites, including SSSIs, and ensure that a consistent approach is taken when monitoring such sites. Within the Fal and Helford the intertidal special interest features which include the mudflats and sand flats fall under the Common Standards Monitoring guidance produced for littoral sediment habitats[4].

For the purposes of monitoring, each feature is represented by a series of attributes, which are measurable indicators of the condition of the feature at the site (see Table 1). For each attribute (e.g. extent of habitat or presence of representative/notable biotopes) a target is set which is considered to correspond to the favourable condition of the feature.

Table 1. Generic attributes that, subject to natural variation, should be used to define the condition of littoral sediment features in site condition monitoring[5].

Attribute	Generic Target
Extent	No change in extent of littoral sediment
Biotope composition	Maintenance of the variety of biotopes
Sediment type	No change in sediment composition
Distribution of Biotopes	Maintenance of the distribution of biotopes
Extent of sub-feature	No change in extent of biotope
Species composition of specific biotope	No change in species composition or loss of notable species
Species population measures	E.g. Maintenance of presence or abundance of named positive indicator species.
Topography	No change in topography of littoral sediment
Carbon content	No increase in carbon content

Conservation objectives and site specific definitions of favourable condition of mudflats and sandflats within the Malpas Estuary SSSI; Upper Fal Estuary and Woods SSSI; and the Lower Fal & Helford Intertidal SSSI have been developed [6, 7, 8].

1.3 Existing Biotope Information

Although previous data exists for the Fal and Helford Marine Sites [9-18] the studies are not extensive or targeted enough to provide a thorough baseline data set under Common Standards Monitoring (CSM). This study therefore aims to provide additional baseline data against which future changes can be measured to support Natural England's overall programme of monitoring and surveillance of the sites into the future.

1.4 Aims and Objectives

The purpose of this study is to:

- Establish a physical and biological baseline data set (where one does not exist) that will then facilitate an assessment of the favourable condition status of the mudflat and sandflat habitats of the Malpas Estuary SSSI, Upper Fal Estuary and Woods SSSI, and the Lower Fal & Helford Intertidal SSSI (therefore fulfilling Natural England's monitoring requirements for the SSSI for condition assessment).

- Identify species and biotopes that are representative and/or notable within the intertidal mudflat and Sandflat features of the Fal and Helford Marine Sites.

1.5 Anthropogenic Influences within the Fal and Helford Marine Sites

Land use within the Fal and Helford catchments is predominantly agricultural. 59% of the land is utilised for agricultural purposes, 29 % of which is arable (winter barley, summer barley maize, oats and wheat). The remainder of the agricultural land is populated by livestock, mainly dairy cattle, with a small number of beef, pigs and sheep [19].

Parts of Fal and Helford, notably the upper Fal estuary, are subject to eutrophication. Although the majority of nutrient inputs in the cSAC may be due to diffuse sources such as agricultural run-off, localised enrichment from sewage treatment works are also significant, particularly in the more enclosed reaches of the upper Fal where chronic contamination and nutrient associated water quality problems have resulted in toxic algal blooms[20]. In 2002 a toxic algal blooms in the Helford resulted in invertebrate mortalities[20]. As a result of nutrient enrichment in the Fal and Helford cSAC, the Upper Fal has been designated as a Sensitive Area (Eutrophic) and a Polluted Water (Eutrophic) under the Urban Wastewater Treatment Directive and Nitrates Directive, respectively[20].

There is relatively little heavy industry left to affect the estuarine ecosystems of the Fal and Helford, although harbours, docks, and a number of marinas are potential sources of disturbance (dredging activities etc.). China clay quarrying also commenced in the 18th century and continues in the upper Fal river catchment. The principal urban centres with major sewage treatment works (STW) are Falmouth and Truro with a number of smaller discharges elsewhere that may influence the Marine Sites at a local level. Most significantly, the Fal Estuary has long suffered the impacts of mining and ore extraction which have been a feature of the area for centuries. The Fal estuary (and in particular Restronguet Creek) has been the site for a number of studies on the effects of long-term heavy metal pollution on marine organisms [21, 22].

The Fal Estuary represents one of the few commercially exploitable fisheries for the native oyster (*Ostrea edulis*) in the UK. The principal stocks are at Messack Point and Parsons Bank. Within the Fal other shellfisheries include mussels and the non-native Pacific oyster. There is also a Pacific oyster fishery in the Percuil.

Biological disturbance via bait digging and peeler crab collection result in the selective extraction of species from the intertidal area. The extent of such impacts are unclear, but the placing of crab shelters on intertidal sediments introduces hard substrata for colonisation by rocky shore species, and may change sediment characteristics by affecting water and oxygen exchange and sedimentation rates[23].

2. Methods

In order to deliver the overall aims and objectives (as outlined in Section 1.4) in the most efficient and cost effective manner, a two phased survey approach was implemented throughout the study areas. Such an approach enabled more effective targeting of effort on intertidal interest features, species and biotopes that are representative and/or notable within the Fal and Helford Marine Sites.

2.1 Transects

In line with the methodology stipulated my Natural England, the Phase I and Phase II sampling strategy was focused on a series of transects placed throughout the study area. The transects ran seawards from the highest extent of the intertidal down to the mean low tide level and comprised a 400m wide belt. The selection of transect locations was based upon three main objectives:

1. To ensure a maximum coverage of monitoring data transects should complement other studies which are in progress on the estuary rather than repeat sampling effort at the same locations.

2. To encounter the largest possible range of biotopes including any species or communities which are specifically mentioned in Appendix III of the Regulation 33 (now Regulation 35) advice.

3. To include any areas where known impacts or changes to the feature or its communities are known to be occurring.

The number of transects allocated within each of the three study areas was based on a preliminary desk study, existing knowledge of the operating areas and recent experience of very similar projects within Southwest estuaries including the Lynher, Tamar-Tavy and St. Johns Lake intertidal SSSIs. A total of 21 transects were considered adequate for coverage of the Upper Fal Estuary SSSI, 21 for the Lower Fal and Helford Intertidal Intertidal SSSI and 7 for the Malpas Estuary SSSI. The corner coordinates of each transect are available in Appendix 1.

Figure 1. Location of transects in the Helford - Lower Fal and Helford Intertidal SSSI (Graticules represent $1km^2$)

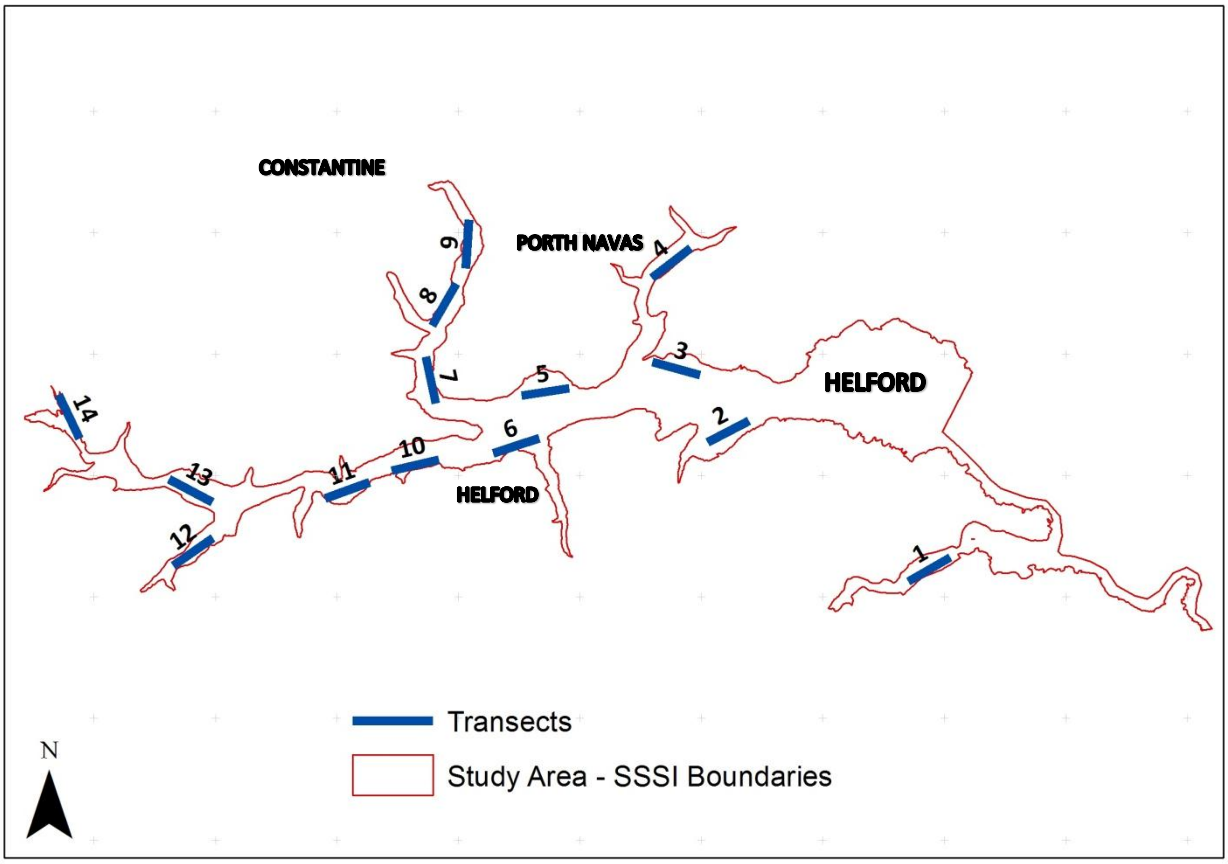


Figure 2. Location of transects in the Percuil - Lower Fal and Helford Intertidal SSSI (Graticules represent 1km^2)

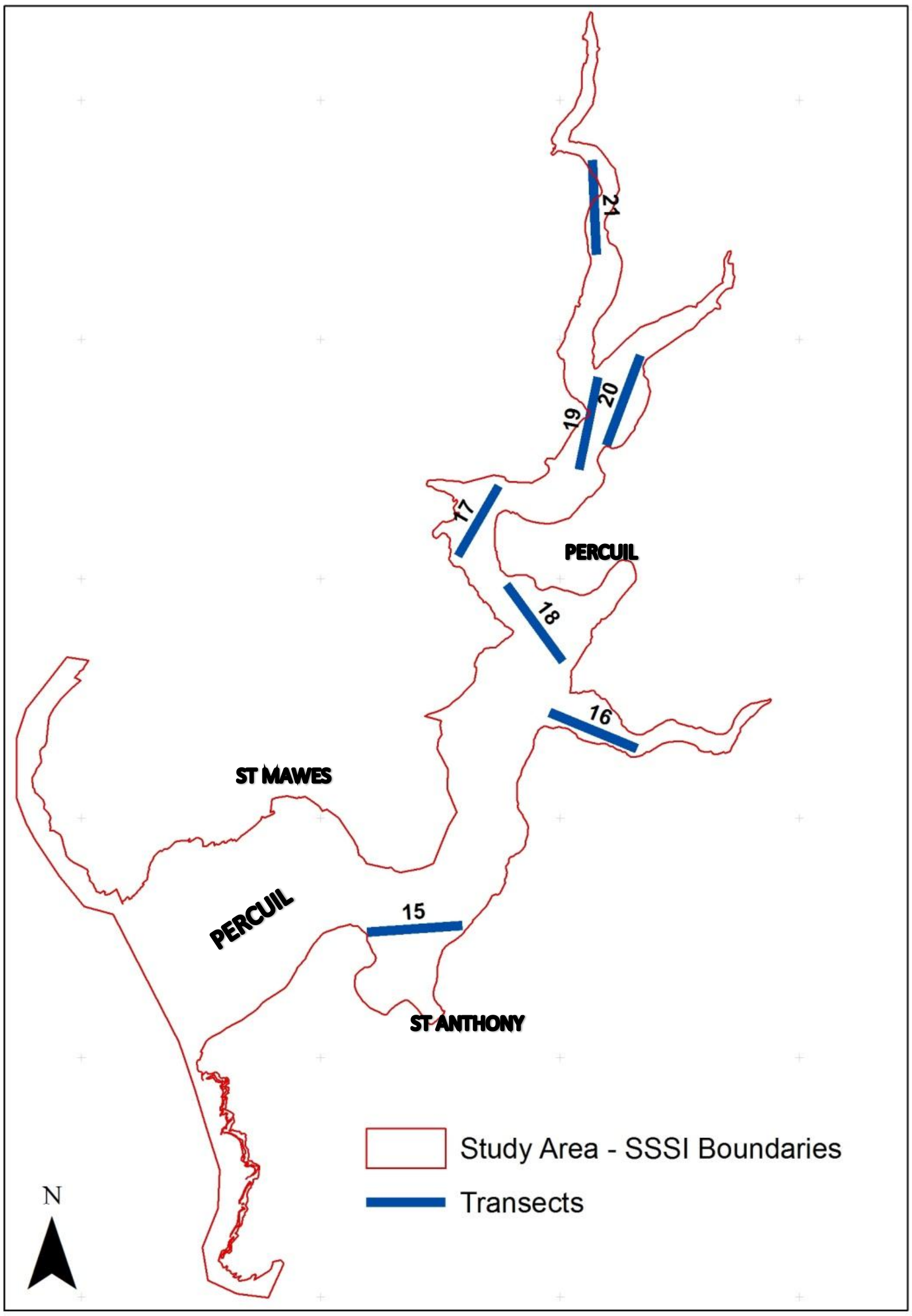
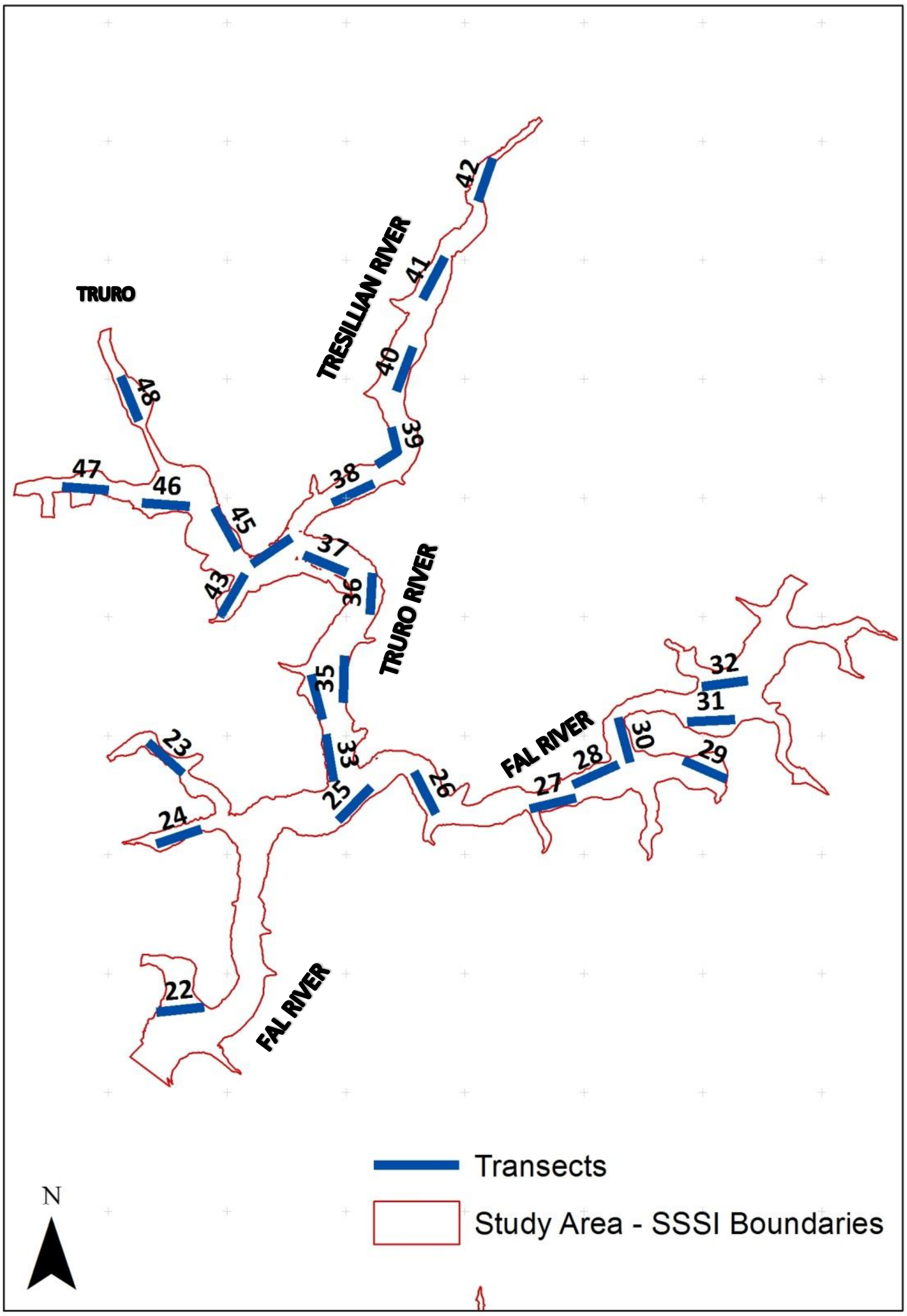


Figure 3. Location of transects in the Fal – Upper Fal and Woods and Malpas Estuary SSSI (Graticules represent 1km^2)



2.2 Phase I

The Phase I component of the survey was carried out during the spring tides that occurred between the 22nd and 27th of November 2011 (LW ranged between 1.2m and 0.7m above chart datum during that time).

The aim of the Phase I survey was to determine the distribution and extent of intertidal biotopes, interest features, and species that are representative and/or notable throughout the Fal and Helford Marine Sites, with specific targeting of efforts within the designated transects. Broadly, this was achieved by examining geo-referenced aerial photography and subsequently ground-truthing discernible habitats via field survey in order to establish the biotopes present (as per Procedural Guidelines 1-1 Inter-tidal resource mapping using aerial photographs in the Marine Monitoring Handbook).

A preliminary digitised map of the intertidal zone was then produced showing the spatial extent of the main biotopes. Target notes were used to indicate the presence of noteworthy features and biotopes that existed in only very limited areas.

2.2.1 Aerial Photographs

The aerial photographs which formed the basis of the intertidal biotope mapping were those that were collected during a 2007 survey carried out by the Channel Coastal Observatory[24]. The photographs were printed onto waterproof paper at an appropriate resolution to distinguish the features on the ground (the precise resolution varied depending on the complexity of the features in different areas of the estuary). Photographs covering the entire extent of the study areas were then incorporated into the project field book and were annotated in the field.

2.2.2 Use of hovercraft

For reasons of efficiency, quality and safety, all fieldwork was conducted from Ecospan Environmental Ltd's MCA coded 4 man hovercraft.

The hovercraft can safely and efficiently cover large areas of mudflat and access areas in which safety considerations would have otherwise limited or prohibited access. When compared to point mapping and interpolating between points (as would have been necessarily be the case if the same survey was undertaken on foot or by boat) much more comprehensive and accurate biotope mapping of the intertidal was possible. Therefore as well as significantly improving survey efficiency, it is considered that that resulting quantity and quality of information gathered was superior to what would have otherwise been achievable.

A further advantage of using a hovercraft is that given that the craft rides upon a cushion of air, disturbance to the littoral sediment habitats being surveyed is minimal; and tracks are not visible after one tide. In contrast, survey teams accessing littoral habitats from the shore may cause disturbance which is apparent following multiple tides.

2.2.3 Topography, Reduction-Oxidisation (Redox) Profile and Sediment Type

The topography at each target location was determined using fixed viewpoint digital photography (Procedural guideline 1-2) as suggested in the Common Standards Monitoring Guidance[4]. The Redox discontinuity layer was determined by visual assessment. The sediment type was also determined visually and described using the Wentworth/Folk scale.

2.2.4 Differentiation and Assignment of Biotopes

The pre-determined transects were both added to the aerial photography maps and loaded into a Garmin GPS 76 differential GPS which was used for all position fixing during the course of the survey. The survey technique was to fly systematically at low speed across each transect achieving maximum possible coverage. Where changes in biotope were observed, the perceived boundaries of the changes were marked on the aerial map.

The littoral sediment habitats and communities present were determined using the JNCC Marine Habitat Classification for Britain and Ireland Version 04.05[26]. Wherever possible, biotopes were assigned in the field by direct observation (i.e. spade sample inspection and species field signs).

Where the species present and resulting biotope was not obvious, a 0.01m^2 core of sediment was taken and sieved through a 0.5 mm sieve to enable closer examination and identification of benthic macrofauna present. In order to keep costs to a minimum, these samples were only processed to a level at which enabled the biotope to be determined (using the SACFOR scale and identification of characterising species only) rather than full faunal enumeration and identification. The macrofauna present and the method of observation was recorded at each sample point together with relevant target notes.

A target position representative of each biotope observed was added to the survey plan and recorded using DGPS, and attributes present (species, topography, redox and sediment character) were recorded using the appropriate MNCR recording forms. Additional target notes were added where variation in sediment character occurred within the same biotope. In addition, the mudflat and sandflat biotopes present between transects were identified; where large expanses of intertidal flats were exposed, a ‘zig zag’ route between transect positions was taken in order to maximise the area covered.

All information gathered was added to a digitised map on ArcGIS using attribute tables for each feature. Photographs of the littoral sediment habitats were also taken at each target location and were also added as a layer on the GIS.

2.3 Phase II

The Phase II survey was undertaken during the springs tides between the 28th of November and 1st of December 2011 (LW ranged between 0.7m and 1.6m above chart datum respectively).

In accordance with the relevant guidance (see section 2.2.1), the aim of the Phase II survey was to produce detailed descriptions of the biotopes present within the Fal and Helford Marine Sites. These descriptions include floral and faunal species lists, abundance and biotope information, as well as detailed sediment character descriptions that include carbon content and sediment granulometry analysis results. The overall objective was to produce a comprehensive digitised map in GIS that both illustrates the distribution and extent of the biotopes identified within the study areas, and outlines the detailed physical and biological data within the attribute layers.

2.3.1 Faunal Sampling

The information gathered during the Phase I survey was used to prepare a preliminary biotope map. This map was subsequently used to determine the locations of 63 intertidal cores which were intended to provide a representative sample of the fauna within each of the biotopes present within transects. Adequate replication was also required; therefore the larger the area covered by each biotope, the greater the number of replicates assigned to that biotope.

Having accessed the target core locations via hovercraft, intertidal cores were taken using a standard 0.01 m^2 box corer which was placed to depth of 15 cm. Faunal samples were separated through a 0.5 mm sieve and preserved in a 10% buffered formalin solution containing the vital stain Rose Bengal. The faunal sampling and preservation was carried out in accordance with standard methodologies (ISO 16665:2005)[25] and according to Ecospan Environmental Ltd's Standard Operating Procedures (SOP) (ES-01, ES-02, ES-07 and ES-08). The benthic macrofauna present in the cores was subsequently identified to species level, enumerated and biomasses in a laboratory setting and according to the National Marine Biological Analytical Quality Control Scheme guidelines and following internal SOP ES-04 and LAB-32.

As in the Phase I, the exact location of each sampling station was recorded using DGPS, and photographs taken of the littoral sediment. The transect numbers which relate to each station can be found in Appendix 1, and the coordinates of the Phase II stations are presented in Appendix 2.

2.3.2 Topography, Reduction-Oxidisation (Redox) Profile and Sediment Type

As in the Phase I survey, the topography at each target location was determined using fixed viewpoint digital photography (Procedural guideline 1-2) as outlined in the Common Standards Monitoring Guidance[3]. Sediment type was again assessed *in-situ* using the Wentworth scale, but in addition, a sediment sample was taken for more detailed and accurate particle size analysis (PSA). PSA was carried out using dry sieving and laser diffraction methods following SOP LAB-25. A second sediment sample was taken at each station for the determination of total carbon by Loss on Ignition (LOI) by a UKAS accredited laboratory.

2.3.3 Univariate and Multivariate Analysis of Faunal Data

Where more than one replicate core was taken within a defined biotope, the data was subjected to statistical analysis. The analysis is intended to establish a clearly defined quantitative baseline of faunal characteristics that could be used to facilitate a more robust condition assessment of the Fal and Helford Marine Sites in the future.

Two statistical methods were used to interrogate the data, a uni-variate approach using species diversity statistics and a multi-variate community analysis approach. The number of taxa per sample and number of individuals per sample were counted and the uni-variate statistics (namely Shannon Wiener's diversity index, Margalef's species richness and Pielou's evenness) were calculated for each station. Community analysis in PRIMER[30] used the multi-variate Bray-Curtis similarity statistic and multidimensional scaling (MDS) plots to assess the communities at each sampling site. MDS plots represent the sample points in three dimensions where the distances between points represent the differences between the samples. In order to reduce the influence of very abundant taxa on the analysis, the benthic invertebrate data set was subjected to a single square root transformation prior to fauna similarity analysis.

2.4 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. Ecospan is also UVDB verified under Achilles services who regularly audit management systems for health, safety, environment, quality and best practices. We undertake all work in accordance with standard operating procedures and recognised national and international guidelines.

2.4.1 Benthic Invertebrate Analysis

A random 10% of samples were selected for re-analysis by a second operator following Ecospan Environmental's internal benthic analysis quality assurance process detailed in SOP ES-05. The second analysis checks the accuracy with which the detritus was sorted and confirms fauna identifications. The limit of error allowed is 10% dissimilarity according to the Bray Curtis measure. The internal quality control results from this project are presented in Appendix 3. Ecospan Environmental also takes part in external quality assurance proceedings under the National Marine Biological Analytical Quality Control Scheme (NMBAQCS) and the Biological Effects Quality Assurance in Monitoring Programmes (BEQUALM).

3. Results

3.1 Phase I Survey

The results of the Phase I survey were used to facilitate the identification of the biotopes and are presented within the GIS files which accompany this report.

3.2 Phase II Survey

A total of 18 littoral sediment biotopes (plus two transitional biotopes) were identified throughout Fal and Helford Marine Site. There do appear to be distributional patterns to biotopes related to geography (upper, mid and lower estuary) and shore height; LS.LMu.MEst.HedMacScr dominates the head of the tributaries and creeks whilst LS.LSa.MuSa.CerPo (and an impoverished form of the *Cerastoderma edule* and Polychaetes biotope) is common in the mid estuary. The mid to low estuary situations of the Fal and Helford Marine Sites are more diverse in terms of the biotopes, but those characterised by the polychaete *Nephtys hombergii* including LS.LMu.MEst.NhomMacStr and LS.LMu.UEst.NhomStr are common. Two usually subtidal biotopes were observed at low-extreme low shore, it is expected that these biotopes are exposed only during spring tides.

Table 2 below provides figures for the estimated total area occupied by each biotope within each of the three SSSIs studied.

Table 2. Estimated total area (m^2) occupied by biotopes within SSSIs

Biotope	SSSI	Area Covered by Biotope (m^2)
LS.LBR.LMus.Myt.Mx	*Malpas Estuary SSSI*	0
	Upper Fal Estuary and Woods SSSI	1042
	Lower Fal and Helford SSSI	70,105
LS.LMu.MEst.HedMacScr	*Malpas Estuary SSSI*	228,751
	Upper Fal Estuary and Woods SSSI	1,082,805
	Lower Fal and Helford SSSI	255,302
LS.LMU.MEst.HedMacScr with *Cerastoderma edule* present	*Malpas Estuary SSSI*	70,312
	Upper Fal Estuary and Woods SSSI	370,160
	Lower Fal and Helford SSSI	0
LS.LMu.MEst.NhomMacStr	*Malpas Estuary SSSI*	0
	Upper Fal Estuary and Woods SSSI	218,484
	Lower Fal and Helford SSSI	72,297
LS.LMu.UEst.NhomStr	*Malpas Estuary SSSI*	0
	Upper Fal Estuary and Woods SSSI	162,992
	Lower Fal and Helford SSSI	546,558
LS.LMx.Mx.CirCer	*Malpas Estuary SSSI*	0
	Upper Fal Estuary and Woods SSSI	29,461
	Lower Fal and Helford SSSI	10,149
LS.LSa.MoSa.Ol.VS	*Malpas Estuary SSSI*	0
	Upper Fal Estuary and Woods SSSI	6,976
	Lower Fal and Helford SSSI	6,527
LS.LSa.MuSa.CerPo	*Malpas Estuary SSSI*	409,150
	Upper Fal Estuary and Woods SSSI	505,334
	Lower Fal and Helford SSSI	463,275
LS.LSa.MuSa.CerPo – Impoverished	*Malpas Estuary SSSI*	0
	Upper Fal Estuary and Woods SSSI	67,962
	Lower Fal and Helford SSSI	457,620
LS.Lsa.MuSa.Lan	*Malpas Estuary SSSI*	5,054
	Upper Fal Estuary and Woods SSSI	33,060
	Lower Fal and Helford SSSI	100,337
SS.SMx.SMxVS.CreMed	*Malpas Estuary SSSI*	0
	Upper Fal Estuary and Woods SSSI	10,088
	Lower Fal and Helford SSSI	0
LS.LMp.LSgr.Znol	*Malpas Estuary SSSI*	0
	Upper Fal Estuary and Woods SSSI	23,737
	Lower Fal and Helford SSSI	0
LS.LBR.LMus.Myt.Mu	*Malpas Estuary SSSI*	0
	Upper Fal Estuary and Woods SSSI	0
	Lower Fal and Helford SSSI	35,362
LS.LMx.Mx	*Malpas Estuary SSSI*	0
	Upper Fal Estuary and Woods SSSI	0

	Lower Fal and Helford SSSI	4,715
SS.SMx.IMxOst	*Malpas Estuary SSSI*	0
	Upper Fal Estuary and Woods SSSI	1026
	Lower Fal and Helford SSSI	19,390
LS.LMx.GvMu.HedMx.Cir	*Malpas Estuary SSSI*	0
	Upper Fal Estuary and Woods SSSI	0
	Lower Fal and Helford SSSI	45,848
SS.SMU.SMuVS.AphTubi	*Malpas Estuary SSSI*	0
	Upper Fal Estuary and Woods SSSI	0
	Lower Fal and Helford SSSI	6,396
LS.LSa.MuSa.HedMacEte	*Malpas Estuary SSSI*	0
	Upper Fal Estuary and Woods SSSI	11,755
	Lower Fal and Helford SSSI	0
LS.LMu.UEst.Hed.Str	*Malpas Estuary SSSI*	0
	Upper Fal Estuary and Woods SSSI	143,954
	Lower Fal and Helford SSSI	0
LS.LCS.Sh	*Malpas Estuary SSSI*	0
	Upper Fal Estuary and Woods SSSI	0
	Lower Fal and Helford SSSI	13,062

Figure 4. Distribution of Biotopes throughout the Fal and Helford Marine Sites – Malpas Estuary SSSI and Upper Fal and Woods SSSI (Graticules represent 1km^2)

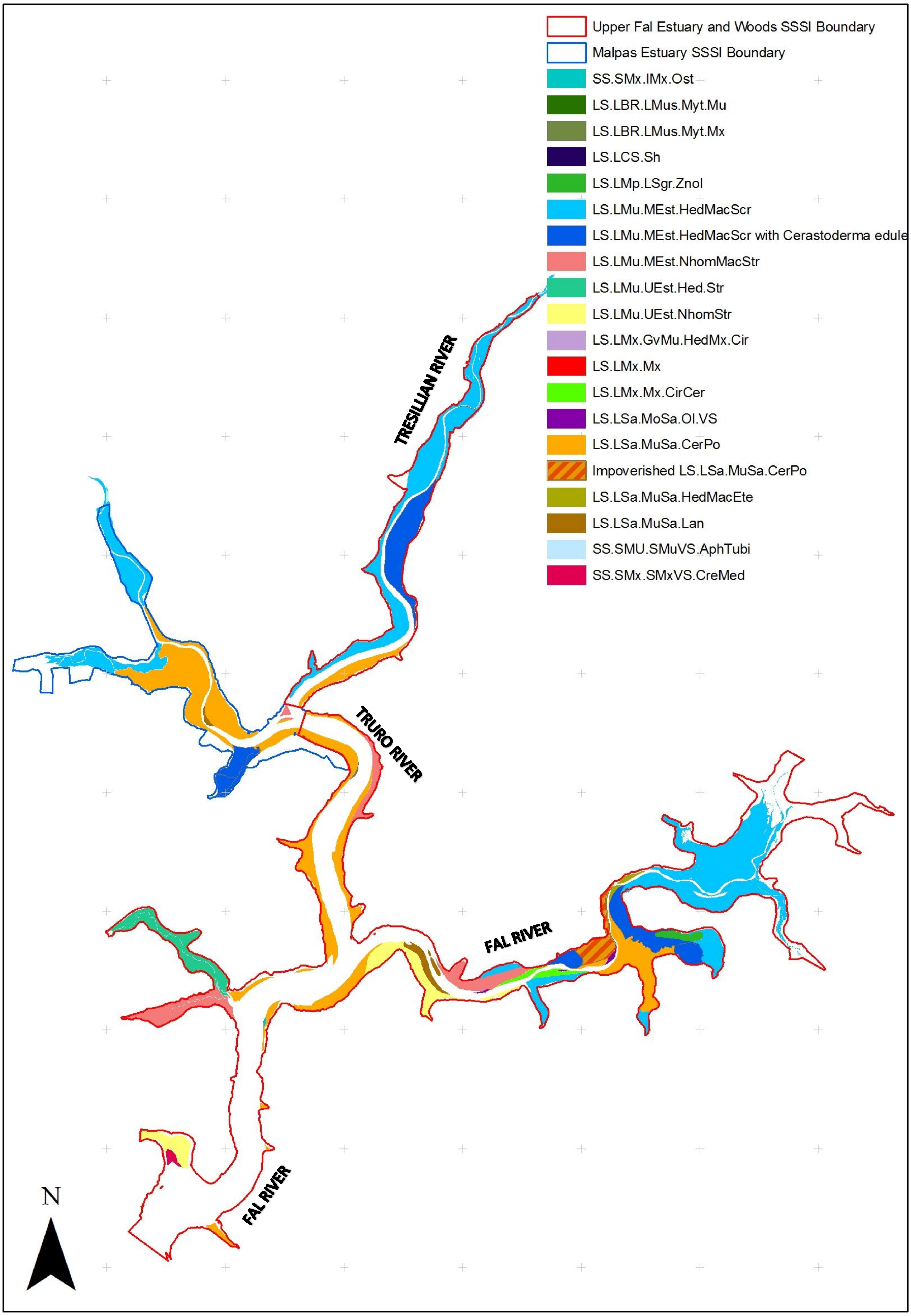
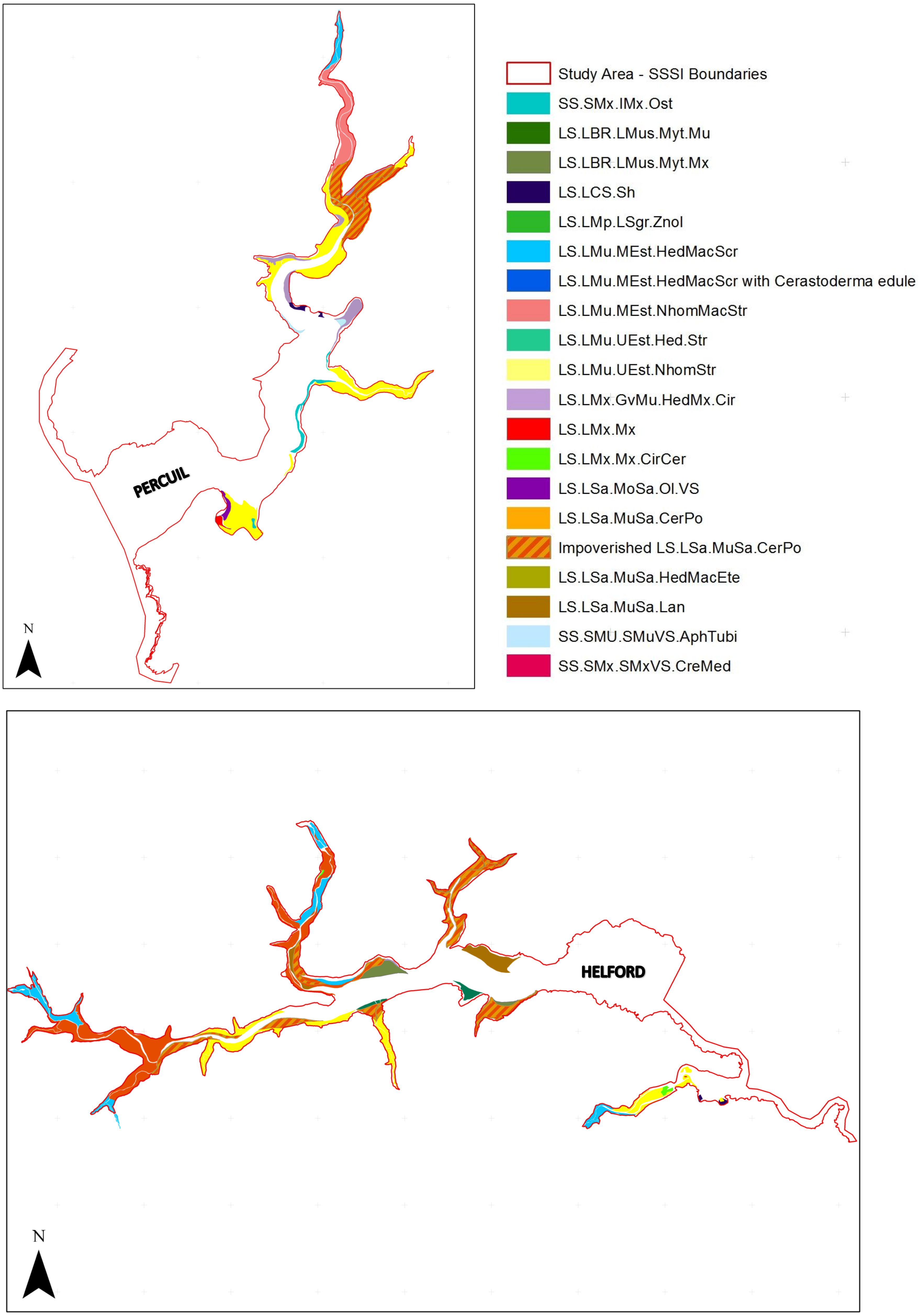


Figure 5. Distribution of Biotopes throughout the Fal and Helford Marine Sites – Lower Fal and Helford Intertidal SSSI (Graticules represent 1km ^{2})



3.3 Physical Characteristics

3.3.1 Particle Size Analysis

The particle size distributions (percentage distribution of sediments by weight) at each target station was summarised into 12 size bands following the Wentworth Scale.

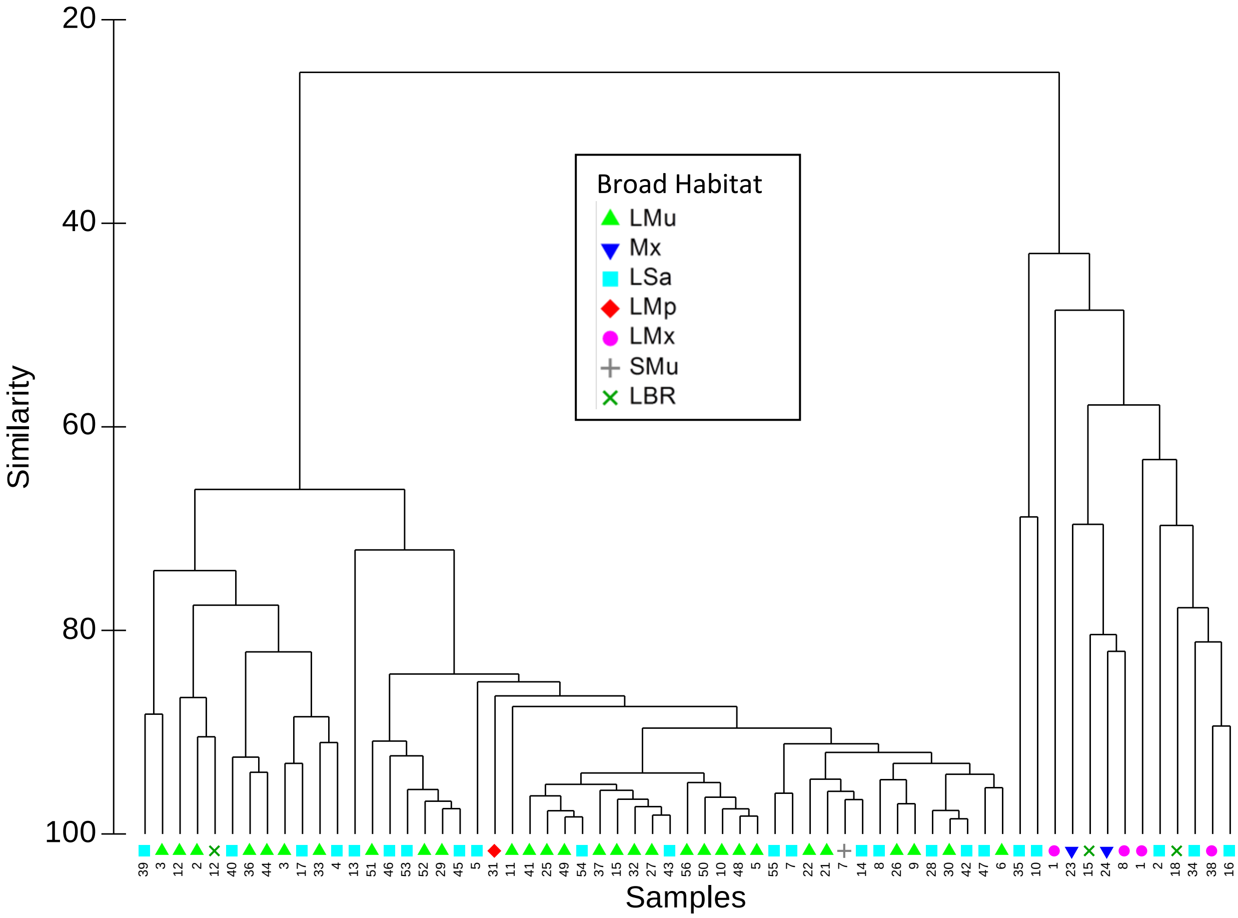
Table 3. Particle size analysis results (Wentworth Scale)

SSSI	Station	>4000 µm Pebbles	>2 <4 mm Granules	>1 <2 mm Very coarse sand	>0.5 <1 mm Coarse sand	>250 <500 µm Medium sand	>125 <250 µm Fine sand	>31 <63 µm Silt	>16 <31 µm Silt	>8 <16 µm Silt	>4 <8 µm Silt	<4 µm Clay
Upper Fal Estuary and Woods SSSI	21	0.00	0.00	0.00	0.00	0.00	1.62	29.08	21.98	14.55	9.21	11.16
	22	0.00	0.00	0.71	0.60	0.60	4.24	28.23	21.50	12.40	8.11	10.21
	23	30.04	17.00	9.51	5.31	0.96	3.26	7.38	7.91	6.64	3.75	3.70
	24	10.12	9.56	6.00	6.37	12.31	9.61	10.32	10.84	8.68	5.10	4.19
	25	0.00	0.00	0.00	0.00	0.02	1.09	23.94	25.76	19.44	11.94	11.53
	26	0.00	0.00	0.00	0.00	0.04	2.51	25.77	24.58	16.35	9.30	11.47
	27	0.00	0.00	0.00	0.00	0.00	1.21	22.76	23.34	19.36	12.00	11.77
	28	0.00	0.00	0.00	0.00	0.00	3.08	24.54	20.23	15.89	11.42	11.66
	29	0.00	0.00	0.00	0.00	0.01	0.75	19.50	24.21	21.59	14.85	14.11
	30	0.00	0.00	0.00	0.00	0.00	1.85	24.03	20.09	17.10	11.79	11.58
	31	0.00	0.00	10.55	1.11	0.00	0.97	20.75	20.39	16.56	11.05	10.73
	32	0.00	0.00	0.00	0.00	0.00	0.32	23.72	22.48	18.61	12.95	12.65
	33	0.00	0.00	0.00	0.00	0.16	9.42	21.35	16.20	13.77	9.54	9.21
	34	4.90	14.59	19.39	23.57	17.13	10.55	1.80	0.94	1.04	0.85	0.98
	35	0.00	1.57	7.70	30.43	43.32	13.25	0.73	0.49	0.56	0.49	0.57
	36	0.00	0.00	0.00	0.00	1.92	16.89	18.79	14.43	12.42	7.27	5.53
	37	0.00	0.00	0.00	0.00	0.00	1.47	23.48	22.80	18.73	11.56	9.27
	38	0.00	14.62	14.04	16.40	17.51	17.02	3.31	2.56	2.57	1.97	2.14
	39	0.00	0.00	0.00	0.00	6.53	26.50	13.81	10.39	8.64	5.66	6.48
	40	0.00	0.00	0.00	0.00	1.28	17.61	18.55	11.13	10.02	7.34	7.61
	41	0.00	0.00	0.00	0.00	0.00	1.17	22.33	24.79	19.93	11.95	9.47
	42	0.00	0.00	0.00	0.00	0.00	2.02	23.39	20.82	17.24	11.94	11.91
	43	0.00	0.00	0.00	0.00	0.00	2.15	22.84	22.34	18.53	12.06	12.05
	44	0.00	0.00	0.00	0.00	3.49	17.86	16.17	13.43	12.35	8.26	8.07
	45	0.00	0.00	0.00	0.00	0.00	0.00	18.71	23.27	21.90	15.70	15.39
	46	0.00	0.00	0.00	0.00	0.00	0.00	17.27	27.34	25.94	14.28	11.63
	47	0.00	0.00	0.00	0.00	0.00	2.99	25.06	21.59	16.55	9.49	8.94
	48	0.00	0.00	0.00	0.00	0.00	1.22	21.03	22.93	19.69	13.65	13.82
	49	0.00	0.00	0.00	0.00	0.02	1.23	23.02	25.41	20.18	12.52	11.09
	50	0.00	0.00	0.00	0.00	0.00	2.39	19.55	21.34	20.30	14.27	13.03
Malpas Estuary SSSI	51	0.00	0.00	0.00	0.00	0.03	1.14	13.99	24.24	23.95	17.42	17.40
	52	0.00	0.00	0.00	0.00	0.00	0.00	20.49	23.93	20.15	14.32	15.06
	53	0.00	0.00	1.02	0.00	0.00	0.00	18.49	25.97	22.02	14.83	14.81
	54	0.00	0.00	0.00	0.00	0.00	0.93	22.22	25.05	20.09	12.43	11.31
	55	0.00	0.00	2.71	0.00	1.50	5.11	23.00	19.58	15.30	10.46	10.24
	56	0.00	0.00	0.00	0.00	0.00	1.33	21.05	24.68	19.68	10.62	14.88

Lower Fal and Helford SSSI	10p	0.00	0.00	0.00	0.00	0.06	2.15	22.63	21.69	17.92	13.72	13.71
	12p	0.00	0.00	0.00	0.00	0.00	16.85	27.73	9.11	4.38	2.27	2.92
	15p	0.00	0.00	0.00	0.00	0.00	0.40	25.20	23.56	18.28	11.71	10.75
	1p	29.72	4.43	4.33	5.77	29.01	16.97	2.27	1.25	0.75	0.46	0.78
	2p	18.85	26.14	19.78	9.20	15.28	5.48	1.12	0.80	0.75	0.60	0.67
	3p	0.00	0.00	0.95	2.11	14.29	25.40	13.88	6.35	5.36	4.35	4.43
	5p	0.00	0.00	0.00	0.00	0.04	2.09	21.24	22.19	19.15	13.78	13.34
	7p	0.00	0.00	0.00	0.00	0.04	2.79	30.08	21.54	13.52	9.10	9.18
	8p	15.52	6.09	5.72	12.42	8.87	12.29	9.07	6.12	5.27	4.12	3.80
	1	58.55	14.76	12.11	8.62	2.09	0.82	0.46	0.62	0.65	0.49	0.56
	2	0.00	0.00	0.00	0.00	6.33	16.23	24.61	9.89	5.80	4.00	4.78
	3	0.00	0.00	0.00	0.00	0.31	5.86	29.91	19.14	10.58	6.19	9.40
	4	0.00	0.00	1.74	0.00	0.95	7.11	26.13	16.51	12.62	5.72	7.48
	5	0.00	0.00	0.00	0.00	0.00	0.30	31.87	27.75	16.47	7.23	5.35
	6	0.00	0.00	0.00	0.00	0.00	2.04	26.97	22.06	18.06	7.92	9.62
	7	0.00	0.00	2.88	0.00	0.52	4.54	25.55	19.58	13.68	9.89	9.98
	8	0.00	0.00	0.00	0.00	0.06	1.30	25.09	24.84	20.40	7.47	11.13
	9	0.00	0.00	0.00	0.00	0.00	1.91	26.78	23.08	15.95	10.63	11.04
	10	0.00	0.00	0.00	9.21	53.30	25.22	3.80	1.76	0.15	0.22	0.80
	11	0.00	0.00	0.00	0.00	0.16	3.65	20.47	17.81	16.07	14.12	17.67
	12	0.00	1.14	2.21	0.00	1.62	18.95	21.79	12.91	5.91	2.33	5.14
	13	0.00	2.41	3.96	10.63	3.15	7.74	17.90	15.70	11.52	8.07	8.28
	14	0.00	0.00	0.00	0.00	0.05	2.79	29.77	23.89	14.55	8.32	7.19
	15	11.99	7.77	9.15	6.42	0.63	9.31	13.96	8.66	6.54	4.74	5.14
	16	5.52	9.46	13.95	13.77	19.31	19.79	2.54	1.91	2.75	1.33	1.46
	17	0.00	0.00	0.00	3.51	0.47	4.87	28.66	20.26	12.06	6.32	4.69
	18	24.71	9.86	12.58	13.96	16.04	10.66	2.29	1.48	1.63	0.87	1.18

It is well documented that the particle size distribution of the sediment has an effect on the community structure of benthic communities[31]. Figure 6 overleaf illustrates how 13 stations have a different particle size fraction (larger) which generally separates the mixed sediment biotopes (Mx, LBR and LMX) from the muddy sediment biotopes (LMu, SMu and LMp) quite well; littoral sand biotopes however are found interspersed with both groups.

Figure 6. Sediment granulometry Bray-Curtis Plot



3.3.2 Sediment Carbon Content

Using loss on Ignition techniques, the carbon content of sediment samples was determined.

Table 4. Sediment organic carbon content (%)

10	Station	Organic Content %
Upper Fal Estuary and Woods SSSI	21	6
	22	4.54
	23	4.02
	24	3.49
	25	7.82
	26	6.79
	27	6.22
	28	7.15
	29	0.63
	30	6.71
	31	4.4
	32	2.8
	33	3.29
	34	4.03
	35	0.63
	36	2.37
	37	7.3
	38	1.55
	39	3.13
	40	2.7
	41	6.71
	42	5.58
	43	6.4
	44	8.3
	45	7.47
	46	7.22
	47	8.36
	48	7.06
	49	6.79
	50	4.23

SSSI	Station	Organic Content %
Malpas Estuary SSSI	51	6.98
	52	6.75
	53	5.67
	54	6.87
	55	6.61
	56	7.25

SSSI	Station	Organic Content %
Lower Fal and Helford SSSI	1p	1.62
	2p	1.5
	3p	2.03
	5p	6.05
	7p	7.35
	8p	3.45
	10p	5.24
	12p	6.18
	15p	7.41
	1	1.49
	2	5.59
	3	7.44
	4	5.78
	5	6.64
	6	8.72
	7	8.81
	8	7.49
	9	8.33
	10	1.47
	11	8.9
	12	5.12
	13	5.82
	14	8.57
	15	3.19
	16	1.49
	17	7.12
	18	0.87

The sediment organic carbon content is relatively low within the Fal and Helford Marine Sites when compared to other similar studies in estuaries in the Southwest[28, 29]. The highest levels appear to be present at the head of creeks and tributaries, whilst the lowest levels are within or adjacent to main channels where there is greater exposure to tidal currents and scouring.

Previous studies have found that the organic carbon content of sediment samples from estuaries is largely dependent on the proportion of fine sediment within the sample[27]. As may therefore be expected, the lowest organic carbon levels were found in those sediments with the least silt and clay content. However low levels of organic carbon were also found within the Fal tributary of the Upper Fal and Helford SSSI, and given the observations in the field it is suspected that this element of sediment character may have been influenced by the historical presence of the china clay industry in the catchment, though this cannot be substantiated given the absence of baseline data.

3.3.3 Sediment Redox Profile

The depth of the Redox potential discontinuity (RPD) layer, a recognisable division zone between oxidized (sub-oxic) and reduced chemical conditions, was determined by visual assessment of depth of sediment colour change.

Table 5. Sediment redox depth data

SSSI	Station	Redox discontinuity depth range (cm)
Upper Fal Estuary and Woods SSSI	21	<1
	22	<1
	23	<1
	24	<1
	25	1 to 5
	26	1 to 5
	27	<1
	28	<1
	29	<1
	30	1 to 5
	31	<1
	32	<1
	33	<1
	34	5 to 20
	35	>20
	36	1 to 5
	37	<1
	38	1 to 5
	39	1 to 5
	40	1 to 5
	41	<1
	42	<1
	43	<1
	44	<1
	45	<1
	46	1 to 5
	47	<1
	48	<1
	49	1 to 5
	50	1 to 5

SSSI	Station	Redox discontinuity depth range (cm)
Malpas Estuary SSSI	51	<1
	52	<1
	53	<1
	54	<1
	55	1 to 5
	56	1 to 5

SSSI	Station	Redox discontinuity depth range (cm)
Lower Fal and Helford SSSI	1p	<1
	2p	>20
	3p	5 to 20
	5p	1 to 5
	7p	1 to 5
	8p	1 to 5
	10p	1 to 5
	12p	1 to 5
	15p	1 to 5
	1	>20
	2	1 to 5
	3	1 to 5
	4	1 to 5
	5	1 to 5
	6	<1
	7	<1
	8	<1
	9	<1
	10	<1
	11	1 to 5
	12	1 to 5
	13	1 to 5
	14	<1
	15	1 to 5
	16	>20
	17	<1
	18	1 to 5

Anoxic conditions are observed within 5cm of the sediment surface in muddy sand biotopes throughout the Fal and Helford Marine Sites. Anoxic conditions appeared to be marginally less (redox discontinuity layer was between 1 to 5 cm deep rather than <1cm) in the upper reaches of tributaries and creeks, and significantly less at a few stations where mixed sediments were present or where sediments were mobile. Given the observation of algal mats and/or evidence of summer opportunistic algae throughout the study area, it is considered likely that these are the principal cause of the anoxic conditions. Principally *Ulvae, Enteromorpha* and some *Chaetomorpha algal* species were observed. The difference in the redox conditions of the low-mid and upper estuarine stations is however probably as a result of a number of confounding variables. The different numbers and types of infaunal species found in the upper estuary for example may display different behavioural characteristics (e.g. burrows, tubes and feeding voids) which introduce oxygen into the sediments. The finer sediments of the upper reaches are also exposed to regular intratidal resuspension and transport during high tides with little time available for consolidation following deposition during slack-water periods as in the lower estuary[19].

3.4 Biotopes Identified within the Fal and Helford Marine Sites

Those species referred to as characteristic within this chapter are characteristic as defined by The Marine Habitat Classification for Britain and Ireland (Vs 04.05)[10].

Those figures in italic within the tables of species composition represent numbers of species which were not specifically named within the Marine Habitat Classification for Britain and Ireland (Vs 04.05), but which are likely to occupy the ecological niche of taxa specifically listed i.e. *Cerastoderma edule* is listed as a characteristic species but only juvenile Cardiacea which are expected to have developed into adult *Cerastoderma edule* were identified.

3.4.1 LS.LMu.UEst.NhomStr

The biotope LS.LMu.UEst.NhomStr (*Nephtys hombergii* and *Streblospio shrubsolii* in littoral mud) is common in the mid estuary and branches and creeks of the Lower Fal and Helford Intertidal SSSI (Helford and Percuil). In the Upper Fal and Woods SSSI this biotope is less widespread and only occurs in two areas in the mid and lower estuary. The biotope is absent from the Malpas SSSI.

Figure 7. Extent and distribution of LS.LMu.UEst.NhomStr in the Helford - Lower Fal and Helford Intertidal SSSI (Graticules represent 1km^2)

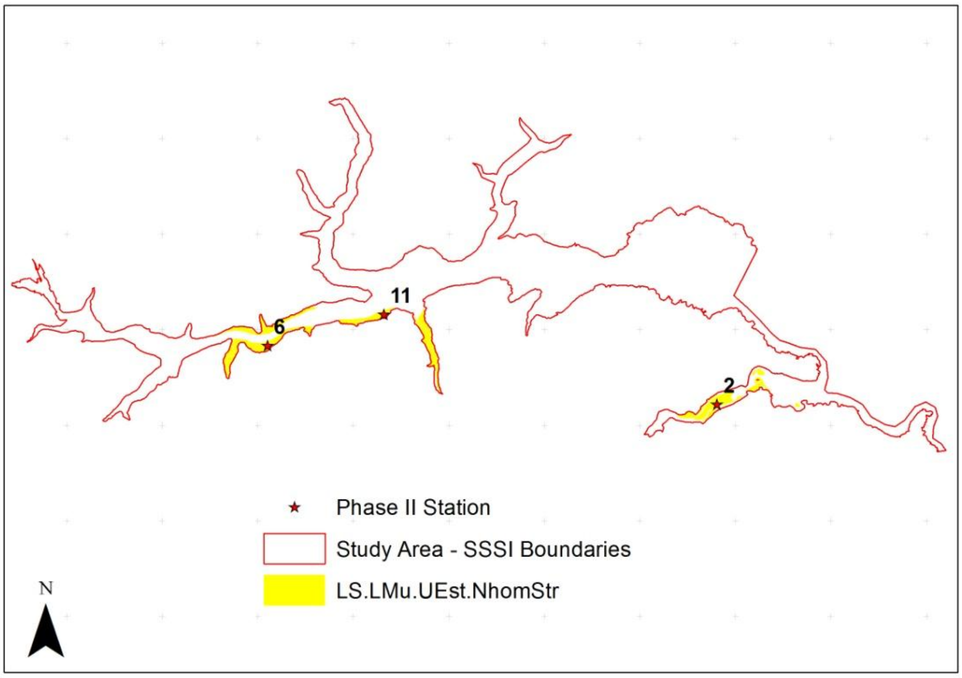


Figure 8. Extent and distribution of LS.LMu.UEst.NhomStr in the Percuil - Lower Fal and Helford Intertidal SSSI (Graticules represent 1km^2)

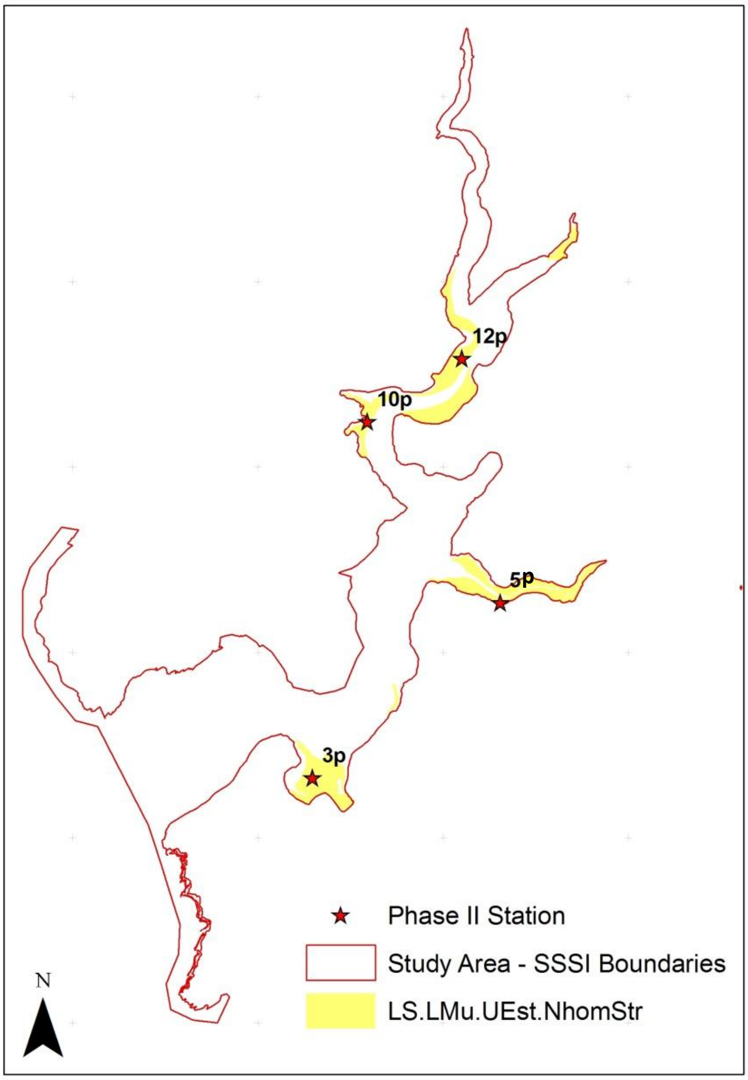
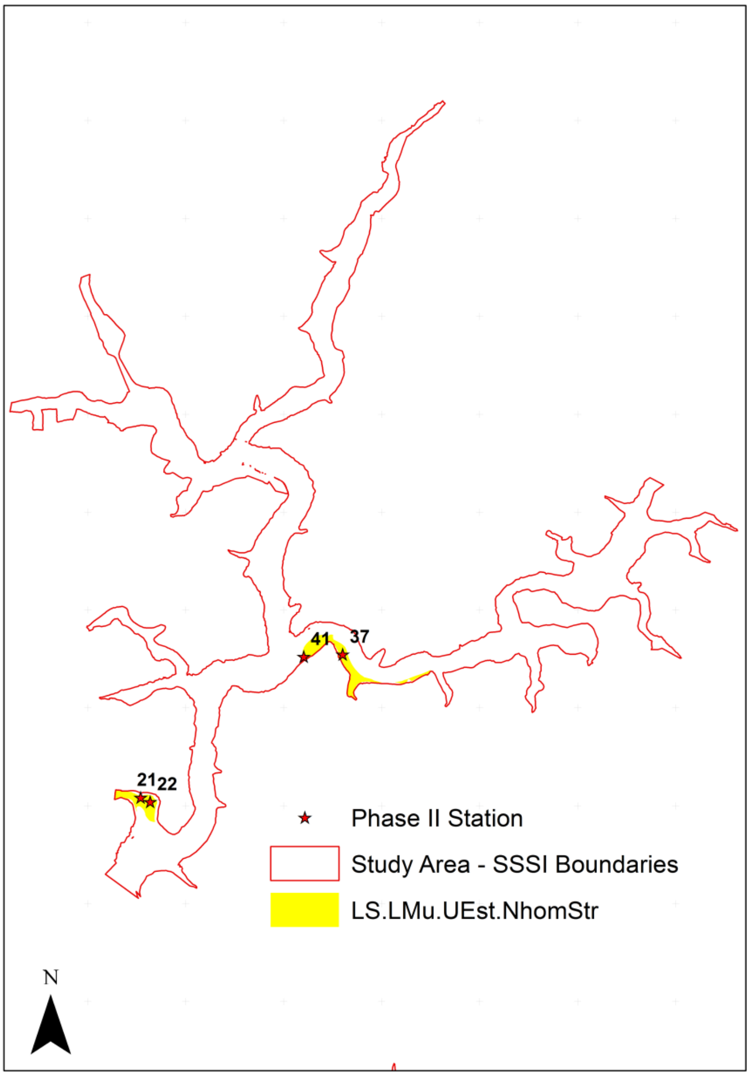


Figure 9. Extent and distribution of LS.LMu.UEst.NhomStr in the Upper Fal and Woods SSSI (Graticules represent 1km^2)



The sediments within the cores taken are described mainly as fine or very fine sand mixed with silt and clay, with the exception being the sediment samples taken at station 3 within the Percuil Estuary and at station 22 at the lowest extent of the Upper Fal and woods SSSI; both of which have a coarse sand element. The carbon content within sediment samples were generally in the moderate range (5.24 to 8.72 %) but again with the exception of stations 3p and 22 which were 2.03 % to 4.54 % respectively. The anoxic layer is present within the first 5cm at all but station 3 where the anoxic layer occurs between 5 and 20 cm of the surface.

The average similarity between stations is 39%. Those species which provide the highest % contribution to similarity are listed in Table 6 below where it can be seen that the most frequently occurring species within replicate cores is the polychaete species *Nephtys hombergii*. Where present however, the most abundant infaunal species is the oligochaete *Tubificoides benedii*, followed by the polychaete *Nephtys hombergii*.

Table 6. Species % contribution in Fal and Helford Marine Sites LS.LMu.UEst.NhomStr biotope

Species	Average Abundance Per Core	Average Similarity	% Contribution
Tubificoides benedii	75.24	9.25	23.70
Hydrobia ulvae	34.70	7.55	19.34
Nephtys sp juv	20.01	7.06	18.09
Streblospio shrubsolii	27.30	6.57	16.83
Cardiacea juv	13.08	3.05	7.81
Tubificoides pseudogaster agg	16.88	1.39	3.56
Melinna palmata	9.31	1.39	3.55
Pygospio elegans	8.41	0.74	1.89
Tubificoides swirencoides	10.11	0.57	1.45
Tharyx 'A'	7.70	0.54	1.39
Cossura sp	4.06	0.23	0.59
Capitella capitata agg	3.10	0.22	0.57
Tellinacea juv	3.10	0.17	0.44

Species diversity, evenness and richness vary throughout the biotope and appear to be loosely correlated with the catchment. The most impoverished communities were observed at stations within the Helford estuary, whilst the most diverse, rich and even communities occur within the Percuil estuary. Stations 37 and 41 situated at the lowest extent of the Upper Fal and Helford SSSI were particularly dominated by the Oligochaete *Tubificoides benedii*.

Table 7. Fal and Helford Marine Sites LS.LMu.UEst.NhomStr biotope community analysis

Station	No. Taxa Per Core S	No. Individuals Per Core N	Margalef's Species Richness d	Pielou's Evenness J'	Shannon Wiener Index H'(log10)	Simpson Diversity Index 1-Lambada'
3p	12	10300	1.19	0.727	1.806	0.7653
5p	14	9000	1.428	0.7866	2.076	0.8305
6	8	33900	0.6711	0.4275	0.8889	0.4053
10p	10	3300	1.111	0.8413	1.937	0.8193
11	7	6700	0.6811	0.3706	0.7211	0.2959
12p	6	18900	0.5078	0.3845	0.689	0.3017
21	9	3600	0.977	0.7447	1.636	0.7178
22	6	1500	0.6837	0.883	1.582	0.765
37	9	62200	0.7248	8.458E-2	0.1858	5.69E-2
41	13	53200	1.103	0.5282	1.355	0.6301
2	6	3100	0.622	0.8409	1.507	0.7453

The characteristics at most stations correspond reasonably well with the LS.LMu.UEst.NhomStr biotope described within The Marine Habitat Classification for Britain and Ireland (Vs 04.05), although there is some deviation from the sediment as described above, and the wave exposure component. Station 21 and 22 may be considered to be more exposed than usual for the biotope. The greatest deviation in characteristics is seen in the faunal component at stations. For example the cirratulid polychaete *Aphelochaeta marioni* is absent. The closely related cirratulid *Tharyx 'A'* is present at less than half of the stations, which may imply some type of ecological niche substitution by the *Tharyx 'A'* species at those locations.

Nephtys hombergii also appears to be absent from many of the stations, however Nephtys sp juveniles which are likely to be *Nephtys hombergii* are present at all stations.

Where characterising species are present their abundance is variable and scales from exceeding that outlined in the biotope description by an order of magnitude at some stations, to lacking by an order of magnitude at others. A number of non-characterising faunal species are also present; the most frequently occurring is juvenile *Cardiacea* bivalves (*Cardioidea* superfamily) which are likely to be juvenile *Cerastoderma edule*.

Table 8. Fal and Helford Marine Sites LS.LMu.UEst.NhomStr replicate core species composition

Species	3p No. m²	5p No. m²	6 No. m²	10p No. m²	11 No. m²	12p No. m²	21 No. m²	22 No. m²	37 No. m²	41 No. m²	2 No. m²	Biotope Characterising Species Abundance
Nephtys hombergii							100		300	100		108
Streblospio shrubsolii	2000	2700	1000	400		600	200	100	300	2800	1100	483
Tharyx 'A'	1400	400		100					300			*2790*
Tubificoides benedii	400	1400	25700	200		15700	700		60400	28300	900	1259
Capitella capitata agg	100	100					200					
Capitellidae sp juv				100								
Cardiacea juv	100	300	800	100	100		400	100	100	800		
Caridea sp juv		200										
Cossura sp		300			300					100		
Crangon crangon					100							
Cyathura carinata				100								
Enchytraeidae	700									100		
Eteone longa agg			100						100			
Hydrobia ulvae		900	4400	1000	300	900	1700	500		15100	400	
Limapontia sp					100							
Manayunkia aestuarina										1300		
Mediomastus fragilis	100											
Melinna palmata	700	100		600				300	100	200		
Melita palmata		100										
Nematoda									100			
Nemertea												
Nephtys sp juv	200	600	500	600	200	200	100	400	500	1000	500	
Pholoe synophthalmica	100	100										
Pygospio elegans		100	1300				100			700	100	
Spio decorata	300											
Tellinacea juv			100					100		200		
Tubificoides pseudogaster agg	4200			100	5600	1300						
Tubificoides swirencoides		1700					100			2500	100	
Bivalvia unident juv						200						

The variations observed are most likely to be attributable to the high degree of local and regional environmental variability found in estuarine environments (i.e. salinity, wave exposure, carbon matter, nutrient input and pollution). However, the differences observed in the fauna at station 11 probably represent a transition to the adjacent biotopes at that location.

3.4.2 Impoverished LS.LSa.MuSa.CerPo

A form of the LS.LSa.MuSa.CerPo biotope (Cerastoderma edule and polychaetes in littoral muddy sand) which appears to be impoverished in terms of the abundance of the characterising bivalve species *Cerastoderma edule* is common throughout the Helford Estuary, tending to occur lower in the estuary than the LS.LSa.MuSa.CerPo biotope. The biotope dominates Rollingey Creek in the upper Percuil estuary, but is limited within the Upper Fal and Woods SSSI to a section of the Northern bank of the River Fal where leaf litter was observed to be blanketing the surface sediments. The biotope is absent from the Malpas SSSI.

Figure 10. Extent and distribution of Impoverished LS.LSa.MuSa.CerPo in the Helford - Lower Fal and Helford Intertidal SSSI (Graticules represent 1km^2)

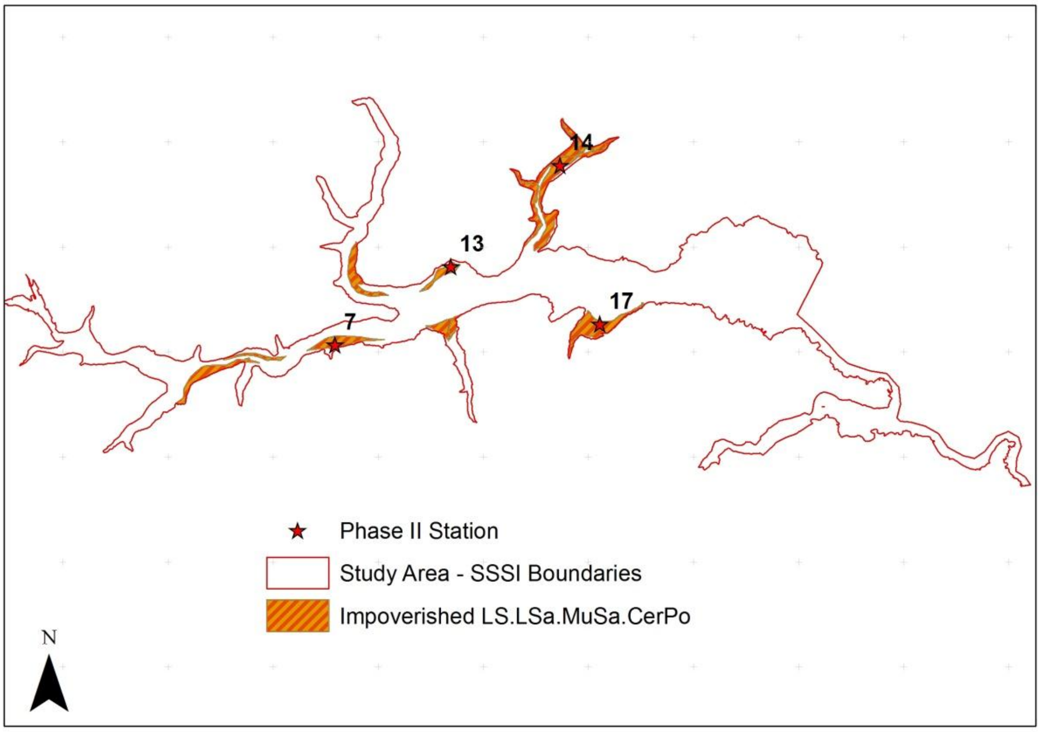


Figure 11. Extent and distribution of Impoverished LS.LSa.MuSa.CerPo in the Percuil - Lower Fal and Helford Intertidal SSSI (Graticules represent 1km^2)

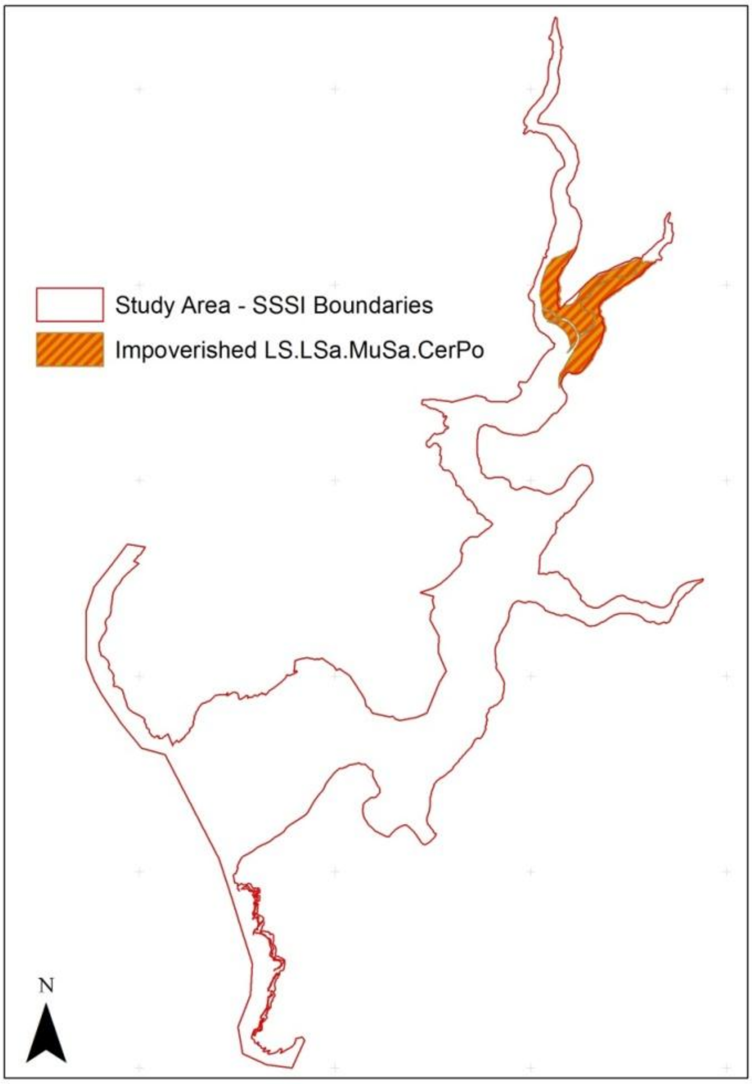
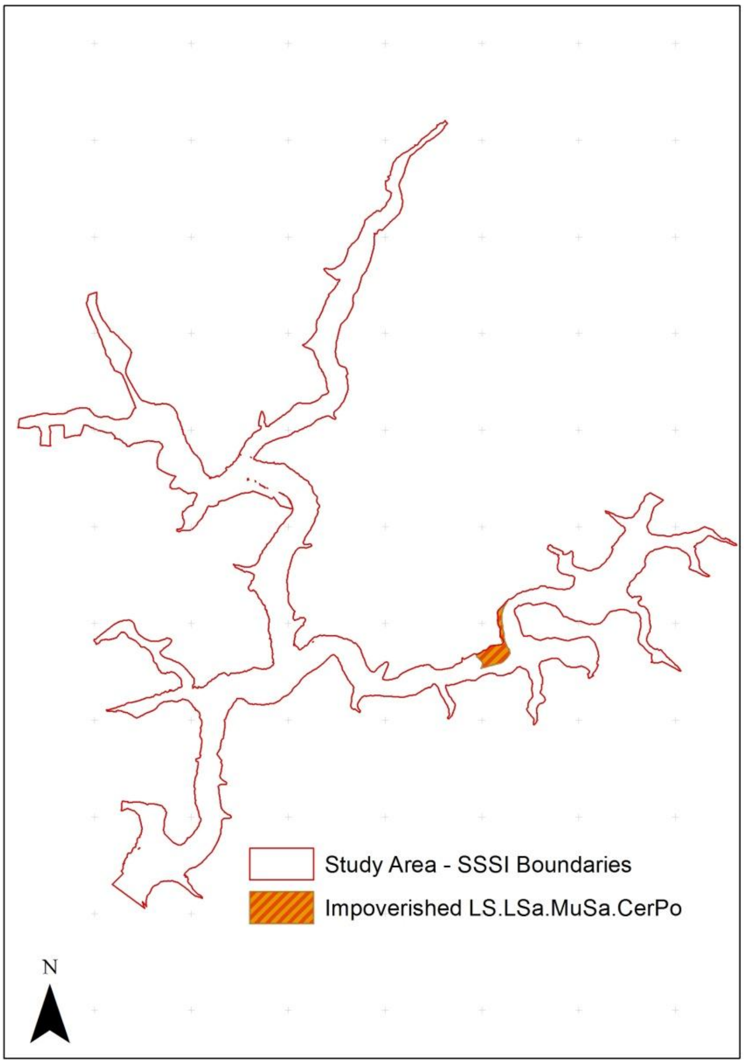


Figure 12. Extent and distribution of Impoverished LS.LSa.MuSa.CerPo in the Upper Fal and Woods SSSI (Graticules represent 1km^2)



The sediment at stations where this biotope is present tends to have larger particle size properties than the LS.LSa.MuSa.CerPo biotope with the largest fractions at station 13 in particular categorised as granules. The carbon content within sediments range from 5.82% to 8.81% with the greatest proportions of carbon generally found higher up the catchments. The redox discontinuity layer was found to be within the first 1cm of the sediment surface at 3 of the 4 stations and within the first 5cm at the remaining station.

Excluding *Cerastoderma edule*, *the* most abundant and frequently occurring species are the Oligochaetes *Tubificoides benedii* and *Tubificoides pseudogaster agg.,* though these species are not characterising for the biotope within the Marine Habitat Classification for Britain and Ireland (Vs 04.05) description. Between 8 and 16 taxa were encountered at the 4 stations; species richness, evenness and diversity is comparable at 3 of the stations, but diversity peaks at station 13 on the northern bank of the Helford.

The average similarity between stations is 44%. Those species which provide the highest % contribution to similarity are listed in Table 9 below. Note that *Cerastoderma edule* is also likely to contribute significantly to the assignment of the biotope, but due to the core size and relatively low number of replicates, the species was not captured in cores. Juvenile *Cardiacea* were however frequently captured and are more than likely to be juvenile *Cerastoderma edule* given that this is the only adult *Cardiacea* species which has been observed in the study areas during this project.

Table 9. Species % contribution in Fal and Helford Marine Sites impoverished LS.LSa.MuSa.CerPo biotope

Species	Average Abundance Per Core	Average Similarity	% Contribution
Tubificoides benedii	95.60	13.30	30.31
Tubificoides pseudogaster agg	67.44	13.11	29.88
Nephtys sp juv	19.25	5.62	12.81
Tharyx 'A'	19.01	2.47	5.63
Pygospio elegans	17.44	2.24	5.11
Eteone longa agg	9.57	1.72	3.92
Cardiacea juv	9.57	1.53	3.49
Streblospio shrubsolii	12.91	1.52	3.45
Mediomastus fragilis	8.09	0.70	1.60
Hydrobia ulvae	8.09	0.43	0.99
Melinna palmata	5.00	0.43	0.99
Capitella capitata agg	5.00	0.40	0.91

Table 10. Impoverished LS.LSa.MuSa.CerPo biotope community analysis

Station	No. Taxa Per Core S	No. Individuals Per Core N	Margalef's Species Richness d	Pielou's Evenness J’	Shannon Wiener Index H’(log10)	Simpson Diversity Index 1-Lambada’
7	16	40500	1.414	0.3456	0.9582	0.3679
13	8	5700	0.8094	0.7994	1.662	0.7579
14	13	26500	1.178	0.3302	0.847	0.3862
17	12	18200	1.121	0.313	0.7777	0.3191

Table 11. Fal and Helford Marine Sites LS.LSa.MuSa.CerPo replicate core species composition

Species	7 No. m²	13 No. m²	14 No. m²	17 No. m²	Biotope Characterising Species Abundance
Amphipoda unident juv	100				*46*
Capitella capitata agg	100		100		160
Cardiacea juv	200		200	100	*715*
Eteone longa agg	200	200	100		67
Hydrobia ulvae	500			100	25
Pygospio elegans	500	1400		100	832
Anaitides mucosa			100		
Cirratulidae unident			100		
Cossura sp				1800	
Exogone hebes	100				
Gammaridae sp juv			100		
Heterochaeta costata	200				
Manayunkia aestuarina	100		100		
Mediomastus fragilis		500		100	
Melinna palmata	100			100	
Nematoda	500				
Nephtys sp juv	500	300	400	300	
Nephtys hombergii				100	
Paranais litoralis			200		
Streblospio shrubsolii	1000	100	100		
Tellinacea juv				100	
Tharyx 'A'	1500		400	300	
Tubificoides benedii	32000	2200	20300	200	
Tubificoides pseudogaster agg	2900	800	4300	14900	
Bivalvia unident juv		200			

The cores correspond reasonably well with the LS.LSa.MuSa.CerPo biotope observed within the study area and the Marine Habitat Classification for Britain and Ireland (Vs 04.05); however, the stations assigned 'impoverished' in this study have been because of the low abundance of the key characterising species *Cerastoderma edule* both in cores and during observations in the field.

Apart from the low of abundance of *Cerastoderma edule*, as with the LS.LSa.MuSa.CerPo biotope the most notable difference between the cores and the faunal communities described as characteristic for the biotope, is that at all stations, only 6 of the total 11 characterising species were present. Similarly a number of additional non-characterising species are present, and these contribute significantly to the species diversity and overall abundance at stations.

3.4.3 LS.LSa.MuSa.CerPo

The biotope LS.LSa.MuSa.CerPo (*Cerastoderma edule* and polychaetes in littoral muddy sand) is common within the mid reaches of the Truro and Fal Rivers within the Upper Fal and Woods SSSI, and dominant within the Malpas SSSI. Within the Lower Fal and Helford Intertidal SSSI the biotope is present within the upper reaches of the Helford, but is absent from the Percuil estuary.

Figure 13. Extent and distribution of LS.LSa.MuSa.CerPo within the Helford – Lower Fal and Helford Intertidal SSSI (Graticules represent 1km^2)

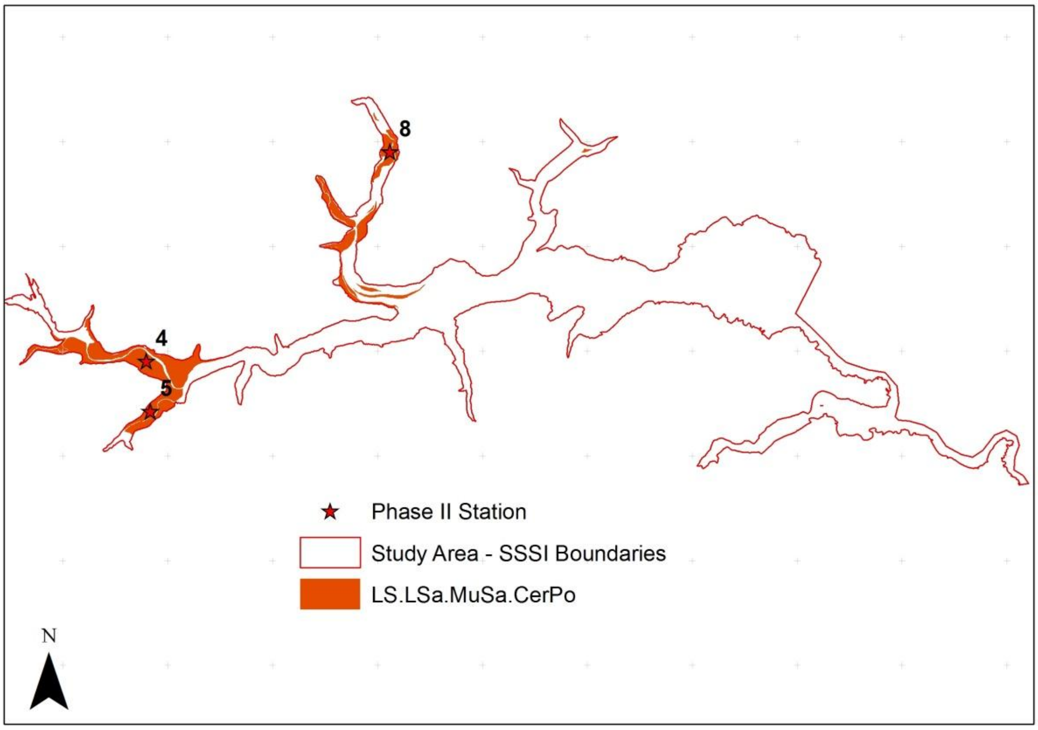
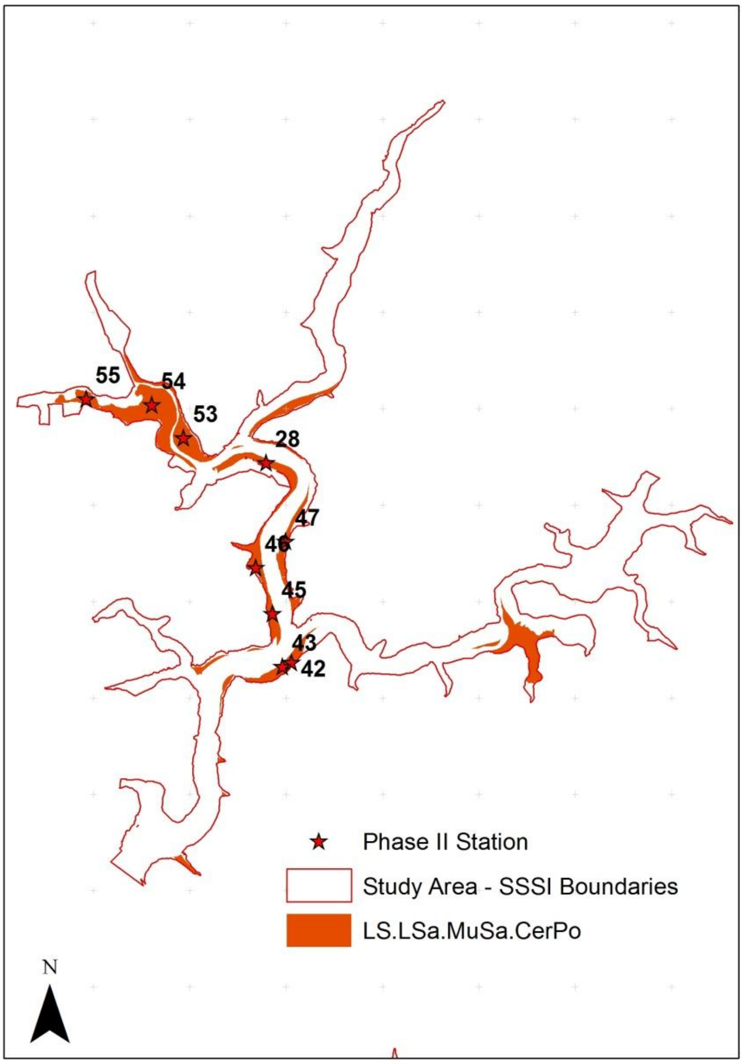


Figure 14. Extent and distribution of LS.LSa.MuSa.CerPo within the Malpas Estuary and Fal and Upper Woods SSSI (Graticules represent 1km^2)



The sediment at stations within this biotope is generally fine sand and very fine sand, mud and clay. Two stations within the Malpas SSSI however have an additional very coarse sand fraction. The carbon content within sediments range from 5.58% to 8.36% with the greatest proportions of carbon generally found higher up the catchments. The redox discontinuity layer was found to be within the first 1cm at 8 of the 12 stations and within the first 5cm at the remainder.

Excluding *Cerastoderma edule*, *the* most abundant and frequently occurring species are the Oligochaetes *Tubificoides benedii* and *Tubificoides pseudogaster agg.*, followed by the spionid polychaetes *Streblospio shrubsolii* and *Pygospio elegans* and the gastropod *Hydrobia ulvae*. Between 8 and 16 taxa were encountered at all 12 stations; species richness, evenness and diversity is comparable throughout the biotope, whilst overall abundance is an order of magnitude lower on the east bank of the Fal.

The average similarity between stations is 53%. Those species which provide the highest % contribution to similarity are listed in Table 12 below.

Table 12. Species % contribution in Fal and Helford Marine Sites LS.LSa.MuSa.CerPo biotope

Species	Average Abundance Per Core	Average Similarity	% Contribution
Tubificoides benedii	95.60	13.30	30.31
Tubificoides pseudogaster agg	67.44	13.11	29.88
Nephtys sp juv	19.25	5.62	12.81
Tharyx 'A'	19.01	2.47	5.63
Pygospio elegans	17.44	2.24	5.11
Eteone longa agg	9.57	1.72	3.92
Cardiacea juv	9.57	1.53	3.49
Streblospio shrubsolii	12.91	1.52	3.45
Mediomastus fragilis	8.09	0.70	1.60
Hydrobia ulvae	8.09	0.43	0.99
Melinna palmata	5.00	0.43	0.99
Capitella capitata agg	5.00	0.40	0.91

Table 13. Fal and Helford Marine Sites LS.LSa.MuSa.CerPo biotope community analysis

Station	No. Taxa Per Core S	No. Individuals Per Core N	Margalef's Species Richness d	Pielou's Evenness J'	Shannon Wiener Index H'(log10)	Simpson Diversity Index 1-Lambada'
4	14	19800	1.314	0.3979	1.05	0.3896
5	12	32700	1.058	0.4088	1.016	0.5454
8	12	46600	1.023	0.5431	1.349	0.6466
28	14	26000	1.279	0.6139	1.62	0.7345
42	16	24000	1.487	0.4785	1.327	0.6241
43	8	7000	0.7906	0.7089	1.474	0.6809
45	9	15400	0.8297	0.609	1.338	0.6427
46	8	18500	0.7124	0.5051	1.05	0.521
47	8	4000	0.844	0.6025	1.253	0.5514
53	10	10400	0.973	0.6795	1.565	0.702
54	11	27900	0.9769	0.4648	1.115	0.5156
55	16	22400	1.497	0.621	1.722	0.6994

Species diversity, evenness and richness are comparable throughout the biotope, with the exception of communities at station 4 in the upper Helford which display lower diversity and evenness.

Table 14. Fal and Helford Marine Sites LS.LSa.MuSa.CerPo replicates core species composition

Species	4	5	8	28	42	43	45	46	47	53	54	55	Biotope Characterising
	No. m^2	No. m^2	No. m^2	No. m^2	No. m^2	No. m^2	No. m^2	No. m^2	No. m^2	No. m^2	No. m^2	No. m^2	Species Abundance
Capitella capitata agg					100				100	100	100		160
Capitellidae sp juv	100												*160*
Cerastoderma edule		200			100	100				200		100	715
Eteone longa agg	200		200	100	100							200	67
Hydrobia ulvae	700	18600	21200	6800	9100	3600	7800	3900		1200	4200	11400	25
Macoma balthica										100			574
Pygospio elegans	700	600	900	800	500		200	100	100	300	300	700	832
Amphipoda unident juv	100												
Anaitides mucosa												100	
Aphelochaeta marioni	100								100				
Carcinus maenas		100											
Cardiacea juv		600	1700	400	300	800	700				400	200	
Cirratulidae unident				500									
Cossura sp				100					300				
Enchytraeidae					100								
Hediste diversicolor					100				200			200	
Heterochaeta costata	300											0	
Heteromastus filiformis											300	1400	
Manayunkia aestuarina				100								100	
Mediomastus fragilis		100					100						
Melinna palmata			300			100	100	100		100			
Nematoda	300										100	200	
Nephtys sp juv	300	100	600	100		400	300		100				
Nephtys hombergii	300			200	400			500		400	100		
Nereidae sp juv			200		200			300					
Paranais litoralis			100										
Scrobicularia plana		300			200						100	400	
Streblospio shrubsolii	100	100	1100	5400	200	100	600	1400	500	2200	3000	1200	
Tellinacea juv		100	300		100			100				100	
Tharyx 'A'	500	100		900	900					800	600	3500	
Tubificoides benedii	15400	11800	17500	10100	11500	800	4700	12100	2600	5000	18700	2000	
Tubificoides pseudogaster agg	700		2500	200		1100						600	
Tubificoides swirencoides							900						
Bivalvia unident juv				300									
Mya arenaria					100								

The cores correspond reasonably well with the LS.LSa.MuSa.CerPo biotope described within The Marine Habitat Classification for Britain and Ireland (Vs 04.05), although there is some minor deviation from the sediment character where 3 of the 12 samples had a very coarse sand element.

The most notable difference between the cores and the faunal communities described as characteristic for the biotope, is that at all stations, only 6 of the total 11 characterising species were present. *Crangon crangon*, *Macoma balthica* and *Cerastoderma edule* were not expected to be consistently captured in cores due to the method of sampling and/or core size rather than the absence of the species. Where *Cerastoderma edule* were not present in cores, the species was observed in the field and therefore determined present for the purposes of assigning a biotope to the target station.

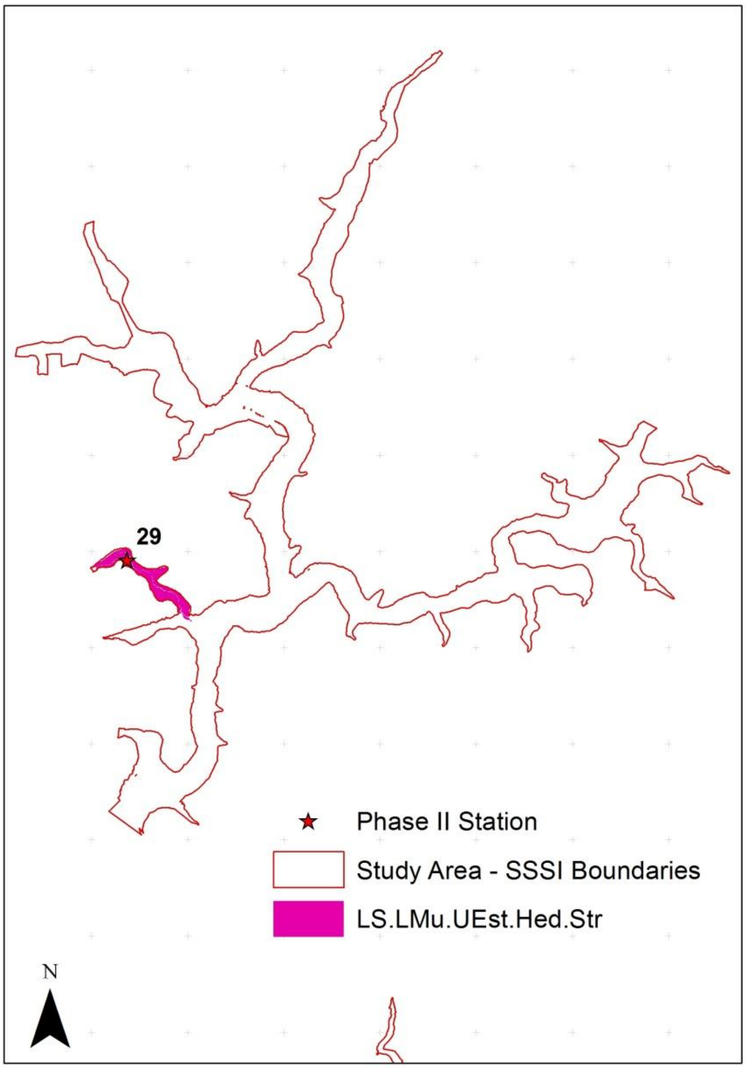
Where characterising species are present however, their abundance is generally lower than that outlined in the biotope description (with the exception of *Hydrobia ulvae*).

A number of non-characterising species are also present, and these contribute greatly to the species diversity and overall abundance at stations. *Tubificoides benedii* and *Streblospio shrubsolii* for example are present in abundance at every station.

3.4.4 LS.LMu.UEst.Hed.Str

The biotope LS.LMu.UEst.Hed.Str (*Hediste diversicolor* and *Streblospio shrubsolii* in littoral sandy mud) was restricted to Cowlands Creek at the lower end of the Upper Fal and Woods SSSI. The biotope was absent from the remainder of the study areas.

Figure 15. Distribution and extent of LS.LMu.UEst.Hed.Str biotope within the Fal and Upper Woods SSSI



The sediment within the biotope is sandy mud (medium to very fine sand with silt and clay), with a carbon content of 6.61%. The redox discontinuity level occurs within the first 1cm of the sediment surface.

Given the limited extent of this biotope only one target station was assigned. A total of 12 species were present within the core; by far the most abundant species was the oligochaete *Tubificoides benedii*.

Table 15. Fal and Helford Marine Sites LS.LMu.UEst.Hed.Str replicate core species composition

Species	29 No. m²	Biotope Characterising Species Abundance
Hediste diversicolor	300	2020
Manayunkia aestuarina	600	4526
Streblospio shrubsolii	2000	3033
Tubificoides benedii	28600	4557
Tubificoides pseudogaster agg	200	6592
Hydrobia ulvae	19100	
Nemertea	100	
Nephtys sp juv	100	
Nephtys hombergii	100	
Nereidae sp juv	200	
Pygospio elegans	600	
Tharyx 'A'	300	

Table 16. Fal and Helford Marine Sites LS.LMu.UEst.Hed.Str biotope community analysis

Station	No. Taxa Per Core S	No. Individuals Per Core N	Margalef's Species Richness d	Pielou's Evenness J'	Shannon Wiener Index H'(log10)	Simpson Diversity Index 1-Lambada'
29	12	52200	1.013	0.4278	1.063	0.5641

The station characteristics correspond well with the LS.LMu.UEst.Hed.Str biotope described within The Marine Habitat Classification for Britain and Ireland (Vs 04.05), the only deviation being aspects of the faunal component; the characterising species are present in numbers far in excess of that expected (i.e. *Tubificoides benedii* are an order of magnitude greater) or in numbers far less than expected (i.e. *Manayunkia aestuarina* and *Hediste diversicolor*). The only characterising species that was absent was *Corophium volutator* though this is not conclusive given the limited sampling effort.

3.4.5 LS.LMu.MEst.NhomMacStr

The biotope LS.LMu.MEst.NhomMacStr (*Nephtys hombergii*, *Macoma balthica* and *Streblospio shrubsolii* in littoral sandy mud) is found within the mid stretches of the Truro and Fal River in the Upper Fal and Woods SSSI. The biotope is also present at Trethem Creek within the Percuil estuary, but is absent from the remainder of the Lower Fal and Helford Intertidal SSSI and the Malpas SSSI.

Figure 16. Extent and distribution of LS.LMu.MEst.NhomMacStr in the Percuil – Lower Fal and Helford Intertidal SSSI (Graticules represent $1km^2$)

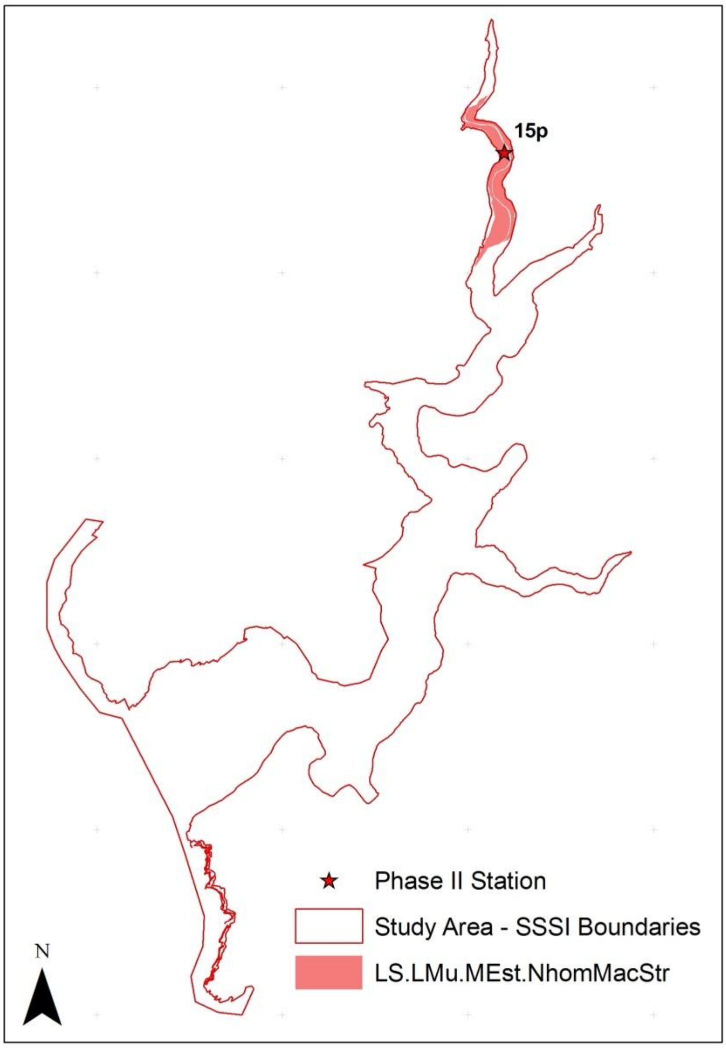
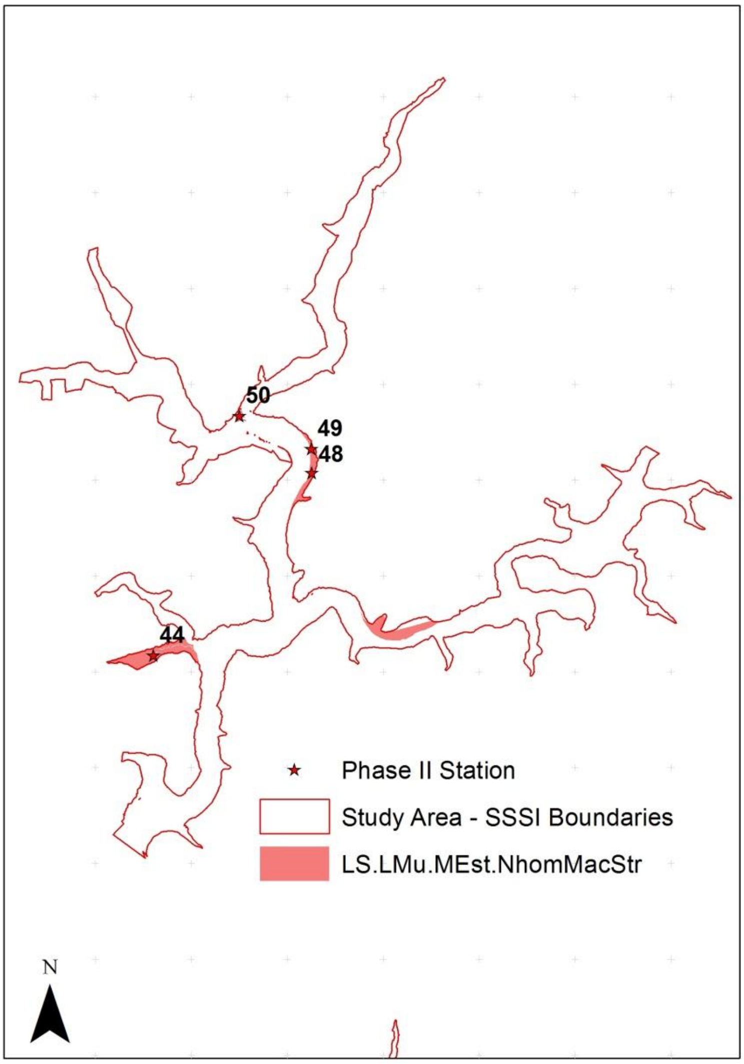


Figure 17. Extent and distribution of LS.LMu.MEst.NhomMacStr in the Upper Fal and Woods SSSIs (Graticules represent $1km^2$)



The sediments at stations within this biotope are described as muddy sand (medium/fine sand, silt and clay). The carbon content within sediment samples ranged from 4.23% at station 50 which is exposed to scouring on the lower shore, to 8.3% at station 44 in Lamouth Creek which is sheltered on the higher shore. The redox discontinuity layer was present at <1cm at stations 44 and 48, and at <5cm at stations 49 and 50 which are lower on the shore.

The most abundant and frequently occurring species within the biotope is the Oligochaete *Tubificoides benedii*. Between 6 and 13 taxa were recorded at the 5 stations. Species richness, evenness and diversity is comparable within the biotope, though diversity appears to be marginally greater at the Truro River stations.

The average similarity between stations is 39%. Those species which provide the highest % contribution to similarity are listed in Table 17 below. Note that *Macoma balthica* is also likely to contribute significantly to the assignment of the biotope but due to the core size and relatively low number of replicates, the species was not represented adequately in cores. The species was however observed in the field during the Phase I survey.

Table 17. Species % contribution in Fal and Helford Marine Sites LS.LMu.MEst.NhomMacStr biotope

Species	Average Abundance Per Core	Average Similarity	% Contribution
Hydrobia ulvae	59.97	14.74	37.38
Tubificoides benedii	52.00	8.54	21.67
Nephtys sp juv	18.66	6.01	15.25
Streblospio shrubsolii	21.20	3.26	8.26
Melinna palmata	6.83	1.42	3.60
Cardiacea juv	10.83	1.36	3.45
Pygospio elegans	8.00	1.30	3.29
Nephtys hombergii	6.83	1.00	2.54
Tubificoides pseudogaster agg	21.28	0.81	2.06
Cirratulidae sp juv	7.66	0.36	0.93
Capitella capitata agg	5.46	0.33	0.84

Table 18. Fal and Helford Marine Sites LS.LMu.MEst.NhomMacStr biotope community analysis

Station	No. Taxa Per Core S	No. Individuals Per Core n	Margalef's Species Richness d	Pielou's Evenness J'	Shannon Wiener Index H'(log10)	Simpson diversity Index 1-Lambda'
15p	9	12800	0.8459	0.6268	1.377	0.6479
44	10	31200	0.8697	0.4464	1.028	0.5665
48	13	15500	1.244	0.619	1.588	0.7222
49	10	6400	1.027	0.744	1.713	0.7692
50	6	1800	0.6671	0.9014	1.615	0.7720

Table 19. Fal and Helford Marine Sites LS.LMu.MEst.NhomMacStr replicate core species composition

Species	15p No. m²	44 No. m²	48 No. m²	49 No. m²	50 No. m²	Biotope Characterising Species Abundance
Nephtys hombergii		200	100	100		133
Nereidae sp juv		100				*124*
Streblospio shrubsolii	1300	100	2100	200		593
Tubificoides benedii	6800	16100	500	200	200	999
Tubificoides pseudogaster agg		800	6100			662
Tubificoides swirencoides				1300		*662*
Ampharete sp juv	100					
Ampharete grubei			100			
Capitella capitata agg	300		100			
Cardiacea juv		900	100		200	
Cirratulidae sp juv			800	100		
Corophium volutator				100		
Cossura sp				2200		
Exogone hebes			100			
Hydrobia ulvae	3000	12700	4900	1600	500	
Macoma balthica	100					
Manayunkia aestuarina		100	100			
Melinna palmata		100		100	200	
Nephtys sp juv	700		400	500	600	
Pygospio elegans	400	100			100	
Tharyx 'A'	100					
Bivalvia unident juv			100			

The station characteristics correspond reasonably well with the LS.LMu.MEst.NhomMacStr biotope described within The Marine Habitat Classification for Britain and Ireland (Vs 04.05), although there is some deviation from the faunal component. Most of the species described as characteristic for the biotope were present at all five stations, but were not all captured in the cores (species not present were observed during the Phase I survey), this includes one of the main characterising species *Hediste diversicolor*. The abundance of characterising species which are present in cores is also somewhat variable.

3.4.6 LS.LMu.MEst.HedMacScr

The biotope LS.LMu.MEst.HedMacScr (*Hediste diversicolor*, *Macoma balthica* and *Scrobicularia plana* littoral sandy mud shores) is common throughout the upper shores and tributaries of the Fal and Helford Marine Sites. It dominates the upper and west banks of the Tressilian River and the large flats of the upper reaches and of the Fal River within the Upper Fal and Woods SSSI. The biotope also spans the upper creeks of the Malpas SSSI (Calenick Creek and Truro River), the upper Trethem Creek within the Percuil estuary as well as the upper reaches of the larger tributaries in the remainder of the Lower Fal and Helford Intertidal SSSI.

Figure 18. Extent and distribution of LS.LMu.MEst.HedMacScr in the Helford - Lower Fal and Helford Intertidal SSSI (Graticules represent $1km^2$)

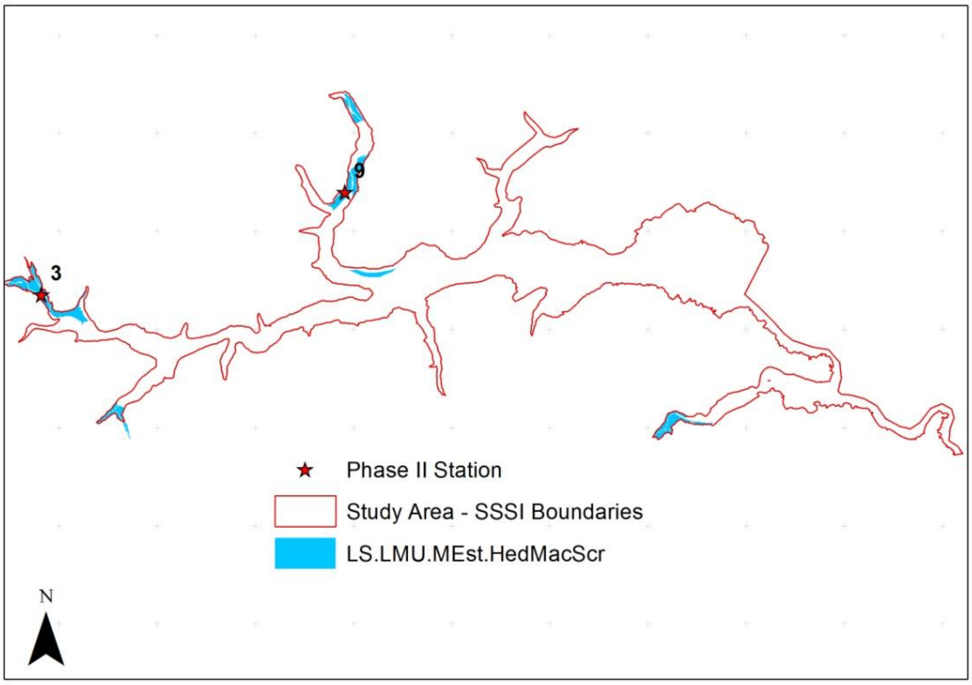


Figure 19. Extent and distribution of LS.LMu.MEst.HedMacScr in the Percuil - Lower Fal and Helford Intertidal SSSI (Graticules represent 1km^2)

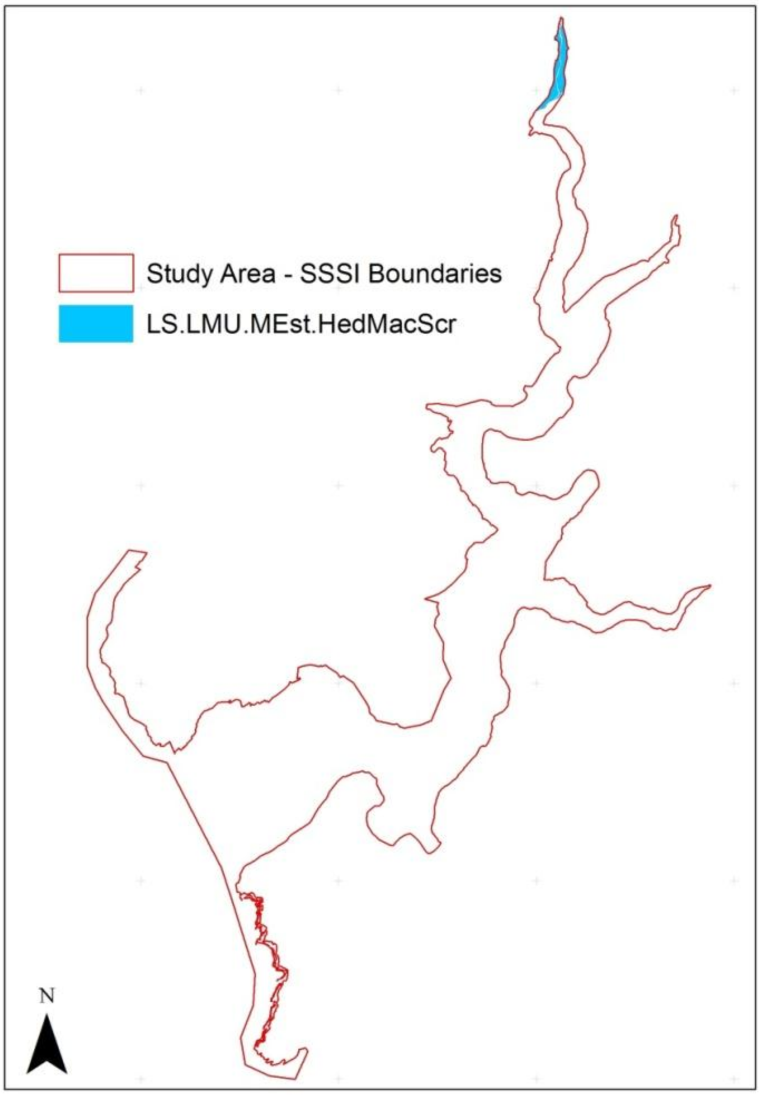
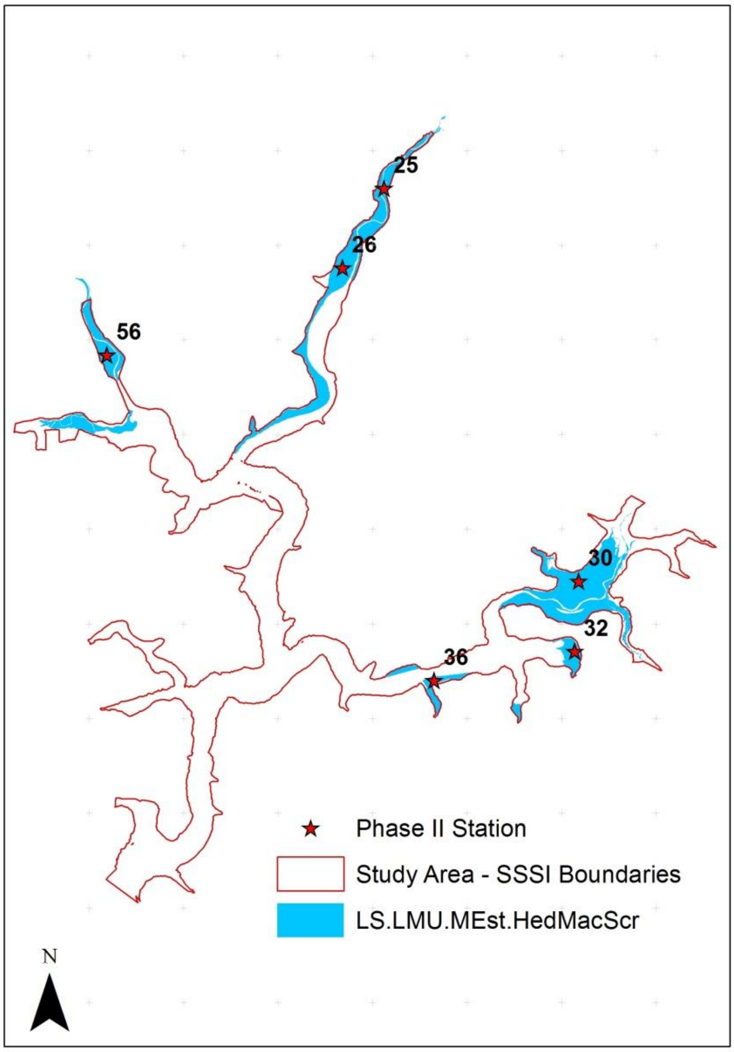


Figure 20. Extent and distribution of LS.LMu.MEst.HedMacScr in Malpas Estuary and Upper Fal and Woods SSSIs (Graticules represent 1km^2)



The sediments at stations within this biotope were medium-fine sandy silt and clay. The carbon content within sediment samples ranged broadly from 2.37-2.80% at stations 36 and 32 to 7.82% at station 25 at the head of the Tresillian River. The anoxic layer was present within the first 5cm at all but stations 9 and 32 where the redox discontinuity was present within the first 1cm of sediment.

The most abundant and frequently occurring species within the biotope is the gastropod *Hydrobia ulvae* followed by the oligochaete *Tubificoides benedii*, which account for 51% and 19% of the the species similarity contribution respectively. Between 9 and 17 taxa were encountered within the 8 replicate cores that were taken. Species diversity, richness and abundance within replicates was generally lowest at stations within the Helford although the core taken at station 30 held the lowest number of taxa; this station is closest to the china clay works which has historically polluted the River Fal. The reduction in species richness may therefore be linked to the works but cannot be concluded given the limited sampling effort.

The average similarity of target stations is 40%. Those species which provide the highest % contribution to similarity are listed in Table 20 below. Note that the observation of at least abundant numbers of *Scrobicularia plana* in the field have also contributed significantly to the assignment of the biotope but are not represented in cores; this is most likely as a result of the small core size.

Table 20. Species % contribution in Fal and Helford Marine Sites LS.LMu.MEst.HedMacScr biotope

Species	Average Abundance Per Core	Average Similarity	% Contribution
Hydrobia ulvae	127.77	24.98	50.95
Tubificoides benedii	83.79	13.24	27.00
Streblospio shrubsolii	28.25	3.64	7.42
Cardiacea juv	11.40	1.59	3.23
Capitella capitata agg	23.79	1.40	2.86
Tubificoides pseudogaster agg	11.16	1.38	2.82
Nephtys sp juv	12.74	0.95	1.93
Tharyx 'A'	5.00	0.45	0.91
Chrysallida sp juv	6.04	0.39	0.79
Pygospio elegans	13.68	0.39	0.79
Chironomidae	26.48	0.32	0.65
Hydrobia ulvae	127.77	24.98	50.95
Tubificoides benedii	83.79	13.24	27.00

Table 21. Fal and Helford Marine Sites LS.LMu.MEst.HedMacScr biotope community analysis

Station	No. Taxa Per Core S	No. Individuals Per Core n	Margalef's Species Richness d	Pielou's Evenness J'	Shannon Wiener Index H'(log10)	Simpson diversity Index 1-Lambda'
3	11	29300	0.9723	0.4672	1.12	0.4793
9	9	18100	0.816	0.4198	0.9224	0.3969
30	6	5000	0.587	0.5122	0.9177	0.4785
32	12	18100	1.122	0.3389	0.8422	0.326
36	12	4200	1.318	0.8452	2.1	0.8301
56	17	17800	1.635	0.6427	1.821	0.7389
25	10	5700	1.041	0.76	1.75	0.7616
26	9	16900	0.8218	0.6771	1.488	0.6969

Table 22. Fal and Helford Marine SItes LS.LMu.MEst.HedMacScr replicate core species composition

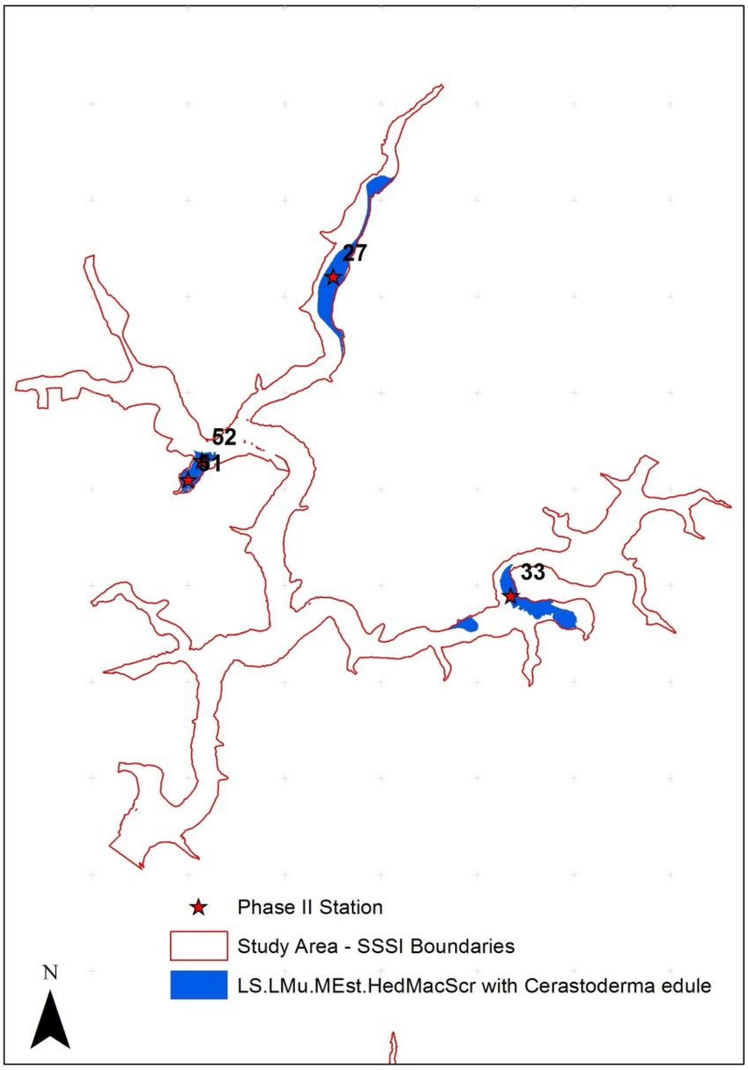
Species	3 No. m²	9 No. m²	30 No. m²	32 No. m²	36 No. m²	56 No. m²	25 No. m²	26 No. m²	Biotope Characterising Species Abundance
Hediste diversicolor		100	1200			200	1200	1900	798
Heterochaeta costata						900			1677
Hydrobia ulvae	1300	1500	3400	14800	300	1500	2300	4700	4118
Pygospio elegans	2400	200		700		300			929
Scrobicularia plana				700		200	300	300	250
Streblospio shrubsolii	1800			700		7900	400	700	392
Tharyx 'A'			100		400	200	100		*537*
Tubificoides benedii	20800	13900	100	100	200	3900	100	7700	2699
Tubificoides pseudogaster agg	1800	1300			300	1200	300	700	1677
Actinaria unident				100					
Capitella capitata agg		200							
Carcinus maenas									
Cardiacea juv	100	500		100	1400	100			
Cerastoderma edule				100					
Crangon crangon				100	100				
Cyathura carinata						400			
Eteone longa agg	200		100	100			100		
Exogone hebes					100				
Mediomastus fragilis					100	100		100	
Melinna palmata					700				
Mya sp juv								100	
Nematoda				100	200				
Nephtys sp juv	600	300			300	200			
Nephtys hombergii	100				100	100			
Nereidae sp juv						100	800		
Notomastus sp						100			
Polydora cornuta				500		400	100	700	
Spionidae unident	100								
Tellinacea juv	100	100							
Tipulidae			100						

The faunal community characteristics correspond well with the LS.LMu.MEst.HedMacScr biotope described within The Marine Habitat Classification for Britain and Ireland (Vs 04.05), although there is some minor deviation from the faunal component. All characterising species are present within the cores (or in the case of *Scrobicularia plana*, the distinctive 'crow's foot' pattern on the sediment surface was observed in abundance at all stations), with the exception of the bivalve *Macoma balthica* which was observed in the field during the Phase I survey at a number of stations. Although the cirratulid *Tharyx killariensis* was also absent, the cirratulid species *Tharyx A* was present and it is therefore likely that the species has substituted *Tharyx killariensis* within that ecological niche.

3.4.7 LS.LMU.MEst.HedMacScr with *Cerastoderma edule*

LS.LMU.MEst.HedMacScr with *Cerastoderma edule* is present in both the Tresillian and Fal tributaries of the Upper Fal and Woods SSSI and within the Malpas SSSI, often adjacent to LS.LSa.MuSa.CerPo and/or LS.LMu.MEst.HedMacScr communities. This biotope has been represented separately for the purposes of this study because it represents definitive large scale transitional communities.

Figure 21. Extent and distribution of LS.LMU.MEst.HedMacScr with Cerastoderma edule in the Malpas Estuary and Upper Fal and Woods SSSIs (Graticules represent 1km^2)



The sediments at stations within this biotope were medium-fine sandy silt and clay. The carbon content within sediment samples ranged broadly from 2.37-2.80% at stations 36 and 32 to 7.82% at station 25 at the head of the Tresillian River. The anoxic layer was present within the first 5cm at all but stations 9 and 32 where the redox discontinuity was present within the first 1cm of sediment.

The most abundant and frequently occurring species within the biotope is the gastropod *Hydrobia ulvae* followed by the oligochate *Tubificoides benedii*, which account for 50% and 7% of the species similarity contribution respectively. Between 10 and 16 taxa were encountered within the 4 replicate cores that were taken. Species diversity, richness and abundance was comparable between stations.

The average similarity of target stations is 49%. Those species which provide the highest % contribution to similarity are listed in Table 23 below. Note that the observation of abundant numbers of the bivalves *Scrobicularia plana* and *Cerastoderma edule* in the field have also contributed significantly to the assignment of the biotope but are not represented in cores as a result of the small core size.

Table 23. Species % contribution in LS.LSa.MuSa.Lan biotope

Species	Average Abundance Per Core	Average Similarity	% Contribution
Hydrobia ulvae	127.77	24.98	50.95
Tubificoides benedii	83.79	13.24	7.00
Streblospio shrubsolii	28.25	3.64	7.42
Cardiacea juv	11.40	1.59	3.23
Capitella capitata agg	23.79	1.40	2.86
Tubificoides pseudogaster agg	11.16	1.38	2.82
Nephtys sp juv	12.74	0.95	1.93
Tharyx 'A'	5.00	0.45	0.91
Chrysallida sp juv	6.04	0.39	0.79
Pygospio elegans	13.68	0.39	0.79
Chironomidae	26.48	0.32	0.65

Table 24. LS.LSa.MuSa.Lan biotope community analysis

Station	No. Taxa Per Core S	No. Individuals Per Core N	Margalef's Species Richness d	Pielou's Evenness J'	Shannon Wiener Index H'(log10)	Simpson Diversity Index 1-Lambada'
27	16	27200	1.469	0.4916	1.363	0.6069
33	14	25800	1.28	0.5531	1.46	0.6767
51	11	64200	0.9034	0.635	1.523	0.7213
52	10	19800	0.9097	0.4256	0.9799	0.4389

Table 25. Fal and Helford Marine Sites LS.LMU.MEst.HedMacScr with *Cerastoderma edule* replicate core species composition

Species	27 No. m²	33 No. m²	51 No. m²	52 No. m²
Heterochaeta costata				100
Hydrobia ulvae	15400	9500	28600	14500
Nereidae sp juv		200		
Pygospio elegans	100	2000		
Scrobicularia plana	0	0	100	
Streblospio shrubsolii	600	1200		2900
Tharyx 'A'	100			100
Tubificoides benedii	7100	10900	13200	1000
Tubificoides pseudogaster agg	100		300	300
Tubificoides swirencoides	1400			
Ampharete grubei		400		
Capitella capitata agg		100	4600	300
Carcinus maenas		100		
Cardiacea juv	300		200	200
Cerastoderma edule		300		
Chironomidae		100	9200	
Chrysallida sp juv	200	100		
Cossura sp	200			
Enchytraeidae	100		7100	
Eteone longa agg		100		
Heteromastus filiformis			400	
Manayunkia aestuarina	200			
Melinna palmata	200			
Mya sp juv		200		
Nematoda			400	
Nephtys sp juv	700	600		
Nephtys hombergii				200
Tellinacea juv	400			
Tipulidae			100	
Bivalvia unident juv				200
Alderia modesta	100			

The station characteristics correspond reasonably well with the LS.LMU.MEst.HedMacScr biotope described within The Marine Habitat Classification for Britain and Ireland (Vs 04.05) and also the LS.LMU.MEst.HedMacScr biotope described above that is found within the study areas; the significant exception being the high abundance of *Cerastoderma edule*, the presence of which has been used to categorise this biotope as transitional.

3.4.8 LS.LSa.MuSa.Lan

Where present, LS.LSa.MuSa.Lan (*Lanice conchilega* in littoral sand) occurs on low-extreme lower shores which are exposed to strong tidal streams. The biotope is present on the northern bank of the mid Helford estuary, at the lower extent of the Malpas SSSI, and within the eastern branch of the River Fal in the upper Fal and Woods SSSI.

Figure 22. Extent and distribution of LS.LMx.GvMu.HedMx.Cir in the Helford - Lower Fal and Helford Intertidal SSSI (Graticules represent 1km^2)

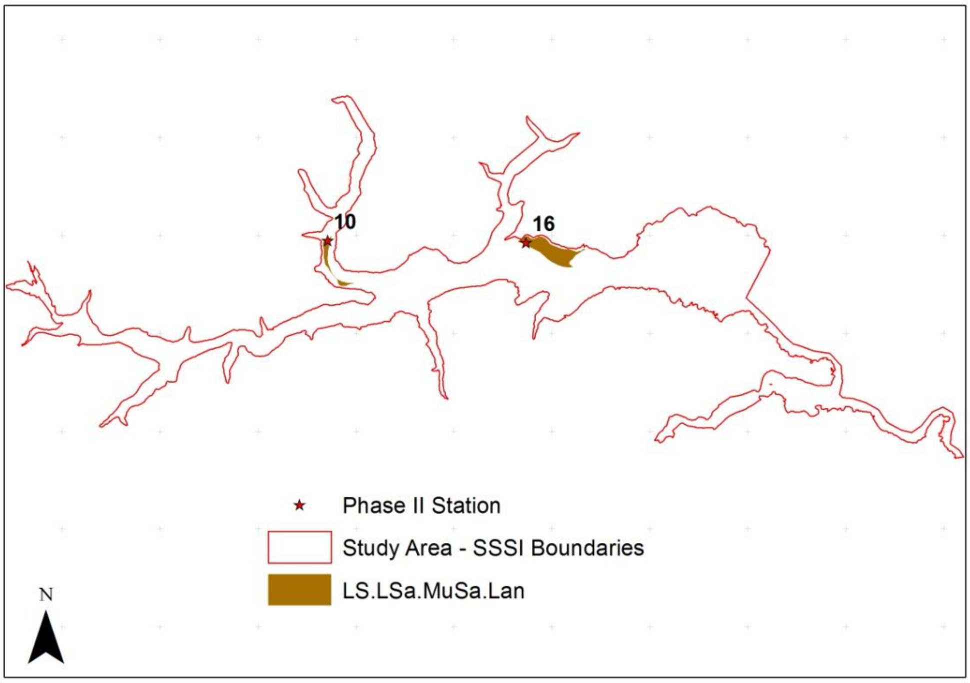
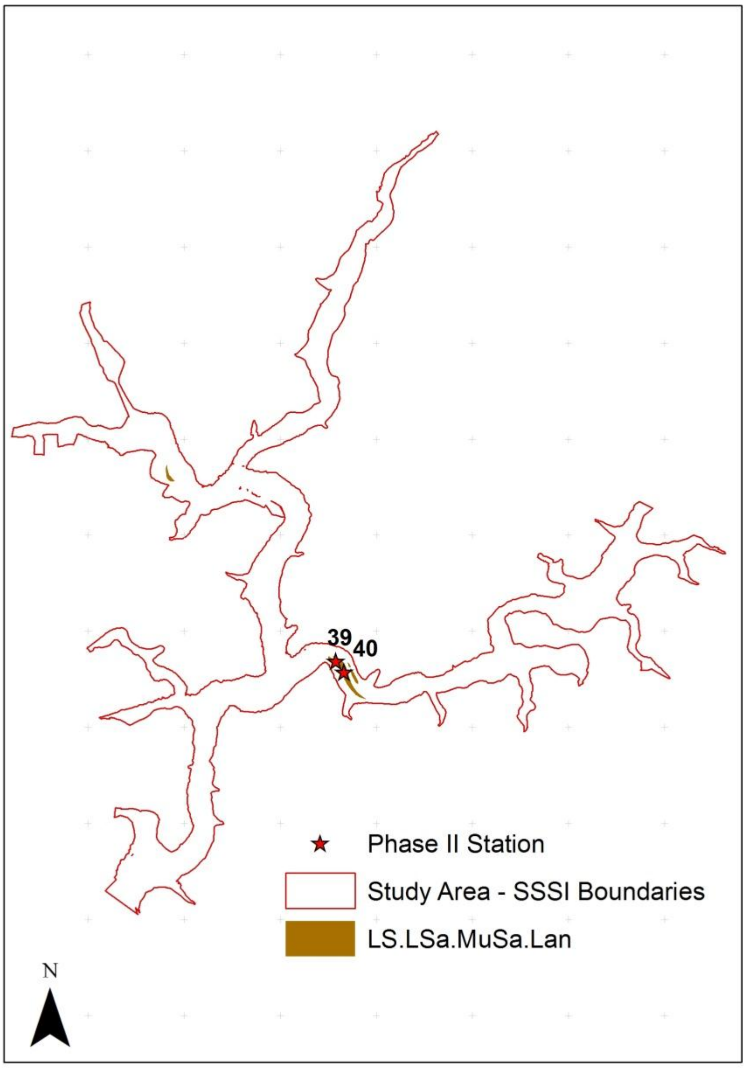


Figure 23. Extent and distribution of LS.LMx.GvMu.HedMx.Cir in the Malpas Estuary and Upper Fal and Woods SSSIs (Graticules represent 1km^2)



The sediment at stations within the biotope is variable with the largest components ranging from medium sand in the Fal, to pebbles in the main channel of the Helford. All stations contain fine sand, silt and clay fractions. The redox discontinuity level is also variable; at station 16 in the main channel of the Helford the redox layer was not observed (>20cm) whilst at station 10 the discontinuity level was reached within the first 1cm of sediment. At the two remaining stations in the Fal the discontinuity layer was reached within the first 5cm of the sediment surface. All stations contain a very low-low proportion of carbon 1.47 - 3.13 %.

The average similarity between the four stations is low at 27 %; though, this value is thought to be an underestimation of the actual similarity of communities as the main characterising species *Lanice conchilega* was not captured in cores due to the core size and the tendency of the species to quickly retract into deep sediment when disturbed. The distinctively constructed tubes of *Lanice conchilega* were present in cores however, and had the tubes contained live polychaetes the numbers would have equated to the species being ranked as abundant on the SACFOR scale at every station.

The most abundant and frequently occurring species which therefore provide the highest percentage contribution to similarity within the replicate cores are the oligochaete *Tubificoides benedii* and the cirratulid *Tharyx A* (see Table 26 below).

Between 12 and 31 taxa were present at the four stations, not including *Lanice conchilega*. Species richness, evenness and diversity are high relative to other biotopes identified within the study areas, with particularly high species richness at station 16 within the Helford. Biotope characterising species are not particularly regular between or within sample replicates, but confidence in the station biotope assignment has been underpinned by field observations.

Table 26. Species % contribution in LS.LSa.MuSa.Lan biotope

Species	Average Abundance Per Core	Average Similarity	% Contribution
Tubificoides benedii	30.83	5.66	21.08
Tharyx 'A'	30.92	3.35	12.46
Nephtys sp juv	11.83	2.09	7.80
Nematoda	14.25	2.04	7.60
Cardiacea juv	12.65	1.84	6.87
Melinna palmata	11.04	1.73	6.46
Capitella capitata agg	17.64	1.67	6.24
Scoloplos armiger	8.54	1.47	5.47
Tellinacea juv	11.63	1.32	4.92
Pygospio elegans	11.61	1.28	4.78
Tubificoides pseudogaster agg	17.58	1.11	4.12
Mediomastus fragilis	26.17	0.64	2.38
Hesionidae sp	9.33	0.59	2.21
Chaetozone gibber	12.89	0.48	1.80
Anaitides mucosa	5.00	0.45	1.68
Exogone hebes	11.85	0.39	1.43
Glycera tridactyla	5.00	0.39	1.43
Eumida bahusiensis	6.04	0.34	1.28

Table 27. LS.LSa.MuSa.Lan biotope community analysis

Station	No. Taxa Per Core S	No. Individuals Per Core N	Margalef's Species Richness d	Pielou's Evenness J'	Shannon Wiener Index H'(log10)	Simpson Diversity Index 1-Lambada'
10	17	19200	1.622	0.6147	1.742	0.7283
16	31	12400	3.183	0.8654	2.972	0.9293
39	20	6000	2.184	0.8732	2.616	0.8979
40	12	4700	1.301	0.7398	1.838	0.729

Table 28. LS.LSa.MuSa.Lan replicate core species composition

Species	10 No. m²	16 No. m²	39 No. m²	40 No. m²	Biotope Characterising Species Abundance
Anaitides mucosa	100		100		161
Cerastoderma edule				100	168
Eumida bahusiensis	100	200			211
Nephtys hombergii			100		77
Pygospio elegans			700	400	303
Scoloplos armiger		200	100	100	329
Tharyx 'A'	5200		1400	200	1484
Abra tenuis				100	
Ampharete grubei		100			
Amphipoda unident juv	100				
Aonides oxycephala		100			
Capitella capitata agg	600	1300	100		
Cardiacea juv	700		100	200	
Chaetozone gibber	200	1400			
Cossura sp				100	
Exogone hebes		1400	100		
Glycera tridactyla		100	100		
Golfingia vulgaris		100			
Hesionidae sp	400	300			
Heteromastus filiformis			200		
Hydrobia ulvae				200	
Mediomastus fragilis	8200		200		
Melinna palmata		100	400	200	
Mya sp juv	200				
Mytilidae	200				
Nematoda	300	500	300		
Nephtys sp juv	100		400	300	
Nereidae sp juv			100		
Notomastus sp		300			
Pholoe synophthalmica			300		
Polydora cornuta		100			
Prionospio fallax		400			
Spio decorata	100				
Streblospio shrubsolii				500	
Tellinacea juv	200	500	100		
Tubificoides benedii	400	1700	200	2300	
Tubificoides pseudogaster agg	2100		600		
Tubificoides swirencoides			400		
Venerupis senegalensis		100			
Ischyroceridae		600			
Amphiuridae sp juv		400			
Amphipholis squamata		400			
Calyptraea chinensis		100			
Musculus discors		100			

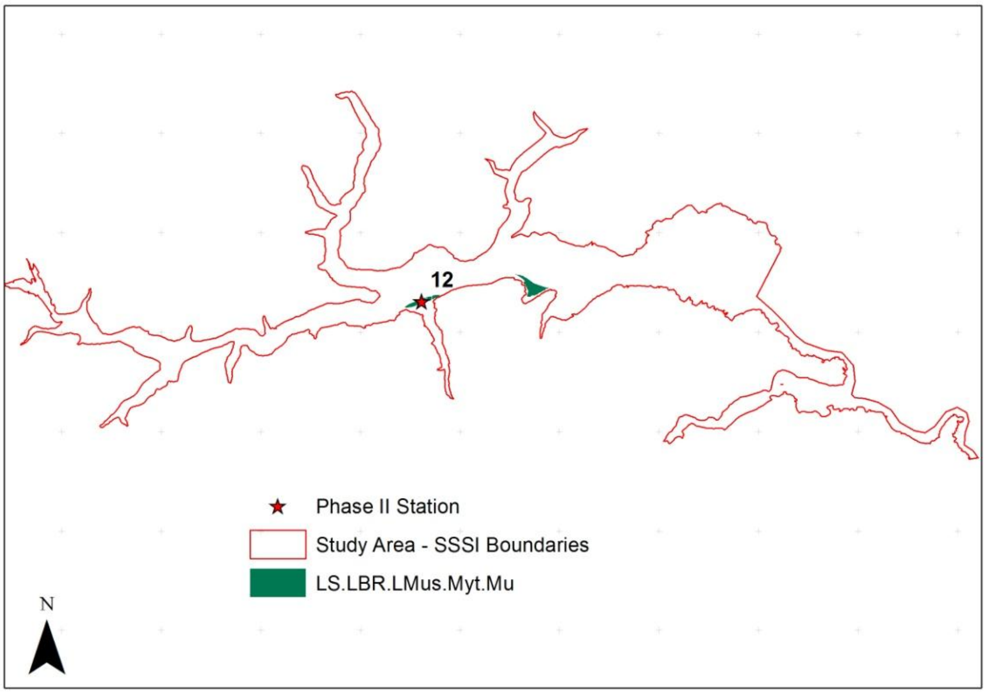
Species	10 No. m²	16 No. m²	39 No. m²	40 No. m²	Biotope Characterising Species Abundance
Phoronis sp		100			
Parvicardium exiguum		200			
Mysella bidentata		100			
Bivalvia unident juv		100			
Pholoe inornata		600			
Lanice conchilega		400			
Oligochaeta unident		300			
Syllidae unident		100			

The station characteristics correspond acceptably with the LSa.MuSa.Lan biotope described within The Marine Habitat Classification for Britain and Ireland (Vs 04.05), but deviations do exist in the faunal component where just 3 to 6 of the total 11 characterising species are present at stations. Many non-characterising species are present, particularly at station 16, adding to the overall diversity and richness of communities considerably. Most notable within the biotope is the abundance and contribution to similarity of the non-characteristic oligochaete *Tubificoides benedii*.

3.4.9 LS.LBR.LMus.Myt.Mu

The LS.LBR.LMus.Myt.Mu (*Mytilus edulis beds* on littoral mud) biotope is limited to the Lower Fal and Helford Intertidal SSSI, specifically on the lower shore on the southern bank of the Helford where two small tributaries intersect the main channel.

Figure 24. Extent and distribution of LS.LBR.LMus.Myt.Mu within the Helford - Lower Fal and Helford Intertidal SSSI (Graticules represent 1km^2)



The sediment within the biotope is gravelly muddy sand, with a low-moderate carbon content of 5.12%. The redox discontinuity level occurs within 5cm of the sediment surface.

Given the limited extent of this biotope only one target station was assigned. A total of 13 species were present within the core; the most abundant species was the oligochaete *Tubificoides pseudogaster agg.*, however, epifaunal species including the main characterising species *Mytilus edulis* were not represented by the core but were key in assigning the biotope. Significantly the BAP species *Ostrea edulis* (native oyster) was also observed to be abundant.

Table 29. Fal and Helford Marine Sites LS.LBR.LMus.Myt.Mu replicate core species composition

Species	12 No. m²
Ampharete grubei	100
Cirratulidae sp juv	500
Cossura sp	400
Glycera tridactyla	100
Hydrobia ulvae	300
Mediomastus fragilis	400
Melinna palmata	200
Nematoda	400
Nephtys sp juv	200
Tharyx 'A'	100
Tubificoides benedii	400
Tubificoides pseudogaster agg	3900
Tubificoides swirencoides	500

Table 30. LS.LBR.LMus.Myt.Mu biotope community analysis

Station	No. Taxa Per Core S	No. Individuals Per Core N	Margalef's Species Richness d	Pielou's Evenness J'	Shannon Wiener Index H'(log10)	Simpson Diversity Index 1-Lambada'
12	13	7500	1.345	0.71	1.821	0.7059

The description of LS.LBR.LMus.Myt.Mu biotope within The Marine Habitat Classification for Britain and Ireland (Vs 04.05) is relatively sparse in terms of the infaunal species expected, but the habitat assigned as LS.LBR.LMus.Myt.Mu in this study does correlate sufficiently to assign the biotope confidently. The infauna however is more rich and diverse than may be expected (though oligochaetes and cirratulids do dominate the species list) and most significantly the BAP species *Ostrea edulis* (native oyster) was observed to be in numbers as high as abundant.

3.4.10 LS.LBR.LMus.Myt.Mx

LS.LBR.LMus.Myt.Mx (*Mytilus edulis beds* on littoral mixed substrata) occurs mainly in the Lower Fal and Helford Intertidal SSSI specifically within the Helford. However it is also present within a small area in the Truro River within the Upper Fal and Helford SSSI. The biotope is mainly observed to be limited to the low-extreme low shore, but also extends to the mid-upper shore in a shallow inlet on the north bank of the Helford.

Figure 25. Extent and distribution of LS.LBR.LMus.Myt.Mx in the Helford - Lower Fal and Helford Intertidal SSSI (Graticules represent 1km^2)

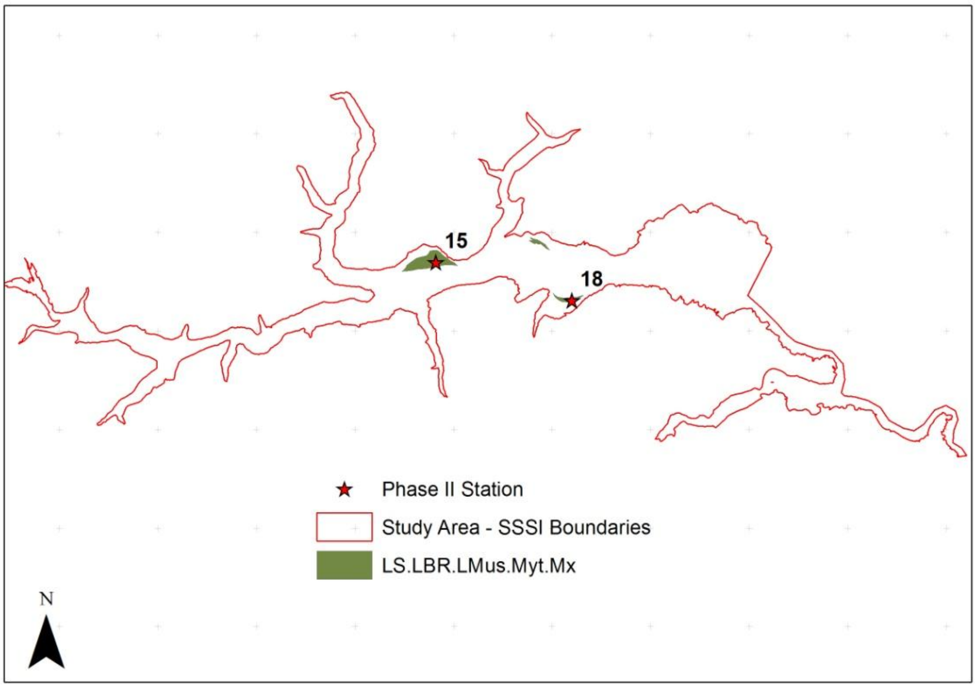
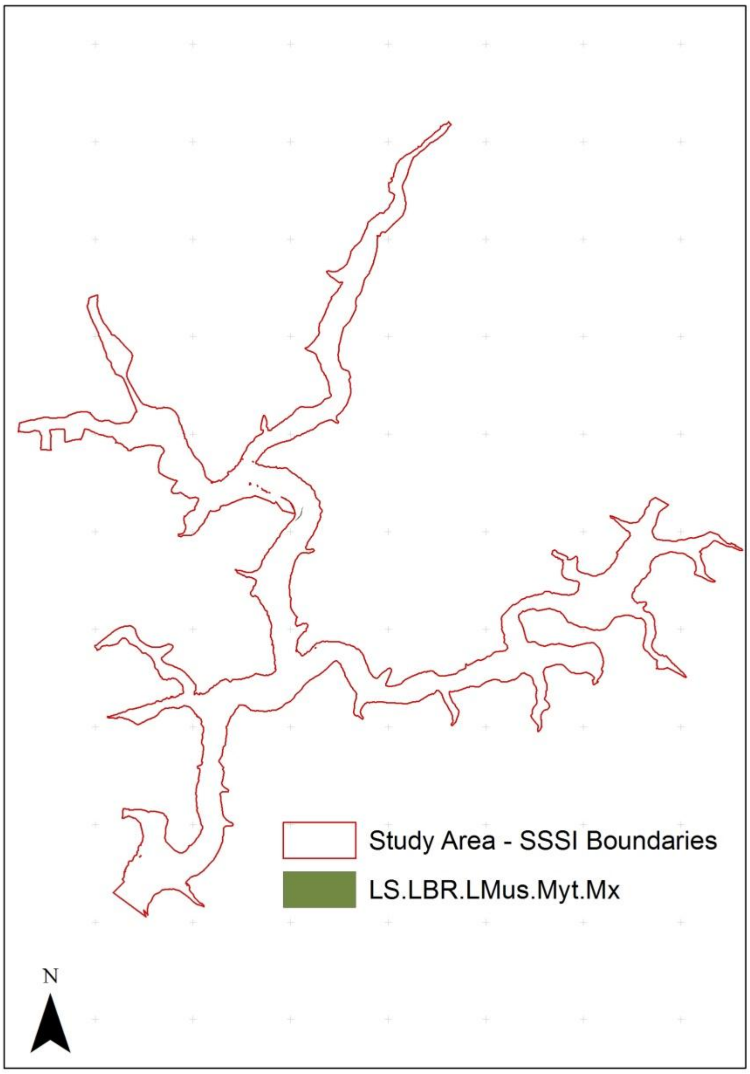


Figure 26. Extent and distribution of LS.LBR.LMus.Myt.Mx in Malpas Estuary and Upper Fal and Woods SSSIs (Graticules represent 1km^2)



The sediment within the biotope is gravelly muddy sand, with a very low-low carbon content of 0.87 and 3.19% at the two station 18 and 15 respectively. The redox discontinuity level occurs within 5cm of the sediment surface at both stations.

Excluding the main characterising species *Mytilus edulis* which was not represented within cores, the fauna was dominated by the Oligochaetes *Tubificoides benedii* and *Tubificoides pseudogaster agg.* which together account for over 50% of the community similarity. Almost double the number of taxa were identified at station 18 (which is closer to the mouth of the Helford estuary), leading to particularly high species richness both within the biotope and in relation to the other biotopes in the study areas. This however has also led to the average similarity between stations to be the lowest 25.17% of all the biotopes identified, though this effect is also likely to be exaggerated by the fact that the main characterising species *Mytilus edulis*, has not been represented in the cores.

Table 31. Species % contribution in the Fal and Helford Marine Sites LS.LBR.LMus.Myt.Mx biotope

Species	Average Abundance Per Core	Average Similarity	% Contribution
Tubificoides benedii	26.18	6.78	26.94
Tubificoides pseudogaster agg	26.99	6.78	26.94
Aphelochaeta marioni	15.73	4.29	17.04
Melinna palmata	17.07	4.29	17.04
Nematoda	25.62	3.03	12.05

Table 32. LS.LBR.LMus.Myt.Mx biotope community analysis

Station	No. Taxa Per Core S	No. Individuals Per Core N	Margalef's Species Richness d	Pielou's Evenness J'	Shannon Wiener Index H'(log10)	Simpson Diversity Index 1-Lambada'
15	12	3800	1.335	0.8436	2.096	0.8396
18	23	14700	2.293	0.7193	2.255	0.8209

Table 33. LS.LBR.LMus.Myt.Mx replicate core species composition

Species	15	18
	No. m²	No. m²
Aphelochaeta marioni	300	200
Aonides oxycephala		700
Arenicola marina		100
Capitella capitata agg		400
Cerastoderma edule		300
Chaetozone gibber		100
Cossura sp		100
Eteone longa agg		100
Exogone hebes		3000
Glycera sp juv		300
Heterochaeta costata		200
Lucinoma borealis		200
Mediomastus fragilis		5000
Melinna palmata	400	200
Nematoda	100	1700
Polydora cornuta		100
Prionospio fallax		300
Sphaeroma sp juv		100
Streblospio shrubsolii		100
Tharyx 'A'		400
Tubificoides benedii	900	500
Tubificoides pseudogaster agg	1000	500
Venerupis senegalensis		100

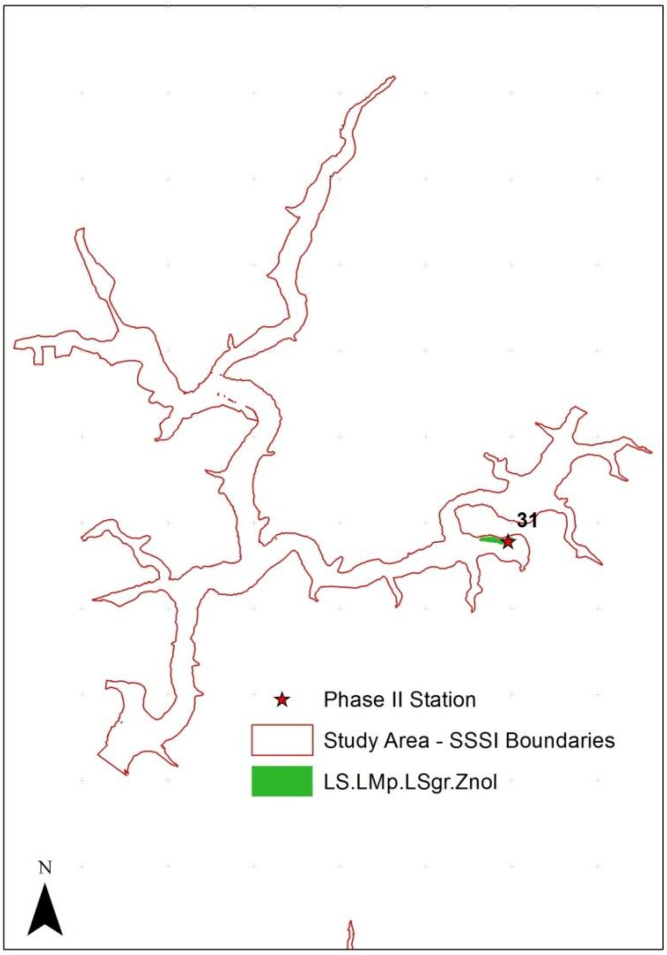
Few infaunal samples have been collected for the biotope and therefore the characterising species list contains only epifauna, but where infaunal communities have been collected they contain a highly diverse range of species. Station 18 characteristics therefore correspond well with the LS.LMx.GvMu.HedMx.Cir biotope described within The Marine Habitat Classification for Britain and Ireland (Vs 04.05), station 15 less so, but can be confidently categorised as LS.LBR.LMus.Myt.Mx given the epifaunal species observed during the Phase I survey.

Notably during the Phase I survey, the native oyster *Ostrea edulis* was observed within the Lower Fal and Helford SSSI distribution of the biotope. On the southern bank of the main Helford channel the notable species was rare, but was frequent in numbers on the northern bank. Significantly on the northern bank, the native species was present along-side the non-native Pacific oyster *Crassostrea gigas*.

3.4.11 LS.LMp.LSgr.Znol

LS.LMp.LSgr.Znol (*Zostera noltii* beds on littoral muddy sand) occurs in a single isolated patch within the Fal tributary of the Upper Fal and Woods SSSI.

Figure 27. Extent and distribution of LS.LMp.LSgr.Znol in the Upper Fal and Woods SSSI (Graticules represent 1km^2)



The sediment within the biotope is a muddy sand which contains a very coarse sand element, but the particle size distribution is more strongly swayed towards very fine sand, silt and clay size fractions. Surprisingly the carbon content is relatively low at 4.40%. The redox discontinuity level occurs within the first 1cm of the sediment surface.

Given the limited extent of this biotope and the sensitivity of *Zostera spp* sediment disturbance, only one target station was assigned and was placed where the *Zostera noltii* was sparse so as to minimise any potential disturbance to this BAP species. A total of 15 species were present within the core; the most abundant by far was the gastropod *Hydrobia ulvae*.

Table 34. LS.LMp.LSgr.Znol replicate core species composition

Species	31 No. m^2	Biotope Characterising Species Abundance
Cerastoderma edule	300	138
Heterochaeta costata	1200	*50*
Hydrobia ulvae	16300	1322
Pygospio elegans	100	371
Tubificoides benedii	900	*50*
ACTINIARIA unident	300	
Cardiacea juv	200	
Eteone longa agg	200	
Nematoda	100	
Nephtys sp juv	100	
Nereidae sp juv	100	
Notomastus sp	100	
Scrobicularia plana	500	
Streblospio shrubsolii	1300	
Idotea chelipes	100	

Table 35. LS.LMp.LSgr.Znol biotope community analysis

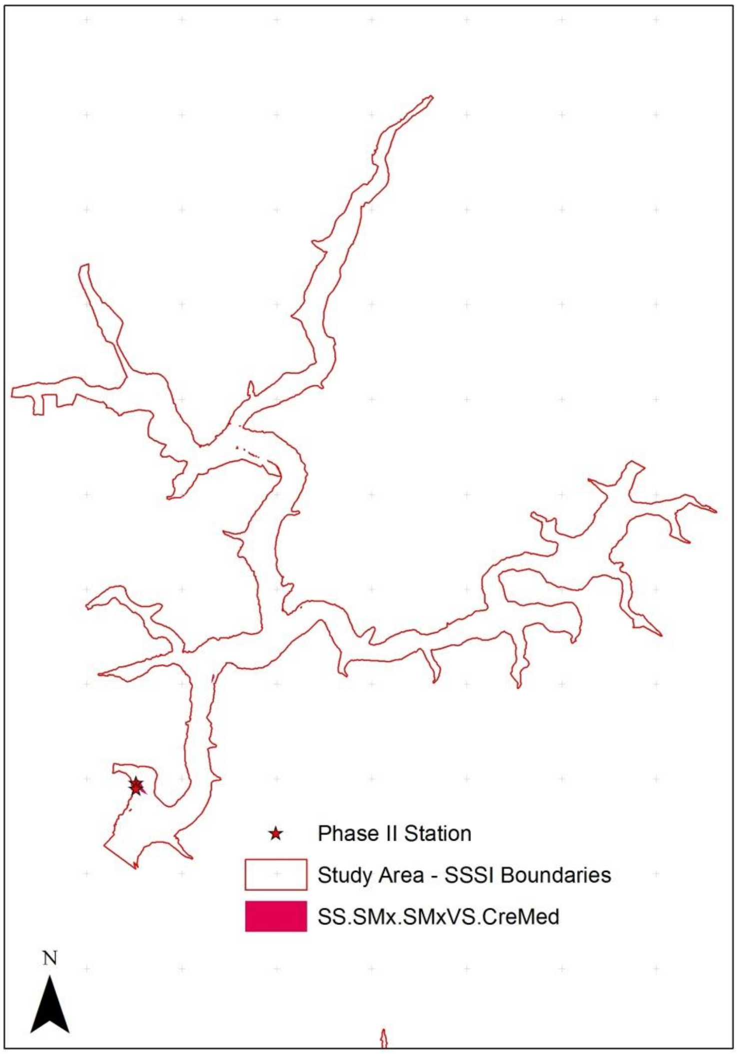
Station	No. Taxa Per Core S	No. Individuals Per Core N	Margalef's Species Richness d	Pielou's Evenness J'	Shannon Wiener Index H'(log10)	Simpson Diversity Index 1-Lambada'
31	15	21800	1.401	0.4119	1.116	0.4315

The station characteristics correspond reasonably well with the LS.LMx.GvMu.HedMx.Cir biotope described within The Marine Habitat Classification for Britain and Ireland (Vs 04.05), the only deviation being aspects of the faunal component. Only 5 of the possible 11 species characteristic of the biotope were present, though in much greater abundance than expected. 9 additional species add significantly to the overall species diversity and appear to be influenced by the biotopes adjacent i.e. *Nephtys hombergii* and *Scrobicularia plana* from the adjoining HedMacScr biotope.

3.4.12 SS.SMx.SMxVS.CreMed

SS.SMx.SMxVS.CreMed (*Crepidula fornicata* and *Mediomastus fragilis* in variable salinity infralittoral mixed sediment) occurs in two small patches of extreme lower shore within the lower end of the Upper Fal and Woods SSSI.

Figure 28. Extent and distribution of SS.SMx.SMxVS.CreMed in Upper Fal and Woods SSSI (Graticules represent $1km^2$)



The sediment within the biotope is gravelly muddy sand, with a relatively low carbon content of 3.49 to 4.02 %. The redox discontinuity level occurs within 1cm of the sediment surface.

8 and 10 taxa respectively were identified at the 2 stations; species richness, evenness and diversity are slightly elevated at the most upper shore station. The average similarity between stations is relatively high at 65.57% as would be expected given the close proximity of the stations on the same shore. Those species which provide the highest % contribution to similarity are listed in Table 36

below. The most abundant and frequently occurring species is the Oligochaete *Tubificoides swirencoides* followed by the cirratulid *Tharyx A* and the key characterising species *Mediomastus fragilis*. Note that *Crepidula fornucata* is also likely to contribute significantly to the assignment of the biotope but due to the core size the species was not captured in cores.

Table 36. Species % contribution in SS.SMx.SMxVS.CreMed biotope

Species	Average Abundance Per Core	Average Similarity	% Contribution
Tubificoides swirencoides	50.62	19.68	30.02
Tharyx 'A'	36.69	16.54	25.22
Mediomastus fragilis	28.71	9.55	14.56
Cossura sp	19.84	8.27	12.61
Melinna palmata	21.21	6.75	10.30
Nephtys sp juv	12.07	4.77	7.28

Table 37. SS.SMx.SMxVS.CreMed biotope community analysis

Station	No. Taxa Per Core S	No. Individuals Per Core N	Margalef's Species Richness d	Pielou's Evenness J'	Shannon Wiener Index H'(log10)	Simpson Diversity Index 1-Lambada'
23	10	5700	1.041	0.8134	1.873	0.8047
24	8	7400	0.7857	0.7182	1.494	0.6944

Table 38. Fal and Helford Marine Sites SS.SMx.SMxVS.CreMed replicate core species composition

Species	23 No. m²	24 No. m²	Biotope Characterising Species Abundance
Mediomastus fragilis	400	1400	320
Melinna palmata	800	200	54
Polydora cornuta	500		53
Tharyx 'A'	1500	1200	*940*
Tubificoides benedii		200	219
Tubificoides swirencoides	1700	3600	588
Nephtys sp juv	200	100	29
Nephtys hombergii		200	36
Cossura sp	300	500	
Enchytraeidae	100		
Hesionidae sp	100		
Notomastus sp	100		

The station characteristics correspond plausibly with the SS.SMx.SMxVS.CreMed biotope described within The Marine Habitat Classification for Britain and Ireland (Vs 04.05), though most obviously the biotope is not totally subtidal; it is therefore likely that the biotope is exposed only during spring tides. As such the faunal component of the biotope is less diverse than would be expected from a fully sublittoral SS.SMx.SMxVS.CreMed biotope; just 7 of the possible 20 characterising species are present. In addition, subtidal characterising cirratulid species including *Aphelochaeta marioni* appear to have been substituted by the cirratulid *Tharyx A* which is common to intertidal habitats. Those characterising species which are present are largely present in number much greater than expected for the biotope.

3.4.13 LS.LMx.Mx.CirCer

LS.LMx.Mx.CirCer (Cirratulids and *Cerastoderma edule* in littoral mixed sediment) is present at one location in the Lower Fal and Helford Intertidal SSSI, and two opposing lower shore locations within the Fal River in the Upper Fal and Woods SSSI. The biotope is absent from the Malpas SSSI.

Figure 29. Extent and distribution of LS.LMx.GvMu.HedMx.Cir in the Helford - Lower Fal and Helford Intertidal SSSI (Graticules represent 1km^2)

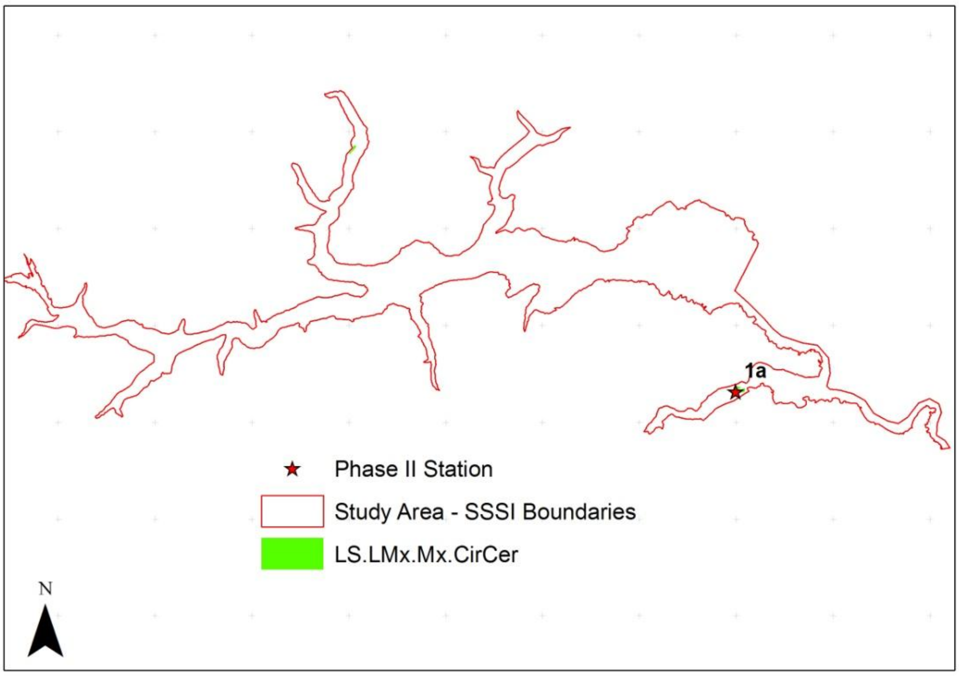
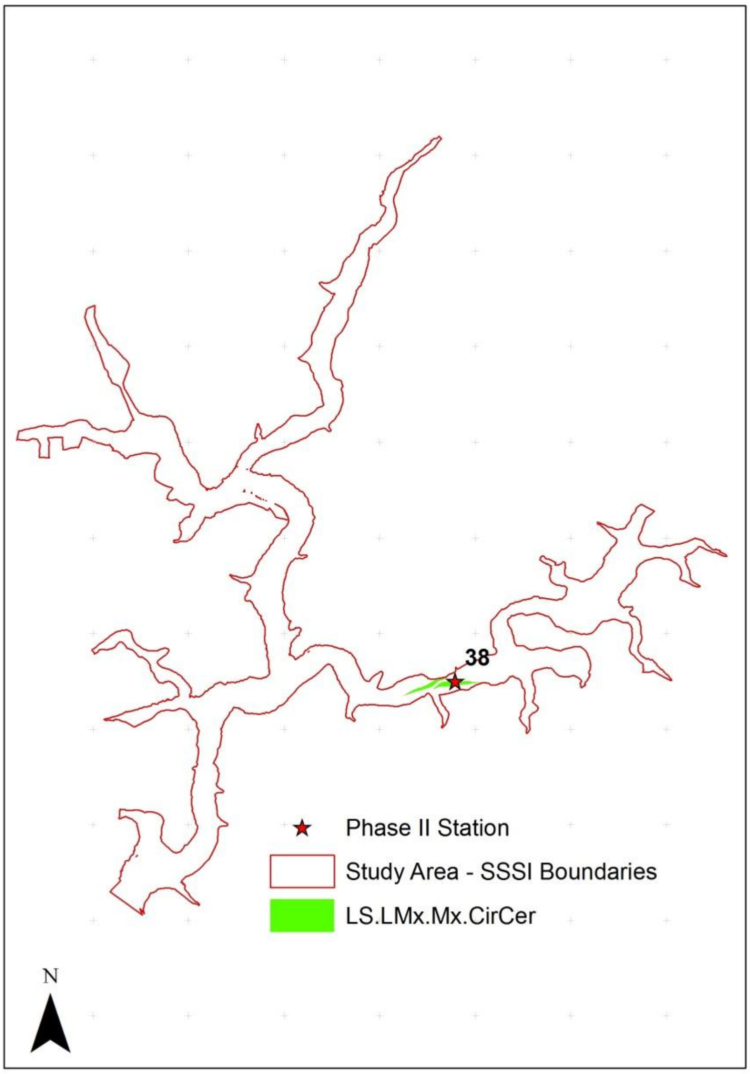


Figure 30. Extent and distribution of LS.LMx.GvMu.HedMx.Cir in the Upper Fal and Woods SSSI (Graticules represent 1km^2)



The sediments within the cores taken from this biotope are gravelly muddy sand with an additional larger pebble component where the biotope is present in the Fal (station 38). The percentage of carbon present within the sediments at the two stations is correspondingly small at 1.49 and 1.55 % at station 1 and 38 respectively. The depth of the redox discontinuity layers are broadly different however; within the Fal catchment the redox layer is present within the first 5cm of sediment, but was not visible (>20cm) in the Heflord catchment.

In terms of benthic faunal communities the average similarity between stations is extremely low at 11%. The low similarity figure was a result of the biotope at station 1 being assigned based primarily on Phase I field observations. It was necessary to use the Phase I data because the proportion of pebbles present within the faunal core resulted in only a small fraction of the faunal species being sampled; many of the species observed were present in the finer fractions of sediments below/between the pebbles and gravel.

The most abundant and frequently occurring species within the biotope according to the replicate infaunal cores is the Oligochaete *Tubificoides benedii*, however given a larger sample size and/or number of replicates it is expected that the cirratulid *Tharyx A* would be most abundant at both stations. Furthermore, the characterising species *Cerastoderma edule* was observed to be present in common abundance (SACFOR scale) during the Phase I but the numbers are not represented in the Phase II cores due to the small core size used. Juvenile Cardiacea species were however identified within the Phase II core from station 38 and it is expected that these would have developed into adult *Cerastoderma edule*.

As expected given the faunal sample issues the communities at the two stations display very different species richness and evenness values (see Table 40 below).

Table 39. Species % contribution in Fal and Helford Marine Sites LS.LMx.Mx.CirCer biotope

Species	Average Abundance Per Core	Average Similarity	% Contribution
Tubificoides benedii	26.39	7.83	71.01
Nematoda	20.00	3.20	28.99

Table 40. LS.LMx.Mx.CirCer biotope community analysis

Station	No. Taxa Per Core S	No. Individuals Per Core N	Margalef's Species Richness D	Pielou's Evenness J'	Shannon Wiener Index H'(log10)	Simpson Diversity Index 1-Lambada'
1	3	4000	0.2411	0.8319	0.9139	0.5364
38	18	41300	1.599	0.357	1.032	0.3821

Table 41. Fal and Helford Marine Sites LS.LMx.Mx.CirCer replicate core species composition

Species	38 No. m²	1 No. m²	Biotope Characterising Species Abundance
Capitella capitata agg	700		787
Capitellidae sp juv	300		*787*
Cardiacea juv	800		*638*
Mediomastus fragilis	1400		268
Pygospio elegans	400		608
Tharyx 'A'	32300		*18535*
Tubificoides benedii	800	600	7945
Tubificoides pseudogaster agg	2300		2938
Anaitides mucosa	100		
Cyathura carinata	200		
Enchytraeidae	0	2500	
Nematoda	100	900	
Nephtys hombergii	100		
Nereidae sp juv	200		
Polydora cornuta	100		
Scoloplos armiger	100		
Streblospio shrubsolii	200		
Polydora sp juv	100		

When considering the Phase I and Phase II observations collectively, the characteristics at the two distributions of the biotope correspond reasonably well with the LS.LMx.Mx.CirCer biotope described within The Marine Habitat Classification for Britain and Ireland (Vs 04.05), although there is some deviation from the faunal component.

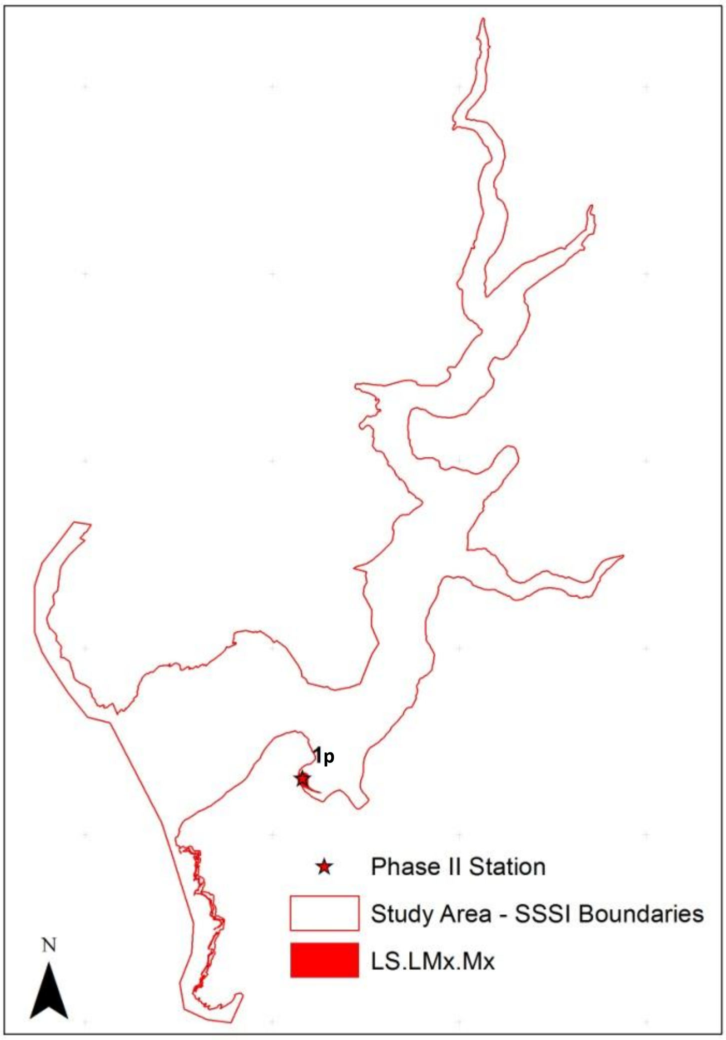
One of the most notable differences is the absence of one of the principal characterising species, the cirratulid *Aphelochaeta marioni*. However, the cirratulid *Tharyx A* is present in common to superabundant numbers; this may imply some type of ecological niche substitution within the Fal and Helford system by this other species of the same taxonomic family.

A number of other characteristic species are also absent; the polychaete *Exogone naidina* for example is absent but is expected to be abundant. Where characterising species are present however, their abundance is generally in line with that outlined in the biotope description. Smaller numbers of non-characterising species also contribute significantly to the species diversity at station 38 in the Fal.

3.4.14 LS.LMx.Mx

LS.LMx.Mx (Species rich mixed sediment shores) occurs in a small isolated patch within the lower Percuil in the Lower Fal and Helford Intertidal SSSI.

Figure 31. Extent and distribution of LS.LMx.Mx in the Percuil - Lower Fal and Helford Intertidal SSSI (Graticules represent $1km^2$)



The sediment within the biotope is comprised of pebbles with sandy gravel and some silt and clay, and contains a very low carbon content of 1.64%. The redox discontinuity level occurs within the first 1cm of the sediment surface.

Given the limited extent of this biotope only one target station was assigned. A total of 19 species was present within the core; the most abundant being two species of *Tubificoides*, unidentified nematodes, and the polychaetes *Malacoceros fuliginosis* and *Streblopsio shrubsolii*.

Table 42.LS.LMx.Mx biotope community analysis

Station	No. Taxa Per Core S	No. Individuals Per Core N	Margalef's Species Richness D	Pielou's Evenness J'	Shannon Wiener Index H'(log10)	Simpson Diversity Index 1-Lambada'
1p	19	34000	1.725	0.6211	1.829	0.7695

Table 43. Fal and Helford Marine Sites LS.LMx.Mx core species composition

Species	1 No. m^2	Biotope Characterising Species Abundance
Capitella capitata agg	500	787
Cardiacea juv	300	*638*
Pygospio elegans	600	608
Tubificoides unident	12400	*2938*
Tubificoides benedii	7000	7945
Abra tenuis	200	
ACTINIARIA unident	200	
Anaitides mucosa	500	
Aonides oxycephala	300	
Arenicola marina	100	
Eteone longa agg	200	
Fabricia sabella	100	
Glycera tridactyla	100	
Hydrobia ulvae	100	
Malacoceros fuliginosus	1700	
Manayunkia aestuarina	300	
Nematoda	7500	
Nereidae sp juv	100	
Streblospio shrubsolii	1800	

The station characteristics correspond reasonably well with the LS.LMx.MX biotope described within The Marine Habitat Classification for Britain and Ireland (Vs 04.05). Elements of the faunal component do vary from that expected in the biotope description, for example only 5 of the possible 13 characterising species are present. Those characterising species which are present are observed in numbers in-line with those expected for the biotope, with the exception of an unidentified *Tubificoides* species which is an order of magnitude greater in abundance. A number of non-characterising species are present however and significantly add to the overall species diversity. Given the limited sampling effort and the taxa identified within the core, the biotope cannot be defined further.

3.4.15 LS.LSa.MoSa.Ol.VS

LS.LSa.MoSa.Ol.VS (Oligochaetes in variable salinity littoral mobile sand) occurs in a small area at the lowest extent of littoral sediment in the Percuil estuary and on the extreme low shore banks within the Fal tributary of the Upper Fal and Woods SSSI.

Figure 32. Extent and distribution of LS.LSa.MoSa.Ol.VS in the Percuil - Lower Fal and Helford Intertidal SSSI (Graticules represent 1km^2)

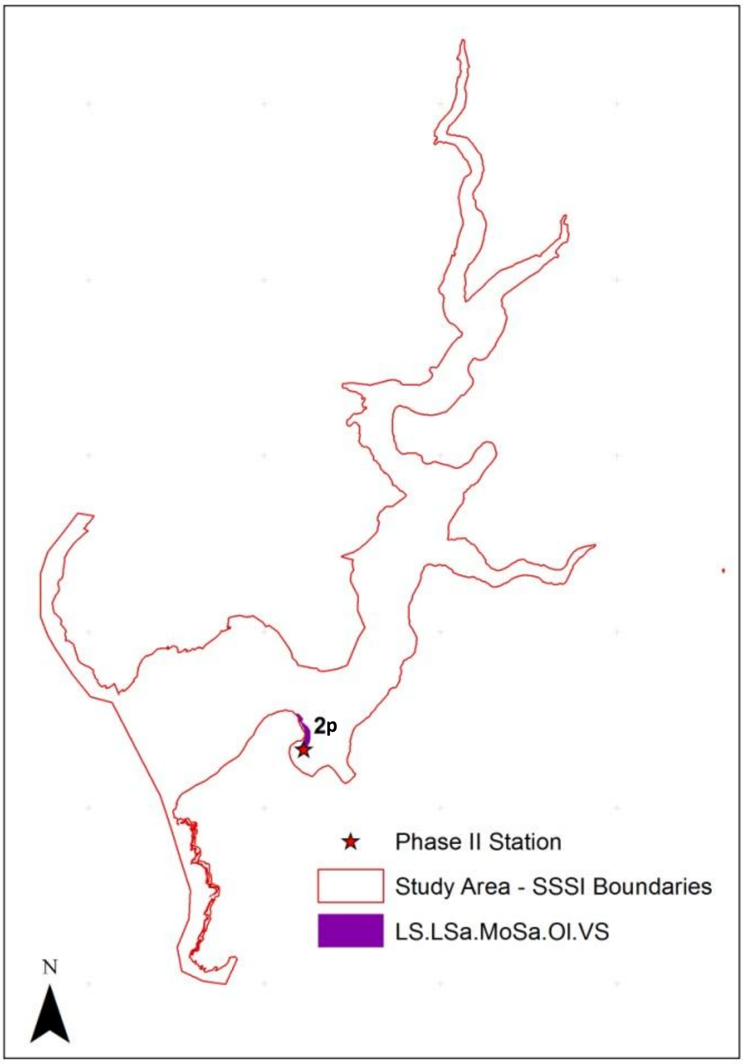
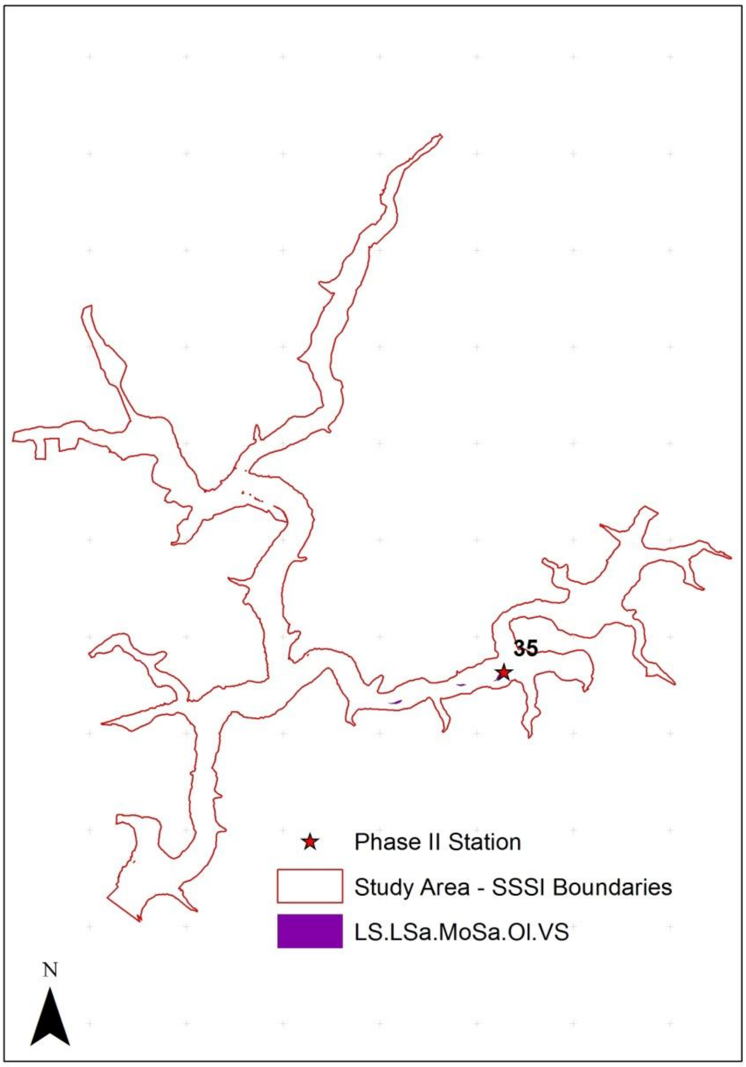


Figure 33. Extent and distribution of LS.LSa.MoSa.Ol.VS in the Upper Fal and Woods SSSI (Graticules represent 1km^2)



The sediment within the biotope is gravelly muddy sand with a small silt and clay fraction, though station 2p in the Percuil also contains a larger pebble component which accounts for 20% of the total sediment at the station. Both stations have a very low carbon content of 1.5 and 0.63 and the redox discontinuity layer was not detected at either station (>20cm).

In terms of benthic faunal communities the average similarity between stations is low at 19.59%. The low similarity figure is likely to be as a result of the distribution of the biotope in different catchments. The number of taxa ranges between 3 and 13. Station 35 in the Fal is more exposed to tidal scouring effects than station 2p, and this is reflected in the faunal communities which are far less rich, diverse and even, as only a limited number of species are able to inhabit the harsh frequently changing environment.

The most abundant species within the biotope according to the replicate infaunal cores are *Enchytraeidae* Oligochaetes and nematodes (neither of which are identified to species level).

Table 44. Species % contribution in LS.LSa.MoSa.Ol.VS biotope

Species	Average Abundance Per Core	Average Similarity	% Contribution
Enchytraeidae	63.24	15.57	79.48
Nematoda	56.48	4.02	20.52

Table 45. LS.LSa.MoSa.Ol.VS biotope community analysis

Station	No. Taxa Per Core S	No. Individuals Per Core N	Margalef's Species Richness d	Pielou's Evenness J'	Shannon Wiener Index H'(log10)	Simpson Diversity Index 1-Lambada'
2p	13	25300	1.184	0.6394	1.64	0.7196
35	3	1700	0.2689	0.4039	0.4438	0.2147

Table 46. LS.LSa.MoSa.Ol.VS biotope replicate core species composition

Species	2 No. m²	35 No. m²	Biotope Characterising Species Abundance
Enchytraeidae	7700	1500	389
Grania sp	100		*2045*
Nematoda	10600	100	37
Tubificoides benedii	1700		*2045*
Abra tenuis	100		
Carcinus maenas	400		
Cardiacea juv	100		
Fabricia sabella	100		
Golfingia vulgaris	1400		
Mediomastus fragilis	600		
Pygospio elegans	1300		
Sphaeroma rugicauda	600		
Tharyx 'A'	600		

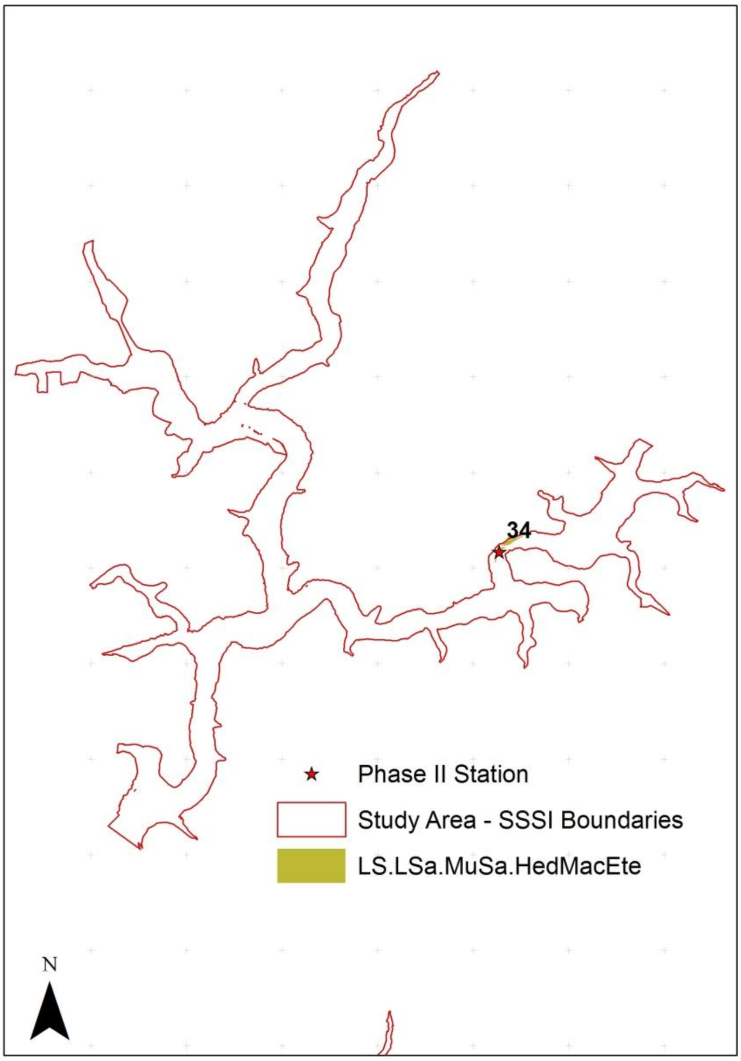
The station characteristics correspond reasonably with the LS.LSa.MoSa.Ol.VS biotope described within The Marine Habitat Classification for Britain and Ireland (Vs 04.05), the only deviation being aspects of the faunal component.

Station 35 contains only two of the four characterising species, whilst station 2 contains all characterising species as well as additional non characterising species which add significantly to the species diversity at the station. The abundance of the *Enchytraidae* are two orders of magnitude greater than expected at both stations, and Nemtodes are between 5 times and 3 orders of magnitude greater in numbers. *Grania sp* and *Tubificoides benedii* are absent within the Fal however. As stated above, the differences in communities observed within the two catchments are thought to be primarily as a result of the different exposure to tidal scouring, but also due to the different biotopes found adjacent on the shore.

3.4.16 LS.LSa.MuSa.HedMacEte

LS.LSa.MuSa.HedMacEte (*Hediste diversicolor, Macoma balthica* and *Eteone longa* in littoral muddy sand) occurs in a single area within the Fal tributary of the Upper Fal and Woods SSSI only, where it found on the lower shore. The distribution is split by the main channel of the Fal.

Figure 34. Extent and distribution of LS.LSa.MuSa.HedMacEte in Upper Fal and Woods SSSI (Graticules represent 1km^2)



The sediment within the biotope is gravelly muddy sand with a small silt and clay element, with a relatively low carbon content of 4.03%. The redox discontinuity level occurs between 5 and 20cm of the sediment surface.

Given the limited extent of this biotope only one target station was assigned. A total of 12 species was present within the core; the most abundant species were the oligochaetes *Tubificoides pseudogaster agg., Tubificoides benedii*, Nematodes and the polychaete *Eteone longa agg*. Species richness and diversity within the biotope is comparable to most of the other biotopes identified within the study area.

Table 47. LS.LSa.MuSa.HedMacEte biotope community analysis

Station	No. Taxa Per Core S	No. Individuals Per Core N	Margalef's Species Richness d	Pielou's Evenness J'	Shannon Wiener Index H'(log10)	Simpson Diversity Index 1-Lambada'
34	12	12200	1.169	0.74	1.839	0.7913

Table 48. Fal and Helford LS.LSa.MuSa.HedMacEte replicate core species composition

Species	34 No. m²	Biotope Characterising Species Abundance
Eteone longa agg	400	275
Nematoda	1800	536
Nereidae sp juv	100	*665*
Pygospio elegans	100	1043
Tubificoides benedii	2300	*5060*
Tubificoides pseudogaster agg	4300	*5060*
Fabricia sabella	100	
Malacoceros fuliginosus	300	
Mediomastus fragilis	100	
Notomastus sp	200	
Streblospio shrubsolii	1800	
Tharyx 'A'	700	

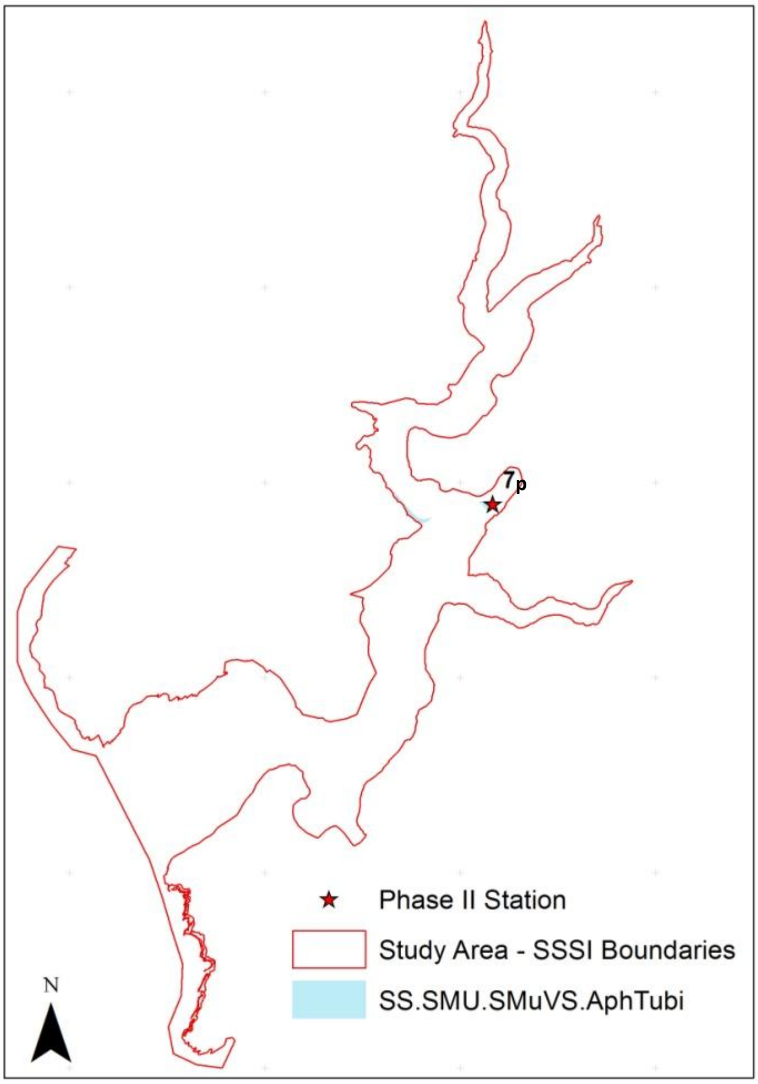
The station characteristics correspond reasonably well with the LS.LSa.MuSa.HedMacEte biotope described within The Marine Habitat Classification for Britain and Ireland (Vs 04.05), though there are components of the sediment character, height band and faunal component which deviate from that expected for the biotope.

The sediment has an additional gravel component and also occurs lower on the shore than expected which may help account for some of the faunal deviation. In terms of the faunal communities, 5 of the 11 characterising species are present. Most notably the main characterising species *Hediste diversicolor* was not present in cores; juvenile *Nereidae sp* were identified however and it is expected that these would have developed into *Hediste diversicolor* as adults given that no other *Nereidae sp* were identified within the study area. The characterising species which were present were generally in numbers less than expected, with the exception of Nematodes and *Eteone longa agg*. which were greater in numbers. The non-characterising spionid *Streblospio shrubsolii* was present in abundant numbers though there is no ecological explanation for this.

3.4.17 SS.SMU.SMuVS.AphTubi

SS.SMU.SMuVS.AphTubi (*Aphelochaeta marioni* and *Tubificoides spp*. in variable salinity infralittoral soft mud) occurs only in the Percuil within the Lower Fal and Helford Intertidal SSSI, where is occupies both banks in the mid regions of estuary on the lower shore.

Figure 35. Extent and distribution of SS.SMU.SMuVS.AphTubi in the Percuil - Lower Fal and Helford Intertidal SSSI (Graticules represent 1km^2)



The sediment within the biotope is muddy fine sand with a particularly large silt fraction and some clay. The carbon content within the sediment accounts for 7.35%. The redox discontinuity level occurs between 1 and 5cm of the sediment surface.

Given the limited extent of this biotope only one target station was assigned. A total of 7 species was present within the core; the most abundant species was the oligochate *Tubificoides pseudogaster agg.,* followed by juvenile *Nephtys spp* and *Tharyx 'A'* polychaetes.

Table 49. SS.SMU.SMuVS.AphTubi biotope community analysis

Station	No. Taxa Per Core S	No. Individuals Per Core N	Margalef's Species Richness d	Pielou's Evenness J'	Shannon Wiener Index H'(log10)	Simpson Diversity Index 1-Lambada'
7p	7	3300	0.7406	0.83	1.615	0.7477

Table 50. Fal and Helford Marine Sites SS.SMU.SMuVS.AphTubi replicate core species composition

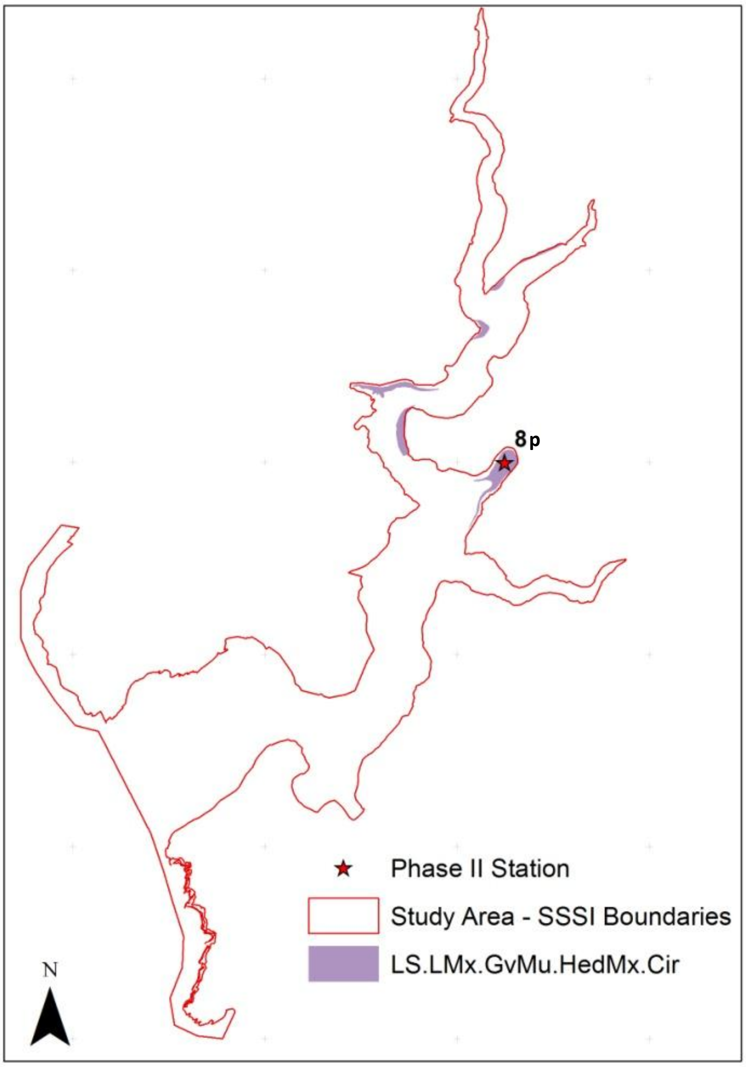
Species	7 No. m²	Biotope Characterising Species Abundance
Cardiacea juv	100	*17*
Melinna palmata	100	250
Nephtys sp juv	600	30
Tharyx 'A'	400	1328
Tubificoides pseudogaster agg	1400	186
Cossura sp	300	
Hydrobia ulvae	400	

The station characteristics correspond plausibly with the SS.SMU.SMuVS.AphTubi biotope described within The Marine Habitat Classification for Britain and Ireland (Vs 04.05), though most obviously the biotope is not totally subtidal; it is therefore likely that the biotope is exposed only during spring tides. As such the faunal component of the biotope is less diverse than would be expected from a fully sublittoral SS.SMU.SMuVS.AphTubi biotope; just 5 of the possible 23 characterising species are present. In addition, the main characterising cirratulid species *Aphelochaeta marioni* appears to have been substituted by the cirratulid *Tharyx A* which is common to intertidal habitats suggesting an ecological niche substitution by the better adapted intertidal species. The abundance of some of the characterising species which are present is greater than expected, this is particularly the case for *Nephtys spp* and *Tubificoides pseudogaster agg*.; whilst the abundance of other species i.e. *Melinna palmata* is lower than expected.

3.4.18 LS.LMx.GvMu.HedMx.Cir

LS.LMx.GvMu.HedMx.Cir (Hediste diversicolor, Cirratulids and Tubificoides spp. in littoral gravelly sandy mud) occupies both banks in the mid reaches of the Percuil estuary within the Lower Fal and Helford Intertidal SSSI. The biotope is absent from other catchments in the study area.

Figure 36. Extent and distribution of LS.LMx.GvMu.HedMx.Cir in the Percuil - Lower Fal and Helford Intertidal SSSI (Graticules represent 1km^2)



The sediment within the biotope is gravelly muddy sand with a strong pebble component. The proportion of carbon present within the sediment is 3.45%. The redox discontinuity level occurs between 1 and 5cm of the sediment surface.

Following the Phase I survey the distribution of the biotope was underestimated and therefore just a single target station was assigned. A total of 14 species was present within the core; by far the most abundant species was the cirratulid *Tharyx 'A'* followed by the *Tubificoides spp.* and the spionids *Streblospio shrubsolii* and *Pygospio elegans.*

Table 51. LS.LMx.GvMu.HedMx.Cir biotope community analysis

Station	No. Taxa Per Core S	No. Individuals Per Core N	Margalef's Species Richness d	Pielou's Evenness J'	Shannon Wiener Index H'(log10)	Simpson Diversity Index 1-Lambada'
8p	14	53800	1.193	0.5295	1.397	0.5912

Table 52. Fal and Helford Marine Sites LS.LMx.GvMu.HedMxCir replicate core species composition

Species	8 No. m²	Biotope Characterising Species Abundance
Pygospio elegans	3400	15
Streblospio shrubsolii	3800	984
Tharyx 'A'	33300	*145*
Tubificoides benedii	4900	106
Tubificoides pseudogaster agg	1000	150
Nereidae sp juv	1200	1040
Capitella capitata agg	700	
Cardiacea juv	400	
Crangon sp juv	100	
Heteromastus filiformis	4600	
Melinna palmata	100	
Nephtys hombergii	100	
Polydora cornuta	100	
Tipulidae	100	

The station characteristics correspond well with the LS.LMx.GvMu.HedMx.Cir biotope described within The Marine Habitat Classification for Britain and Ireland (Vs 04.05), the only deviation being aspects of the faunal component.

The principal characterising species Cirratulids (*Tharyx ‘A’*) and *Tubificoides spp.* (*Tubificoides benedii*) are present in superabundance. However, the ragworm *Hediste diversicolor* is absent despite being observed in the field during the Phase I Survey. Juvenile Nereidae were captured within the core however, and given that *Hediste diversicolor* is the only Nereidae species that has been observed in any of the study areas it is likely that the juveniles would have developed into *Hediste diversicolor*. 4 of the total 10 characterising species listed are not present. The presence of the cirratulid *Tharyx ‘A’* and not the characterising cirratulids species *Tharyx killariensis* may imply some type of ecological niche substitution by the *Tharyx ‘A’* species, as also suggested elsewhere in this study. A number of other non-characterising species are also present, significantly adding to the overall species diversity observed within the core.

Most notable within the biotope is the abundance of both characteristic and non-characteristic species. *Heteromastus filiformis* for example is present in abundance whilst many of the characterising species are present in numbers an order of magnitude greater than would be expected. Exceptionally, *Tharyx 'A'* is present in numbers two orders of magnitude greater than expected.

Sections 3.4.19 to 3.4.20 describe biotopes where no faunal cores, PSA or LOI were taken because they do not fall within the predetermined transects and or they occupy only a very small area. These biotopes were therefore assigned accordingly based on field observations.

3.4.19 SS.SMx.IMxOst

SS.SMx.IMxOst (Ostrea edulis beds on shallow sublittoral muddy mixed sediment) only occurs in the Percuil estuary, on the eastern bank of the river.

Figure 37. Extent and distribution of LS.LMx.GvMu.HedMx in the Percuil - Lower Fal and Helford Intertidal SSSI (Graticules represent 1km^2)

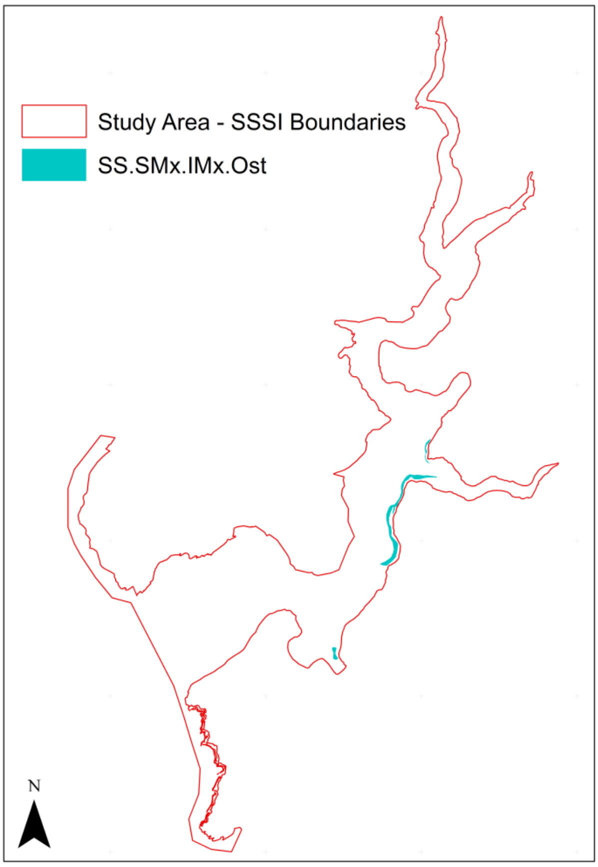
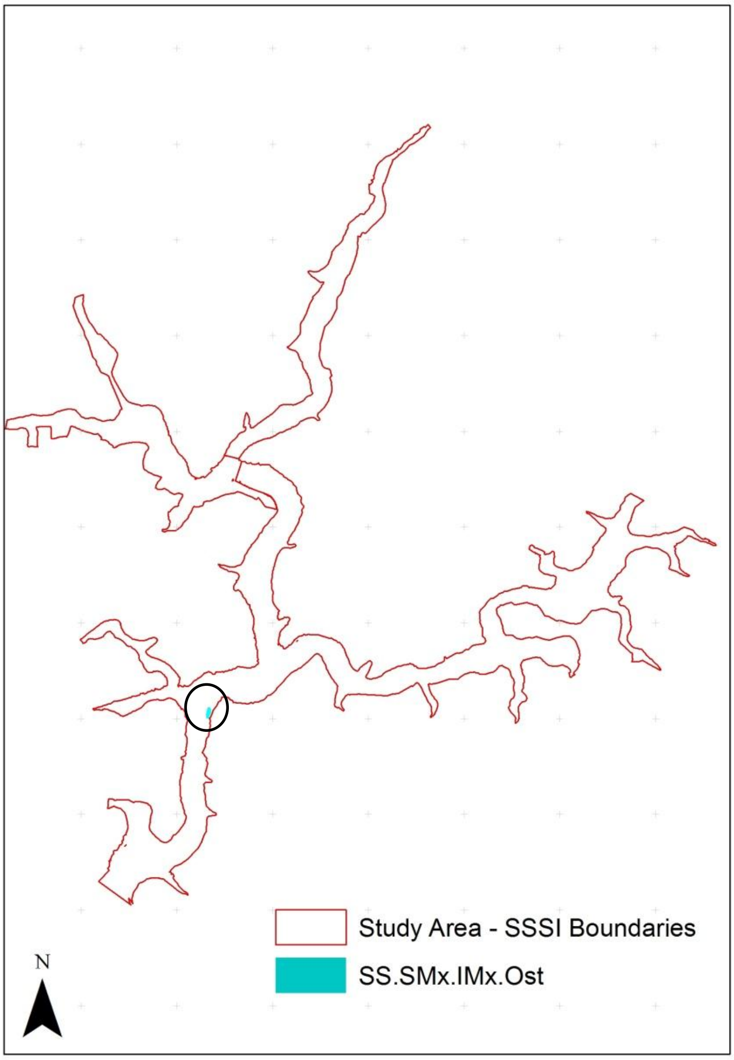


Figure 388. Extent and distribution of LS.LMx.GvMu.HedMx in the Fal - Upper Fal Estuary and woods SSSI (Graticules represent 1km^2)



Field observations determined the sediment to be mixed pebbles, gravel, fine sand and mud.

Using the SACFOR scale the fauna within the biotope is comprised of common numbers of the BAP species *Ostrea edulis*, frequent numbers of the polychaetes *Melinna Palmata* and *Hediste diversicolor*, and occasional *Arenicola marina* and the non-native *Crepidula fornicata*.

Given the list of species observed in the field the biotope characteristics correspond reasonably with the SS.SMx.IMxOst biotope described within The Marine Habitat Classification for Britain and Ireland (Vs 04.05), with the obvious deviation of the biotope within this study being intertidal rather than subtidal; it is likely that the biotope is only exposed during spring tides. Other deviations from the habitat description also include stronger tidal streams and lower density of *Ostrea edulis* than expected for SS.SMx.IMxOst biotope. Most notably is the presence of the non-native mollusc *Crepidula fornicata*.

3.4.20 LS.LCS.Sh

The LS.LCs.Sh (Shingle, pebble and gravel shores) biotope was present within the Percuil estuary on the western bank, and in the outer Helford in Gillan creek.

Figure 39. Extent and distribution of LS. LS.LCs.Sh in the Percuil - Lower Fal and Helford Intertidal SSSI (Graticules represent 1km2)

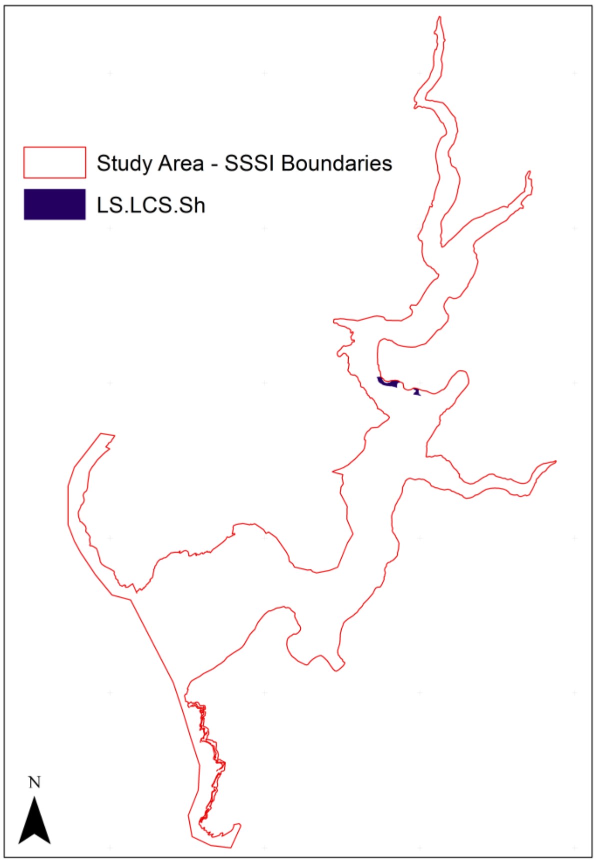
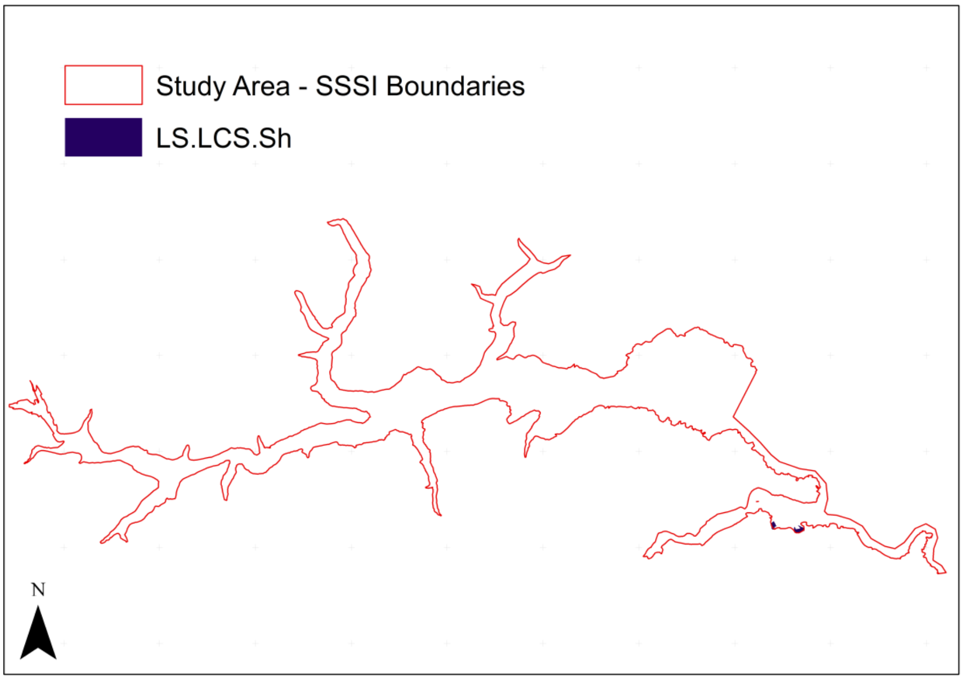


Figure 40. Extent and distribution of LS. LS.LCs.Sh in the Helford - Lower Fal and Helford Intertidal SSSI (Graticules represent 1km2)



Field observations determined the sediment to be mixed shingle gravel and coarse sand which was highly compacted in some areas, particularly where boat retrieval activity was concentrated around slipways. The sediments has little or no fine silt content and appeared to dry between the tides. No fauna was observed.

The station characteristics corresponds well with the LS.LCS.Sh biotope biotope described within The Marine Habitat Classification for Britain and Ireland (Vs 04.05).

3.5 Faunal Biomass

This chapter describes the faunal species and groups which account for the biomass within the SSSI study areas, biotopes and individual stations. It should be noted however that as explained in Chapter 3 above, some species are under-represented by the cores due to the core size and low number of replicates in some cases. Therefore species including *Cerastoderma edule*, *Macoma balthica*, *Mytilus edulis* and *Lanice conchilega* are also under-represented in terms of biomass. In addition the biotope SS.SMx.IMxOst was not subject to faunal sampling and therefore its biomass is not represented at all.

Tables 53 to 55 below list the top five species that contribute the most to biomass within each of the three SSSIs. The biomass within all three SSSIs (the Malpas Estuary SSSI, Upper Fal Estuary and Woods SSSI and the Lower Fal and Helford Intertidal SSSI) is dominated by bivalve species; *Cerastoderma edule* accounts for the greatest contributions. In the Malpas Estuary SSSI and Upper Fal Estuary and Woods SSSI the bivalve *Scrobicularia plana* also accounts for the third largest proportion, whilst *Venerupis senegalensis* accounts for the second largest proportion in the Lower Fal and Helford Intertidal SSSI. The gastropod *Hydrobia ulvae* accounts for the second largest proportion of biomass within both the Malpas Estuary SSSI and Upper Fal Estuary and Woods SSSI.

Polychaetes are also present in the top 5 species which contribute to biomass within the SSSIs. *Hediste diversicolor* is in the top 5 contributing species within the Malpas Estuary SSSI and Upper Fal Estuary and Woods SSSI, though the species contributes less than 1% to the overall biomass within cores. *Arenicola marina* is in the top 5 contributing species within the Lower Fal and Helford Intertidal SSSI, though this species also contributes less than 1% to the overall biomass within the SSSI.

Table 53. Top 5 species contributing to biomass in Malpas Estuary SSSI

Species	Average Biomass Per Core (g)	% Contribution
Cerastoderma edule	1.430	83.00
Hydrobia ulvae	0.615	11.60
Scrobicularia plana	0.311	3.00
Macoma balthica	0.143	2.05
Hediste diversicolor	0.053	0.13

Table 54. Top 5 species contributing to biomass in Upper Fal and Woods SSSI

Species	Average Biomass Per Core (g)	% Contribution
Cerastoderma edule	0.953	92.09
Hydrobia ulvae	0.176	5.17
Scrobicularia plana	0.127	2.30
Hediste diversicolor	0.052	0.34
Nephtys hombergii	0.029	0.04

Table 55. Top 5 species contributing to biomass in Lower Fal and Helford Intertidal SSSI

Species	Average Biomass Per Core (g)	% Contribution
Cerastoderma edule	1.900	71.41
Venerupis senegalensis	1.400	28.30
Arenicola marina	0.073	0.15
Hydrobia ulvae	0.106	0.13
Macoma balthica	0.012	0.001

Table 56 below lists the biotopes where more than one faunal core was taken and outlines the three species in each which contribute the most biomass within that biotope. The bivalves *Cerastoderma edule* and Scrobicularia plana re-occur as a significant contributor within a number of the biotopes where just a few individuals account for a large biomass contribution. The gastropod *Hydrobia ulvae* and polychaete *Nephtys hombergii* also appears frequently in the table; however, in contrast to the bivalve species these species biomass represents large numbers of individuals.

Table 56. Top 3 species contributing to biomass in each biotope where more than one station was assigned

Biotope	Species	Average Biomass Per Core (g)	% Contribution
LS.LBR.LMus.Myt.Mx	*Cerastoderma edule*	20.400	85.15
	Venerupis senegalensis	8.4800	14.66
	Arenicola marina	0.9440	0.18
LS.LMu.MEst.HedMacScr	*Hydrobia ulvae*	0.4160	69.48
	Scrobicularia plana	0.3380	26.39
	Hediste diversicolor	0.1940	3.71
LS.LMU.MEst.HedMacScr with *Cerastoderma edule* present	*Cerastoderma edule*	0.9640	77.83
	Hydrobia ulvae	0.7440	21.00
	Scrobicularia plana	0.0988	0.82
LS.Lmu.Mest.NhomMacStr	*Macoma balthica*	0.0677	78.89
	Hydrobia ulvae	0.0396	10.29
	Nephtys hombergii	0.0377	7.78
LS.LMu.UEst.NhomStr	*Tubificoides benedii*	0.0315	68.54
	Hydrobia ulvae	0.0147	18.71
	Nephtys hombergii	0.0081	6.23
LS.LMx.Mx.CirCer	*Scoloplos armiger*	0.0570	57.15
	Tharyx 'A'	0.0356	22.28
	Nephtys hombergii	0.0323	18.33
LS.LSa.MoSa.Ol.VS	*Carcinus maenas*	0.0991	99.35
	Hydrobia ulvae	0.0039	0.15
	Abra tenuis	0.0037	0.14
LS.LSa.MuSa.CerPo	*Cerastoderma edule*	2.6400	97.10
	Hydrobia ulvae	0.3010	1.73
	Scrobicularia plana	0.1420	0.71
LS.LSa.MuSa.CerPo -Impoverished	*Tubificoides benedii*	0.0193	51.91
	Hydrobia ulvae	0.0089	21.64
	Pygospio elegans	0.0076	15.03
LS.Lsa.MuSa.Lan	*Venerupis senegalensis*	5.1900	86.94
	Cerastoderma edule	2.0100	13.05
	Lanice conchilega	0.0313	<0.01
SS.SMx.SMxVS.CreMed	*Melinna palmata*	0.0951	91.18
	Nephtys hombergii	0.0109	8.52
	Mediomastus fragilis	0.0161	0.13

Table 56 provides average biomass values for a station within each biotope. On average LS.LBR.LMus.Myt.Mx, LS.Lsa.MuSa.Lan, LS.LMp.LSgr.Znol and LS.LSa.MuSa.CerPo have the greatest biomass. It may therefore be deduced that these biotopes have the potential to be the most important in terms of bird feeding grounds; however, this is difficult to substantiate given the limited sampling effort within the study.

Table 57. Average biomass at each station within each biotope

Species	Average Biomass (g)
LS.Lsa.MuSa.HedMacEte	0.01918
SS.SMU.SMuVS.AphTubi	0.05249
LS.LSa.MuSa.CerPo - Impoverished	0.05633
LS.LBR.LMus.Myt.Mu	0.05952
LS.LMu.UEst.NhomStr	0.07838
LS.LSa.MoSa.Ol.VS	0.12139
SS.SMx.SMxVS.CreMed	0.13554
LS.LMx.Mx.CirCer	0.14866
LS.LMx.Mx	0.18435
LS.Lmu.Mest.NhomMacStr	0.22220
LS.LMx.GvMu.HedMx.Cir	0.61209
LS.Lmu.Uest.Hed.Str	0.67392
LS.LMU.MESt.HedMacScr	1.03645
LS.LMU.MESt.HedMacScr with *Cerastoderma edule* present	1.97093
LS.LSa.MuSa.CerPo	3.25988
LS.LMp.LSgr.Znol	6.08668
LS.Lsa.MuSa.Lan	7.33692
LS.LBR.LMus.Myt.Mx	30.0179

Individually Station 18 (a LS.LSa.MuSa.CerPo biotope) and Station 5 (a LS.LBR.LMus.Myt.Mx) had the greatest faunal biomass within a core at 11.81g and 60.03g respectively, both stations are located within the Helford Estuary.

4. Univariate and Multivariate Analysis

The results of the univariate analysis have been incorporated into the relevant chapters in Section 3 above.

Community analysis in PRIMER[30] used the multi-variate Bray-Curtis similarity statistic and multidimensional scaling (MDS) plots to assess the communities at each target station. MDS plots represent the sample points in three dimensions where the distances between points represent the dissimilarities between the samples. In order to reduce the influence of very abundant taxa on the analysis, the benthic invertebrate data set was subjected to a single square root transformation prior to fauna similarity analysis.

The MDS output in figures 40 and 41 below represent the replicate cores from all biotopes in which more than one replicate was taken (the plot therefore excludes those biotopes of limited size and/or distribution).

Figure 41. Three dimensional MDS plot

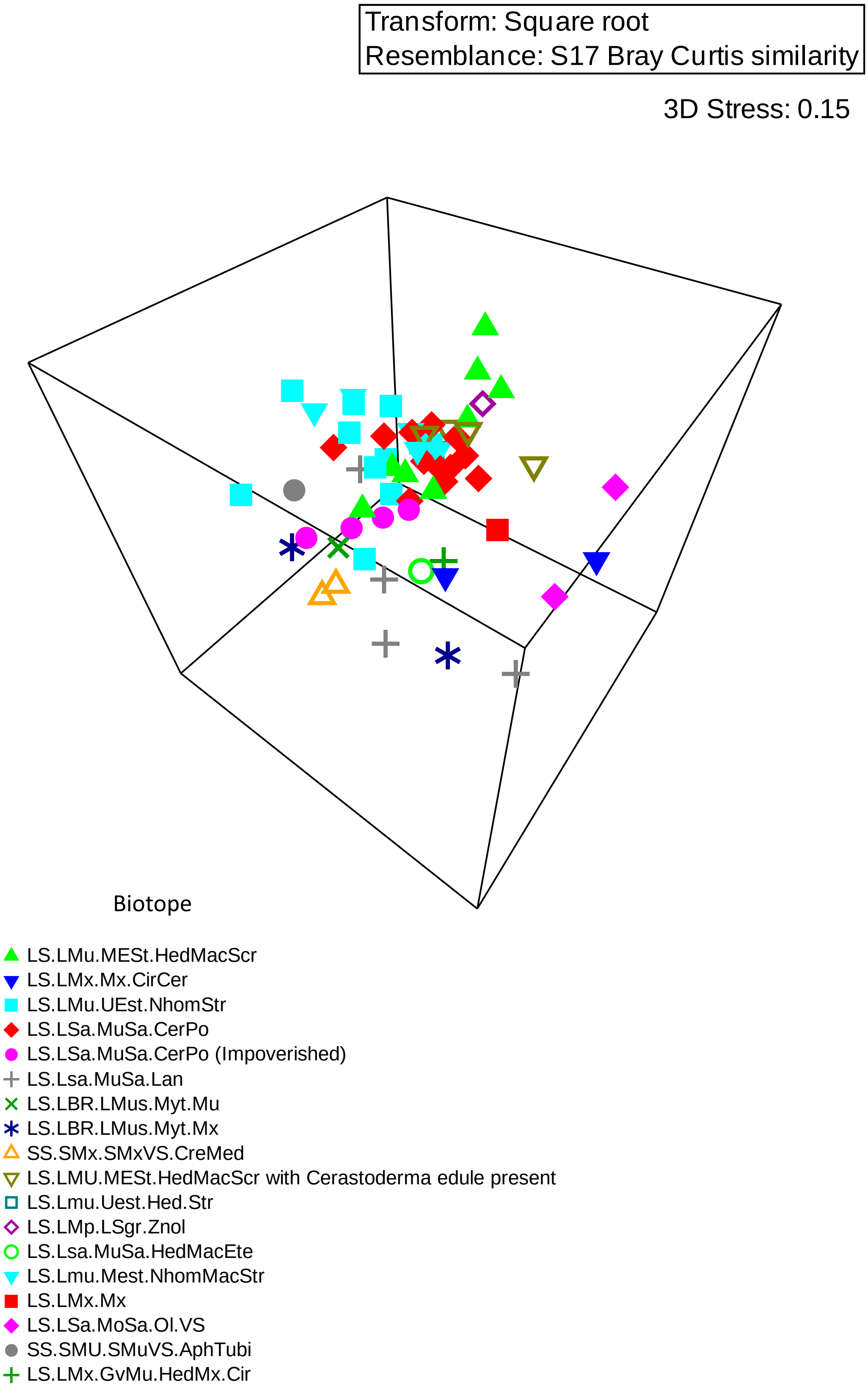
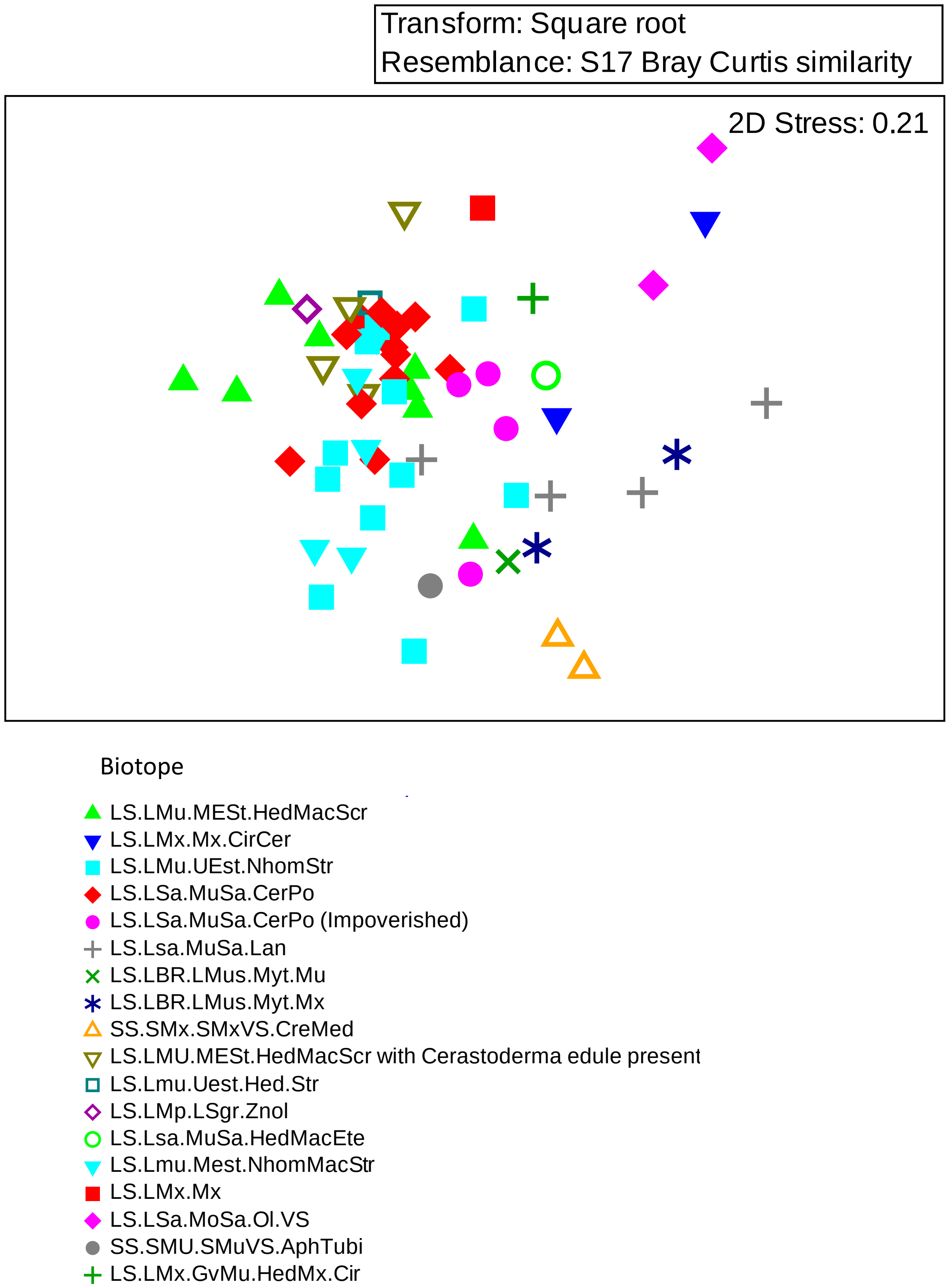


Figure 42. Two dimensional MDS plot



The plots demonstrate a reasonably good similarity and therefore grouping of replicates from the same biotopes. Some biotopes do however demonstrate better Bray-Curtis similarity values than others. The SS.SMx.SMxVS.CreMed biotope for example has the highest Bray-Curtis value of 65.5%, whilst the LS.LMx.Mx.CirCer biotope has the lowest value at 11.03%.

A number of factors contribute to weak similarities between biotope replicates and are likely to include the fact that the study was spread throughout three sub catchments (Fal, Helford and Percuil) resulting in different environmental variables within each, that subsequently influence the same biotope communities differently. Low similarity values are also likely to result in biotopes such as SS.SMx.SMxVS.CreMed and LS.LSa.MuSa.Lan, where the main characterising species (i.e. *Crepidula fornicata* and *Lanice conchilega* respectively) were not consistently captured in cores due to the core size and low sample replication.

5. Discussion

5.1 Condition Assessment

5.1.1 Mudflats and Sandflats

Although previous data exists for the Fal and Helford Marine Sites [11-18] it is not extensive or targeted enough to provide a thorough baseline data set under Common Standards Monitoring (CSM). As a result, in terms of condition assessment, comparison of this study with previous studies is not possible. Instead, professional judgment based on observations and information gathered during the survey has been used to inform the condition of the Malpas Estuary, Upper Fal Estuary and Woods and Lower Fal and Helford Intertidal SSSIs. This study will however provide a comprehensive baseline from which change can be measured within any future condition assessments. The attributes and measures that were included within this study are as follows:

- Sediment character: Organic carbon content, oxidation-reduction profile (Redox layer) and sediment type.
- Extent and distribution of biotopes
- Extent of sub-feature or representative/ notable biotopes
- Biotope composition of littoral sediment
- Species composition of representative or notable biotopes
- Species population measures: Population structure of a species and presence or abundance of specified species

(Topography was outside of the remit of this study)

The determination of sediment character was carried out using methods that included loss on ignition analysis (to determine organic carbon content), particle size analysis using dry sieving and laser diffraction methods and Redox discontinuity according to the MNCR scale. The littoral sediment habitats and communities present were determined using the JNCC Marine Habitat Classification for Britain and Ireland Version 04.05[26]. All information gathered was digitised to produce a comprehensive map in GIS that both illustrates the distribution and extent of the biotopes identified within the study areas, and outlines the detailed physical and biological data within the attribute layers. The GIS also enabled the total area encompassed by each biotope to be accurately estimated and presented in results. Two statistical methods were used to interrogate the faunal data, a uni-variate approach using species diversity statistics and a multi-variate community analysis approach. The faunal analysis provides a clearly defined quantitative baseline of faunal characteristics that can be used to facilitate a more robust condition assessment of the Fal and Helford Marine Sites in the future.

In respect of the current condition of the interest features, parts of Fal and Helford, notably the upper Fal estuary, have been identified at least historically as having a tendency towards being eutrophic [20]. Observations made during the study, namely the presence of the green algae's *Ulvae* and *Enteromorphae* in all tributaries, even in winter months, suggest that this is potentially still the case within the three SSSIs studied, though the Percuil estuary within the Lower Fal and Helford Intertidal SSSI appears to be the least affected. The redox layer was present within the first 5cm (and often within the first 1cm) of sediment throughout the mid and upper shores of the Upper Fal Estuary and Woods SSSI, a parameter which can also indicate eutrophic conditions.

An explanation for the presence of what has been labelled for the purpose of this study as 'impoverished' LS.LSa.MuSa.CerPo (where the biotope fits best with the LS.LSa.MuSa.CerPo biotope but where abundance of the cockle *Cerastoderma edule* is low) is not available without further investigation. It may be the case that these communities are simply transitional, or that the presence of opportunistic algal mats in some areas has led to smothering of the cockle beds. There has also been some studies to suggest that contamination of sediments by Cu and Zn act to inhibit the settlement of juvenile bivalves, including *Cerastoderma edule*, in some parts of the Fal estuary [20]; though this is considered to be a less likely scenario given the high abundance of *Cerastoderma edule* within the LS.LMu.MEst.HedMacScr biotope (labelled as LS.LMu.MEst.HedMacScr with *Cerastoderma edule* for the purpose of this study).

There is some evidence of biological disturbance through the selective extraction of species, namely the presence of peeler crab traps. Traps were observed to be present within the Helford on the southern bank of the River adjacent to Helford village. Traps were also present in the Fal on both the east and west banks adjacent to Polgerran Wood, Trevean, Higher Trelease, St Clement and within Cowlands Creek. Peeler crab traps were less common in the Percuil and only observed in the creek south of Trewince. Bait digging was also being carried out in the Helford on the west bank between Groyne Point and Polpenwith. The placing of crab traps on intertidal sediments may change sediment characteristics by affecting water and oxygen exchange and sedimentation rates [23], as well alter trophic interactions within an ecosystem. Despite the potentially negative influences of the selective extraction of species within all three of SSSIs studied; at present such activity is not thought to be at a scale which threatens the overall condition of the intertidal designated features of interest.

The sediment within the Fal tributary of the Upper Fal and Woods SSSI (above Philleigh and Nancarrow) did have a different consistency compared to the remainder of the study areas, with a particularly compacted silt and clay element. These properties were not however distinguished within the particle size analysis, but did have comparatively low carbon content when compared to other sediments with similar proportions of silt and clay. It is suspected that the sediment composition has been altered by the presence of the china clay industry upstream within the River Fal and the associated historical unconsented discharges (one such discharge occurred in 2000 when part of a tailings dam collapsed, releasing waste into the River Fal[20]). Siltation of the estuary bed or intertidal communities may therefore have occurred within the Fal tributary of the Upper Fal and Woods SSSI, though given the lack of previous comparable studies the extent of this siltation and its potential effect on the intertidal communities cannot be determined. It is also likely that any historical siltation of the estuary bed or intertidal communities is now an improving scenario given the tighter environmental regulation which exists today. To determine the effect of any siltation from the china clay industry on the intertidal macrofauna, further more targeted quantitative sampling would be required.

To conclude, there was no evidence to confirm adverse anthropogenic impact within the Malpas Estuary, Lower Fal and Helford Intertidal and Upper Fal and Woods SSSIs in terms of:

- Removal of estuarine habitats
- Abrasion of the estuarine habitats
- Increased synthetic and/or non-synthetic toxic contamination
- Increases in turbidity
- Siltation of the estuary bed or intertidal communities

Although it is known that anthropogenic impacts have occurred in the area historically[20], this study was unable to establish current impacts because of the lack of comparable baseline data. As most historical sources are no longer present or considerably reduced in scale it is likely that the condition of the Malpas Estuary, Upper Fal and Woods, and Lower Fal and Helford SSSIs is improving. The condition can only be established following the next condition assessment in 2017.

5.2 Notable Biotopes and Species

5.2.1 Notable Biotopes

Estuaries, mudflats & sandflats not covered by seawater at low tide, coastal lagoons and large shallow inlets & bays are all listed in Annex 1 of the Habitats Directive (92/43/EEC). As such, member states are required to take measures to maintain or restore these habitats at a favourable conservation status.

The majority of the habitats and biotopes which are present within the Malpas Estuary, Lower Fal and Helford Intertidal and Upper Fal and Woods SSSIs have also been listed as priorities for conservation action under the National UK Biodiversity Action Plan (BAP). A number of these habitats are specifically listed in Local Biodiversity Action Plans (LBAPs), and have therefore had specific targets set by LBAP partnerships.

Table 58. The presence of biotopes listed as priority BAP habitats (and identified within relevant LBAPs) within Each of the SSSIs studied

Priority BAP Habitat	Biotope	The Malpas Estuary SSSI	The Upper Fal Estuary and Woods SSSI	The Lower Fal and Helford SSSI	LBAP
Seagrass Beds	LS.LMp.LSgr.Znol		✓		Cornwall
Intertidal Mudflats	LS.Lsa.MuSa.HedMacEte		✓		Cornwall
	LS.LBR.LMus.Myt.Mu			✓	Cornwall
	LS.LSa.MoSa.Ol.VS		✓	✓	Cornwall
	LS.LMu.UEst.NhomStr		✓	✓	Cornwall
	LS.Lmu.Mest.NhomMacStr		✓	✓	Cornwall
	LS.Lmu.Uest.Hed.Str		✓		Cornwall
	LS.LMU.MESt.HedMacScr	✓	✓	✓	Cornwall
	LS.LSa.MuSa.CerPo	✓	✓	✓	Cornwall
	LS.LSa.MuSa.Lan		✓	✓	Cornwall
	SS.SMU.SMuVS.AphTubi			✓	Cornwall
Sheltered Muddy Gravels	LS.LMx.Mx.CirCer		✓	✓	
	LS.LMx.Mx			✓	
	LS.LMx.GvMu.HedMx.Cir			✓	
	*SS.SMx.SMxVS.CreMed^*		✓		
	SS.SMx.IMxOst^*		✓	✓	
	*SS.SMU.SMuVS.AphTubi^*			✓	
	LS.LBR.LMus.Myt.Mx		✓	✓	

*The non-indigenous slipper limpet *Crepidula fornicata* was observed to be present within this biotope; the species has been identified as a potential threat to the condition of some sheltered muddy gravel biotopes.
^These biotopes are subtidal in the Marine Biotope Description for Britain and Ireland, however were observed here to be uncovered by seawater in the event of spring tides and could therefore be categorised with other intertidal sheltered muddy gravels in terms of BAP designation.

The importance of these habitats within the Malpas Estuary, Lower Fal and Helford Intertidal and Upper Fal and Woods SSSIs largely lies in the provision of invertebrates for the internationally and nationally important aggregations of wading birds including the Black-tailed Godwit *Limosa limosa*.

5.2.2 Notable species

The native Oytster *Ostrea edulis*, which is a UK National and Local BAP species, was observed to be present both within the Lower Fal and Helford Intertidal and Upper Fal Estuary and Woods SSSIs. The National and Local BAP targets for *Ostrea edulis* include:

T1 Maintain the existing geographical distribution of the native oyster within UK inshore waters.
T2 Expand the existing geographical distribution of the native oyster within UK inshore waters, where biologically feasible.
T3 Maintain the existing abundance of the native oyster within UK inshore waters.

T4 Increase the abundance of the native oyster within UK inshore waters, where biologically feasible.

Notable species within the Upper Fal Estuary and Woods SSSI

Within the Upper Fal Estuary and Woods SSSI *Ostrea edulis* was observed in frequent numbers in some areas on the extreme lower shore within the SS.SMx.SMxVS.CreMed biotope (Transect 22) where it was present along-side frequent numbers of the non-native slipper limpet *Crepidula fornicata*. The species is also present within a limited distribution of the SS.SMx.IMxOst biotope that was identified on the lower eastern bank of the Fal on the extreme lower shore (outside of any transects).

Notable species within the Lower Fal and Helford SSSI

Within the Lower Fal and Helford SSSI the *Ostrea edulis* was observed throughout the LS.LBR.LMus.Myt.Mx biotope in the Helford. Within the Helford on the southern bank of the main Helford channel the notable species was rare, but was frequent in numbers in patches of the northern bank. Significantly on the northern bank, the native species was present along-side the non-native species of Pacific oyster *Crassostrea gigas* (which were common) and the slipper limpet *Crepidula fornicata* (which were occasional).

Ostrea edulis was also present within the LS.LBR.LMus.Myt.Mu biotope within the Helford where it was present in up to abundant numbers. Within the Percuil the SS.SMx.IMxOst biotope was assigned on the basis of common numbers of *Ostrea edulis* being present, but again the species was present along-side the non-native *Crepidula fornicata* which was occasional in abundance.

Notable species within the Malpas Estuary SSSI

No notable species were observed within the Malpas Estuary SSSI.

5.3 Application of Biotope Methods

A degree of infaunal community variation both between replicates, and between the replicates and the communities described as characteristic for the biotope was observed for all biotopes. These variations are most likely to be attributable to the high degree of natural fluctuations that are found at both a local and regional scale in estuarine environments[32] (i.e. salinity, wave exposure, carbon matter, nutrient input and pollution), highlighting some of the weaknesses of biotope mapping. However, variations are likely to also be attributable to the presence of transitional areas between biotopes, and perhaps most significantly, the small sample size and sampling frequency employed within each identified biotope which were dictated by budgetary restraints.

5.4 Recommendations

It is suggested that in future condition assessments of the Fal and Helford Marine Sites the application of transects within the Phase I and Phase II methods for the project (as was done here at the request of Natural England) are not applied if work is carried out using a hovercraft. This is because the hovercraft facilitates access to all areas of the mudflats and sandflats in a safe and efficient way that results in accurate and comprehensive coverage of the entire study area, resulting in a redundancy of the transect approach. Two main disadvantages of the transect approach were identified:

1. It was found that by selecting transect locations prior to the Phase I and based on only limited studies of the study area, there was a large degree of potential for biotopes to be missed completely from the Phase II element of the study.
2. In an effort to encompass as many biotopes as possible (i.e. in complex areas of the estuary where environmental variables are diverse), large transitional areas may be captured more frequently within transects resulting in fewer Phase II stations which accurately represent the biotopes present in terms of the fauna present.

It is considered that the transect approach may have a more useful application in large areas of open coast where mudflats and sandflats tend to be more homogenous.

In order to carry out future condition assessments the results presented here should be used a baseline from which to compare the attributes and measures outlined in table 59 below (with the exception of topography which was beyond the scope of this study).

Table 59. Attributes or measures to be assessed as outlined in by Natural England in their tender specification for this work[33]

Feature	Attribute or Measure
Littoral sediment	Distribution of biotopes
	Extent
	Extent of sub-feature or representative/ notable biotopes
	Species population measures: Population structure of a species
	Species population measures: Presence or abundance of specified species
	Sediment character: Organic carbon content
	Sediment character: Oxidation-reduction profile (Redox layer)
	Sediment character: sediment type
	Topography
	Biotope composition of littoral sediment
	Species composition of representative or notable biotopes

The distribution and extent of biotopes (including those which are representative and/or notable) will be most efficiently compared using GIS software to map and measure the attributes area.

The determination of sediment character should be carried out using the similar methods to this study to facilitate direct comparison of parameters in future. Methods should therefore include loss on ignition analysis (to determine organic carbon content) and particle size analysis using dry sieving and laser diffraction methods. It is recommended however that redox is determined using a redox meter which should be used to provide results in mV at 1, 2, 4, 6, 8 and 10 cm depths rather than according to the MNCR scale, as this will provide much more objective data from which more robust conclusions can be drawn.

The biotopes present should be determined in accordance with the most up-to-date Marine Habitat Classification for Britain and Ireland (currently Vs 04.05). The presence and abundance of notable species should be recorded using the SACFOR scale and compared to distribution and abundance of such species recorded during both the Phase I and Phase II data gathered in this study.

Particular emphasis should be placed on species population measures as it is these measures which are most likely to indicate the presence of anthropogenic stressors. Both univariate and multivariate analysis of the faunal data should be carried out. Univariate analysis should include measures such as the Shannon Wiener diversity index, Margalef's species richness and Pielou's eveness. Perhaps more usefully a statistical package such as PRIMER[30] should be used to carry out multivariate community analysis. Multi-variate Bray-Curtis similarity statistic and multidimensional scaling (MDS) plots should be used to assess the communities present within biotopes. Such plots are capable of representing communities within samples in two or three dimensions where the distances between points represent the dissimilarities between the communities. By plotting community data from this survey alongside future survey data, temporal trends in community assemblages should become apparent. Any directional changes in these plots could indicate anthropogenic stressors. However, the dynamic nature of physical processes within estuarine systems (including wave exposure, riverine floods, tidal surges or storm events) means that the gross distribution of habitats and species can be expected to change over time naturally to some extent. Therefore, it will be necessary to discern whether any changes observed (i.e. loss in extent of a particular biotope) is attributable to anthropogenic factors as opposed to natural factors, as the distinction would be necessary to determine the condition of the SSSIs. If it is not possible to derive the information to make such distinctions from the information available, then further work outside the remit if the initial condition assessment may be necessary.

In order to strengthen the multivariate analysis and enhance its usefulness, it is suggested that in future condition assessments, where finance permits, more quantitative faunal assessment should be carried out within each biotope (i.e. minimum of five replicates per biotope). This would provide further advantage when defining communities accurately to monitor any future change given the ambiguity associated with biotopes within the study SSSIs in terms of their fitting with those outlined in The Marine Habitat Classification for Britain and Ireland (Vs 04.05).

By implementing these recommendations it is considered that a more comprehensive, statistically sound assessment of the designated interest features can be made. Results from such studies would provide a better foundation from which to base scientifically robust conclusions regarding any temporal changes that may observed in the future, whether positive or negative in terms of conservation targets.

6. Glossary

Abundance	Total number of all animals (individuals) in a sample
Benthic	"Bottom dwelling", pertaining to the sea bed or estuary bed
Bray Curtis similarity	Statistic that compares fauna samples in terms of abundance and number of taxa
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
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
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
LS.LMu.UEst.NhomStr	*Nephtys hombergii* and *Streblospio shrubsolii* in littoral mud
LS.LSa.MuSa.CerPo	*Cerastoderma edule* and polychaetes in littoral muddy sand
Impoverished LS.LSa.MuSa.CerPo	*Cerastoderma edule* and polychaetes in littoral muddy sand - with lower abundance of *Cerastoderma edule* than expected for the biotope
LS.LMu.UEst.Hed.Str	*Hediste diversicolor Streblospio shrubsolii* in littoral sandy mud

LS.LSa.MuSa.Lan	*Lanice conchilega* in littoral sand
LS.LMu.MEst.NhomMacStr	*Nephtys hombergii*, *Macoma balthica* and *Streblospio shrubsolii* in littoral sandy mud
LS.LMu.MEst.HedMacScr	*Hediste diversicolor*, *Macoma balthica* and *Scrobicularia plana* littoral sandy mud shores
LS.LMu.MEst.HedMacEte	*Hediste diversicolor, Macoma balthica* and *Eteone longa* in littoral muddy sand
LS.LMx.GvMu.HedMx.Cir	*Hediste diversicolor*, Cirratulids and *Tubificoides spp*. in littoral gravelly sandy mud
LS.LMx.GvMu.HedMx	*Hediste diversicolor* in littoral gravelly muddy sand and gravelly sandy mud
LS.LMu.MEst.HedMacScr with *Cerastoderma edule*	*Hediste diversicolor*, *Macoma balthica* and *Scrobicularia plana* in littoral sandy mud shores - with unexpected high number of *Cerastoderma edule* present
LS.LBR.Lmus.Myt.Mx	*Mytilus edulis beds on littoral mixed substrata*
LS.LBR.LMUs.Myt.Mu	*Mytilus edulis beds on littoral mud*
LS.LMp.LSgr.Znol	*Zostera noltii* beds on littoral muddy sand
LS.LMx.Mx	Species rich mixed sediment shores
LS.LSa.MoSa.Ol.VS	Oligochaetes in variable salinity littoral mobile sand
SS.SMU.SmuVS.AphTubi	*Aphelochaeta marioni* and *Tubificoides spp*. in variable salinity infralittoral soft mud
SS.SMx.SMxVS.CreMed	*Crepidula fornicata* and *Mediomastus fragilis* in variable salinity infralittoral mixed sediment

7. References

[1] Natural England (1992). Citation: Site Name: Malpas Estuary SSSI
http://www.sssi.naturalengland.org.uk/citation/citation_photo/1004029.pdf

[2] Natural England (1996). Citation: Site Name: Upper Fal and Woods SSSI
http://www.sssi.naturalengland.org.uk/citation/citation_photo/2000127.pdf

[3] Natural England (1997). Citation: Site Name: Upper Fal and Woods SSSI
http://www.sssi.naturalengland.org.uk/citation/citation_photo/2000174.pdf

[4] JNCC (2004) Common Standards Monitoring Guidance for Littoral Sediment Habitats http://www.jncc.gov.uk/PDF/CSM_marine_littoral_sediment.pdf

[5] Anon. (1998). A Statement on Common Standards Monitoring. Peterborough: JNCC.

[6] Natural England (2010). Conservation objectives and definitions of favourable condition for designated features of interest: Malpas Estuary SSSI. Truro: Natural England.

[7] Natural England (2010). Conservation objectives and definitions of favourable condition for designated features of interest: Upper Fal and Woods SSSI. Truro: Natural England.

[8] Natural England (2010). Conservation objectives and definitions of favourable condition for designated features of interest: Lower Fal and Helford Intertidal SSSI. Truro: Natural England.

[9] Gainey, P. A. (1997). A Survey of the Heacoralline Anthozoans (Sea Anemones & Corals) of the Helford Estuary. A Reporte to the Helford Voluntary Marine Conservation Area Group.

[10] JNCC (2004). Common Standards Monitoring Guidance for Littoral Sediment Habitats. Version August 2004, Updated from (February 2004). JNCC. ISSN 1743-8160 (online)
Jones, S. N., April 1993. A Population Study of the Common Cockle (Cerastoderma edule) in the beds at Helford Passage. A Report to the Helford Voluntary Marine Conservation Area Advisory Group.

[11]Lange, M. (1994). The Sedimentary Shore Fauna of the Helford River at Helford Passage, Conwall.

[12] Moore, J. J., Smith, J., & Northen, K. O. (1999). Inlets in the wesern English Channel: area summaries - Helford River. Marine Nature Conservation Review Sector 8. JNCC.

[13] Moore, J. J., Smith, J., Dalkin, M. Hill, T. & Northen, K. (1999). Inlets in the western English Channel: area summaries - Carrick Roads and the River Fal. Marine Nature Conservation Review Sector 8. JNCC.

[14] Pirrie, D., Hughes, S. H., & Pullin, H. (1996). The Effect of Mining on Sedimentation Over the Last 500 Years in the Fal Estuary, Cornwall. In Healy, M. G. (ed), 1996. Late Quaternary coastal change in West Cornwall, UK, Field Guide. Environmental Research Centre, University of Durham, Research Publication 3, 75-82.

[15] Roberts, N. & Edwards, T. (1996). Falmouth Bay and Estuaries - A Nature Conservation Overview. Volum 1. A report to the Falmouth Bay & Estuaries Initiative. Environmental Consultants (CTNC) Ltd.

[16] Rostron, D. (1987). Surveys of the Harbours, Rias & Estuaries in Southern Briatain: The Helford River. Volume 1. A Report to the Nature Conservancy Council from the Field Studies Council Oil Pollution Research Unit. FSC/OPRU/17/87.

[17] Rostron, D. (1985). Surveys of the Harbours, Rias & Estuaries in Southern Briatain: Falmouth. Volume 1. A Report to the Nature Conservancy Council from the Field Studies Council Oil Pollution Research Unit. FSC/OPRU/49/85.

[18] Tompsett, P. E. (1997). Helford River Survey Monitoring Report No. 5 for 1996. A Report to the Helford Voluntary Marine Conservation Area Group.

[19] Cycleau Project (2000). Fal and Helford Catchment: Catchment Use.
http://www.cycleau.org/index.asp?id=1003438

[20] Langston, W.J., Chesman, B.S., Burt, G.R., Hawkins, S.J., Readman, J., Worsfold, P. (2003) Site Characterisation of the South West European Marine Sites: Fal and Helford cSAC. A study carried out on behalf of the Environment Agency and English Nature by the Marine Biological Association of the United Kingdom, Plymouth (UK).

[21] Bryan, G.W. and Gibbs, P.E. (1983) Heavy metals in the Fal estuary, Cornwall: A study of long term contamination by mining waste and its effects on estuarine organisms. Occasional Publication of the Marine Biological Association 2. Marine Biological Association of the United Kingdom, Plymouth (UK).

[22] Bryan, G.W. and Langston, W.J. (1992). Bioavailability, accumulation and effects of heavy metals in sediments with special reference to United Kingdom Estuaries: a review. Environmental Pollution 76: 89-131

[23] Fowler, S., (1999) Guidelines for managing the collection of bait and other shoreline animals within UK marine Special Areas of Conservation. The Nature Conservation Bureau Ltd, Newbury (UK Marine SACs Project)

[24] Channel Coastal Observatory (2007). Map viewer and data catalogue. http://www.channelcoast.org/data_management/online_data_catalogue/

[25] International Organisation for Standardisation (2005) ISO 16665:2005 Water quality - Guidelines for quantitative sampling and sample processing of marine soft-bottom macrofauna.
http://www.iso.org/iso/catalogue_detail.htm?csnumber=32348

[26] Connor, D.W., Allen, J.H., Golding, N., Howell, K.L., Lieberknecht, L.M., Northern, K.O., and Reker, J.B., (2004). The Marine Habitat Classification for Britain and Ireland Version 04.05. JNCC, Peterborough

[27] Stephens, J., Uncles, R., Barton, M., Fitzpatrick, F. (1992). Bulk properties of intertidal sediments in a muddy, macrotidal estuary. Marine Geology 103: 445-460

[28] Curtis, L.A and Field, M.D (2010). Lynher SSSI Littoral Biotope Report. Written for and on behalf of Natural England, Truro (UK).

[29] Curtis, L.A and Field, M.D (2010). Tamar-Tavy and St. Johns Lake SSSI Littoral Biotope Report. Written for and on behalf of Natural England, Truro (UK).

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

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

[32] Ducrotoy, J., (2010) The use of biotopes in assessing the environmental quality if tidal estuaries in Europe. Estuarine, Coastal and Shelf Science 86: 317-321

[33] Natural England (2010) Request for Quotation: Condition Monitoring of the Intertidal Mudflats and Sandflats Feature at Fal and Helford Marine Sites. 020 Version May 2010.

8. Appendix 1

Table 60. Table of transect corner coordinates and corresponding Phase II stations

SSSI	Transect	Date Surveyed		Phase II Station(s)	Corner Coordinates	
		Phase I	Phase II		x	y
Lower Fal and Helford Intertidal SSSI	1	23-24/11/11	28-29/11/11	1, 2	178082	25296
					177735	25097
					177682	25161
					178029	25358
	2	23-24/11/11	28-29/11/11	17, 18	176453	26403
					176131	26162
					176350	26502
	3	23-24/11/11	28-29/11/11	16	175609	26990
					176006	26931
					175591	26881
					175977	26722
	4	23-24/11/11	28-29/11/11	14	175617	27611
					175927	27862
					175889	27893
					175575	27645
	5	23-24/11/11	28-29/11/11	13, 15	174513	26739
					174907	26793
					174534	26588
					174927	26648
	6	23-24/11/11	28-29/11/11	11, 12	174276	26122
					174662	26235
					174668	26378
					174287	26257
	7	23-24/11/11	28-29/11/11	10	173938	26637
					173794	27005
					173679	26960
					173796	26588
	8	23-24/11/11	28-29/11/11	9	173718	27285
					173947	27615
					173796	27222
					174011	27568

	9	23-24/11/11	28-29/11/11	8	173973	27718
					174008	28117
					174089	28108
					174061	27705
	10	23-24/11/11	28-29/11/11	7	173463	26028
					173857	26101
					173449	26060
					173830	26163
	11	23-24/11/11	28-29/11/11	6	172900	25811
					173271	25944
					172863	25868
					173243	25986
	12	23-24/11/11	28-29/11/11	5	172013	25454
					171680	25236
					171633	25288
					171946	25536
	13	23-24/11/11	28-29/11/11	4	171939	25731
					171581	25919
					171650	26019
					172008	25832
	14	23-24/11/11	28-29/11/11	3	170897	26310
					170728	26674
					170695	26661
					170865	26297
	15	22/11/2011	23/11/2011	1p, 2p, 3p	185148	32277
					185508	32196
					185193	32526
					185591	32553
	16	22/11/2011	23/11/2011	5p	185938	33389
					186320	33264
					185969	33491
					186332	33323
	17	22/11/2011	23/11/2011	10p	185557	34089
					185733	34407
					185760	34376
					185593	34094

	18	22/11/2011	23/11/2011	7p, 8p	185774	33978
					186253	34092
					186012	33656
					186309	34016
	19	22/11/2011	23/11/2011	12p	186027	34836
					185946	34448
					186208	34840
					186120	34454
	20				186378	34933
					186243	34553
					186290	34935
					186154	34562
	21	22/11/2011	23/11/2011	15p	186093	35754
					186118	35358
					186177	35751
					186183	35352
Upper Fal Estuary and Woods SSSI	22	25-27/11/11	30/11/11 to 1/12/11	21, 22, 23, 24	183291	39100
					183694	39097
					183806	38738
					183408	38697
	23	25-27/11/11	30/11/11 to 1/12/11	29	183300	40922
					183608	40657
					183363	40983
					183652	40702
	24	25-27/11/11	30/11/11 to 1/12/11	44	183424	40045
					183798	40201
					183380	40127
					183769	40235
	25	25-27/11/11	30/11/11 to 1/12/11	41, 42, 43	184972	40236
					185257	40524
					184895	40339
					185165	40631
	26	25-27/11/11	30/11/11 to 1/12/11	37, 39, 40	185493	40681
					185674	40325
					185645	40721
					185833	40363

	27	25-27/11/11	30/11/11 to 1/12/11	36, 38	186570	40346
					186962	40435
					186518	40434
					186905	40533
	28	25-27/11/11	30/11/11 to 1/12/11	35	186873	40659
					187241	40815
					187105	40525
					187338	40735
	29	25-27/11/11	30/11/11 to 1/12/11	31, 32	187854	40831
					188217	40679
					187823	40749
					188191	40593
	30	25-27/11/11	30/11/11 to 1/12/11	33, 34	187325	41166
					187461	40791
					187206	41139
					187344	40764
	31	25-27/11/11	30/11/11 to 1/12/11		187875	41069
					188275	41065
					187873	41181
					188271	41228
	32	25-27/11/11	30/11/11 to 1/12/11	30	187980	41576
					188374	41642
					188010	41213
					188394	41303
	33	25-27/11/11	30/11/11 to 1/12/11	45	184791	41014
					184843	40611
					184870	41020
					184947	40623
	34	25-27/11/11	30/11/11 to 1/12/11	46	184639	41515
					184767	41141
					184764	41521
					184840	41136

	35	25-27/11/11	30/11/11 to 1/12/11	47	185027	41680
					185001	41278
					184940	41681
					184951	41276
	36	25-27/11/11	30/11/11 to 1/12/11	48, 49	185249	42010
					185242	42387
					185197	42361
					185155	42031
	37	25-27/11/11	30/11/11 to 1/12/11	28	184622	42485
					184990	42329
					184664	42563
					185028	42417
	38	25-27/11/11	30/11/11 to 1/12/11		184903	42937
					185269	43101
					184861	42997
					185200	43150
	39	25-27/11/11	30/11/11 to 1/12/11		185244	43293
					185360	43594
					185446	43639
					185258	43218
	40	25-27/11/11	30/11/11 to 1/12/11	27	185492	43880
					185642	44249
					185340	43920
					185457	44308
	41	25-27/11/11	30/11/11 to 1/12/11	26	185555	44713
					185757	45059
					185729	44630
					185873	45006
	42	25-27/11/11	30/11/11 to 1/12/11	25	186154	45485
					186277	45854
					186066	45501
					186199	45871

Malpas Estuary SSSI	43	25-27/11/11	30/11/11 to 1/12/11	51, 52	183909	42033
					184092	42395
					183970	41986
					184206	42337
	44	25-27/11/11	30/11/11 to 1/12/11	50	184179	42486
					184521	42691
					184208	42440
					184555	42647
	45	25-27/11/11	30/11/11 to 1/12/11	53	183928	42940
					184115	42583
					183990	42505
					183774	42846
	46	25-27/11/11	30/11/11 to 1/12/11	54	183277	42902
					183678	42874
					183288	43011
					183691	42989
	47	25-27/11/11	30/11/11 to 1/12/11	55	183003	43041
					182605	43085
					182617	43142
					183028	43144
	48	25-27/11/11	30/11/11 to 1/12/11	56	183208	43635
					183048	44006
					183293	43671
					183143	44043

9. Appendix 2

Table 61. Phase II Station coordinates and corresponding SSSI

SSSI	Phase II Station	x	y
Lower Fal and Helford SSSI	1p	185161	32306
	2p	185224	32333
	3p	185295	32322
	5p	186307	33268
	7p	186167	33892
	8p	186249	34000
	10p	185589	34246
	12p	186102	34586
	15p	186196	35650
	1	177994	25314
	2	177810	25222
	3	170821	26355
	4	171795	25904
	5	171835	25426
	6	173107	25837
	8	174117	27903
	7	173586	26067
	9	173913	27397
	10	173710	26945
	11	174323	26163
	12	174616	26309
	13	174690	26815
	14	175728	27775
	15	174822	26697
	16	175736	26925
	17	176110	26266
	18	176200	26307
Malpas Estuary SSSI	51	184001	42098
	52	184143	42295
	53	183935	42701
	54	183604	43043
	55	182924	43104
	56	183190	43841

Upper Fal Estuary and Woods SSSI	21	183541	39087
	22	183639	39042
	23	183521	38958
	24	183520	38901
	25	186124	45605
	26	185684	44763
	27	185503	44209
	28	184791	42444
	29	183369	40907
	30	188181	41454
	31	187959	40781
	32	188136	40709
	33	187346	40894
	34	187274	41169
	35	187283	40638
	36	186652	40405
	37	185603	40548
	38	186791	40499
	39	185575	40690
	40	185661	40578
	41	185205	40526
	42	185057	40368
	43	184963	40329
	44	183601	40171
	45	184856	40877
	46	184683	41355
	47	184996	41626
	48	185255	42074
	49	185248	42327
	50	184498	42671

10. Appendix 3

Table 62 below compares the original sample analysis results against the quality control results, the Bray-Curtis Similarity value of the two analyses are also presented. It can be seen that all analyses were well within the 10% dissimilarity value and therefore passed internal and external quality control procedures.

Table 62. Faunal analysis quality control results

Species	Phase II Station Sample													
	55		29		25		28		54		50		35	
	Check	Original	Check	Original	Check	Original	Check	Original	Check	Original	Check	Original	Check	Original
Abra tenuis														
Actinaria unident														
Alderia modesta														
Ampharete spp. juv.														
Ampharete grubei														
Amphipholis squamata														
Amphipoda unident. Juv.														
Amphiuridae spp. juv.														
Anaitides mucosa	1	1												
Aonides oxycephala														
Aphelochaeta marioni														
Arenicola marina														
Bivalvia unident. Juv.							3	3						
Calyptraea chinensis														
Capitella capitata agg.									1	1				
Capitellidae spp. juv.														
Carcinus maenas														
Cardiacea juv.	2	1					4	4	4	4	2	2		
Caridea spp. juv.														
Cerastoderma edule	1	1												
Chaetozone gibber														
Chironomidae														
Chrysallida spp. juv.														
Cirratulidae spp. juv.														
Cirratulidae unident.							5	5						
Corophium volutator														
Cossura spp.							1	1						
Crangon spp. juv.														
Crangon crangon														
Cyathura carinata														
Enchytraeidae													15	14
Eteone longa agg.	2	2			1	1	1	1						
Eumida bahusiensis														
Exogone hebes														
Fabricia sabella														
Galathowenia oculata														
Gammaridae spp. juv.														

Glycera spp. juv.														
Glycera tridactyla														
Golfingia vulgaris														
Grania spp.														
Hediste diversicolor	2	2	3	3	12	12								
Hesionidae spp.														
Heterochaeta costata														
Heteromastus filiformis	14	14							3	3				
Hydrobia ulvae	114	112	191	183	23	22	68	66	42	39	5	5	1	1
Idotea chelipes														
Ischyroceridae														
Lanice conchilega														
Limapontia spp.														
Lucinoma borealis														
Macoma balthica														
Malacoceros fuliginosus														
Manayunkia aestuarina	1	1	6	6			1	1						
Mediomastus fragilis														
Melinna palmata											2	2		
Melita palmata														
Musculus discors														
Mya spp. juv.														
Mya arenaria														
Mysella bidentata														
Mytilidae spp. juv.														
Nematoda	2	2							1	1			1	1
Nemertea			1	1										
Nephtys spp. juv.			1	1			2	2	1	1				
Nephtys hombergii			1	1			1	1			6	6		
Nereidae spp. juv.			2	2	8	8								
Notomastus spp.														
Oligochaeta unident.														
Paranais litoralis														
Parvicardium exiguum														
Pholoe inornata														
Pholoe synophthalmica														
Phoronis spp.														
Polydora spp. juv.					1	1								
Polydora cornuta														
Prionospio fallax														
Pygospio elegans	7	7	6	6			8	8	3	3	1	1		
Scoloplos armiger														
Scrobicularia plana	4	4			3	3			1	3				
Sphaeroma spp. juv.														
Sphaeroma rugicauda														
Spio decorata														
Spionidae unident.														
Streblospio shrubsolii	12	12	20	20	4	4	54	57	30	31				
Syllidae undient.														
Tellinacea juv.	1	1												
Tharyx 'A'	35	36	3	3	1	1	9	9	6	6				

Tipulidae														
Tubificoides undient	20	21	286	279	1	1	101	96	187	185	2	2		
Tubificoides benedii	6	6	2	2	3	3	2	2						
Tubificoides pseudogaster agg.														
Tubificoides swirencoides														
Venerupis senegalensis														
Bray- Curtis Similarity (%)	99.217		99.491		99.473		99.349		98.503		100		98.869	

Further information

Natural England evidence can be downloaded from our **Access to Evidence Catalogue**. For more information about Natural England and our work see **Gov.UK**. For any queries contact the Natural England Enquiry Service on 0300 060 3900 or e-mail **enquiries@naturalengland.org.uk** .

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