Tamar Tavy & St John's Lake SSSI Intertidal Biotope Survey 2010

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1. Introduction

1.1 The Tamar-Tavy SSSI

The Tamar-Tavy Estuary is a Site of Special Scientific Interest (SSSI) notified under Section 28 of the Wildlife and Countryside Act 1981 (as amended). The site was designated as a SSSI in 1991 because of its international importance for nature conservation, in particular as a wintering site for wildfowl and waders. The Tamar-Tavy SSSI also lies within the Plymouth Sound and Estuaries Special Area of Conservation (SAC) and Tamar Estuaries Complex Special Protection Area (SPA) sites, which combined form part of the Tamar Estuaries European Marine Site.

The Tamar Estuary system is a large marine inlet on the English Channel coast into which a series of rivers drain an extensive catchment within Devon and Cornwall. The Estuary is an example of a ria system (drowned river valley) which has been formed as a result of rising sea levels since the Holocene marine transgression (circa 10,000 years BP). The Tamar-Tavy Estuary SSSI comprises the upper reaches of this system, and extends from the Tamar Bridge upstream to the limits of the tidal influence in both rivers and the Kingsmill and Tamerton Lakes. The majority of the total 1422.33 Ha of area designated as SSSI is comprised of intertidal habitats (the focus of this study) with a proportion of subtidal habitats, and some ancient woodland.

1.1.1 Reasons for SSSI Notification (Littoral Habitats and Communities) (1)

Littoral sediment special interest features of the Tamar-Tavy Estuary SSSI include:

- Wintering Wildfowl Assemblages (& the intertidal mud flats and sand flats that support these assemblages).
- Saltmarsh Communities
- Vascular Plant Assemblages

The Tamar-Tavy Estuary SSSI supports a nationally important wintering population of Avocet *Recurvirostra avosetta*,* and encompasses a section of the River Tamar that is considered to be of national significance for its marine biological interest. The site includes estuarine habitats and uncommon species that are notable in their extent, and also supports the only British population of Triangular Club-rush.

The site is underlain by slates and thin limestones covered for the most part by silt and sands. In the lower, broader reaches of the rivers these sediments form extensive tidal mudflats bordered by saltmarsh communities, inundation grassland and at local points, rocky shoreline.

For several decades the mudflats and marshes have attracted an increasing number of Avocet and now regularly support more than 20% of the British wintering population. Other passage or wintering wading birds for which the Tamar complex as a whole is nationally important also rely at times on feeding and roosting sites within the Tamar-Tavy Estuary SSSI. Such species include Black-tailed Godwit *Limosa limosa*, Redshank *Tringa totanus*, Dunlin *Calidris alpina* and Whimbrel *Numenius phaeopus*. Uncommon British wintering species including Greenshank *Tringa nebularia*,

* These species are listed in Annex I of the EC Council Directive on the Conservation of Wild Birds

Spotted Redshank *T. erythropus,* and Green Sandpiper *T. ochropus* and large numbers of Golden Plover *Pluvialis apricaria** are also dependent on parts of the SSSI in winter.

The main input of freshwater into the estuary is from the Tamar River. It has a large catchment (c. 916 km^2) and a great range of flow resulting in conditions of highly variable salinity along the transition from marine to freshwater habitats.

The sediment invertebrate communities between Weir Quay and Calstock are particularly well developed for estuarine conditions and nicely represent the change in composition and species richness associated with the variation in salinity.

The River Tamar's rocky shore habitats, unusual so far up an estuary, support communities that are considered to be the best examples of their type in tidal inlets in Southern Britain and are the only known examples in the Southwest. Also of interest is the occurrence near Calstock of the prawn *Palaemon longirostris*, which has been recorded from only two other estuaries in Britain.

Areas of saltmarsh communities border the tidal mudflats and occur as far upstream as Cotehele Quay. These typically contain a strong grassy component of Common Saltmarsh-grass *Puccinellia maritima*, Red Fescue *Festuca rubra* and Sea Couch *Elymus pycanthus*. Characteristic associates include Sea Purslane *Halimione portulacoides*, Sea Aster *Aster tripolium*, Sea Arrowgrass *Triglochin maritima*, English Scurvygrass *Cochlearia anglica* and Sea Club-rush *Scirpus maritimus*. Small beds of Common Cordgrass *Spartina anglica* have also become established locally. Two nationally scarce species of grass are found within the SSSI: Stiff Saltmarsh-grass *Puccinellia rupestris* and Bulbous Fox-tail *Alopecurus bulbosus*. Other plants of interest associated with the estuarine margins are the notable Beaked Tasselweed *Ruppia maritime,* Carrot Broomrape *Orobanche maritime,* a parasite of Wild Carrot *Daucus carota* and Grass-leaved Orache *Atriplex littoralis.*

In parts of the upper estuary where freshwater predominates there are extensive bankside beds of the Common Reed *Phragmites australis*. The Triangular Club-rush *Schoenoplectus triqueter* listed as specially protected under the 1981 Wildlife and Countryside Act occurs in stands amongst the Common Reeds at one locality; this is now the only known British Isles population.

1.2 St John's Lake SSSI

St. John's Lake is a Site of Special Scientific Interest (SSSI) notified under Section 28 of the Wildlife and Countryside Act 1981 (as amended). The site was designated as a SSSI in 1986 because of its international importance for nature conservation, in particular as a wintering site for wildfowl and waders. St. John's Lake SSSI also lies within the Plymouth Sound and Estuaries Special Area of Conservation (SAC) and Tamar Estuaries Complex Special Protection Area (SPA) sites, which combined form part of the Tamar Estuaries European Marine Site.

St. Johns Lake is an embayment that lies immediately south of Torpoint, in the lower reaches of the Tamar Estuarine system. At low tide, extensive mud flats are exposed providing important feeding grounds for large populations of wintering wildfowl and waders. The lake also has interesting areas of species-rich saltmarsh, and the underlying Devonian slates form fringing shingle beaches and.shallow rock cliffs. The majority of the total 279.2 Ha of area designated as SSSI is comprised of intertidal habitats (the focus of this study) with a small proportion of subtidal habitats.

* These species are listed in Annex I of the EC Council Directive on the Conservation of Wild Birds

1.2.1 Reasons for Notification [2]

Littoral sediment special interest features of St. John's Lake SSSI include:

- Wintering Wildfowl Assemblages
- Intertidal Mud Flats and Sand Flats
- Saltmarsh Communities

St. John's Lake is of national importance for its wintering population of around 6,000 wildfowl and 10,000 waders. The mudflats sustain considerable swathes of the green algae *Enteromorpha* and the dwarf eel grass Z*ostea noltii*. The alga and eel grass beds are particularly important as they provide feeding areas for a large population of up to 5,000 wigeon *Anas penelope*. The Mute swan *Cygnus olor*, Brent geese *Branta bernicla*, shelduck *Tadorna tadorna* and teal *Anas crecca* all occur in high numbers. A nationally important population of the black tailed godwit *Limosa limosa* is regularly present in winter, representing 3–4% of the British wintering population. The mud flats are also an important feeding ground for some 3,000 dunlin *Calidris alpina*, 600 knot *C. canutus*, 300 oystercatchers *Haematopus ostralegus*, 200 curlew *Numenius arquata* and 600 redshank *Tringa totanus*. Turnstone *Arenaria interpres*, spotted redshank *Tringa erythropus*, grey plover *Pluvialis squatarola* and ringed plover *Charadrius hiaticula* also frequent the site. In addition, there is a very large gull roost containing up to 14,000 black-headed gulls *Larus ridibundus*.

The saltmarsh habitats are not extensive and consist predominantly of common cord-grass *Spartina anglica*, but they also support Common salt marsh-grass *Puccinellia maritime* with sea plantain *Plantago maritima*, sea milkwort *Glaux maritima* and saltmarsh rush *Juncus gerardi.* There is also a strong population of sea purslane *Halimoine portulacoides*, a species which is uncommon in Cornwall.

1.3 Anthropogenic Influences within the SSSI's

Land use within the Tamar catchment is a mixture of urban development and agriculture. The largest populations influencing the estuary are the city of Plymouth, and towns of Saltash, Torpoint and Tavistock.

There are a number of continuous and intermittent sewage discharges directly into the Tamar-Tavy Estuary SSSI including those from Saltash, Torpoint, St. Dominick, Cargreen, Ernesettle and Calstock Sewage Treatment Works (STWs) [4]. St. John's STW discharges into St John's Lake. Since 2000 a number of improvements have been made to both continuous and intermittent discharges in the Tamar catchment driven by the Shellfish Waters Directive; these include the installation of UV disinfection, secondary treatment and screening.

The Tamar catchment is popular with tourists in the summer months. The pressures created by large seasonal population increases such as the increased use of accommodation, leisure and transport facilities results in seasonal increases in nutrient loadings and the risk of pollution.

Most of the agricultural land is grassland that supports intensive dairy and beef practices, with a quantity of land for growing maize for feedstuff. Excess nutrient loading is thought to be primarily derived from diffuse agricultural pollution and to a lesser degree from sewage infrastructure; although the percentage contribution from each source changes with the seasons[3]. Nutrient levels within the site are potentially capable of supporting persistent algal blooms in the summer, particularly during long periods of low river flows within the upper estuary [3]. It has been estimated that the overall loadings from anthropogenic sources have decreased to some extent over the past 10 years or so, primarily as a consequence of improved treatment of discharges, although the absolute significance of this reduction is not clear[3].

In terms of abstraction within the Tamar catchment, the vast majority of the licences in the catchment are unlikely to adversely affect the integrity of the SSSI [5]. However, the most significant licences by volume are for public water supply at Roadford Reservoir, Upper Tamar Lake and Gunnislake. Although likely to be mitigated to some extent by the cross-catchment transfer of water from the Tavy, these 5 licences are likely to significantly influence flows into the SSSI (possibly impacting the designated species within the Plymouth Sound and Estuaries European Marine Site (EMS))[5]. Within the Tavy, the Environment Agency is unable to reach a conclusion of no adverse effect on the integrity of the EMS in relation to two abstractions which result in reduced flows at Lopwell Dam.

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[6]. The vulnerability of Plymouth Sound and its associated estuaries to peeler crab collection has been highlighted by previous studies[12][8].

Historical mining activities (particularly in the headwaters) have resulted in historical contamination of the Tamar waters and sediments to varying degrees by metalliferous compounds [7][9]. In addition to spatial and seasonal variation in concentrations of heavy metals in the Tamar, As, Zn, Pb and Cu have also been shown to increase with sediment depth in St Johns Lake; reflecting the decline from peak mining activity in the 19th century [9].

1.4 Condition Monitoring of Designated SSSI's

Site Condition Monitoring is (SCM) is 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 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 Tamar-Tavy and St John's Lake the intertidal special interest features which include the mud flats fall under the Common Standards Monitoring guidance produced for littoral sediment habitats[10].

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 should be used to define the condition of littoral sediment features in site condition monitoring[11].

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 if 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 saltmarsh and mud flats within the Tamar-Tavy Estuary and St John's Lake SSSI's have been developed[21] [22].

1.5 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 littoral sediment habitats of the Tamar-Tavy and St Johns Lake SSSI's (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 Tamar-Tavy St John's Lake Estuarine systems.

1.6 Existing Biotope Information

The southern end of the Tamar-Tavy Estuary SSSI (up only as far as Thorn point and Cargreen) and the entire extent of St. John's Lake SSSI were the subject of Phase I biotope surveys that were carried out on behalf of Natural England in 2001[13]. These surveys however focused on the supralittoral and littoral rock biotopes rather than the mudflats, and were not progressed to the Phase II stage. Therefore although the survey's provided a comprehensive assessment of the supralittoral and littoral rock biotopes, the mud flat biotopes were less rigorously assessed; the lack of a hovercraft during survey meant that biotopes were observed principally from the shoreline or boat.

Figures 1 and 2 below illustrate the distribution of the littoral sediment biotopes in the Tamar-Tavy SSSI and St. John's Lake SSSI respectively, as reported in 2001.

Figure 1. Tamar-Tavy SSSI littoral sediment biotopes as reported in 2001

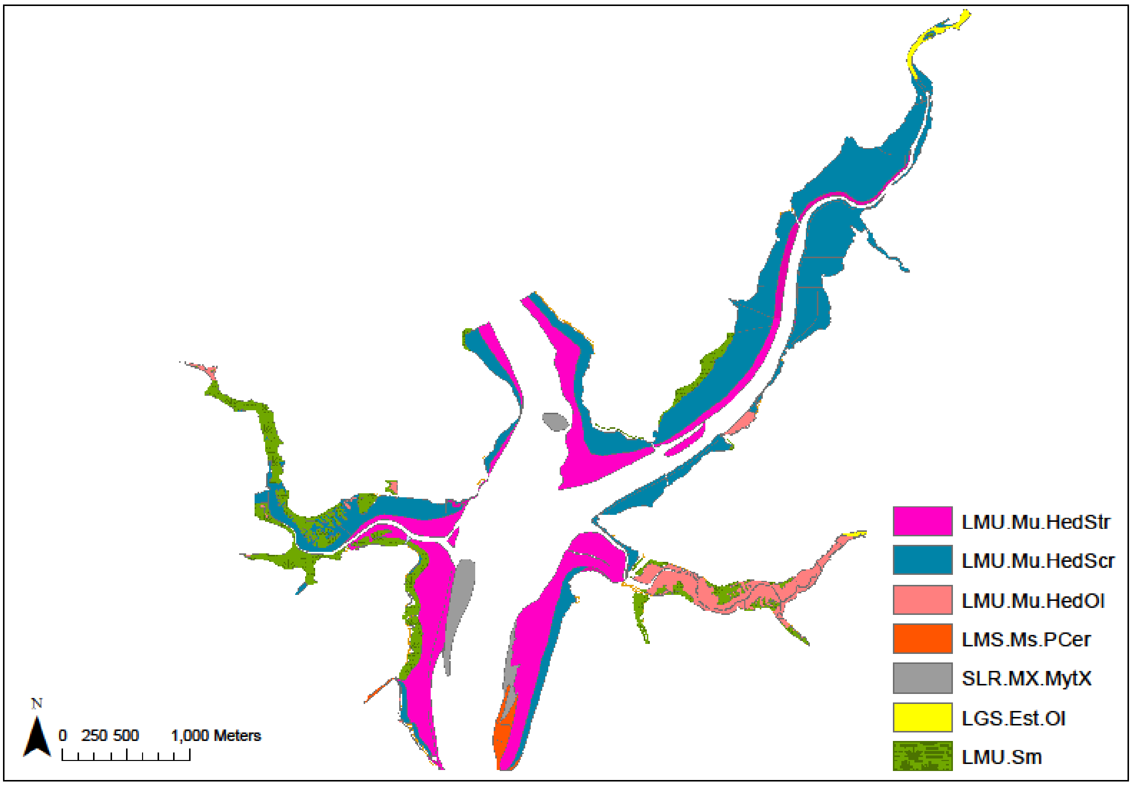

Figure 2. Tamar-Tavy SSSI littoral sediment biotopes as reported in 2001

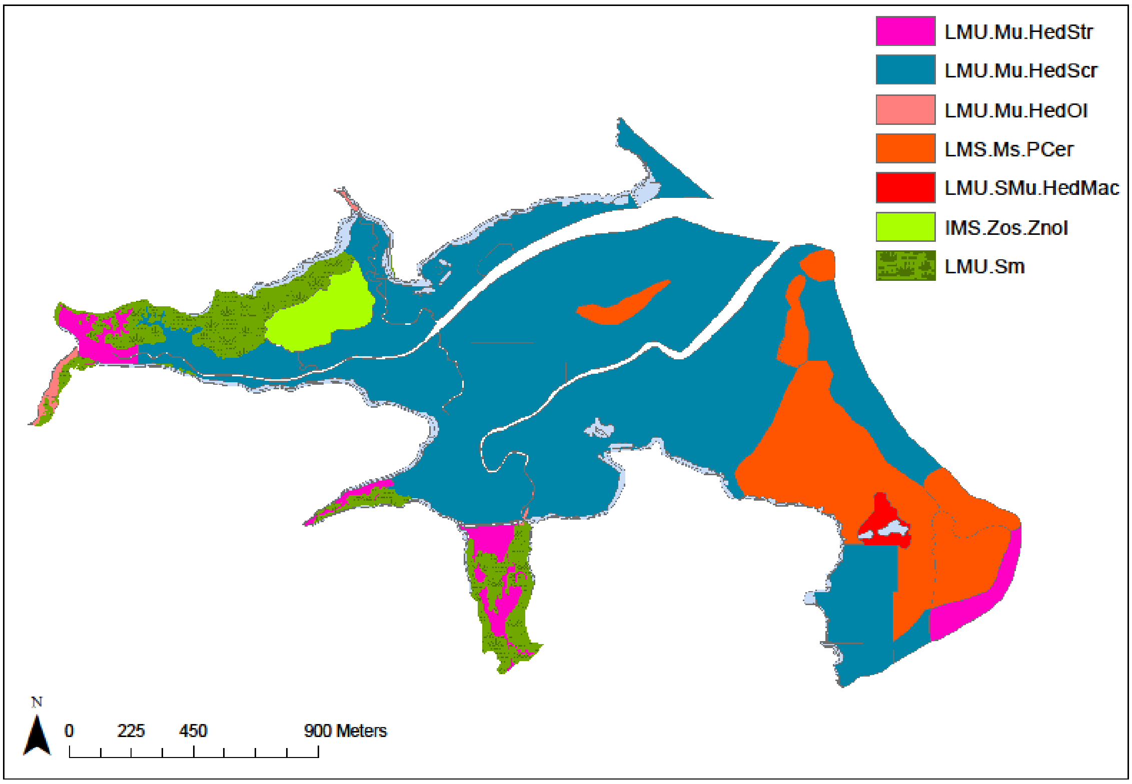

Figure 1 illustrates that *Hediste diversicolor* and the bivalve *Scrobicularia plana* were reported to dominate the upper shore in the Tamar-Tavy SSSI, whilst *Hediste diversicolor* and the spionid

Streblospio shrubsolii dominated the lower shore. Oligochaetes dominated the most upper reaches of the tributaries and creeks.

Figure 2 illustrates that St. John's Lake SSSI was reported to be dominated by *Hediste diversicolor* and the bivalve *Scrobicularia plana*, with some lower shore areas occupied by beds of the cockle *Cerastoderma edule* and polychaetes. Beds of the eelgrass *Zostera noltei* were reported to occupy a proportion of Eastbank Lake, whilst *Hediste diversicolor* and the spionid *Streblospio shrubsolii* mainly occupied the upper reaches of the creeks.

2. Methods

A previous biotope survey of both the Tamar-Tavy Estuary and St John's Lake SSSI was carried out by consultants on behalf of Natural England in 2001. The Tamar-Tavy survey area however did not encompass the entire area designated as SSSI, and in the Tamar tributary was limited to the southern end. Furthermore the survey carried out in 2001 was limited to a Phase I approach and was not progressed to a Phase II.

In order to deliver the objectives set out by Natural England in the most efficient and cost effective manner, here, a two phased survey approach was implemented throughout the Tamar-Tavy and St John's Lake. Such an approach enabled more effective targeting of effort on intertidal interest features, species and biotopes that are representative and/or notable within the study areas.

2.1 Phase I

The aim of the Phase I survey was to make a preliminary assessment of the distribution and extent of intertidal biotopes, interest features, and species that are representative and/or notable within the Tamar-Tavy and St Johns Lake Estuarine SSSI's. This was achieved by examining geo-referenced aerial photography and subsequently ground-truthing defined 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(14)). The littoral sediment habitats and communities present within the SSSI were determined using the JNCC Marine Habitat Classification for Britain and Ireland Version 04.05 (15). A 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.

The Phase I component of the survey was carried out during the spring tides that occurred between the 8th and 11th of October 2010 (LW 0.4m to 0.7m above chart datum).

2.1.1 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(16). 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 SSSIs were then incorporated into the project field book and were annotated in the field. Specific attention was paid to determining whether the extent of the saltmarsh matched that within the photographs.

2.1.2 Use of hovercraft

For reasons of efficiency, quality and safety, all fieldwork was conducted from Ecospan Environmental Ltd's 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 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 with tracks not visible after one tide. In contrast, survey teams accessing littoral habitats from the shore may cause disturbance which is apparent following multiple tides.

2.1.3 Target Stations

Pre-determined target stations were established at approximately 500m intervals throughout the study area. These stations were both added to the aerial photographs and loaded into a Garmin 76 differential GPS which was used for all position fixing during the course of the survey.

The survey technique was to fly from one point to another via hovercraft. Where changes in biotope were observed, the perceived boundaries of the changes were marked on the aerial map. An additional target position representative of the new biotope was then added to the survey plan and attributes present (species, topography, redox and sediment type) recorded.

The positions of all target locations were recorded using GPS. The hovercraft speed was kept to ensure that changes were observed. In addition, where large expanses of mudflats were exposed, a 'zig zag' transect route between target positions was taken in order to maximise the area covered.

2.1.4 Topography, Reduction-Oxidisation (Redox) Profile & 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[14]. The Redox discontinuity layer was determined by visual assessment. The sediment type was also determined visually and described using the Wentworth/Folk scale.

2.1.5 Assignment of Biotopes

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 therefore 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. All information gathered was then added to the digitised map on GIS using the 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.

Although the majority of survey effort was directed towards biotope mapping the littoral sediment habitats within the SSSI's as required by the tender; the rocky shore biotopes were also identified and recorded *in situ*. However, since this was not a primary aim of the survey, target positions were not allocated to rocky shore habitats and fewer stops were made at these biotopes.

2.1.6 Mapping Saltmarsh Extent

The distribution and extent of saltmarsh in the study areas was determined by cross-referencing the aerial photographs from the 2007 Coastal Observatory survey with observations made in the field. Specific attention was paid to determining whether the extent of the saltmarsh matched that within the photographs. Where there were larger swathes of saltmarsh, the hovercraft was used to fly around the perimeter and tracks were recorded on the DGPS. By subsequently downloading the tracks onto GIS it was possible to determine any changes in the extent of saltmash since 2007. Any notable factors or negative impact indicators (such as signs of disturbance, smothering etc) were also recorded.

2.2 Phase II

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 Tamar-Tavy Estuary and St. John's Lake SSSI's. These descriptions include floral and faunal species lists and abundance information, as well as detailed sediment character descriptions that include organic 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, as well as outline the detailed physical and biological data within the attribute layers.

The Phase II survey was undertaken during the spring tides between the 6th and 9th of November 2010 (LW ranged from 0.7m to 1.1m above chart datum).

2.2.1 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 49 intertidal cores (40 in the Tamar-Tavy Estuary and 9 in St. John's Lake) which were intended to provide a representative sample of the fauna within each of the biotopes present. 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)[16] and according to Ecospan Environmental Ltd's standard operating procedures (ES-01, ES-02, ES-07 and ES-08). The benthic macrofauna present in the cores was subsequently identified to species level and enumerated in a laboratory setting and according to the National Marine Biological Analytical Quality Control Scheme guidelines following SOP ES-04.

As in the Phase I, the exact location of each sampling station was recorded using DGPS, and photographs taken of the littoral sediment and adjacent shoreline.

2.2.2 Topography, Reduction-Oxidisation (Redox) Profile & 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[14]. 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. Redox was determined in situ in the field using a redox meter. Redox (measured in mV) was determined at the surface and at depths of 1, 2, 4, 6, 8 and 10cm.

2.2.3 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 Tamar-Tavy Estuary and St. John's Lake SSSI's 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[17] 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.

2.3 Quality Assurance

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

2.3.1 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. 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 17 littoral sediment biotopes and 7 littoral rock biotopes were identified throughout the Tamar-Tavy Estuary and St. John's Lake SSSI. There do appear to be distributional patterns to biotopes related to geography (upper, mid and lower estuary) and shore height.

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Figure 2. Distribution of biotopes & Phase II target stations throughout the Tamar-Tavy Estuary SSSI November 2010

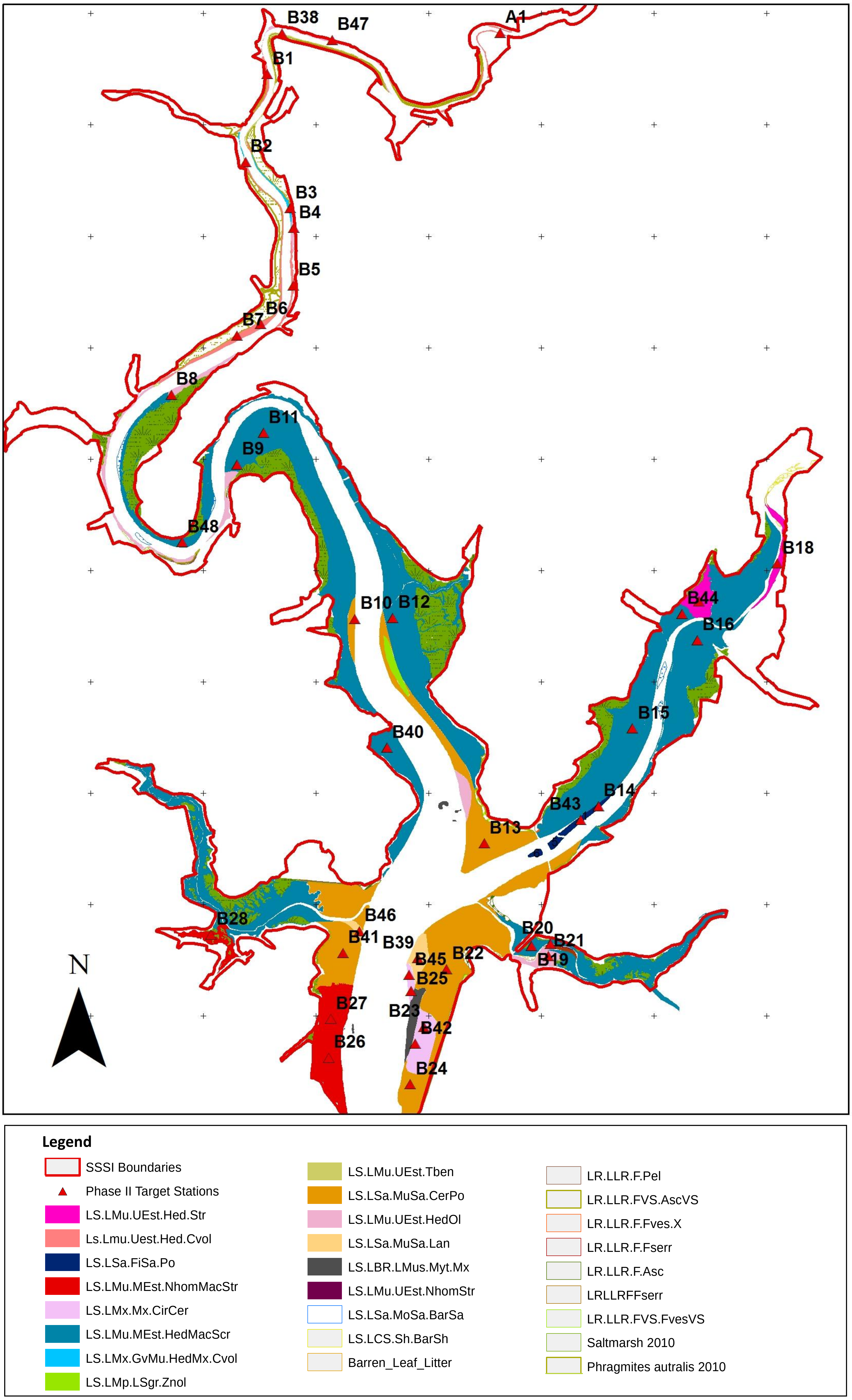
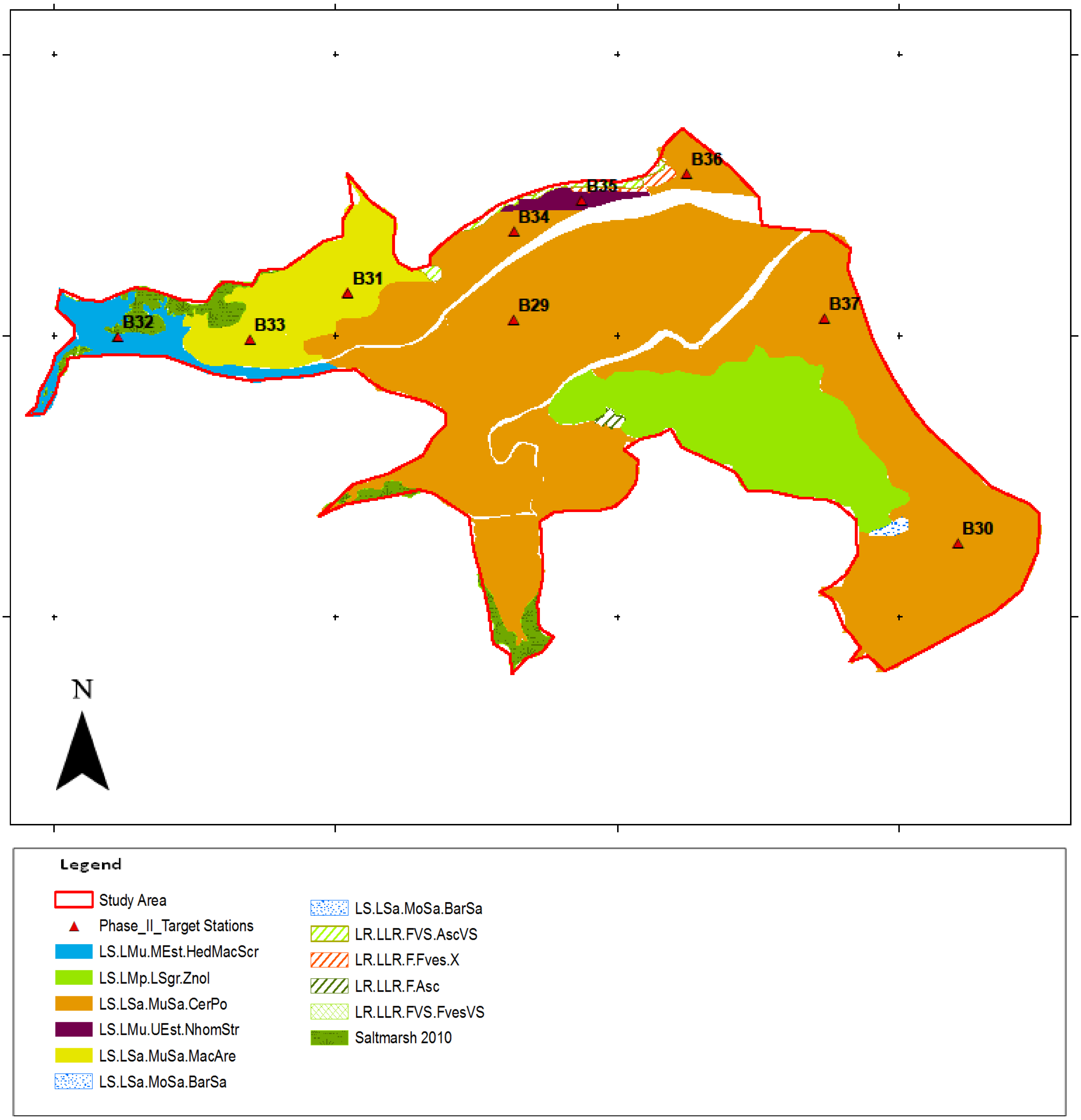


Figure 3. Distribution of biotopes & Phase II target stations throughout St. John's Lake SSSI November 2010



3.3 Physical Characteristics

3.3.1 Particle Size Analysis

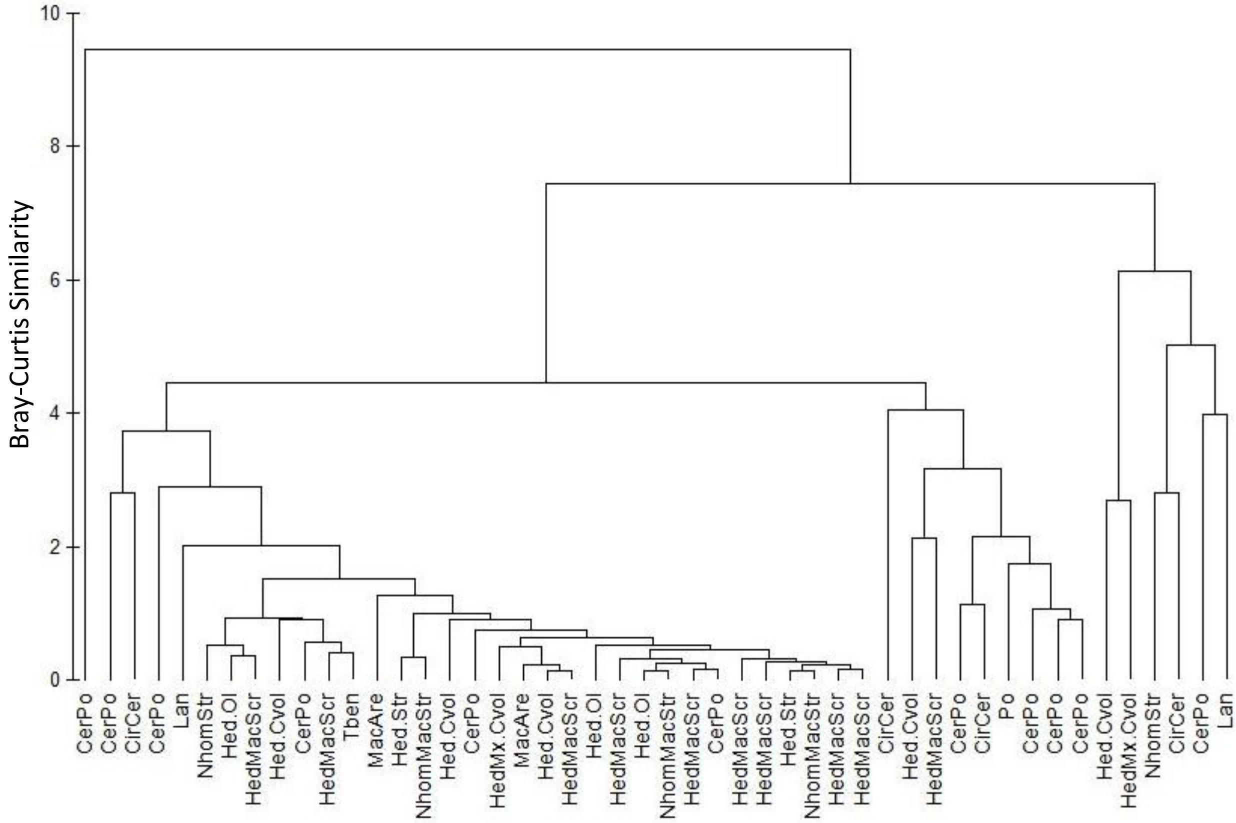
The particle size distributions (percentage distribution of sediments by weight) at each target station was summarised into 12 size bands following the Wentworth Scale.

Table 2. Particle size analysis results (Wentworth Scale)

Station	>4000 µm Pebbles	>2 <4 mm Granules	>1 <2 mm Very coars sand	>0.5 <1 mm Coarse sand	>250 <500 µm Medium sand	>125 <250 µm fine sand	>63 <125 µm Very fine sand	>31 <63 µm Silt	>16 <31 µm Silt	>8 <16 µm Silt	>4 <8 µm Silt	<4 µm Clay
B1	0.00	0.00	0.00	0.00	0.06	2.58	11.48	27.87	22.34	14.48	9.55	11.65
B2	19.76	5.72	4.61	8.53	0.07	2.45	6.62	15.03	13.33	9.61	6.61	7.67
B3	34.14	4.13	3.20	7.05	0.72	2.93	5.90	12.69	10.26	7.23	5.28	6.46
B4	0.00	0.00	0.11	1.83	0.22	2.53	9.02	24.32	21.23	15.51	11.41	13.84
B5	1.08	0.50	2.40	0.91	0.00	0.32	8.33	23.83	22.14	16.14	11.21	13.17
B6	0.00	0.00	0.00	0.00	0.96	20.03	32.25	21.12	8.48	6.17	4.81	6.18
B7	0.00	0.00	0.00	0.00	0.09	2.59	9.75	25.10	21.55	15.33	11.42	14.19
B8	0.00	0.00	0.00	0.00	0.00	1.01	8.73	24.69	23.26	16.38	11.61	14.32
B9	0.00	0.00	0.00	0.00	0.00	0.46	9.60	25.29	22.95	16.39	11.47	13.84
B10	0.00	15.25	12.85	16.42	3.82	9.23	8.10	10.63	8.29	5.81	4.28	5.33
B11	0.00	0.00	0.58	0.50	3.08	26.42	23.27	14.74	9.36	7.81	6.34	7.89
B12	0.00	0.00	0.00	0.00	0.00	3.08	15.07	27.50	20.08	12.83	9.33	12.14
B13	0.00	0.00	0.00	0.75	0.00	3.65	20.31	28.65	16.87	10.81	8.32	10.65
B14	0.00	0.00	1.53	5.80	23.95	41.34	8.31	4.74	4.81	3.41	2.70	3.40
B15	0.00	0.00	0.00	0.00	0.07	2.66	10.32	25.00	21.15	15.16	11.34	14.33
B16	0.00	0.00	0.00	0.00	0.00	1.48	8.33	23.23	22.98	16.88	11.99	15.10
B17	0.00	0.00	0.00	0.00	0.03	1.62	7.67	23.84	22.95	17.01	12.08	14.81
B18	0.00	0.00	0.00	0.00	0.00	0.00	6.07	22.27	23.39	18.17	13.48	16.61
B19	0.00	0.00	0.00	0.41	0.03	1.57	7.73	24.77	23.31	16.65	11.66	13.89
B20	1.19	3.72	11.07	18.00	11.18	21.10	7.26	7.15	6.30	4.76	3.71	4.54
B21	0.00	0.00	0.00	0.00	0.23	3.29	8.71	22.92	21.44	16.66	12.28	14.47
B22	0.00	0.00	1.75	0.54	0.00	2.58	22.23	30.65	16.35	9.56	7.20	9.14
B23	0.00	7.46	8.39	9.28	8.93	28.16	11.56	7.58	6.19	4.61	3.54	4.29
B24	0.00	0.00	1.06	0.83	0.00	7.26	23.97	27.40	15.23	9.38	6.72	8.15
B25	3.57	3.66	8.02	3.73	1.90	23.73	22.52	11.25	6.75	5.36	4.01	5.48
B26	0.00	0.00	0.00	0.00	0.00	0.95	8.30	25.10	23.11	16.17	11.89	14.47
B27	0.00	0.00	0.31	0.00	0.03	1.94	7.72	23.47	23.05	16.81	12.09	14.55
B28	0.00	0.00	0.00	0.00	0.03	1.61	6.45	22.09	23.18	17.95	13.00	15.72
B29	0.00	0.00	1.24	1.06	0.00	1.97	16.98	27.02	17.66	13.25	14.58	6.28
B30	0.00	3.63	4.04	3.49	0.19	7.21	14.45	16.94	14.10	12.43	10.38	13.18
B31	0.00	0.00	0.90	1.10	0.00	0.86	9.55	21.16	19.45	16.53	13.78	16.67
B32	0.00	0.00	0.00	0.00	0.02	1.09	7.16	24.64	23.07	16.45	12.47	15.16
B33	0.00	0.00	0.00	0.00	0.29	2.91	8.80	24.94	21.78	15.44	11.42	14.40
B34	0.77	0.00	0.00	0.00	0.03	1.56	7.70	24.68	23.23	16.59	11.62	13.84
B35	0.00	0.00	0.00	0.00	0.00	1.05	13.34	25.52	19.79	14.71	11.67	13.89
B36	0.00	0.00	0.00	0.00	0.00	2.84	16.42	25.45	19.02	13.61	10.10	12.56
B37	0.00	2.56	3.12	3.07	0.23	12.48	25.13	19.06	10.38	8.56	6.89	8.52
B38	0.00	0.00	0.00	0.00	0.00	0.94	15.07	28.46	19.87	13.43	10.10	12.12
B39	0.00	0.63	0.55	4.81	0.00	0.57	11.72	27.47	21.18	13.26	8.85	11.03
B40	0.00	0.00	0.00	0.00	0.05	1.88	6.97	23.03	23.71	17.22	12.19	14.98
B41	0.0	0.0	0.0	0.0	0.0	0.2	7.6	26.8	24.3	16.6	11.5	13.1
B42	0.00	2.92	0.68	1.95	1.17	12.42	21.38	21.68	12.50	8.80	7.20	9.27
B43	0.00	0.20	1.39	6.54	0.00	5.60	20.23	24.96	14.49	9.55	7.46	9.56
B44	0.00	0.00	0.00	0.00	0.00	0.51	8.55	23.80	22.92	16.89	12.00	15.32
B45	4.38	6.73	9.29	6.89	0.03	1.72	7.48	19.27	16.18	11.08	7.61	9.35
B46	15.56	14.03	15.29	5.66	0.43	3.47	5.45	11.38	10.04	7.20	5.20	6.30
B47	0.00	0.00	0.00	0.00	0.09	4.15	12.16	24.51	20.57	15.09	10.68	12.75
B48	0.00	0.00	0.00	0.00	0.00	3.25	13.11	24.70	19.91	14.48	10.81	13.74

It is well documented that the particle size characteristics of the sediment has an effect on the structure of benthic communities[17]. However, Figure 4 overleaf illustrates only a relatively loose association between the biotope (and therefore benthic communities) and the sediment granulometry. This is partly because biotopes focus on relatively few species which are weighted as important, if all faunal data was weighted equally then it is likely that a stronger correlation between faunal communities and sediment granulometry would be observed. However, results do suggest that other environmental variables within the Tamar system are likely to be having a strong influence on the benthic communities; this is expected given the well-developed salinity gradient that exists within the Tamar-Tavy study area in particular, as well as the high degree of local variability in wave exposure, carbon matter, nutrient input and pollution that exists in both study areas.

Figure 4. **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 3. Sediment organic carbon content (%)

Station	Organic Carbon Content (%)	Station	Organic Carbon Content (%)
B1	11.04	**B25**	3.59
B2	10.24	**B26**	9.27
B3	10.19	**B27**	9.35
B4	8.89	**B28**	7.58
B5	11.92	**B29**	5.22
B6	9.28	**B30**	4.93
B7	9.50	**B31**	4.69
B8	10.42	**B32**	6.90
B9	10.73	**B33**	6.89
B10	5.52	**B34**	7.51
B11	7.13	**B35**	5.67
B12	7.46	**B36**	6.04
B13	5.4	**B37**	3.24
B14	2.9	**B38**	11.43
B15	8.92	**B39**	3.35
B16	10.98	**B40**	10.18
B17	10.16	**B41**	8.74
B18	10.36	**B42**	3.63
B19	8.64	**B43**	3.43
B20	4.35	**B44**	10.96
B21	11.19	**B45**	4.32
B22	5.88	**B46**	8.02
B23	4.45	**B47**	10.57
B24	4.77	**B48**	11.22

The sediment organic carbon content ranges from moderate to high in the Tamar-Tavy and low to moderate in St. John's Lake. As expected the highest levels are present in the upper estuarine reaches of the Tamar and within Tamerton creek.

Previous studies have found that the organic carbon content of sediment samples from the Tamar is largely dependent on the proportion of fine sediment within the sample[18]. As may therefore be expected, the lowest organic carbon levels were generally found in those sediments with the least silt and clay content due their exposure to tidal currents and scouring.

3.3.3 Sediment Redox Profile

The depth of the Redox potential discontinuity (RPD) layer, a recognizable division zone between oxidized (sub-oxic) and reduced chemical conditions, is represented by the transition of positive to negative mV values.

Table 4. Sediment redox profile (mV)

Target Station	Redox (mV)						
	Surface	1cm	2cm	4cm	6cm	8cm	10cm
B1	101	99	96	62	n/a	n/a	n/a
B2	142	115	20	-49	n/a	n/a	n/a
B4	41	5	-43	-126	-146	n/a	n/a
B5	120	94	93	91	86	-15	-49
B6	117	98	35	3	-47	-60	-68
B7	80	55	29	-6	-36	-60	-85
B8	175	128	63	23	-15	-128	-173
B9	143	137	130	12	-37	-59	-74
B10	182	111	10	-14	-24	-29	-37
B11	164	160	161	142	40	-5	-18
B12	104	70	26	-27	-59	-70	-80
B13	35	-40	-50	-62	-70	-74	-80
B14	168	198	197	195	187	186	183
B15	130	104	12	-60	-98	-115	-120
B16	55	32	54	-90	-112	-120	-124
B17	63	49	44	-10	-47	-74	-12
B18	133	106	50	-100	-124	-149	-153
B19	159	153	53	-4	-41	-55	-73
B20	103	104	63	-9	-41	-82	-140
B21	105	57	6	-38	-60	-69	-78
B22	54	38	-4	-46	-125	-128	-134
B23	105	61	10	-96	-103	-111	-119
B24	144	98	30	-44	-82	-104	-104
B25	107	83	78	-134	-135	-137	-137
B26	130	-3	-26	-58	-71	-80	-84
B27	98	62	-15	-80	-91	-101	-100
B28	167	-34	-61	-79	-125	-172	-110
B29	102	85	79	44	-17	-62	-125
B30	166	70	-92	-134	-131	-143	-144
B31	113	73	-10	-45	-55	-68	-66
B32	80	62	11	-43	78	-96	-107
B33	141	90	-5	-24	-32	-40	-65
B34	130	94	-30	-34	-38	-2	-56
B35	161	152	131	50	24	7	-5
B36	143	56	67	-77	-110	-123	-131
B37	242	194	152	52	-31	-70	-91
B38	75	63	42	*25*	*2*	-22	n/a
B39	126	90	93	100	98	104	102
B40	106	52	-25	-54	-77	-85	-94
B41	125	93	65	9	-51	-65	-76
B42	139	147	146	41	-32	-76	-126
B43	154	148	147	145	152	106	55
B44	98	75	28	-48	-75	-90	-99
B45	232	224	195	42	-131	-295	-271
B46	144	118	32	-42	-92	-127	-135
B48	129	111	109	71	-16	-49	-70

Within both the Tamar-Tavy and St. John's Lake there is no obvious pattern to the distribution of the most anoxic conditions. Both survey phases were carried out in late autumn/winter and therefore the presence of opportunistic algal mats (*Enteromorphae* and *Ulvae Spp*.) were less obvious, nonetheless such mats are likely to be a primary influencing factor amongst a number of confounding variables. The different numbers and types of infaunal species found distributed throughout the estuary for example, display different behavioural characteristics (e.g. burrows, tubes and feeding voids) which introduce oxygen into the sediments with variable levels of effectiveness. It has also been hypothesised that the finer sediments of the upper reaches are 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(18); a factor which may contribute to alleviating the anoxic conditions at upper estuarine stations(18).

3.4 Saltmarsh Extent and Distribution

3.4.1 Tamar-Tavy

Figure 5. Extent and distribution of saltmarsh in the Tamar-Tavy SSSI 2010 (Graticules represent 1km^2)

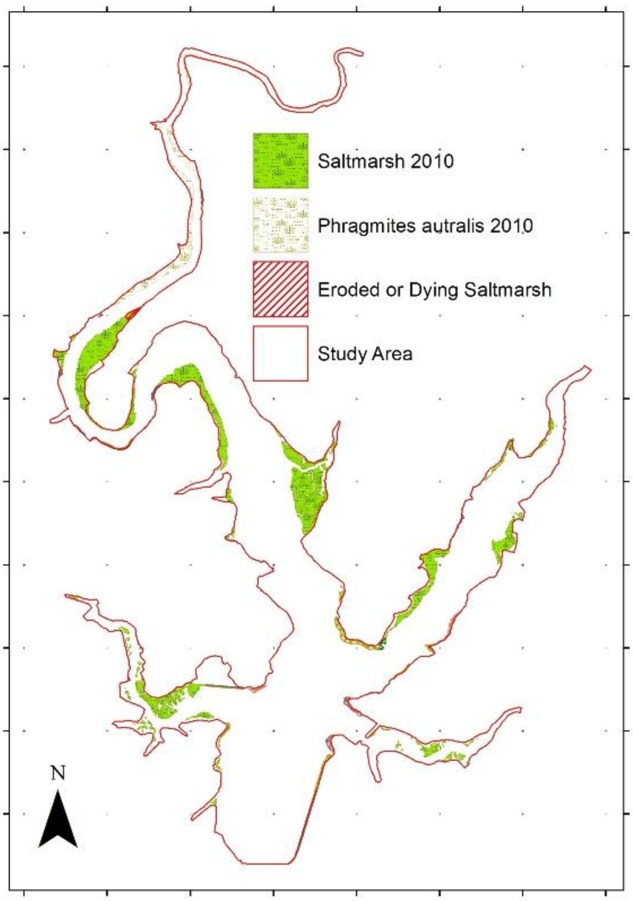
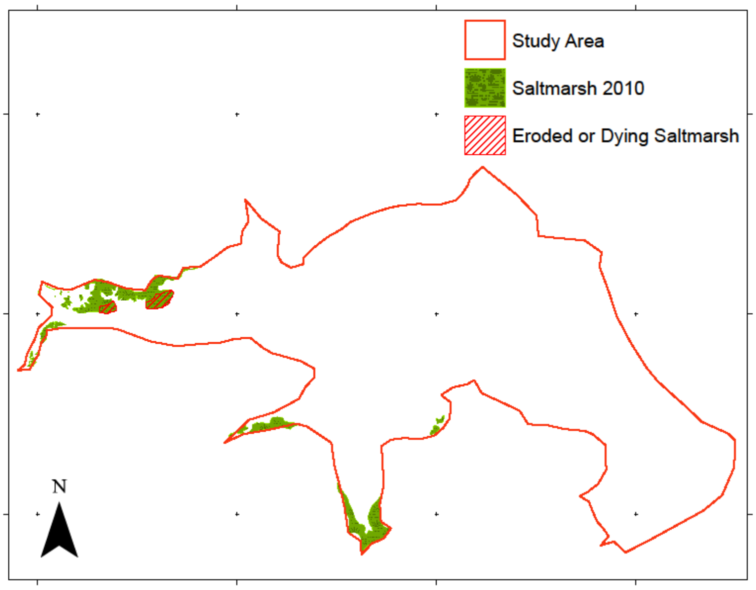


Figure 6. Extent and distribution of saltmarsh in St. John's Lake SSSI 2010 (Graticules represent 1km^2)



Within the Tamar-Tavy SSSI field observations determined that there was one possible area of saltmarsh accretion, opposite Weir Quay. However, this cannot be confirmed due to the very limited scale of the area which is not discernable from the 2007 aerial photography. Erosion however, was apparent at those saltmarshes which lie between Weir Quay and Thorn Point (Figures 7 and 8), and those opposite Crosspark Wood on the Eastern bank of the upper estuary (Figure 9). The erosion was indicated by undercut, steeply sloping or exposed sediment banks bordering the saltmarsh.

Figure 7. Eroded saltmarshes between weir Quay and Thorn Point

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Figure 8. Eroded saltmarshes between weir Quay and Thorn Point

Figure 9. Eroded saltmarshes opposite Crosspark Wood on the Eastern bank of the upper Tamar

In addition, at the most northern extent of the *Spartina spp* distribution on the eastern Tamar bank opposite Chapel Farm, an area approximately 20 m^2 although still alive, had an unhealthy 'scorched' appearance.

The extent of overall erosion and/or die-back within the Tamar-Tavy SSSI is not at a scale which is detectable when compared to the Coastal Observatory aerial photography from the 2007 survey using DGPS, and therefore it is difficult to discern whether the 1% threshold of loss in extent has occurred since 2007.

3.4.2 St. Johns Lake

The distribution of saltmarsh within St. John's Lake is not extensive and is limited to the northern shore west of Eastdown Lake, and relatively narrow fringes within Penhale and Insworke Creeks.

There is no evidence of pioneer saltmarsh or saltmarsh accretion anywhere within the lake; however die-back (rather than erosion) of the saltmarsh west of Eastdown Lake was observed specifically at its lower shore distribution either side of the sewage outfall. The 2007 aerial photography would suggest that this area of saltmarsh had died back or was in the process of die-back at that time.

The extent of overall die-back within the St. John's Lake SSSI is not at a scale which was detectable when compared to the Coastal Observatory 2007 aerial photography, and therefore it is difficult to discern whether the 1% threshold of loss in extent has occurred since 2007.

3.5 Biotopes Identified within the Tamar-Tavy Estuary and St. John's Lake SSSI's

3.5.1 LS.LMu.UEst.NhomStr

The biotope LS.LMu.UEst.NhomStr (*Nephtys hombergii* and *Streblospio shrubsolii* in littoral mud) is restricted to one small area in each of the SSSI's. In the Tamar-Tavy within Tamerton Creek, and in St. John's Lake on the northern shore.

Figure 10. Extent and distribution of LS.LMu.UEst.NhomStr in the Tamar-Tavy (Graticules represent 1km^2)

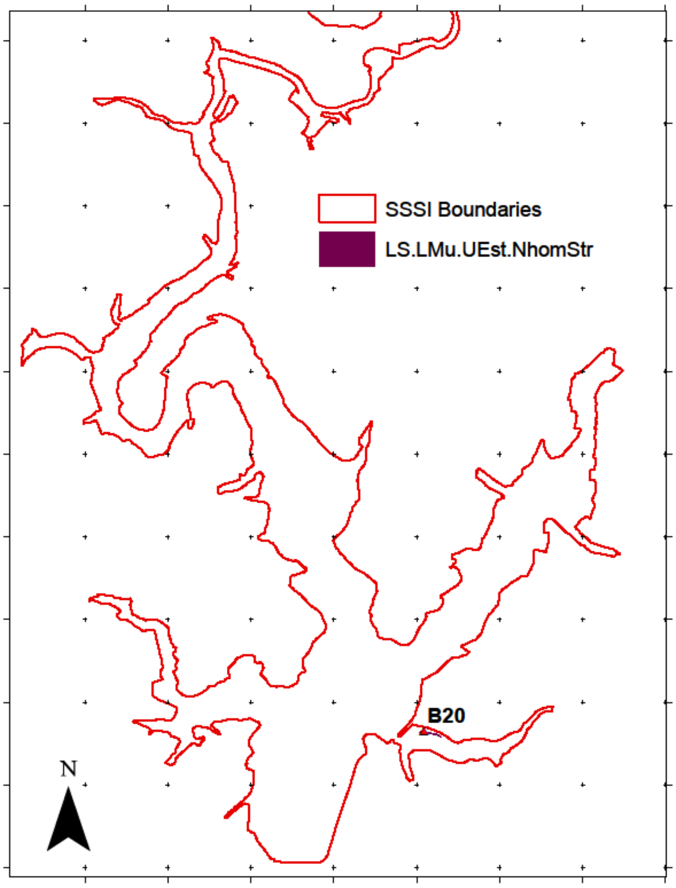
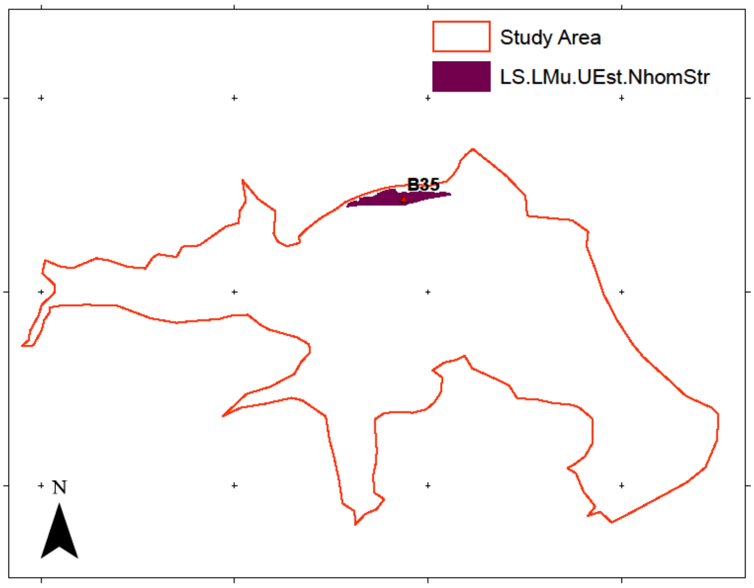


Figure 11. Extent and distribution of LS.LMu.UEst.NhomStr in St. John's Lake (Graticules represent 1km^2)



The sediments within the two cores taken from the biotope are different; those sediments in Tamerton Creek are described as slightly gravelly muddy sand, whilst those in St. Johns Lake are more in-line with those commonly found within the biotope, namely sandy mud. Redox conditions were also variable with the station in the Tamar-Tavy displaying more anoxic conditions (the discontinuity later was at 2-4cm depth and at 10cm depth -140 mV was recorded, as opposed to 8-10cm and -5 mV respectively in St. John's Lake). The proportion of organic carbon within sediment samples was comparable 5.67% at station B35 and 4.35% at B20.

The average similarity between the two stations in terms of the infaunal assemblages present is low at 29%. This is probably as a result of the stations distribution in two distinctly different areas of the estuarine system and the different sediment types present. Those species which provide the highest percentage contribution to similarity are listed in Table 6 below. As expected for the biotope the most abundant and frequently occurring species are the polychaetes *Streblospio shrubsolii* and *Nephtys hombergii*.

Table 5. Species % contribution in Tamar system LS.LMu.UEst.NhomStr biotope

Species	Average Abundance	Average Similarity	% Contribution
Pygospio elegans	250	8.58	29.29
Nephtys Sp. Juv.	600	8.58	29.29
Heterochaeta costata	200	6.07	20.71
Streblospio shrubsolii	1600	6.07	20.71

Biotope communities represented at the Tamar-Tavy station display slightly higher species diversity, evenness and richness.

Table 6. LS.LMu.UEst.NhomStr biotope community analysis

Station	No. Taxa Per Core	No. Individuals	Margalef's Species	Pielou's Evenness	Shannon Wiener	Simpson diversity
	s	Per Core n	Richness d	J'	Index H'(log10)	Index 1-Lambda'
B20	8	63	1.690	0.614	0.555	0.641
B35	7	56	1.491	0.516	0.436	0.488

The characteristics at stations correspond loosely with the LS.LMu.UEst.NhomStr biotope described within The Marine Habitat Classification for Britain and Ireland (Vs 04.05), deviation from the described biotope exists both in the substratum and faunal components.

At the station within Tamerton Creek there is a gravel component to the sediment which is not usual for the biotope. One of the most notable differences in terms of the infaunal assemblages within the biotope is that species diversity is higher than expected, particularly within the Tamar-Tavy. Despite this elevated species diversity however, there is an absence of specific characteristic species including the cirratulid *Aphelochaeta marioni* at both stations, and the oligochaete *Tubificoides benedii* at the St. Johns' Lake station. However, the cirratulid *Tharyx A* is abundant at the Tamar-Tavy station whilst the oligochaete *Heterochaeta costata* is common at both stations which may imply some type of ecological niche substitution by these other closely related species in the Tamar system.

Where characterising species are present, their abundance also deviates from that outlined in the biotope description; *Streblospio shrubsolii* for example is present in the Tamar-Tavy in numbers 6 times greater than expected, but is far less abundant than expected at the St. John's Lake Station (see table 7 below).

Table 7. Tamar system LS.LMu.UEst.NhomStr replicate core species composition

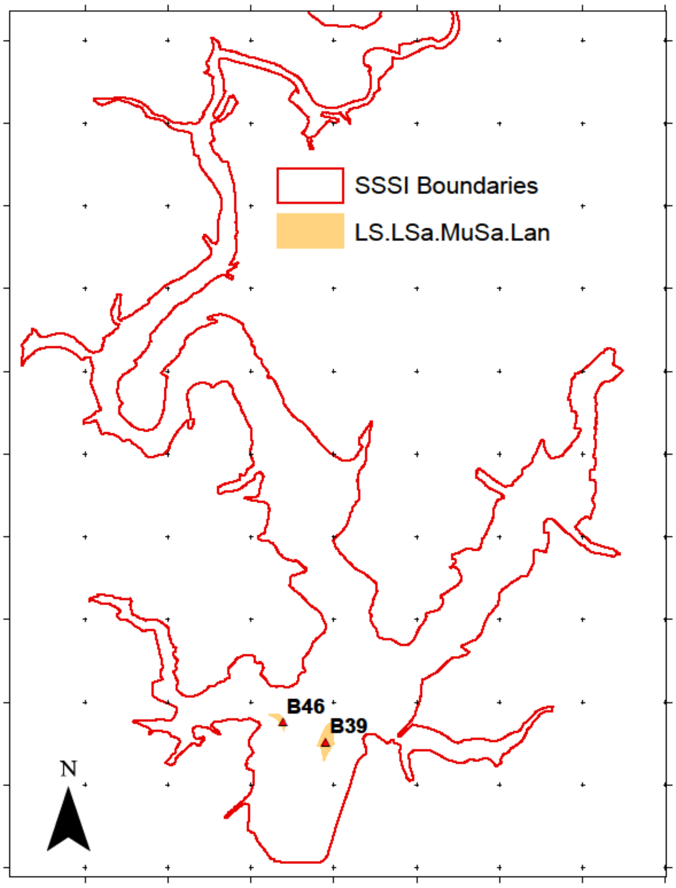
Species	B20 No. m²	B35 No. m²	Biotope Characterising Species Abundance
Nephtys hombergii	100	0	108
Nephtys Spp.Juv	200	1000	(108)
Streblospio shrubsolii	3100	100	483
Pygospio elegans	200	300	
Tharyx A	2200	0	
Cossura Spp.	100	0	
Melinna palmata	0	100	
Ampharete grubei	0	100	
Heterochaeta costata	300	100	
Tubificoides benedii	100	0	
Hydrobia ulvae	0	3900	

The variations observed are 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). In addition, the differences observed in the fauna at the two LS.LMu.UEst.NhomStr stations specifically are likely to be as a result of the small areas they cover, and therefore represent transitional variations to the different neighbouring biotopes at the two locations.

3.5.2 LS.LSa.MuSa.Lan

The biotope LS.LSa.MuSa.Lan (*Lanice conchilega* in littoral sand) is found in the Tamar-Tavy SSSI on the tide-swept lower shores on either side of the main Tamar-Tavy channel, below the point at which the two catchments merge.

Figure 12. Extent and distribution of LS.LSa.MuSa.Lan in the Tamar-Tavy SSSI (Graticules represent $1km^2$)



The sediments within the cores taken from the biotope are described as slightly gravelly sandy mud (eastern bank) and gravelly mud (western bank). The carbon content within sediment samples range from 3.35% (eastern bank) to 8.02% (western bank). Redox conditions are also irregular; the sediments of the eastern bank are more oxygenated and at 10cm depth the redox value is still highly positive at 102 mV. In contrast, the redox discontinuity layer on the western bank is present within 2-4cm, and at 10cm depth the redox value is -138.

The average similarity between the two stations is 35.70%; this is low given the close proximity of the two stations. The most abundant and frequently occurring species which therefore provide the highest percentage contribution to similarity within the replicate cores are the cirratulid *Tharyx A*, and the oligochaete *Heterochaeta costata* (see Table 8 below).

Table 8. Species % contribution in Tamar system LS.LSa.MuSa.Lan biotope

Species	Average Abundance	Average Similarity	% Contribution
Tharyx A	8.00	16.17	45.31
Heterochaeta costata	5.00	11.44	32.04
Lanice conchilega	1.50	8.09	22.65

Communities at the western bank station display higher species richness and slightly higher diversity, whilst evenness is comparable between the two stations.

Table 9. 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-Lambda'
B39	6	34	1.418	0.805	0.626	0.750
B46	9	18	2.768	0.868	0.829	0.856

The characteristics at stations correspond reasonably well with the LS.LSa.MuSa.Lan biotope described within The Marine Habitat Classification for Britain and Ireland (Vs 04.05), although there is some deviation from the faunal component.

The species diversity is similar to that expected for the biotope but the composition and abundance of species varies somewhat; *Lanice conchilega* for example is present in numbers only a fraction of those expected for the biotope, whilst oligochaetes are not characteristic but commonly present (see table 10 below).

Table 10. Tamar system LS.LSa.MuSa.Lan replicate core species composition

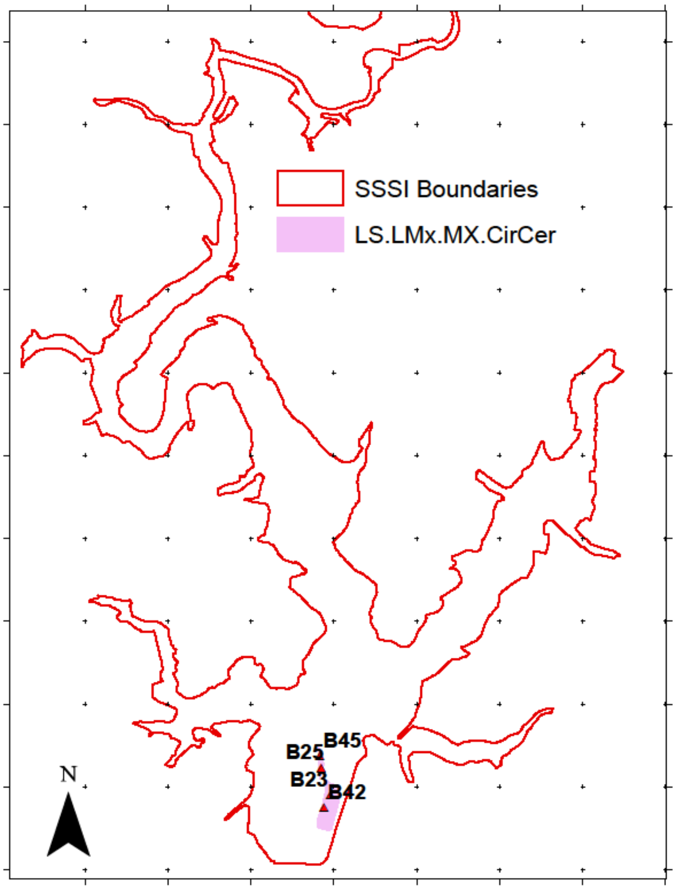
Species	No. m²		
	B39	B46	Biotope Characterising Species Abundance
Nephtys Spp.Juv	100	0	(77)
Tharyx A	1200	400	1484
Lanice conchilega	200	100	959
Corophium volutator	0	100	(1921)
Hediste diversicolor	0	100	
Heteromastus filiformis	1000	0	
Ampharete grubei	0	100	
Heterochaeta costata	800	200	
Tubificoides benedii	0	100	

The variations observed in the physical and biological components of the two LS.LSa.MuSa.Lan stations are likely to be attributable to the different influences which are exerted on each side of the channel; most notably the eastern bank is more exposed to tidal scour. In addition the low number of replicate samples is likely to be an exacerbating factor; if a greater number of samples were taken within the biotope then the average similarity is likely to rise.

3.5.3 LS.LMx.Mx.CirCer

The biotope LS.LMx.Mx.CirCer (Cirratulids and *Cerastoderma edule* in littoral mixed sediment) is found in two defined areas on the eastern bank of the lower Tamar-Tavy SSSI.

Figure 13. Extent and distribution of LS.LMx.Mx.CirCer in the Tamar-Tavy (Graticules represent 1km^2)



The sediments within the cores taken from this biotope are described as gravelly muddy sand, slightly gravelly sandy mud and gravelly mud. The carbon content within sediment samples are low to moderate ranging from 3.59% to 4.45%. Redox conditions between stations are more variable. Station 45 was particularly different as it displayed highly oxygenated readings at the surface (232 mV) and highly anoxic conditions at 10 cm depth (-271). At the remaining stations the redox value ranged from -119 to -137 at 10cm depth. The discontinuity layer occurred at 2-6cm at all stations.

In terms of benthic faunal communities the average similarity between the four stations is low at 34.07%. Those species which provide the highest percentage contribution to similarity are listed in Table 11 below.

Table 11. Species % contribution in Tamar system LS.LMx.Mx.CirCer biotope

Species	Average Abundance	Average Similarity	% Contribution
Tharyx A	86.50	14.30	41.98
Heteromastus filiformis	13.00	3.07	9.00
Pygospio elegans	3.00	2.70	7.93
Streblospio shrubsolii	3.50	2.60	7.64
Nephtys hombergii	0.75	2.31	6.78
Tubificoides benedii	5.50	1.96	5.74
Sphaerosyllis Spp.	1.00	1.53	4.49
Cossura Spp.	0.50	1.16	3.40
Melita palmata	3.25	0.81	2.38
Polydora cornuta	2.25	0.81	2.38

The most abundant and frequently occurring species within the replicate cores is the cirratulid *Tharyx A*. The characterising species *Cerastoderma edule* is also present but the numbers are under-represented in cores due to the small core size used.

The communities at the four stations all display relatively high species richness, whilst diversity and evenness are variable within both distributions of the biotope (see Table 12 below).

Table 12. 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-Lambda'
B23	17	296	2.812	0.380	0.467	0.419
B25	9	14	3.031	0.852	0.813	0.835
B42	11	39	2.730	0.804	0.837	0.819
B45	16	182	2.882	0.560	0.675	0.650

The characteristics at stations 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 either abundant or super-abundant at all but station B25 (where it is common), which may imply some type of ecological niche substitution within the Tamar 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, their abundance is generally far lower than that outlined in the biotope description. A number of non-characterising species also contribute significantly to the species diversity at all stations.

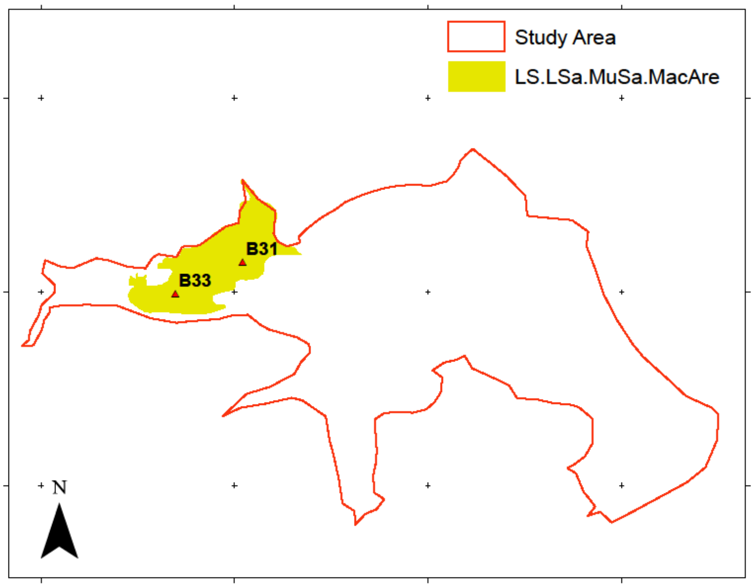
Table 13. Tamar system LS.LMx.Mx.CirCer replicate core species composition

Species	No. m^2 B23	B25	B42	B45	Biotope Characterising Species Abundance
Pygospio elegans	300	100	800	0	608
Capitellidae Spp.Juv	0	100	0	0	(787)
Capitella capitata Agg.	0	0	0	200	787
Melinna palmata	100	100	0	0	648
Tubificoides benedii	100	0	300	1800	7945
Cardiacea Spp.Juv.	100	0	200	0	(638)
Cerastoderma edule	0	0	100	0	638
Nemertea Unident	100	0	0	0	
Syllidia Spp.Juv	0	0	0	100	
Sphaerosyllis Spp.	100	0	200	100	
Nereidae Spp.Juv	0	100	0	100	
Hediste diversicolor	1400	0	0	0	
Nephtys hombergii	100	100	100	0	
Nephtys Spp.Juv	100	0	0	100	
Polydora cornuta	400	0	0	500	
Streblospio shrubsolii	700	0	500	200	
Tharyx A	22400	600	1400	10200	
Cossura Spp.	0	100	100	0	
Heteromastus filiformis	2300	0	100	2800	
Lagis koreni	100	0	0	0	
Ampharete grubei	0	0	100	100	
Lanice conchilega	0	0	0	100	
Oligochaete Unident	0	0	0	800	
Heterochaeta costata	800	0	0	0	
Amphipoda Unident	0	100	0	0	
Gammaridae Spp.Juv	0	100	0	0	
Gammaridae Unident	0	0	0	100	
Melita palmata	400	0	0	900	
Corophium Spp.Juv.	0	0	0	100	
Hydrobia ulvae	100	0	0	0	

3.5.4 LS.LSa.MuSa.MacAre

The biotope LS.LSa.MuSa.MacAre (*Macoma balthica and Arenicola marina* in littoral muddy sand) is restricted to one area in St. John's Lake SSSI, within Eastborne Lake.

Figure 14. Extent and distribution of LS.LSa.MuSa.MacAre in St. John's Lake (Graticules represent 1km^2)



The sediments within cores taken at both stations within this biotope are described as sandy mud. The carbon content within sediments range from 4.69% to 6.89%. The redox conditions are also similar; the discontinuity layer is reached within 2cm of the surface at both stations, and at 10cm depth conditions are not particularly anoxic at around -65 mV.

The average similarity of the infaunal assemblages at the two stations is high at 70.54%. Those species which provide the highest percentage contribution to similarity are listed in Table 14 below. By far the most abundant and frequently occurring species within the replicate cores is the cirratulid *Tharyx A*. The presence of the characterising species *Arenicola marina* is not represented within the cores due to the core size, but was observed to be present in the field and therefore significant in assigning the biotope at stations.

Table 14. Species % contribution in Tamar system LS.LSa.MuSa.MacAre biotope

Species	Average Abundance	Average Similarity	% Contribution
Tharyx A	204.00	39.66	56.22
Tubificoides benedii	19.50	11.32	16.05
Pygospio elegans	4.00	6.83	9.68
Nephtys Spp. Juv.	4.00	5.91	8.38

Communities within the biotope displayed similar species diversity, evenness and richness.

Table 15. LS.LSa.MuSa.MacAre 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'
B31	7	163	1.178	0.376	0.318	0.309
B33	11	321	1.733	0.271	0.283	0.269

The characteristics at stations correspond fairly well with the LS.LSa.MuSa.MacAre biotope described within The Marine Habitat Classification for Britain and Ireland (Vs 04.05), although there is some deviation from the faunal component.

Macoma balthica and *Arenicola marina* were not represented by the faunal analysis of the cores but were observed to be present in common numbers in the field. With the exception of *Scoloplos armige*r, all other characterising species are present in numbers at least an order of magnitude greater than expected for the biotope. A number of non-characterising species such as *Nephtys spp* and the terribelid *Ampharete grubei* are also present, and add considerably to the species diversity within the biotope, particularly at station B33.

Table 16. Tamar system LS.LSa.MuSa.MacAre replicate core species composition

Species	No. m^2		
	B31	B33	Biotope Characterising Species Abundance
Pygospio elegans	400	400	58
Tubificoides benedii	1100	2800	(48)
Cerastoderma edule	300	0	116
Macoma balthica	100	100	248
Hediste diversicolor	0	200	
Nephtys hombergii	0	100	
Nephtys Spp.Juv	500	300	
Streblospio shrubsolii	0	300	
Tharyx A	0	100	
Ampharete grubei	400	100	
Hydrobia ulvae	13500	27300	
Bivalve Juv.Unident	0	400	

3.5.5 LS.LSa.MuSa.CerPo

The biotope LS.LSa.MuSa.CerPo (*Cerastoderma edule* and polychaetes in littoral muddy sand) is widespread throughout both the mid-lower sections of the Tamar-Tavy SSSI and throughout St. John's Lake SSSI.

Figure 15. Extent and distribution of LS.LSa.MuSa.CerPo in the Tamar-Tavy (Graticules represent 1km^2)

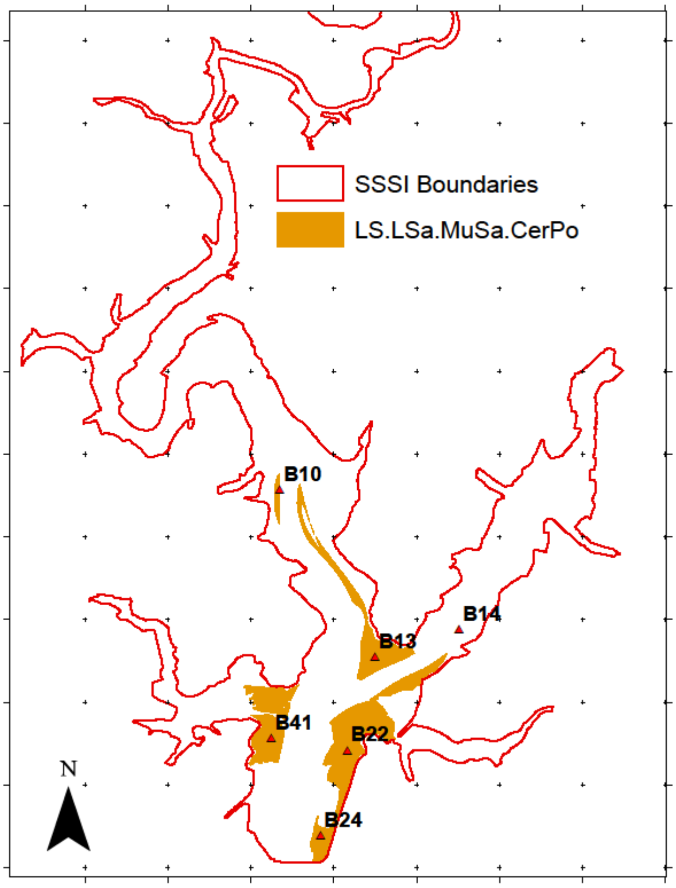
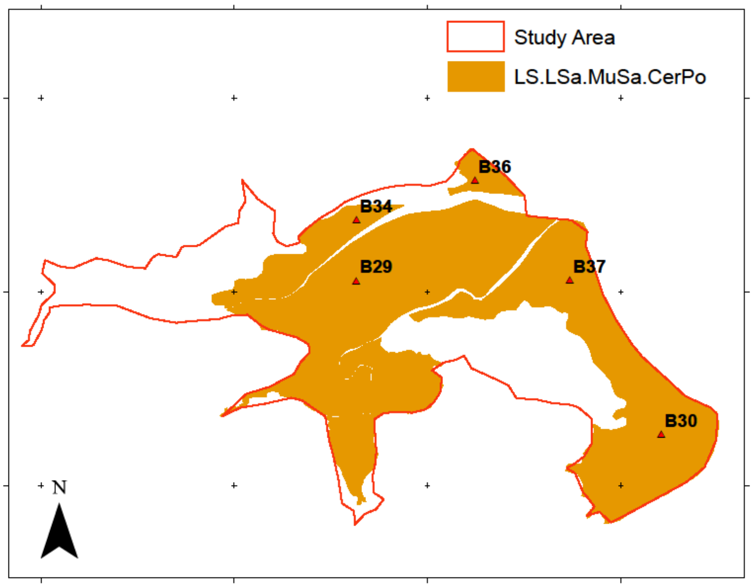


Figure 8. Extent and distribution of LS.LSa.MuSa.CerPo in St. John's Lake (Graticules represent 1km^2)



As a result of the widespread distribution of the biotope throughout the Tamar system the sediments at stations are variable in character; sediments range from being described as mud, to gravelly muddy sand. The proportion of organic carbon within sediments ranges from 3.24% to 8.74%. Generally the most organically rich sediments are found on the upper shore and at the upper estuarine distributions of the biotope. The redox discontinuity layer within sediments is present at varying depths ranging from <1cm to >10cm from the surface.

The average similarity of faunal assemblages between stations is 37.20%. Those species which provide the highest percentage contribution to similarity are listed in Table 17 below. Although the presence of *Cerastoderma edule* is not represented in Table 17 due to the small core size used, in practical terms the presence of the species in the field contributes significantly to the similarity of stations within the biotope.

Table 17. Species % contribution in Tamar system LS.LSa.MuSa.CerPo biotope

Species	Average Abundance	Average Similarity	% Contribution
Hydrobia ulvae	77.64	9.49	25.52
Streblospio shrubsolii	6.91	7.30	19.63
Tharyx A	22.18	5.16	13.86
Nephtys Spp Juv	5.00	4.57	12.28
Pygospio elegans	4.64	3.01	8.10
Tubificoides benedii	9.45	2.90	7.80
Nephtys hombergii	1.36	1.18	3.17

The most frequently occurring species excluding *Hydrobia ulvae* is the spionid *Streblospio shrubsolii*, however the most abundant species when present is the cirratulid *Tharyx A*. Between 1 and 13 taxa were encountered at all 11 stations; species richness and diversity is greatest at those stations within St. John's Lake.

Table 18. Tamar system 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-Lambda'
B10	9	94	1.761	0.348	0.332	0.309
B13	1	198	1.891	0.471	0.490	0.488
B14	8	1060	1.501	0.468	0.423	0.479
B22	8	73	1.632	0.632	0.570	0.594
B24	10	56	2.236	0.701	0.701	0.691
B29	12	548	1.744	0.394	0.426	0.461
B30	6	24	1.573	0.949	0.738	0.844
B34	12	262	1.975	0.404	0.436	0.532
B36	13	114	2.534	0.568	0.632	0.594
B37	11	41	2.693	0.844	0.879	0.846
B41	7	65	1.437	0.486	0.411	0.424

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 deviation from the sediment character and faunal component.

The sediments within St. John's Lake contain a gravel component which is unusual for the biotope. The most notable difference between the infaunal communities recorded, and those described as characteristic for the biotope, is that only 5 of the total 11 characterising species were present at any of the stations. *Crangon crangon* 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. However, 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 polychaete species are present their abundance is also generally lower than that outlined in the biotope description with the exception of those at station B13, which is located in the Tamar-Tavy SSSI at the point at which the Tamar and Tavy catchments merge.

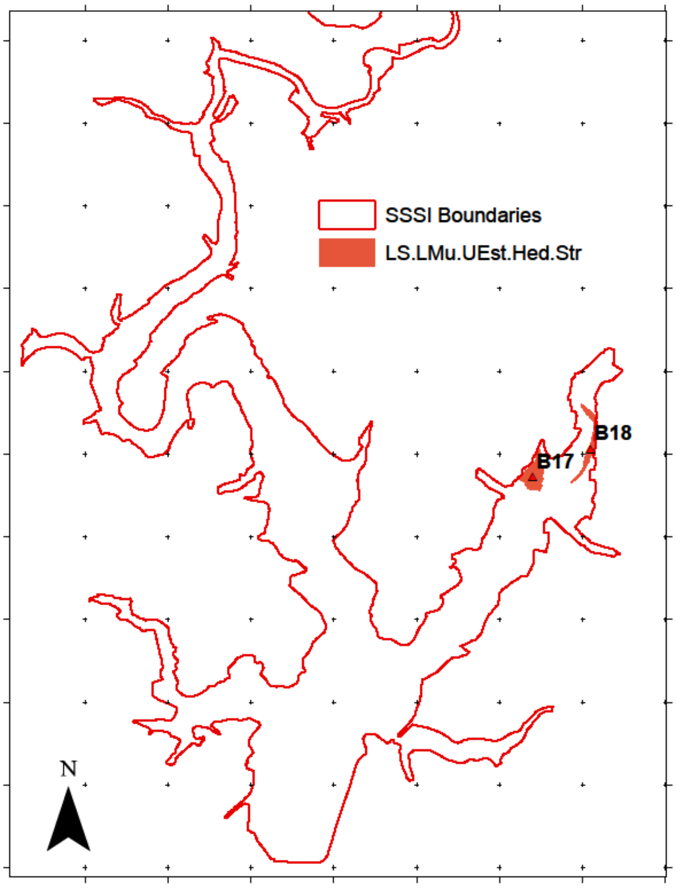
Table 19. Tamar system LS.LSa.MuSa.CerPo replicate core species composition

Species	B10 No. m^2	B13 No. m^2	B14 No. m^2	B22 No. m^2	B24 No. m^2	B29 No. m^2	B30 No. m^2	B34 No. m^2	B36 No. m^2	B37 No. m^2	B41 No. m^2	Biotope Characterising Species Abundance
Pygospio elegans	0	2400	800	300	100	400	0	0	200	800	100	832
Capitellidae Spp.Juv	0	300	0	0	0	0	0	0	0	0	0	160
Hydrobia ulvae	0	13900	0	1100	3000	39100	0	16000	7100	300	4900	25
Cerastoderma edule	0	200	0	0	0	100	500	0	200	300	0	715
Macoma balthica	0	100	0	0	0	0	0	100	0	0	0	574
Diptera larvae	0	0	0	0	0	0	0	100	0	0	0	
Actinia Unident	0	0	0	0	0	0	500	0	0	0	0	
Anaitides maculata	0	0	0	0	100	0	0	0	0	0	0	
Nereidae Spp.Juv	100	0	0	200	0	100	0	0	0	0	0	
Nephtys hombergii	0	0	0	500	200	0	0	100	0	200	500	
Nephtys Spp.Juv	100	300	0	100	0	600	500	1100	1100	1300	400	
Marenzelleria viridis	0	0	100	0	0	0	0	0	0	0	0	
Polydora cornuta	300	0	100	0	0	0	0	0	0	0	0	
Streblospio shrubsolii	600	1500	1900	400	700	0	500	0	1100	500	400	
Cirratulidae Spp.Juv	0	0	0	0	400	0	0	0	0	0	0	
Tharyx A	7800	500	7400	4500	100	3700	0	0	300	0	100	
Cossura Spp.	0	0	0	0	0	0	0	0	200	0	0	
Heteromastus filiformis	100	0	0	0	0	100	0	0	0	0	0	
Melinna palmata	0	200	0	0	400	100	100	100	0	100	0	
Ampharete grubei	0	0	0	0	0	1800	0	100	100	300	0	
Manayunki aestuarina	0	0	0	0	0	0	0	0	100	0	0	
Oligochaete Unident	100	0	0	0	0	0	0	0	0	0	0	
Heterochaeta costata	0	0	0	0	0	100	0	8100	400	0	0	
Tubificoides benedii	100	300	0	200	400	8600	300	0	400	100	0	
Amphipoda Unident	0	0	0	0	0	0	0	0	0	100	0	
Pontocrates altamarinus	0	0	100	0	0	0	0	0	0	0	0	
Melita palmata	0	0	0	0	0	0	0	0	100	0	0	
Idotea Spp.Juv.	0	0	0	0	0	0	0	100	100	0	0	
Carcinus maenas	0	0	0	0	0	100	0	0	0	0	0	
Retusa obtusa	0	0	0	0	200	0	0	0	0	0	0	
Nudibranchia Unident	0	0	0	0	0	0	0	100	0	0	0	
Mytilidae Spp.Juv.	0	0	0	0	0	0	0	0	0	100	0	
Bivalve Juv.Unident	0	0	0	0	0	0	0	100	0	0	0	
Cardiacea Spp.Juv.	200	0	100	0	0	0	0	200	0	0	100	
Scrobicularia plana	0	0	100	0	0	0	0	0	0	0	0	
Mya arenaria	0	100	0	0	0	0	0	0	0	0	0	

3.5.6 LS.LMu.UEst.Hed.Str

The biotope LS.LMu.UEst.Hed.Str (*Hediste diversicolor* and *Streblospio shrubsolii* in littoral sandy mud) distribution is limited to two areas within the Tavy.

Figure 16. Distribution and extent of LS.LMu.UEst.Hed.Str



The sediments at both stations are described as mud (coarse silt) with consistently high organic carbon contents of 10.16% and 10.36%. The redox discontinuity layer was present at 2-4cm at both stations.

The average similarity between stations is 48.93%. Those species which provide the highest percentage contribution to similarity are listed in Table 20 below.

Table 20. Species % contribution in Tamar system LS.LMu.UEst.Hed.Str biotope

Species	Average Abundance	Average Similarity	% Contribution
Streblospio shrubsolii	27.00	20.60	42.10
Nereidae Spp. Juv	27.50	18.72	38.27
Hydrobia ulvae	7.50	9.60	19.63

The most frequently occurring and abundant species at stations within this biotope are the polychaetes *Streblospio shrubsolii* and juvenile *Nereidae spp* (*Hediste diversicolor*). Between 5 and 8 taxa were encountered within the 2 replicate cores, species richness, diversity and evenness are variable within the biotope.

Table 21. Tamar systems 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-Lambda'
B17	8	104	1.507	0.864	0.780	0.820
B18	5	92	0.885	0.853	0.596	0.714

The cores correspond reasonably well with the LS.LMu.UEst.Hed.Str biotope described within The Marine Habitat Classification for Britain and Ireland (Vs 04.05), although there is some deviation from the faunal component.

Individually, the cores captured only 3 of the total 7 characteristic species. The principal characterising species *Streblospio shrubsolii* was present at station B17 but only juvenile *Hediste* were present at that station. Juvenile *Hediste* also dominated the fauna at station B18. The abundance of the remaining characterising species is generally lower than expected

A number of non-characterising species contribute considerably to the overall species diversity at station C17, but this was not the case at station C18.

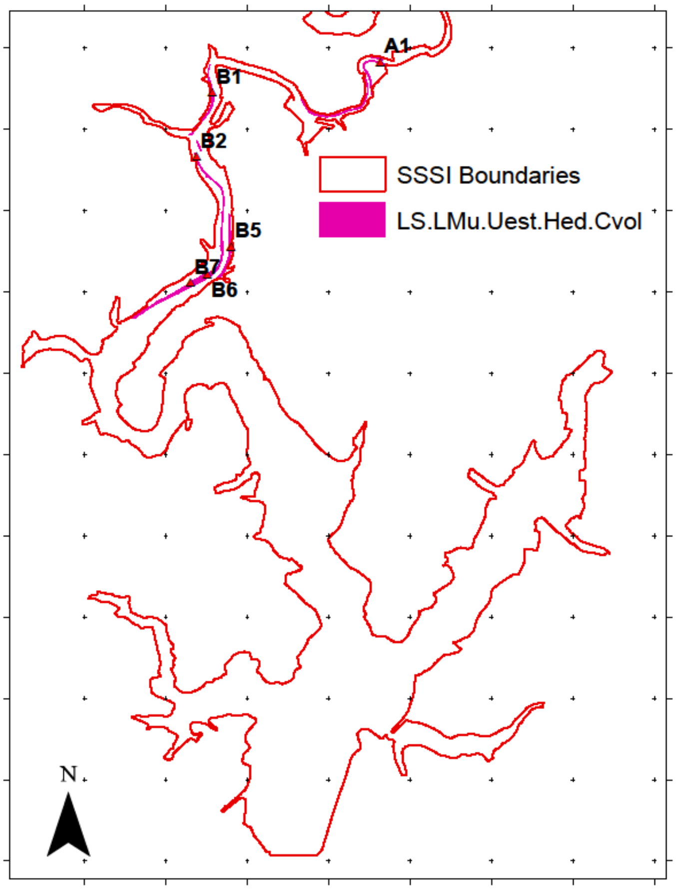
Table 22. Tamar system LS.LMu.UEst.Hed.Str replicate core species composition

Species	C17 No. m^2	C18 No. m^2	Biotope Characterising Species Abundance No. m^2
Nereidae Spp.Juv	1900	3600	(2020)
Streblospio shrubsolii	2300	3100	3033
Hediste diversicolor	0	1100	2020
Oligochaete Unident	1000	0	6592
Heterochaeta costata	0	900	2386
Polydora cornuta	2900	0	
Ampharete grubei	200	0	
Cyathura carinata	1000	0	
Hydrobia ulvae	1000	500	
Bivalve Juv.Unident	100	0	

3.5.7 LS.LMu.Uest.HedCvol

The biotope LS.LMu.Uest.HedCvol (*Hediste diversicolor* and *Corophium volutator* in littoral mud) dominates the upper reaches of the Tamar tributary of the Tamar-Tavy Estuary SSSI. The biotope is found adjacent to main the main channels of reduced salinity water, frequently fringed by saltmarsh on the upper shore.

Figure 17. Extent and distribution of LS.LMu.Uest.HedCvol (Graticules represent 1km^2)



The sediments at stations are variable in character and are described as sandy mud, slightly gravely sandy mud or gravelly mud (no sediment data was available for the most upstream station A1). The carbon content within sediments is high and ranges from 9.28% to 11.92%. The depth of the redox discontinuity layer is variable throughout the biotope, ranging from 2cm to 8cm at all stations except A1. The sediment at station A1 was steeply banking but had a high water content and was very fluid making access for any length of time difficult with the hovercraft, the redox discontinuity layer was not reached within 10 cm of the surface at that station.

As expected for the biotope the most abundant and frequently occurring species is the polychaete *Hediste diversicolor*, followed by the amphipod *Corophium volutator*. The oligochaete *Heterochaeta costata* was also frequent at the 3 most downstream stations. The average similarity between stations is relatively low at 36.64%, which is expected given that the biotope exists at various stages of the salinity gradient. Those species which provide the highest percentage contribution to similarity are listed in Table 23 below.

Table 23. Species % contribution in Tamar system LS.LMu.Uest.HedCvol biotope

Species	Average Abundance	Average Similarity	% Contribution
Hediste diversicolor	25.67	16.92	46.17
Corophium volutator	13.33	9.35	25.51
Heterochaeta costata	13.00	4.97	13.55
Nereidae Spp Juv	6.67	4.27	11.65

Between 4 and 7 taxa were identified at the five stations; species richness, diversity and evenness varied considerably between target stations.

Table 24. Tamar system LS.LMu.Uest.HedCvol 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'
B1	4	6	1.674	0.959	0.577	0.867
B2	4	90	0.667	0.649	0.391	0.547
B5	7	93	1.324	0.795	0.672	0.778
B6	5	90	0.889	0.658	0.460	0.589
B7	5	92	0.885	0.787	0.550	0.688
A1	4	39	0.819	0.257	0.154	0.150

The cores correspond well with the LS.LMu.UEst.Hed.Cvol biotope described within The Marine Habitat Classification for Britain and Ireland (Vs 04.05), although there is some minor deviation from the sediment character and elements of the faunal component.

The sediment analysis at stations determined that 1 of the 5 cores had no sand component as expected within the biotope, and that 2 cores had a gravel component which is also not expected. The two characterising species were present at all target stations, but only juvenile *Hediste* were present at one station. With the exception of station B2, the abundance of *Corophium volutator* is lower than that outlined in the biotope description. *Hediste diversicolor* is more abundant than expected at 4 of the 6 stations and is particularly abundant at the stations with greatest saline influence.

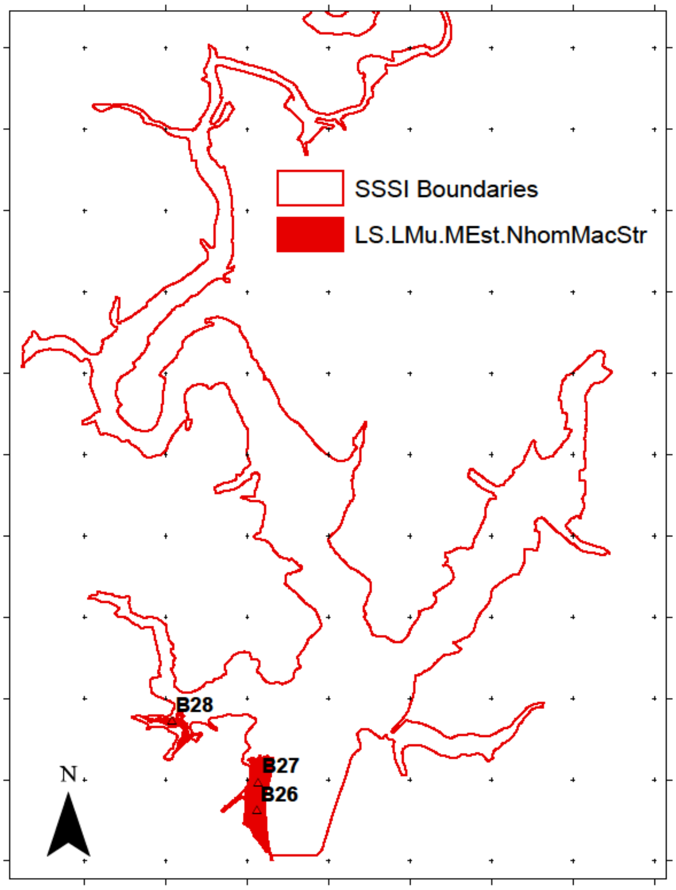
Table 25. Tamar system LS.LMu.Uest.HedCvol replicate core species composition

Species	No. m²						Biotope Characterising Species Abundance
	B1	B2	B5	B6	B7	A1	
Hediste diversicolor	0	500	2300	5100	3900	3600	1783
Corophium volutator	100	5100	2300	200	200	100	4257
Corophium Spp.Juv.	0	3300	0	0	0	0	
Diptera larvae	0	0	100	0	0	0	
Nematoda Unident	200	0	0	0	0	0	
Nereidae Spp.Juv	100	0	20	0	1800	100	
Streblospio shrubsolii	0	0	0	1000	400	0	
Tharyx A	0	0	0	100	0	0	
Oligochaete Unident	200	0	0	0	0	0	
Heterochaeta costata	0	0	2300	2600	2900	0	
Amphipoda Unident	0	0	100	0	0	0	
Hydrobia ulvae	0	0	200	0	0	100	
Cardiacea Spp.Juv.	0	100	0	0	0	0	

3.5.8 LS.LMu.MEst.NhomMacStr

The biotope LS.LMu.MEst.NhomMacStr (*Nephtys hombergii*, *Macoma balthica* and *Streblospio shrubsolii* in littoral sandy mud) is found on the west bank of the lower stretches of the Tamar-Tavy Estuary SSSI, where it spans from the lower shore to the upper shore. It is also found within a tributary of Kingsmill Lake, a inlet on the western shore of the SSSI.

Figure 18. Extent and distribution of LS.LMu.MEst.NhomMacStr (Graticules represent 1km^2)



The sediments at stations range from being described as mud to sandy mud. The carbon content within sediment samples were moderate to high ranging from 7.58% to 9.35%. The redox discontinuity layer was present at <1cm at stations B26 and B28, and at <2cm at B27.

The average similarity between stations is 58.76%. Those species which provide the highest percentage contribution to similarity are listed in Table 26 below. Excluding the gastropod *Hydrobia ulvae*, the most abundant mature species within the biotope is the spionid *Streblospio shrubsolii*.

Table 26. Species % contribution in Tamar system LS.LMu.MEst.NhomMacStr biotope

Species	Average Abundance	Average Similarity	% Contribution
Hydrobia ulvae	163	26.68	45.40
Tubificoides benedii	9.00	8.21	13.97
Streblospio shrubsolii	19.67	6.07	10.33
Nephtys Sp. Juv.	7.00	5.55	9.45
Nephtys hombergii	5.33	5.16	8.79
Pygospio elegans	13.33	3.71	6.31

Between 8 and 17 taxa were recorded at the 3 stations. Species richness and faunal abundance is significantly greater at station B26.

Table 27. Tamar system 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'
B26	17	419	2.650	0.405	0.499	0.479
B27	11	178	1.930	0.406	0.423	0.407
B28	8	82	1.588	0.530	0.479	0.511

The station characteristics correspond 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 sediment character and faunal component. The sediments at stations B26 and B28 lack a sand component as expected for the biotope.

All of the principal characterising species were present at all three stations with the exception of *Macoma balthica* which was absent at B28. With the exception of *Macoma balthica* the abundance of characterising species was generally far greater than expected. Species richness was particularly elevated by the presence of 9 non-characterising species at station B26.

Table 28. Tamar system LS.LMu.MEst.NhomMacStr replicate core species composition

Species	No. m²			Biotope Characterising Species Abundance
	B26	B27	B28	
Nereidae Spp.Juv	200	0	0	*(124)*
Hediste diversicolor	0	0	100	*124*
Nephtys hombergii	500	200	900	*133*
Nephtys Spp.Juv	1100	800	200	*(133)*
Streblospio shrubsolii	4500	1200	200	*593*
Tubificoides benedii	500	1200	1000	*999*
Hydrobia ulvae	29700	13600	5600	*5093*
Macoma balthica	100	100	0	*373*
Pygospio elegans	3600	300	100	
Tharyx A	200	0	100	
Capitellidae Spp.Juv	200	0	0	
Melinna palmata	200	100	0	
Ampharete grubei	0	100	0	
Manayunki aestuarina	100	0	0	
Sphaeroma rugicauda	100	0	0	
Gastropoda Undient	100	100	0	
Mytilidae Spp.Juv.	0	100	0	
Bivalve Juv.Unident	200	0	0	
Cardiacea Spp.Juv.	500	0	0	
Cerastoderma edule	0	0	0	

3.5.9 LS.LMu.MEst.HedMacScr

The biotope LS.LMu.MEst.HedMacScr (*Hediste diversicolor*, *Macoma balthica* and *Scrobicularia plana* littoral sandy mud shores) is widespread and dominates the mid and lower reaches of the Tamar-Tavy Estuary SSSI, but is limited to the upper reaches of Eastborne Lake in St. Johns Lake.

Figure 19. Extent and distribution of LS.LMu.MEst.HedMacScr in the Tamar-Tavy (Graticules represent 1km^2)

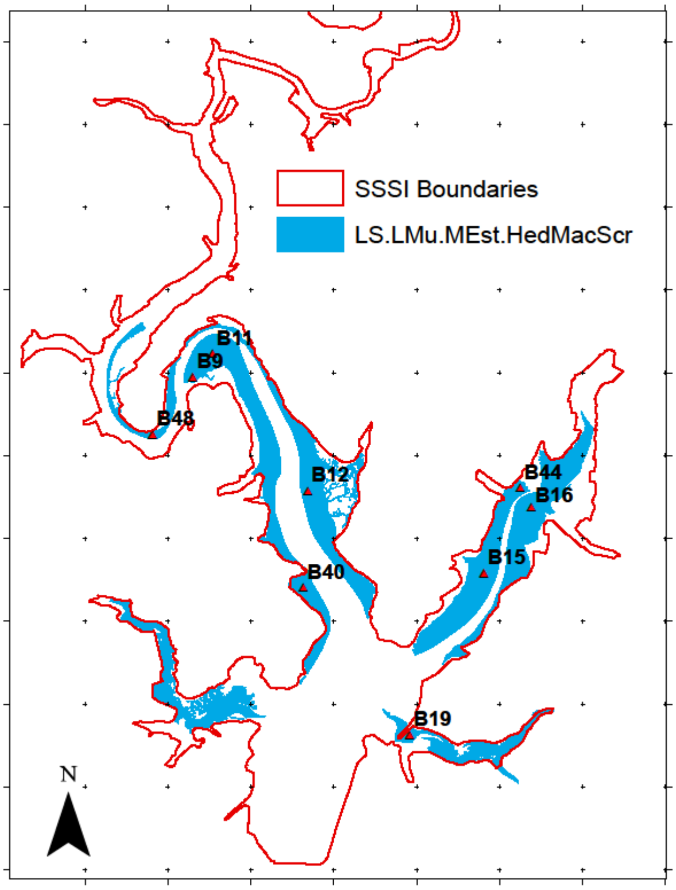
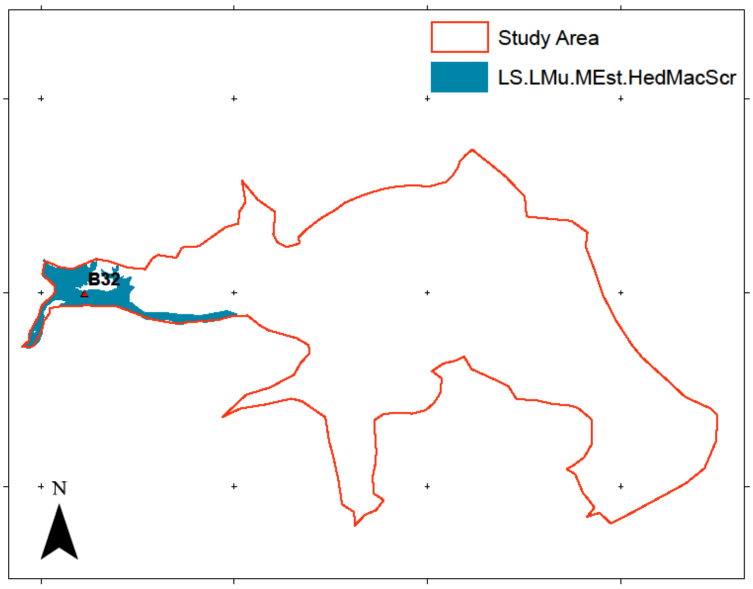


Figure 20. Extent and distribution of LS.LMu.MEst.HedMacScr in St. Johns Lake (Graticules represent 1km^2)



The sediments at stations can all be described as sandy mud or muddy sand. The carbon content within sediment samples ranged from 7.13% to 11.22%. The redox discontinuity layer was present within the first 4cm at all but one of the stations, B9, where it was present within 6cm of the sediment surface.

The average similarity of the faunal component at target stations is 45.00%. Those species which provide the highest percentage contribution to similarity are listed in Table 29 below. Note that *Scrobicularia plana* also contributes significantly to the assignment of the biotope, but due to the core size and relatively low number of replicates the species was not representatively captured in cores. Excluding *Hydrobia ulvae* the most frequently occurring and abundant species within the biotope is the spionid *Streblospio shrubsolii*.

Table 29. Species % contribution in Tamar system LS.LMu.MEst.HedMacScr biotope

Species	Average Abundance	Average Similarity	% Contribution
Hydrobia ulvae	64.40	11.03	24.51
Streblospio shrubsolii	26.60	10.36	23.02
Heterochaeta costata	23.70	4.84	10.74
Tubificoides benedii	58.00	4.40	9.79
Nereidae Sp. Juv	8.00	2.17	4.83
Cyathura carinata	4.10	2.08	4.63
Hediste diversicolor	4.50	2.08	4.61
Pygospio elegans .	13.00	1.85	4.12
Polydora cornuta	4.00	1.37	3.04
Scrobicularia plana	2.70	1.24	2.75

Between 6 and 16 taxa were encountered within the 4 replicate cores that were taken. Species diversity, richness and abundance within replicates were generally high compared to other biotopes within both study areas.

Table 30. Tamar system 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'
B9	9	183	1.536	0.615	0.588	0.594
B11	15	207	2.625	0.858	1.009	0.887
B12	16	432	2.472	0.603	0.727	0.751
B15	16	234	2.750	0.670	0.807	0.764
B16	12	153	2.187	0.715	0.772	0.789
B19	9	305	1.399	0.608	0.580	0.667
B32	9	378	1.348	0.556	0.531	0.627
B40	9	308	1.396	0.631	0.602	0.679
B44	10	156	1.782	0.580	0.580	0.558
B48	6	62	1.211	0.793	0.617	0.714

Table 31. Tamar systems LS.LMu.MEst.HedMacScr replicate core species composition

	No. M2										
Species	B9	B11	B12	B15	B16	B19	B32	B40	B44	B48	Biotope Characterising Species Abundance
Hediste diversicolor	500	400	100	100	100	0	400	0	100	2800	798
Pygospio elegans	0	2800	7800	300	100	100	800	1100	0	0	929
Streblospio shrubsolii	1000	3500	6100	4800	2600	1500	2500	2100	1000	1500	392
Oligochaete Unident	0	1900	1100	0	0	3900	0	0	0	0	1677
Heterochaeta costata	1600	3300	0	98	54	0	0	2000	600	1000	-1677
Tubificoides benedii	0	600	17600	15	0	8600	18000	11700	0	0	2699
Hydrobia ulvae	11300	3200	7600	21	30	200	14200	12600	10200	0	4118
Macoma balthica	0	0	0	1	1	0	0	0	0	0	438
Scrobicularia plana	600	0	100	0	0	100	1400	0	300	200	250
Tharyx A	0	700	1000	2	1	14800	0	100	0	0	-537
Diptera larvae	0	0	0	0	0	0	100	0	0	0	
Nematoda Unident	0	500	0	0	0	0	0	0	0	0	
Enoplus brevis	0	0	400	2	1	0	0	0	0	0	
Nereidae Spp.Juv	2100	1400	100	17	21	0	0	0	600	0	
Nephtys hombergii	0	0	300	0	0	0	100	100	0	0	
Nephtys Spp.Juv	0	100	600	3	0	100	300	900	0	0	
Polydora cornuta	900	1200	0	2	8	0	0	0	900	0	
Capitellidae Spp.Juv	0	0	100	0	0	0	0	0	0	0	
Capitella capitata Agg.	0	0	0	1	0	0	0	0	0	0	
Heteromastus filiformis	0	0	0	0	0	1200	0	0	0	0	
Melinna palmata	0	0	100	11	0	0	0	0	700	0	
Manayunki aestuarina	0	200	0	1	0	0	0	0	100	200	
Neomysis integer	0	0	0	0	2	0	0	0	0	0	
Cyathura carinata	200	800	0	8	7	0	0	0	1100	500	
Carcinus maenas	100	0	0	0	0	0	0	0	0	0	
Gastropoda Undient	0	0	0	0	0	0	0	200	0	0	
Bivalve Juv.Unident	0	100	100	0	0	0	0	0	0	0	
Cardiacea Spp.Juv.	0	0	100	0	0	0	0	0	0	0	
Mya arenaria	0	0	0	0	0	0	0	0	0	0	

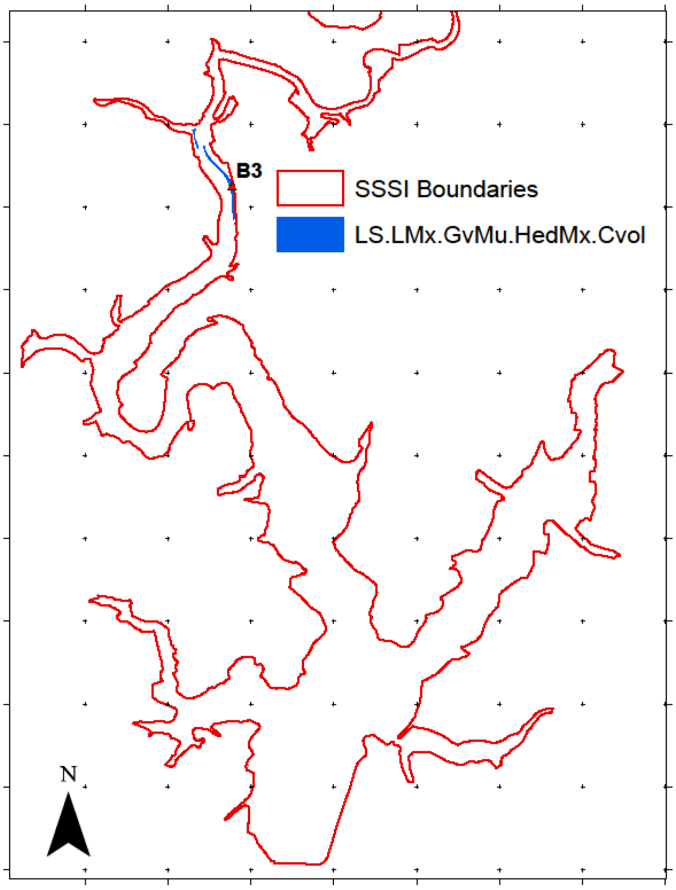
The station characteristics correspond well with the LS.LMu.MEst.HedMacScr biotope described within The Marine Habitat Classification for Britain and Ireland (Vs 04.05), although there is some minor deviation from the faunal component mainly in terms of species abundance. All characterising species are 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 cirratulid *Tharyx killariensis* which was absent. The cirratulid *Tharyx A* is present however which may suggest some type of ecological niche substitution by the species in the Tamar system.

Abundance of species is widely variable; *Tubificoides benedii* for example is present in abundance 2 orders of magnitude less than expected at some stations but 2 orders of magnitude greater than expected at other stations. A number of non-characterising species are also present, generally doubling the overall species diversity at many of the stations.

3.5.10 LS.LMx.GvMu.HedMx.Cvol

The biotope LS.LMx.GvMu.HedMx.Cvol (*Hediste diversicolor* and *Corophium volutator* in littoral gravelly sandy mud) occurs in the upper reaches of the Tamar tributary where the meanders in the channel are scoured by the tide, exposing mixed sediments.

Figure 21. Extent and distribution of LS.LMx.GvMu.HedMx.Cvol in the Tamar-Tavy (Graticules represent 1km^2)



The sediment within the biotope is sandy mud (very fine sand with very coarse silt), with a relatively high carbon content of 10.19%. The redox discontinuity level occurs within 4cm of the sediment surface.

Given the limited extent of this biotope only one target station was assigned. A total of 4 species were present within the core; the most abundant species was the oligochaete *Heterochaeta costata*, followed by juveniles of the polychaete *Hediste diversicolor*.

Table 32. Tamar system LS.LMx.GvMu.HedMx.Cvol replicate core species composition

Species	No. m² B3	Biotope Characterising Species Abundance
Hediste diversicolor	1400	1542
Heterochaeta costata	18100	14311
Corophium volutator	500	9057
Nereidae Spp.Juv	4000	

Table 33. Tamar system LS.LMx.GvMu.HedMx.Cvol 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'(lg10)	Simpson diversity Index 1-Lambda'
B3	4	240	0.547	0.547	0.329	0.401

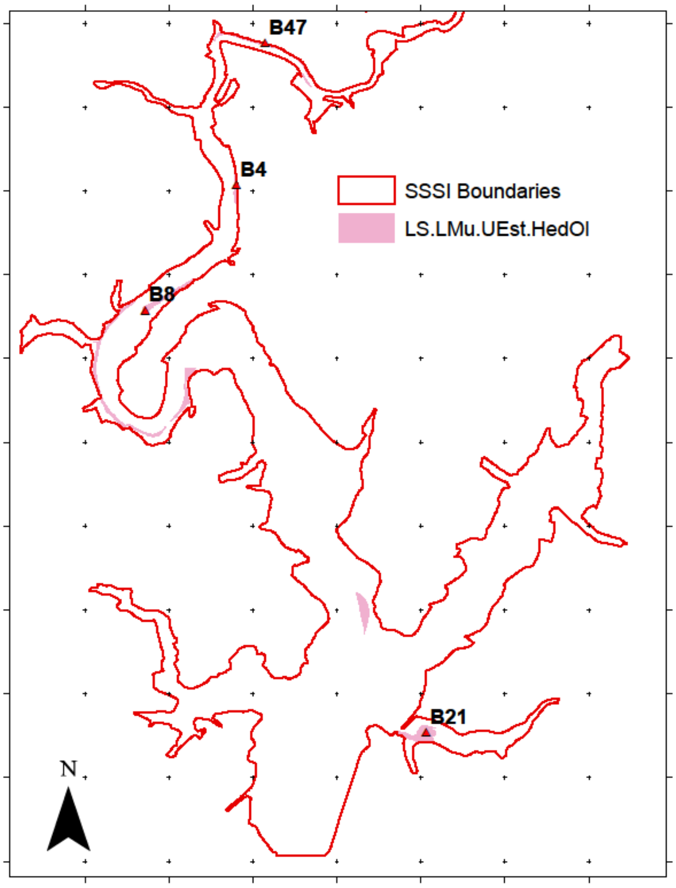
The station characteristics correspond reasonably well with the LS.LMx.GvMu.HedMx.Cvol biotope described within The Marine Habitat Classification for Britain and Ireland (Vs 04.05), the only deviation being aspects of the faunal component.

The principal characterising polychaetes and oligochaetes are present in numbers in line with those expected. However, the abundance of the crustacean *Corophium volutator* is an order of magnitude lower than expected, and 6 of the 9 characterising species are absent altogether. The overall species richness and diversity at the station is much lower than expected for the biotope, probably as a result of its limited extent and strong influence from neighbouring biotopes.

3.5.11 LS.LMu.UEst.Hed.Ol

The biotope LS.LMu.UEst.Hed.Ol (*Hediste diversicolor* and *Oligochaetes* in littoral mud) occurs in the mid to upper reaches of the Tamar tributary where it forms narrow steep sided banks.

Figure 22. Extent and distribution of LS.LMu.UEst.Hed.Ol (Graticules represent 1km^2)



The sediments within the biotope are described mainly as sandy mud, with a high organic carbon content that ranges between 8.89% and 11.19%. The redox conditions are variable within the biotope and the discontinuity level occurs at between 1 and 6cm of the sediment surface.

At 24.02% the average similarity between target stations is the lowest of all biotopes identified within this study. Between 4 and 15 species are present at stations; the *oligochaete Heterochaeta* costata being the most abundant and frequently occurring.

Species	Average Abundance	Average Similarity	% Contribution
Heterochaeta costata	164.00	50.03	58.02
Nereidae Sp. Juv	45.50	26.10	30.26
Hediste diversicolor	10.00	10.11	11.72

Table 34. Species % contribution in Tamar system LS.LMu.UEst.HedOl biotope

Species	Average Abundance	Average Similarity	% Contribution
Heterochaeta costata	24.00	6.16	41.29
Hediste diversicolor	1.67	2.45	16.43
Streblospio shrubsolii	29.67	1.96	13.13
Nereidae Sp. Juv	29.67	1.52	10.17
Tubificoides benedii	168.00	0.74	4.94
Tharyx A	26.33	0.74	4.94

Table 35. Tamar system LS.LMu.UEst.Hed.Ol 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'
B4	4	205	0.564	0.515	0.310	0.425
B8	5	146	0.803	0.623	0.436	0.567
B21	15	946	2.043	0.593	0.698	0.681
B47	5	5	2.485	1.000	0.699	1.000

The species richness, evenness and diversity are highly variable between stations; the infaunal communities at station B21 in Tamerton Creek are particularly rich and abundant.

Table 36. Tamar system LS.LMu.UEst.Hed.Ol replicate core species composition

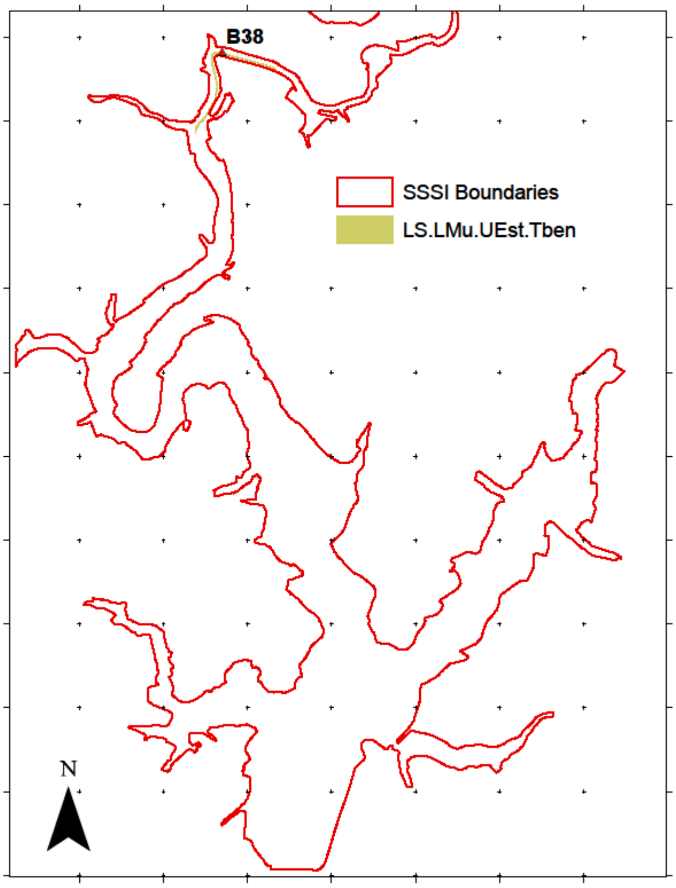
	No. m^2				
Species	**B8**	**B4**	**B21**	**B47**	**Biotope Characterising Species Abundance**
Hediste diversicolor	400	600	0	100	1899
Pygospio elegans	0		4300	0	(468)
Streblospio shrubsolii	1000		7900	0	(468)
Oligochaete Unident	0		700	0	(2026)
Heterochaeta costata	4800	14700	2300	100	2127
Tubificoides benedii	0		50300	100	1840
Diptera larvae	0		0	0	
Nereidae Spp.Juv	8300	5100	600	0	
Nephtys hombergii	0		100	0	
Nephtys Spp.Juv	0		500	100	
Polydora cornuta	0		7800	0	
Tharyx A	0		7800	100	
Capitellidae Spp.Juv	0		600	0	
Melinna palmata	0		100	0	
Hydrobia ulvae	0		11200	0	
Cerastoderma edule	0		100	0	
Scrobicularia plana	100		300	0	

The station characteristics correspond reasonably well with the LS.LMu.UEst.Hed.Ol biotope described within The Marine Habitat Classification for Britain and Ireland (Vs 04.05). However all of the characterising species are not present at every station and where present, the abundance of characterising species deviates significantly from those expected.

3.5.12 LS.LMu.UEst.Tben

The biotope LS.LMu.UEst.Tben (*Tubificoides benedii* and other Oligochaetes in littoral mud) occurs on one stretch of bank in the upper reaches of the Tamar tributary of the Tamar-Tavy SSSI.

Figure 23. Extent and distribution of LS.LMu.UEst.Tben in the Tamar-Tavy (Graticules represent 1km^2)



The sediment within the biotope is mud (coarse silt), with a high organic carbon content of 11.43%. The sediment redox discontinuity level occurs at between 6 and 8cm of the sediment surface.

Given the limited extent of this biotope only one target station was assigned, and at that station only 2 species were present.

Table 37. Tamar system LS.LMu.UEst.Tben 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'
B38	2	5	0.621	0.722	0.217	0.400

Table 38. Tamar system LS.LMu.UEst.Tben replicate core species composition

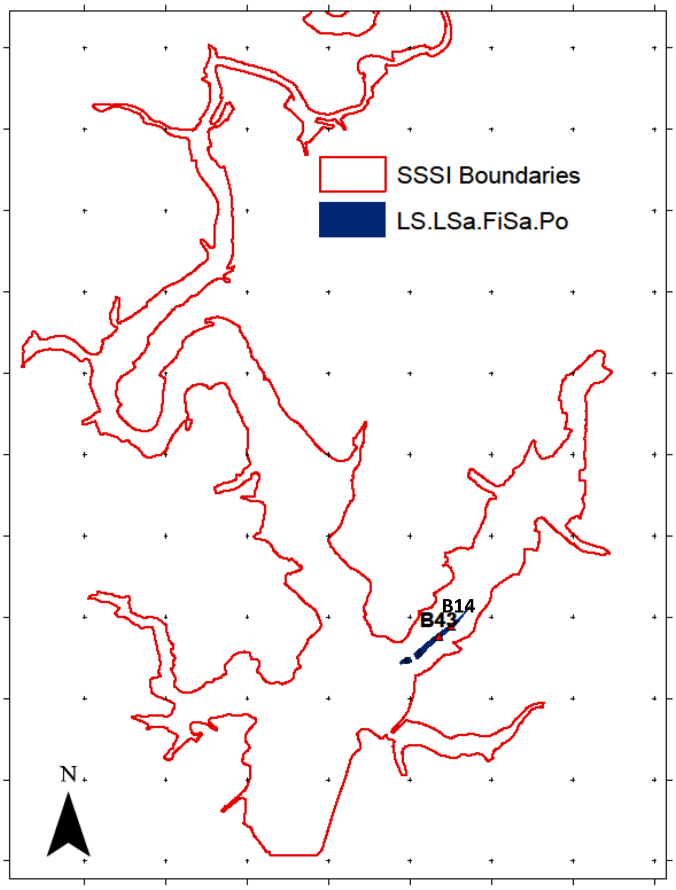
Species	No. m^2 B38	Biotope Characterising Species Abundance
Heterochaeta costata	400	53741
Corophium volutator	100	

The station characteristics fit loosely with the LS.LMu.UEst.Tben biotope described within The Marine Habitat Classification for Britain and Ireland (Vs 04.05), but the presence of *Corophium* and absence of *Tubificoides species* would suggest that the biotope is being strongly influenced by the neighbouring biotopes.

3.5.13 LS.LSa.FiSa.Po

The biotope LS.LSa.FiSa.Po (Polychaetes in littoral fine sand) occurs on the extreme lower shore in one area in the Tavy tributary of the Tamar-Tavy SSSI.

Figure 24. Extent and distribution of LS.LSa.FiSa.Po (Graticules represent 1km^2)



The sediment within the biotope is muddy sand (Station 14) and slightly gravelly sandy mud (Station 43), with a low carbon content of 2.9 to 3.43%. The redox discontinuity is not present within 10cm of the sediment surface.

Given the limited extent of this biotope only one target station was assigned. A total of 6 species were present within the core; the cirratulid *Tharyx A* and the spionids *Streblospio shrubsolii* and *Pygospio elegans* are the most abundant.

Table 39. Tamar system LS.LSa.FiSa.Po 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'
B43	6	192	0.951	0.541	0.421	0.509

Table 40. Tamar system LS.LSa.FiSa.Po replicate core species composition

Species	No. m^2 B43	Biotope Characterising Species Abundance
Pygospio elegans	2100	69
Polydora cornuta	200	
Streblospio shrubsolii	3700	
Tharyx A	12800	
Amphipoda Unident	100	
Hydrobia ulvae	300	

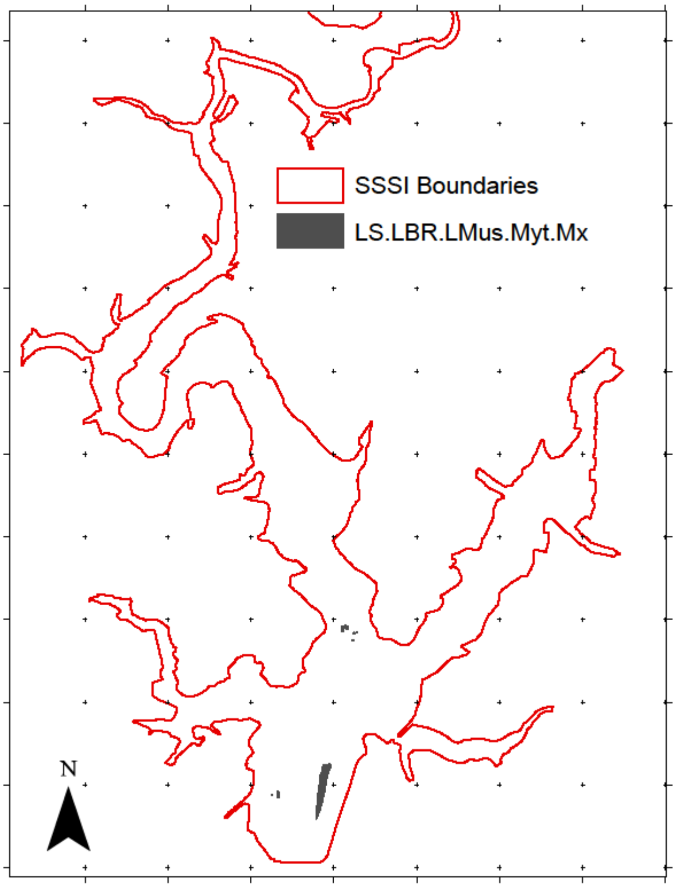
The station characteristics correspond loosely with the LS.LSa.FiSa.Po biotope described within The Marine Habitat Classification for Britain and Ireland (Vs 04.05), the main deviation being the lack of characterising species within the Tamar biotope and the high abundance of the species which are present.

Sections 3.5.14 to 3.5.17 describe biotopes where no faunal cores, PSA or LOI were taken but which were assigned accordingly based on field observations during the Phase I and Phase II study.

3.5.14 SS.LMx.LMus.Myt.Mx

SS.LMx.LMus.Myt.Mx (*Mytilus edulis* beds on littoral mixed substrata) occurs in the mid-lower reaches of the Tamar-Tavy Estuary SSSI mainly on the lower shores of the eastern bank, but also in parts of the main channel.

Figure 25. Extent and distribution of SS.LMx.LMus.Myt.Mx (Graticules represent 1km^2)



The fauna was dominated by *Mytilus edulis* with a common presence of *Cerastoderma edule* and occasional *Crepidula fornicata*.

The biotope fits reasonably well with the SS.SBR.SMus.MytSS biotope described in The Marine Habitat Classification for Britain and Ireland (Vs 04.05), though because of the density of the *Mytilus edulis* beds, a core was not taken and therefore the infaunal species listed within the description were not observed.

3.5.15 LS.LMp.LSgr.Znol

LS.LMp.LSgr.Znol (*Zostera noltii* beds on littoral muddy sand) is found in a very limited area within the Tamar-Tavy SSSI, on the lower shore of the eastern bank of the Tamar tributary. In St. Johns Lake the biotope covers a relatively large area of the sheltered south-western shore of the lake.

Figure 26. Extent and distribution of LS.LMp.LSgr.Znol (Graticules represent 1km^2)

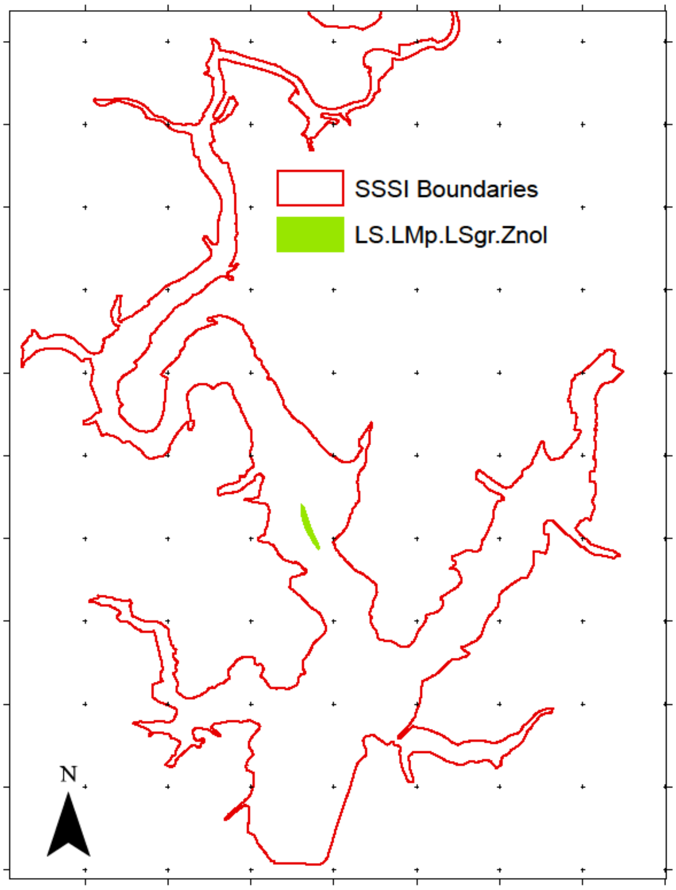
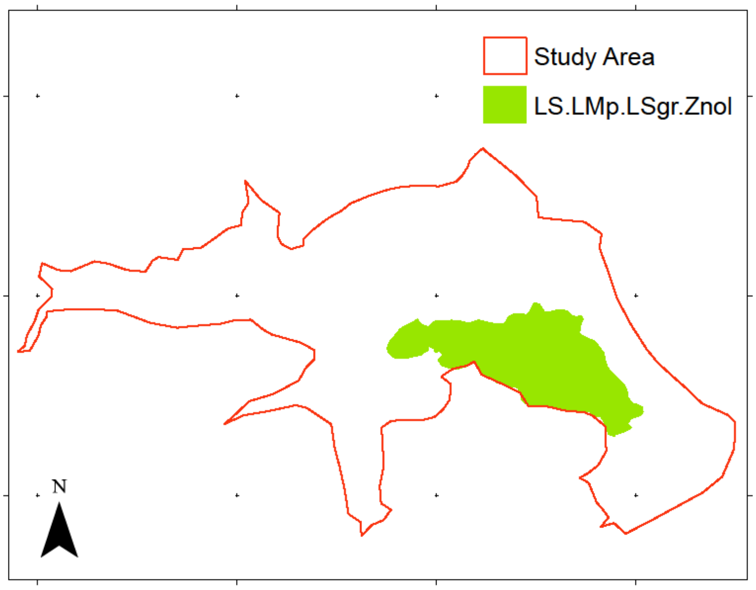


Figure 27. Extent and distribution of LS.LMp.LSgr.Znol (Graticules represent 1km^2)



Due to the sensitivity of this biotope to disturbance only the density of the *Z. noltii* was observed and recorded. No information was collected regarding sediment characteristics or infaunal assemblages and therefore aspects of the biotope were not able to be compared with the

LS.LMp.LSgr.Znol biotope described in The Marine Habitat Classification for Britain and Ireland (Vs 04.05). The density of the *Z. noltii* however was generally greatest on the mid and upper shores where it was often present at 100% cover; at the biotopes lower shore mapped extent it was generally at approximately 50% cover and tapered off quickly to around 15% cover where it merged with the LS.LSa.MuSa.CerPo biotope.

3.5.16 LS.LCS.Sh.BarSh & LS.LSa.MoSa.BarSa

Biotopes which were barren of fauna were generally found in parts of the Tamar-Tavy that were exposed to very high tidal energy where sediments were mobile therefore hindering colonisation by faunal communities. Communities were also found to be absent from low energy sites where leaf litter accumulates. A single bank of barren sand was observed in St. John's Lake.

Figure 28. Extent and distribution of barren biotopes in the Tamar-Tavy (Graticules represent 1km^2)

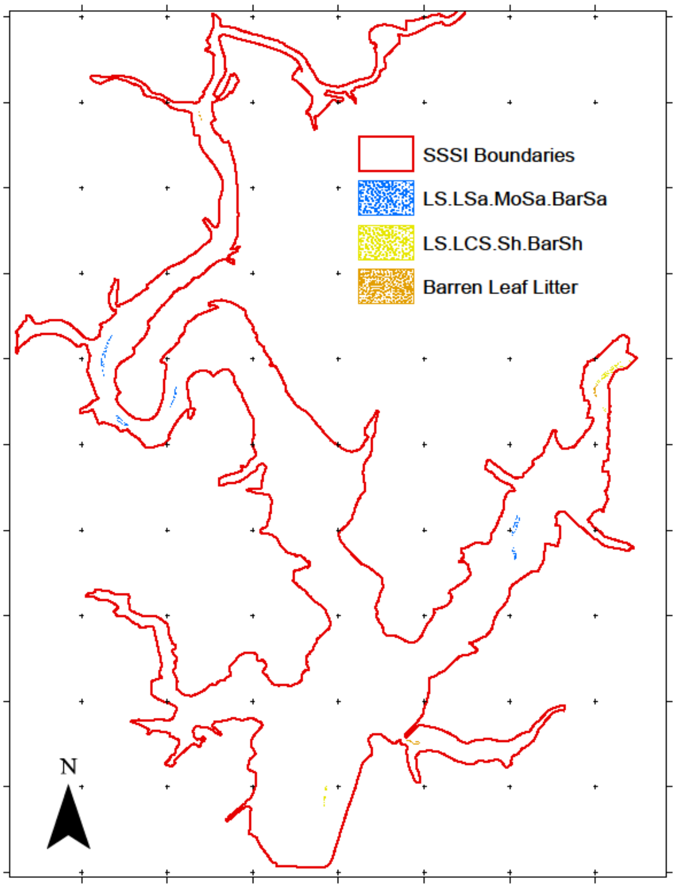
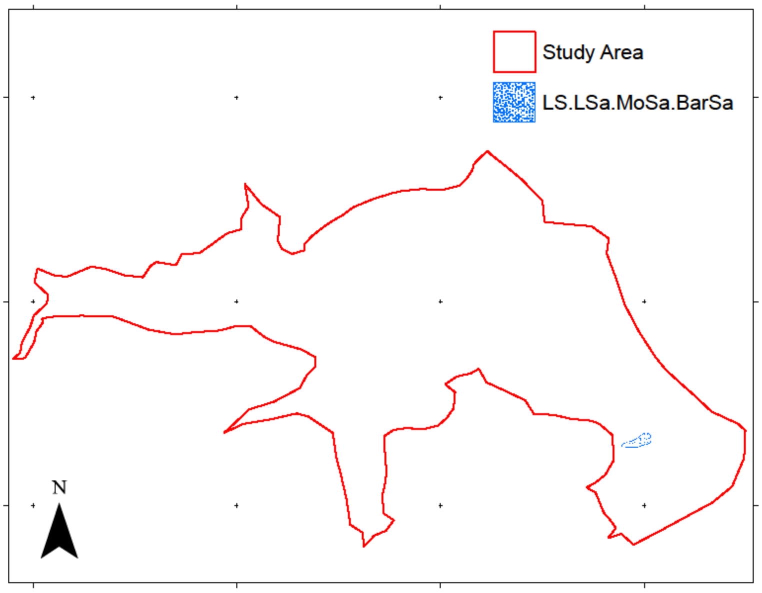


Figure 29. Extent and distribution of barren biotopes in St. John's Lake (Graticules represent 1km^2)



3.5.17 Littoral Rock Biotopes

The littoral rock biotopes LR.LLR.FVS.FvesVS, LR.LLR.F.Fves, LR.LLR.FVS.AscVS, LR.LLR.F.Asc, LR.LLR.F.Pel, LR.LLR.F.Fserr are patchily distributed mainly throughout the mid and lower stretches of the Tamar-Tavy estuary SSSI, but are also found on the steep banks in the upper stretches of the Tamar where the tidal energy exposes the bedrock. In St. Johns Lake the fucoid biotopes were predominantly observed on the northern shore.

Figure 28. Extent and distribution of littoral rock biotopes (Graticules represent 1km²)

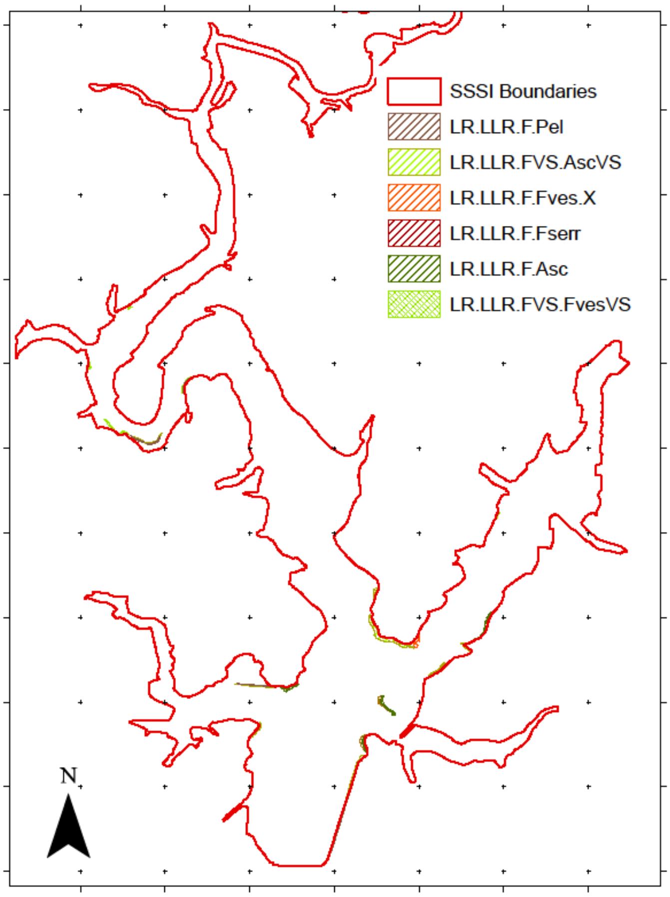
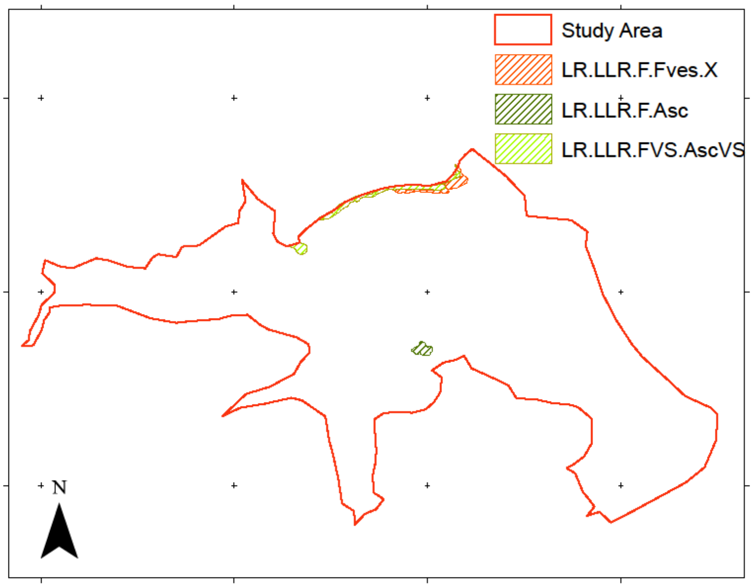


Figure 29. Distribution and extent of littoral rock biotopes (Graticule represents 1km²)



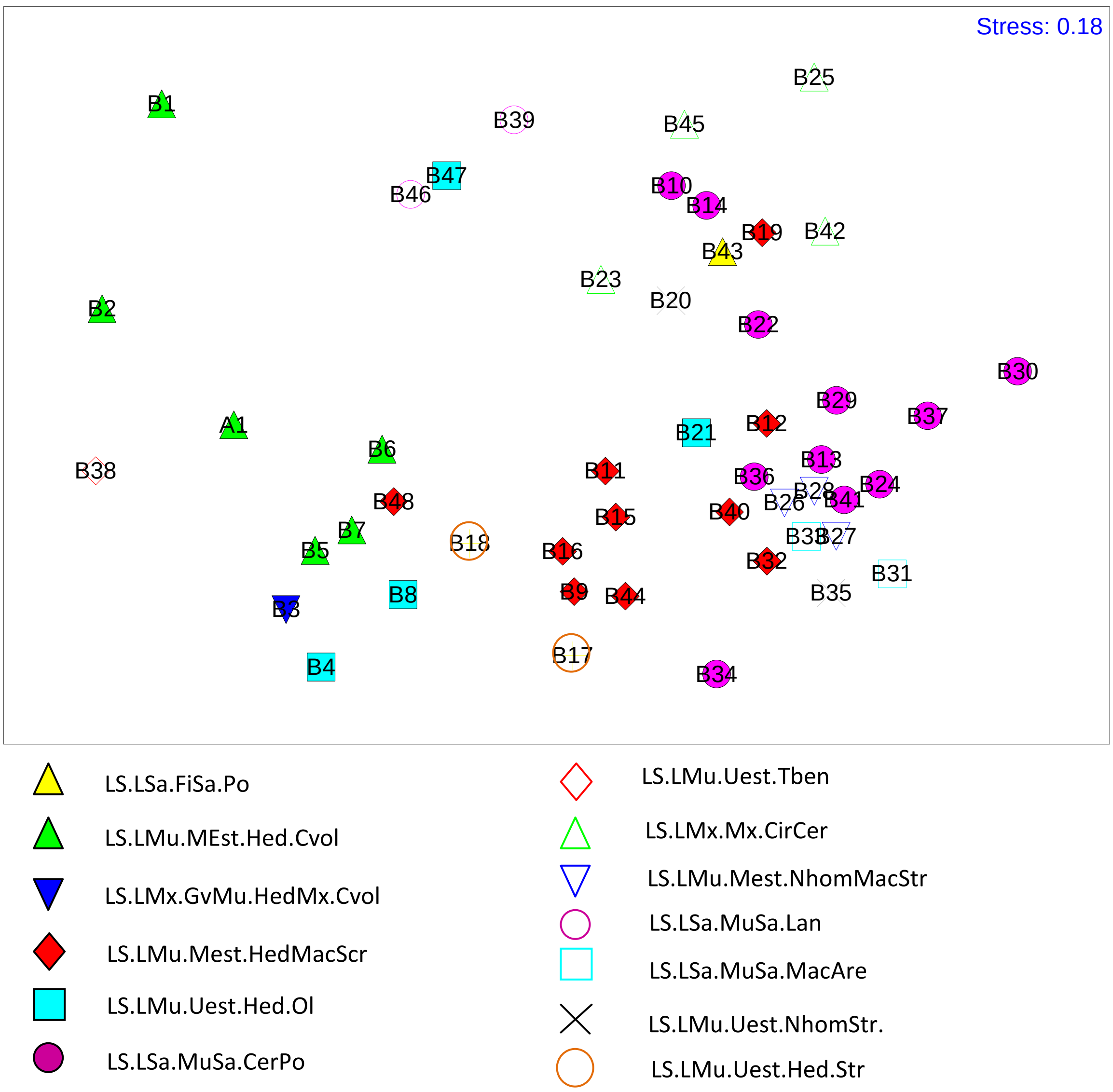
The rock biotopes all correspond well with those described within The Marine Habitat Classification for Britain and Ireland (Vs 04.05) and with the rock biotopes reported in the 2001 survey [13].

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(19) 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 two 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 30 and 31 below represent the replicate cores from all biotopes except those where no faunal sample was taken (it therefore excludes LS.LBR.LMus.Myt.Mx biotope and rock biotopes).



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 LS.LSa.MuSa.MacAre biotope for example has the highest Bray-Curtis value of 70.54%, whilst the LS.LMu.Uest.Hed.Ol biotope has the lowest value at 24.02%.

The weaker similarities observed within the LS.LMu.Uest.Hed.Ol biotope replicates may be associated with the fact that the biotope is distributed throughout the estuary in small areas and influenced by neighbouring biotopes, whilst LS.LSa.MuSa.CerPo is limited to one isolated location.

5. Discussion

5.1 Condition Assessment

5.1.1 Saltmarsh

In terms of condition assessment of the Saltmarsh, many of the site-specific standards that are intended for defining favourable condition of the Saltmarsh in the Tamar-Tavy Estuary and St. Johns Lake SSSI were not within the scope of this study i.e. width of vegetation zones, vegetation structure and composition. These aspects of condition assessment are being carried out independently by Natural England.

The Saltmarsh habitat extent objectives were however within the scope of this study. Field observations determined that there was a possible area of accretion in the Tamar-Tavy SSSI on the western bank opposite Weir Quay, though this is uncertain as the area is not discernable when compared with the 2007 aerial photography. Erosion however was apparent as indicated by undercut, steeply sloping or exposed sediment banks bordering those saltmarshes which lie between Weir Quay and Thorn Point, and those opposite Crosspark Wood on the Eastern bank of the upper Tamar tributary. In addition, at the most northern extent of the *Spartina spp*. distribution on the eastern Tamar bank opposite Chapel Farm, an area of approximately 20 m^2 although still alive had an unhealthy 'scorched' appearance.

The extent of erosion was not at a scale which was detectable when compared to the Coastal Observatory aerial photography from the 2007 survey using DGPS, and therefore it is difficult to discern whether the 1% threshold of loss in extent has occurred since 2007.

There is no evidence of pioneer saltmarsh or saltmarsh accretion anywhere within St. Johns Lake; however die-back (rather than erosion) of the saltmarsh west of Eastdown Lake was observed specifically at its lower shore distribution either side of the sewage outfall. The 2007 aerial photography would suggest that this area of saltmarsh had died back or was in the process of die-back at that time.

The extent of overall die-back within the St. John's SSSI is not at a scale which was detectable when compared to the Coastal Observatory 2007 aerial photography, and therefore it is difficult to discern whether the 1% threshold of loss in extent has occurred since 2007.

Importantly with respect to condition assessment, the cause of erosion/die-back within the Tamar-Tavy Estuary and St. John's Lake SSSI's is not definitively known, but in both cases thought potentially to be as a result of anthropogenic influences. In the Tamar-Tavy SSSI boat activity and the resulting wake is suspected to be at least a contributing factor resulting in erosion of banks. In St. Johns lake excessive nutrient loading from the sewage discharge is thought to potentially lead to at least localised eutrophication, resulting in opportunistic algal mats smothering the saltmarsh vegetation at high tide.

In both cases however, natural change is thought also likely to be contributing factor responsible for saltmarsh erosion. The dynamic nature of physical processes within estuarine systems (including wave exposure, riverine floods, tidal surges or storm events), including those within the Tamar system, means that the gross distribution of habitats can be expected to change over time naturally to some extent.

In order to establish whether the saltmarshes are in a favourable condition it is essential to determine the extent of saltmarsh loss and the cause of loss; specifically it is necessary to determine whether the loss is greater than 1% and whether it is as a result of anthropogenic influences.

Given that the loss in extent of habitat is not discernable from the 2007 aerial photography, it has to be assumed that the loss is less than 1%. Therefore based on habitat extent objectives only the Saltmarsh within the Tamar-Tavy Estuary and St. Johns Lake Estuary SSSI's are considered to be in a favourable condition.

5.1.2 Coastal Flats

Although previous biotope surveys were carried out in a portion of the Tamar-Tavy Estuary and in St. John's Lake SSSI's in 2001, the methods used and focus of the surveys were different to that carried out here. The 2001 survey's primarily focused on the littoral rock biotopes rather than the littoral sediment biotopes (where access and observations were restricted by the methods used). Furthermore the 2001 survey's did not incorporate Phase II studies and therefore were considerably less comprehensive that those which were carried out here. Consequently, the biotopes identified during the 2001 survey are somewhat different to those identified during this study. The differences observed are therefore suspected not to be representative of temporal changes but as a result of different survey methods and sampling efforts employed. As a result, in terms of condition assessment, comparison of the two studies is not considered to be a useful approach. Instead, professional judgment has been used based to determine the condition of the Tamar-Tavy Estuary and St. John's Lake SSSI's based on observations and information gathered during the survey. This study will however provide a comprehensive baseline which can be implemented within any future condition assessments.

In respect of the current condition of the interest features, the Tamar Estuary as a whole has been identified as moderately to highly vulnerable to nutrient and organic enrichment respectively(6); observations made during the study, namely the presence of the opportunistic green algae's *Ulvae* and *Enteromorphae* on both the north and south banks suggest that this is potentially still the case within the SSSI.

There is also some evidence of biological disturbance through the selective extraction of species, namely the presence of peeler crab traps and bait digging in Tamerton Creek. The extent of impacts from such activity is likely to be only minor, particularly as it is limited to one relatively small area of the SSSI; but the placing of crab traps on intertidal sediments may change sediment characteristics by affecting water and oxygen exchange and sedimentation rates (6). The vulnerability of Plymouth Sound and its associated estuaries to peeler crab collection has been highlighted by previous studies(12)(8).

There was no evidence of adverse anthropogenic impact within the Tamar-Tavy Estuary or St. John's Lake SSSI in terms of:

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

Despite the potentially negative influences within the Tamar-Tavy Estuary SSSI from selective extraction of species, at present such activity is not thought to be at a scale which threatens the overall condition of the intertidal designated features of interest. As such the Tamar-Tavy Estuary and St. John's Lake SSSI coastal flats are deemed to be in a **favourable condition**.

5.2 Notable Species, Biotopes and Communities

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 Tamar-Tavy and St. Johns Lake 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 41. Biotopes listed as priority BAP habitats and identified within relevant LBAPs

BAP Priority Habitat	Biotope	LBAP
Saltmarsh	LS.LMp.Sm	Cornwall
Seagrass beds	LS.LMp.LSgr.Znol	Cornwall
Intertidal mudflats	LS.LBR.LMus.Myt.Mx*	Cornwall
	LS.LMu.MEst.NhomMacStr	Cornwall
	LS.LMu.UEst.Hed.Str	Cornwall
	LS.LMu.MEst.HedMacScr	Cornwall
	LS.LMu.UEst.Hed.Cvol	Cornwall
	LS.LMu.UEst.NhomStr	Cornwall
	LS.LMu.UEst.Tben	Cornwall
	LS.LMu.Uest.HedOl	Cornwall
	LS.LSa.MuSa.CerPo	Cornwall
	LS.LSa.MuSa.Lan	Cornwall
	LS.LSa.FiSa.Po	Cornwall
Sheltered muddy gravels	LS.LMx.GvMu.HedMx.Cir	
	LS.LMx.GvMu.HedMx.Cvol	
	LS.LMx.Mx.CirCer	
Estuarine Rocky Habitats	LR.LLR.FVS.FvesVS	
	LR.LLR.F.Pel	
	LR.LLR.FVS.AscVS	
	LR.LLR.F.Fves.X	
	LR.LLR.F..Fserr	
	LR.LLR.F.Asc	

*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 sheltered muddy gravel biotopes.

The importance of these habitats within the Tamar-Tavy SSSI and St. John's Lake SSSI largely lies in the provision of invertebrates for the internationally and nationally important aggregations of wintering wildfowl including the Avocet *Recurvirostra avosetta*. No intertidal species of notable importance were identified within the actual littoral sediments and habitats specifically however.

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[20] (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 survey.

5.4 Recommendations

Given the ambiguity associated with biotopes within the Tamar-Tavy Estuary and St. John's Lake SSSI's in terms of their fitting with those outlined in The Marine Habitat Classification for Britain and Ireland (Vs 04.05), it is suggested that in future condition assessments, where finance permits, more quantitative faunal assessment should be carried out within each biotope (i.e. larger number of replicates and larger sample sizes).

By implementing these recommendations it is considered that a more comprehensive, statistically sound qualitative 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 be observed in the future, whether positive or negative in terms of conservation targets.

It is also recommended that further studies are carried out to determine the most significant causes of erosion and/or die back of saltmarsh in both the Tamar-Tavy Estuary and St. John's Lake SSSI's so that a more comprehensive assessment of the saltmarsh condition can be made in the future given that the outcome of such assessments are dependent on the causes of loss in extent of habitat.

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
LS.LMu.UEst.Hed.Str	*Hediste diversicolor Streblospio shrubsolii* in littoral sandy mud
LS.LMu.Uest.HedCvol	*Hediste diversicolor* and *Corophium volutator* in littoral mud
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.HedMac	*Hediste diversicolor* and *Macoma balthica* in littoral sandy mud
LS.LMx.GvMu.HedMx.Cvol	*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.LSa.MuSa.Lan	*Lanice conchilega* in littoral sand
LS.LMx.Mx.CirCer	Cirratulids and *Cerastoderma edule* in littoral mixed sediment
LS.LSa.MuSa.MacAre	*Macoma balthica* and *Arenicola marina* in littoral muddy sand
LS.LMu.UEst.Hed.Ol	*Hediste diversicolor* and Oligochaetes in littoral mud
LS.LMu.UEst.Tben	*Tubificoides benedii* and other Oligochaetes in littoral mud
LS.LSa.FiSa.Po	Polychaetes in littoral fine sand
SS.LMx.LMus.Myt.Mx	*Mytilus edulis* beds on littoral mixed substrata
LS.LMp.LSgr.Znol	*Zostera noltii* beds on littoral muddy sand
LS.LCS.Sh.BarSh	Barren littoral shingle
LS.LSa.MoSa.BarSa	Barren littoral coarse sand
LR.LLR.F.Fves	*Fucus vesiculosus* on moderately exposed to sheltered mid eulittoral rock
LR.LLR.F.Asc	*Ascophyllum nodosum* on very sheltered mid-eulittoral rock
LR.LLR.F.Pel	*Pelvetia canaliculata* on sheltered littoral fringe rock
LR.LLR.F.Fserr	*Fucus serratus* on sheltered lower eulittoral rock
LR.LLR.FVSFvesVS	*Fucus vesiculosus* on variable salinity mid eulittoral boulders and stable mixed substrata.
LR.LLR.FVS.FspiVS	*Fucus spiralis* on sheltered variable salinity upper eulittoral rock
LR.FLR.LicYG	Yellow and grey lichens on supralittoral rock
LR.LLR.FVS.PelVS	*Pelvetia canaliculata* on sheltered variable salinity littoral fringe rock
LR.LLR.FVS.AscVS	*Ascophyllum nodosum* and *Fucus vesiculosus* on variable salinity mid-eulittoral rock

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