Plymouth Sound and Estuaries SAC Littoral Habitats Condition Monitoring 2017

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EXECUTIVE SUMMARY

Plymouth Sound and Estuaries Special Area of Conservation (SAC) is located on the south coast of England and spans the border between Devon and Cornwall. Plymouth Sound and its associated tributaries comprise a complex site of marine inlets. The broad salinity conditions and high diversity of reef and sedimentary habitats give rise to a diverse array of communities.

Natural England commissioned surveys in order to monitor and assess the extent and condition of the littoral and rock and littoral sediment communities which are sub-features of the 'Large shallow inlets and bays' and/or 'Estuary complex' features within the SAC. Site Condition Monitoring (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.

Littoral rock data that was collected during the 2017 survey in Plymouth Sound and the Yealm Estuary (Sectors 1 and 3 respectively) will provide a baseline for measuring the 'presence and spatial distribution of biological communities on littoral rock' attribute in future years. The littoral rock baseline data that was collected in 2010 in the Lynher, Tamar-Tavy and St. Johns Lake areas of the SAC (Sector 2) has made it possible to determine that no significant changes in the littoral rock habitat types have occurred since 2010 within either the Tamar-Tavy and St. Johns Lake SSSI of the Lynher Estuary SSSI components of the SAC.

The littoral sediment data collected within Plymouth Sound and the Yealm in 2017 will provide a baseline for the assessment of the various biological communities as well as physiochemical attributes within the SAC in future. Within the Lynher, Tamar-Tavy and St. Johns Lake however, temporal comparisons have been possible between fauna, particle size and organic carbon content data collected in 2010 and 2017, despite some limitations imposed by differing analysis methods in the physiochemical data between years.

Analysis of faunal data from Sector 2 has shown that within both the Tamar-Tavy and St Johns Lake SSSI and Lynher Estuary SSSI species richness within each area overall has increased since 2010, as has the diversity in the Lynher Estuary SSSI. When considered at the Habitat type level, significant differences in community composition were observed within two habitat types within the Tamar-Tavy and St Johns Lake SSSI, and one in the Lynher Estuary SSSI. A large proportion of the temporal differences observed were found to be driven by relatively small differences in the abundances of a number of commonly occurring species. It was also revealed that a greater number of taxa contributed to the community similarities within the habitat types that had significantly changed in composition. The changes in community composition are considered to be as a result of natural variable recruitment rather than being brought about by any anthropogenic influence.

Temporal analysis of sediment granulometry and organic content has revealed significant differences in the proportions of silt and clay between 2010 and 2017. It is likely that these differences are a result of different analysis methods rather than a representation of real broad scale change.

Additional surface sediment samples for contaminant analysis were taken at 11 stations throughout Sectors 1 and 3 of the SAC: 5 in the Tamar-Tavy and St Johns Lake SSSI, 4 in the Lynher Estuary SSSI and 2 in the Yealm Estuary SSSI. The OSPAR Environmental Assessment Criteria (EAC) or Effects Range Low (ERL) thresholds were breached at 9 of the stations. Within Sector 2, the concentrations of lead and 3 Polycyclic Aromatic Hydrocarbons (PAH) compounds caused the exceedances. At one station in the Yealm Estuary SSSI mercury and lead and every PAH analysed for, except Napthalene, exceeded the ERL or EAC, but neither the ERL or EAC was exceeded for any analyte at the second station within the Yealm.

Three INNS were recorded in 2017 within Plymouth Sound (Sector 1) and the Yealm estuary (Sector 3), these were *Caulacanthus spp.* and *Magallana gigas* which were identified within both Sectors, whilst *Sargassum muticum* was recorded only in Sector 1 as was *Magallana gigas* in Sector 2. The distribution of *Magallana gigas* in Sector 2 does not appear to have changed since 2010. The distribution and density of *Magallana gigas* in 2017 in Newton Creek has been mapped and compared with surveys that were carried out in 2014. The results suggest that no substantial changes in the extent or distribution of the INNS have occurred in that 3 year period.

An additional objective of surveys was to map areas of littoral habitat that had been 'notably' altered by the presence of the Pacific oyster *Magallana gigas*, such areas were mapped in the Yealm estuary and St Johns Lake. Within the Yealm estuary less than 1% of the total area of littoral rock that was mapped in the SAC in 2017 was considered to be 'notably' affected. Within St Johns Lake the total area of littoral sediment that was mapped as 'notably' affected amounted to 11% of the total area of littoral sediment mapped within the SAC.

The nationally scarce tentacle lagoon worm *Alkmaria romijni* was sampled in cores from 11 stations within the Tamar Tavy and St Johns Lake and 22 stations within the Lynher Estuary. No other species of conservation interest (SOCI) were observed within the SAC.

1. INTRODUCTION

Plymouth Sound and Estuaries Special Area of Conservation (SAC) is located on the south coast of England and spans the border between Devon and Cornwall (Figure 1). Plymouth Sound and its associated tributaries comprise a complex site of marine inlets. The broad salinity conditions and high diversity of reef and sedimentary habitats give rise to a diverse array of communities which are characteristic of such ria systems. Some unusual features include abundant southern Mediterranean-Atlantic species rarely found in Britain.

The Tamar-Tavy and Lynher and Yealm estuaries lie within the boundaries of the SAC. They encompass extensive mudflats that form a highly productive system. The varied infaunal communities are rich in bivalves and other invertebrates, and provide important feeding grounds for internationally important numbers of wildfowl[2]. On the Yealm estuary at Cofflete creek the nationally scarce tentacled lagoon worm (*Alkmaria romijni*) has been recorded[2]. Intertidal reefs with rockpools at Wembury, Penlee, Hooe Lake Point and the mouth of the Yealm support a nationally uncommon sponge, seasquirt and red algae community. The intertidal underboulder communities at Jennycliff are of note for their species richness. The crevice dwelling brittlestar (*Ophiopsila aranea*) has been recorded as abundant around the Mewstone, but is nationally rare[2].

Natural England commissioned surveys in order to monitor and assess the extent and condition of the intertidal habitats within the SAC. Site Condition Monitoring (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 has a duty to monitor and assess the condition of the intertidal habitats and report on the conservation status once every six years.

Natural England in association with other countryside agencies has established a series of common standards for the monitoring of sites of nature conservation interest. These common standards apply to a number of statutory designated sites, including SSSIs, and ensure that a consistent approach is taken when monitoring such sites. Within the Plymouth Sound and Estuaries SAC intertidal special interest features, which include the littoral and rock and littoral sediment communities, fall under the Common Standards Monitoring guidance produced for littoral rock habitats[2] and littoral sediment habitats[3].

The conservation objectives for the intertidal habitats, which in the Plymouth Sound and Estuaries SAC, are sub-features of the 'Large shallow inlets and bays' and/or 'Estuary complex' features[3,4], are as follows:

Subject to natural change, ensure that the integrity of the site is maintained or restored as appropriate, and ensure that the site contributes to achieving the Favourable Conservation Status of its Qualifying Features, by maintaining or restoring;

- The extent and distribution of qualifying natural habitats and habitats of qualifying species
- The structure and function (including typical species) of qualifying natural habitats
- The structure and function of the habitats of qualifying species
- The supporting processes on which qualifying natural habitats and the habitats of qualifying species rely
- The populations of qualifying species, and,
- The distribution of qualifying species within the site.

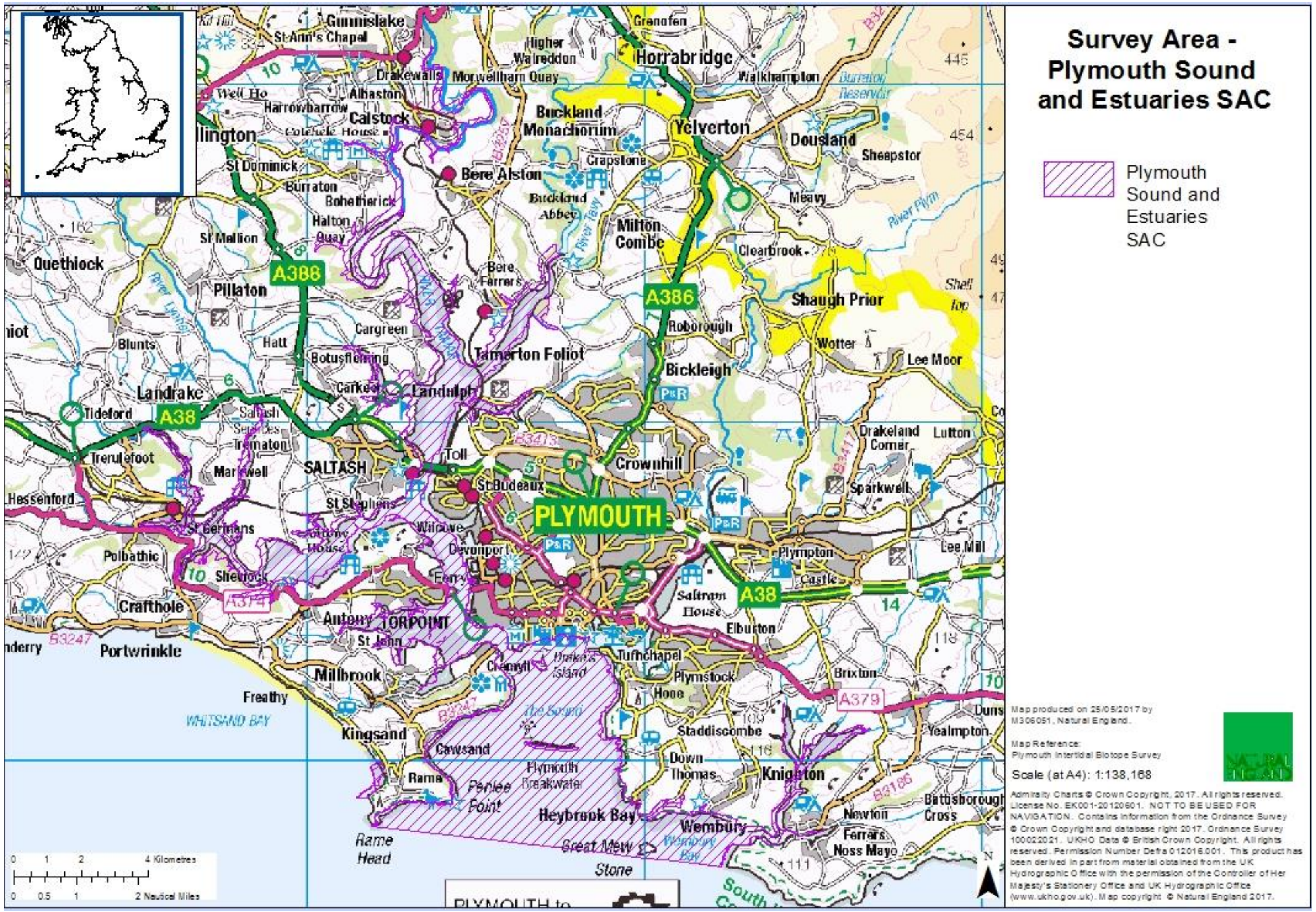

Figure 1. Boundaries of the Plymouth Sound and Estuaries SAC.

2. AIMS

- Acquire high quality biological data of suitable resolution to allow key attributes of condition to be assessed according to Common Standards Monitoring guidance for the intertidal rock and intertidal sediment.
- Identify and map the intertidal communities to the highest possible level and compare, where possible, to previous habitat maps of the site highlighting any significant changes.
- Determine the percentage of intertidal reef and sediment subfeature area where the community has been significantly altered by Pacific Oyster abundance
- Report on temporal and spatial variability in the sediment subfeature diversity and community structure in order to inform condition monitoring of the intertidal subfeatures.

3. OBJECTIVES

The specific attributes there have been monitored and reported are listed in Table 1.

Table 1. Attributes that have been monitored.

Feature/Subfeatures	Attribute	Target
Littoral rock and littoral sediment.	Distribution: presence and spatial distribution of biological communities	Restore/Maintain the presence and spatial distribution of (subfeature) communities, according to the map.
Littoral rock and littoral sediment.	Structure: non-native species and pathogens	Reduce the introduction and spread of non-native species and pathogens, and their impacts
Littoral sediment	Structure: species composition of component communities	Maintain the species composition of component communities
Littoral sediment	Structure: sediment composition and distribution	Maintain the existing distribution of sediment composition types across the feature.
Littoral sediment	Structure: sediment total organic carbon content	Maintain total organic carbon (TOC) content in the sediment at existing levels
Littoral sediment	Supporting processes: sediment contaminants	Reduce surface sediment contaminants (<1cm from the surface) to below the OSPAR Environment Assessment Criteria (EAC) or Effects Range Low (ERL) threshold.
Littoral rock and littoral sediment.	Structure: habitat zonation*	Maintain the estuary zonation, which is affected by both changes in salinity gradient and tides in the estuary from river to sea (horizontally) and with shore height (vertically) from terrestrial to subtidal.
Native oyster	Presence and spatial distribution of the species	Recover the presence and spatial distribution of the species.

In addition to those listed in Table 1, the surveys had an additional three objectives. These were to record:

- The presence and location of the alga *Caulacanthus spp.* (*C. okamurae* or *C. ustulatus*) in addition to any other Invasive Non-Native Species (INNS).
- The area of each subfeature where the community was significantly affected by the abundance of Pacific oysters (*Magallana gigas*).
- The area over which macroalgae >5% cover was distributed.

4. METHODS

1.1 Survey Area

The SAC does not include littoral habitats where there is no underpinning SSSI. The survey area therefore encompassed only those areas within the SAC where there was an underlying SSSI that included marine features (i.e. all of the littoral habitats within the SAC with the exception of the upper Yealm estuary). Data was not required for areas outside these SSSIs. For both survey and reporting purposes the SAC was subdivided into 3 Sectors as follows (Figure 2):

- Sector 1: Plymouth Sound
- Sector 2: Tamar-Tavy, Lynher Estuary, St John's Lake
- Sector 3: lower Yealm Estuary

Although the intertidal areas of Newton Creek, within the Yealm Estuary, were not within the SAC, a separate Pacific oyster distribution survey within this area of the Yealm was commissioned as a fourth study area:

- Sector 4: Newton Creek in the Yealm Estuary (Figure 3).

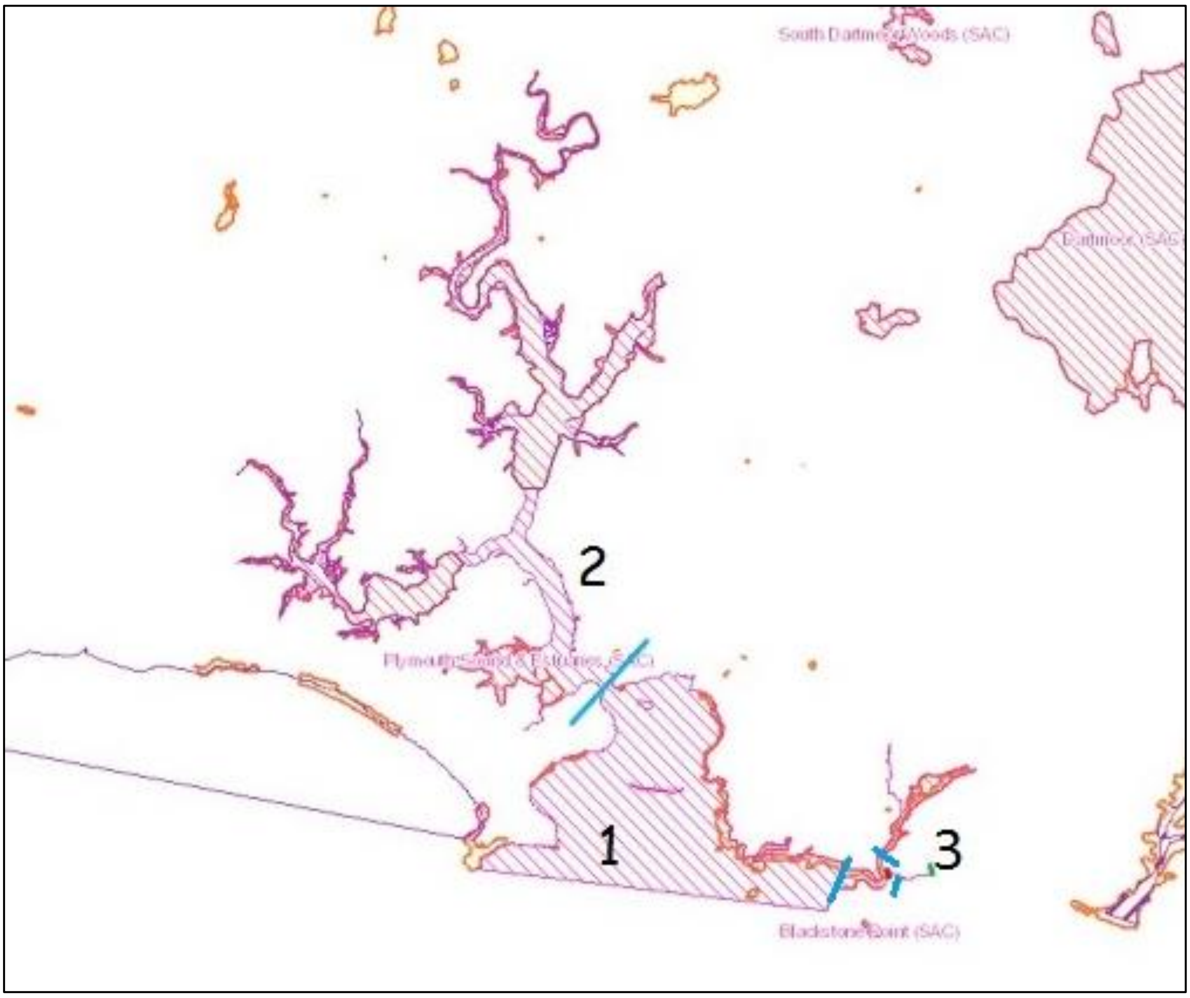

Figure 2. The 3 survey Sectors of Plymouth Sound and Estuaries SAC.

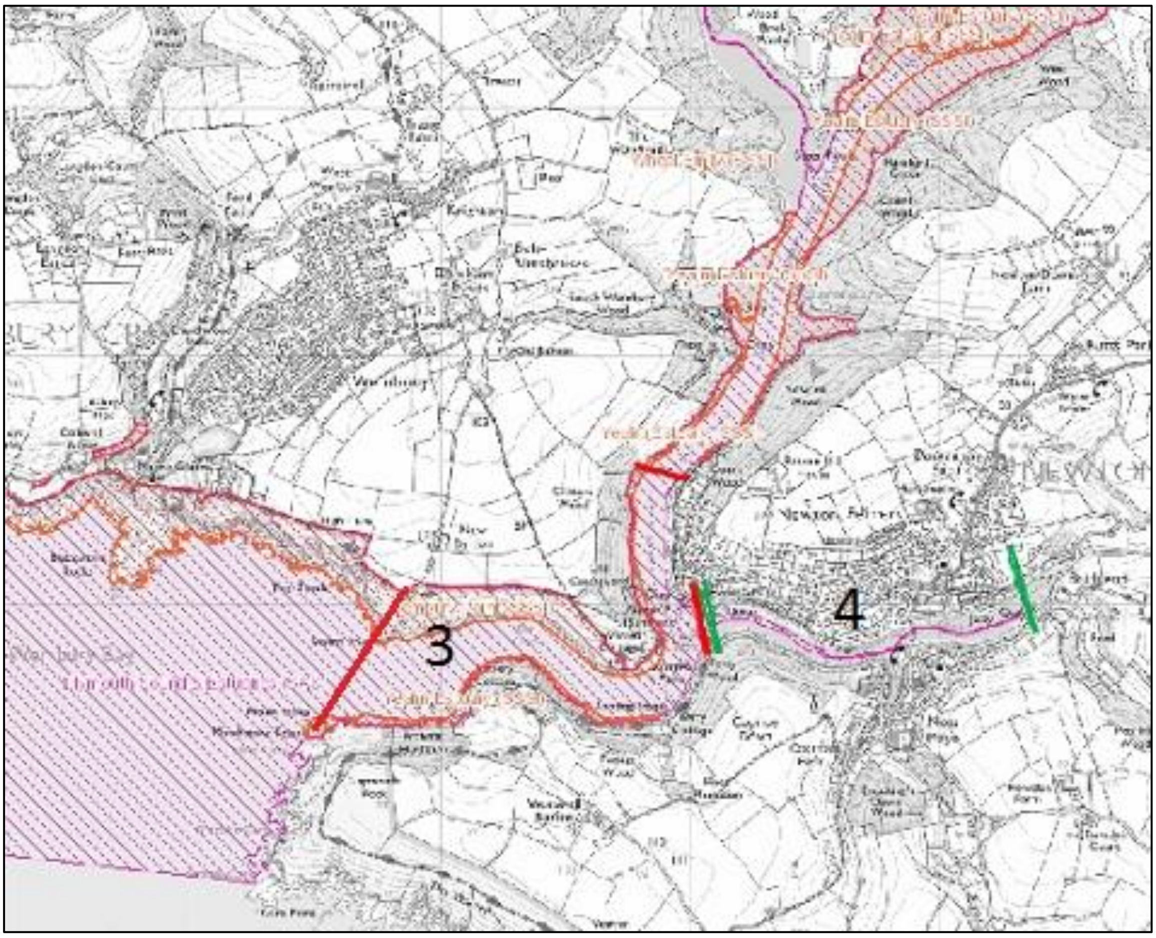

Figure 3. Extent of the Yealm Estuary to be included within Sector 3 (red lines) and additional 4th Sector within Newton Creek (green lines).

4.1 Sampling Strategy

In order to deliver the objectives set out by Natural England in the most efficient and cost effective manner, a two phased survey approach was carried out within the littoral sediment habitats. Given that no community composition data was required for the littoral rock habitats, surveys were limited to the collection of Phase I data within these habitats.

During all of the surveys, the presence of notable habitats and/or species (e.g. habitats or species of conservation interest) was highlighted where encountered and the positions recorded using DGPS.

Potential anthropogenic influences (e.g. sewers, land drains etc.) were also recorded throughout both survey phases and any obvious impacts noted.

4.2 Access

Within Sectors 1 and 3, with the exception of a small area of the upper shore at Wembury Point which was accessed on foot, access was achieved using Ecospan Environmental Ltd's MCA coded 5.5 m 6 person inflatable boat *Inshore Surveyor*. Within Sectors 2 and 4, Ecospan Environmental's Ltd 4 man MCA coded hovercraft *Redshank* was used.

4.3 Survey Dates

Spring tides were required to ensure that the lower shore habitats were exposed sufficiently to study. For this reason, the Phase I surveys were carried out during the spring tides that occurred between the 21st and 26th of August 2017 (low water ranged between 0.5m and 0.8m above chart datum during that time). The Phase II surveys were undertaken between the 4th and 11th, and 18th and 22nd of September (low water ranged between 0.8m and 1.5m above chart datum).

4.4 Phase I Protocol (carried out in Sectors 1 and 3)

The aim of the Phase I survey was to determine the distribution and extent of inter-tidal rock and sediment habitat types, interest features, and species that were representative and/or notable within the study area. This was achieved by examining geo-referenced aerial photography and subsequently ground-truthing defined habitats via field survey in order to establish the habitat types (as per Procedural Guidelines 1-1 Inter-tidal resource mapping using aerial photographs in the Marine Monitoring Handbook). All Phase I sampling undertaken was consistent with the relevant guidelines[1,2,5,6]. All littoral rock and littoral sediment Habitat types were assigned according to the Marine Habitat Classification for Britain and Ireland Version 15.03[8].

The Phase I survey achieved 100% coverage of the inter-tidal habitat types. For both littoral rock and littoral sediments pre-determined target transects (which were lay perpendicular to the shoreline) were established at approximately 500 m intervals where these habitats existed within the SAC. These transects were then added to field books containing the aerial photographs of the area, and loaded into a DGPS which was used for all position fixing during the course of the survey.

4.4.1 Littoral Rock.

Along each transect the vertical extent of each biotope was gauged and recorded as accurately as possible using a combination of DGPS and the aerial photography. The abundance of the main characteristic species within each major habitat type on the transect was recorded using the SACFOR scale. Photographs of zonation patterns at each transect were also taken. Having habitat mapped the immediate area around each transect, experience has shown that the major habitat types for some distance either side can be assessed and these boundaries drawn onto the aerial photographs. The survey team then walked, or were ferried by boat to the next target transect. Whilst doing this, the observed habitat types were super-imposed onto the aerial photography. To ensure that no significant areas of littoral habitat were missed between transects, the survey team investigated any areas of rock that appeared different to surrounding areas whilst traversing the shores. The coordinates of the Phase I transects listed in Appendix 1 together with the Habitat types that were identified.

4.4.2 Littoral sediment

The survey technique was to walk, or be ferried by boat, from one transect to another within each bay. Where changes in habitat type were observed, the perceived boundaries of the changes were marked on the aerial map (and using DGPS where necessary). At least one station was established on each transect, so that each of the different habitat types within the survey area were represented. Where large expanses of littoral sediment were exposed, a ‘zig zag’ transect route between target stations was taken in order to maximise coverage of the sediment at all tidal heights. At each station the following information was recorded:

- The exact position of the sampling stations (using DGPS).
- Sediment description
- Description of the topography and approximate tidal height (Upper, mid, low)
- Depth of redox discontinuity layer (cm)

- Interstitial salinity (where sediments are not freely draining)
- Presumptive habitat type (using The Marine Habitat Classification for Britain & Ireland v15.03)
- Abundance (SACFOR) of characterising species.
- Comments (presence of negative indicators, organic enrichment, SOCI, INNS etc)
- Digital image of the sediment surface and upshore, downshore and alongshore images
- Date and time

Given that some littoral sediment habitat types can be confused in the field, whilst undertaking the Phase I survey, sediment samples were taken for faunal analysis to confirm the habitat type assigned. These samples were processed at Ecospan's benthic laboratory, but analysis was limited to a level at which the habitat type could be determined (rapid assessment cores) rather than full faunal enumeration and identification.

4.5 Phase II (carried out in Sectors 1, 2 and 3)

The aim of the Phase II survey was to provide details on the species composition (community structure) of component communities within the sediment habitats only. Within Sectors 1 and 3 the Phase II surveys were designed following the Phase I surveys described above. Within Sector 2 the Phase I littoral rock and littoral sediment components of the survey were carried out concurrently with the Phase II sampling. The littoral rock and littoral sediment habitat maps that were produced following surveys in 2010 were overlaid onto detailed aerial photographs. These maps were then used in the field and the boundaries verified when operating in each area. Where significant variation or features of interest were observed, these were noted and the new boundary drawn using professional judgement.

Within Sector 2, the sampling methodology reflected that undertaken in 2010 where a total 49 stations were sampled within the Tamar-Tavy Estuary and St Johns Lake, and 30 in the Lynher Estuary. The same 79 positions were targeted (+/- 5 m) in 2017. At each station, a visual assessment was made of whether the habitat type matched the description of the species and abiotic habitat features according to the 2010 habitat maps. If the station fell within in a transitional area, or was within a clearly different habitat type, the position was moved to the correct habitat type. If no obviously correct habitat type was available nearby, the sample will be taken at the target position and the new habitat type recorded. Where significant differences in habitat types/boundaries were observed, these were noted and the new boundary drawn.

Within Sectors 1 and 3 efforts were made to ensure a good geographical spread of Phase II samples, as well as to achieve sufficient sample replication and representation of communities within each of the main habitat types observed. It was agreed with Natural England that barren sands or gravel habitat types identified during the Phase I were not sampled. Within Sector 1 a total of 25 stations were sampled, in Sector 2 a total of 79, and in Sector 3, 18 were sampled. The sampled station coordinates and habitat types are listed together in Appendix 2.

At each Phase II sampling station a single 0.01 m^2 core was taken following the relevant guidelines and internal SOPs[6,8,9,10]. These were sieved through a 0.5 mm mesh and preserved in 10% buffered formaldehyde. A further 0.01m^2 core was collected for Particle Size Analysis (PSA) and Total Organic Carbon (TOC) analysis at each station. The following information was recorded at each Phase II station on a pro-forma:

- The exact position of the sampling stations (using DGPS).

- Interstitial salinity
- Sediment description according to the Folk scale
- Description of the topography and tidal height (upper, mid, low)
- Depth of redox discontinuity layer (cm)
- Habitat type (The Marine Habitat Classification for Britain & Ireland v15.03)
- Abundance (SACFOR) of conspicuous species
- Comments (presence of negative indicators, surface features, fauna and flora, INNS, SOCI etc)
- Digital image of the sediment, upshore, downshore and alongshore
- Date and time

No contaminant analysis was required within Sector 1. In Sector 2 however, at 6 of the 50 stations (B4, B11, B15, B22, B29 and B40) additional sediment surface scrapes were taken (avoiding the anoxic layer) for analysis of heavy metals, PAHs and organic contaminants. In Sector 3, additional sediment surface scrapes were taken for contaminant analysis at Phase II stations Y2 and Y14. The rationale for the positioning of all contaminant analysis samples was to achieve a good geographical spread within each of the sectors being sampled.

The occurrence of habitats or species of conservation interest (including Invasive Non-Native Species (INNS)) and negative indicators such as anthropogenic inputs, bait digging etc. was recorded wherever observed. Specifically the presence and location of the alga *Caulacanthus spp.* and the Pacifica oyster *Magallana gigas* were noted.

4.6 *Magallana gigas* survey Sector 4

Within Newton Creek, areas where the density of *Magallana gigas* was considered to have formed a reef (100% cover or more) were recorded and mapped separately from areas that were considered ‘significantly affected’, but had not yet formed a reef.

5. RESULTS

5.1 Littoral Rock Habitat Types Present in 2017

5.1.1 Sector 1 - Plymouth Sound

Maps showing the locations of the Phase I littoral rock transects that were visited within Sector 1 are shown in Figure 4. The coordinates (OSGB 1936 BUG) of each transect, the Habitat types identified and the vertical extent of each are listed in Table A in Appendix 1. The SACFOR abundance data that was collected from within each Habitat type on each of the transects is listed in Table B in Appendix 1.

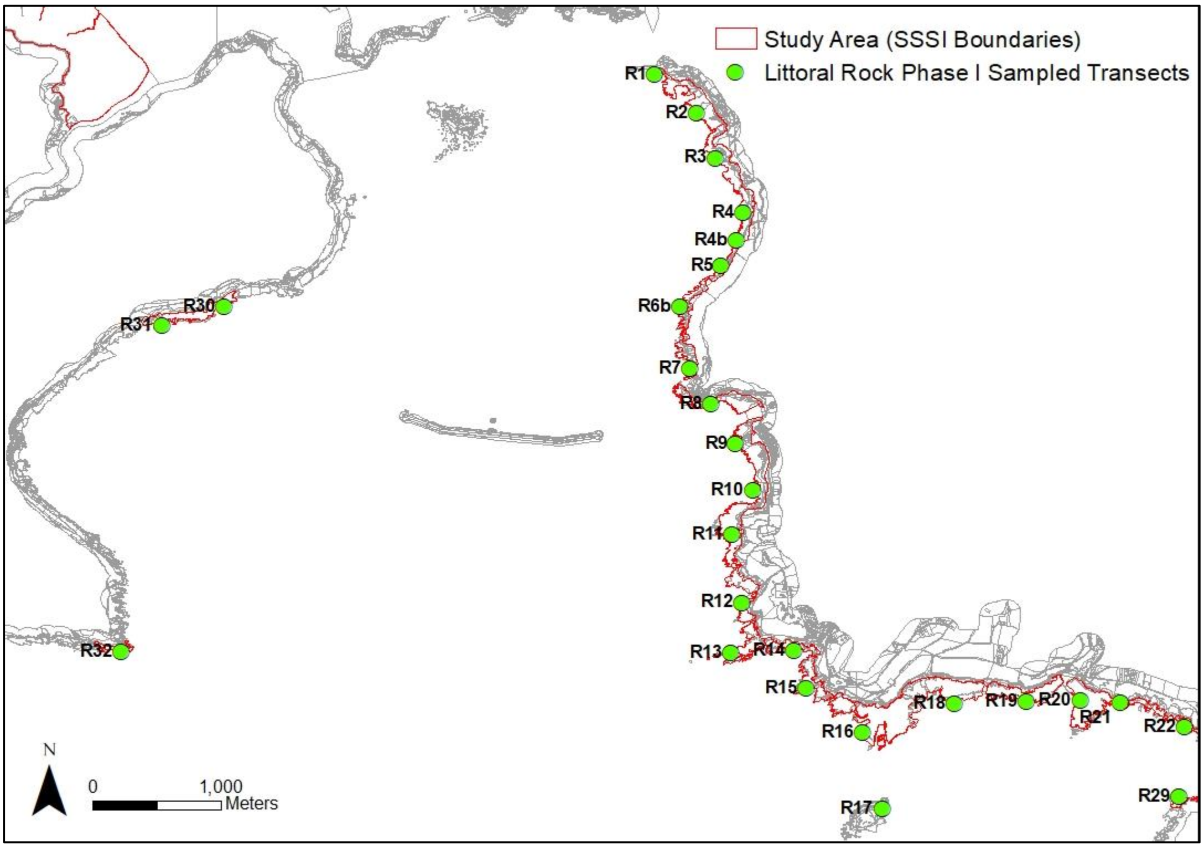

Figure 4. Littoral rock transects sampled during the Phase I survey in Sector 1.

Within Sector 1 a total of 14 sub-biotopes were recorded. These comprised communities which are generally considered to be characteristic of either high or medium energy littoral rock habitats, but also included freshwater and/or sand influenced littoral rock features:

- LR.HLR.MusB.Cht.Cht — *Chthamalus montagui* and *Chthamalus stellatus* on exposed upper eulittoral rock.
- LR.HLR.MusB.Cht.Lpyg — *Chthamalus* spp. and *Lichina pygmaea* on steep exposed upper eulittoral rock.
- LR.HLR.MusB.SemSem — *Semibalanus balanoides*, *Patella vulgata* and *Littorina* spp. on exposed to moderately exposed or vertical sheltered eulittoral rock.
- LR.HLR.FR.Him — *Himanthalia elongata* and red seaweeds on exposed to moderately exposed lower eulittoral rock.
- LR.HLR.FR.Mas — *Mastocarpus stellatus* and *Chondrus crispus* on very exposed to moderately exposed lower eulittoral.
- LR.HLR.FR.Osm — *Osmundea pinnatifida* on moderately exposed mid eulittoral rock
- LR.MLR.BF.PelB — *Pelvetia canaliculata* and barnacles on moderately exposed littoral fringe rock.
- LR.MLR.BF.FvesB. — *Fucus vesiculosus* and barnacle mosaics on moderately exposed mid eulittoral rock.
- LR.MLR.BF.Fser.R — *Fucus serratus* and red seaweeds on moderately exposed lower eulittoral rock.
- LR.MLR.BF.Fser.Bo — *Fucus serratus* and under-boulder fauna on lower eulittoral boulders.
- LR.MLR.BF.FspiB — *Fucus spiralis* on full salinity exposed to moderately exposed upper eulittoral rock
- LR.FLR.Eph.EphX — Ephemeral green and red seaweeds on variable salinity and/or disturbed eulittoral mixed substrata.
- LR.FLR.Eph.EntPor — *Enteromorpha* spp. on freshwater-influenced and/or unstable upper eulittoral rock.

- LR.LLR.F.Fves — Fucus vesiculosus on moderately exposed to sheltered mid eulittoral rock

Due to the large area, complex distribution and number of habitat types within Sector 1 it has not been possible to usefully display a map of the extent and distribution of every habitat type that was recorded within this report. However, a full and detailed habitat map is available in the accompanying shapefiles (that have been produced using ArcMap 10.5). The extent and distribution of the four most extensive habitat types within the study area is shown in Figures 5 to 8; these were *Chthamalus* spp. on exposed upper eulittoral rock (LR.HLR.MusB.ChtCht and/or LR.HLR.MusB.Cht.Lpyg), *Fucus vesiculosus* and barnacle mosaics on moderately exposed mid eulittoral rock (LR.MLR.BF.FvesB), *Himanthalia elongata* and red seaweeds on exposed to moderately exposed lower eulittoral rock (LR.HLR.FR.Him) and *Fucus serratus* and red seaweeds on moderately exposed lower eulittoral rock (LR.MLR.BF.Fser.R).

The zonation observed within Sector 1 was typical of a moderately exposed shoreline. The lower shore bedrock throughout the study area was almost exclusively characterised by the wrack *Himanthalia elongata* (LR.HLR.FR.Him). The width of the lower shore zone varied from 0.5 m in the most exposed areas such as at Wembury Point, to 20 m in more sheltered, inshore locations such as at Mount Batten. In all but the most exposed areas such as at Ramscliff Point, and between Andurn Point and Wembury Point, a band of *Fucus serratus* (LR.MLR.BF.Fser.R) (usually around 2 m wide) was found above the LR.HLR.FR.Him. Where gullies ran inshore from the sea the LR.MLR.BF.Fser.R habitat type often displaced the LR.HLR.FR.Him habitat type entirely in those localised areas. In the less exposed areas such as at Mount Batten, the *Fucus serratus* had established upon boulders (LR.MLR.BF.Fser.Bo) which also supported a mores dense understorey of red algae which frequently included: *Mastocarpus stellatus*, *Osmundea pinnatifida*, *Palmaria palmata*, *Corallina officinalis* as well as green algae such as *Ulva* and *Chaetomorpha*.

Communities characterised by the mid shore fucoid *Fucus vesiculosus* (LR.MLR.BF.FvesB) were found where the shoreline was broader and sheltered from the direct prevailing southwesterly swell (e.g. south of Jennycliff beach and east of Wembury Point, leeward of the Mewstone). Small discrete areas where communities dominated by red algae species such as *Mastocarpus stellatus* (LR.HLR.FR.Mas) and *Osmundea pinnatifida* (LR.HLR.FR.Osm) were also found in Jennycliff Bay and at Wembury Point.

Inshore of the Mewstone the littoral rock protruded for almost 300 metres. There, two series of zonation had formed. On the higher half of the shore communities typical of more sheltered shores were found; these included the upper shore wrack *Pelvetia canaliculata* (LR.MLR.BF.PelB) and *Fucus spiralis* (LR.MLR.BF.FspiB) below which a dense canopy of *Fucus vesiculosus* (LR.LLR.F.Fves) had established. Below these 3 habitat types a further 3 were found on the lower shore which reflected those found throughout the wider study area (LR.HLR.MusB.ChtCht, LR.HLR.FR.Mas and LR.HLR.FR.Him).

Chthalamus barnacle species formed a distinct band on the mid-high tidal heights throughout the Sector (LR.HLR.MusB.Cht.Cht). On the most vertical and exposed rock which were less susceptible to desiccation, this zone formed a patchy mosaic with tufts of the dark brown lichen *Lichina pygmaea* (LR.HLR.MusB.Cht.Lpyg). Between Andurn Point and Blackstone Rocks the less desiccation tolerant barnacle *Semibalanus balanoides* (LR.HLR.MusB.SemSem) formed a band below the LR.HLR.MusB.Cht.Lpyg and/or LR.HLR.MusB.ChtCht communities. The zonation of habitat types on the eastern side of the study area was replicated on the small areas that were studied on the western side where *Himanthalia elongata*, *Fucus Serratus* and *Chthalamus spp* dominated.

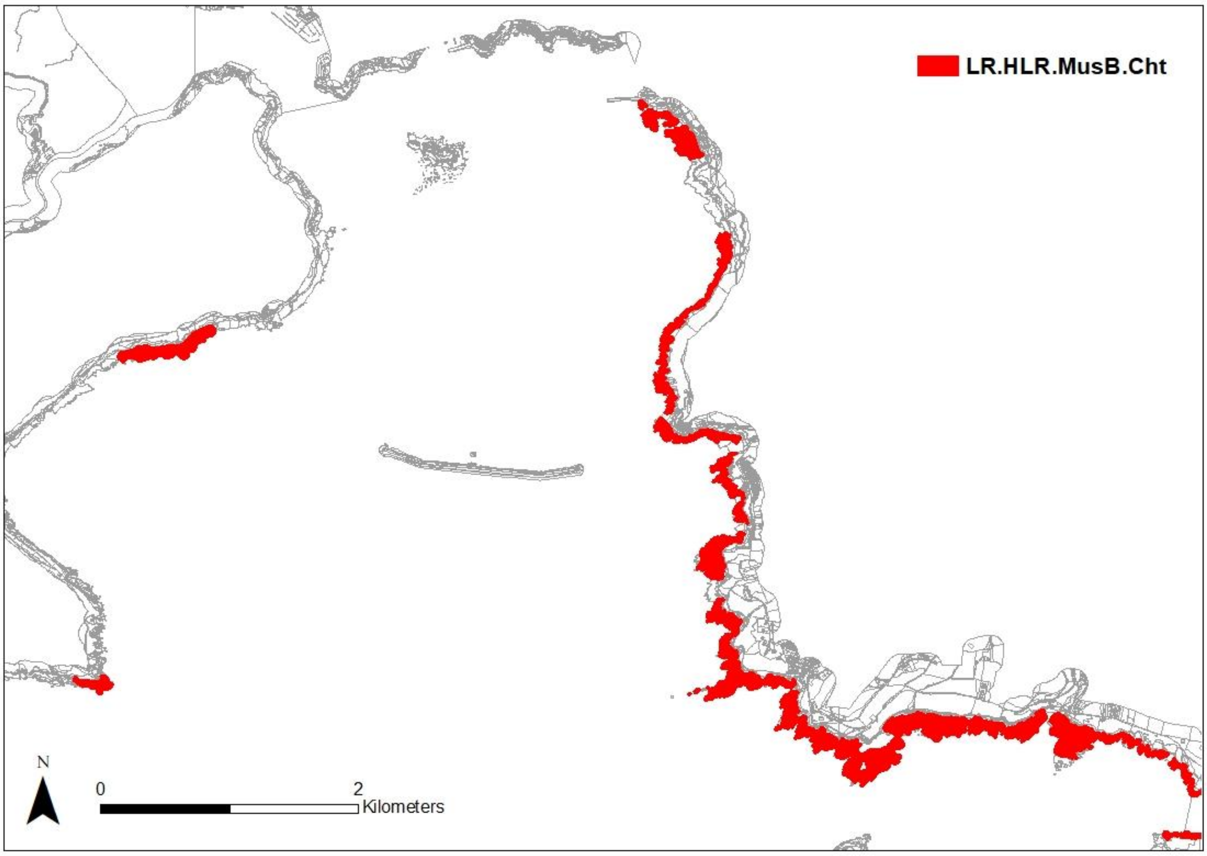

Figure 5. Extent and distribution of LR.HLR.MusB.Cht within Sector 1.

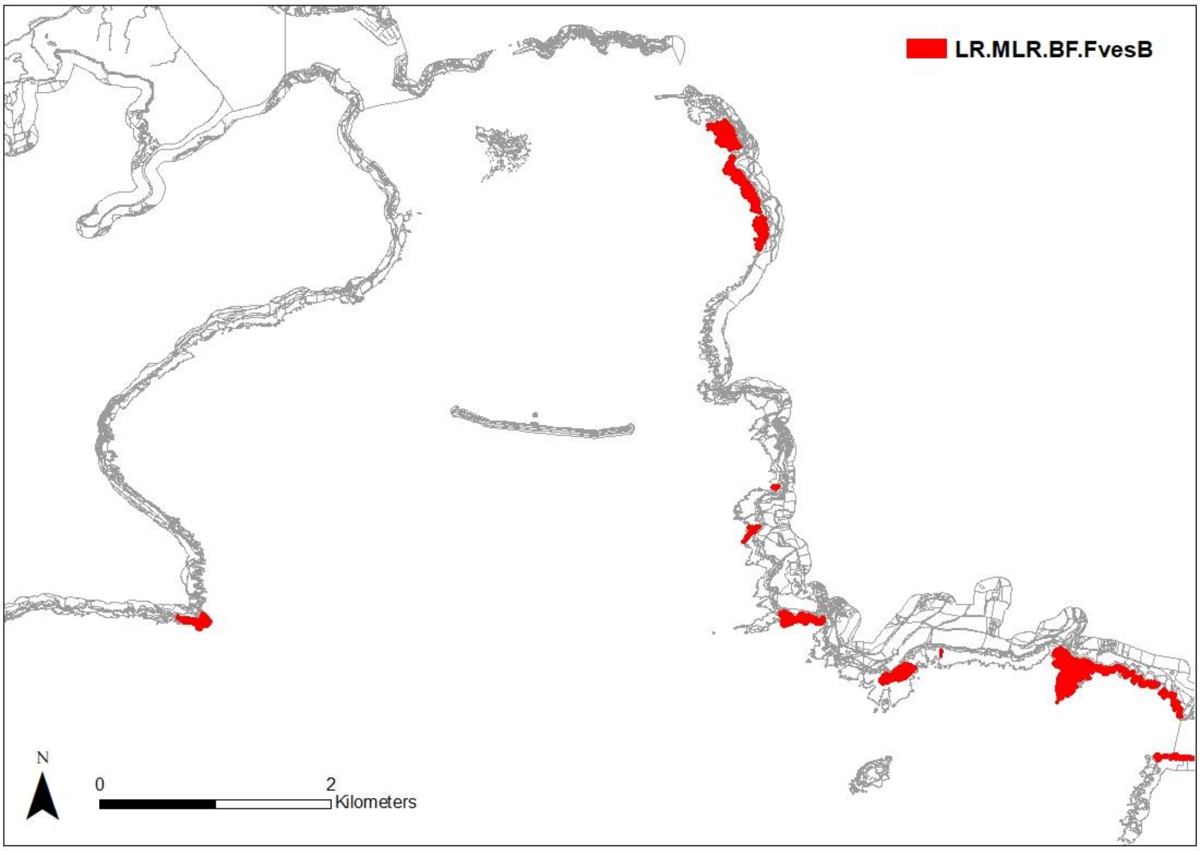

Figure 6. Extent and distribution of LR.MLR.BF.FvesB within Sector 1.

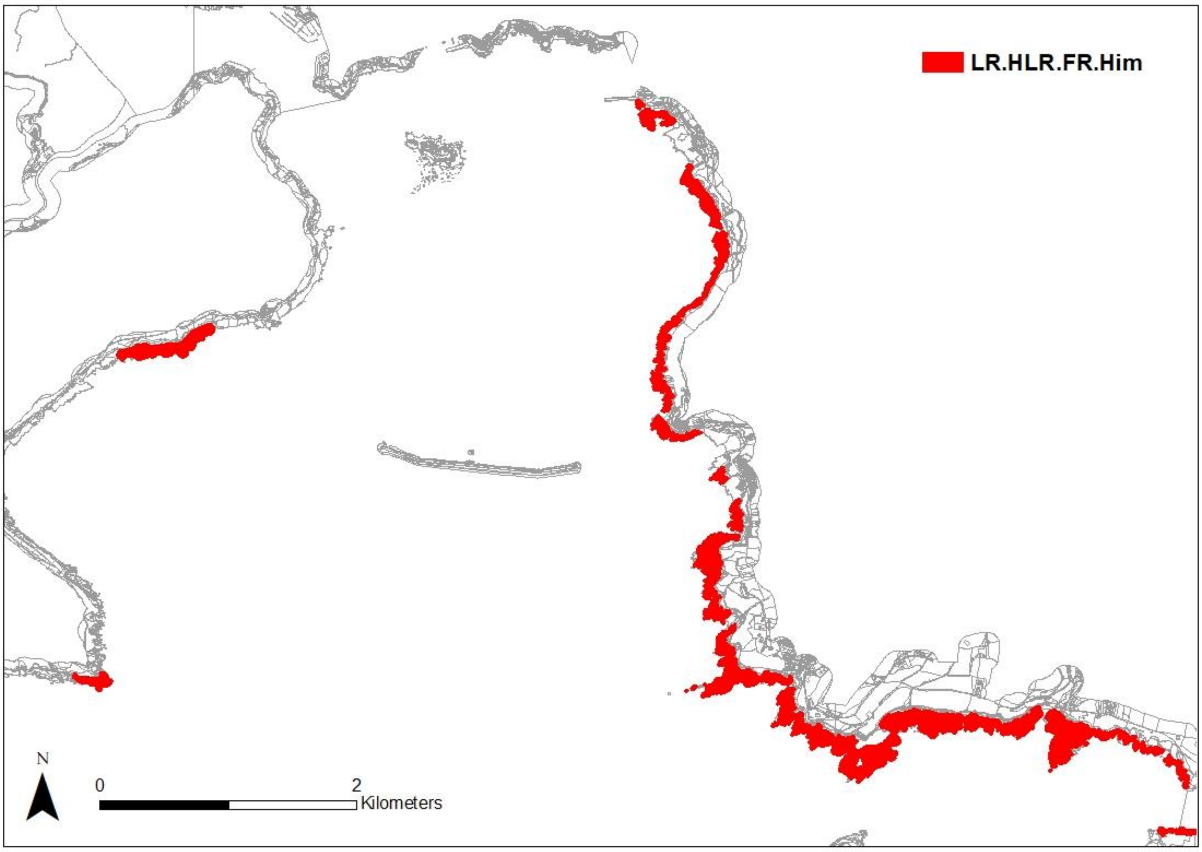

Figure 7. Extent and distribution of LR.HLR.FR.Him within Sector 1.

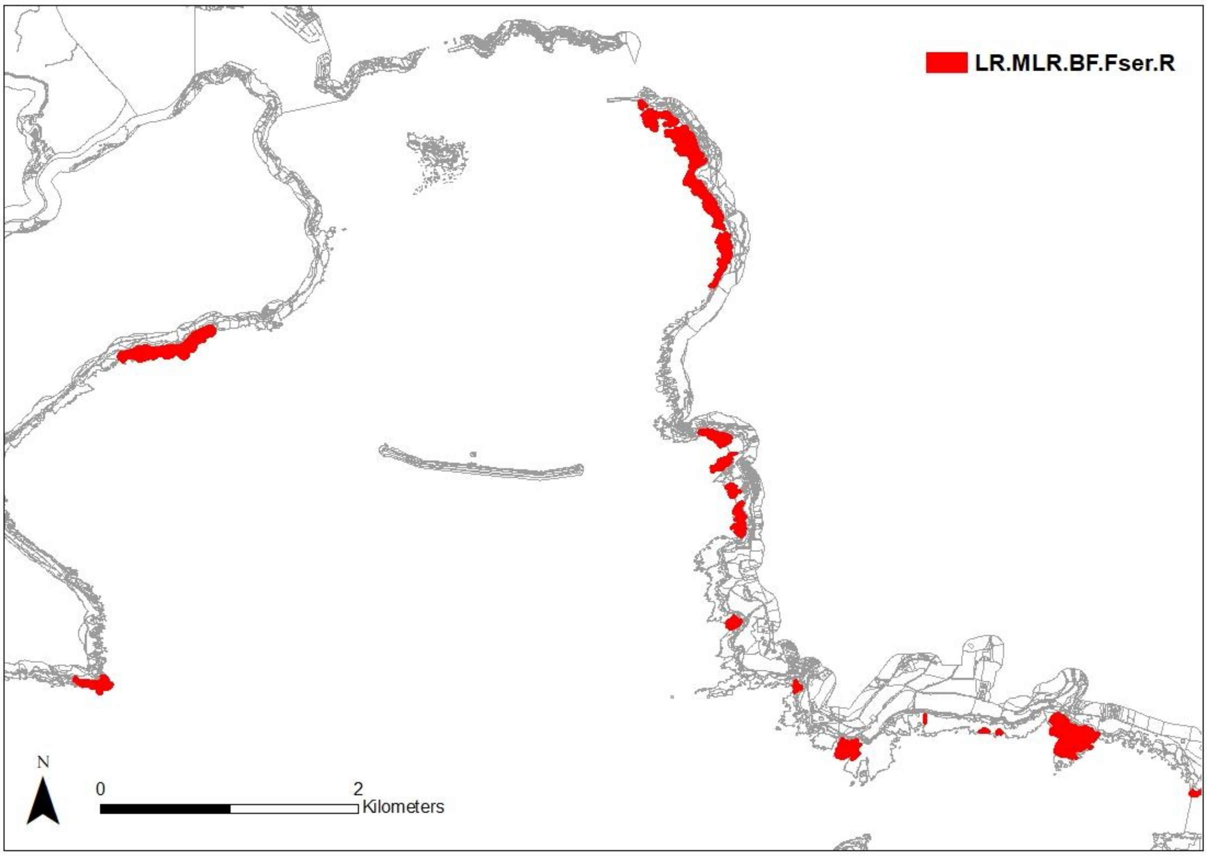

Figure 8. Extent and distribution of LR.MLR.BF.Fser.R within Sector 1.

5.1.2 Sector 2 - Tamar-Tavy, St Johns Lake and the Lynher Estuary

The method used to assess the extent and distribution of littoral rock habitat types in Sector 2 varied from those employed within Sectors 1 and 3. The approach used was to verify the littoral rock habitat map that was produced in 2010. No differences in the littoral rock habitat types present or their extent or distribution were identified between 2010 and 2017, full descriptions and maps of the habitat types identified can be found in the 2010 reports [11,12].

5.1.3 Sector 3 - The Yealm Estuary

Maps showing the locations of the Phase I littoral rock transects that were visited within Sector 3 are shown in Figure 9. The coordinates (OSGB 1936 BUG) of each transect, the habitat types identified and the vertical extent of each are listed in Table A in Appendix 1. The SACFOR abundance data collected from within each habitat type on each of the transects is also listed in Table B in Appendix 1.

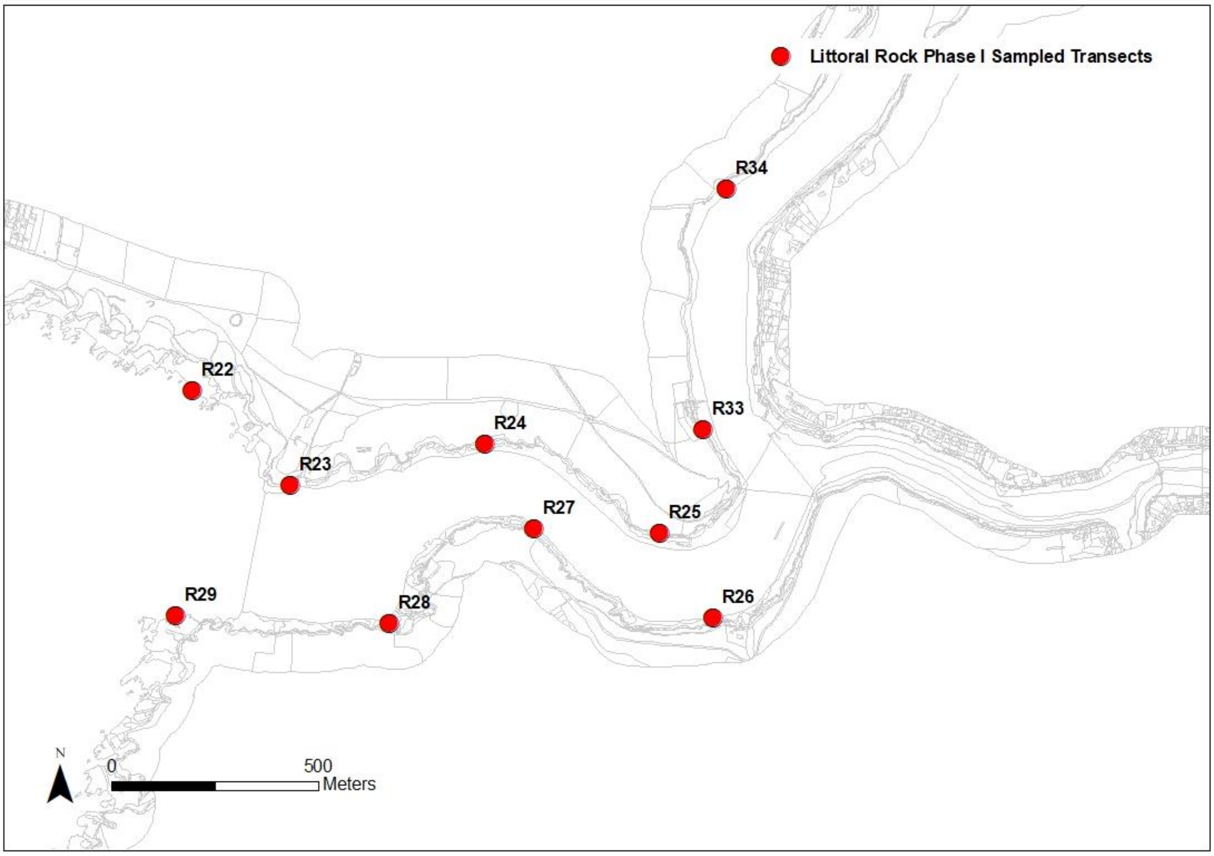

Figure 9. Littoral rock transects sampled during the Phase I survey in Sector 3.

A total of 16 littoral rock habitat types were recorded within the Yealm estuary (Sector 3):

- LR.HLR.MusB.Cht.Cht — *Chthamalus montagui* and *Chthamalus stellatus* on exposed upper eulittoral rock.
- LR.HLR.MusB.Cht.Lpyg — *Chthamalus* spp. and *Lichina pygmaea* on steep exposed upper eulittoral rock.
- LR.HLR.MusB.SemSem — *Semibalanus balanoides*, *Patella vulgata* and *Littorina* spp. on exposed to moderately exposed or vertical sheltered eulittoral rock.
- LR.HLR.FR.Him — *Himanthalia elongata* and red seaweeds on exposed to moderately exposed lower eulittoral rock.

• LR.HLR.FR.Osm	*Osmundea pinnatifida* on moderately exposed mid eulittoral rock
• LR.MLR.BF.PelB	*Pelvetia canaliculata* and barnacles on moderately exposed littoral fringe rock.
• LR.MLR.BF.FvesB.	*Fucus vesiculosus* and barnacle mosaics on moderately exposed mid eulittoral rock.
• LR.MLR.BF.Fser.R	*Fucus serratus* and red seaweeds on moderately exposed lower eulittoral rock.
• LR.LLR.FVS.FspiVS	*Fucus spiralis* on sheltered variable salinity upper eulittoral rock
• LR.LLR.FVS.PelVS	*Pelvetia canaliculata* on sheltered, variable salinity littoral fringe rock
• LR.LLR.FVS.FserVS	*Fucus serratus* and large *Mytilus edulis* on variable salinity lower eulittoral rock
• LR.LLR.FVS.AscVS	*Ascophyllum nodosum* and *Fucus vesiculosus* on variable salinity mid eulittoral rock
• LR.LLR.FVS.Fcer	*Fucus ceranoides* on reduced salinity eulittoral rock
• LR.FLR.Eph.EphX	Ephemeral green and red seaweeds on variable salinity and/or disturbed eulittoral mixed substrata.
• LR.LLR.FVS.FvesVS	*Fucus vesiculosus* on mid eulittoral variable salinity boulders and stable mixed substrata
• LR.LLR.FVS.FserVS	Fucus serratus and large Mytilus edulis on variable salinity lower eulittoral rock

As would be expected, the communities that were identified range from those representing variable salinity and/or sheltered conditions further within the estuary, to those typical of high energy fully saline conditions at the mouth (Figure 10). At the estuary mouth, the zonation of high energy habitat types reflected those found throughout Sector 1 where *Himanthalia elongata* and/or *Fucus serratus* (LR.MLR.BF.Fser.R) frequently characterised the lower shore before transitioning to *Fucus vesiculosus* (LR.MLR.BF.FvesB) and barnacles on the mid-upper shores (LR.HLR.MusB.Cht.Cht). The habitat types changed into those typical of sheltered variable salinity sites 500m into the estuary. Much more dense canopies of fucoid seaweeds dominated the rocky shores. Typically, the wrack *Pelvetia canaliculata* (LR.LLR.FVS.PelVS) occured on the upper shore, with either the wrack *Fucus spiralis* (LR.LLR.FVS.FspiVS) or *Fucus ceranoides (*LR.LLR.FVS.Fcer) below. The middle shore was frequently dominated by broader areas of *Ascophyllum nodosum* and/or *Fucus vesiculosus* (LR.LLR.FVS.AscVS). The wrack *Fucus serratus* (LR.LLR.FVS.FserVS) was found on the lower shore bedrock and boulders throughout the study area, whilst ephemeral green algae covered the mixed sediments on the mid-lower shore of Cellars Cove beach.

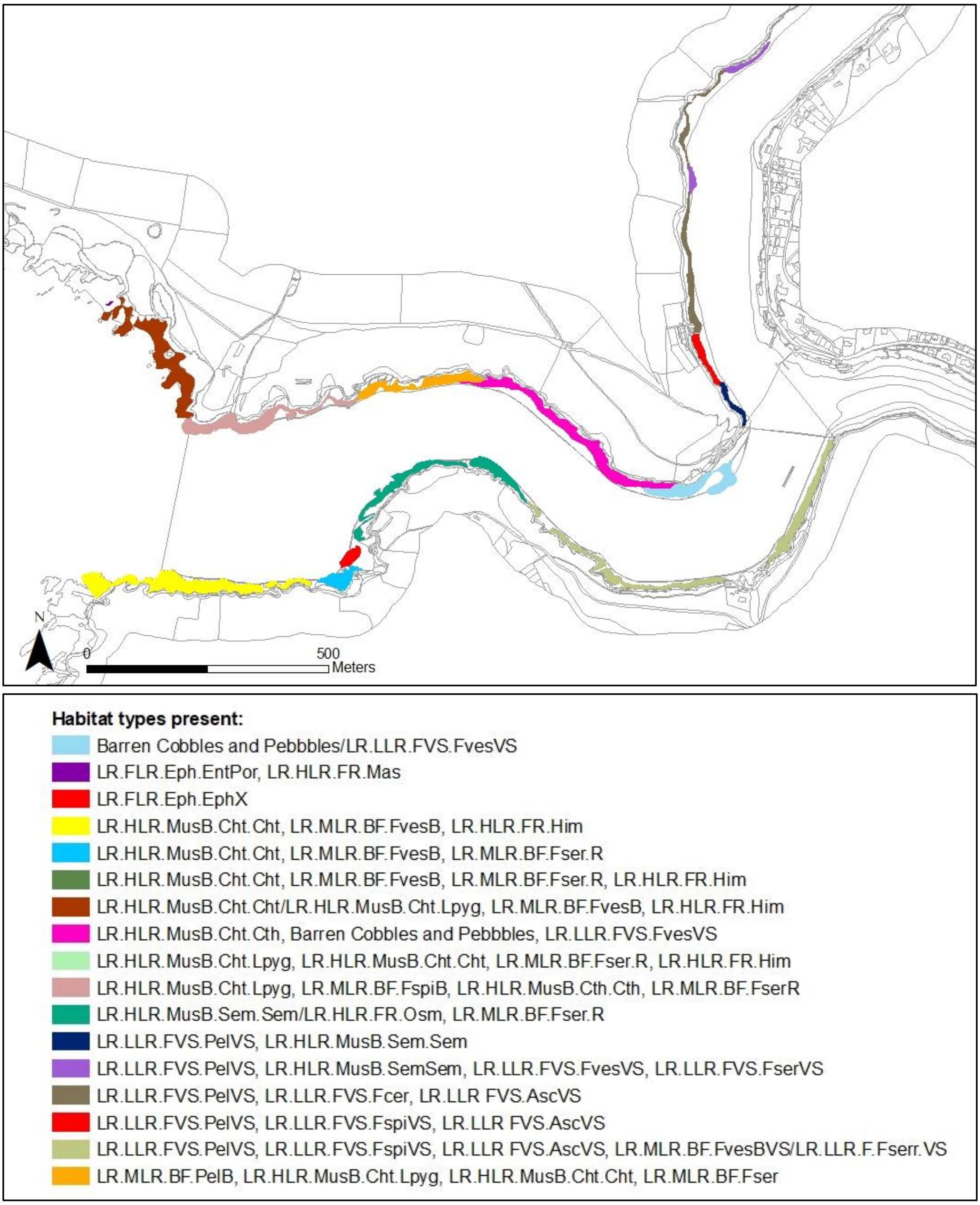

Figure 10. Extent and distribution of littoral rock Habitat types within Sector 3 (where Habitat types are separated by a '/' this represents two or more Habitat types mosaicking at the same shore height, commas separate the shore heights).

5.2 Littoral Sediment Habitat Types Present in 2017

Maps showing the positions of the sampled Phase II stations within each Sector of the SAC are shown in Figures 11 to 21. The co-ordinates (OSGB 1936 BUG) of each Phase II stations together with the Habitat type sampled at each are presented in Tables A to C in Appendix 2. Due to the large volume of data, the full species abundance list for all stations has been provided electronically.

5.2.1 Sector 1 - Plymouth Sound

A total of 13 littoral sediment Habitat types were recorded within the Sector 1, these were:

- LS.LCS.Sh.BarSh — Barren littoral shingle
- LS.LSa.St.Tal — Talitrids on the upper shore and strand-line
- LS.LSa.MoSa — Barren or amphipod dominated mobile sand shores
- LS.LSa.MoSa.BarSa — Barren littoral coarse sand
- LS.LMx.Mx — Species-rich mixed sediment shores
- LS.LSa.MoSa.AmSco.Sco — *Scolelepis* spp. in littoral mobile sand
- LS.LSa.MoSa.AmSco.Eur — *Eurydice pulchra* in littoral mobile sand
- LS.LSa.MoSa.AmSco.Pon — *Pontocrates arenarius* in littoral mobile sand
- LS.LSa.MoSa.Ol.FS — Oligochaetes in full salinity littoral mobile sand
- LS.LSa.MoSa.Ol.VS — Oligochaetes in variable salinity littoral mobile sand
- LS.LSa.FiSa.Po — Polychaetes in littoral fine sand
- LS.LSa.MuSa.CerPo — *Cerastoderma edule* and polychaetes in littoral muddy sand
- LS.LMu.UEst.NhomStr — *Nephtys hombergii* and *Streblospio shrubsolii* in littoral mud

Within Plymouth Sound and along the coast to Wembury Beach barren littoral shingle and/or barren sands accounted for the most exposed, south-westerly facing shores. Where littoral rock fringed and stabilised narrower channels of fine sands on areas of mid to lower shore, more diverse communities of polychaetes were found. Moderately exposed, and therefore mobile, fine to medium sands (such as those on Bovisand and Wembury Beaches) were characterised by the presence of species such as *Scolelepis* spp., *Eurydice pulchra* and *Pontocrates arenarius.* To the east of Wembury Point littoral rock fringed the lower-mid shore, but above that the rock gave way to coarse sands on the upper shore which supported species poor communities of oligochaetes. A 1-3m zone of drift algae and associated populations of Talitrid amphipods was present wherever littoral sediment extended to the upper shore with the exception of at Mount Batten Beach and Andurn Point.

The results of the univariate analysis for each station and the mean diversity indices for each Habitat type have been incorporated into Table A of Appendix 5. Given that the sampling effort within each of the Habitat types was different, a degree of caution should be applied when comparing the mean indices between Habitat types. However, it can be seen that species richness and diversity was generally relatively low within the Sector.

Habitat types on the lower shore generally exhibited greater species diversity and richness. For example, the greatest mean diversity value (Shannon Wiener Index = 1.3) was derived from the LS.LSa.FiSa Habitat type, whilst the greatest richness was found in the LS.LSa.MoSa.AmSco.Sco communities (mean Maraglef's species richness = 1.4). In contrast, analysis of the LS.LSa.MoSa.Ol.FS communities which were found on the higher shore produced the lowest richness and diversity values (0.6 and 0.2 respectively). This disparity in diversity between the lower shore and upper shore communities is expected given the more variable and extreme environmental variables that fauna are exposed to on the upper shore. On the upper shore, generally, only a few species that are tolerant of desiccation, temperature and salinity stress can survive.

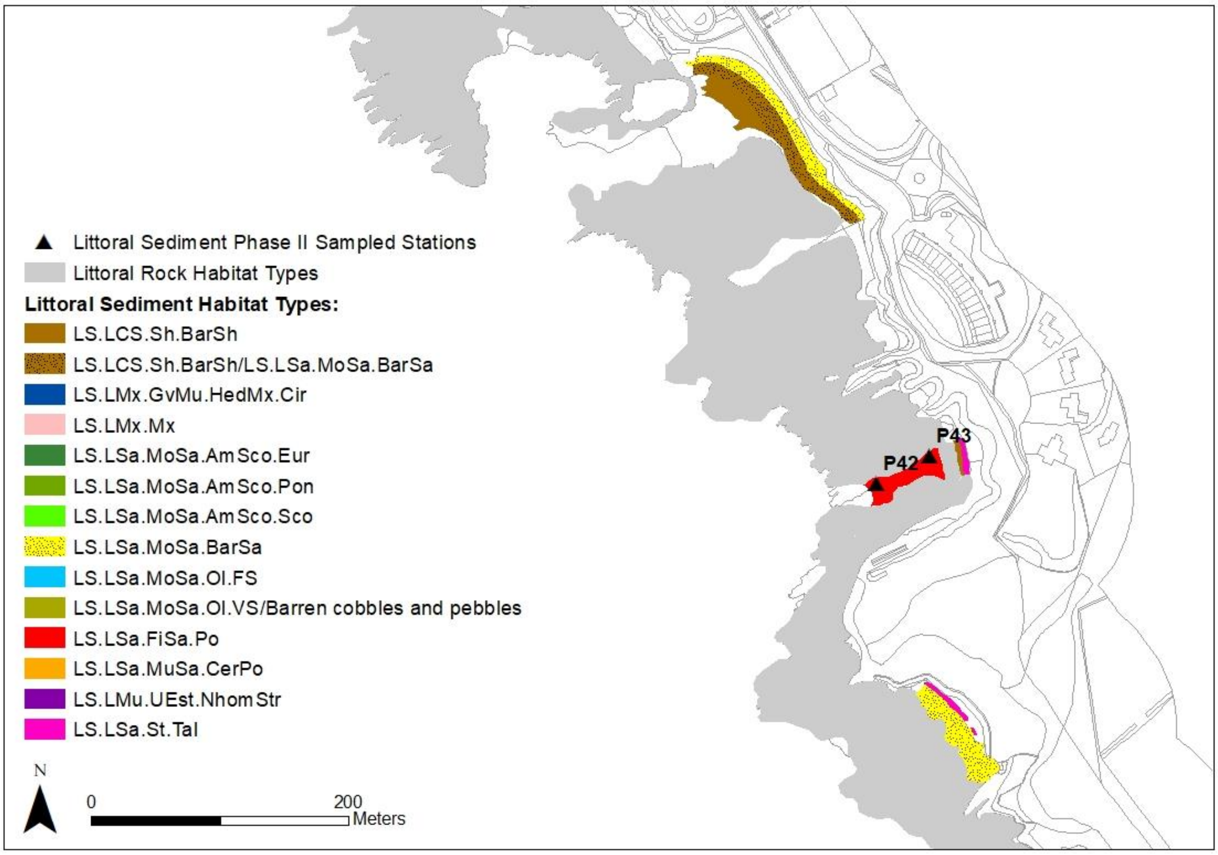

Figure 11. Littoral sediment sampled station locations within Sector 1: Mount Batten to Rum Bay

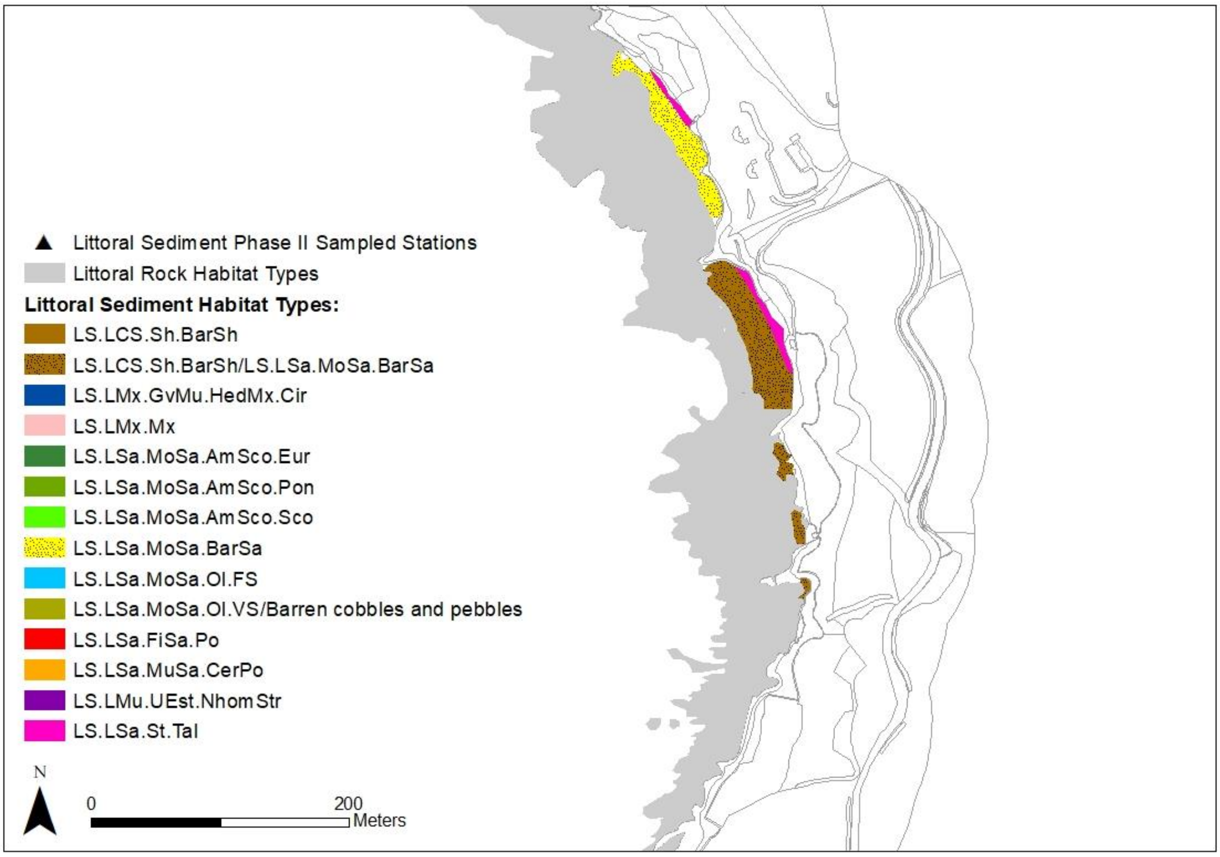

Figure 12. Littoral sediment sampled station locations within Sector 1: Rum Bay to Jennycliff Bay

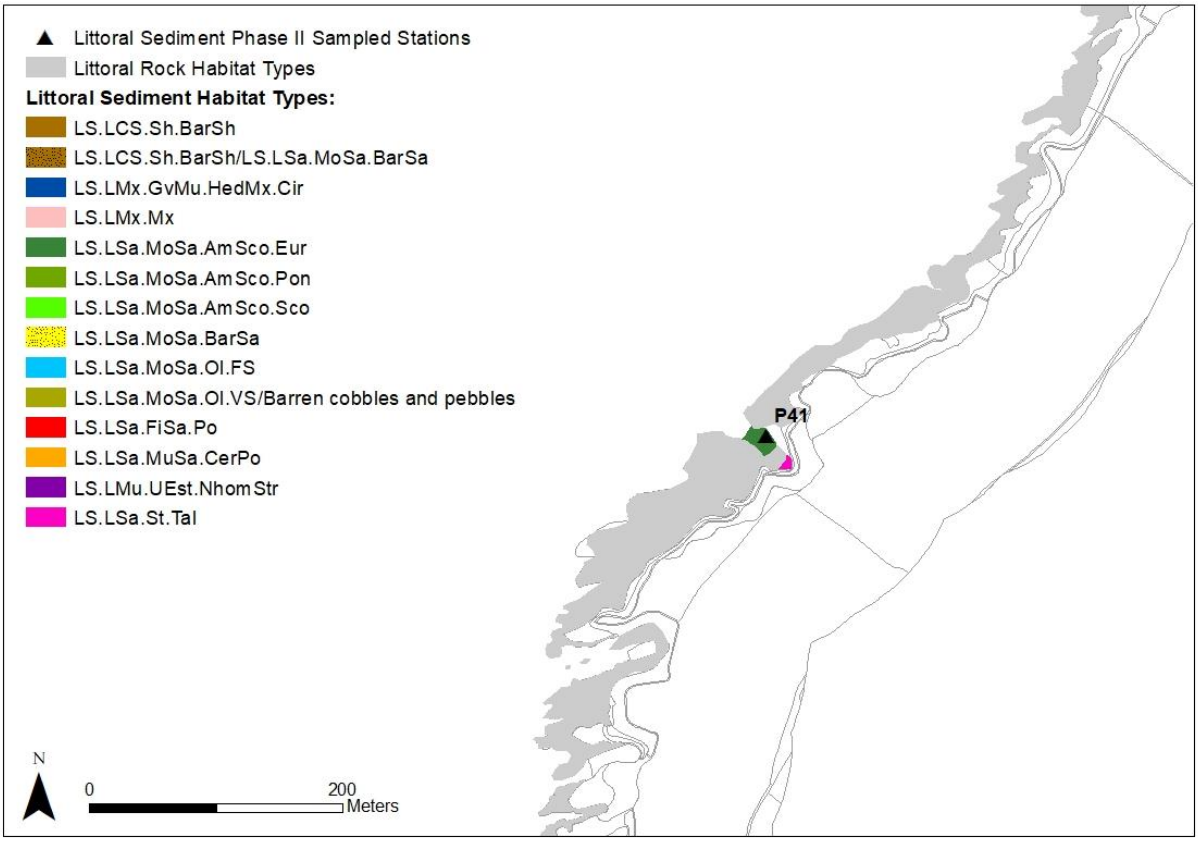

Figure 13. Littoral sediment sampled station locations within Sector 1: Jennycliff Bay to Ramscliff Point

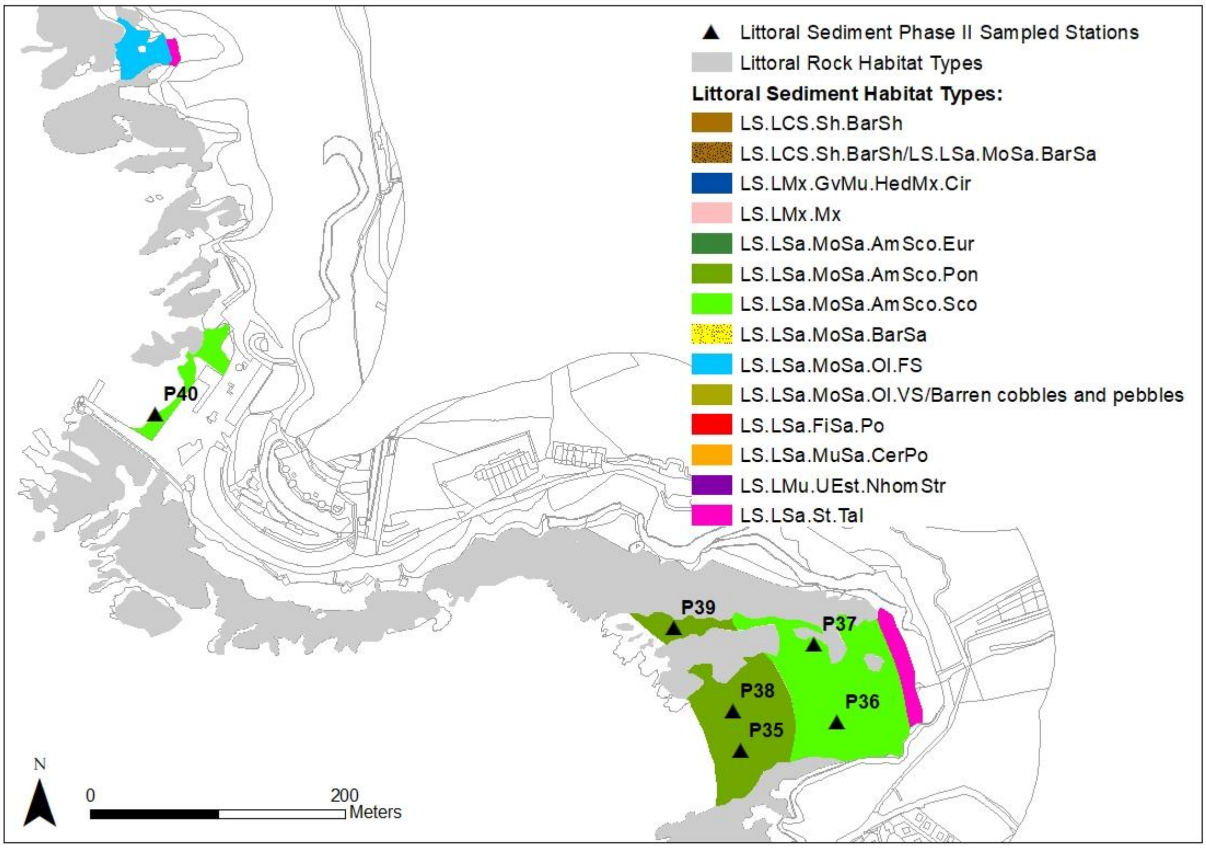

Figure 14. Littoral sediment sampled station locations within Sector 1: Ramscliff Point to Bovisand Bay

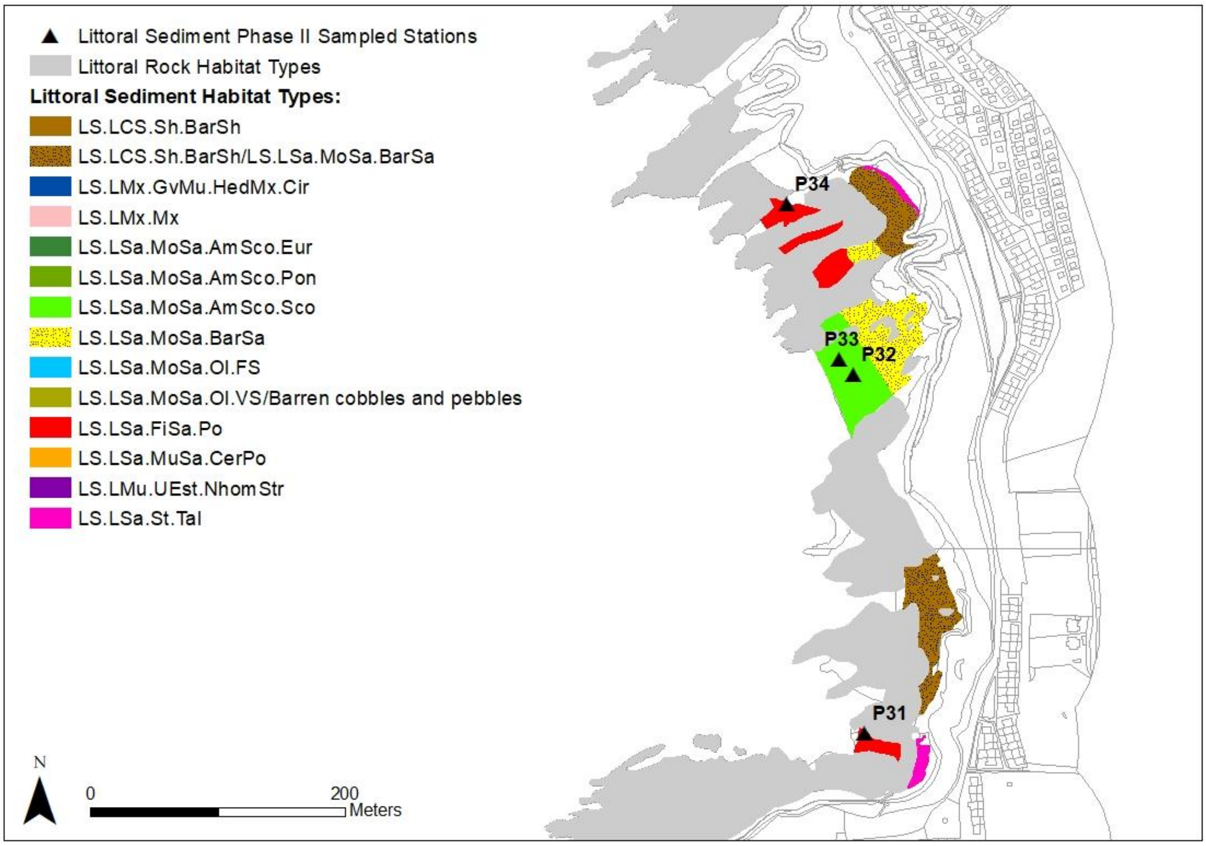

Figure 15. Littoral sediment sampled station locations within Sector 1: Crownhill Bay to Andurn Point

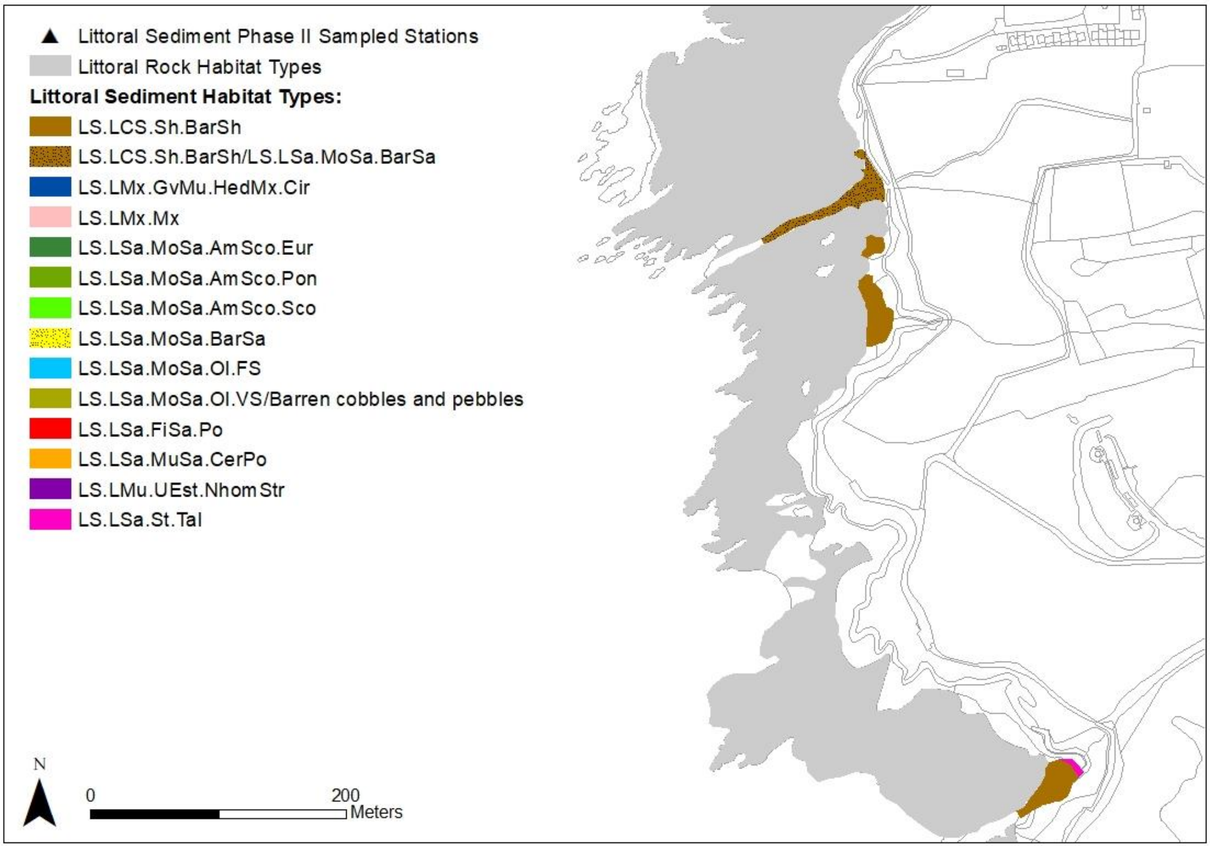

Figure 16. Littoral sediment sampled station locations within Sector 1: Andurn Point to Westlake Bay

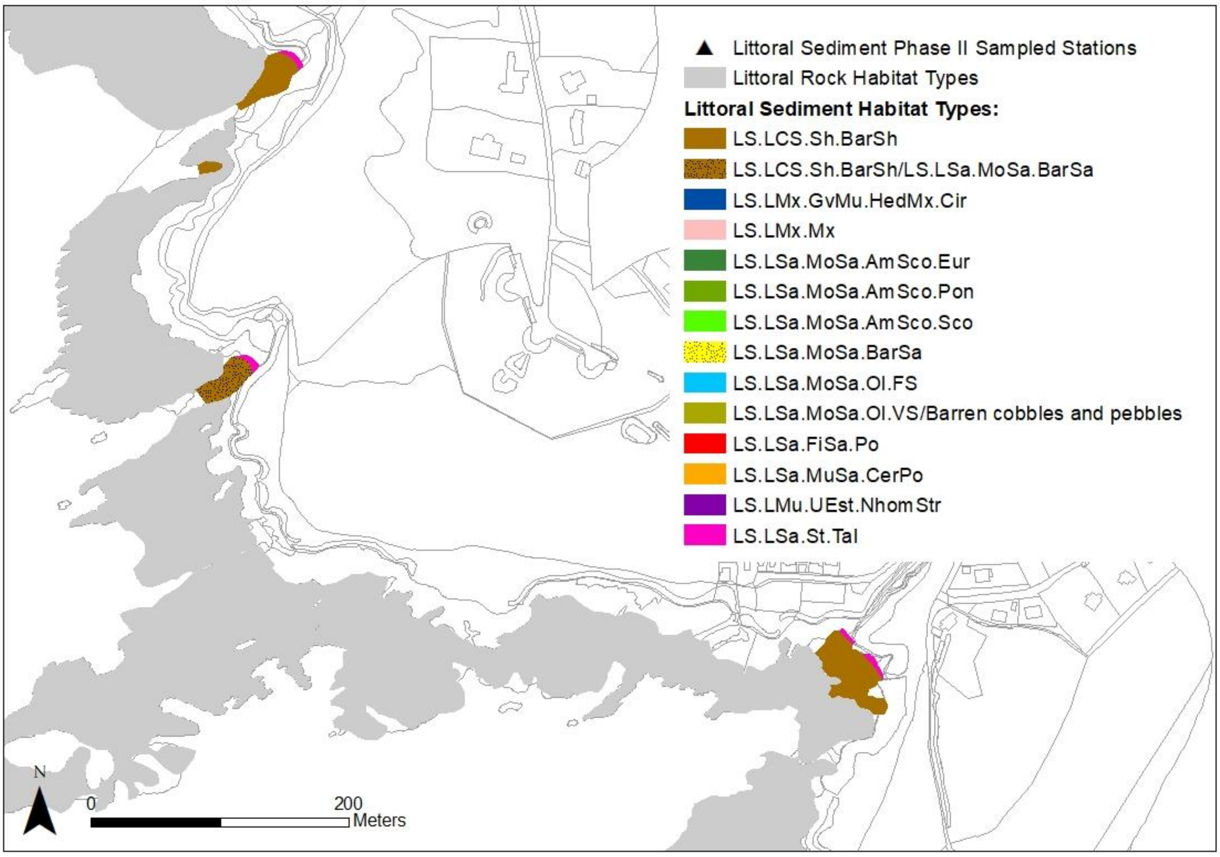

Figure 17. Littoral sediment sampled station locations within Sector 1: Westlake Bay to Heybrook Bay

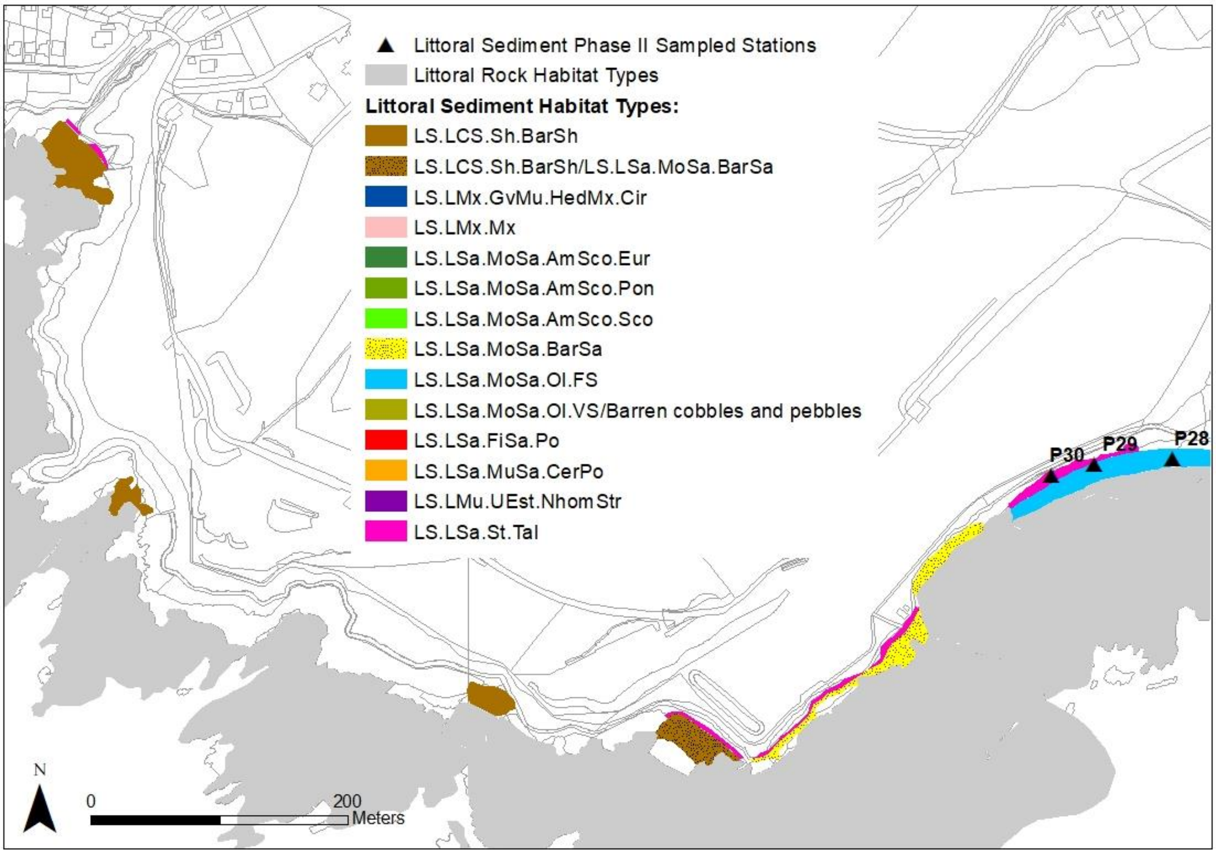

Figure 18. Littoral sediment sampled station locations within Sector 1: Heybrook Bay and Wembury Point

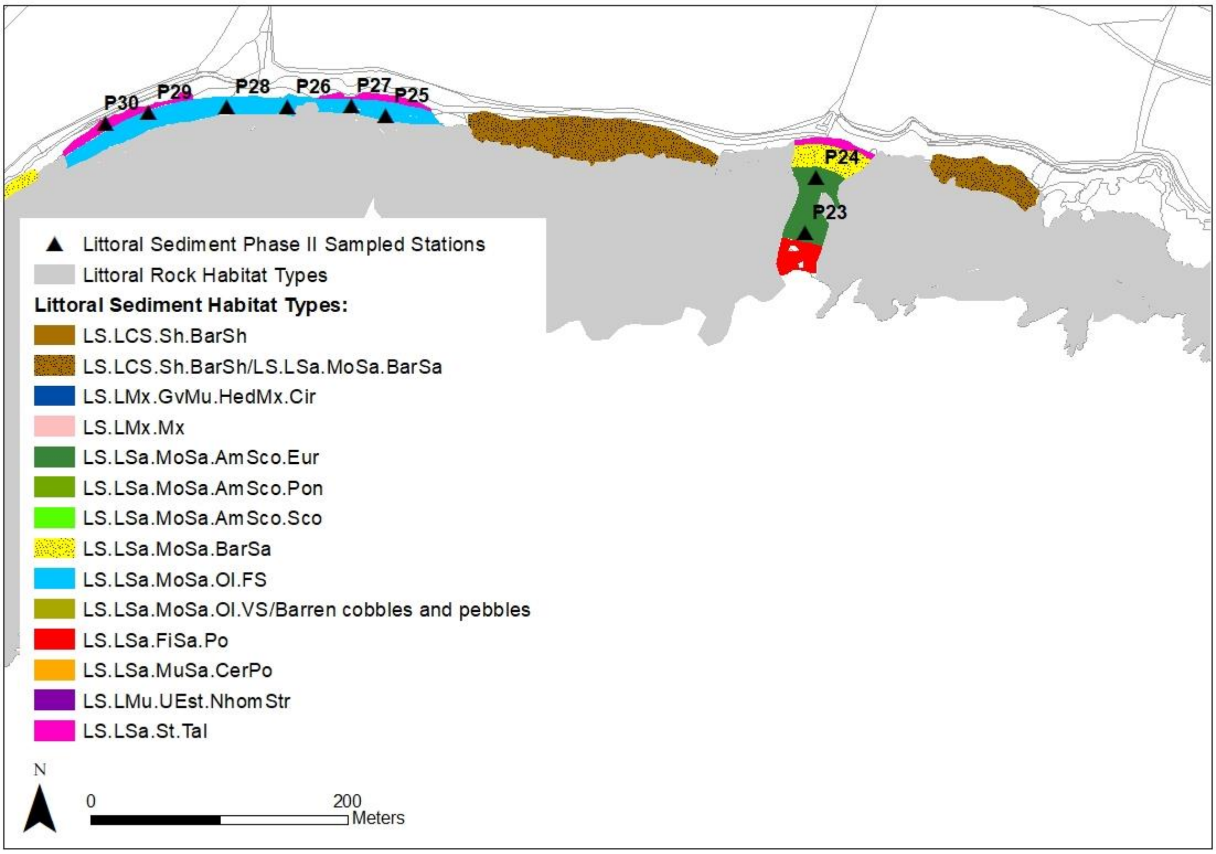

Figure 19. Littoral sediment sampled station locations within Sector 1: Wembury Point to Wembury Bay

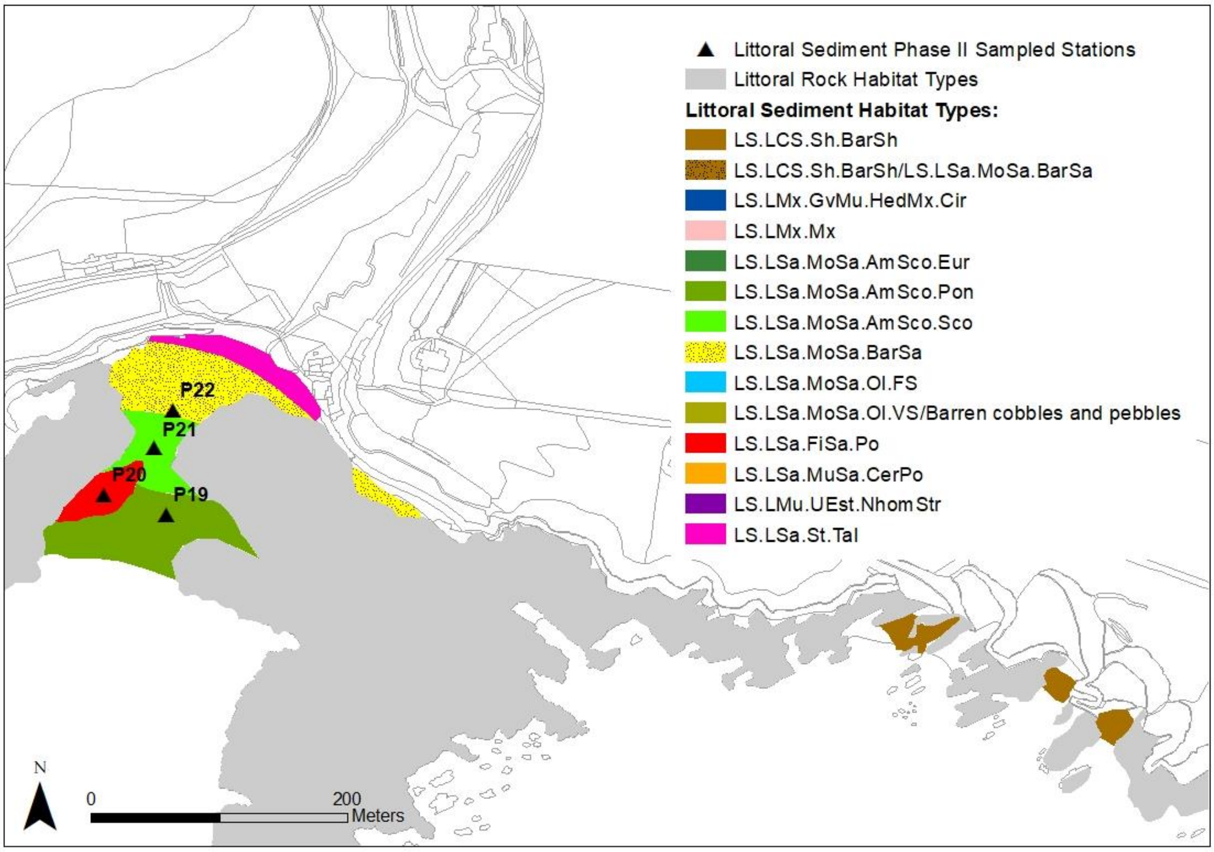

Figure 20. Littoral sediment sampled station locations within Sector 1: Wembury Beach to The Tomb

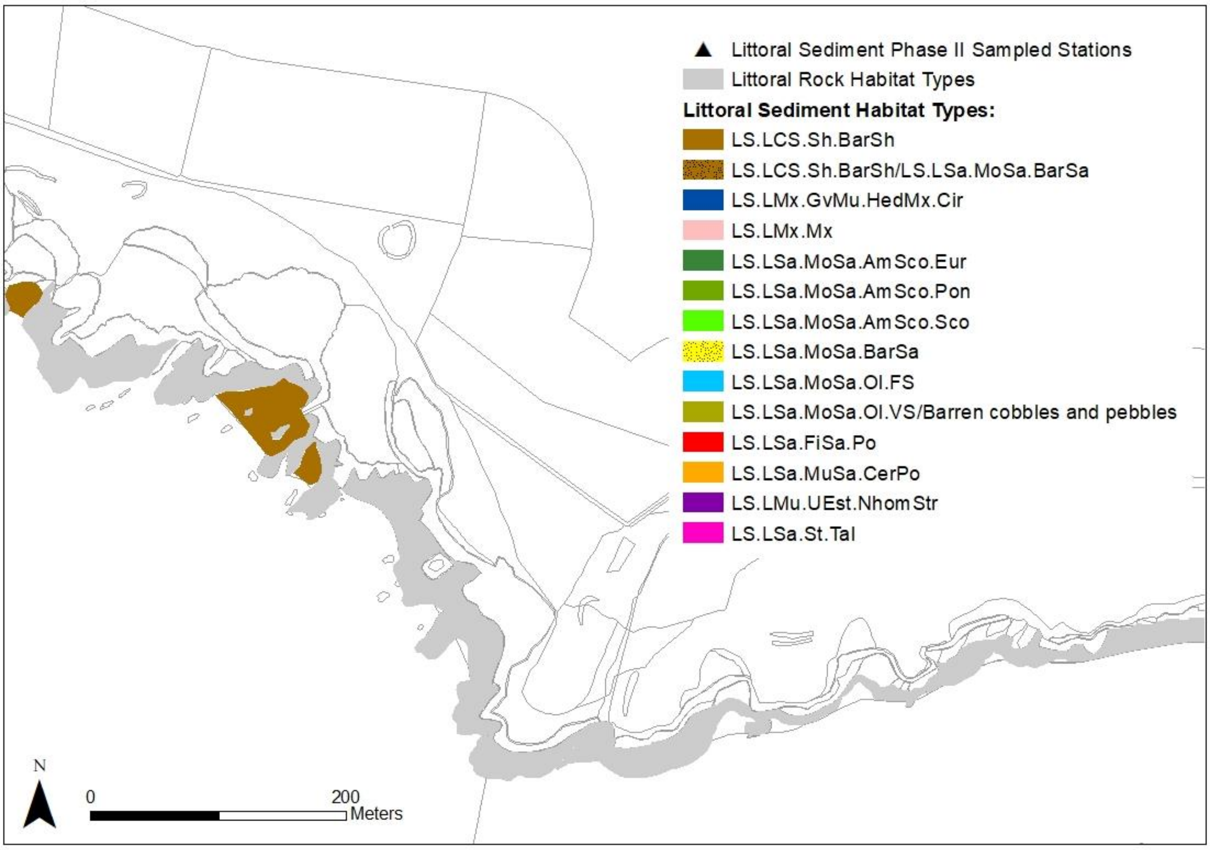

Figure 21. Littoral sediment sampled station locations within Sector 1: The Tomb and Season Point

5.2.1.1 Particle size distribution and organic content.

The particle size distributions of the sediment samples obtained from each of the stations within Sector 1 are expressed as percentage distributions (by weight) across 8 size bands as devised by Wentworth [14] (Table A1 of Appendix 3).

It is well documented that the particle size distribution of the sediment has an effect on the structure of benthic communities[15]. The overall degree of similarity in the mean sediment particle size between each station has been determined using PRIMER 6[16] and is illustrated by the Principle Component Analysis (PCA) plot in Figure 22. Within the PCA plot the vectors represent proportions of each sediment size fraction.

The plot shows that the station sediment granulometry results were not entirely distinct between many of the Habitat types and that many of the sediments were characterised by a mixture of fine to coarse sands in variable proportions. The LS.LSa.MoSa.Ol.FS sediments, however, had an additional very coarse sand, gravel and pebble component, as many of the sands in which the communities were found were very shallow and overlaid shingle shores. The LS.LSa.St.Tal sediments were set apart to the left of the plot due to the large very coarse sand fraction, whilst one of the LS.Lsa.MoSa.AmSco.Eur stations also comprised a significant pebble component.

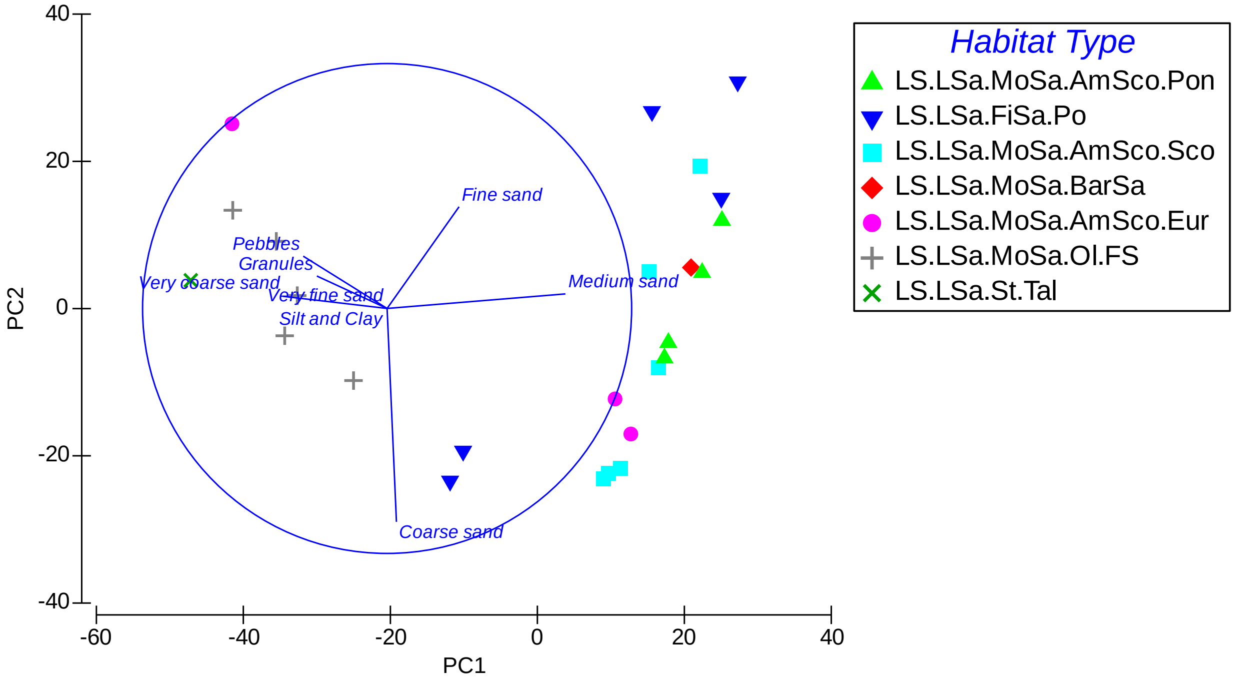

Figure 22. Principal component analysis (PCA) of station sediment granulometry similarities

The organic loading of the sediments as determined by Loss on Ignition (LOI) is shown in Table A1 of Appendix 3. It can be seen that the LOI over the entire Sector was extremely low at all stations within the Sector with half of the samples containing <1% (those samples collected at stations to the west of Wembury Point) and the other half containing <2% (those stations to the East of Wembury Point). In contrast to what would normally be expected [19], the organic content of the sediments did not correlate with an increasing percentage of silt and clay (R^2 = 0.0004).

5.2.1.2 Influence of sediment physico-chemical parameters on community structure at stations within Sector 1

The relationship between the community structure of the benthic macrofauna at each station has been compared with the respective particle size and salinity data using the BIOENV routine in PRIMER[14]. This routine determines whether any of these factors are influencing the distribution observed. The best individual correlation was the proportion of very fine sand in the sediments, but the best overall correlation was the proportion of silt and clay, medium and very coarse sand. Both correlations were moderately low (0.371 and 0.4225 respectively). When the pattern of physico-chemical data was analysed with respect to the distribution of the fauna data using RELATE, there was no significant correlation (P=0.1).

5.2.2 Sector 2 - Tamar-Tavy, St Johns Lake and the Lynher Estuary

5.2.2.1 Tamar-Tavy and St.Johns Lake SSSI

As described and reported in 2010[12], a total of 17 littoral sediment Habitat types were identified within the Tamar-Tavy Estuary and St. John's Lake SSSI (Figures 23 to 26).

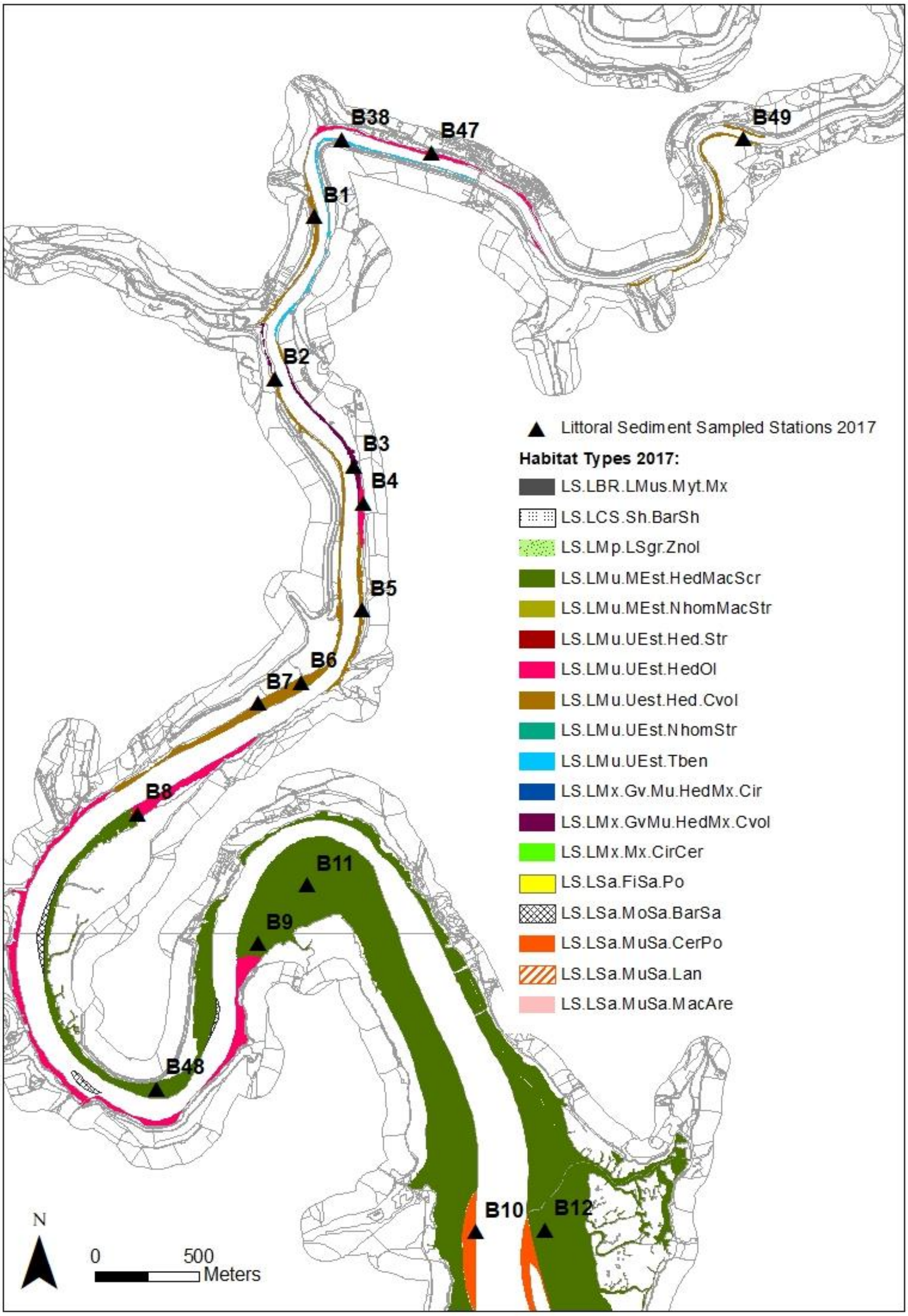

Figure 23. Littoral sediment sampled station locations within the upper Tamar Estuary: Calstock to Cargreen.

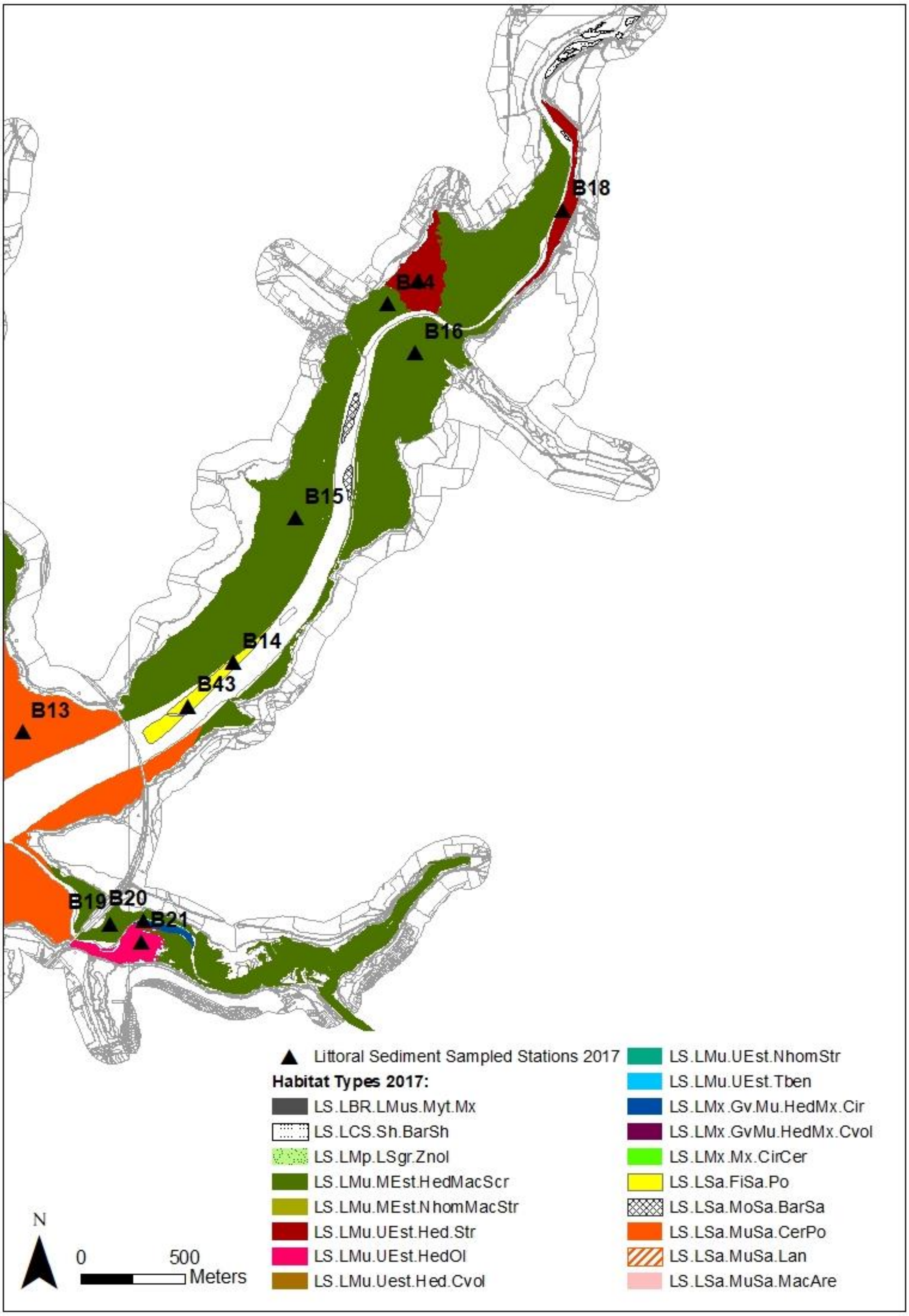

Figure 24. Littoral sediment sampled station locations within the Tamar-Tavy Estuary: Landulph to Lopwell Dam.

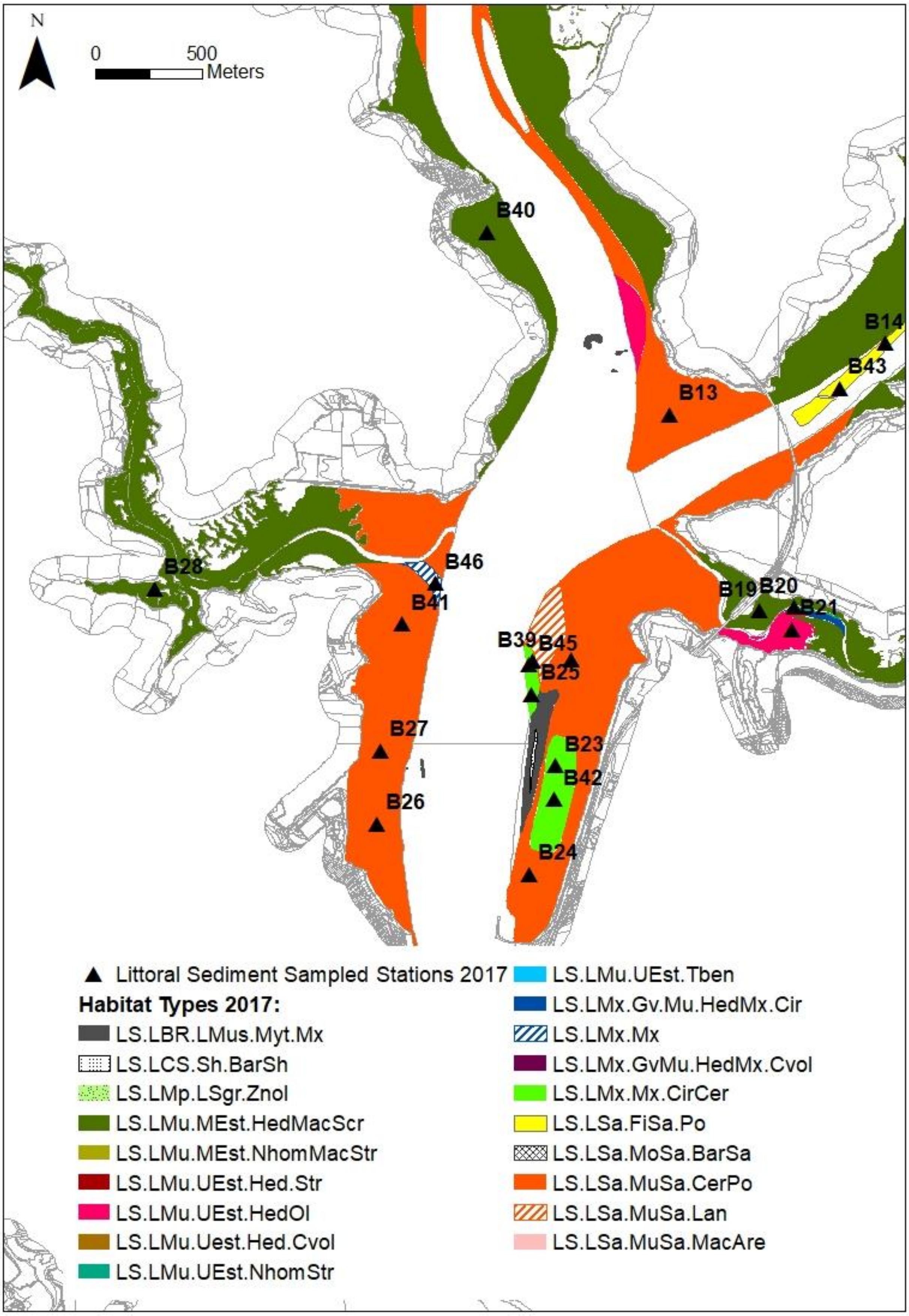

Figure 25. Littoral sediment sampled station locations within the Lower Tamar Estuary: Cargreen to Saltash.

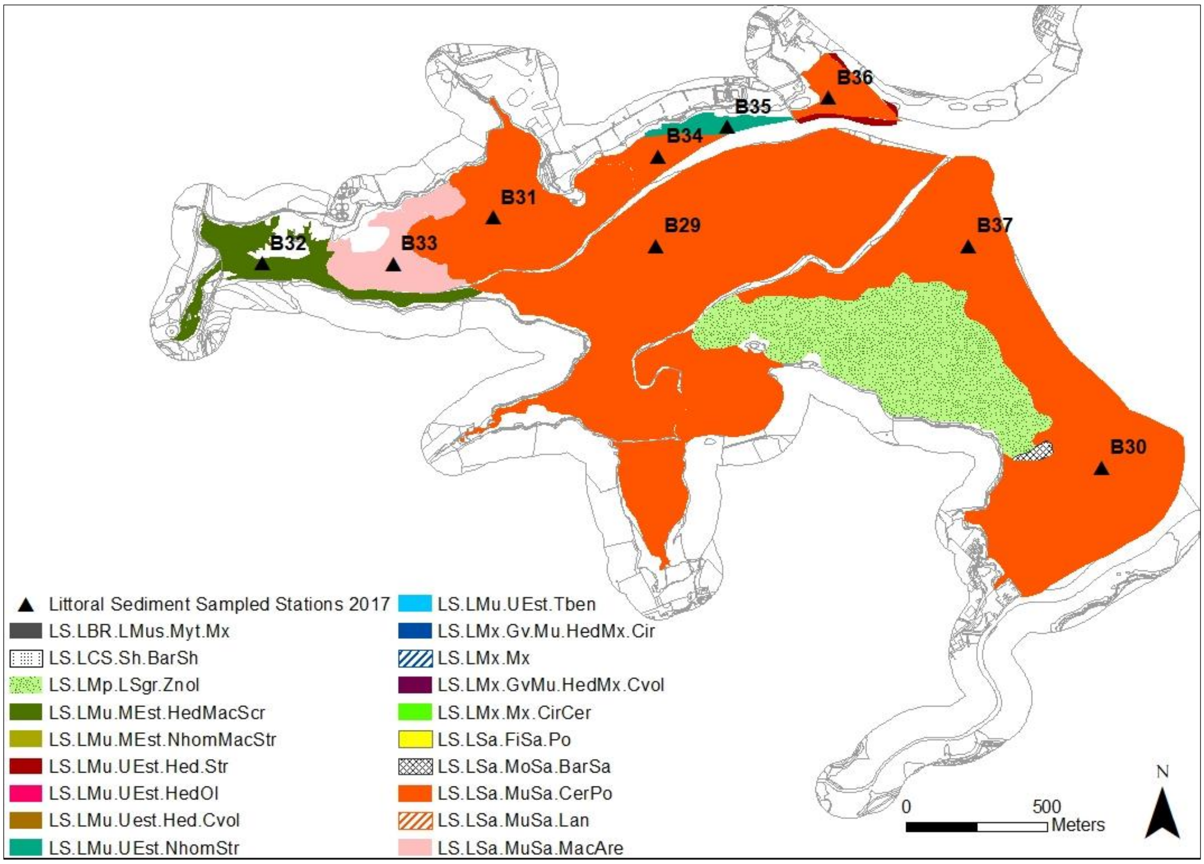

Figure 26. Littoral sediment sampled station locations within St. Johns Lake.

Following the 2017 surveys a number of minor changes were made to the habitat maps that were produced in 2010, the changes in the Tamar-Tavy have been highlighted in Figure 27, those in St Johns Lake in Figure 28 and those in the Lynher estuary in Figure 29. The LS.LSa.MuSa.Lan Habitat type at station B46 was changed to Cirratulids and *Cerastoderma edule* in littoral mixed sediment (LS.LMx.Mx.CirCer) due to the absence of *Lanice conchilega* and increased abundance of *Tharyx* Type A and *Cerastoderma edule* (Figure 27). Stations B42 and B43 were also moved slightly in 2017 to accommodate small changes (<80 m) in Habitat type boundaries. Stations B26, B27, B31 and C29 the communities were also reassigned to the LS.LSa.MuSa.CerPo Habitat type due to apparent shifts in the faunal communities present, whilst station B28 was changed to LS.LMu.MEst.HedMacScr due to the additional presence of *Scrobicularia plana* at the station in 2017.

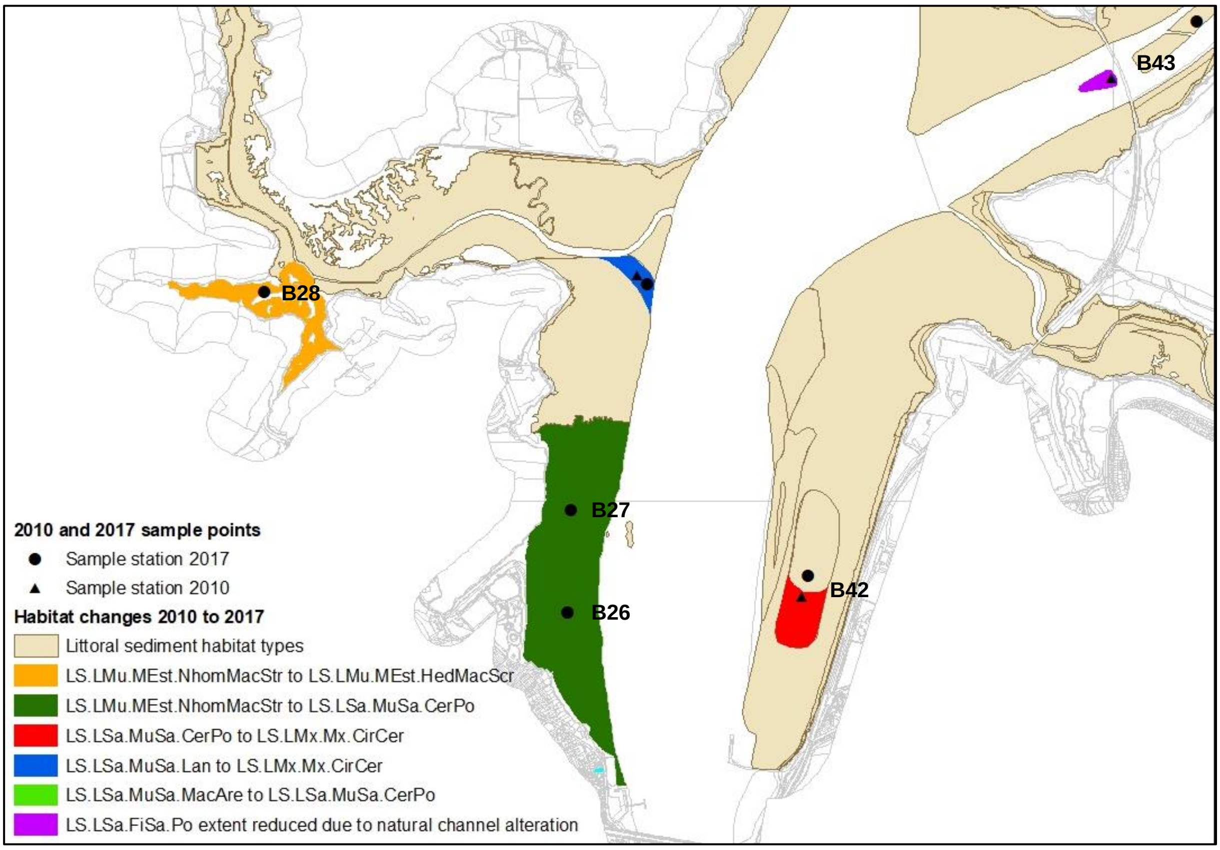

Figure 27. Habitat extent/distribution changes between 2010 and 2017 in the Tamar-Tavy estuary.

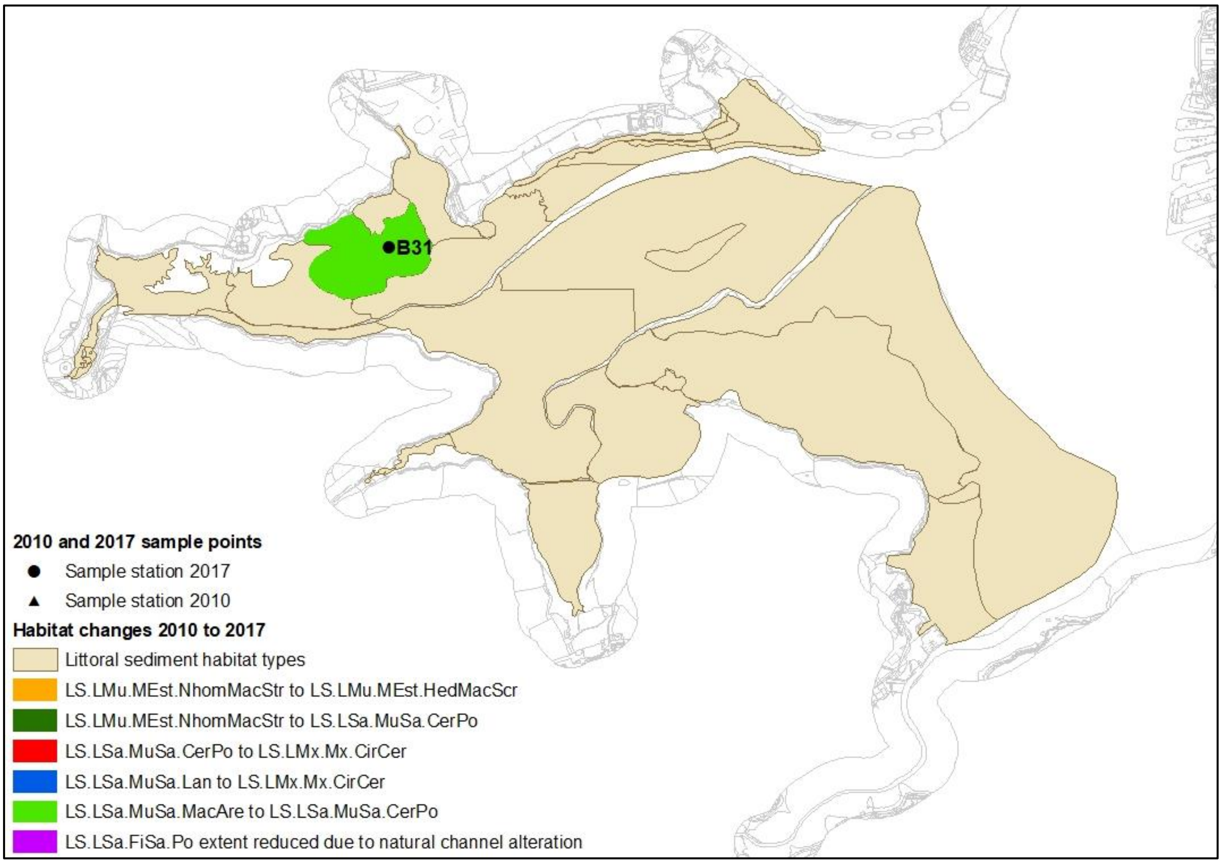

Figure 28. Habitat extent/distribution changes between 2010 and 2017 in St. Johns Lake.

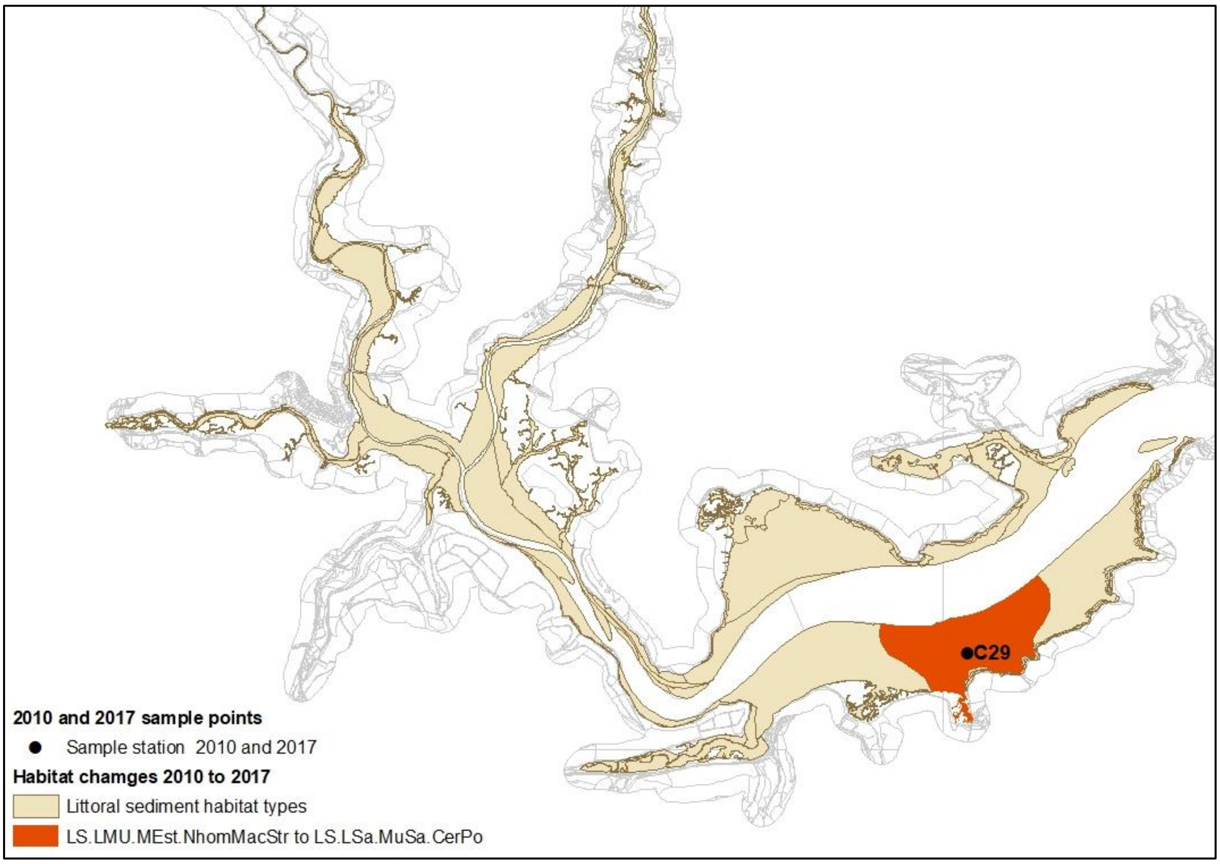

Figure 29. Habitat extent/distribution changes between 2010 and 2017 in the Lynher estuary.

5.2.2.1.1 Particle Size Distribution and Organic Content

The particle size distributions of the sediment samples obtained from stations within the Tamar Tavy and St Johns Lake SSSI are expressed according to the Wentworth Scale[16] in Table A2 of Appendix 3. Alongside this data the percentage of organic content within the sediments is also shown.

The overall degree of similarity in the mean sediment particle size between each station has been determined using PRIMER 6[16] and is illustrated by the PCA plot in Figure 30. The plot shows that the sediment granulometry within the study area was most commonly represented by large proportions of silt and clay. Results were not entirely distinct between within all of the Habitat types as some of the LS.LSa.MuSa.CerPo stations contained significant proportions of sand as did one of the LS.LSa.FiSa.Po samples. As expected the mixed sediment Habitat type (LS.LMx.Mx.CirCer) contained varying proportions of coarse sediments (as well as silt and clay) and as such, these stations are found on both the left and right of the plot. The organic content of the sediments did not correlate with an increasing percentage of silt and clay in sediment samples (R^2 = 0.0151). .

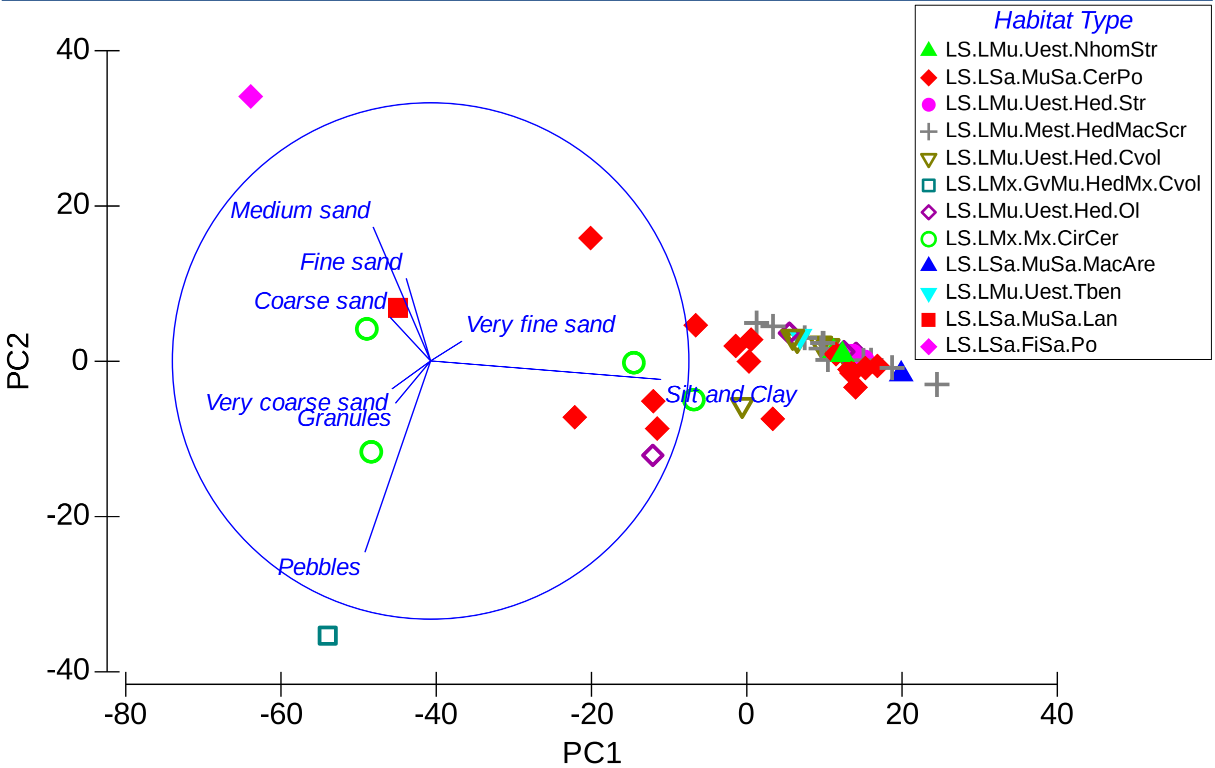

Figure 30. Principal component analysis (PCA) of station sediment granulometry similarities

5.2.2.1.2 Influence of sediment physico-chemical parameters on community structure at stations within the Tamar-Tavy and St Johns Lake SSSI

Using the BIOENV routine as described for Sector 1 (but excluding the salinity data), the best individual correlation between the faunal communities and physico-chemical variables within the Tamar-Tavy and St Johns Lake SSSI was the proportion of silt and clay. The best overall correlation was the proportion of fine and very coarse sand, and granules. However, both correlations were low (0.185 and 0.233 respectively). When the pattern of physico-chemical data was analysed with respect to the distribution of the fauna data using RELATE, the correlation was not a significant at the 5% level (P=0.052).

5.2.2.2 Lynher Estuary SSSI

A total of 11 littoral sediment Habitat types were identified within the Lynher Estuary SSSI (Figure 31), these were largely the same as were described and reported in 2010[13]. However, following the 2017 surveys the Habitat type at station C29 was changed from LS.LMU.Uest.Nhomstr to LS.LSa.MuSa.CerPo as a result of the increased abundance of adult and juvenile *Cerastoderma edule* at that station and in the area of mudflat surrounding it. In 2010 cockles were not captured in the core nor observed in the field.

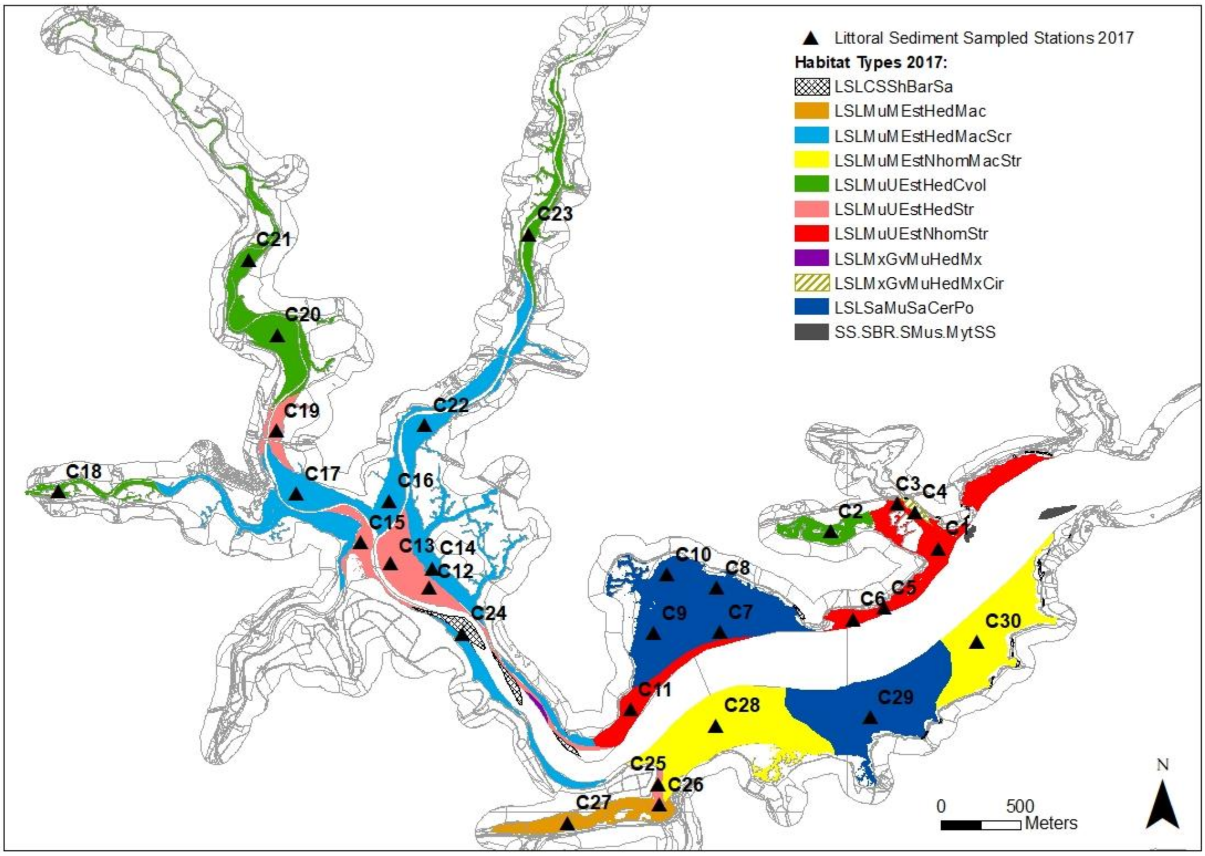

Figure 31. Littoral sediment sampled station locations within the Lynher Estuary.

5.2.2.2.1 Particle Size Distribution and Organic Content

The particle size distributions within the sediments of the Lynher Estuary SSSI are expressed according to the Wentworth Scale[14] in Table A3 of Appendix 3 together with the percentage of organic content.

The overall degree of similarity in the mean sediment particle size between each station has been illustrated by the PCA plot in Figure 32. The plot shows that the sediment granulometry within the study area was most commonly represented by large proportions of silt and clay. Results were not entirely distinct within all of the Habitat types as some of the LS.LMu.Uest.HedStr stations contained higher proportions of very fine sand. The single LS.LCS.Sh.BarSa station was separated from the remaining stations by containing the largest proportion of medium sand. The organic content of the sediments did not correlate with an increasing percentage of silt and clay in sediment samples (clay (R^2 = 0.0456).

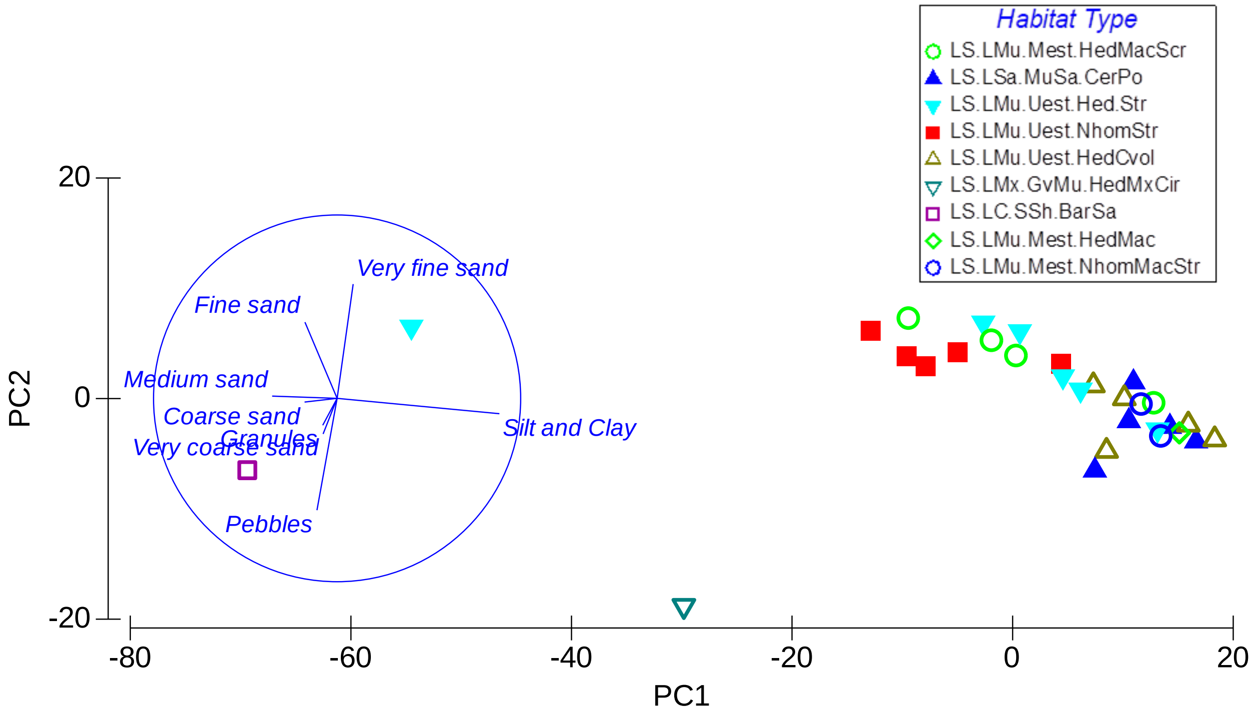

Figure 32. Principal component analysis (PCA) of station sediment granulometry similarities

5.2.2.2.2 Influence of sediment physico-chemical parameters on community structure at stations within the Lynher Estuary SSSI

Using the BIOENV routine the best individual correlation between the faunal communities and particle size and LOI within the Lynher Estuary SSSI was the proportion of granules, however, this correlation was low (0.194). Granules alone also resulted in the best overall correlation. When the pattern of physico-chemical data was analysed with respect to the distribution of the fauna data using RELATE, the correlation was not a significant (P=0.09).

5.2.3 Sector 3 - The Yealm Estuary

A total of 8 littoral sediment Habitat types were recorded within the Sector 3 (Figure 33), these were:

- LS.LCS.Sh.BarSh — Barren littoral shingle
- LS.LSa.MoSa.BarSa — Barren littoral coarse sand
- LS.LSa.MoSa.OlVS — Oligochaetes in variable salinity littoral mobile sand
- LS.LMx.Mx — Species-rich mixed sediment shores
- LS.LSa.MuSa.CerPo — *Cerastoderma edule* and polychaetes in littoral muddy sand
- LS.LSa.FiSa.Po — Polychaetes in littoral fine sand
- LS.LMu.UEst.NhomStr — *Nephtys hombergii* and *Streblospio shrubsolii* in littoral mud

At the mouth of the estuary, within Cellars Cove, the exposed westerly facing beach was characterised by mosaics of barren sands and barren shingle (LS.LSa.MoSa.BarSa/ LS.LCS.Sh.BarSh) on the mid shore above which barren sands dominated. Either side of the lower shore rocks stabilised finer sands which supported more diverse polychaete communities (LS.LSa.FiSa.Po). Higher in the estuary the sediments became mixed supporting a relatively high diversity of infauna (LS.LMx.Mx) including polychaetes (commonly spionids and capitellids), isopods, amphipods, nematodes, bivalves and gastropods. Where fine sands had become deposited on the mid shore on the inside of the main channel at Warren Point, polychaete communities had established (LS.LSa.FiSa.Po), although these were more sparse than would usually be expected for the Habitat type. Lower on the shore at Warren Point the more mobile scoured bank supported impoverished oligochaete communities (LS.LSa.MoSa.OlVS). Higher in the study area the species rich mixed sediment shores continued, but where the proportion of silt and clay dominated, the communities were characterised by the presence of *Nephtys hombergii* (LS.LMu.UEst.NhomStr).

The results of the univariate analysis for each station and the mean diversity indices for each Habitat type have been incorporated into Table B of Appendix 5. From this table it can be seen that the community species richness and diversity were relatively high within the Sector. The greatest diversity and richness indices were derived from the LS.LMu.Uest.NhomStr communities. The sediments supporting these communities also contained the greatest proportions of silt and clay, whilst the least rich and diverse communities were sampled at stations with some of the lowest proportions of silt and clay (Table A4 Appendix 3). The relationship between particle size, salinity and community composition was explored using the BEST routine in PRIMER. A low to moderate but significant correlation between the proportion of silt and clay in sediments and the community composition was found (correlation = 0.295, P=0.002). The correlation between salinity and community composition was low (0.163), probably because of the relatively limited sampling over the salinity gradient (22-35 ppt).

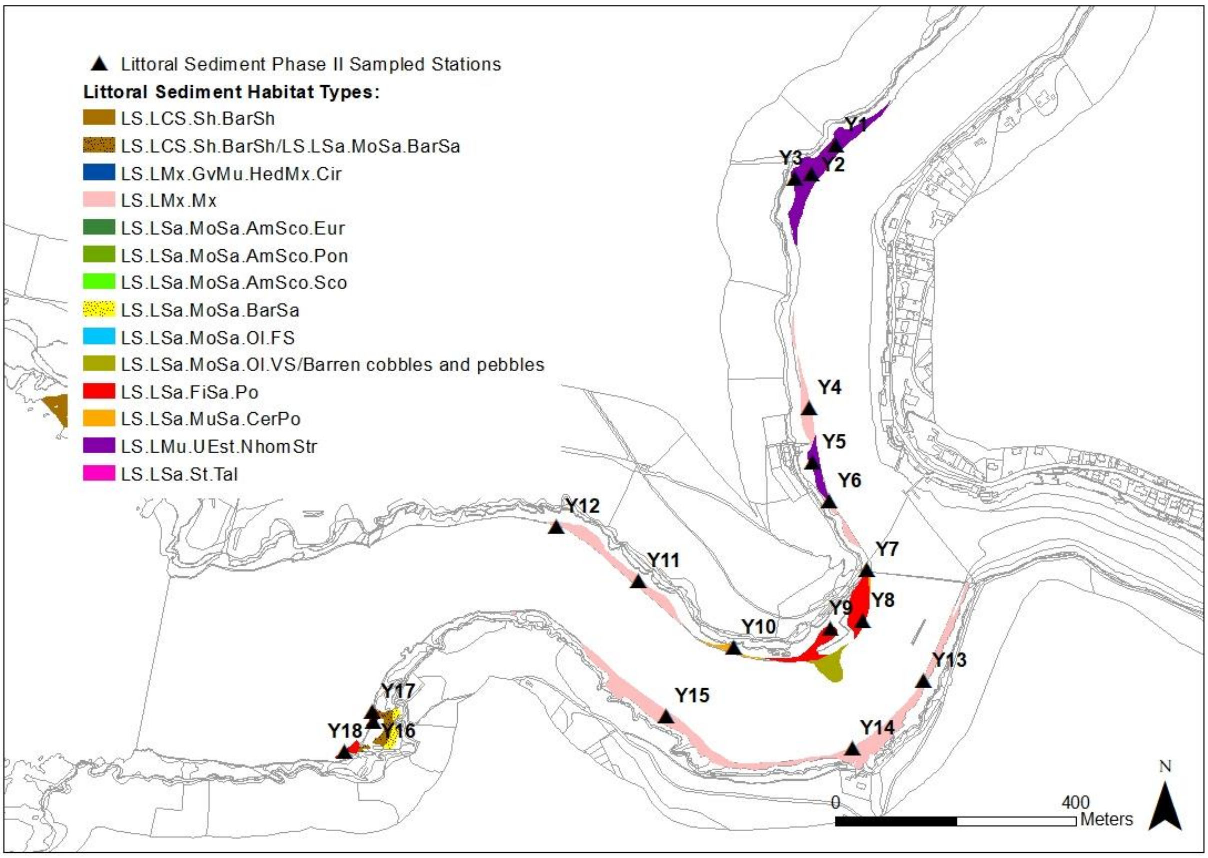

Figure 33. Littoral sediment sampled station locations within the Yealm Estuary.

5.2.3.1 Particle Size Distribution and Organic Content

The results of the particle size analysis of the sediments collected within the Yealm Estuary SSSI can be found in Table A4 of Appendix 3 together with the percentage of organic content.

The overall degree of similarity in the mean sediment particle size between each station has been illustrated by the PCA plot in Figure 34. The plot shows that the sediment granulometry was somewhat distinct between the Habitat types, although the fine sand Habitat type (LS.Lsa.FiSa.Po) contained some large particle size fractions in one sample, as did the muddy sand habitat type LS.LSa.MuSa.CerPo. The organic content of the sediments did not correlate strongly with an increasing percentage of silt and clay in sediment samples (pair wise correlation 0.13).

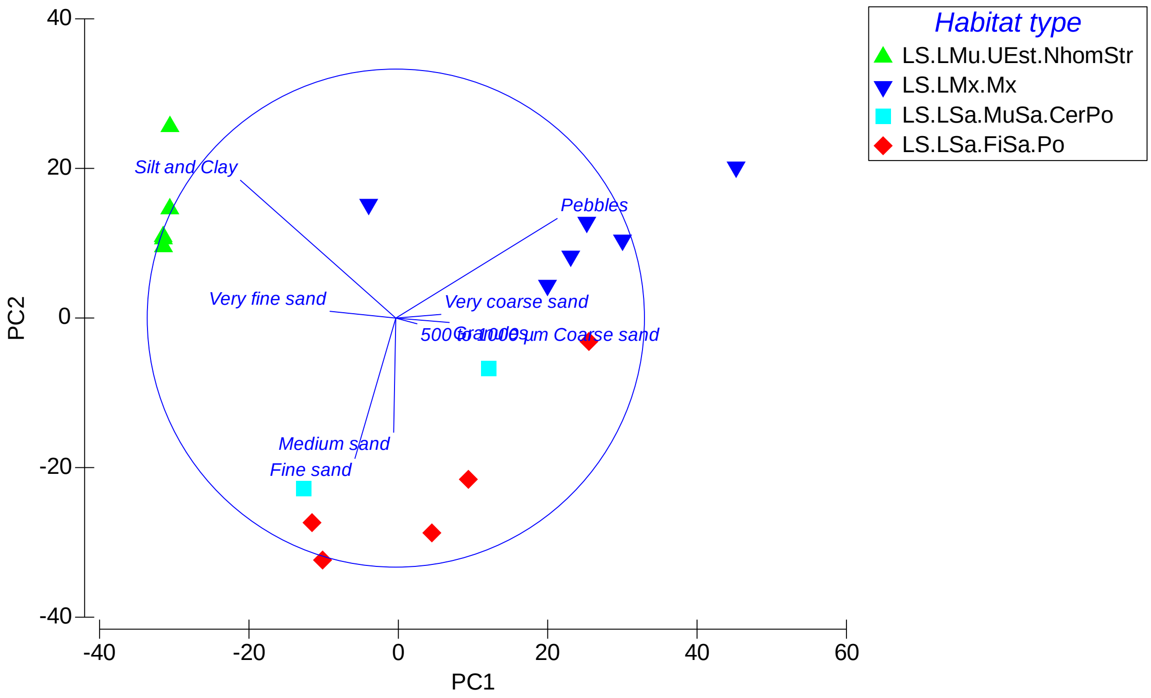

Figure 34. Principal component analysis (PCA) of station sediment granulometry similarities

5.2.3.2 Influence of sediment physico-chemical parameters on community structure at stations within Sector 3

Using the BIOENV routine using particle size, LOI and salinity data, the best individual correlation between the faunal communities and physico-chemical variables in Sector 3 was the proportion of very fine sand, but the correlation was low (0.295). The best overall correlation was the proportion of very fine sand and medium sand. This correlation was much stronger (0.474) and when the pattern of physico-chemical data was analysed with respect to the distribution of the fauna data using RELATE, there was significant correlation (P=0.004).

5.3 Temporal Analysis - Sector 2 (Tamar-Tavy, St Johns Lake and the Lynher Estuary)

Surveys based on the same methodology as this study were also carried out in 2010 in the Tamar-Tavy and St. Johns lake SSSI and the Lynher Estuary SSSI. Consequently it has

been possible to carry out statistical analysis in order to temporally compare the littoral sediment infaunal communities that were sampled in 2010 and 2017.
To interpret the data, both univariate statistics (such as the number of taxa, number of individuals, Shannon Wiener diversity and Margalef's species richness) and multivariate statistics have been used. Multivariate methods of data analysis are considered to provide a more sensitive measure of community change than univariate methods[17], since all the data are analysed collectively with no loss of information such as that which occurs when reducing the data to a single number or univariate statistic. The data were subjected to a square root transformation to reduce the influence of the very abundant species on the analysis prior to multivariate analysis.

5.3.1 Tamar-Tavy and St. Johns Lake SSSI

An MDS (Multi-dimensional Scaling) plot of the similarities in the macrofauna communities between 2010 and 2017 within the Tamar-Tavy and St Johns Lake SSSI is shown in Figure 35. It can be seen from this plot that there is considerable overlap between stations in 2010 and 2017. The 2017 stations which are set apart to the right of the plot represent stations B47 and B49. The reason that these communities are dissimilar to those of the remaining stations is that in 2017 the communities at these stations are represented by the sole presence of the oligochaete *Tubifex tubifex*.

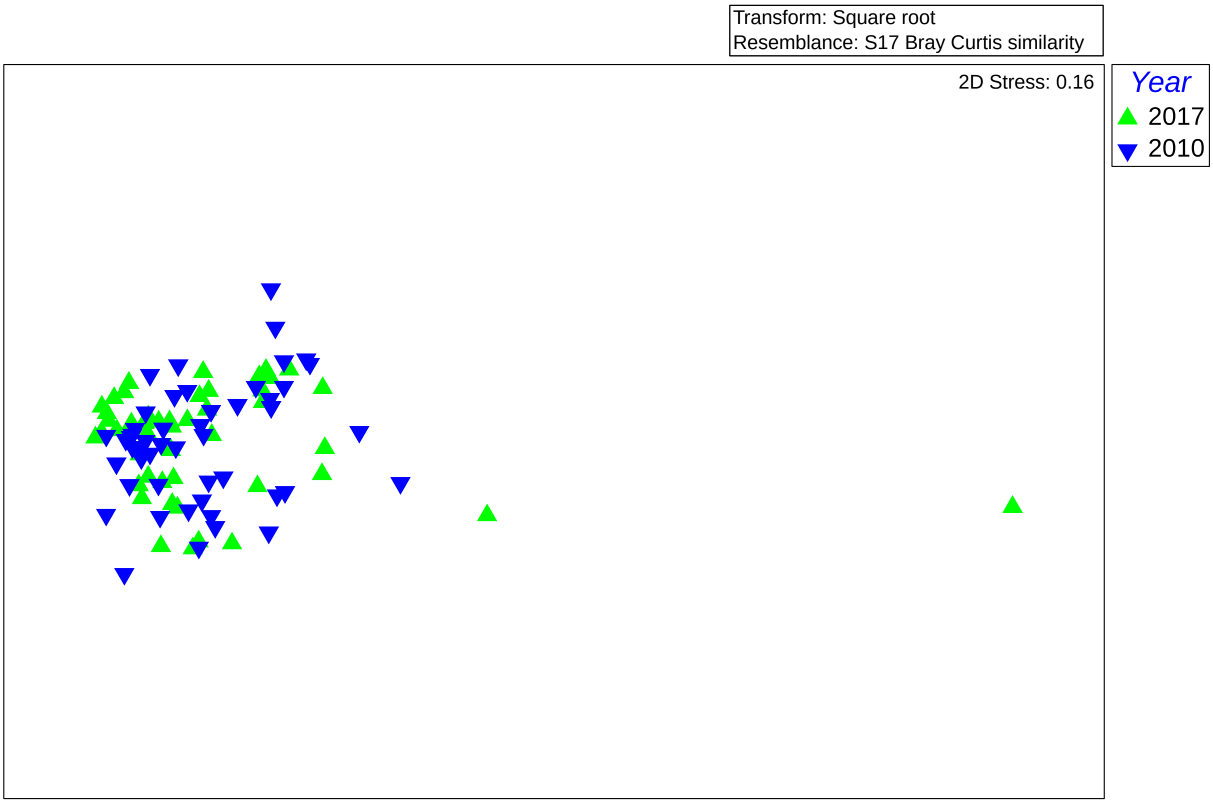

Figure 35. MDS plot illustrating differences in littoral sediment community structures between 2010 and 2017.

Statistical analysis of the fauna data using the ANOSIM routine in PRIMER[14] has shown that the differences in community structure between sampling events is statistically significant (p=0.001).

The species contributions to the similarities within sampling years and the differences between them have been examined using the SIMPER routine in PRIMER[16]. From this analysis (Table A1 of Appendix 4) it can be seen that there is considerable variation in the faunal communities between years (Average dissimilarity = 77%). Further examination of the SIMPER analysis output (Table A2 Appendix 4) reveals that much of the variability is due to slight differences in the numbers of the species present between years. However, in 2010 stations tended to have a smaller range of species present with 9 taxa responsible for 91% of the similarity in community structure compared to 12 in 2017. The 4 taxa which additionally contributed to the top 91% of similarity in 2017 were juvenile cockles (*Cerastoderma edule*), the isopod *Cyathura carinata* and the oligochaete *Tubificoides pseudogaster agg.* and the capitellid *Heteromastus filiformis* which collectively accounted for 10% of the similarity.

5.3.1.1 Temporal Comparisons of Community Composition

One of the attribute targets within the Plymouth Sound and Estuaries SAC is to determine whether the species composition of the component communities has changed. The data was run though the DIVERSE routine in PRIMER[16] in order to calculate the univariate indices. The results for each station and the mean indices for each Habitat type have been incorporated into Table B of Appendix 5. A degree of caution should be applied when comparing these indices between habitat types given that the level of replication within each was variable.

The greatest richness and diversity, on average, is found within the mixed sediment shores. These habitat types were also only found in the lower estuary and therefore may be expected to be inherently more diverse due to the smaller fluctuations in salinity and stress compared to the habitats found higher in the estuary.

Using a paired t-test it has been determined that the number of taxa (and therefore Margalef's species richness) was significantly higher in 2017 than in 2010, but none of the other univariate indices measured have been found to be statistically different between the two sampling events.

Table 2. Results of paired t-test between community univariate indices derived from 2010 and 2017 faunal data.

Paired T-Test 2010 v 2017 Univariate Indices	
Indices	P Value
S	*0.015**
N	0.484
d	*0.020**
J'	0.817
H'	0.229
1 Lambada	0.966

**Significant difference.*

The level of sample replication has permitted statistical analysis using ANOSIM in PRIMER[16] within 5 of the littoral sediment Habitat types that were sampled. The analysis has shown that the difference between the community composition between 2010 and 2017 was significant within 3 of these Habitat types. The most significant difference was between the LS.LMu.UEst.Hed.Cvol communities (P=0.006 and n=6), followed by LS.LMu.MEst.HedMacScr (P=0.018 and n=11) and LS.LSa.MuSa.CerPo (P=0.026 and n=11/15). ANOSIM was also carried out on the data using the original, 2010 Habitat type allocations for each station. Stations were not added or removed from the

LS.LMu.UEst.Hed.Cvol Habitat type and therefore the significance does not alter. However, 3 stations were added to the LS.LSa.MuSa.CerPo Habitat type based on the presence/abundance of the main characterising species *Cerastoderma edule*. If these stations are removed from the ANOSIM analysis for this Habitat type then then difference is no longer considered significant (P=0.056 and n=12/11). The single station that was added to the LS.LMu.MEst.HedMacScr Habitat type in 2017 does not alter the significance of community differences between 2010 and 2017. This disparity in community differences within the LS.LSa.MuSa.CerPo communities is driven by the intrinsic weakness of classifying communities using Habitat types, where the presence of certain species can add disproportionate weighting to how communities are described, therefore suggesting a large spatial or temporal change, when in fact, the changes may be insignificant.

MDS plots representing the changes in the LS.LMu.UEst.Hed.Cvol and LS.LMu.MEst.HedMacScr communites sampled in 2010 and 2017 are shown in Figures 36 and 37.

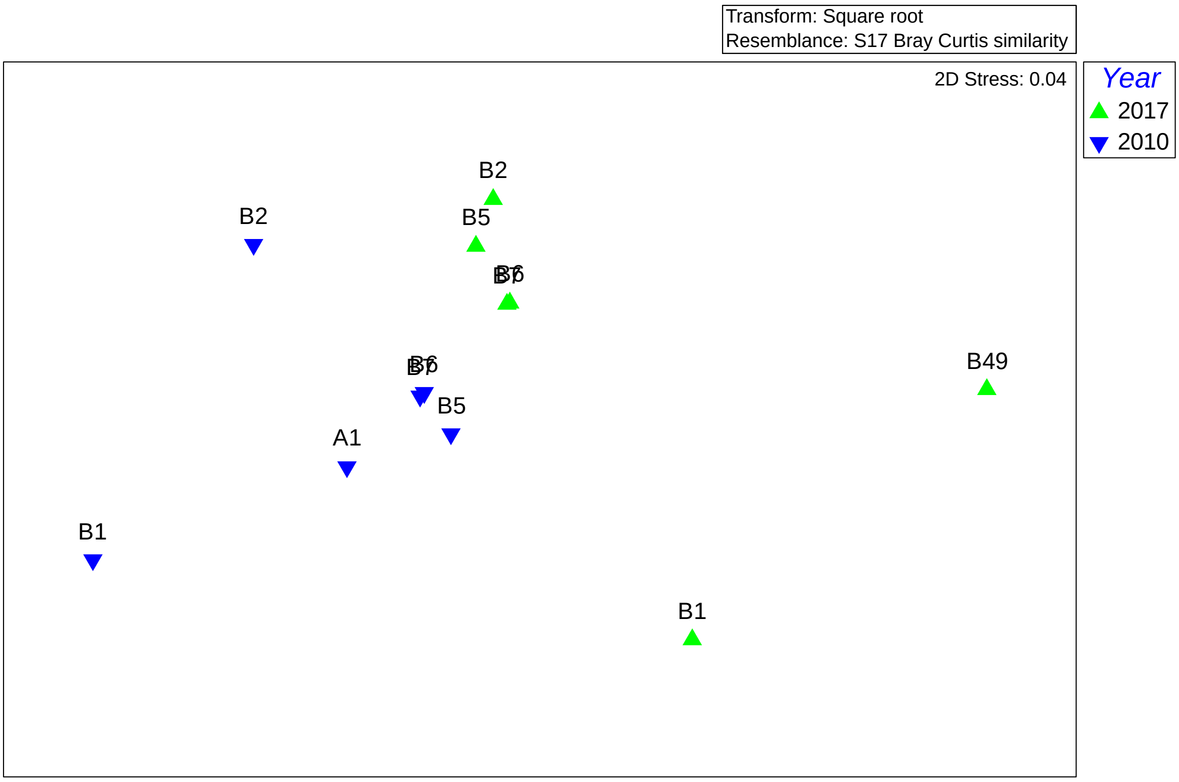

Figure 36. MDS plot illustrating differences in the LS.LMu.UEst.Hed.Cvol communities between 2010 and 2017.

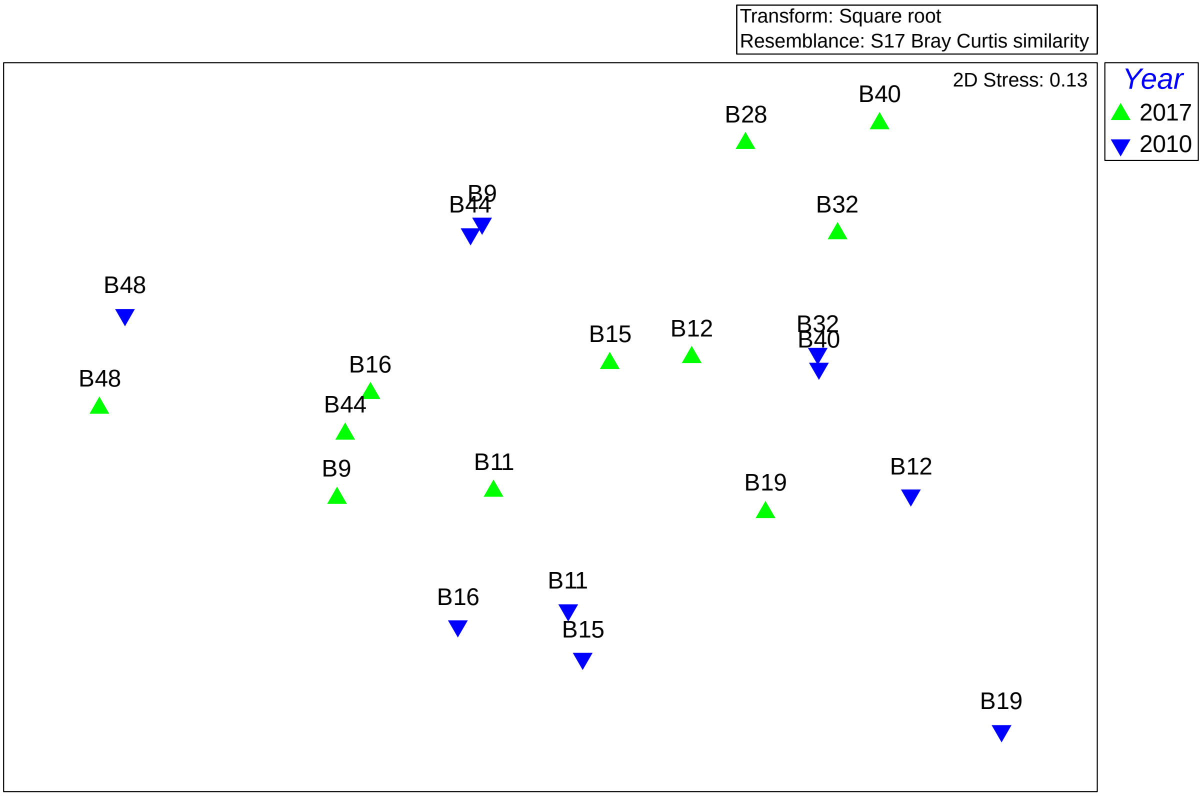

Figure 37. MDS plot illustrating differences in the LS.LMu.MEst.HedMacScr communities between 2010 and 2017.

The SIMPER routine has been used to explore what community changes have caused the differences (and therefore the spatial separation of stations on the MDS plots above) within the LS.LMu.UEst.Hed.Cvol and LS.LMu.MEst.HedMacScr Habitat types (Appendix 4, Tables B1 and B2). The analysis shows that a large proportion (32%) of the dissimilarity between the LS.LMu.UEst.Hed.Cvol communities between 2010 and 2017 have been driven by the greater abundance of the oligochaete *Baltridrilus costatus* (this species is known to occupy a distinct niche in mid-range salinities in the intertidal but is not particular about sediment type[18]). The presence of the oligochaete *Tubifex tubifex* (a species usually found in low salinity[18]), the lower abundance of the ragworm *Hediste diversicolor* and the higher abundance of the mud shrimp *Corophium volutator* in 2017 also contribute 16%,12% and 11% respectively to the differences observed between years. Within the LS.LMu.MEst.HedMacScr communities the presence/abundance of a greater number of species contributed the observed differences between years, with 20 species responsible for 90% of the similarity in community structure compared to 9 within the LS.LMu.UEst.Hed.Cvol communities. The lower abundance of the mud snail *Peringia ulvae*, higher abundance of the oligochaetes *Tubificoides benedii* and *Baltidrilus costatus*, and absence of *Tubificoides pseudogaster* agg. in 2017 influenced the differences most, each contributing 12%, 12%, 8% and 8% respectively.

5.3.1.2 Temporal Analysis of Sediment Granulometry and Organic Content

The sediment granulometry and organic content within the Tamar-Tavy and St, Johns Lake SSSI in 2017 has been described in Section 5.2.2.1. Temporal differences have been explored using the ANOSIM routine in PRIMER[16] which suggests that there has been a significant change in the particle size range of sediments within the wider SSSI (p=0.001). Differences in sediment granulometry were subsequently explored using ANOSIM within each Habitat type. ANOSIM analysis was possible within 7 of the 12 Habitat types sampled, and within 3 of these the difference was significant, these were: LS.LSa.MuSa.CerPo, LS.LMu.UEst.Hed.Cvol and LS.LMu.MEst.HedMacScr where P=0.03, P=0.004 and P=0.001 respectively. When stations were grouped within the Habitat types that were allocated to stations in 2010 the differences remained significant in the LS.LMu.MEst.HedMacScr and LS.LSa.MuSa.CerPo Habitat types (0.001 and 0.017). The differences were explored using SIMPER analysis which revealed that higher proportions of silt and lower proportions of clay in 2017 accounted for approximately 86% and 90% of the particle size differences within the LS.LMu.MEst.HedMacScr and LS.LSa.MuSa.CerPo Habitat types respectively.

Paired t tests were used to test for differences in LOI within Habitat types between years. All differences were calculated to be significantly higher in 2017 ($P<0.05$) except within the LS.LMu.Mu.HedOl, LS.LMu.UEst.Hed.Cvol and LS.LMx.Mx.CirCer Habitat types.

5.3.2 Lynher Estuary SSSI

An MDS plot of the similarities in the macrofauna communities between 2010 and 2017 within the Lynher Estuary SSSI is shown in Figure 38. There is considerable overlap between stations in 2010 and 2017, but those communities in 2017 are slightly set further towards the top of the plot.

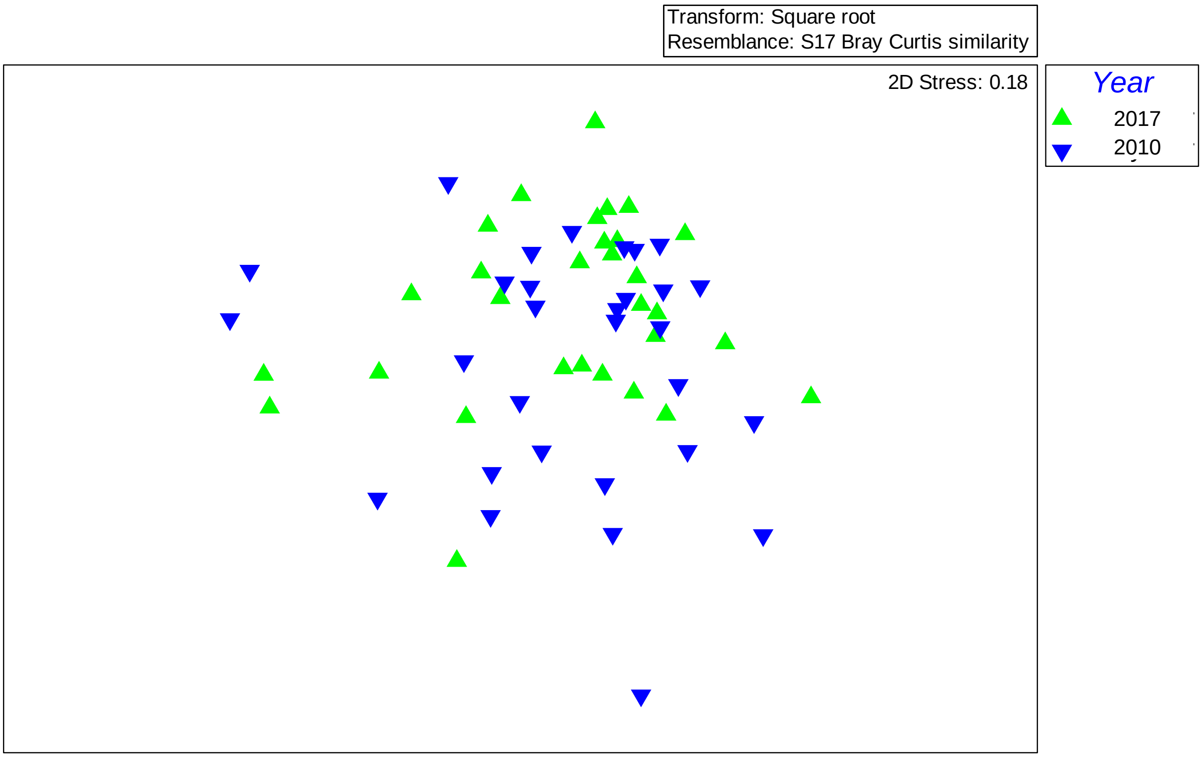

Figure 38. MDS plot illustrating differences in littoral sediment community structures between 2010 and 2017.

Statistical analysis of the fauna data using the ANOSIM routine in PRIMER[16] has shown that the differences in community structure between sampling events is statistically significant (P=0.001).

The species contributions to the similarities within sampling years and the differences between them have been examined using the SIMPER routine (Table C1 of Appendix 4). This analysis reveals that there is considerable variation in the sampled faunal communities between 2010 and 2017 (Average dissimilarity = 66.5%). Further examination of the

SIMPER analysis output (Table C2 of Appendix 4) reveals that much of the variability is due to slight differences in the numbers of the species present between years. However, in 2010 a smaller range of taxa contributed to the similarities between stations with just 8 taxa responsible for 91% of the similarity in community structure, compared to 13 in 2017. A number of polychaetes including the nationally scarce tentacled lagoon worm (*Alkmaria romijni*) which is Species of Conservation Interest (SOCI), as well as juvenile cockles (*Cerastoderma edule*) collectively accounted for 15% of the similarity in 2017.

5.3.2.1 Temporal Comparisons of Community Composition

In order to determine whether the species composition of the component communities has changed. The univariate indices have been calculated using the DIVERSE routine in PRIMER[16]. The results for each station and the mean indices for each Habitat type have been incorporated into Table C Appendix 5.

Using a paired t-test it has been determined that the number of taxa, Margalef's species richness and the Shannon Wiener diversity index was significantly higher in 2017 than in 2010.

Table 3. Results of paired t-test between community univariate indices derived from 2010 and 2017 faunal data.

Paired T-Test 2010 v 2017 Univariate Indices	
Indices	P Value
S	*<0.001**
N	0.228
d	*<0.001**
J'	0.653
H'	*<0.001**
1 Lambada	0.010*

**Significant difference.*

The level of sample replication has permitted statistical analysis using ANOSIM in PRIMER[16] within 5 of the littoral sediment Habitat types that were sampled. The analysis has shown that the difference between the community composition between 2010 and 2017 was significant within 1 of these Habitat types; LS.LMu.MEst.HedMacScr where P=0.029 (n=6). ANOSIM was also carried out on the data using the original, 2010 Habitat type allocations for each station (as station C29 was changed from the LS.LMu.Uest.NhomStr to the LS.LMu.MEst.HedMacScr Habitat type in 2017), but this did not alter the resulting significance.

An MDS plot representing the changes in the LS.LMu.MEst.HedMacScr communities sampled in 2010 and 2017 are shown in Figure 39.

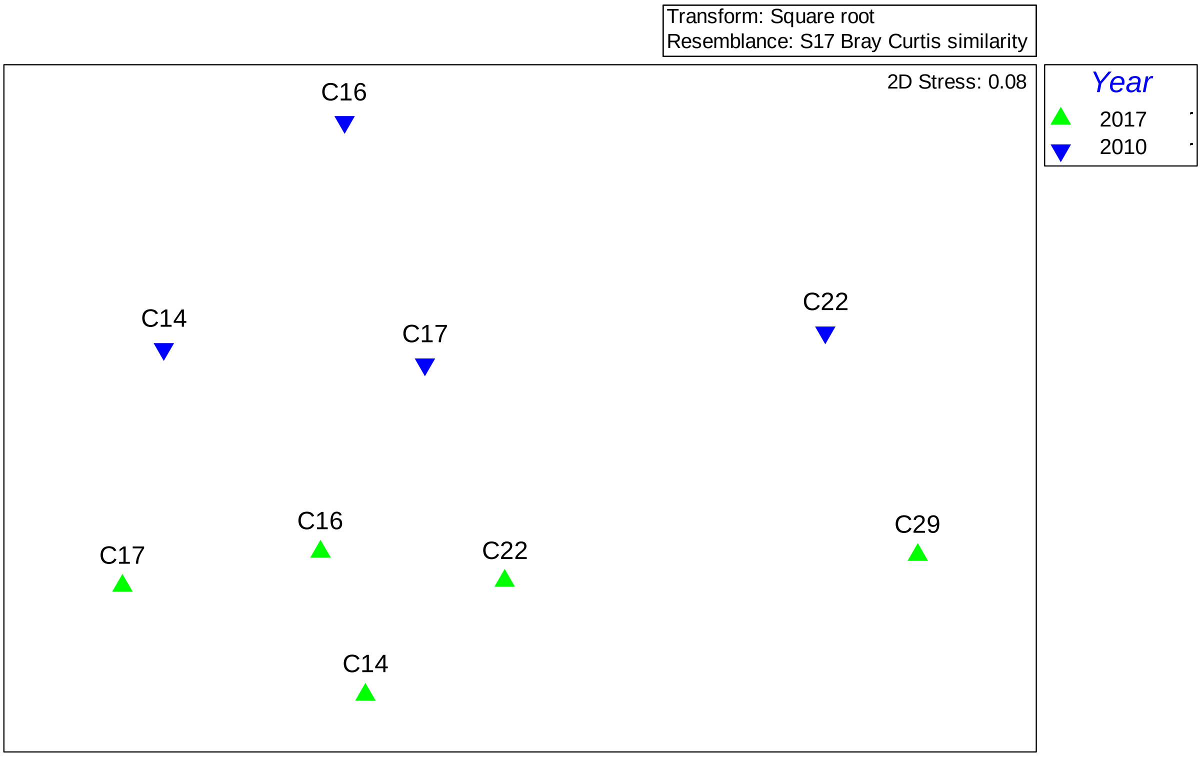

Figure 39. MDS plot illustrating differences in the LS.LMu.MEst.HedMacScr communities between 2010 and 2017.

The SIMPER routine has been used to explore what community changes have caused the significant differences (and therefore the spatial separation of stations on the MDS plot above) within the LS.LMu.MEst.HedMacScr Habitat type (Appendix 4, Table D1). The analysis shows that the taxa contributing the most to the dissimilarity between years are, in fact, taxa that have been frequently sampled within the Habitat type in both years, but which occur in slightly variable abundances. With the exception of the oligochaetes *Tubificoides pseudogaster agg.* and *Paranais litoralis* which were absent in 2010, as well as some juvenile/unidentified taxa that have been left at genus level, all other species contributing to the top 90% of the dissimilarity were present in both 2010 and 2017.

The greatest proportion of the dissimilarity (9%) between the LS.LMu.MEst.HedMacScr communities between 2010 and 2017 have been driven by the slightly greater abundance of the oligochaete *Tubificoides benedii*, followed by marginally lower abundances of *Streblospio* and *Peringia ulvae* in 2017 (each contributing 8% respectively).

5.3.2.2 Temporal Analysis of Sediment Granulometry and Organic Content

The sediment granulometry and organic content within the Lynher SSSI in 2017 has been described in Section 5.2.2.2. Temporal differences have been explored using the ANOSIM routine in PRIMER[16] which, as was found in the Tamar Tavy and St Johns Lake SSSI, suggests that there has been a significant change in the particle size range of sediments within the wider SSSI (p=0.001). Analysis within each Habitat type using ANOSIM was possible within 6 of the Habitat types sampled, and within 5 of these the difference was significant (P=<0.05), these were: LS.LMu.UEst.NhomStr, LS.LMu.UEst.Hed.Cvol, LS.LSa.MuSa.CerPo, LS.LMu.UEst.Hed.Str, and LS.LMu.MEst.HedMacScr. SIMPER analysis was used to determine that over 90% of the differences in particle size within

Habitat types between years was attributable to higher proportions of silt and lower proportions of clay in 2017.

Paired t tests were used to test for differences in LOI within Habitat types between years within the Lynher Estuary. Replication permitted analysis within 5 of the Habitat Types sampled, significant increases in organic content (P=<0.05) were found within 2 of these: LS.LMu.UEst.Hed.Str, and LS.LMu.MEst.HedMacScr, but it is not clear as to whether these differences are as a result of differing analysis methods.

5.4 Habitats/Species of Conservation Importance

5.4.1 Sector 1 - Plymouth Sound

No intertidal species of conservation importance were identified within Sector 1 of the SAC. However, the invasive non-native species (INNS) of red algae, *Caulacanthus* spp. was observed in SACFOR abundances ranging from 'rare' to 'abundant'. This INNS of algae was most frequently observed, and most abundant, on the lower shore within the *Fucus serratus* and red seaweeds dominated habitat type (LR.MLR.BF.Fser.R) (Plate 1) where it was recorded at 10 of the 17 Phase I stations. It was also recorded at 6 Phase I stations on the mid shore within the *Fucus vesiculosus* and barnacle mosaic habitat type (LR.MLR.BF.FvesB) (Plates 2 and 3). The abundance of *Caulacanthus* spp. was very patchy and varied substantially at a local scale, forming distinct clumps on some areas of rock, particularly within fissures and/or crevices (Plate 4). Although the presence of *Caulacanthus* spp. was not sufficient to change the habitat type assignment anywhere where it was identified within the Sector, it cannot be ruled out that the community composition may have been changed significantly by its presence; however, statistical analysis that is outside the scope of this study would be required to confirm this.

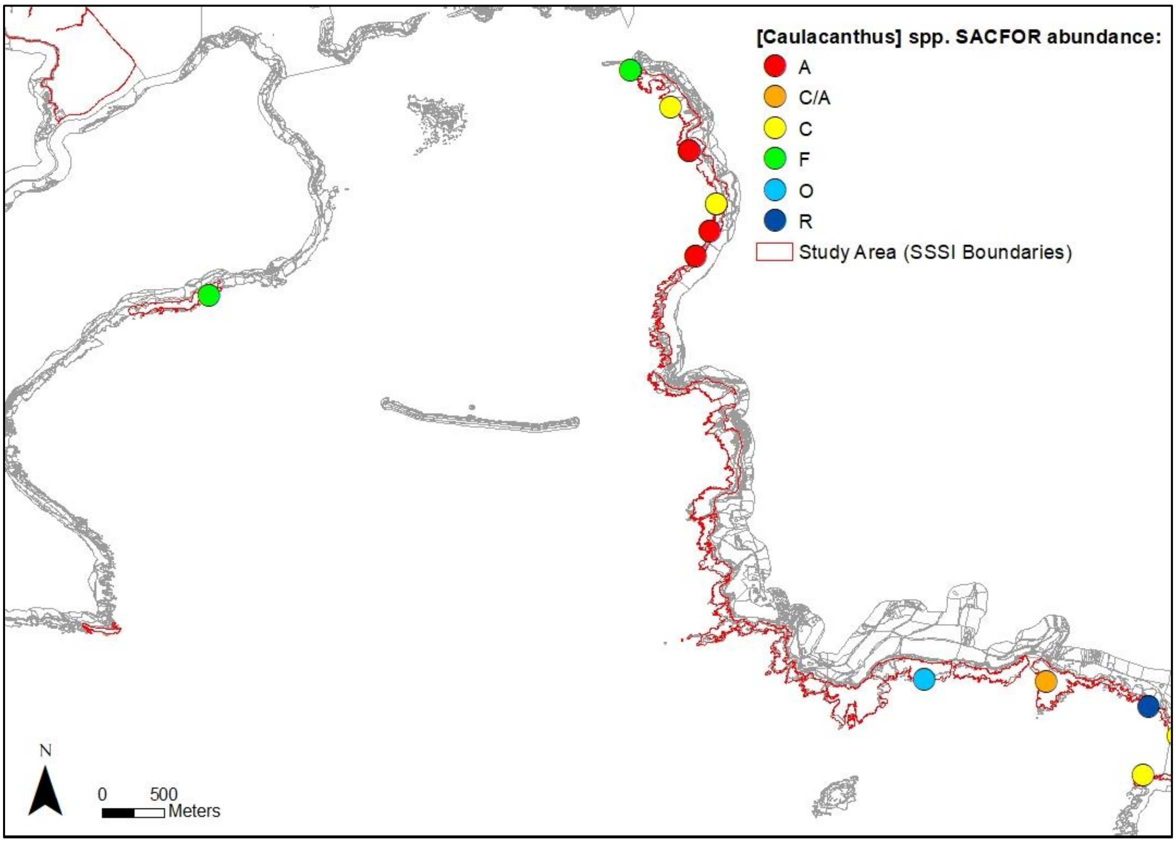

Figure 40. Map showing the distribution and SACFOR abundance of *Caulacanthus* spp. within Sector 1.

Plate 1. *Caulacanthus* spp. within the LR.MLR.BF.Fser.R habitat type at Phase I station R1 at Mount Batten Point.

Plate 2. *Caulacanthus* spp. within the LR.MLR.BF.FvesB habitat type at Phase I station R3 at Dunstone Point.

Plate 3. Patchy distribution of *Caulacanthus* spp. at Wembury Point.

Plate 4. *Caulacanthus* spp. in rock crevices/fissures in Jennycliff Bay (indicated by arrows), Plymouth Sound.

The invasive algae *Sargassum muticum* and Pacific Oyster *Magallana gigas* (Plate 5) were also observed within Sector 1. The locations at which these INNS were recorded and their SACFOR abundance are shown in Figures 41 and 42 respectively. Due to their low abundance, neither of these species were considered to have substantially altered the composition of littoral communities or change the habitat type assigned.

Plate 5. *Magallana gigas* at Phase I station R2 (between Mount Batten Point and Dunstone Point).

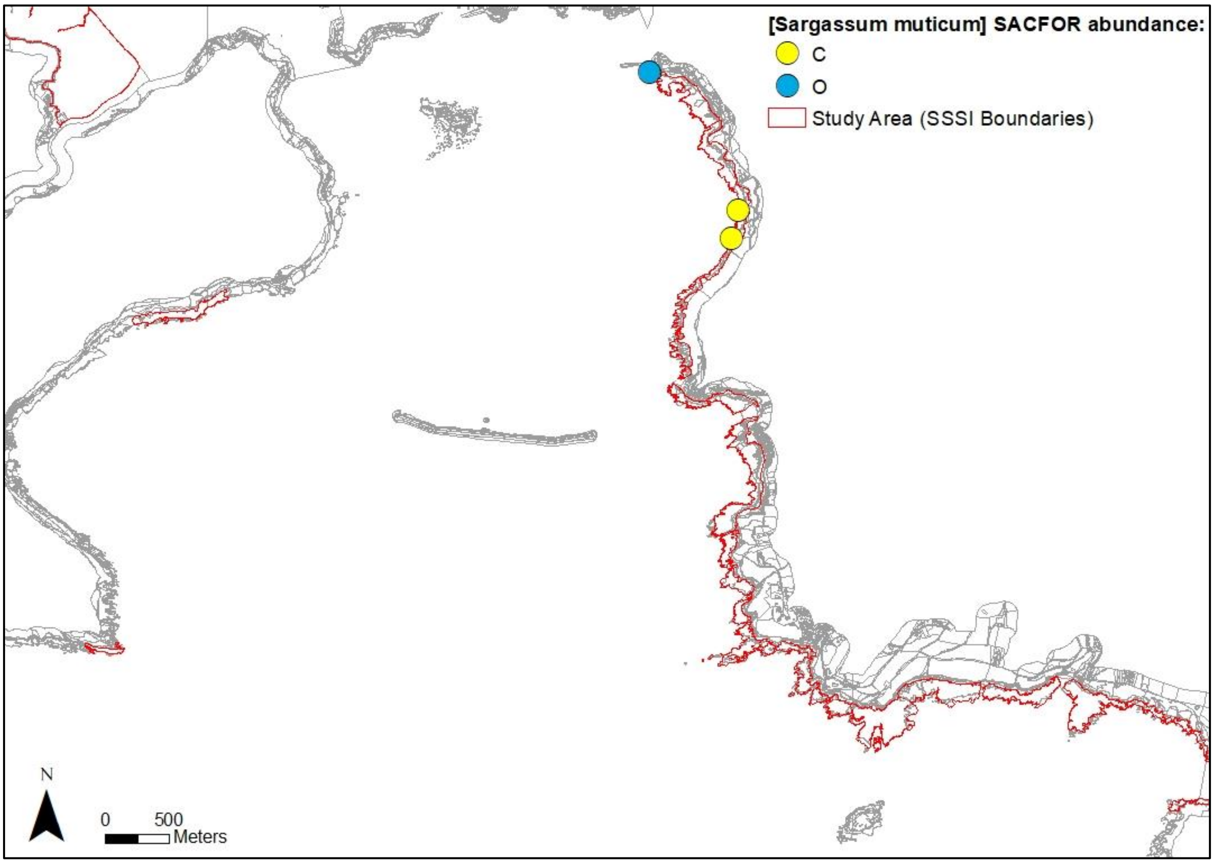

Figure 41. Map showing the distribution and SACFOR abundance of *Sargassum muticum* within Sector 1.

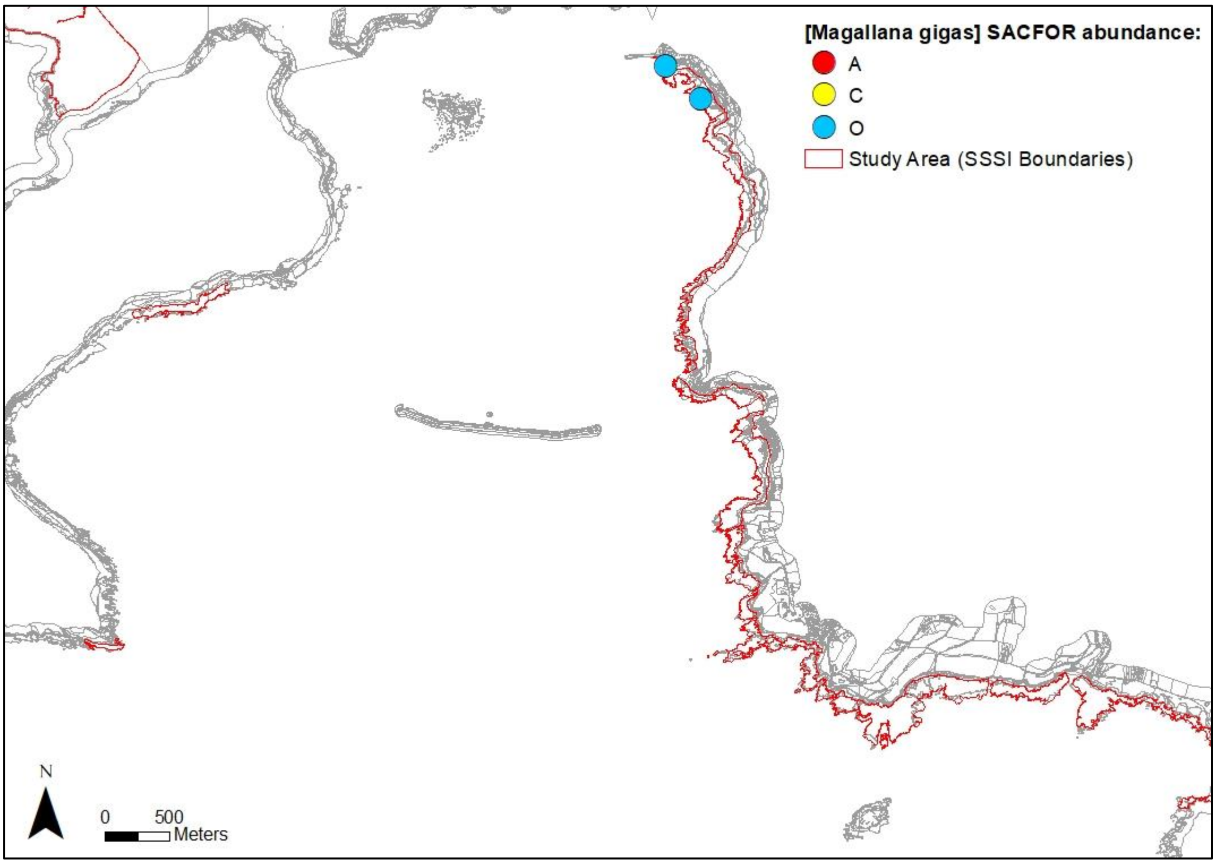

Figure 42. Map showing the distribution and SACFOR abundance of *Magallana gigas* within Sector 1.

5.4.2 Sector 2 - Tamar-Tavy, St Johns Lake and the Lynher Estuary

Blue mussel beds (*Mytilus edulis*) and native oysters (*Ostrea edulis*) are listed as features of interest within the Tamar Estuary Sites Marine Conservation Zone (MCZ). During the 2017 surveys within Sector 2, no native oysters were seen, however, the blue mussel beds (LS.LBR.LMus.Myt.Mx) were observed to have not changed significantly in extent or distribution since 2010. The nationally scarce tentacle lagoon worm *Alkmaria romijni* was sampled in cores from 11 stations within the Tamar Tavy and St Johns Lake SSSI (Figure 43) and 22 stations within the Lynher Estuary SSSI (Figure 44).

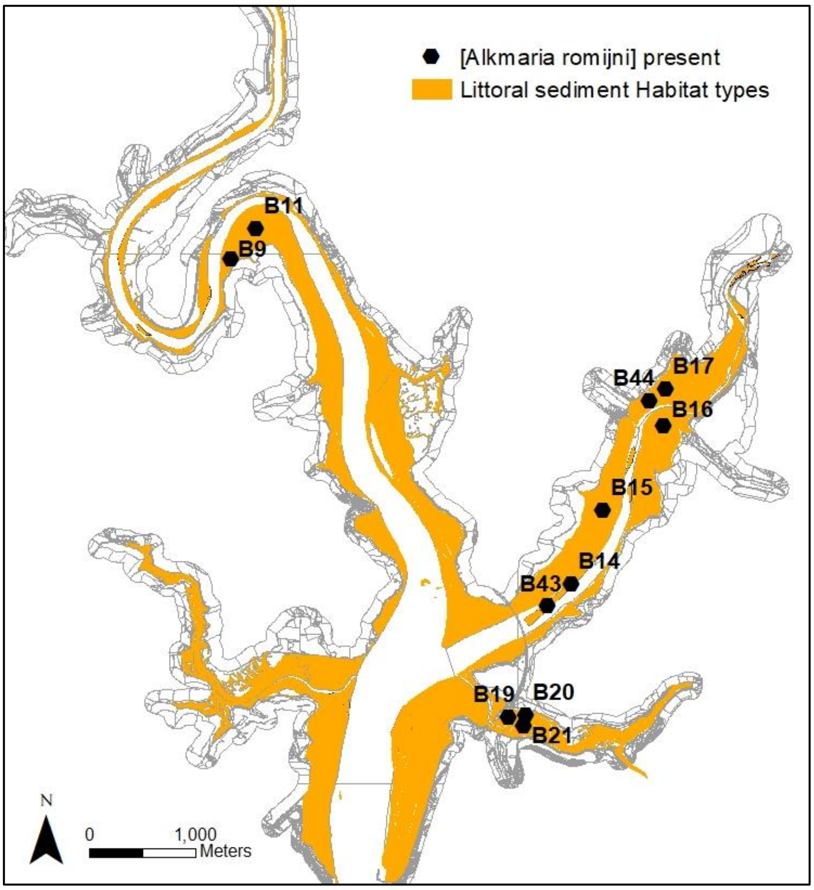

Figure 43. Map showing stations where the tentacle lagoon worm *Alkmaria romijni* was captured in cores in Sector 2: the Tamar Tavy and St Johns Lake SSSI.

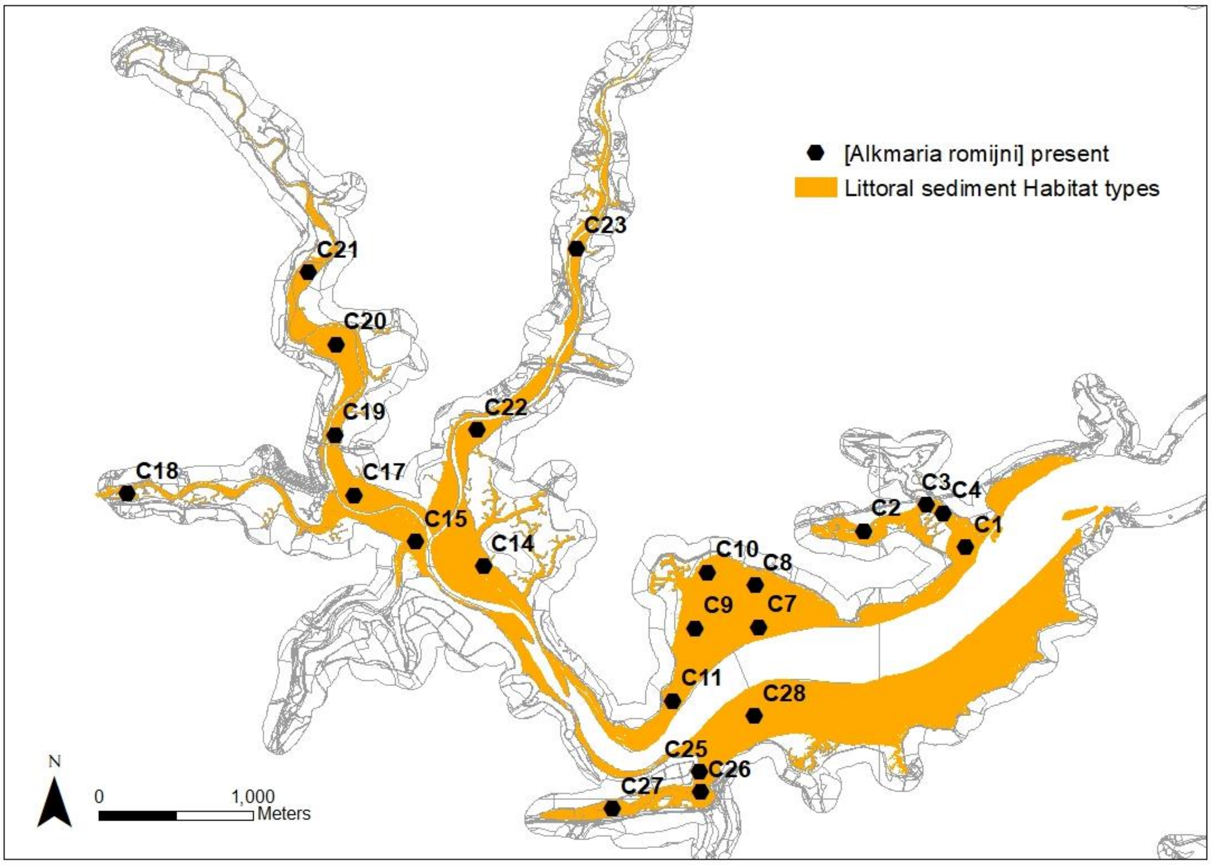

Figure 44. Map showing stations where the tentacle lagoon worm *Alkmaria romijni* was captured in cores in Sector 2: the Lynher Estuary SSSI.

The INNS *Magallana gigas* was not seen in the Lynher Estuary, but it was identified at a number of locations in the lower Tamar-Tavy Estuary (Figure 45, Plate 6). Within this area of the SAC the abundance was not considered to be sufficient to result in 'notable' changes to the communities within which they were present. For the purposes of this report 'notable' community changes have been defined as areas where the abundance of *Magallana gigas* is 'common' or above according to the SACFOR scale (i.e. 1 to 9 individuals per square metre or more). 'Notable' numbers of *Magallana gigas* were mapped within St Johns Lake however, mostly on the lower shore within the cockle dominated habitat type (LS.LSa.MuSa.CerPo); these areas are shown in Figure 46 and Plates 7 and 8. The total area of littoral sediment habitat type that has been mapped as 'notably' affected equates to 11% of the total area of littoral sediments that have been mapped in the SAC.

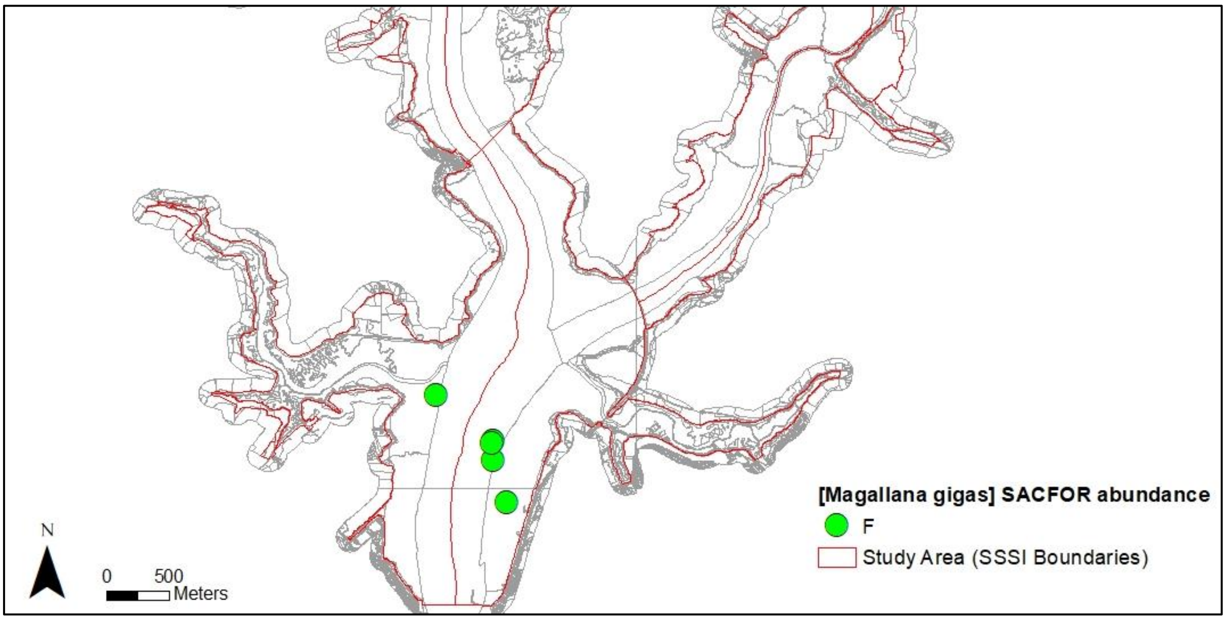

Figure 45. Map showing the presence of *Magallana gigas* in Sector 2: Lower Tamar Estuary.

Plate 6. *Magallana gigas* on the western bank of the lower Tamar-Tavy estuary (station B46).

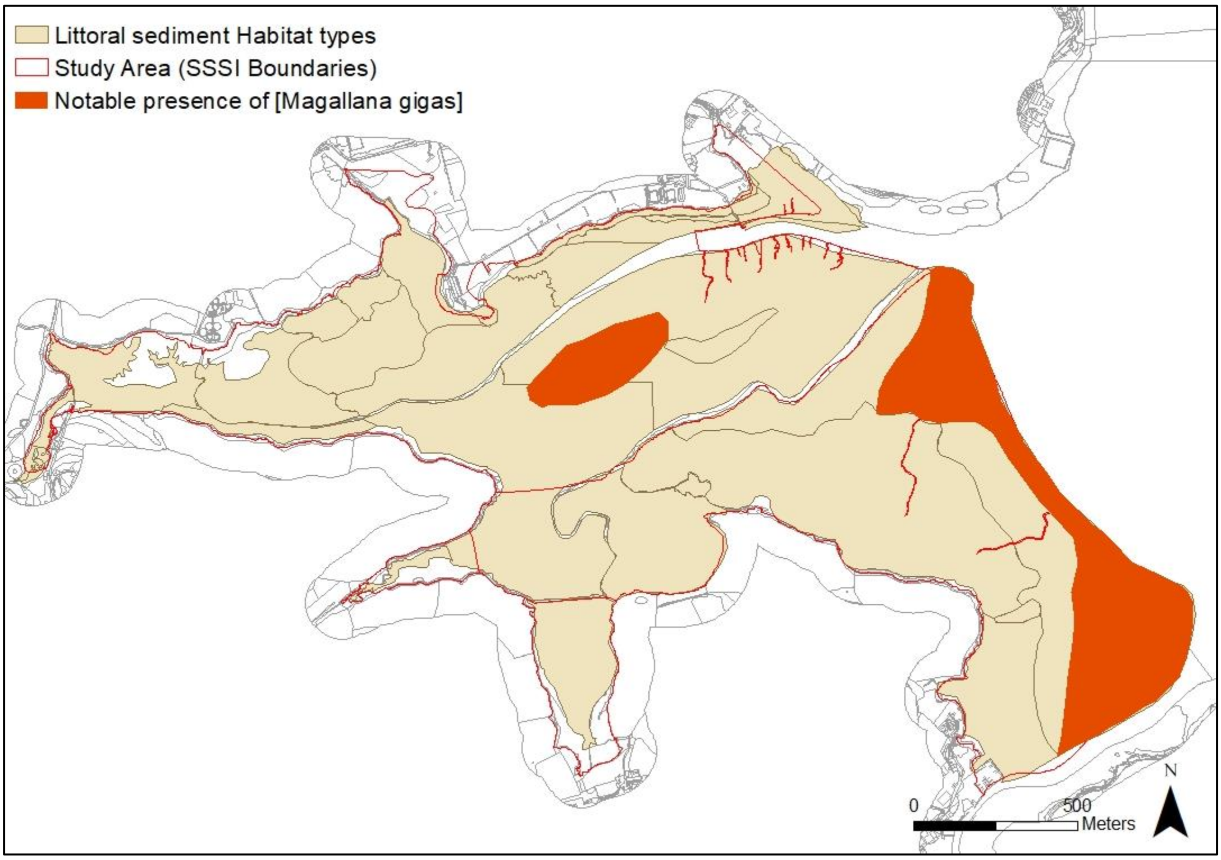

Figure 46. Map showing where the abundance of *Magallana gigas* was 'common' according to the SACFOR scale in Sector 2: St. Johns Lake.

Plate 7. *Magallana gigas* in area where there is a 'notable' abundance of the species within St Johns Lake (at station 30).

Plate 8. *Magallana gigas* in area where there is a 'notable' abundance of the species within St Johns Lake (at station 30).

5.4.3 Sector 3 – The Yealm Estuary

Within Sector 3, the invasive red algae *Caulacanthus spp.* was frequently observed in 'common' SACFOR abundances (10% -19% cover) lower in the estuary, and 'occasional' (1%-5% cover) above the confluence of the Yealm channel with Newton Creek. The locations where this INNS was recorded as present are shown in Figure 47. As was observed in Plymouth Sound, the species was most commonly recorded within the mid and lower shore habitat types LR.MLR.BF.FvesB (Plate 9) and LR.MLR.BF.Fser.R. The INNS of red algae was also seen to colonise the periphery of rockpools at the mouth of the Yealm (Plate 10).

The Pacific Oyster *Magallana gigas* was more abundant in the Yealm estuary than anywhere else within the SAC. Recorded abundances ranged from 'occasional' (1-9 individuals per 1000 square metres) to 'abundant' (1-9 individuals per square metre) (Figure 48). The areas of the estuary where the abundance of *Magallana gigas* was considered to be having a 'notable' effect on community composition (SACFOR abundance of 'common' or above) have been mapped in Figure 49. The total area of littoral rock over which a 'notable' effect on community composition has been mapped has been calculated and equates to less than 1% of the total area of littoral rock mapped within the SAC. The most dense aggregations of *Magallana gigas* were found between Warren Cottages and Clitters Wood (Plate 11). At that location they were found mostly on the mixed stable substrata that was colonised by *Fucus vesiculosus* and/or *Fucus serratus* (LR.MLR.BF.FvesB or LR.MLR.BF.Fser.R), but individuals were also attached to bedrock outcrops that were dominated by barnacle communities.

Plate 9. *Caulacanthus* spp. at Phase I station R27 in the Yealm estuary.

Plate 10. Photograph of *Caulacanthus* spp. at Phase I station R23.

and occasionally fringing mid shore rock pools (Plate 1).

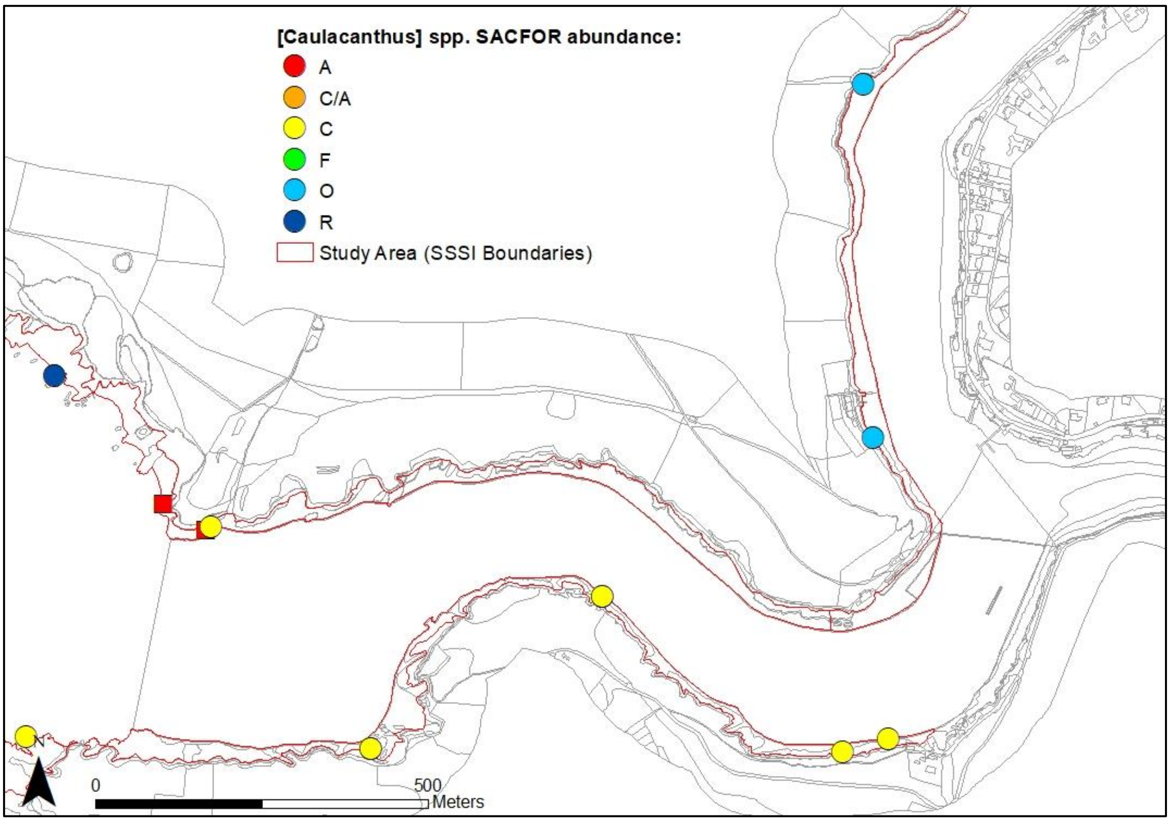

Figure 47. Map showing the abundance of *Caulacanthus* spp. in Sector 3: the Yealm estuary.

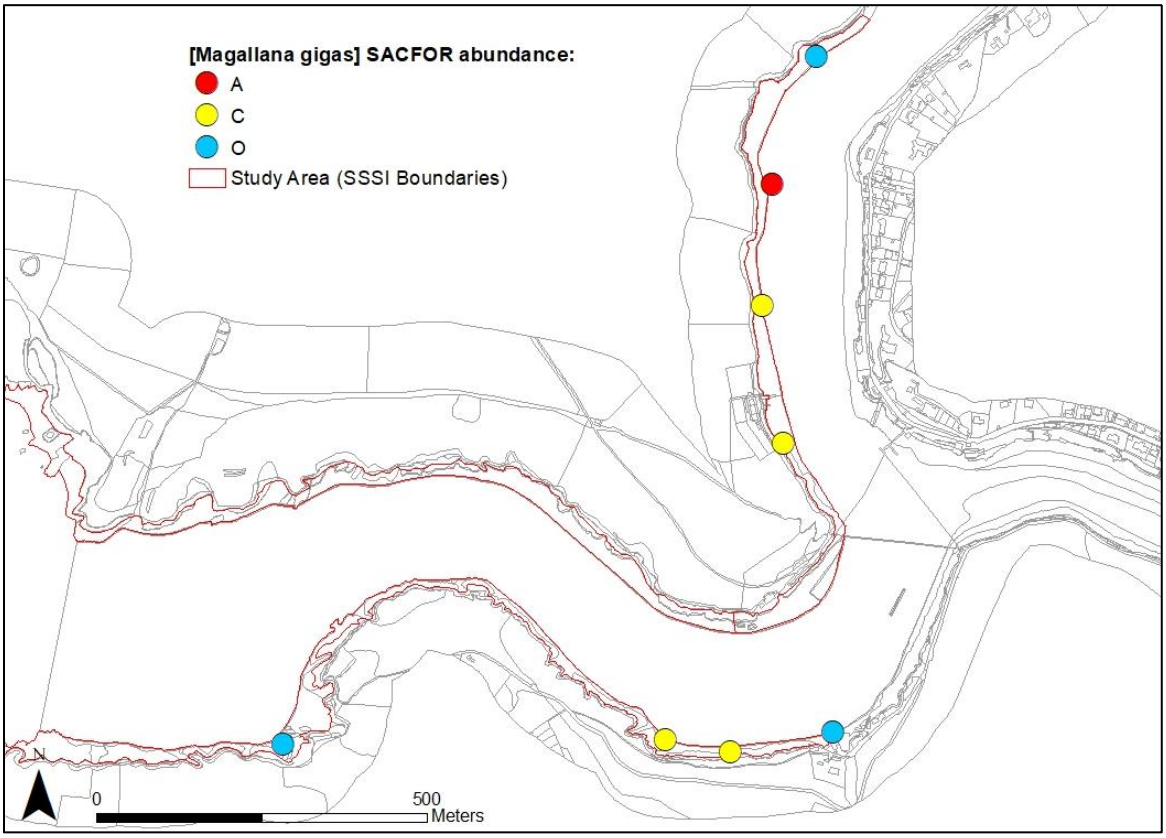

Figure 48. Map showing the abundance of *Magallana gigas* in Sector 3: the Yealm estuary.

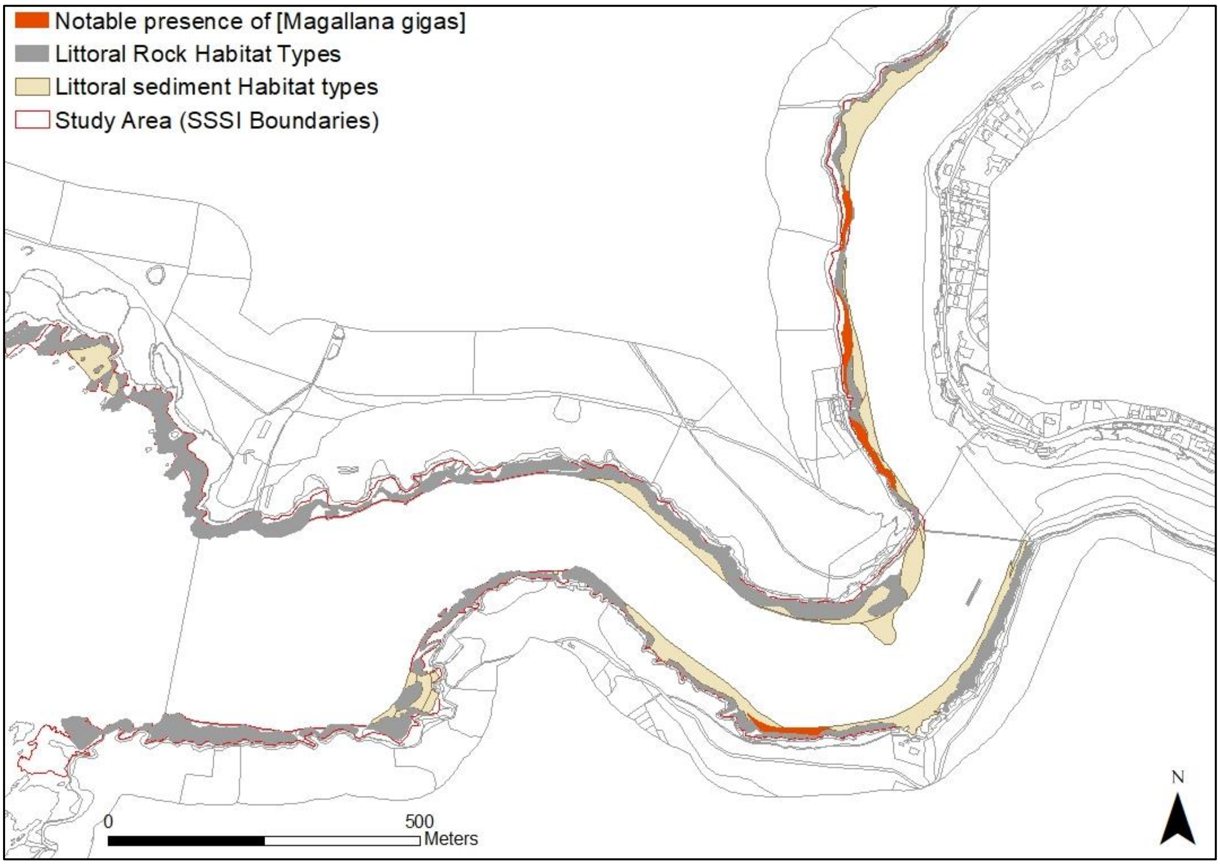

Figure 49. Map showing where the abundance of *Magallana gigas* was considered to have a 'notable' effect on the community composition in Sector 3: the Yealm estuary.

Plate 11. *Magallana gigas* between Warren Cottages and Clitters Wood.

5.5 Sediment Contaminant Analysis

5.5.1 Sector 1 - Plymouth Sound

No samples were collected for sediment contamination analysis within Sector 1.

5.5.2 Sector 2 - Tamar-Tavy, St Johns Lake and the Lynher Estuary

5.5.2.1 Tamar-Tavy and St. Johns Lake SSSI

Samples were taken at stations B4, B11, B15, B22 and B29 for contaminant analysis, the location of these stations is shown in Figure 50.

The results of the analysis are summarised in Table 4 together with the guideline limits for each analyte where they exist. The guideline limits that have been used to compare the data against include the Canadian sediment quality guidelines for the protection of aquatic life ISQG level[20] (often referred to as the Threshold Effect Level i.e. the concentration that may affect certain sensitive species, the Canadian sediment quality guidelines PEL (Probable Effects Level - a concentration that will affect a wide range of species), together with the UK's CEFAS Action Level limits[21] which are used to assess sediments suitability for disposal at sea. Most significantly in terms of this assessment however are the OSPAR Environment Assessment Criteria (EAC) or Effects Range Low (ERL) thresholds[22]. These are sediment guidelines used to protect against the adverse biological effects on organisms. The EAC represents the contaminant concentration in sediment below which no chronic effects are expected to occur in marine species, whilst the ERL is the value at which adverse effects on organisms are observed if concentrations are exceeded. These latter guidelines are pertinent to the data collected in this instance because the target attribute for surface sediment contaminants references these OSPAR criteria and requires sediment contaminants to fall to below these values to meet the favourable condition status.

It can be seen from Table 4 that the ERL or EAC limits have been exceeded for lead at stations B4, B15 and B40. The ERL or EAC thresholds for the PAHs Benzo(a)anthracene, and Benzo(ghi)perylene were exceeded at all stations with the exception of B29, whilst Indeno(1,2,3-c,d)pyrene was exceeded at stations B4, B11, B15 and B40. The sediments at station B29 in St Johns Lake were comparatively clean.

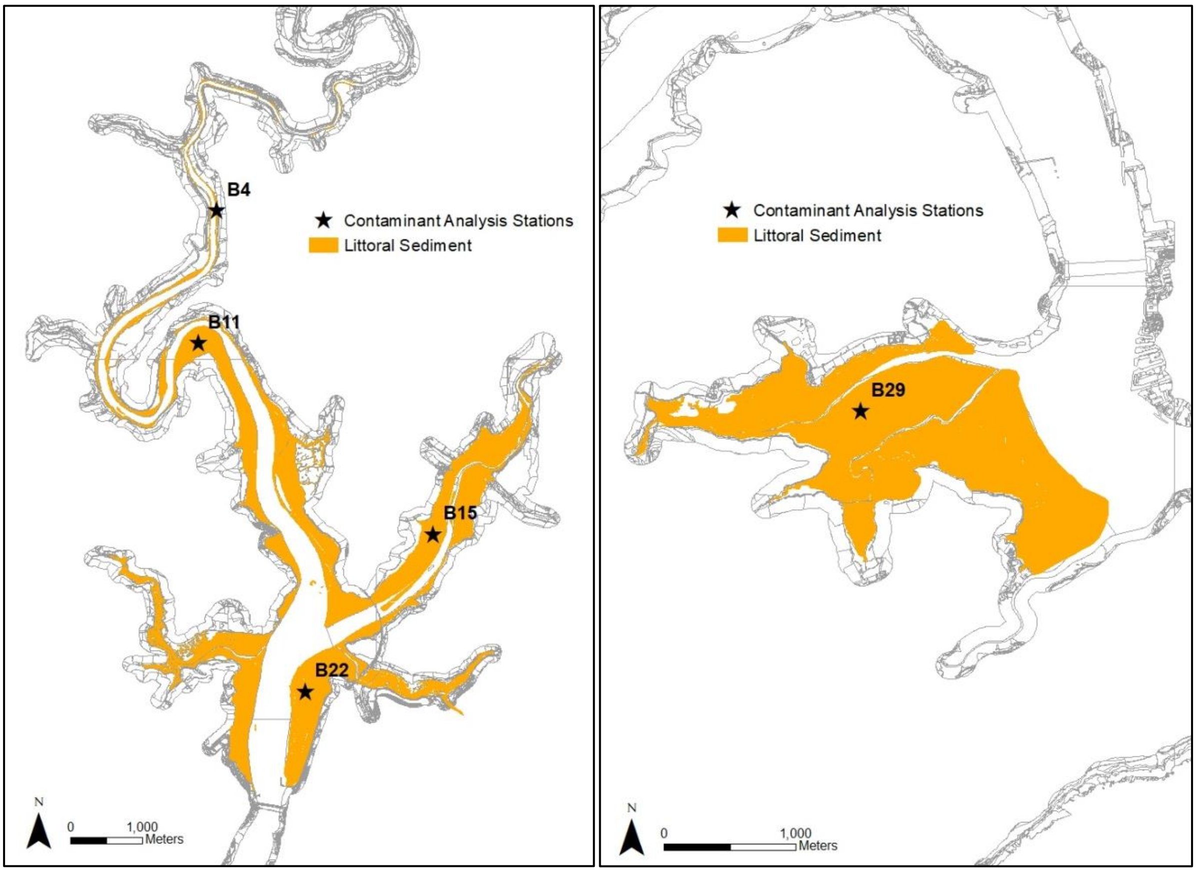

Figure 50. Location of samples collected for sediment contaminant analysis in the Tamar Tavy and St Johns Lake SSSI.

Table 4. Results of sediment contaminant analysis within the Tamar-Tavy and St. Johns Lake SSSI

Analyte	Units	Stations B4	B11	B15	B22	B29	B40	CEFAS Action Level 1	CEFAS Action Level 2	CCME Guidelines ISQG Level	CCME Guidelines PEL Level	OSPAR ERL	OSPAR EAC
Nitrogen		5550	3640	4070	2540	4540	4890	N/A	N/A	N/A	N/A		
Mercury	mg/kg	0.535**	0.0646	0.513**	0.32**	0.0667	0.454**	0.3	3	0.13	0.7	0.15	
Aluminium, HF Digest		86400	64800	74100	59100	56100	78400	N/A	N/A	N/A	N/A		
Iron, HF Digest		48700	32100	41900	32100	27500	43000	N/A	N/A	N/A	N/A		
Arsenic, HF Digest		90.3	42.2	118	87.6	34.8	93.7	20	100	7.24	41.6		
Cadmium, HF Digest		0.978	0.177	0.619	0.383	0.157	0.57	0.4	5	0.7	4.2	1.2	
Chromium, HF Digest		109	81.4	99.1	78.1	71.2	93	40	400	52.3	160		
Copper, HF Digest		272	32.7	214	122	26.9	209	40	400	18.7	108		
Lead, HF Digest		148**	54.2	136**	77.1	50.9	136**	50	500	30.2	112	47	
Lithium, HF Digest		147	107	135	107	84.4	135	N/A	N/A	N/A	N/A		
Manganese, HF Digest		824	326	559	443	309	436	N/A	N/A	N/A	N/A		
Nickel, HF Digest		57	33.6	43.3	33.3	28.1	43.6	20	200	N/A	N/A		
Zinc : HF Digest		410	122	331	216	102	326	130	800	124	271		
Hexachlorobenzene	ug/kg	0.134	<0.1	0.114	<0.1	<0.1	0.108						
Hexachlorobutadiene		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1						
Anthracene		49.3	61.9	50.3	31.3	2.07	36	100	N/A	46.9	245	85	
Benzo(a)anthracene		296**	319**	297**	209	11.4	217	100	N/A	74.8	693	261	
Benzo(a)pyrene		398	383	413	282	16.2	312	100	N/A	88.8	763	430	
Benzo(ghi)perylene		314**	284**	302**	193**	13.9	242**	100	N/A	N/A	N/A	85	
Chrysene + Triphenylene		335	325	333	239	13.8	255		N/A			384	
Fluoranthene		457	545	482	360	21.4	364	100	N/A	113	1494	600	
Indeno(1,2,3-c,d)pyrene		327*	297**	308**	212	14.7	246**	100	N/A	N/A	N/A	240	
Naphthalene		45.4	33.6	47.9	25.4	<5	35.4	100	N/A	34.6	391	160	
Phenanthrene		145	147	142	107	7.99	106	100	N/A	86.7	544	240	
Pyrene		461	467	482	348	21	357	100	N/A	153	1398	665	
Hexabromodiphenyl ether {PBDE 153}		0.021	<0.03	<0.02	<0.02	<0.03	<0.02						
Hexabromodiphenyl ether {PBDE 154}		0.04	<0.03	0.025	<0.02	<0.03	0.027						
Pentabromodiphenyl ether{PBDE 99}		0.91	<0.07	0.083	0.063	<0.06	0.073						
Pentabromodiphenyl ether {PBDE 100}		0.029	<0.03	0.026	<0.02	<0.03	0.023						
Tetrabromodiphenyl ether {PBDE 47}		0.079	<0.09	0.075	<0.07	<0.08	0.074						
Tribromodiphenyl ether{PBDE 28}		<0.02	<0.03	<0.02	<0.02	<0.03	<0.02						
PCB - 028		0.135	<0.1	0.144	<0.1	<0.1	0.135			N/A	N/A		1.7
PCB - 052		0.155	0.112	0.189	<0.1	<0.1	0.19			N/A	N/A		2.7
PCB - 101		0.489	0.357	0.549	0.397	<0.1	0.583			N/A	N/A		3
PCB - 118		0.569	0.473	0.699**	0.519	<0.1	0.67			N/A	N/A		0.6
PCB - 138		0.648	0.531	0.745	0.738	<0.1	0.762			N/A	N/A		7.9
PCB - 153		0.616	0.492	0.698	0.586	<0.1	0.721			N/A	N/A		40
PCB - 180		0.286	0.203	0.296	0.253	<0.1	0.312			N/A	N/A		12
PCB's sum of ICES-7		2.898	2.168	2.621	2.493	<0.1	3.373	10	N/A				
Tributyl Tin		3.68	2.46	4.4	2.26	2.29	<4						

Levels within ISQG and CEFAS Action Level 1 — Levels over the ISQG or CEFAS Action Level 1 — Levels over the PEL or CEFAS Action Level 2

No CCME or CEFAS Action Levels available — ** Levels exceeding ERL or EAC

5.5.2.2 Lynher Estuary SSSI

Contaminant analysis was carried out on sediment samples taken from stations C9, C20, C22 and C30, the location of these stations within the Lynher Estuary is shown in Figure 51.

The results of the analysis are summarised in Table 5 together with the guideline limits for each analyte where they exist as outlined in section 5.5.2.1. above. It can be seen that the ERL or EAC for mercury and lead are exceeded at all 4 stations. These guideline limits are also exceeded for the PAHs Benzo(ghi)perylene at all 4 stations, Benzo(a)anthracene at stations C20 and C30, Benzo(a)pyrene at station C30 and Indeno(1,2,3-c,d)pyrene at stations C9, C20 and C22.

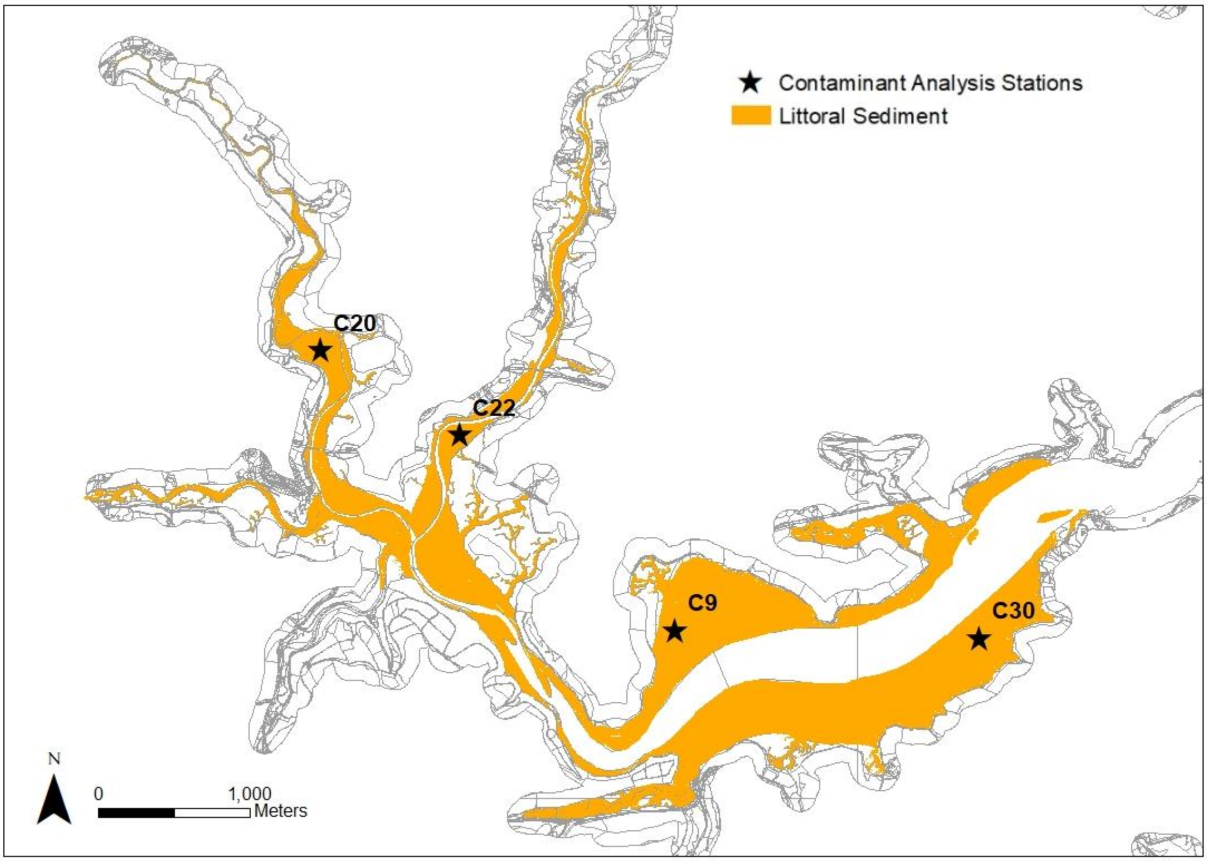

Figure 51. Location of samples collected for sediment contaminant analysis in the Lynher Estuary SSSI.

Table 5. Results of sediment contaminant analysis within Lynher Estuary SSSI

Analyte	Units	Stations				CEFAS Action Level 1	CEFAS Action Level 2	CCME Guidelines ISQG Level	CCME Guidelines PEL Level	OSPAR ERL	OSPAR EAC
		C9	C20	C22	C30						
Nitrogen		5060	6620	5710	3960	N/A	N/A	N/A	N/A		
Mercury	mg/kg	0.536**	0.535**	0.514**	0.608**	0.3	3	0.13	0.7	0.15	
Aluminium, HF Digest	mg/kg	82700	88400	82000	79200	N/A	N/A	N/A	N/A		
Iron, HF Digest	mg/kg	36300	49900	44500	39800	N/A	N/A	N/A	N/A		
Arsenic, HF Digest	mg/kg	85.1	314	108	97.5	20	100	7.24	41.6		
Cadmium, HF Digest	mg/kg	0.479	0.409	0.518	0.422	0.4	5	0.7	4.2	1.2	
Chromium, HF Digest	mg/kg	107	108	96.7	108	40	400	52.3	160		
Copper, HF Digest	mg/kg	246	276	273	215	40	400	18.7	108		
Lead, HF Digest	mg/kg	158**	186**	163**	148**	50	500	30.2	112	47	
Lithium, HF Digest	mg/kg	73	140	132	134	N/A	N/A	N/A	N/A		
Manganese, HF Digest	mg/kg	346	541	436	416	N/A	N/A	N/A	N/A		
Nickel, HF Digest	mg/kg	45.5	48.4	42.8	45	20	200	N/A	N/A		
Zinc : HF Digest	mg/kg	349	385	360	312	130	800	124	271		
Hexachlorobenzene	ug/kg	0.188	0.174	0.128	0.1						
Hexachlorobutadiene	ug/kg	<0.1	<0.1	<0.1	<0.1						
Anthracene	ug/kg	35.8	38.4	33.9	49.5	100	N/A	46.9	245	85	
Benzo(a)anthracene	ug/kg	220	261**	215	269**	100	N/A	74.8	693	261	
Benzo(a)pyrene	ug/kg	343	371	329	455**	100	N/A	88.8	763	430	
Benzo(ghi)perylene	ug/kg	288**	282**	281**	337**	100	N/A	N/A	N/A	85	
Chrysene + Triphenylene	ug/kg	268	320	259	323		N/A			384	
Fluoranthene	ug/kg	372	426	353	467	100	N/A	113	1494	600	
Indeno(1,2,3-c,d)pyrene	ug/kg	272**	335**	281**	365	100	N/A	N/A	N/A	240	
Naphthalene	ug/kg	39.8	41.4	34.8	46.1	100	N/A	34.6	391	160	
Phenanthrene	ug/kg	108	125	106	140	100	N/A	86.7	544	240	
Pyrene	ug/kg	383	419	357	574	100	N/A	153	1398	665	
Hexabromodiphenyl ether {PBDE 153}	ug/kg	0.02	0.02	0.02	0.02						
Hexabromodiphenyl ether {PBDE 154}	ug/kg	0.023	0.025	0.023	0.02						
Pentabromodiphenyl ether{PBDE 99}	ug/kg	0.074	0.059	0.058	0.05						
Pentabromodiphenyl ether {PBDE 100}	ug/kg	0.02	0.02	0.02	0.02						
Tetrabromodiphenyl ether {PBDE 47}	ug/kg	0.07	0.07	0.07	0.07						
Tribromodiphenyl ether{PBDE 28}	ug/kg	0.02	0.02	0.02	0.02						
PCB - 028	ug/kg	0.184	0.178	0.155	0.156			N/A	N/A		1.7
PCB - 052	ug/kg	0.163	0.136	0.139	0.173			N/A	N/A		2.7
PCB - 101	ug/kg	0.538	0.415	0.425	0.523			N/A	N/A		3
PCB - 118	ug/kg	0.68**	0.644**	0.609**	0.507			N/A	N/A		0.6
PCB - 138	ug/kg	0.727	0.73	0.706	0.522			N/A	N/A		7.9
PCB - 153	ug/kg	0.679	0.7	0.654	0.544			N/A	N/A		40
PCB - 180	ug/kg	0.332	0.303	0.279	0.315			N/A	N/A		12
PCB's sum of ICES-7	ug/kg	2.623	2.462	2.358	2.74	10	N/A				
Tributyl Tin	ug/kg	5.48	3.4	3.36	2						

Levels within ISQG and CEFAS Action Level 1 — Levels over the ISQG or CEFAS Action Level 1 — Levels over the PEL or CEFAS Action Level 2

No CCME or CEFAS Action Levels available — ** Levels exceeding ERL or EAC

5.5.3 Sector 3 - The Yealm Estuary

Additional samples were taken at stations Y2 and Y15 for contaminant analysis (Figure 52). The results of the analysis are summarised in Table 6 together with the guideline limits for each analyte where they exist. It can be seen that at station Y2 the ERL or EAC has been exceeded for the heavy metals mercury and lead, and every PAH listed except Napthalene. In contrast, neiether the ERL or EAC was exceeded for any analyte at station Y15, although the ISQG or CEFAS action level 1 was exceeded for a number of heavy metals at station Y15.

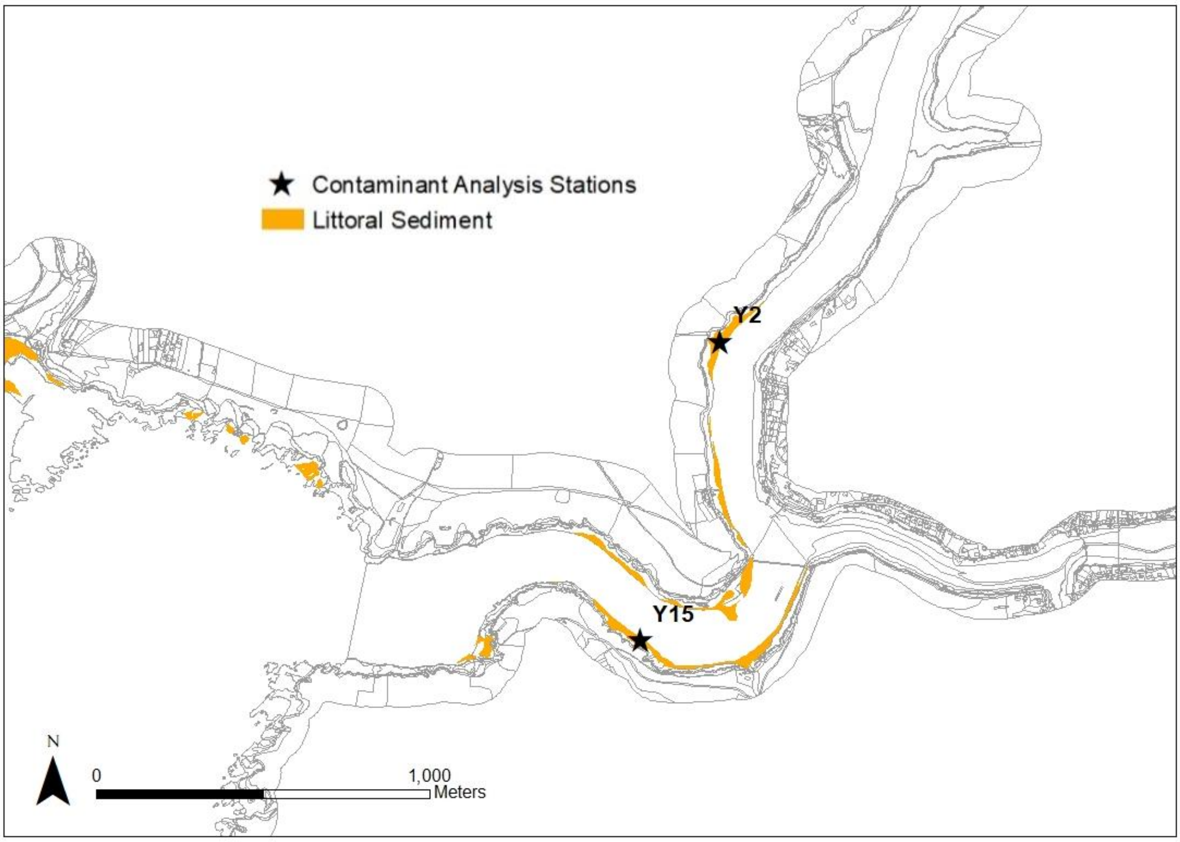

Figure 52. Location of samples collected for sediment contaminant analysis.

Table 6. Results of sediment contaminant analysis within Yealm Estuary SSSI

Analyte	Units	Stations		CEFAS Action Level 1	CEFAS Action Level 2	CCME Guidelines ISQG Level	CCME Guidelines PEL Level	OSPAR ERL	OSPAR EAC
		Y2	Y15						
Nitorgen		3130	1610	N/A	N/A	N/A	N/A		
Mercury	mg/kg	0.52**	0.0317	0.3	3	0.13	0.7	0.15	
Aluminium, HF Digest	mg/kg	66100	41900	N/A	N/A	N/A	N/A		
Iron, HF Digest	mg/kg	28800	28800	N/A	N/A	N/A	N/A		
Arsenic, HF Digest	mg/kg	22.5	12.4	20	100	7.24	41.6		
Cadmium, HF Digest	mg/kg	0.191	0.048	0.4	5	0.7	4.2	1.2	
Chromium, HF Digest	mg/kg	83.1	67.7	40	400	52.3	160		
Copper, HF Digest	mg/kg	38.2	13.9	40	400	18.7	108		
Lead, HF Digest	mg/kg	48**	11.5	50	500	30.2	112	47	
Lithium, HF Digest	mg/kg	136	54.1	N/A	N/A	N/A	N/A		
Manganese, HF Digest	mg/kg	304	347	N/A	N/A	N/A	N/A		
Nickel, HF Digest	mg/kg	37.7	35.5	20	200	N/A	N/A		
Zinc : HF Digest	mg/kg	117	62.3	130	800	124	271		
Hexachlorobenzene	ug/kg	<0.1	<0.1						
Hexachlorobutadiene	ug/kg	<0.1	<0.1						
Anthracene	ug/kg	152**	6.93	100	N/A	46.9	245	85	
Benzo(a)anthracene	ug/kg	710**	22.3	100	N/A	74.8	693	261	
Benzo(a)pyrene	ug/kg	781**	28.4	100	N/A	88.8	763	430	
Benzo(ghi)perylene	ug/kg	470**	20.8	100	N/A	N/A	N/A	85	
Chrysene + Triphenylene	ug/kg	748**	25.3		N/A			384	
Fluoranthene	ug/kg	1200**	37.8	100	N/A	113	1494	600	
Indeno(1,2,3-c,d)pyrene	ug/kg	484**	21.6	100	N/A	N/A	N/A	240	
Naphthalene	ug/kg	97.1	<5	100	N/A	34.6	391	160	
Phenanthrene	ug/kg	439**	21.6	100	N/A	86.7	544	240	
Pyrene	ug/kg	1100**	37.2	100	N/A	153	1398	665	
Hexabromodiphenyl ether {PBDE 153}	ug/kg	<0.02	<0.02						
Hexabromodiphenyl ether {PBDE 154}	ug/kg	<0.02	<0.02						
Pentabromodiphenyl ether{PBDE 99}	ug/kg	<0.05	<0.05						
Pentabromodiphenyl ether {PBDE 100}	ug/kg	<0.02	<0.02						
Tetrabromodiphenyl ether {PBDE 47}	ug/kg	<0.07	<0.07						
Tribromodiphenyl ether{PBDE 28}	ug/kg	<0.02	<0.02						
PCB - 028	ug/kg	0.101	<0.1			N/A	N/A		1.7
PCB - 052	ug/kg	0.27	<0.1			N/A	N/A		2.7
PCB - 101	ug/kg	0.798	<0.1			N/A	N/A		3
PCB - 118	ug/kg	0.833**	<0.1			N/A	N/A		0.6
PCB - 138	ug/kg	0.773	<0.1			N/A	N/A		7.9
PCB - 153	ug/kg	0.71	<0.1			N/A	N/A		40
PCB - 180	ug/kg	0.351	<0.1			N/A	N/A		12
PCB's sum of ICES-7	ug/kg	3.003	<0.1	10	N/A				
Tributyl Tin	ug/kg	5.57	<1						

Levels within ISQG and CEFAS Action Level 1 | Levels over the ISQG or CEFAS Action Level 1 | Levels over the PEL or CEFAS Action Level 2

No CCME or CEFAS Action Levels available | ** Levels exceeding ERL or EAC

5.6 Sector 4 - Newton Creek Pacific Oyster (*Magallana gigas*) Survey

The results of the survey for Pacific Oyster in Newton Creek have been presented in Figure 53. Densities are presented as number of individuals per 10 m^2 and are comparable to those densities reported from a survey that was carried out in 2014[23].

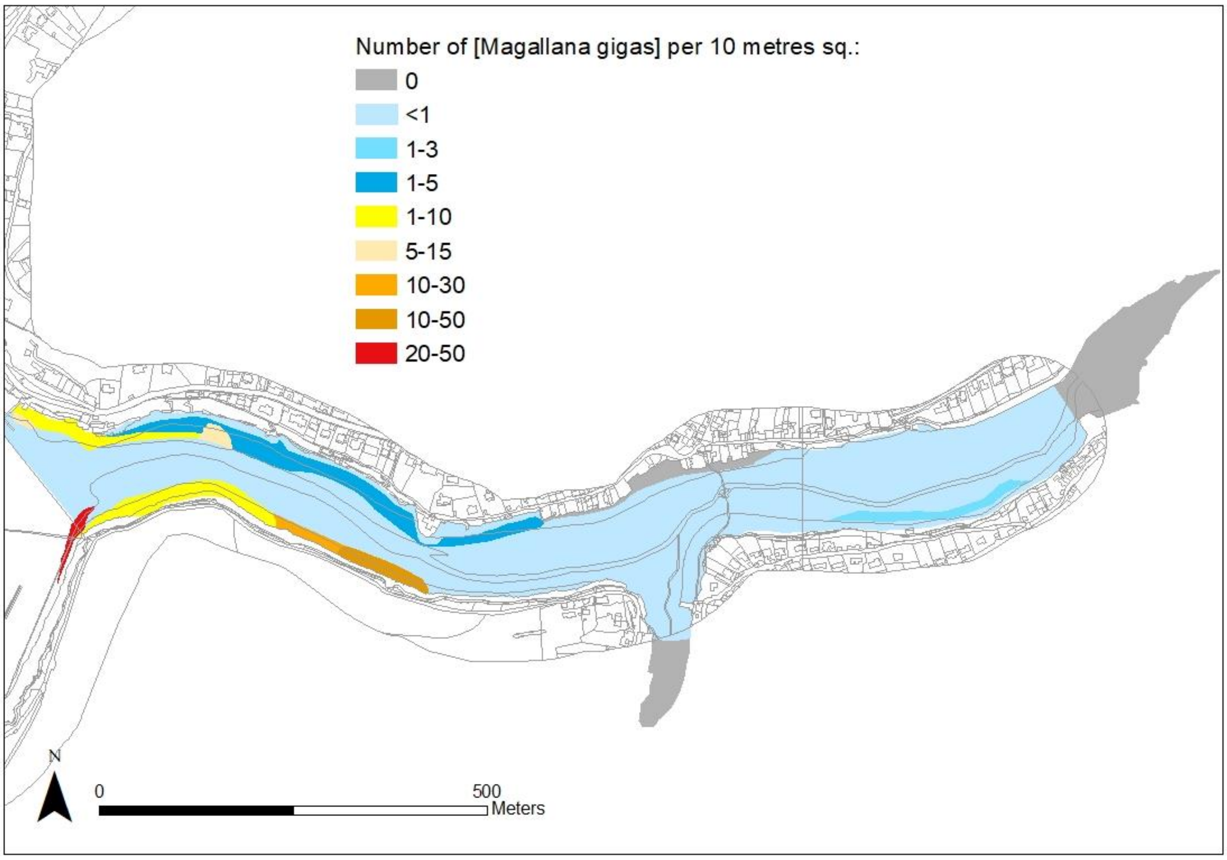

Figure 53. Map showing the density of *Magallana gigas* in Newton Creek in 2017.

5.7 Extent and Distribution of Macroalgae

Macroalgae mats were observed only within Sector 2. The area over which the density of macroalgae exceeded 5% cover has been mapped and is shown in Figures 54 and 55.

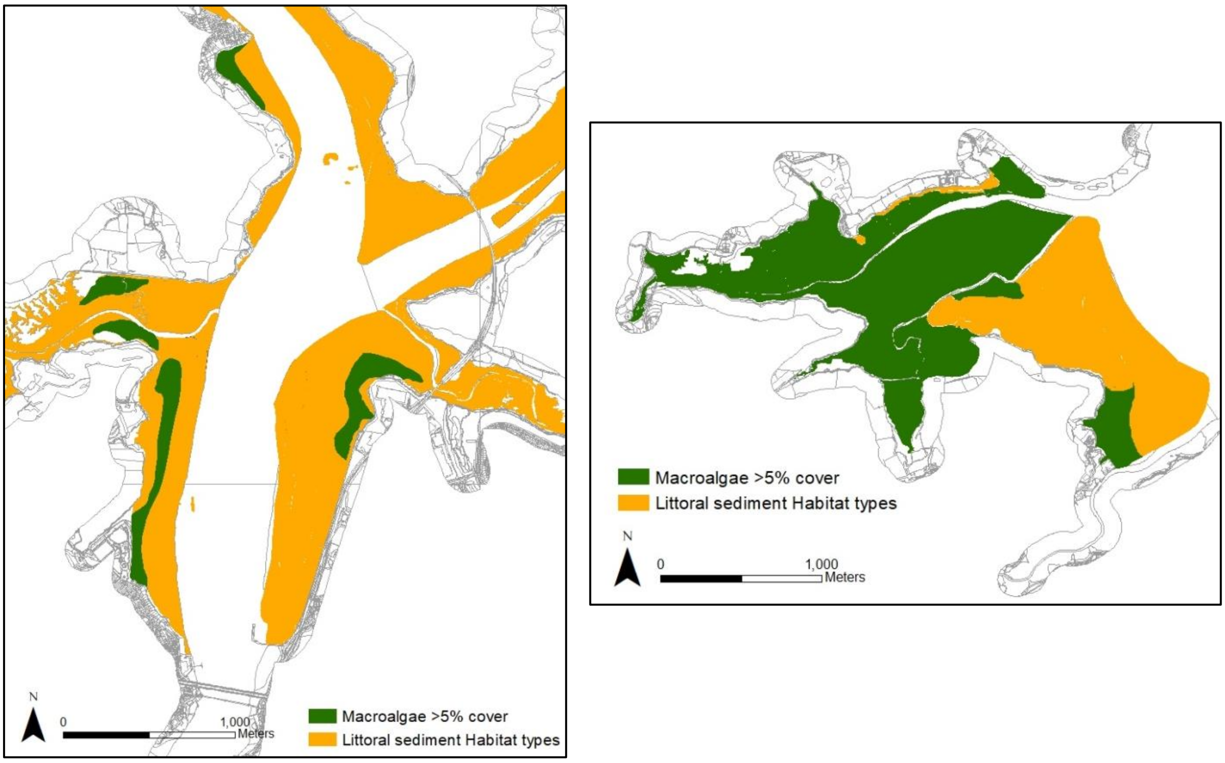

Figure 54. Map showing the extent and distribution of macroalgae in the Tamar Tavy and St Johns Lake SSSI 2017.

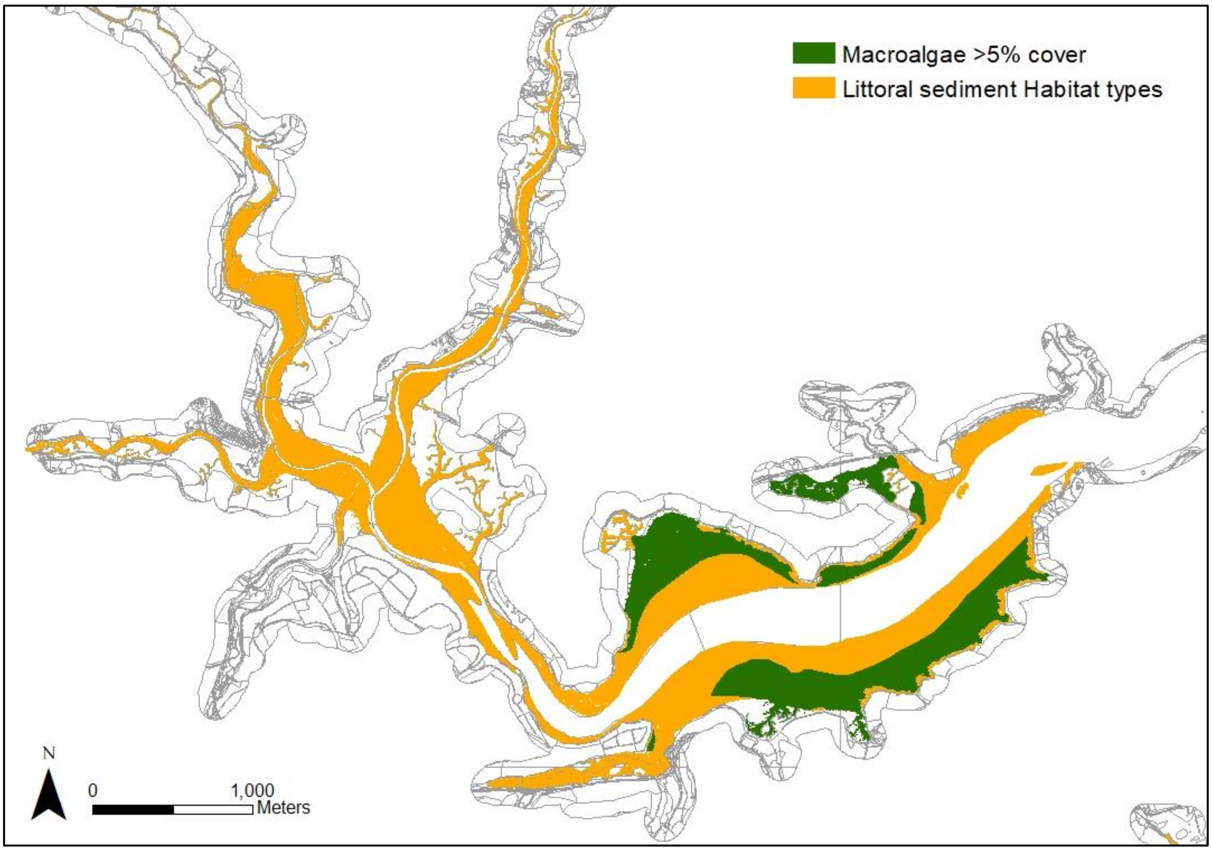

Figure 55. Map showing the extent and distribution of macroalgae in the Lynher Estuary SSSI 2017.

6. DISCUSSION

Qualitative descriptions of the littoral habitats that resulted from surveys that were carried out in Sectors 1 and 3 (Plymouth Sound and the Yealm estuary) in 2001[24] has enabled some broad comparisons of the main habitat types present to be made. These comparisons have shown that the main habitat types, which are typical of the coastline in the southwest, have remained broadly similar between 2001 and 2017. The data collected during the 2017 survey will provide a baseline for measuring the 'presence and spatial distribution of biological communities' attribute more completely and with more confidence in future years. The littoral rock baseline data that was collected in 2010 in Sector 2 has made it possible to determine that no significant changes in either the extent or distribution of the littoral rock habitat types have occurred since 2010 within either the Tamar-Tavy and St. Johns Lake SSSI of the Lynher Estuary SSSI components of the SAC.

The littoral sediment data collected within Sectors 1 and 3 in 2017 will provide a baseline for the assessment of the various biological communities as well as physiochemical attributes within the SAC. Within Sector 2 however, it has been possible to make temporal comparisons between 2010 and 2017 fauna, particle size and organic carbon content data, despite some limitations which have been brought about by different analysis methods in the physiochemical data.

There was some disparity in Habitat types assigned between 2010 and 2017, but this was largely driven by the intrinsic weakness of classifying communities using Habitat types, where the presence of certain species can add disproportionate weighting to how communities are described, therefore suggesting a large spatial or temporal change, when in fact, the changes may be insignificant. Univariate and multivariate analysis has shown that within both the Tamar-Tavy and St Johns Lake SSSI and Lynher Estuary SSSI species richness (Margalef's) within each area overall had increased since 2010, as had the diversity (Shannon Weiner) in the Lynher Estuary SSSI. When considered at the Habitat type level significant differences in community composition were observed within two habitat types within the Tamar-Tavy and St Johns Lake SSSI, and one in the Lynher Estuary SSSI. The Habitat types in which these changes were observed account for relatively large areas of the mudflat and sandflat features within each of their constituent SSSIs. Further community analysis revealed that a large proportion of the temporal differences observed are driven by relatively small differences in the abundances of a number of commonly occurring species. One of the main species that contributed to community change statistics was the mud snail *Peringia ulvae*, the abundance of which is not particularly ecologically significant as this gastropod floats onto and off the mudflats with the tide. In both SSSIs within Sector 2 a greater number of taxa contributed to the community similarities within the Habitat types that had significantly changed in composition. Within the LS.LMu.UEst.HedCvol communities however, the increased abundance of the oligochaete *Baltidrilus cotstatus* in 2017 accounted for 32% of the community change from 2010. The changes in community composition are of a nature that they are considered highly likely to be as a result of natural variable recruitment rather than being brought about by anthropogenic influence. Furthermore the net increase in diversity represents a positive change, as such, the attributes relating to infaunal community composition have been assessed to be in favourable condition.

Temporal analysis of sediment granulometry in Sector 2 has revealed significant differences between 2010 and 2017 both within each SSSI as a whole, and within a number of the component Habitat types. Further analysis has shown that the differences have resulted from changes in the proportions of silt and clay. However, the particle size analysis was carried out by different laboratories in 2010 and 2017. The NMBAQC scheme which provides external quality assurance services to laboratories engaged in the production of marine biological data has established that different laser diffraction units can vary relatively widely in the results they produce. Furthermore, different models can be applied within the same analysis unit. In 2010 the PSA was carried out by Ecospan Environmental Ltd, and at that time, the Faunhofer model was used. In 2017 the analysis was carried out by the NLS and Mie model was applied. The main difference in output that these two models produce are associated with the proportions of clay and silt fractions. Therefore it is considered highly likely that the significant differences in the sediment granulometry observed between sampling events are as a result of different analysis methods, rather than a representation of real broad scale change. The sediment composition and distribution of the mudflat and sandflat communities in Sector 2 of the SAC is therefore considered to be in a favourable condition.

Organic content derived from LOI analysis can be a function of organic enrichment (either from sources such as sewage or organic chemicals such as oils) as well as natural inputs such as plant or animal matter. Statistical analysis of organic content in sediments from both the Tamar Tavy and St. Johns Lake SSI and Lynher Estuary SSSI has shown a significant increase in the organic content of sediments since 2010. However, again methods of analysis between 2010 and 2017 differed. Although it is very unlikely that organic content will have increased generically across the Sector, it has not been possible to determine whether any real changes in this attribute have occurred because any such changes may have been masked by the different analysis methods. Consequently it has not been possible to make a meaningful assessment of the condition of the total organic content of the sediments within Sector 2.

Additional surface sediment samples for contaminant analysis were taken at 11 stations throughout the SAC: 5 in the Tamar-Tavy and St Johns Lake SSSI, 4 in the Lynher Estuary SSSI and 2 in the Yealm Estuary SSSI. The OSPAR EAC or ERL thresholds were breached at 9 of the stations. Within Sector 2, the concentrations of lead and 3 PAH compounds caused the exceedances. At one station in Sector 3 mercury and lead and every PAH analysed for, except Napthalene, exceeded the ERL or EAC, but in contrast, neither the ERL or EAC was exceeded for any analyte at the second station within the Sector.

Three INNS were recorded in 2017 within Sectors 1 and 3, these were *Caulacanthus spp.* and *Magallana gigas* which were identified within both Sectors 1 and 3, whilst *Sargassum muticum* was recorded only in Sector 1 (although this species is known to be common in the inshore periphery of the seagrass beds in Cellars Cove at the mouth of the Yealm). *Magallana gigas* was the only INNS to be recorded in Sector 2. Broad comparisons of the 2017 *Magallana gigas* abundance data in the Yealm estuary (Sector 3) has been compared with 2014/2015[23] survey data. Although different methods were employed and the 2014/2015[23] survey was more targeted, the data appears to show that the target of 'reducing the introduction and spread of INNS' has not been met in that area of the SAC. Also, given that the distribution of Pacific oyster does not appear to have changed within the Yealm estuary since 2010, it has been possible to assess the status of the relevant attribute as being in an unfavourable condition. The distribution and density of *Magallana gigas* in Newton Creek (which is outside of the SAC boundary) has been mapped and is broadly comparable with the 2014 data[23] and suggests no substantial changes in the abundance of *Magallana gigas* in Newton Creek since 2014.

7. CONCLUSION: SAC Preliminary Condition Assessment

The ability to make confident temporal comparisons of the attributes of the littoral habitats within Sectors 1 and 3 of the Plymouth Sound and Estuaries SAC study area has been limited, to some degree, by the application of different methods in previous studies. However, the attributes that have been selected by Natural England as specific objectives of this study have been addressed as far as possible in Tables 6 and 7 for Sectors 1 and 3, and Sector 2 respectively. The confidence of each recommended condition status has been provided based on the information available.

Table 7. Condition recommendation of attributes that, subject to natural change, contribute to defining the condition of the littoral habitat features of Sectors 1 and 3 of the Plymouth Sound and Estuaries SAC.

SAC Attribute	Target	Condition Recommendation
Littoral rock and littoral sediment - presence and spatial distribution of biological communities	Restore/Maintain the presence and spatial distribution of (subfeature) communities, according to the map.	Broad qualitative comparisons between 2001 and 2017 data suggest that the main habitat types, which are typical of the coastline in the southwest, have remained broadly similar between 2001 and 2017. The condition of this attribute is therefore **favourable**$^{\Delta}$ (low confidence).
Littoral rock and littoral sediment – presence of non-native species and pathogens	Reduce the introduction and spread of non-native species and pathogens, and their impacts	The INNS *Caulacanthus spp.* and *Magallana gigas* were identified within both Sectors 1 and 3, whilst *Sargassum muticum* was only found intertidally within Sector 1. A 2001 study mentions the presence of *Sargassum muticum* and *Magallana gigas* at that time, and broad qualitative comparisons with the 2017 results suggest that the distribution and abundance of both of these species have not changed substantially since 2001. However, there was no mention of *Caulacanthus* spp. in the 2001 report. As such, it can only be assumed that the distribution and abundance of *Caulacanthus* spp. has increased since 2001. The condition of this attribute must currently therefore be assessed as **unfavourable declining** $^{\Delta}$ (low confidence).
Littoral sediment - species composition of component communities	Maintain the species composition of component communities	No suitable baseline data exists with which to compare current results. Consequently it has not been possible to make temporal comparisons of the species composition of the mudflat and sandflat communities in Sectors 1 and 3 of the SAC. The condition of this attribute is therefore **unknown**$^{\Delta}$.

Littoral sediment -sediment composition and distribution	Maintain the existing distribution of sediment composition types across the feature.	Broad qualitative comparisons between 2001 and 2017 data suggest that the main mudflat and sandflat habitat types have remained broadly similar between 2001 and 2017. The condition of this attribute is therefore **favourable**$^{\Delta}$ (low confidence).
Littoral sediment - sediment total organic carbon content	Maintain total organic carbon (TOC) content in the sediment at existing levels	No suitable baseline data exists with which to compare current results. Consequently it has not been possible to make temporal comparisons of the TOC content in the sediments of the mudflat and sandflat communities in Sectors 1 and 3 of the SAC. The condition of this attribute is therefore **unknown**$^{\Delta}$.
Littoral sediment - sediment contaminants	Reduce surface sediment contaminants (<1cm from the surface) to below the OSPAR Environment Assessment Criteria (EAC) or Effects Range Low (ERL) threshold.	Data was not collected from Sector 1 for assessment of contaminants. Due to the absence of suitable baseline data it has not been possible to determine whether there have been temporal changes in the surface sediment contaminants in Sector 3, but the 2017 data shows numerous exceedances of the ERL or EAC limits at one station. Consequently this attribute has been assessed as in an **unfavourable condition** (high confidence).
Littoral rock and littoral sediment – habitat zonation	Maintain the estuary zonation, which is affected by both changes in salinity gradient and tides in the estuary from river to sea (horizontally) and with shore height (vertically) from terrestrial to subtidal.	Broad qualitative comparisons between 2001 and 2017 data suggest that the main habitat types, and therefore zonation patterns, have remained broadly similar between 2001 and 2017. The condition of this attribute is therefore **favourable**$^{\Delta}$ (low confidence).

Native oyster – presence and spatial distribution	Recover the presence and spatial distribution of the species.	Although recording but not specifically searching for native oysters (*Ostrea edulis*) was an objective, none were observed during the surveys. The INNS *Magallana gigas* was recorded however, and although no baseline data for *Ostrea edulis* exists with which to compare, it can only be assumed that the absence of the species on those transects and stations that were surveyed indicates that the species has not yet recovered within Sectors 1 and 3 of the SAC. It is therefore suggested that the condition of this attribute is assessed as **unfavourable** $^{\Delta}$ (moderate confidence)**.**

$^{\Delta}$ *This study provides either a full or partial baseline for future condition assessment of these*

Table 8. Condition recommendation of attributes that, subject to natural change, contribute to defining the condition of the littoral habitat features of Sector 2 of the Plymouth Sound and Estuaries SAC.

SAC Attribute	Target	Condition Recommendation
Littoral rock - presence and spatial distribution of biological communities	Restore/Maintain the presence and spatial distribution of (subfeature) communities, according to the map.	No changes in the extent or distribution of the littoral rock habitats were observed. Consequently this attribute is considered to be in **favourable** condition (high confidence).
Littoral sediment - presence and spatial distribution of biological communities	Restore/Maintain the presence and spatial distribution of (subfeature) communities, according to the map.	Some changes in this attribute have been observed. Most notably, mudflat polychaete communities characterised by the additional presence of the cockle *Cerastoderma edule* (LS.LSa.MuSa.CerPo) have increased in distribution and potentially extent in both in the Tamar-Tavy and St John's Lake SSSI and the Lynher Estuary SSSI. This is also the case for a small area of the LS.LMu.MEst.HedMacScr communities which are characterised by the presence of the bivalve

		Scrobicularia plana. The changes observed are likely to be attributable to natural estuarine processes and variable recruitment (or a combination of both) rather than anthropogenic influences, particularly as no significant human pressures were identified within the areas of *where* change has occurred. Consequently this attribute is considered to be in **favourable** condition (high confidence).
Presence of non-native species and pathogens	Reduce the introduction and spread of non-native species and pathogens, and their impacts	The INNS *Magallana gigas* was identified within the lower reaches of the Tamar-Tavy and in St Johns Lake in both 2010 and 2017. Given that the distribution of this species within Sector 2 does not appear to have changed since 2010 this attribute is considered to be in an **unfavourable** condition (high confidence).
Littoral rock – habitat zonation	Maintain the estuary zonation, which is affected by both changes in salinity gradient and tides in the estuary from river to sea (horizontally) and with shore height (vertically) from terrestrial to subtidal.	A comparison of the 2010 habitat type maps with those produced from the 2017 surveys has shown that no I differences in the communities have occurred as a result of natural variable recruitment, and that the zonation of communities along the estuaries as well as up the shores has largely remained unchanged. Consequently this attribute is considered to be in **favourable** condition (high confidence).
Littoral sediment – habitat zonation	Maintain the estuary zonation, which is affected by both changes in salinity gradient and tides in the estuary from river to sea (horizontally) and with shore height (vertically) from terrestrial to subtidal.	A comparison of the 2010 habitat type maps with those produced from the 2017 surveys has shown only minor differences in the communities have occurred as a result of natural variable recruitment, and that the zonation of communities along the estuaries as well as up the shores has largely remained unchanged. Consequently this attribute is considered to be in **favourable** condition (high confidence).

Native oyster – presence and spatial distribution	Recover the presence and spatial distribution of the species.	No native oysters (*Ostrea edulis*) were observed during the 2010 or 2017 surveys. Searching for this species was not a specific objective of this study, the species was only to be recorded if observed in the course of carrying out the Phase II sampling and Habitat type verification. Therefore the condition of this attribute must currently be assessed as **unknown**.
Littoral sediment - species composition of component communities	Maintain the species composition of component communities	Temporal analysis has shown that species richness within the Tamar-Tavy and St Johns Lake SSSI, and both species richness and diversity within the Lynher Estuary SSSI, has significantly increased since 2010. When considered at the Habitat type level, significant community differences were found in two Habitat types within the Tamar-Tavy and St Johns Lake SSSI, and one within the Lynher Estuary SSSI. The differences were largely driven by many small differences in the numbers of individual taxa, but were also a result of widespread increases in the numbers of oligochaetes within one habitat type in particular. These changes are considered to be as a result of natural variable population recruitment, and given that the overall richness has increased, this attribute is considered to be in **favourable** condition (high confidence).
Littoral sediment -sediment composition and distribution	Maintain the existing distribution of sediment composition types across the feature.	Analysis of the sediment granulometry both within each SSSI as a whole, and within a number of the component Habitat types has shown significant change in the proportions of silt and clay. However, given that the changes are almost entirely as a result of different proportions of silt and clay components only, and that it is very unlikely that a broad

		scale change in sediment character throughout the Sector has occurred, this differences observed are considered to be as a result of different particle size analysis methods. The sediment composition and distribution of the mudflat and sandflat communities in Sector 2 of the SAC is therefore considered to be in a **favourable** condition (high confidence).
Littoral sediment - sediment total organic carbon content	Maintain total organic carbon (TOC) content in the sediment at existing levels	Statistical analysis of LOI data from both the Tamar Tavy and St. Johns Lake SSI and Lynher Estuary SSSI has shown a significant increase in the organic content of sediments since 2010. However, methods of analysis between 2010 and 2017 differed, and as such, it is not possible to determine whether any real changes in this attribute have occurred as they may have been masked by the different analysis methods. Consequently it has not been possible to make temporal comparisons of the TOC content in the sediments of the mudflat and sandflat communities in Sector 2 of the SAC. The condition of this attribute is therefore **unknown**.
Littoral sediment - sediment contaminants	Reduce surface sediment contaminants (<1cm from the surface) to below the OSPAR Environment Assessment Criteria (EAC) or Effects Range Low (ERL) threshold.	Due to the absence of suitable baseline data it has not been possible to determine whether there have been temporal changes in the surface sediment contaminants in Sector 2, but the 2017 data shows numerous exceedances of the ERL or EAC limits at 7 of the 10 stations monitored for contaminants within the Tamar-Tavy and St Johns Lake SSSI and Lynher Estuary SSSI. Consequently this attribute has been assessed as in an **unfavourable** condition (high confidence).

Δ *This study provides either a full or partial baseline for future condition assessment of these*

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APPENDIX I

Table A. Littoral rock transect coordinates (OSGB 1936 BUG) and Habitat types identified during the Phase I survey in Sectors 1 and 3, and the vertical extent of each on the shore.

Station	Habitat Type (/ = mosaic)	Width of zone (m)	X	Y
R1	LR.HLR.MusB.Cht.Cht	5	248428	53185
	LR.MLR.BF.Fser.R	3		
	LR.HLR.FR.Him	5		
R2	LR.HLR.MusB.Cht.Cht	10	248751	52883
	LR.MLR.BF.LR.LLR.F.FvesB	40		
	LR.MLR.BF.Fser.R	10		
R3	LR.LLR.F.Fves	20	248899	52536
	LR.MLR.BF.Fser.R	17.5		
	LR.HLR.FR.Him	30		
	LR.HLR.FR.Him	5		
R4b	LR.HLR.MusB.Cht.Cht	3	249060	51896
	LR.MLR.BF.Fser.R	4		
	LR.HLR.FR.Him	1		
R4	LR.HLR.MusB.Cht.Cht	0.5	249116	52112
	LR.MLR.BF.LR.LLR.F.FvesB	20		
	LR.MLR.BF.Fser.R	2.5		
	LR.HLR.FR.Him	20		
R5	LR.HLR.MusB.Cht.Cht	2	248947	51692
	LR.HLR.FR.Osm	1.5		
	LR.HLR.FR.Him	1		
R6b	LR.HLR.MusB.Cht.Lpyg	0.25	248623	51375
	LR.HLR.MusB.Cht.Cht	4.5		
	LR.HLR.FR.Him	1		
R7	LR.HLR.MusB.Cht.Cht/LR.HLR.MusB.Cht.Lpyg	4	248698	50888
	LR.HLR.FR.Him	1		
R8	LR.HLR.MusB.Cht.Cht	15	248862	50611
	LR.HLR.FR.Him	1		
R9	LR.HLR.MusB.Cht.Lpyg	2	249090	50433
	LR.HLR.MusB.Cht.Cht	25		
	LR.HLR.MusB.SemSem	5		
	LR.HLR.FR.Him	5		
R10	LR.HLR.MusB.SemSem	1.5	249191	49936
	LR.HLR.FR.Mas	2		
	LR.HLR.FR.Him	4		
R11	LR.HLR.MusB.Cht.Lpyg	0.25	249027	49598
	LR.HLR.MusB.Cht.Cht	2		
	LR.HLR.FR.Osm	0.25		
	LR.HLR.FR.Mas	0.25		
	LR.HLR.FR.Him	1		
R12	LR.HLR.MusB.Cht.Lpyg	1	249107	49063
	LR.HLR.MusB.SemSem	2		
	LR.HLR.FR.Him	1		

Table A contd. Littoral rock transect coordinates (OSGB 1936 BUG) and Habitat types identified during the Phase I survey in Sectors 1 and 3, and the vertical extent of each on the shore.

Station	Habitat Type (/ = mosaic)	Width of zone (m)	X	Y
R13	LR.HLR.MusB.Cht.Lpyg	5	249022	48667
	LR.HLR.MusB.SemSem	3		
	LR.HLR.FR.Him	8		
R14	LR.HLR.MusB.Cht.Lpyg	0.25	249516	48690
	LR.MLR.BF.LR.LLR.F.FvesB	2		
	LR.HLR.FR.Him	0.5		
R15	LR.HLR.MusB.Cht.Lpyg	0.5	249613	48389
	LR.HLR.MusB.SemSem	2.5		
	LR.HLR.FR.Him	0.25		
R16	LR.HLR.MusB.SemSem	2	250054	48048
	LR.HLR.FR.Him	1		
R17	LR.HLR.MusB.Cht.Cht	1.5	250202	47455
	LR.HLR.FR.Mas	0.25		
	LR.HLR.FR.Him	0.5		
R18	LR.HLR.MusB.Cht.Cht	1	250769	48271
	LR.HLR.MusB.SemSem	0.5		
	LR.HLR.FR.Him	0.75		
R19	LR.HLR.MusB.Cht.Lpyg	1	251329	48292
	LR.HLR.MusB.Cht.Cht	3		
	LR.HLR.FR.Him	3		
R20	LR.HLR.MusB.Cht.Cht/LR.HLR.MusB.Cht.Lpyg	3	251748	48297
	LR.MLR.BF.LR.LLR.F.FvesB	2		
	LR.HLR.FR.Mas	0.25		
	LR.MLR.BF.Fser.R	2		
	LR.HLR.FR.Him	10		
R21	LR.HLR.MusB.Cht.Lpyg	1	252066	48282
	LR.MLR.BF.LR.LLR.F.FvesB	6.5		
	LR.HLR.FR.Him	2		
R22	LR.HLR.MusB.Cht.Cht	5	252566	48090
	LR.MLR.BF.LR.LLR.F.FvesB	2		
	LR.HLR.FR.Him	0.5		
R23	LR.HLR.MusB.Cht.Lpyg	0.25	252801	47863
	LR.LLR.F.Fspi	0.75		
	LR.HLR.MusB.Cht.Cht	2		
	LR.MLR.BF.Fser.R	2		
R24	LR.MLR.BF.PelB	0.25	253272	47962
	LR.HLR.MusB.Cht.Lpyg/LR.HLR.MusB.Cht.Cht	1		
	LR.HLR.MusB.Cht.Cht	8		
	LR.MLR.BF.Fser/LR.LLR.F.Fves	8		
R25	LR.HLR.MusB.Cht.Cht	2	253694	47747
	LR.LLR.F.FvesVS	8		

Table A contd. Littoral rock transect coordinates (OSGB 1936 BUG) and Habitat types identified during the Phase I survey in Sectors 1 and 3, and the vertical extent of each on the shore.

Station	Habitat Type (/ = mosaic)	Width of zone (m)	X	Y
R26	LR.LLR.FVS.PelVS	0.3	253821	47544
	LR.LLR.FVS.FspiVS	0.3		
	LR.LLR.FVS.AscVS	0.5		
	LR.LLR.F.FvesVS/Fserr.VS	7		
R27	LR.LLR.FVS.PelVS	0.2	253390	47758
	LR.HLR.MusB.SemSem/LR.HLR.FR.Osm	6		
	LR.MLR.BF.Fser.R	2.5		
R28	LR.HLR.MusB.Cht.Cht	2	253042	47529
	LR.LLR.F.Fves	3		
	LR.MLR.BF.Fser.R	2		
R29	LR.HLR.MusB.Cht.Cht	3.5	252524	47547
	LR.MLR.BF.LR.LLR.F.FvesB	2		
	LR.HLR.FR.Him	2		
R30	LR.HLR.MusB.Cht.Lpyg	3	245062	51378
	LR.HLR.MusB.Cht.Cht	3		
	FserR/LR.HLR.FR.Him	1		
R32	LR.HLR.MusB.Cht.Cht	2	244259	48681
	LR.MLR.BF.LR.LLR.F.FvesB	15		
	FserR/LR.HLR.FR.Him	0.5		
R33	LR.LLR.FVS.PelVS	0.2	253798	47997
	LR.LLR.FVS.FspiVS	0.25		
	LR.LLR.FVS.AscVS	2		
R34	LR.LLR.FVS.PelVS	0.5	252069	54032
	LR.LLR.FVS.Fcer	0.75		
	LR.LLR.FVS.AscVS	4		

Table B. The SACFOR abundance data collected from within each Habitat type on transects in Sectors 1 and 3.

Transect:	R1	R1	R1	R2	R2	R2	R2	R3	R3	R3	R4b	R4b	R4b	R4	R4	R4	R4	R5	R5	R5
Zone:	a	b	c	a	b	c	d	a	b	c	a	b	c	a	b	c	d	a	b	c
Width of zone (m):	5	3	5	10	40	10	5	20	18	30	3	4	1	0.5	20	2.5	20	2	1.5	1
Actinia equina																				
Chthamalus	C			A	F						A			A				A		
Semibalanus balanoides					F				C					F	F	O		F	C	
Anurida maritima																				
Spirorbis																				
Patella				C					F		C			C	C	F		C	C	
Littorina littorea																				
Littorina obtusata																				
Littorina saxatilis																				
Nucella lapillus														O	C	F		O		
Mytilus edulis																				
Magallana gigas					O															
Steromphala umbilicalis																				
Phorcus lineatus																				
Porphyra																				
Ceramium																				
Polysiphonia																				
Chaetomorpha																				
Gelidium			C																	
Osmundea pinnatifida		C										C				C			C	
Corallina officinalis							A		F	C						C	C			
Bifurcaria bifurcata																				
Ascophyllum nodosum								R								R				
Fucus ceranoides																				
Fucus serratus		S				S			A			A							R	
Fucus spiralis																				
Fucus vesiculosus					C			A				R			A					
Pelvetia canaliculata																				
Himanthalia elongata							A			A			A				S			A
Catenella caespitosa																				
Caulacanthus ustulatus		F				C		C	A			A			C	C			A	
Chondrus crispus			C																	
Mastocarpus stellatus			F			C			C			C								
Laminaria digitata																				
Saccorhiza polyschides																				
Nemalion elminthoides																				
Palmaria palmata			C			C														
Colpomenia peregrina																				
Ulva lactuca																			R	
Lichina pygmaea																				
Verrucaria maura																				
Verrucaria mucosa																				
Ulva intestinalis																				
Sargassum muticum			O														C			
Orange sponge																				

Table B contd. The SACFOR abundance data collected from within each Habitat type on transects in Sectors 1 and 3.

Transect:	R6b	R6b	R6b	R7	R7	R8	R8	R9	R9	R9	R9	R10	R10	R10	R11	R11	R11	R11	R11
Zone:	a	b	c	a	b	a	b	a	b	c	d	a	b	c	a	b	c	d	e
Width of zone (m):	0.3	4.5	Him	4	1	15	1	2	25	5	5	1.5	2	4	0.3	2	0.3	0.3	1
Actinia equina										O									
Chthamalus	A	A		A		C		A	S	S		O			S	S			
Semibalanus balanoides		F		O	O	O					O	S	A		O			O	
Anurida maritima		O				O													
Spirorbis																			
Patella	C	C		C		C		F	C	A	C	C	F	F	O	F	C	C	
Littorina littorea																			
Littorina obtusata																			
Littorina saxatilis	C	C		C		O			F	F									
Nucella lapillus						C			F	F	O		C				F		
Mytilus edulis																			
Magallana gigas																			
Steromphala umbilicalis																			
Phorcus lineatus																F			
Porphyra						R													
Ceramium											O								
Polysiphonia													C						
Chaetomorpha																			
Gelidium															O		C		
Osmundea pinnatifida											F						A		
Corallina officinalis			A		C		A			F	A						C		
Bifurcaria bifurcata																	R		
Ascophyllum nodosum																			
Fucus ceranoides																			
Fucus serratus															O				
Fucus spiralis																			
Fucus vesiculosus																			
Pelvetia canaliculata																			
Himanthalia elongata			A		A		S				S			A			R		C
Catenella caespitosa																			
Caulacanthus ustulatus																			
Chondrus crispus															C				
Mastocarpus stellatus							C				C		C	A				C	C
Laminaria digitata														O					
Saccorhiza polyschides														R					
Nemalion elminthoides										R									
Palmaria palmata															O				
Colpomenia peregrina																			
Ulva lactuca									O	O	R								
Lichina pygmaea	C			F				C							C				
Verrucaria maura						C													
Verrucaria mucosa										O									
Ulva intestinalis						O													
Sargassum muticum																			
Orange sponge									R	R									

Table B contd. The SACFOR abundance data collected from within each Habitat type on transects in Sectors 1 and 3.

Transect:	R12	R12	R12	R13	R13	R13	R14	R14	R14	R15	R15	R15	R16	R16	R17	R17	R17	R18	R18	R18
Zone:	a	b	c	a	b	c	a	b	c	a	b	c	a	b	a	b	c	a	b	c
Width of zone (m):	1	2	1	5	3	8	0.3	2	0.5	0.5	2.5	0.3	2	1	1.5	0.3	0.5	1	0.5	0.8
Actinia equina																				
Chthamalus	O			S			S	C		S	O				S			A		
Semibalanus balanoides	A	S			S			A			A		A						C	C
Anurida maritima																				
Spirorbis																				
Patella	C	C		C	C		C	C		C	C		C		C			C	C	
Littorina littorea																				
Littorina obtusata																				
Littorina saxatilis		F		C																
Nucella lapillus		C		O				C												
Mytilus edulis																				
Magallana gigas																				
Steromphala umbilicalis																				
Phorcus lineatus																				
Porphyra																				
Ceramium																				O
Polysiphonia														O						
Chaetomorpha																				
Gelidium														C						
Osmundea pinnatifida																				
Corallina officinalis		O	C		O	A			A			A		A		A	A			A
Bifurcaria bifurcata																				
Ascophyllum nodosum																				
Fucus ceranoides																				
Fucus serratus						A														
Fucus spiralis																				
Fucus vesiculosus								C												
Pelvetia canaliculata																				
Himanthalia elongata			A			C			A			A		A			A			A
Catenella caespitosa																				
Caulacanthus ustulatus																				
Chondrus crispus																				F
Mastocarpus stellatus			C			F						C				A	C			C
Laminaria digitata																				
Saccorhiza polyschides																				
Nemalion elminthoides																			C	
Palmaria palmata																				
Colpomenia peregrina																				
Ulva lactuca						R														R
Lichina pygmaea	C			A			C			C										
Verrucaria maura																				
Verrucaria mucosa																			C	
Ulva intestinalis																				
Sargassum muticum																				
Orange sponge																		R		

Table B contd. The SACFOR abundance data collected from within each Habitat type on transects in Sectors 1 and 3.

Transect:	R19	R19	R19	R20	R20	R20	R20	R20	R21	R21	R21	R22	R22	R22	R23	R23	R23	R23
Zone:	a	b	c	a	b	c	d	e	a	b	c	a	b	c	a	b	c	d
Width of zone (m):	1	3	3	3	2	0.3	2	10	1	6.5	2	5	2	0.5	0.3	0.8	2	2
Actinia equina																		
Chthamalus	A	S		A	C				A	A		S	C				A	
Semibalanus balanoides		F	A	O	O	F	F	F	C	A		F	S				O	
Anurida maritima																		
Spirorbis																		
Patella	F	F	C						C			F	C				C	
Littorina littorea	F	F								A		C	C					
Littorina obtusata																		
Littorina saxatilis						O	F	F	C								F	
Nucella lapillus										F								C
Mytilus edulis		R										O	F					
Magallana gigas																		
Steromphala umbilicalis																		
Phorcus lineatus			O						O									
Porphyra																		
Ceramium			C															
Polysiphonia																		
Chaetomorpha						F	F	F										
Gelidium																		
Osmundea pinnatifida					F			F									O	
Corallina officinalis			A/S				C	C										
Bifurcaria bifurcata																		
Ascophyllum nodosum																		
Fucus ceranoides																		
Fucus serratus							A	C										A
Fucus spiralis																C		
Fucus vesiculosus					A					F			A					
Pelvetia canaliculata															O			
Himanthalia elongata			A				O	S			A			A				
Catenella caespitosa																		
Caulacanthus ustulatus							C/A						R					C
Chondrus crispus						F	C											
Mastocarpus stellatus			A			A	C	C										
Laminaria digitata																		
Saccorhiza polyschides																		
Nemalion elminthoides			O															
Palmaria palmata							F											
Colpomenia peregrina																	O	
Ulva lactuca							O											
Lichina pygmaea				C					A			R			A			
Verrucaria maura																		
Verrucaria mucosa			C							R								
Ulva intestinalis			R															
Sargassum muticum																		
Orange sponge																		

Table B contd. The SACFOR abundance data collected from within each Habitat type on transects in Sectors 1 and 3.

Transect:	R24	R24	R24	R24	R25	R25	R26	R26	R26	R26	R27	R27	R27	R29	R29	R29	R30	R30	R30
Zone:	a	b	c	c	a	b	a	b	c	d	a	b	c	a	b	c	a	b	c
Width of zone (m):	0.3	1	8	8	2	8	0.3	0.3	0.5	7	0.2	6	2.5	3.5	2	2	3	3	1
Actinia equina																			
Chthamalus	C	A	A		F									A	A		A	S	
Semibalanus balanoides		O										A	C			F			
Anurida maritima																			
Spirorbis																			
Patella		C			C					C		C	O		C	F			
Littorina littorea																			
Littorina obtusata																			
Littorina saxatilis					F														
Nucella lapillus													C						
Mytilus edulis																			
Magallana gigas																			
Steromphala umbilicalis																			
Phorcus lineatus		C			C	C				C		C	C						
Porphyra																			
Ceramium																			
Polysiphonia																			
Chaetomorpha																			
Gelidium																			
Osmundea pinnatifida										O		A	A			C			
Corallina officinalis																O		C	
Bifurcaria bifurcata																			
Ascophyllum nodosum									A	O									
Fucus ceranoides																			
Fucus serratus				S						A			A						A
Fucus spiralis								A											
Fucus vesiculosus				A	R	A				C		R			F				
Pelvetia canaliculata	C/A						A				C								
Himanthalia elongata										R						A			A
Catenella caespitosa																			
Caulacanthus ustulatus										C		O	C					F	
Chondrus crispus																			
Mastocarpus stellatus													A			C			
Laminaria digitata																			
Saccorhiza polyschides																			
Nemalion elminthoides																			
Palmaria palmata																			
Colpomenia peregrina															C				
Ulva lactuca																			
Lichina pygmaea																	C		
Verrucaria maura	A																		
Verrucaria mucosa																			
Ulva intestinalis																			
Sargassum muticum																			
Orange sponge												R							

Table B contd. The SACFOR abundance data collected from within each Habitat type on transects in Sectors 1 and 3.

Transect:	R31	R31	R31	R32	R32	R32
Zone:	a	b	c	a	b	c
Width of zone (m):	1	2	2	2	15	0.5
Actinia equina					O	
Chthamalus	A	A		S	S	
Semibalanus balanoides			F		F	
Anurida maritima						
Spirorbis						
Patella		C	F	C	C	
Littorina littorea						
Littorina obtusata						
Littorina saxatilis					F	
Nucella lapillus						
Mytilus edulis					F	
Magallana gigas						
Steromphala umbilicalis					O	
Phorcus lineatus						
Porphyra						
Ceramium						
Polysiphonia						
Chaetomorpha						
Gelidium						
Osmundea pinnatifida						
Corallina officinalis			A			F
Bifurcaria bifurcata						
Ascophyllum nodosum						
Fucus ceranoides						
Fucus serratus						A
Fucus spiralis						
Fucus vesiculosus					O	
Pelvetia canaliculata						
Himanthalia elongata			A			A
Catenella caespitosa						
Caulacanthus ustulatus						
Chondrus crispus						
Mastocarpus stellatus			C			
Laminaria digitata						
Saccorhiza polyschides						
Nemalion elminthoides					O	
Palmaria palmata						
Colpomenia peregrina						
Ulva lactuca						
Lichina pygmaea	C			A	F	
Verrucaria maura					O	
Verrucaria mucosa						
Ulva intestinalis						
Sargassum muticum						
Orange sponge						

APPENDIX 2

Table A. Littoral sediment Phase II sample station coordinates (OSGB 1936 BUG) and Habitat types assigned in Sector 1.

Station No.	Habitat Type 2017	X	Y
P19	LS.LSa.MoSa.AmSco.Pon	251636	48380
P20	LS.LSa.FiSa.Po	251587	48395
P21	LS.LSa.MoSa.AmSco.Sco	251627	48432
P22	LS.LSa.MoSa.BarSa	251641	48461
P23	LS.LSa.MoSa.AmSco.Eur	251001	48384
P24	LS.LSa.MoSa.AmSco.Eur	251010	48426
P25	LS.LSa.MoSa.Ol.FS	250674	48475
P26	LS.LSa.MoSa.Ol.FS	250598	48481
P27	LS.LSa.MoSa.Ol.FS	250648	48482
P28	LS.LSa.MoSa.Ol.FS	250551	48482
P29	LS.LSa.MoSa.Ol.FS	250489	48477
P30	LS.LSa.St.Tal	250455	48469
P31	LS.LSa.FiSa.Po	249223	49855
P32	LS.LSa.MoSa.AmSco.Sco	249214	50137
P33	LS.LSa.MoSa.AmSco.Sco	249204	50149
P34	LS.LSa.FiSa.Po	249162	50272
P35	LS.LSa.MoSa.AmSco.Pon	249129	50502
P36	LS.LSa.MoSa.AmSco.Sco	249205	50525
P37	LS.LSa.MoSa.AmSco.Sco	249187	50585
P38	LS.LSa.MoSa.AmSco.Pon	249123	50532
P39	LS.LSa.MoSa.AmSco.Pon	249076	50598
P40	LS.LSa.MoSa.AmSco.Sco	248669	50766
P41	LS.LSa.MoSa.AmSco.Eur	248792	51541
P42	LS.LSa.FiSa.Po	248892	52765
P43	LS.LSa.FiSa.Po	248933	52786

Table B. Littoral sediment Phase II sample station coordinates (OSGB 1936 BUG) and Habitat types assigned in Sector 2.

Station No.	Habitat Type 2010	Habitat Type Change 2017	Distance and Direction Station Moved in 2017 from that in 2010	X	Y
B1	LS.LMu.Uest.Hed.Cvol	-	-	242570	68450
B2	LS.LMu.Uest.Hed.Cvol	-	-	242377	67670
B3	LS.LMx.GvMu.HedMx.Cvol	-	-	242762	67250
B4	LS.LMu.Uest.Hed.Ol	-	-	242803	67073
B5	LS.LMu.Uest.Hed.Cvol	-	-	242799	66556
B6	LS.LMu.Uest.Hed.Cvol	-	-	242508	66209
B7	LS.LMu.Uest.Hed.Cvol	-	-	242298	66107
B8	LS.LMu.Uest.Hed.Ol	-	-	241716	65575
B9	LS.LMu.Mest.HedMacScr	-	-	242296	64950
B10	LS.LSa.MuSa.CerPo	-	-	243346	63563
B11	LS.LMu.Mest.HedMacScr	-	-	242537	65233
B12	LS.LMu.Mest.HedMacScr	-	-	243683	63570
B13	LS.LSa.MuSa.CerPo	-	-	244492	61548
B14	LS.LSa.MuSa.CerPo	-	-	245507	61882
B15	LS.LMu.Mest.HedMacScr	-	-	245808	62578
B16	LS.LMu.Mest.HedMacScr	-	-	246382	63372
B17	LS.LMu.Uest.Hed.Str	-	-	246396	63719
B18	LS.LMu.Uest.Hed.Str	-	-	247092	64060
B19	LS.LMu.Mest.HedMacScr	-	-	244916	60624
B20	LS.LMu.Uest.NhomStr	-	-	245076	60642
B21	LS.LMu.Uest.Hed.Ol	-	-	245065	60537
B22	LS.LSa.MuSa.CerPo	-	-	244025	60393
B23	LS.LMx.Mx.CirCer	-	-	243954	59898
B24	LS.LSa.MuSa.CerPo	-	-	243833	59386
B25	LS.LMx.Mx.CirCer	-	-	243842	60231
B26	LS.LMu.Mest.NhomMacStr	LS.LSa.MuSa.CerPo	-	243116	59622
B27	LS.LMu.Mest.NhomMacStr	LS.LSa.MuSa.CerPo	-	243131	59969
B28	LS.LMu.Mest.NhomMacStr	LS.LMu.Mest.HedMacScr	-	242070	60729
B29	LS.LSa.MuSa.CerPo	-	-	242628	54051
B30	LS.LSa.MuSa.CerPo	-	-	244210	53265
B31	LS.LSa.MuSa.MacAre	LS.LSa.MuSa.CerPo	-	242048	54154
B32	LS.LMu.Mest.HedMacScr	-	-	241228	53991
B33	LS.LSa.MuSa.MacAre	-	-	241695	53989
B34	LS.LSa.MuSa.CerPo	-	-	242635	54370
B35	LS.LMu.Uest.NhomStr	-	-	242879	54476
B36	LS.LSa.MuSa.CerPo	-	-	243240	54579
B37	LS.LSa.MuSa.CerPo	-	-	243738	54052
B38	LS.LMu.Uest.Tben	-	-	242703	68822
B39	LS.LSa.MuSa.Lan	-	-	243846	60388
B40	LS.LMu.Mest.HedMacScr	-	-	243634	62405
B41	LS.LSa.MuSa.CerPo	-	-	243235	60564
B42	LS.LMx.Mx.CirCer	-	70 m to east as mixed sediments had shifted slightly higher on the shore	243949	59740
B43	LS.LSa.FiSa.Po	-	20 m to southeast as main channel had shifted slightly	245289	61672
B44	LS.LMu.Mest.HedMacScr	-	-	246248	63607
B45	LS.LMx.Mx.CirCer	-	-	243833	60370
B46	LS.LSa.MuSa.Lan	LS.LMx.Mx.CirCer	-	243391	60754
B47	LS.LMu.Uest.Hed.Ol	-	-	243136	68757
B48	LS.LMu.Mest.HedMacScr	-	-	241812	64251
B49	LS.LMu.Uest.Hed.Cvol	-	-	244637	68823

Table B contd. Littoral sediment Phase II sample station coordinates (OSGB 1936 BUG) and Habitat types assigned in Sector 2.

Station No.	Habitat Type 2010	Habitat Type Change 2017	Distance and Direction Station Moved in 2017 from that in 2010	X	Y
C1	LS.LMu.Uest.NhomStr	-	-	240566	56633
C2	LS.LMu.Uest.HedCvol	-	-	239902	56737
C3	LS.LMu.Uest.NhomStr	-	-	240310	56911
C4	LS.LMx.GvMu.HedMxCir	-	-	240421	56857
C5	LS.LMu.Uest.NhomStr	-	-	240231	56265
C6	LS.LMu.Uest.NhomStr	-	-	240039	56194
C7	LS.LSa.MuSa.CerPo	-	-	239220	56113
C8	LS.LSa.MuSa.CerPo	-	-	239197	56387
C9	LS.LSa.MuSa.CerPo	-	-	238807	56107
C10	LS.LSa.MuSa.CerPo	-	-	238888	56471
C11	LS.LMu.Uest.NhomStr	-	-	238662	55633
C12	LS.LMu.Uest.Hed.Str	-	-	237414	56390
C13	LS.LMu.Uest.Hed.Str	-	-	237175	56543
C14	LS.LMu.Mest.HedMacScr	-	-	237432	56509
C15	LS.LMu.Uest.Hed.Str	-	-	236990	56670
C16	LS.LMu.Mest.HedMacScr	-	-	237169	56929
C17	LS.LMu.Mest.HedMacScr	-	-	236591	56971
C18	LS.LMu.Uest.HedCvol	-	-	235116	56984
C19	LS.LMu.Uest.Hed.Str	-	-	236465	57364
C20	LS.LMu.Uest.HedCvol	-	-	236472	57954
C21	LS.LMu.Uest.HedCvol	-	-	236295	58422
C22	LS.LMu.Mest.HedMacScr	-	-	237389	57395
C23	LS.LMu.Uest.HedCvol	-	-	238033	58577
C24	LS.LC.SSh.BarSa	-	-	237622	56105
C25	LS.LMu.Uest.Hed.Str	-	-	238834	55173
C26	LS.LMu.Uest.Hed.Str	-	-	238841	55044
C27	LS.Lmu.Mest.HedMac	-	-	238271	54932
C28	LS.Lmu.Mest.NhomMacStr	-	-	239192	55535
C29	LS.Lmu.Mest.NhomMacStr	LS.LSa.MuSa.CerPo	-	240148	55586
C30	LS.Lmu.Mest.NhomMacStr	-	-	240807	56055

Table C. Littoral sediment Phase II sample station coordinates (OSGB 1936 BUG) and Habitat types assigned in Sector 3.

Station No.	Habitat Type 2017	X	Y
Y1	LS.LMu.UEst.NhomStr	253844	48560
Y2	LS.LMu.UEst.NhomStr	253805	48511
Y3	LS.LMu.UEst.NhomStr	253778	48504
Y4	LS.LMx.Mx	253801	48123
Y5	LS.LMu.UEst.NhomStr	253807	48033
Y6	LS.LMu.UEst.NhomStr	253834	47970
Y7	LS.LSa.MuSa.CerPo	253887	47858
Y8	LS.LSa.FiSa.Po	253889	47772
Y9	LS.LSa.FiSa.Po	253835	47758
Y10	LS.LSa.MuSa.CerPo	253675	47727
Y11	LS.LMx.Mx	253518	47838
Y12	LS.LMx.Mx	253382	47930
Y13	LS.LMx.Mx	253991	47671
Y14	LS.LMx.Mx	253872	47560
Y15	LS.LMx.Mx	253565	47613
Y16	LS.LSa.FiSa.Po	253079	47605
Y17	LS.LSa.FiSa.Po	253077	47621
Y18	LS.LSa.FiSa.Po	253032	47555

APPENDIX 3

Table A1. Sector 1 Sediment Particle Size and Organic Content.

Station	<3.91 to 62.5 µm Silt and Clay	62.5 to 125 µm Very fine sand	125 to 250 µm Fine sand	250 to 500 µm Medium sand	500 to 1000 µm Coarse sand	1000 to 2000 µm Very coarse sand	2000 to 4000 µm Granules	>4000 µm Pebbles	% Loss on Ignition @ 500°C
P19	0.0	0.1	19.8	58.3	21.7	0.2	0.0	0.0	1.9
P20	0.5	0.4	22.5	57.1	19.4	0.1	0.0	0.0	1.8
P21	0.0	0.1	13.9	50.6	27.5	3.0	1.8	3.2	1.6
P22	0.0	0.1	16.4	54.4	27.3	1.0	0.5	0.3	1.6
P23	0.0	0.0	7.2	44.7	43.2	2.5	1.1	1.4	1.7
P24	0.0	0.0	4.8	46.6	47.2	0.8	0.3	0.2	1.8
P25	0.0	0.6	0.9	11.5	33.8	31.4	8.3	13.5	1.2
P26	0.1	0.3	0.3	13.7	29.7	19.4	15.4	21.2	1.4
P27	0.1	0.3	0.6	12.8	23.6	16.4	13.9	32.2	1.5
P28	0.3	0.3	0.4	8.4	19.1	17.8	26.4	27.3	1.4
P29	1.5	1.5	1.3	17.0	38.8	27.2	8.8	3.7	1.9
P30	0.0	0.0	0.0	4.1	24.5	47.4	20.7	3.2	0.1
P31	3.3	3.9	3.9	19.8	54.2	7.1	2.3	5.6	0.7
P32	0.0	0.0	7.4	51.6	38.7	0.8	0.4	1.2	0.3
P33	0.0	0.0	3.2	42.0	53.1	1.1	0.5	0.0	0.3
P34	0.0	0.0	0.7	27.3	49.5	9.9	5.9	6.6	1.2
P35	0.0	0.0	10.2	50.9	38.1	0.6	0.1	0.0	0.4
P36	0.0	0.0	3.5	44.4	51.7	0.3	0.0	0.0	0.3
P37	0.0	0.0	3.4	42.8	52.4	1.1	0.3	0.1	0.3
P38	0.0	0.1	16.1	55.7	27.9	0.1	0.0	0.0	0.4
P39	0.2	0.1	11.3	51.3	36.3	0.7	0.2	0.0	0.3
P40	0.7	2.0	29.4	50.5	17.3	0.1	0.0	0.0	0.4
P41	0.5	0.1	3.1	10.4	9.1	16.4	21.5	38.9	0.6
P42	0.8	1.6	31.4	46.0	10.6	5.1	2.0	2.5	0.5
P43	0.6	0.8	35.5	55.6	7.3	0.1	0.0	0.0	0.5

Table A2. Sector 2: Tamar-Tavy and St Johns Lake SSSI Sediment Particle Size and Organic Content.

Station	<3.91 to 62.5 µm Silt and Clay	62.5 to 125 µm Very fine sand	125 to 250 µm Fine sand	250 to 500 µm Medium sand	500 to 1000 µm Coarse sand	1000 to 2000 µm Very coarse sand	2000 to 4000 µm Granules	>4000 µm Pebbles	% Loss on Ignition @ 500°C
B1	63.8	21.1	10.5	3.3	1.0	0.1	0.1	0.2	13.6
B2	59.2	16.7	8.0	3.0	1.8	0.3	0.6	10.3	13.4
B3	15.5	4.4	3.3	4.4	5.8	7.8	8.5	50.4	-
B4	50.2	11.1	6.1	3.1	0.8	5.6	6.7	16.3	40.8
B5	69.8	21.3	8.8	0.2	0.0	0.0	0.0	0.0	30.2
B6	67.5	18.1	8.9	3.9	1.4	0.1	0.0	0.0	12.1
B7	68.3	18.5	9.4	3.1	0.8	0.0	0.0	0.0	18.7
B8	72.8	14.7	8.1	3.4	0.9	0.0	0.0	0.1	13.6
B9	68.2	17.0	9.1	4.0	1.4	0.2	0.1	0.0	16.4
B10	49.1	13.6	7.4	5.3	2.6	5.9	6.3	9.7	18.5
B11	59.2	20.0	10.8	5.7	3.9	0.2	0.2	0.1	52.7
B12	65.0	20.1	10.4	4.1	0.1	0.1	0.1	0.0	12.0
B13	57.6	23.4	11.5	3.5	2.0	0.2	0.1	1.8	8.0
B14	40.5	13.2	25.1	17.2	3.2	0.2	0.1	0.5	7.3
B15	68.1	16.9	8.2	4.3	1.6	0.2	0.1	0.7	15.1
B16	74.5	15.4	7.0	2.4	0.7	0.0	0.0	0.0	53.0
B17	72.1	15.9	7.6	3.1	1.1	0.1	0.0	0.0	30.7
B18	73.2	16.9	7.1	2.2	0.5	0.0	0.0	0.0	31.5
B19	73.6	15.2	7.3	2.6	0.6	0.2	0.3	0.2	33.0
B20	70.8	12.5	7.7	4.7	2.6	0.5	0.6	0.8	44.5
B21	70.9	16.2	7.9	3.2	1.5	0.2	0.0	0.0	49.6
B22	55.3	25.8	8.9	4.0	3.0	0.1	0.2	2.8	10.6
B23	53.2	17.0	7.4	3.7	3.7	2.5	3.0	9.8	16.7
B24	48.5	19.1	9.6	2.8	1.6	1.0	1.6	15.9	12.7
B25	13.2	14.4	18.1	11.7	8.2	12.4	13.3	8.7	4.5
B26	73.2	14.6	5.1	2.3	0.5	0.4	0.2	3.7	21.0
B27	75.6	14.6	5.8	2.7	0.3	0.3	0.4	0.3	10.3
B28	70.2	12.3	7.2	5.0	1.0	1.5	1.3	1.5	11.7
B29	63.9	13.2	5.3	2.5	0.9	2.9	1.9	9.5	24.9
B30	59.3	17.7	9.0	5.3	1.1	1.8	1.5	4.4	6.1
B31	71.5	17.1	6.9	1.9	0.0	1.0	0.5	1.2	11.7
B32	83.4	12.4	3.6	0.4	0.0	0.1	0.1	0.0	8.9
B33	78.2	15.5	4.4	1.5	0.0	0.0	0.1	0.2	9.6
B34	68.5	21.7	7.5	2.1	0.1	0.1	0.1	0.0	11.9
B35	69.9	19.6	6.9	2.6	0.8	0.1	0.1	0.0	32.8
B36	72.9	18.3	7.0	0.8	0.0	0.2	0.4	0.4	17.3
B37	48.6	29.7	17.1	1.8	0.1	0.7	0.5	1.5	4.1
B38	65.0	18.1	10.3	4.4	2.1	0.1	0.1	0.0	22.3
B39	17.3	13.9	16.1	13.3	13.3	8.2	10.9	7.1	7.5
B40	77.7	13.4	5.5	2.3	0.8	0.1	0.1	0.1	35.3
B41	72.5	14.8	6.2	3.0	0.6	0.3	0.4	2.3	-
B42	45.6	16.9	9.5	5.9	7.9	4.2	2.6	7.3	7.4
B43	4.4	0.5	18.5	47.9	21.9	6.4	0.4	0.0	2.0
B44	67.6	18.9	9.4	3.9	0.2	0.1	0.0	0.0	11.8
B45	16.9	7.2	8.0	7.1	7.4	17.7	16.0	19.8	4.3
B46	40.3	10.8	6.3	5.0	5.1	11.5	9.6	11.5	6.8
B47	62.8	21.0	10.7	4.5	0.7	0.1	0.0	0.0	13.2
B48	61.1	20.1	11.3	5.2	2.1	0.1	0.0	0.0	12.5
B49	62.7	22.8	11.2	3.2	0.1	0.0	0.0	0.0	-

Table A3. Sector 2: Lynher Estuary SSSI Sediment Particle Size and Organic Content.

Station	<3.91 to 62.5 µm Silt and Clay	62.5 to 125 µm Very fine sand	125 to 250 µm Fine sand	250 to 500 µm Medium sand	500 to 1000 µm Coarse sand	1000 to 2000 µm Very coarse sand	2000 to 4000 µm Granules	>4000 µm Pebbles	% Loss on Ignition @ 500°C
C1	51.7	19.7	11.6	7.9	7.1	0.9	0.8	0.4	9.1
C2	73.6	10.3	6.2	5.0	0.9	1.1	1.1	1.9	7.5
C3	58.9	19.1	10.2	5.6	3.5	0.6	1.0	1.1	6.8
C4	36.0	7.4	5.2	7.1	6.9	8.5	6.4	22.6	5.0
C5	55.6	17.2	10.6	8.4	6.8	0.4	0.5	0.6	11.6
C6	57.5	16.1	10.0	8.3	7.1	0.3	0.4	0.3	12.1
C7	73.9	17.4	7.1	1.7	0.0	0.0	0.0	0.0	10.0
C8	77.8	13.8	5.1	1.9	0.1	0.1	0.1	1.1	17.9
C9	80.4	12.4	4.4	1.5	0.2	0.2	0.2	0.8	-
C10	74.5	13.7	6.9	2.9	0.0	0.1	0.2	1.8	9.4
C11	67.9	18.3	8.5	4.2	1.0	0.1	0.1	0.0	9.2
C12	60.5	21.2	12.1	4.8	0.6	0.4	0.3	0.2	8.8
C13	17.4	9.3	26.3	26.6	9.5	4.1	4.8	2.1	3.6
C14	64.2	18.1	10.2	5.2	1.8	0.1	0.1	0.2	9.1
C15	63.3	21.6	9.9	3.2	1.6	0.1	0.1	0.1	7.8
C16	61.6	19.9	10.8	5.0	2.0	0.1	0.1	0.5	8.2
C17	54.4	21.1	12.9	6.4	3.7	0.3	0.4	0.7	8.7
C18	82.2	11.7	4.7	1.4	0.1	0.0	0.0	0.0	21.5
C19	68.5	16.4	9.1	4.2	1.3	0.1	0.1	0.2	12.0
C20	73.9	15.5	6.4	3.6	0.7	0.0	0.0	0.0	-
C21	79.5	13.5	4.8	1.7	0.5	0.0	0.0	0.0	11.8
C22	76.2	15.2	6.3	2.0	0.2	0.0	0.0	0.0	-
C23	71.1	15.9	8.0	3.4	1.5	0.0	0.0	0.0	11.3
C24	6.4	1.2	16.2	37.7	16.8	6.1	6.8	8.7	1.6
C25	77.6	11.9	5.9	3.4	1.1	0.0	0.1	0.1	9.8
C26	70.2	15.5	7.9	3.9	1.9	0.2	0.3	0.2	9.5
C27	79.5	10.8	7.1	2.2	0.0	0.1	0.1	0.1	10.1
C28	75.3	15.0	6.2	3.0	0.3	0.1	0.1	0.0	9.9
C29	71.2	13.1	5.4	2.0	0.2	0.2	0.3	7.8	9.9
C30	77.3	12.5	5.1	2.3	0.3	0.8	0.8	0.8	-

Table A4. Sector 3 Sediment Particle Size and Organic Content.

Station	<3.91 to 62.5 µm Silt and Clay	62.5 to 125 µm Very fine sand	125 to 250 µm Fine sand	250 to 500 µm Medium sand	500 to 1000 µm Coarse sand	1000 to 2000 µm Very coarse sand	2000 to 4000 µm Granules	>4000 µm Pebbles	% Loss on Ignition @ 500°C
Y1	44.2	19.6	16.3	9.4	4.1	0.3	0.2	0.1	23.5
Y2	42.7	21.9	18.3	8.3	3.5	0.3	0.3	0.2	38.7
Y3	53.4	17.3	9.5	3.5	1.5	0.4	0.7	7.8	31.2
Y4	29.4	12.5	9.9	6.4	4.0	6.6	8.0	19.4	3.4
Y5	43.7	20.7	17.5	8.4	3.2	0.4	0.5	0.5	27.4
Y6	46.3	18.8	14.7	8.0	3.7	0.8	0.6	2.6	18.8
Y7	11.7	19.9	34.9	22.1	6.1	1.1	1.5	1.9	9.6
Y8	7.7	12.5	40.2	30.0	6.6	0.7	0.9	0.6	4.0
Y9	9.8	16.2	38.0	24.8	5.5	2.4	1.8	0.7	5.0
Y10	5.7	7.5	16.1	11.0	4.3	19.6	23.4	12.0	3.3
Y11	2.8	2.9	6.8	8.0	4.9	3.2	4.3	66.8	4.2
Y12	7.9	6.6	9.3	8.2	6.5	14.1	12.8	33.6	2.9
Y13	9.6	6.7	7.6	8.8	9.8	7.2	8.4	41.1	3.2
Y14	4.1	1.9	1.5	7.6	19.9	14.6	16.3	33.7	1.5
Y15	7.4	2.8	4.7	10.8	15.0	21.2	15.6	21.6	1.7
Y16	2.1	6.3	32.5	21.3	1.2	6.3	15.1	15.1	2.4
Y17	1.4	4.4	19.3	11.3	0.5	10.4	20.5	32.1	1.8
Y18	1.7	4.2	27.6	35.3	13.7	5.3	4.9	7.3	2.0

APPENDIX 4

Table A1. Tamar-Tavy and St Johns Lake SSSI Simper Analysis results: Species contributing the most to the infaunal communities between years

Species	Mean Abundance per Station 2010	Mean Abundance per Station 2017	Mean Dissimilarity	% Contribution	Cumulative % Contribution
Peringia ulvae	4.7	4.9	10.9	14.2	14.2
Baltidrilus costatus	2.4	3.1	8.3	10.8	25.0
Tubificoides benedii	2.5	2.4	5.8	7.5	32.5
Tharyx Type A	2.5	1.0	5.1	6.6	39.1
Streblospio	2.7	2.5	4.9	6.4	45.5
Hediste diversicolor	1.3	1.4	3.9	5.1	50.5
Pygospio elegans	1.5	1.0	3.1	4.1	54.6
Tubificoides pseudogaster agg	0.0	1.3	2.5	3.3	57.9
Corophium volutator	0.4	0.8	2.1	2.7	60.6
Nephtys hombergii	0.5	0.9	2.0	2.6	63.2
Nephtys juv	1.1	0.1	2.0	2.6	65.8
Polydora cornuta	0.7	0.5	1.8	2.4	68.2
Heteromastus filiformis	0.4	0.8	1.8	2.3	70.5
Cyathura carinata	0.4	0.7	1.6	2.0	72.6
Tubifex tubifex	0.0	0.5	1.5	1.9	74.5
Cerastoderma edule juv	0.1	0.7	1.3	1.7	76.2
Ampharete acutifrons	0.4	0.5	1.3	1.6	77.9
Melinna palmata	0.4	0.5	1.2	1.6	79.5
Cerastoderma edule	0.2	0.4	1.0	1.3	80.7
Nematoda	0.1	0.5	0.9	1.1	81.9
Alkmaria romijni	0.0	0.5	0.9	1.1	83.0
Scrobicularia plana	0.3	0.2	0.9	1.1	84.1
Oligochaeta	0.5	0.0	0.8	1.1	85.2
Manayunkia aestuarina	0.1	0.4	0.8	1.0	86.2
Melita palmata	0.1	0.3	0.6	0.7	86.9
Limecola balthica	0.2	0.1	0.4	0.6	87.5
Cardioidea juv	0.2	0.0	0.4	0.6	88.0
Cossura pygodactylata	0.1	0.1	0.4	0.5	88.5
Lekanesphaera levii	0.0	0.3	0.4	0.5	89.0
Mya arenaria juv	0.0	0.2	0.4	0.5	89.5
Corophium juv	0.1	0.0	0.3	0.4	89.9
Paranais litoralis	0.0	0.2	0.3	0.4	90.3

Table A2. Tamar-Tavy and St Johns Lake SSSI Simper Analysis results: Species contributing the most to the infaunal community similarities within years.

2010				2017			
Species	Mean Abundance per Station	% Contribution	Cumulative % Contribution	*Species*	Mean Abundance per Station	% Contribution	Cumulative % Contribution
Peringia ulvae	4.73	21.5	21.5	*Peringia ulvae*	4.92	29.3	29.3
Streblospio	2.74	19.7	41.2	*Streblospio*	2.47	16.3	45.6
Baltidrilus costatus	2.4	12.2	53.4	*Tubificoides benedii*	2.43	10.2	55.8
Tharyx Type A	2.54	10.1	63.5	*Hediste diversicolor*	1.41	6.2	62.0
Tubificoides benedii	2.51	7.1	70.6	*Nephtys hombergii*	0.93	6.1	68.2
Hediste diversicolor	1.26	6.6	77.2	*Baltidrilus costatus*	3.07	6.1	74.3
Pygospio elegans	1.52	6.4	83.5	*Tubificoides pseudogaster agg*	1.29	4.6	78.9
Nephtys juv	1.1	6.0	89.5	*Pygospio elegans*	1.04	3.8	82.7
Nephtys hombergii	0.5	1.8	91.4	*Tharyx* Type A	1.03	2.8	85.5
				Cerastoderma edule juv	0.7	2.5	88.0
				Heteromastus filiformis	0.77	1.7	89.7
				Cyathura carinata	0.66	1.5	91.2

Table B1. Tamar-Tavy and St Johns Lake SSSI Simper Analysis results: Species contributing the most to dissimilarities in the LS.LMu.UEst.HedCvol communities between years.

Species	Mean Abundance per Station		Mean Dissimilarity	% Contribution	Cumulative % Contribution
	2010	2017			
Baltidrilus costatus	2.6	13.0	25	32	32
Tubifex tubifex	0.0	3.8	12	16	47
Hediste diversicolor	4.4	2.7	9	12	59
Corophium volutator	2.8	3.8	9	11	70
Streblospio	0.9	2.9	6	8	79
Tubificoides pseudogaster agg	0.0	1.5	4	5	84
Corophium juv	1.0	0.0	2	3	87
Peringia ulvae	0.4	0.3	2	3	89
Paranais litoralis	0.0	0.7	1	2	91

Table B2. Tamar-Tavy and St Johns Lake SSSI Simper Analysis results: Species contributing the most to dissimilarities in the LS.LMu.MEst.HedMacScr communities between years.

Species	Mean Abundance per Station		Mean Dissimilarity	% Contribution	Cumulative % Contribution
	2010	2017			
Peringia ulvae	6.4	5.0	8	12	12
Tubificoides benedii	4.8	5.4	7	12	24
Baltidrilus costatus	1.1	3.7	5	8	32
Tubificoides pseudogaster agg	3.4	0.0	5	8	39
Pygospio elegans	2.1	3.0	4	6	46
Streblospio	4.3	5.6	4	6	51
Polydora cornuta	2.0	1.1	3	5	56
Heteromastus filiformis	1.3	1.3	3	4	60
Hediste diversicolor	2.2	1.7	2	4	64
Tharyx Type A	0.3	1.7	2	4	68
Alkmaria romijni	1.6	0.0	2	3	71
Cyathura carinata	1.3	1.1	2	3	75
Melinna palmata	0.0	1.0	1	2	77
Scrobicularia plana	0.6	0.8	1	2	79
Polydora juv	0.0	0.8	1	2	81
Manayunkia aestuarina	0.8	0.5	1	2	83
Nephtys juv	0.1	1.0	1	2	85
Oligochaeta	0.0	1.0	1	2	87
Nephtys hombergii	0.9	0.3	1	2	89
Cerastoderma edule juv	0.6	0.0	1	2	91

Table C1. Lynher Estuary SSSI Simper Analysis results: Species contributing the most to the infaunal communities between years.

Species	Mean Abundance per Station 2010	Mean Abundance per Station 2017	Mean Dissimilarity	% Contribution	Cumulative % Contribution
Peringia ulvae	6.3	7.1	9.0	13.5	13.5
Tubificoides benedii	5.1	5.9	7.7	11.6	25.1
Streblospio	3.5	4.9	5.2	7.8	32.9
Pygospio elegans	2.6	2.9	3.8	5.7	38.7
Tharyx Type A	1.4	1.5	3.2	4.9	43.5
Baltidrilus costatus	1.4	1.3	3.0	4.6	48.1
Hediste diversicolor	1.5	1.5	3.0	4.5	52.6
Alkmaria romijni	0.0	2.1	2.7	4.1	56.7
Heteromastus filiformis	1.1	1.2	2.3	3.4	60.1
Polydora cornuta	0.7	1.2	2.2	3.2	63.3
Manayunkia aestuarina	0.8	1.6	2.1	3.2	66.5
Tubificoides pseudogaster agg	0.0	1.6	2.0	3.0	69.5
Nephtys hombergii	1.0	1.3	1.9	2.9	72.4
Paranais litoralis	0.0	1.4	1.7	2.6	75.0
Melinna palmata	1.1	0.4	1.6	2.5	77.5
Cyathura carinata	0.0	0.9	1.3	2.0	79.5
Cerastoderma edule juv	0.0	1.0	1.3	1.9	81.4
Nephtys juv	0.6	0.2	1.1	1.6	83.0
Nematoda	0.3	0.4	0.9	1.4	84.3
Capitella agg	0.4	0.5	0.9	1.3	85.6
Mya arenaria juv	0.0	0.7	0.9	1.3	86.9
Cyprideis torosa	0.0	0.5	0.8	1.3	88.1
Corophium juv	0.4	0.0	0.7	1.0	89.1
Tellinoidea juv	0.0	0.6	0.6	0.9	90.0

Table C2. Lynher Estuary SSSI Simper Analysis results: Species contributing the most to the infaunal community similarities within years.

2010				2017			
Species	Mean Abundance per Station	% Contribution	Cumulative % Contribution	Species	Mean Abundance per Station	% Contribution	Cumulative % Contribution
Peringia ulvae	6.3	32.0	32.0	*Peringia ulvae*	7.1	21.7	21.7
Tubificoides benedii	5.1	17.1	49.1	*Streblospio*	4.9	19.4	41.0
Streblospio	3.5	16.2	65.3	*Tubificoides benedii*	5.9	17.2	58.3
Pygospio elegans	2.6	9.6	74.9	*Pygospio elegans*	2.9	8.0	66.2
Hediste diversicolor	1.5	5.4	80.4	*Alkmaria romijni*	2.1	5.0	71.3
Nephtys hombergii	1.0	3.9	84.3	*Hediste diversicolor*	1.5	3.9	75.2
Melinna palmata	1.1	3.8	88.1	*Nephtys hombergii*	1.3	3.8	79.0
Baltidrilus costatus	1.4	3.2	91.3	*Paranais litoralis*	1.4	2.2	81.2
				Manayunkia aestuarina	1.6	2.2	83.4
				Polydora cornuta	1.2	2.1	85.5
				Cerastoderma edule juv	1.0	2.0	87.5
				Heteromastus filiformis	1.2	1.9	89.3
				Tharyx Type A	1.5	1.8	91.1

Table D1. Lynher Estuary SSSI Simper Analysis results: Species contributing the most to dissimilarities in the LS.LMu.MEst.HedMacScr communities between years.

Species	Mean Abundance per Station		Mean Dissimilarity	% Contribution	Cumulative % Contribution
	2010	2017			
Tubificoides benedii	5.5	6.5	5	9	9
Streblospio	7.2	4.7	5	8	17
Peringia ulvae	6.4	5.4	5	8	25
Tubificoides pseudogaster agg	0.0	4.0	4	7	33
Pygospio elegans	4.6	3.2	4	7	40
Heteromastus filiformis	3.6	2.8	4	7	46
Polydora juv	2.9	0.0	4	6	53
Baltidrilus costatus	3.7	1.9	3	6	59
Hediste diversicolor	2.2	2.3	3	5	63
Polydora cornuta	0.6	2.0	2	4	67
Alkmaria romijni	0.0	2.0	2	4	70
Manayunkia aestuarina	0.6	2.0	2	3	74
Melinna palmata	1.8	0.0	2	3	77
Nephtys hombergii	0.3	1.0	1	2	79
Cyprideis torosa	0.0	1.1	1	2	81
Cyathura carinata	0.0	1.0	1	2	83
Tubificoides	0.6	0.0	1	2	85
Myrianida	0.0	0.8	1	2	86
Tharyx Type A	0.7	0.4	1	1	88
Nephtys juv	0.8	0.0	1	1	89
Paranais litoralis	0.0	0.8	1	1	90

APPENDIX 5

Table A. Univariate community analysis of littoral sediment communities in Sector 1.

Habitat Type	Station	Total No. Taxa per Station S	Mean Abundance N	Margalef's Species Richness d	Pielou's Evenness J'	Shannon Wiener Index H'(log10)	Simpson Diversity Index 1-Lambada'
LS.LSa.FiSa.Po	P20	4	1238	0.4	0.3	0.5	0.3
	P31	9	1047	1.2	0.7	1.6	0.8
	P34	10	93	2.0	0.8	1.9	0.8
	P42	5	40	1.1	0.8	1.4	0.7
	P43	7	105	1.3	0.7	1.4	0.7
	Mean:	*7*	*505*	*1.2*	*0.7*	*1.3*	*0.7*
LS.LSa.MoSa.AmSco.Eur	P23	4	30	0.9	0.8	1.1	0.6
	P24	3	38	0.5	0.2	0.2	0.1
	P41	3	19	0.7	0.8	0.9	0.6
	Mean:	*3*	*29*	*0.7*	*0.6*	*0.7*	*0.4*
LS.LSa.MoSa.AmSco.Pon	P19	5	42	1.1	0.6	1.0	0.5
	P35	4	20	1.0	0.8	1.1	0.6
	P38	3	6	1.1	0.9	1.0	0.7
	P39	4	13	1.2	0.9	1.2	0.7
	Mean:	*4*	*20*	*1.1*	*0.8*	*1.1*	*0.6*
LS.LSa.MoSa.AmSco.Sco	P21	5	17	1.4	0.8	1.3	0.7
	P32	4	8	1.4	0.9	1.2	0.8
	P33	4	7	1.5	0.9	1.3	0.8
	P36	6	63	1.2	0.6	1.1	0.5
	P37	8	25	2.2	0.7	1.5	0.7
	P40	3	75	0.5	0.4	0.5	0.3
	Mean:	*5*	*33*	*1.4*	*0.7*	*1.1*	*0.6*
LS.LSa.MoSa.BarSa	P22	5	7	2.1	1.0	1.6	0.9
LS.LSa.MoSa.Ol.FS	P25	8	1396	1.0	0.2	0.5	0.3
	P26	4	145	0.6	0.7	0.9	0.5
	P27	5	353	0.7	0.4	0.6	0.4
	P28	4	4647	0.4	0.1	0.1	0.0
	P29	5	5587	0.5	0.1	0.1	0.0
	Mean:	*5*	*2426*	*0.6*	*0.3*	*0.5*	*0.2*
LS.LSa.St.Tal	P30	4	143	0.6	0.5	0.7	0.4

Table B. Univariate community analysis of littoral sediment communities in the Tamar Tavy and St. Johns Lake SSSI (Sector 2)

Habitat Type	Station	Total No. Taxa per Station S	Mean Abundance N	Margalef's Species Richness d	Pielou's Evenness J'	Shannon Wiener Index H'(log10)	Simpson Diversity Index 1-Lambada'
LS.LMu.MEst.HedMacScr	B9	13	202	2.3	0.7	1.8	0.8
	B11	17	157	3.2	0.8	2.3	0.9
	B12	10	231	1.7	0.7	1.6	0.7
	B15	12	135	2.2	0.6	1.6	0.7
	B16	11	72	2.3	0.8	1.8	0.8
	B19	10	167	1.8	0.7	1.5	0.7
	B28	12	151	2.2	0.3	0.8	0.3
	B32	8	212	1.3	0.4	0.9	0.4
	B40	4	122	0.6	0.5	0.6	0.4
	B44	12	139	2.2	0.8	1.9	0.8
	B48	6	48	1.3	0.9	1.6	0.8
	Mean:	*10*	*149*	*1.9*	*0.7*	*1.5*	*0.7*
LS.LMu.UEst.Hed.Cvol	B1	4	7	1.5	0.9	1.3	0.8
	B2	11	870	1.5	0.3	0.8	0.4
	B5	8	526	1.1	0.3	0.5	0.2
	B6	6	317	0.9	0.5	0.9	0.5
	B7	8	283	1.2	0.4	0.7	0.3
	B49	1	357	0.0	****	0.0	0.0
	Mean:	*6*	*393*	*1.0*	*0.5*	*0.7*	*0.4*
LS.LMu.UEst.Hed.Ol	B4	7	533	1.0	0.2	0.3	0.1
	B8	7	242	1.1	0.5	1.1	0.5
	B21	10	153	1.8	0.5	1.1	0.5
	B47	2	8	0.5	0.5	0.4	0.3
	Mean:	*7*	*234*	*1.1*	*0.4*	*0.7*	*0.4*
LS.LMu.UEst.Hed.Str	B17	10	80	2.1	0.9	2.1	0.9
	B18	8	91	1.6	0.7	1.4	0.7
	Mean:	*9*	*86*	*1.8*	*0.8*	*1.7*	*0.8*
LS.LMu.UEst.NhomStr	B20	10	62	2.2	0.7	1.7	0.8
	B35	13	308	2.1	0.3	0.8	0.3
	Mean:	*12*	*185*	*2.1*	*0.5*	*1.2*	*0.5*
LS.LMu.UEst.Tben	B38	5	8	1.9	0.9	1.4	0.8
LS.LMx.GvMu.HedMx.Cvol	B3	6	234	0.9	0.3	0.5	0.2
LS.LMx.Mx	B46	16	116	3.2	0.7	2.0	0.8
	B23	10	52	2.3	0.8	1.8	0.8
	B25	26	195	4.7	0.8	2.7	0.9
	B42	20	119	4.0	0.7	2.1	0.8
	B45	24	222	4.3	0.7	2.3	0.8
	Mean:	*19*	*141*	*4*	*1*	*2*	*1*
LS.LSa.FiSa.Po	B43	11	27	3.0	0.9	2.1	0.9
LS.LSa.MuSa.CerPo	B10	5	31	1.2	0.8	1.3	0.7
	B13	13	131	2.5	0.5	1.3	0.5
	B14	9	52	2.0	0.7	1.6	0.7
	B22	10	36	2.5	0.9	2.0	0.9
	B24	17	79	3.7	0.8	2.3	0.9
	B26	10	74	2.1	0.5	1.2	0.5
	B27	16	406	2.5	0.2	0.5	0.2
	B29	11	122	2.1	0.4	1.1	0.4
	B30	16	77	3.5	0.8	2.4	0.9
	B31	5	83	0.9	0.2	0.3	0.1
	B34	10	484	1.5	0.5	1.2	0.6
	B36	17	426	2.6	0.4	1.2	0.5
	B37	14	150	2.6	0.4	1.0	0.4
	B41	11	82	2.3	0.6	1.4	0.6
	Mean:	*12*	*160*	*2*	*1*	*1*	*1*
LS.LSa.MuSa.Lan	B39	35	197	6.4	0.8	2.8	0.9
LS.LSa.MuSa.MacAre	B33	6	137	1.0	0.2	0.3	0.1

Table C. Univariate community analysis of littoral sediment communities within the Lynher Estuary SSSI (Sector 2).

Habitat Type	Station	Total No. Taxa per Station S	Mean Abundance N	Margalef's Species Richness d	Pielou's Evenness J'	Shannon Wiener Index H'(log10)	Simpson Diversity Index 1-Lambada'
LS.LC.SSh.BarSa	*C24*	*7*	*16*	*1.8*	*0.9*	*1.7*	*0.9*
LS.LMu.Mest.HedMac	*C27*	*14*	*180*	*2.3*	*0.5*	*1.2*	*0.5*
LS.LMu.Mest.HedMacScr	C14	*19*	264	3.0	0.7	2.1	0.8
	C16	*15*	142	2.6	0.8	2.0	0.8
	C17	*19*	480	2.8	0.7	2.0	0.8
	C22	*15*	243	2.4	0.8	2.0	0.8
	Mean:	*17*	*282*	*2.7*	*0.7*	*2.0*	*0.8*
LS.LMu.Mest.NhomMacStr	C28	*18*	918	2.3	0.3	1.0	0.4
	C29	*12*	54	2.5	0.6	1.4	0.6
	C30	*10*	*43*	*2.1*	*0.8*	*1.7*	*0.8*
	Mean:	*13*	*338*	*2.3*	*0.6*	*1.4*	*0.6*
LS.LMu.Uest.Hed.Str	*C12*	*11*	*48*	*2.3*	*0.6*	*1.5*	*0.6*
	C13	*12*	103	2.2	0.5	1.3	0.6
	C15	*17*	267	2.7	0.7	2.1	0.8
	C19	*16*	*446*	*2.3*	*0.7*	*2.0*	*0.8*
	C25	*15*	670	2.0	0.6	1.7	0.7
	C26	*16*	472	2.3	0.7	1.9	0.8
	Mean:	*15*	*334*	*2.3*	*0.7*	*1.7*	*0.7*
LS.LMu.Uest.HedCvol	C2	*12*	181	1.9	0.5	1.2	0.5
	C18	*8*	43	1.6	0.6	1.2	0.6
	C20	*8*	50	1.5	0.8	1.5	0.8
	C21	*9*	94	1.5	0.9	1.8	0.8
	C23	*12*	241	1.8	0.8	1.9	0.8
	Mean:	*10*	*122*	*1.7*	*0.7*	*1.5*	*0.7*
LS.LMu.Uest.NhomStr	C1	*24*	135	4.5	0.9	2.7	0.9
	C3	*35*	1280	4.6	0.7	2.4	0.8
	C5	*16*	97	3.1	0.8	2.2	0.9
	C6	*11*	77	2.1	0.8	1.8	0.8
	C11	*17*	353	2.6	0.6	1.8	0.8
	Mean:	*21*	*388*	*3.4*	*0.8*	*2.2*	*0.8*
LS.LMx.GvMu.HedMxCir	C4	*18*	147	3.2	0.7	2.0	0.8
LS.LSa.MuSa.CerPo	C7	*11*	125	1.9	0.6	1.4	0.7
	C8	*14*	295	2.1	0.6	1.4	0.7
	C9	*16*	410	2.3	0.6	1.5	0.6
	C10	*20*	377	3.0	0.5	1.6	0.7
	Mean:	*15*	*302*	*2.3*	*0.6*	*1.5*	*0.7*

Table D. Univariate community analysis of littoral sediment communities in Sector 3.

Habitat Type	Station	Total No. Taxa per Station S	Mean Abundance N	Margalef's Species Richness d	Pielou's Evenness J'	Shannon Wiener Index H'(log10)	Simpson Diversity Index 1-Lambada'
LS.LMu.UEst.NhomStr	Y1	14	123	2.7	0.8	2.1	0.8
	Y2	15	159	2.8	0.7	1.9	0.8
	Y3	15	88	3.1	0.8	2.1	0.8
	Y5	17	122	3.3	0.8	2.3	0.9
	Y6	11	19	3.4	0.9	2.2	0.9
	Mean:	*14*	*102*	*3.1*	*0.8*	*2.1*	*0.8*
LS.LMx.Mx	Y4	25	462	3.9	0.8	2.4	0.9
	Y11	32	545	4.9	0.7	2.5	0.9
	Y12	32	643	4.8	0.6	2.2	0.8
	Y13	18	991	2.5	0.3	0.8	0.3
	Y14	13	405	2.0	0.4	1.1	0.5
	Y15	20	606	3.0	0.5	1.4	0.5
	Mean:	*23*	*609*	*3.5*	*0.5*	*1.7*	*0.6*
LS.LSa.FiSa.Po	Y8	14	99	2.8	0.5	1.4	0.6
	Y9	13	215	2.2	0.5	1.4	0.6
	Y16	7	8	2.9	1.0	1.9	1.0
	Y17	7	17	2.1	0.7	1.4	0.7
	Y18	10	60	2.2	0.8	1.8	0.8
	Mean:	*10*	*80*	*2.5*	*0.7*	*1.6*	*0.7*
LS.LSa.MuSa.CerPo	Y7	13	419	2.0	0.6	1.4	0.7
	Y10	18	403	2.8	0.3	1.0	0.4
	Mean:	*16*	*411*	*2.4*	*0.5*	*1.2*	*0.6*