Littoral Biotope Baseline Survey of Upper Fowey and Pont Pill Marine Conservation Zone

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EXECUTIVE SUMMARY

Natural England commissioned baseline surveys in order to monitor and assess the extent and condition of the designated littoral habitats within Upper Fowey and Pont Pill MCZ. Phase I surveys of the littoral rock and sediment habitats were undertaken by Ecospan Environmental Ltd in July 2018. Phase II surveys of the littoral rock communities were also carried out later that month. For the purposes of Water Framework Directive Assessment, the Environment Agency undertook quantitative sampling of the littoral sediments within the MCZ over two days in May and September 2018. The data was then used to inform this study.

Four main littoral rock Habitat types were recorded and mapped within the Upper Fowey and Pont Pill MCZ. An additional three habitat types were identified within a very small, localised area at the western boundary of the MCZ within the Pont Pill or at the southern extent of the Upper Fowey MCZ boundary. All four of the main Habitat types are described as low energy littoral rock supporting fucoids in variable salinity. The three additional Habitat types that were identified are classified alongside low energy, high and moderate energy littoral rock respectively within the EUNIS classification.

A total of twelve littoral sediment Habitat types were recorded and mapped within the MCZ. All fall within one of three EUNIS level 3 categories, these were: littoral sands and muddy sands, littoral mud and littoral mixed sediments. The sediments with a substantial sandy element were restricted to the lower shore in/adjacent to the main Fowey river channel, whilst those dominated by mud were found higher in the estuary, on the mid and upper shores of the mid estuary and throughout the Lerryn, Penpoll and Pont Pill tributaries. Mixed sediments were mostly restricted to localised areas of scour in the mid-upper Fowey estuary and at the head of the Lerryn. Eight littoral sediment Habitats types were were captured by the quantitative sampling that was carried out by the Environment Agency. The four that were not accounted for only a very limited area of the littoral sediments within the MCZ.

A few anthropogenic influences were noted and mapped during the course of the surveys and included bait digging and the setting of peeler crab traps. The impacts from these appeared to be negligible given the spatial scale at which they were present, and none were considered to have the potential alone to result in a decline in the condition of any features or habitats of conservation importance within the MCZ.

Additional surface sediment samples for contaminant analysis were taken at 4 stations within the MCZ. The OSPAR Effects Range Low (ERL) threshold for lead was breached at one of the stations, whilst that for the Polycyclic Aromatic Hydrocarbon (PAH) compounds benzo(a)anthracene and fluoranthene was exceeded at two stations. These threshold exceedances have led to the 'supporting processes of littoral sediment habitats' attribute being considered to be in an unfavourable condition.

The tentacled lagoon worm *Alkmaria romijni* (which is considered nationally scarce) was the only Secies if Conservation Interest that was identified within the study area, and was captured in cores from 14 of the 43 stations sampled.

Three invasive non-native species were identified during the study. The Pacific oyster *Magallana gigas* was also observed within the upper reaches of the Fowey estuary between the southern boundary of the MCZ and Golant in 'common' to 'rare' abundances. Much higher

densities were found within the Pont Pill where up to 25 individuals per square metre were observed in patches, mostly along the littoral rock/littoral sediment interface. However, less than 1% of the total area of littoral communities within the MCZ are considered to be signifcantly affected by the abundance of this INNS. The red algae *Caulacanthus* spp. was frequently observed in SACFOR abundances ranging from 'rare' to 'abundant' and the Australasian barnacle *Austrominius modestus* was also often encountered (although only in 'rare' to 'occasional' abundances).

Due to a lack of previous relevant studies it has not been possible to make temporal comparisons of the littoral habitats of the Upper Fowey and Pont Pill MCZ. Conseqently, it has not been possible to make reccomendations with regard to the condition of each of the attributes. The output from this study will however provide a baseline from which a change in the condition of the attributes can be measured within any future condition assessments. Depending upon the specific aims of any future monitoring, further targeted work may be necessary to discern whether any changes observed (e.g. loss in extent of a particular habitat type) are attributable to anthropogenic factors as opposed to natural factors.

CONTENTS

1. INTRODUCTION

1.1 Study Area

The Upper Fowey and Pont Pill MCZ was identified by the Finding Sanctuary MCZ project[1]. This estuarine site is located on the south Cornwall coast and protects a total area of 2 km^2, making it one of the smallest MCZs in the UK. The MCZ consists of two spatially separate areas (Figure 1). The boundaries of the larger of the two areas include the upper tidal reaches of the Fowey estuary extending to Lostwithiel and including the estuarine River Lerryn, Penpoll Creek and Bodmin Pill. The smaller area comprises Pont Pill, a tributary estuary flowing into the Fowey on the Eastern side near Polruan.

The Upper Fowey and Pont Pill MCZ is representative of estuarine habitats found across southwest England. The site encompasses a range of littoral sediment types including mud, sand, muddy-sand, coarse sediment and sheltered muddy gravels, as well as saltmarsh and saline reedbeds. Littoral, low energy estuarine rock fringes the upper shore throughout most of the estuary, and extends to the lower shore where tidal currents scour the sediments away. The habitats and species within the site are considered to make it an important contribution to the Marine Protected Areas (MPA) network.

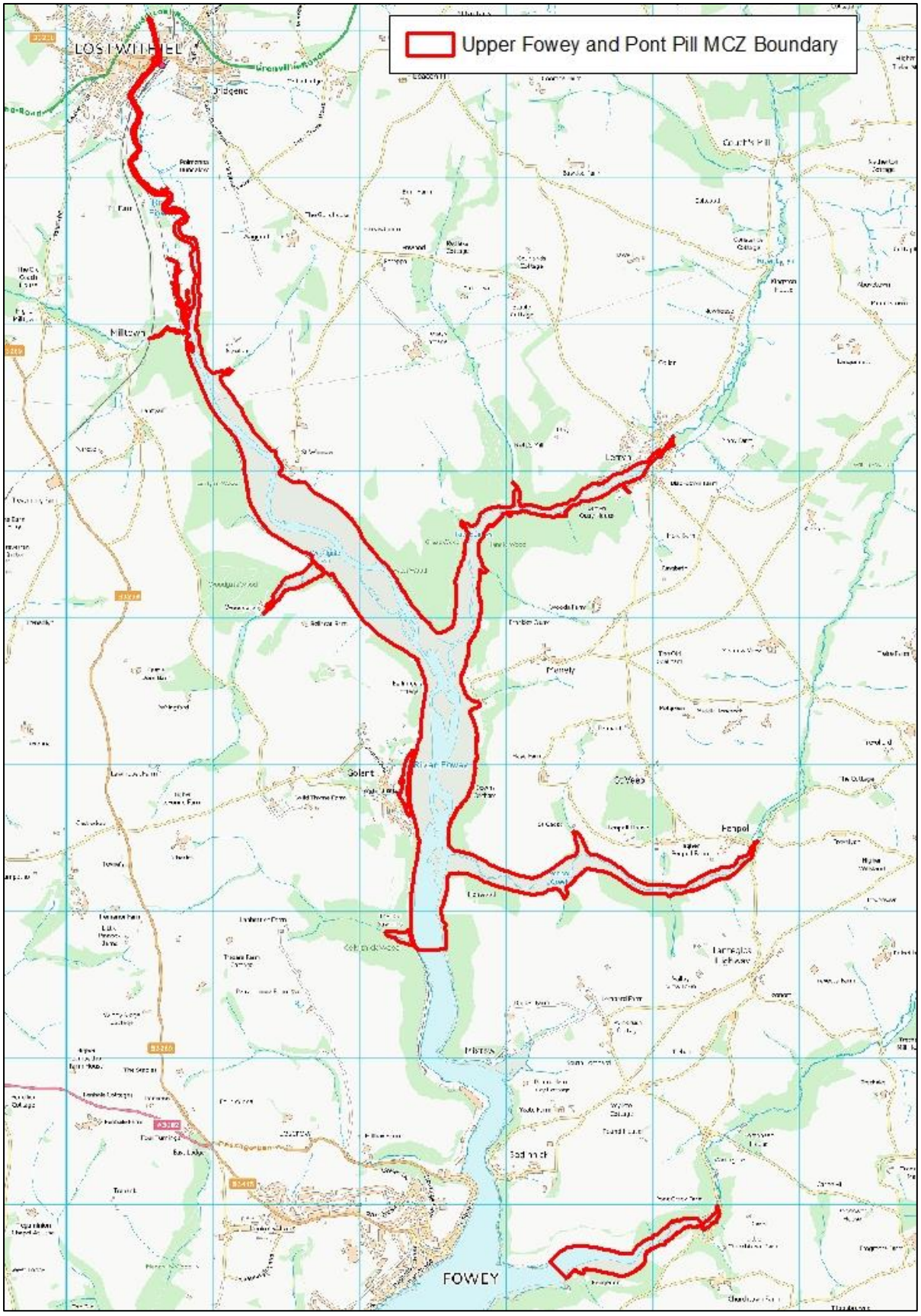

Figure 1. Boundaries of the Upper Fowey and Pont Pill MCZ.

2. AIMS and OBJECTIVES

The specific aims of this study of the littoral communities within the Upper Fowey and Pont Pill MCZ were to:

- 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 littoral rock and littoral sediment features of the MCZ.
- Identify and map the littoral communities to the highest possible level and, where possible, compare to previous habitat maps of the site highlighting any significant changes.
- Report on temporal and spatial variability in the diversity and community structure of the sediment sub-feature in order to inform condition monitoring of the littoral sub-features.
- Identify and record the presence, and as far as possible the abundance, of invasive non-native species (INNS), specifically including the alga *Caulacanthus spp*.
- Determine the percentage of littoral reef and sediment sub-feature area where the community has been significantly altered by the abundance of Pacific oysters.
- Map the area of each sub-feature where the community was significantly affected by the abundance of Pacific oysters (*Magallana gigas*). Map areas where the density of *Magallana gigas* was considered to have formed a reef (100% cover or more) separately from areas that were significantly affected, but had not yet formed a reef.

The specific attributes within the MCZ that require monitoring and reporting upon are listed in Table 1.

Table 1. Upper Fowey and Pont Pill MCZ attributes to be monitored

Feature/Sub-features	Attribute	Target
Littoral rock and 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 sediment	Structure: non-native species and pathogens	Reduce the introduction and spread of non-native species and pathogens, and their impacts
Littoral rock and sediment	Structure: species composition of component communities	Maintain the species composition of component communities
Sediment features only	Structure: sediment composition and distribution	Maintain the existing distribution of sediment composition types across the feature.
Sediment features only	Structure: sediment total organic carbon content	Maintain total organic carbon (TOC) content in the sediment at existing levels.
Sediment features only	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 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.

3. METHODS

3.1 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 rock habitats. Given that the Environment Agency had previously collected sediment cores in the area for Water Framework Directive monitoring requirements, the data from these cores was used to determine the community composition within the littoral sediment habitats where possible.

During all of the surveys, the presence of notable habitats and/or species (e.g. Habitats or Species of Conservation Interest (HOCI/SOCI)) was highlighted where encountered and the positions recorded using Differential Geographical Positioning System (DGPS).

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

3.2 Access

For reasons of efficiency, quality and safety, access to the upper Fowey area was achieved using Ecospan Environmental Ltd's 4 man hovercraft. The Pont Pill was accessed on foot due to the absence of appropriate nearby launch sites and the very high number of leisure craft in the lower harbour during the survey period.

3.3 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 undertaken during the spring tides on the 12th,13th and 16th of July 2018 (low water ranged between 0.4m and 0.7m above chart datum during that time). The Phase II rock surveys were undertaken on the 13th, 16th and 17th of July 2018 (low water ranged between 0.4m and 0.5m above chart datum).

The Environment Agency undertook the quantitative sampling of the littoral sediments on the 15th of May and 25th of September.

3.4 Phase I Protocol

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 are 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[2] and the Recommended operating guidelines for aerial photography). Habitats were assigned according to the highest EUNIS classification level[3] possible.

To ensure that 100% coverage of the littoral Habitat types was achieved, pre-determined transects were established at approximately 500 m intervals within the littoral rock Habitat types, whilst target stations were established every 500 m within littoral sediment Habitat types, where these habitats exist. These target transects and stations were added to the latest aerial photographs from the channel coast observatory and loaded into a DGPS which was used for all position fixing during the course of the survey.

3.4.1 Littoral Rock

All sampling was consistent with the relevant guidelines[2,4,5]. At each transect the vertical extent of each Habitat type was gauged and recorded as accurately as possible using a combination of DGPS and the aerial photography. The abundance of the main characterising species within each Habitat type on each transect was recorded using the semi-quantitative SACFOR scale. Photographs of the zonation patterns on each transect were also be taken. Having mapped the communities in the immediate area around each transect, the main Habitat types for some distance either side were assessed, and these boundaries drawn onto the aerial photographs. The survey team then walked, or were ferried by hovercraft to the next target transect. To ensure that changes in Habitat type between transects were captured and mapped accurately, the survey team observed the littoral rock communities present between the transects whilst transiting. Any communities that appeared different to the adjacent areas were investigated more closely. All information gathered was recorded in field note books, super-imposed on aerial photography and recorded using DGPS where necessary. A map of the littoral rock Habitat types was produced following the Phase I survey and this was used to inform the detailed design of the Phase II survey.

3.4.2 Littoral Sediment

All sampling was consistent with the relevant guidelines[2,4,6]. At each station the observed taxa and physical and environmental attributes (characterising species, presumptive Habitat type, topography, depth of redox, interstitial salinity, sediment type, date and time) were recorded in a proforma field notebook, and the exact position recorded using DGPS. Photographs of the substrate surface and up, down and along shore aspects were also taken. Where large expanses of littoral sediment are exposed, a 'zig zag' transect route between target stations was taken in order to maximise coverage of the sediment at all tidal heights. Where changes in Habitat type were observed, the perceived boundaries of the changes were marked on the aerial map, and using DGPS where necessary.

Given that some littoral sediment Habitat types can be confused in the field, whilst undertaking the Phase I survey, sediment cores were taken for faunal analysis to confirm the EUNIS Habitat type assigned. In order to keep the costs to a minimum, these samples were processed only to a level at which the Habitat type could be confirmed (rapid assessment cores). A preliminary biotope map was produced from the Phase I which was then corroborated with the quantitative fauna data that was collected by the Environment Agency in May 2018.

3.5 Phase II Quantitative Sampling

The aim of the Phase II survey was to gather information sufficient to produce detailed descriptions of the littoral rock Habitat types present within the study area including their distribution, extent and the community composition. The littoral rock surveys were carried out in accordance with the relevant guidance (JNCC Common Standards Monitoring Guidance for Littoral Rock and Inshore Sublittoral Rock Habitats 2004[5], the Marine Monitoring Handbook 2001[2]). As well as taxa abundance data, detailed habitat descriptions were gathered using an MNCR type detailed littoral habitat survey form that included aspects such as substrate characteristics, features and modifiers.

In order to enable the data collected in 2018 to be compared with future survey data in way that enables temporal change to be elucidated statistically, it was planned that a minimum of 5 replicate stations were sampled within each major littoral rock Habitat type identified. The

location of the Phase II stations was determined following the Phase I survey and were selected on the basis of achieving a good geographical spread throughout each Habitat type, as well as throughout the study area.

At each station at least one of the main Habitat types present was sampled using 5 quadrats. In order to maintain consistency of monitoring rMCZs/pMCZs in the southwest, 0.25m^2 quadrats were used. To strengthen the statistical analysis when comparing temporal data in future years, the precise positioning of quadrats was selected randomly within the target Habitat type at each station (stratified random sampling). Since the littoral rock Habitat types were restricted in their vertical extent, the quadrats were placed at randomly allocated distances along the central belt of the target Habitat type. The rationale behind this was that by placing quadrats within the middle of each Habitat type, transitional areas were avoided. Consequently, replicates are likely to be more similar than if the Habitat type was sampled over its entire vertical extent. Randomisation was achieved using a random number generator to generate 5 positions (no's 1-10 corresponding to 1-10m to the left of the station and 11-20 corresponding to 1-10m to the right of the station). To save time, the distances were measured by pacing rather than by using a tape measure. Given the patchy nature of estuarine littoral rock Habitat types, quadrats did not always fall upon the target communities. In this case, more random numbers were generated until 5 quadrats fell within the target communities. The co-ordinates of all transect start and finish positions as well as the co-ordinates of each quadrat were recorded using DGPS.

Within each quadrat the abundance of fauna and flora was assessed and recorded. Where possible, individual fauna were counted, but, for species that were very numerous (e.g. juvenile *Littorina saxatilis* and *Spirorbis spirorbis*) abundances were recorded using estimates. Natural England previously requested that Ecospan record barnacles using percentage cover (rather than SACFOR) for MCZ verification surveys. Algae were also recorded using percentage cover. Each quadrat was assigned a unique number and photographed. As well as the taxa lists and abundance data, detailed habitat descriptions were gathered using an MNCR type detailed littoral habitat survey form (these are JNCC designed recording forms onto which field data including details of the physical and biological nature of the habitat are transcribed). The specific survey form used included aspects such as substrate characteristics, tidal height, features and modifiers. The time and date was also noted.

3.6 INNS, SOCI, HOCI and Anthropogenic Influences

During all surveys the presence of potential anthropogenic influences (e.g. sewers, land drains, bait digging etc.), SOCI (such as the Native oyster), or any other relevant factors were recorded, photographed, and any obvious impacts noted.

In particular the presence and abundance of Invasive Non Native Species (INNS) such as the 'Pom Pom' algae *Caulacanthus ustulatus* was recorded, as was that of the Pacific oyster *Magallana gigas*. Where it is considered that communities were significantly affected by *Magallana gigas*, the extent of effects were mapped, as were areas where the species had formed a reef (100% cover).

3.6.1 Macroalgal mats

Where macroalgal matts were encountered, those areas having a above 5% were defined from those where the density was greater than 15% where possible. The dominant macroalgal species present within the matt were also recorded where possible.

3.7 Data Analysis and Reporting

Two methods have been used to statistically analyse the quantitative data gathered from the main Habitat types identified: a univariate approach using diversity statistics and multivariate community analysis.

Simple univariate statistics have been calculated and compared between sample points; these included the mean number of taxa, mean abundance, and diversity/equitability indices including the Shannon Wiener diversity index, Margalefs species richness and Pielou's eveness.

Multivariate methods of data analysis are considered to provide a more sensitive measure of community change than univariate methods, since there is no loss of information such as occurs when reducing the data to a single number or univariate statistic. Multivariate community analysis in PRIMER 6[8] has used multidimensional scaling (MDS) plots and the multivariate Bray-Curtis similarity statistic to assess the community similarities between stations both in terms of their constituent taxa and relative abundance. MDS plots represent the similarity in community structure at stations in two dimensions where the distances between points represent the differences between the communities sampled.

In order to reduce the influence of very numerous species on the results, the mean data collected from the 5 quadrats (in littoral rock communities) or three cores (in littoral sediment communities) at each sample station was subjected to a square root transformation prior to all analysis. SIMPER ('similarity percentage') analysis was also used to determine the contribution of each species to the observed similarity within Habitat types and enabled identification of the species that are most important in creating the observed patterns of similarity.

The overall degree of similarity in the mean sediment particle size between each station has also been determined using PRIMER 6[8] and has been illustrated using a Principle Component Analysis (PCA) plot.

All raw data associated with this report is available in excel spreadsheets. The GIS shapefiles are also available which present the extent and distribution of the littoral rock and littoral sediment Habitat types, Phase I and Phase II sample stations (and associated sample data), distribution and abundance of INNS and extent, density and distribution of macroalgae.

3.8 Quality Assurance

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

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

4. RESULTS

4.1 Extent and Distribution of Littoral Rock Habitat Types

A total of four main littoral rock Habitat types (classified to EUNIS level 5[3]) were recorded and mapped within the Upper Fowey and Pont Pill MCZ. An additional three habitat types were identified within a very small, localised area at the western boundary of the MCZ within the Pont Pill or at the southern extent of the Upper Fowey MCZ boundary. All four of the main Habitat types are described as low energy littoral rock supporting fucoids in variable salinity (EUNIS Level 4 - A1.32). The three additional Habitat types that were identified are classified alongside low energy, moderate and high energy littoral rock respectively within the EUNIS classification[2]. Although these communities may be classified alongside higher energy Habitat types usually found on more exposed open coasts, this is not necessarily representative of the energy within the MCZ. The communities simply resemble those of higher energy sites due to the shore topography (e.g. *Semibalanus balanoides* on exposed to moderately exposed or vertical sheltered eulittoral rock).

The seven Habitat types observed in total are listed below. Four that were considered main habitat types were included within the Phase II sampling. The remaining three were found over such a limited area that it was not possible to gain multiple sample replication within the communities, these were therefore excluded from the Phase II survey and are annotated with a '*' below:

- A1.1131* — *Semibalanus balanoides*, *Patella vulgata* and *Littorina* spp. on exposed to moderately exposed or vertical sheltered eulittoral rock.
- A1.221* — *Mytilus edulis* and *Fucus vesiculosus* on moderately exposed mid eulittoral rock
- A1.321 — *Pelvetia canaliculata on sheltered variable salinity littoral fringe rock*
- A1.323 — *Fucus vesiculosus* and barnacle mosaics on moderately exposed mid eulittoral rock
- A1.324 — *Ascophyllum nodosum* and *Fucus vesiculosus* on variable salinity mid eulittoral rock
- A1.326* — *Fucus serratus* and large *Mytilus edulis* on variable salinity lower eulittoral rock.
- A1.327 — *Fucus ceranoides* on reduced salinity eulittoral rock

The communities that were characterised by the presence of *Ascophyllum nodosum* and *Fucus vesiculosus* (A1.324) were found both on rock, and mixed substrata. The EUNIS classification[2] does not separate the variable salinity Habitat types based on substrate (as it does for the full salinity Habitat types). However, for the purposes of the Phase II sampling, these communities have been separated based on the substrate type as this is expected to have some effect on the community composition.

The extent and distribution of all seven Habitat types mapped during the study are shown in Figures 2 to 5 together with the Phase II sampling stations. Littoral rock communities were found throughout the estuary up as far as Milltown. There were distributional patterns to Habitat types which are related to geography (lower, mid and upper estuary) as well as some

zonation relating to shore height. The coordinates of each of the Phase II littoral Rock quadrats are provided in Appendix I together with the widths of each Habitat type sampled.

A description of the biotic and abiotic features within each of the littoral rock communities/habitat types that were sampled within the MCZ are provided in section 4.1.1. Species abundance data from the quadrats at each Phase II station are presented in tables. Within the tables, numbers represent counts (or estimated counts) or percentage cover. Maps of the distribution of each individual Habitat type in relation to the Phase II sampling stations (note that the vertical extent of rock within these maps has been exaggerated for clarity and does not accurately represent the scale of extent of littoral rock perpendicular to the coast). Distribution maps and broad descriptions (taken from the EUNIS classification[3]) of the Habitat types not included within the Phase II survey are also provided.

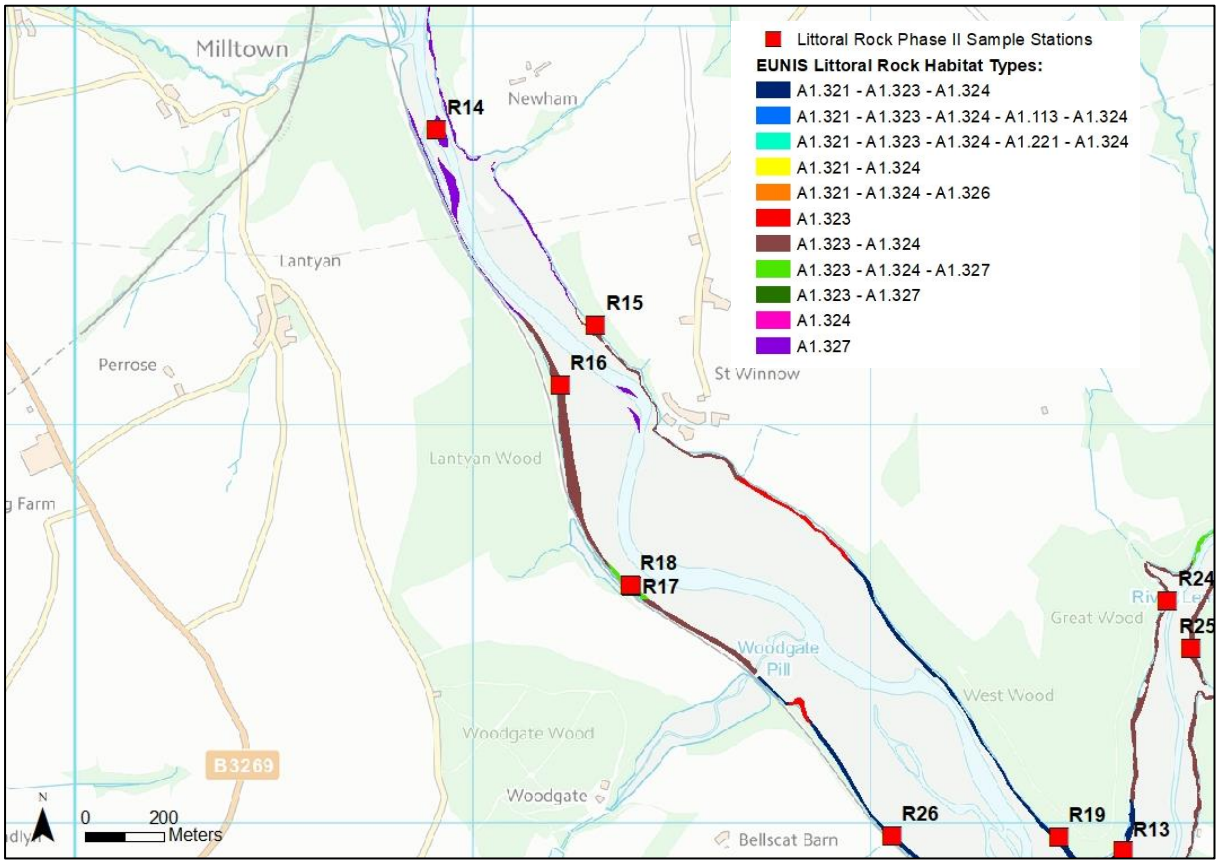

Figure 2. Extent and distribution of littoral rock communities in the Upper Fowey and Pont Pill MCZ - Woodgate to Milltown.

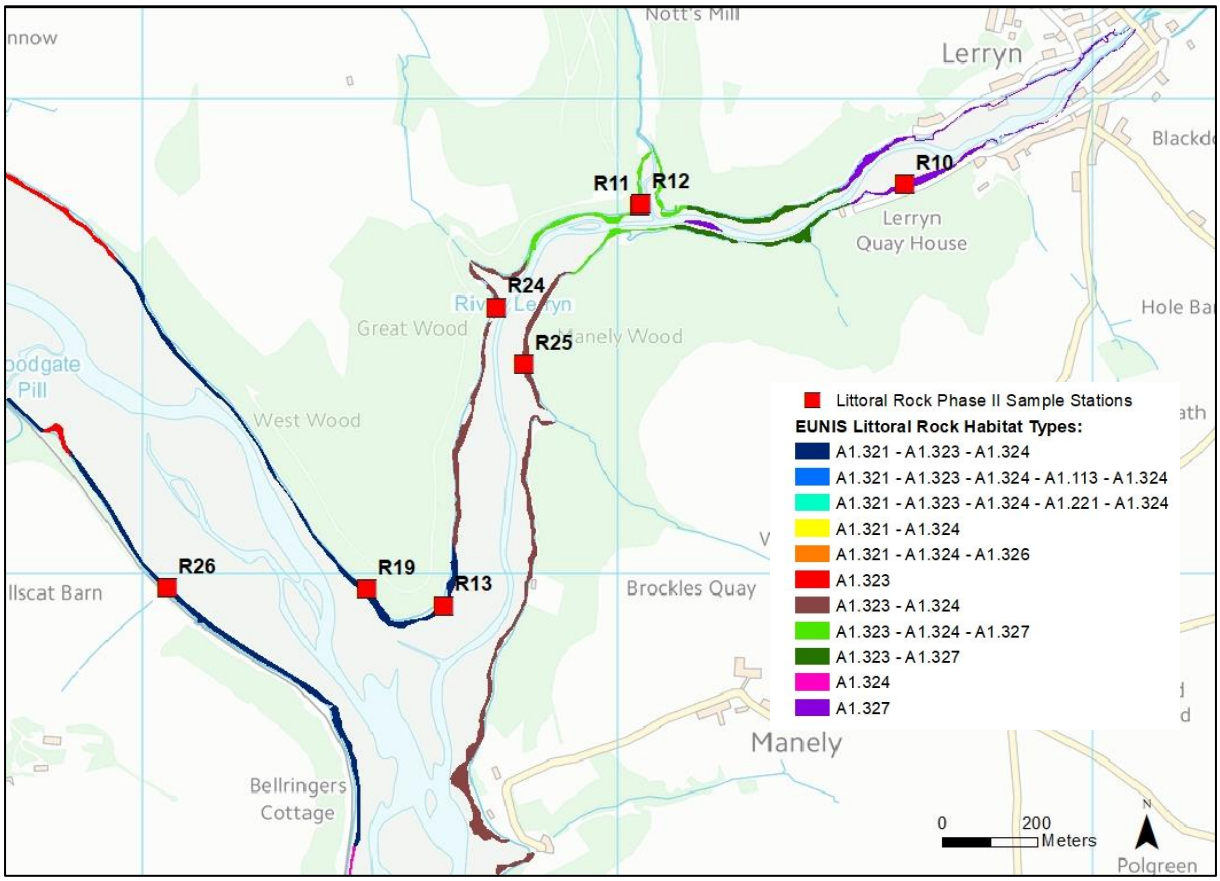

Figure 3. Extent and distribution of littoral rock communities in the Upper Fowey and Pont Pill MCZ – Golant to Milltown and Lerryn.

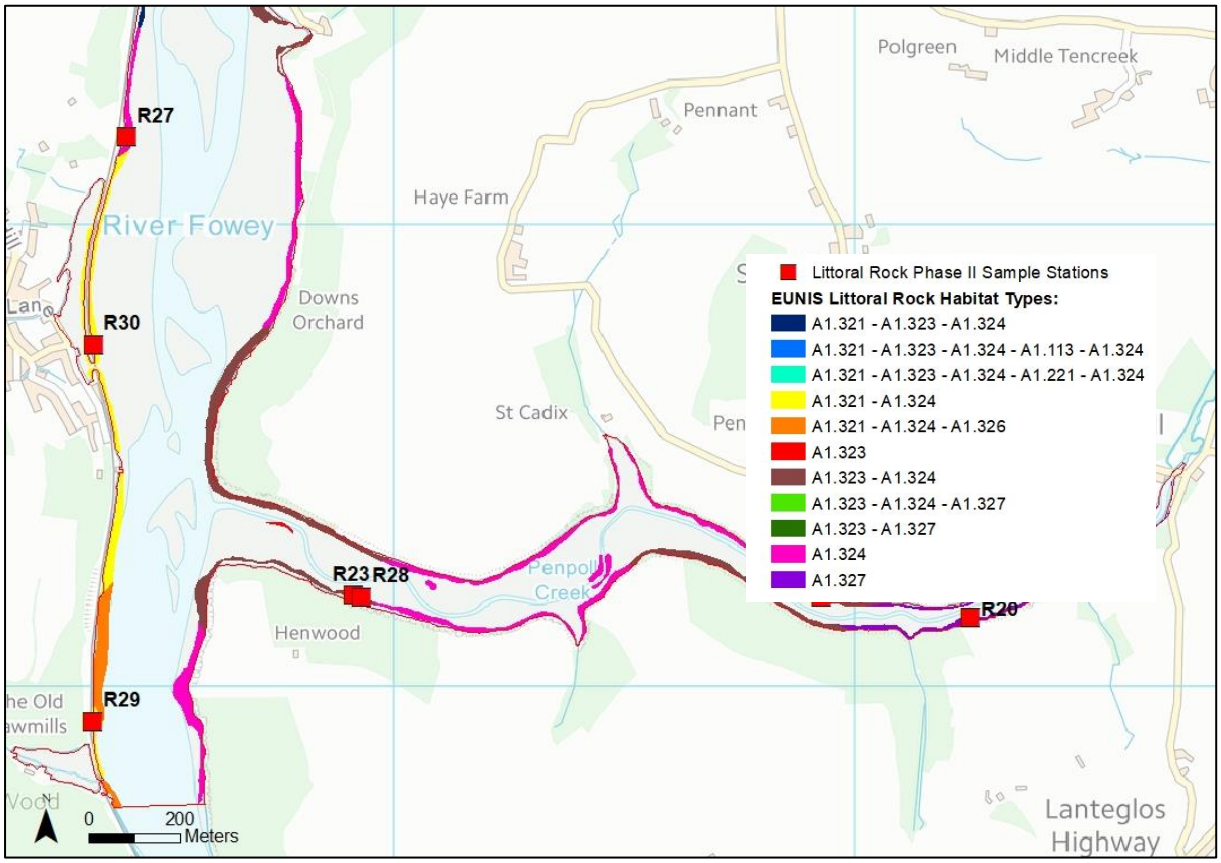

Figure 4. Extent and distribution of littoral rock communities in the Upper Fowey and Pont Pill MCZ – Golant to Penpoll.

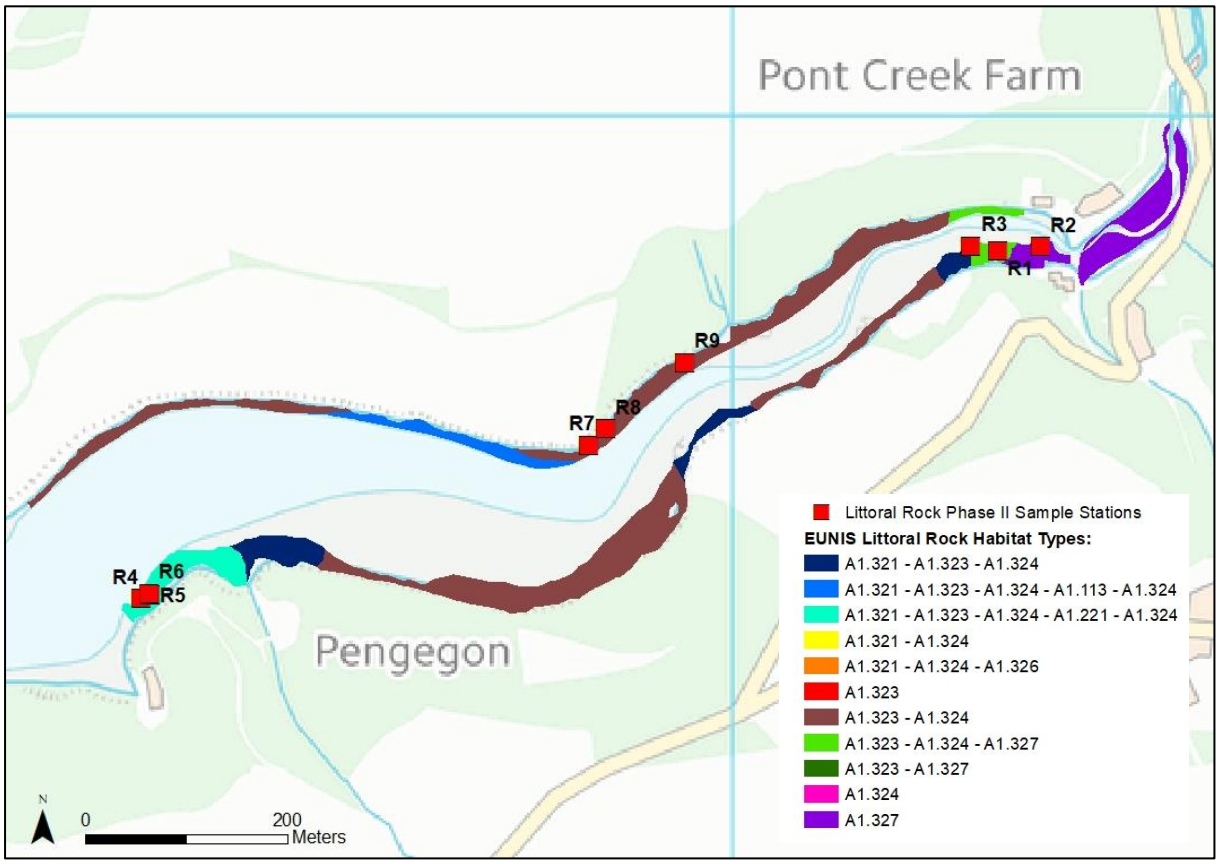

Figure 5. Extent and distribution of littoral rock communities in the Upper Fowey and Pont Pill MCZ – Pont Pill

4.1.1 Littoral Rock Habitat Type Descriptions

A1.1131 - *Semibalanus balanoides*, *Patella vulgata* and *Littorina* spp. on exposed to moderately exposed or vertical sheltered eulittoral rock

The A1.1131 Sub-biotope is described within the EUNIS classification[3] as:

"Very exposed to sheltered mid to upper eulittoral bedrock and large boulders characterised by dense barnacles [Semibalanus balanoides] and the limpet [Patella vulgate]. The community has a relatively low diversity of species though occasional cracks and crevices in the rock can provide a refuge for small individuals of the mussel [Mytilus edulis], the winkle [Littorina] spp. and the whelk [Nucella lapillus]. Seaweeds are usually not found in high numbers though fissures and crevices in the bedrock can hold a sparse algae community, though patches of the red seaweed [Osmundea pinnatifida] can be present throughout the zone. On some shores the olive green lichen [Verrucaria mucosa] can be present in some abundance (Frequent)."

Within the study area this Sub-biotope was limited to a stretch of rock approximately 300 m long on the northern shore of the Pont Pill (Figure 6). There, the barnacle dominated communities occupied a band of shore approximately 1.2 m high. Due to its extremely limited extent, this Sub-biotope was not included within Phase II and therefore no quantitative data is available for A1.1131 within the Upper Fowey and Pont Pill MCZ. The species listed as present during the Phase I survey however are consistent with the EUNIS description[3]. The Pacific oyster *Magallana gigas* (an INNS) was also found in superabundant densities in this zone, and the species distribution on this part of the shore extended down onto the A1.324 communities on mixed sediments below. A1.324 communities also bordered the upper shore

extent of the A1.1131 Biotope, but there the *Ascophyllum nodosum* and *Fucus vesiculosus* was attached to bedrock.

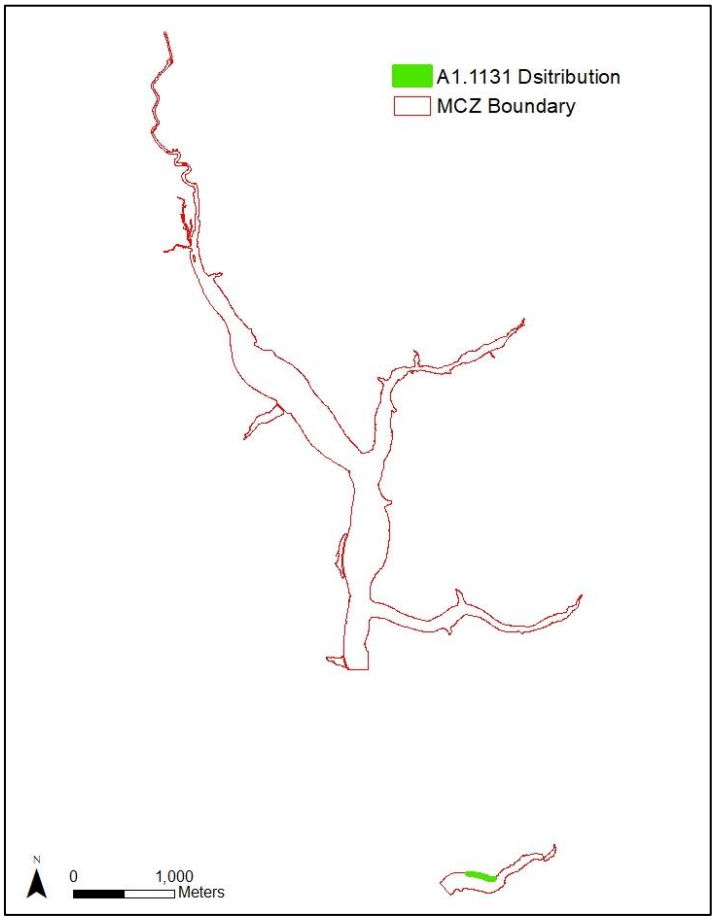

Figure 6. Map of the distribution of the A1.1131 Sub-biotope within the Upper Fowey and Pont Pill MCZ.

A1.221 - *Mytilus edulis* and *Fucus vesiculosus* on moderately exposed mid eulittoral rock

Within the EUNIS classification[3] the A1.221 Biotope is described as:

"Mid eulittoral exposed to moderately exposed bedrock, often with nearby sediment, covered by a dense band or large patches of the mussel [Mytilus edulis]. The community often supports scattered [Fucus vesiculosus] and occasional foliose red seaweeds such as [Porphyra umbilicalis], [Osmundea pinnatifida], [Mastocarpus stellatus], [Palmaria palmate] or the calcareous algae [Corallina officinalis]. The ephemeral green seaweeds [Ulva intestinalis] and [Ulva lactuca] commonly occur on the shells of the mussels. The barnacle [Semibalanus balanoides] is common on both the mussel valves and on patches of bare rock, where the limpet [Patella vulgate] also can be found. The whelk [Nucella lapillus] and the winkle [Littorina littorea] can be found within the mussel bed."

This Biotope was limited to the Pont Pill where *Mytilus edulis* occurred in patches (c. 5 m^2) over a small stretch of littoral rock (c. 130 m) at the most western extent of the MCZ boundary (Figure 7). In this area the rocks of the lower estuary are exposed to the greatest wave fetch and prevailing weather from the southwest. The shore height over which these communities were distributed varied between 1 and 5 m depending upon the shore topography and localised rock aspect. Due to the very localised extent of the A1.221 communities they were

not included within Phase II survey. The species listed as present during the Phase I survey however are consistent with the EUNIS description[3]. A1.324 communities were found on the shore, above and in patches below.

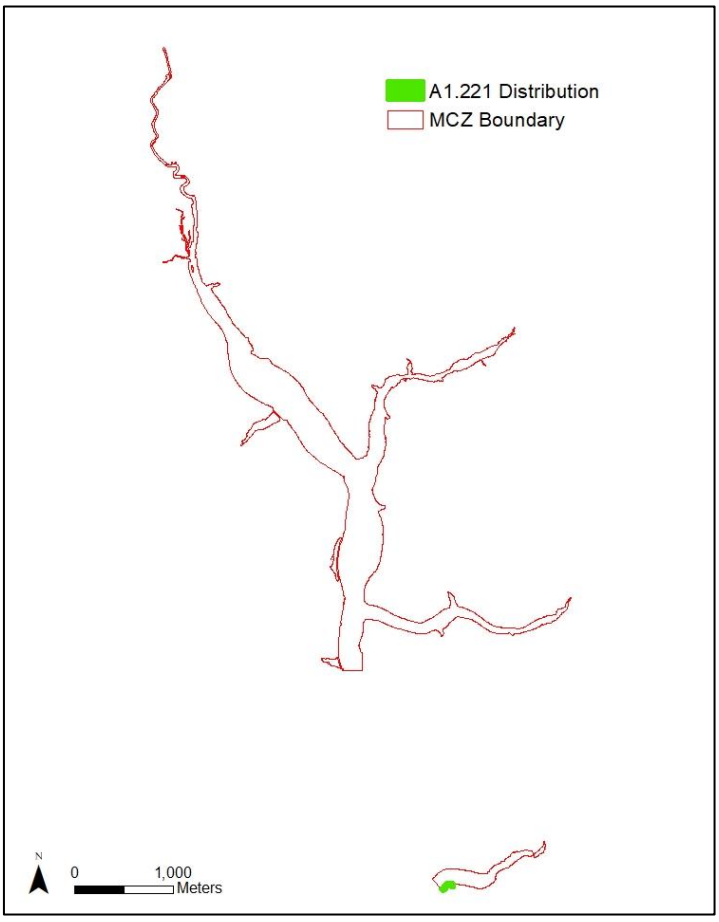

Figure 7. Map of the distribution of the A1.1131 Sub-biotope within the Upper Fowey and Pont Pill MCZ.

A1.321 - *Pelvetia canaliculata* on sheltered variable salinity littoral fringe rock

The A1.321 Biotope is described by EUNIS classification[3] as:

"Lower littoral fringe bedrock or stable boulders and mixed substrata on very sheltered to extremely sheltered variable salinity shores characterised by a dense cover of the wrack [Pelvetia canaliculata], which often overgrows a crust of black lichens [Verrucaria maura]. The wrack [Fucus spirali]s can be present among the [Pelvetia canaliculata]. This biotope lacks the density of barnacles found among the [Pelvetia canaliculata] on more exposed shores though the occasional [Semibalanus balanoides] or [Austrominius modestus] can be found. The winkle [Littorina saxatilis] occurs, as do a variety of amphipods. The red alga [Catenella caespitosa] can be present in more shaded areas as well as the green seaweed [Ulva intestinalis]."

The extent and distribution of A1.321 communities within the MCZ were largely dictated by that of stable upper shore substrate such as bedrock, boulders and constructed walls which are required to support *Pelvetia canaliculata* wrack. These communities were, therefore, most common along the west side of the upper Fowey from the southern MCZ boundary (of the Upper Fowey and Pont Pill MCZ) up to Woodgate where sea walls support an adjacent railway track on that side of the estuary (Figure 8). On the east side of the Upper Fowey the A1.321 communities were found only on the bedrock which bordered West Wood. Within the Pont

Pill, *Pelvetia canaliculata* was found only where the bedrock protruded out creating more substantial rocky outcrops. The A1.321 Biotope often formed a patchy band of between 0.1 m and 1 m height above *Fucus vesiculosus* and/or *Ascophyllum nodosum* (A1.323/A1.324).

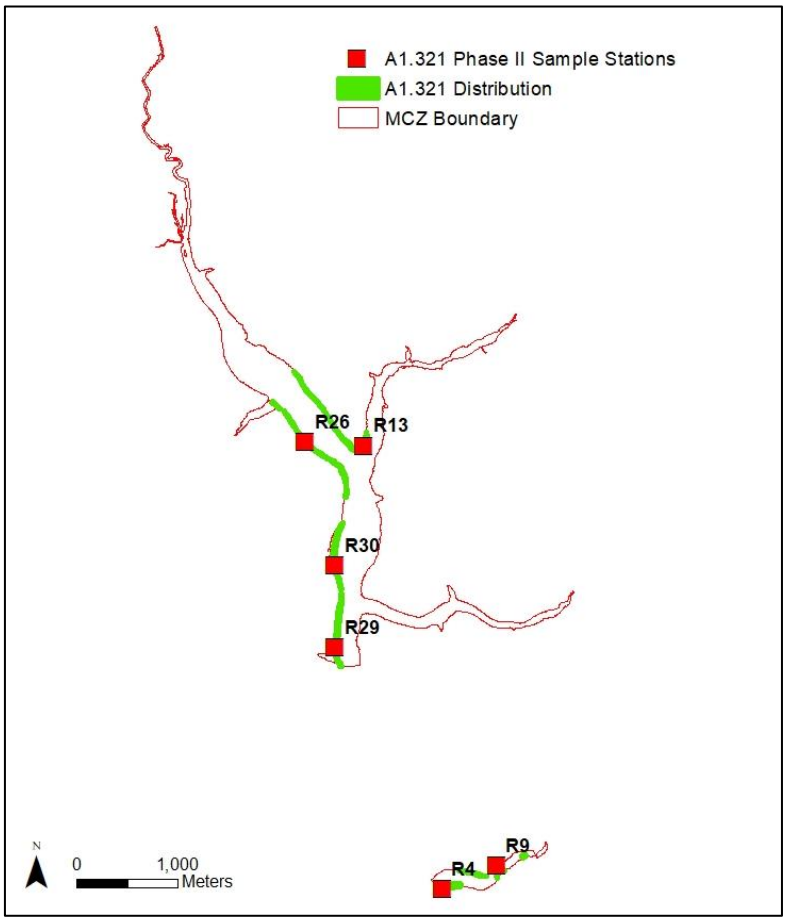

Figure 8. Map of the distribution of the A1.321 Biotope within the Upper Fowey and Pont Pill MCZ and the location of the Phase II sampling stations within the A1.321 communities.

Photographs of the A1.321 Biotope at Station R4 in the Pont Pill and R26 in the Upper Fowey are shown in Plates 1 and 2 respectively. These show the variability in the physical and biological attributes of the Biotope within the study area.

The A1.321 communities sampled within the Upper Fowey and Pont Pill MCZ correspond well with the EUNIS description of the Biotope[3]. With the exception of *Fucus spiralis*, all species listed as characterising were present at a proportion of the stations that were sampled (Table 1).

The most common additional species that was recorded at four of the six stations sampled was the INNS red algae *Caulacanthus ustulatus*. The distribution of this species was locally extremely patchy but the percentage cover captured in quadrats at stations, on average, ranged from occasional to common according to the SACFOR scale (1-19% cover). The Australasian barnacle *Austrominius modestus* was also rare at one of the six stations.

The mean Bray-Curtis similarity between the communities sampled in quadrats at the six stations was 49% (this was the lowest mean Bray-Curtis value of all the communities sampled in this study). Those species which provided the highest percentage contribution to similarity are listed in Table 2. The main characterising taxa, *Pelvetia canaliculata*, accounted for the highest proportion of similarity in the biotic data set accounting for 62%. The INNS

Caulacanthus ustulatus contributed the second most to community similarity although this was just 12%.

Table 1. Mean taxa abundance within quadrats at stations within the A1.321 Biotope with the Upper Fowey and Pont Pill MCZ.

Taxa	R3	R4	R9	R13	R26	R29
Austrominius modestus		0.2				
Gammaridae		14	0.8			
Semibalanus balanoides		0.2				
Carcinus maenas juv.					0.2	
Anurida maritima				15.4		
Littorina littorea					0.2	
Littorina saxatilis	5.2					1.6
Ulva lactuca			1.2			
Chaetomorpha			15			21
Ulva intestinalis		5			44	8.6
Fucus vesiculosus		5.6	7	0.6	7	2.4
Pelvetia canaliculata	64	61	41	55	13	21
Vertebrata lanosa			17			
Rhodophyta		4.2				
Catenella caespitosa	11.8	1.2	5.6			9
Caulacanthus ustulatus	4.6			7.4	22	1 .6
Verrucaria maura		32		16		27

Table 2. Taxa contributions to similarities in community structure within the A1.321 Habitat type with the Upper Fowey and Pont Pill MCZ.

Taxa	Mean Abundance per Quadrat	Mean Similarity	% Contribution	Cumulative % Contribution
Pelvetia canaliculata	6.2	30.1	62	62
Caulacanthus ustulatus	2.0	5.8	12	74
Fucus vesiculosus	1.4	3.4	7	81
Ulva intestinalis	1.8	2.9	6	86
Catenella caespitosa	1.4	2.8	6	92
Chaetomorpha	1.3	1.5	3	95
Gammaridae	0.7	0.7	1	97
Littorina saxatilis	0.5	0.6	1	98
Anurida maritima	0.6	0.5	1	99
Vertebrata lanosa	0.7	0.4	1	100

Plate 1. Photograph of the A1.321 Biotope within the Upper Fowey and Pont Pill MCZ at Station R4.

Plate 2. Photograph of the A1.321 Biotope within the Upper Fowey and Pont Pill MCZ at Station R26.

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

The EUNIS habitat classification[3] describes the A1.323 Biotope as:

"Sheltered to extremely sheltered mid eulittoral pebbles and cobbles lying on sediment subject to variable salinity and characterised by the wrack [Fucus vesiculosus]. The wrack [Ascophyllum nodosum] can occasionally be found on larger boulders, while the barnacles [Semibalanus balanoides] and [Austrominius modestus] and the mussel [Mytilus edulis] can be present on cobbles. Winkles, particularly [Littorina littorea], commonly graze on the

seaweeds, while [Littorina saxatilis] can be found in crevices. Ephemeral seaweeds such as [Ulva intestinalis] can occupy available space. Patches of sediment found between the hard substrata often contains the lugworm [Arenicola marina] or the sand mason [Lanice conchilega], while the crab [Carcinus maenas], gammarids and amphipods occur on and under cobbles."

The estuarine *Fucus vesiculosus* dominated communities were almost ubiquitous within the Pont Pill, absent only from the very top of the tributary where the conditions were most influenced by freshwater input (Figure 9). Within the upper Fowey these communities extended from Newham on the River Fowey, and Lerryn Quay House on the River Lerryn, down the estuary as far as Manley. These communities were less widespread within Penpoll Creek occurring only over part of the southern bank and either side of the creek mouth.

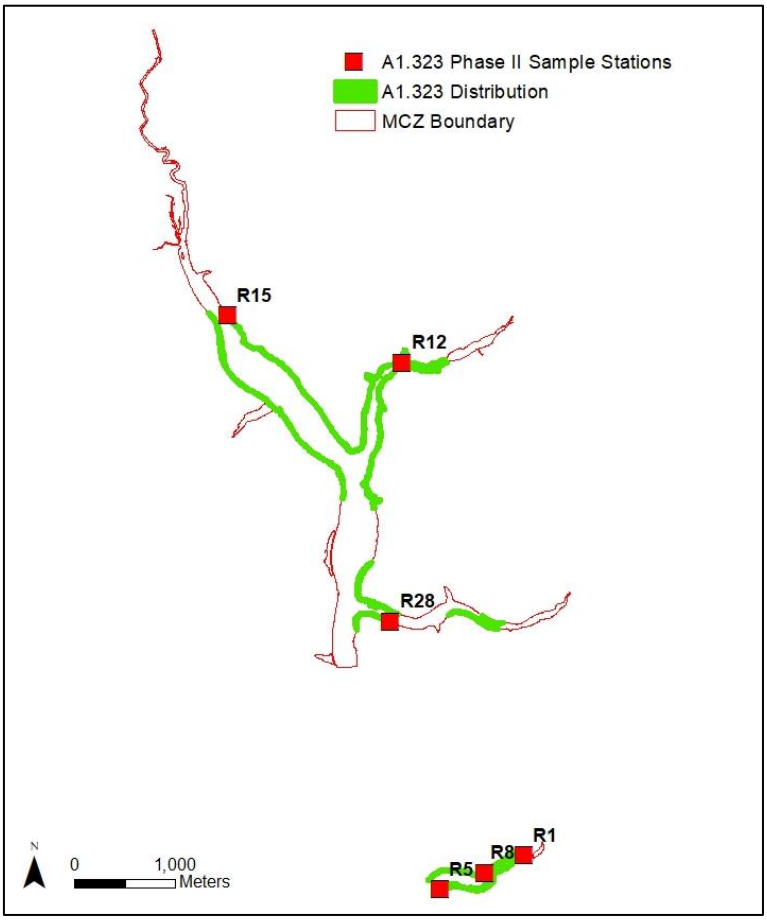

Figure 9. Map of the distribution of the A1.323 Biotope within the Upper Fowey and Pont Pill MCZ and the location of the Phase II sampling stations within the A1.323 communities.

The width of shore over which the *Fucus vesiculosus* zone was measured was, as would be expected, largely associated with shore topography. Where the shore was more gently sloping, or where fallen trees were found along the shoreline, the mid shore fucoid band was up to 6 m, elsewhere the band was as little as 0.25 m. Where there was stable substrate above the A1.323 Biotope, a band of *Pelvetia canaliculata* was often present, but where the mixed sediments interfaced with the supralittoral zone the A1.323 Biotope was the highest shore littoral rock Habitat type present. Most commonly found below the A1.323 Biotope were A1.324 communities, within these the *Fucus vesiculosus* was interspersed with *Ascophyllum nodosum* to varying proportions. Where the littoral rock was found in close proximity to a main river channel however, *Fucus ceranoides* (A1.327) (which is more tolerant of reduced salinity than other fucoids) was found below the band of *Fucus vesiculosus*. Photographs of the

A1.323 Biotope at Station R15 in the Upper Fowey and R5 in the Pont Pill are shown in Plates 3 and 4 respectively.

Plate 3. Photograph of the A1.323 Biotope within the Upper Fowey and Pont Pill MCZ at Station R15.

Plate 4. Photograph of the A1.323 Biotope within the Upper Fowey and Pont Pill MCZ at Station R5.

An examination of the average species abundance data (Table 3) shows that the communities recorded within the MCZ are largely consistent with the EUNIS description[3] of the Biotope. Additional species present within the MCZ, which are not listed as characterising for the Biotope, include the creeping chain weed *Catenella caespitosa* which was recorded at all stations sampled within the A1.323 Biotope (probably as a result of the shade offered by overhanging trees which is characteristic of much of the littoral rock throughout the MCZ). The INNS *Caulacanthus ustulatus* was also recorded at three of the six stations at up to 10% cover on average.

The mean similarity between the communities sampled using quadrats within the A1.323 Biotope was 56% (this was the lowest mean Bray-Curtis value of all the communities sampled in this study).

Those species which provided the highest percentage contribution to similarity are listed in Table 4. The main characterising species, *Fucus vesiculosus*, contributed 78% to the overall similarity of the community data.

Table 3. Mean taxa abundance within quadrats at stations within the A1.323 Biotope in the Upper Fowey and Pont Pill MCZ.

Taxa	R1	R5	R8	R12	R15	R28
Austrominius modestus		1.2	0.2	0.2		
Gammaridae		18	0.4	0.4		3
Semibalanus balanoides		5.2	0.6			
Carcinus maenas juv.	1.2	0.2	0.2		0.2	
Collembola		4				
Neobisium maritimum		0.2				
Anurida maritima		8				
Littorina juv.		0.6				
Patella		0.4				
Littorina littorea		0.8	0.2			
Ulva lactuca	0.8					
Chaetomorpha	1 .2		6.6			11
Cladophora		3				
Ulva intestinalis			0.6			6
Ascophyllum nodosum	1.8	0.4	5			9
Fucus ceranoides				1	2	
Fucus vesiculosus	9	84	55	69	61	3
Pelvetia canaliculata		0.4	0.4			
Catenella caespitosa	15.4	13	6.4	1.4	0.4	23
Caulacanthus ustulatus				3.6	9.2	1

Table 4. Taxa contributions to similarities in community structure within the A1.323 Biotope in the Upper Fowey and Pont Pill MCZ.

Taxa	Mean Abundance per Quadrat	Mean Similarity	% Contribution	Cumulative % Contribution
Fucus vesiculosus	7.9	43.9	78	78
Catenella caespitosa	2.3	6.0	11	88
Chaetomorpha	1.3	2.4	4	93
Caulacanthus ustulatus	0.7	1.1	2	95
Ascophyllum nodosum	0.8	0.9	2	96
Gammaridae	1.0	0.9	2	98
Semibalanus balanoides	0.5	0.4	1	98
Austrominius modestus	0.3	0.2	0	99
Carcinus maenas juv.	0.2	0.2	0	99

A1.324 - *Ascophyllum nodosum* and *Fucus vesiculosus* on variable salinity mid eulittoral rock

The A1.324 Biotope is described as *"very sheltered to extremely sheltered mid eulittoral bedrock, boulders or cobbles subject to variable salinity characterised by an impoverished community dominated by a mixture of the wracks [Ascophyllum nodosum] and [Fucus vesiculosus]. Underneath the canopy are a few green seaweeds including [Ulva intestinalis] and [Cladophora] spp., while the red seaweed [Vertebrata lanosa] can be found as an epiphyte*

on [Ascophyllum nodosum]. On the rock and among the boulders are the winkles [Littorina littorea] and [Littorina saxatilis], the crab [Carcinus maenas], the barnacles [Semibalanus balanoides] and [Austrominius modestus] and even the occasional mussel [Mytilus edulis]. Among the seaweeds and underneath the boulders a variety of gammarids can be found."

The *Ascophyllum nodosum* and *Fucus vesiculosus* communities (A1.324) are the most commonly occurring littoral rock communities within the MCZ. Their distribution geographically within the estuary largely reflects that of the *Fucus vesiculosus* dominated communities (A1.323), except that in the upper Fowey the A1.324 communities extend all the way down to the southern MCZ boundary on both sides of the estuary (Figures 10 and 11).

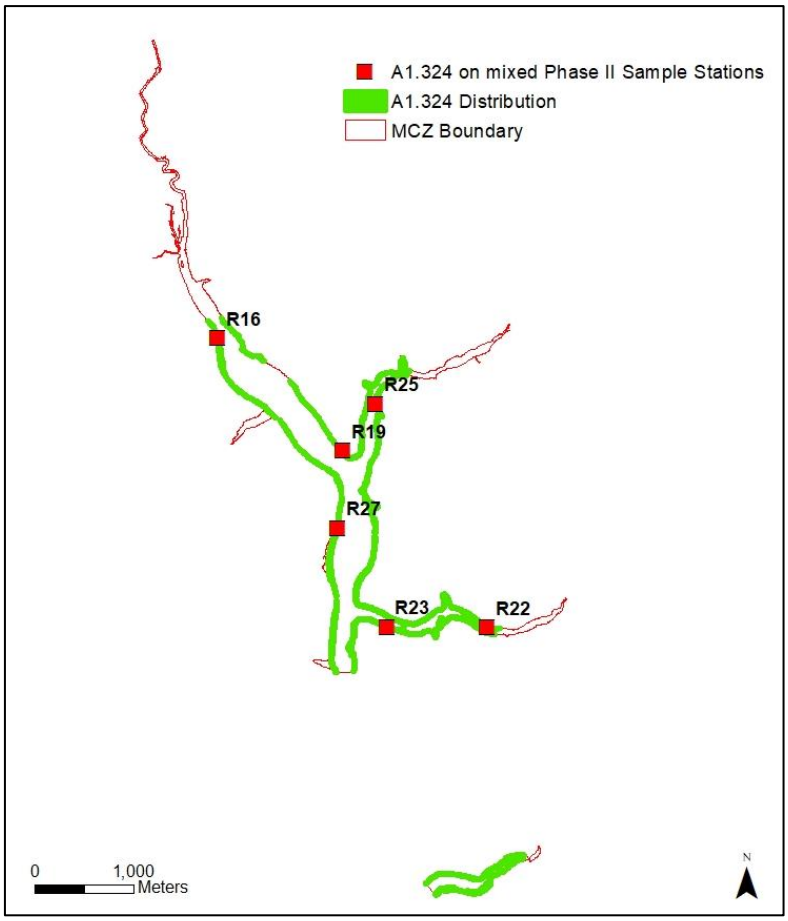

Figure 10. Map of the distribution of the A1.324 communities on mixed sediments within the Upper Fowey and Pont Pill MCZ, and the location of the Phase II sampling stations within the A1.324 (on mixed sediment) communities.

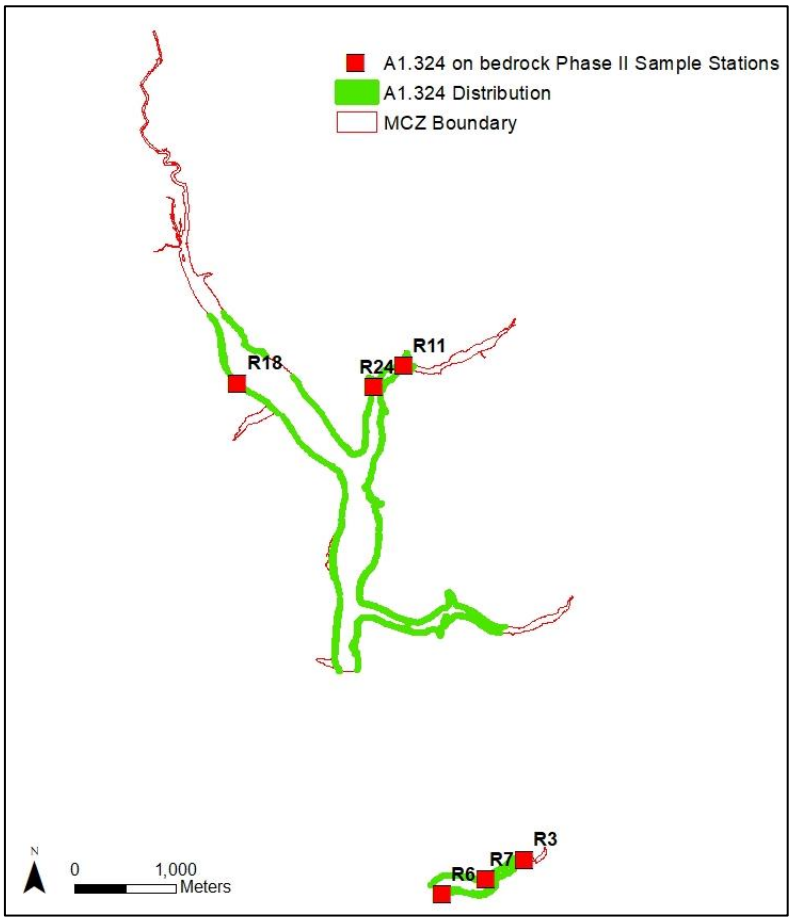

Figure 11. Map of the distribution of the A1.324 communities on bedrock within the Upper Fowey and Pont Pill MCZ, and the location of the Phase II sampling stations within the A1.324 (on bedrock) communities.

The EUNIS habitat classification does not distinguish between A1.324 communities on rock and those on stable mixed substrata. However, due to the variability in the communities found on these two different types of substrate within the MCZ, sample replication was targeted and analysed separately within each substrate type (Tables 5 and 6). Photographs of the A1.324 Biotope on rock and that on mixed sediments are shown in Plates 5 and 6, and Plates 7 and 8 respectively. The A1.324 communities often occurred on rock above those on mixed sediments at the same station. Therefore when measuring height of shore over which the Biotope occurred, often both the rock and stable mixed sediments were incorporated into a single measurement; the height ranged between 0.75 m (in the River Lerryn) and 25 m (in the Pont Pill).

Table 5. Mean taxa abundance within quadrats at stations within the A1.324 communities on mixed sediments with the Upper Fowey and Pont Pill MCZ.

Taxa	R16	R19	R22	R23	R25	R27
Polychaeta					0.2	
Austrominius modestus		0.6		2.2	0.4	0.2
Gammaridae	1.2	3	1	0.8	14.6	7.4
Semibalanus balanoides				5.6		0.6
Carcinus maenas juv.		1.4		0.4		
Carcinus maenas		0.2				
Anurida maritima				1	1.4	
Littorina littorea				2		4.2
Littorina obtusata				1		1.4
Littorina saxatilis				0.6		
Ulva lactuca	3					
Ascophyllum nodosum	31	77	31	28	54.4	54
Fucus ceranoides	7.4		1			
Fucus vesiculosus	17	1		5	26	17
Vertebrata lanosa		5.4		14		
Caulacanthus ustulatus				0.6		
Mastocarpus stellatus				0.4		

Table 6. Mean taxa abundance within quadrats at stations within the A1.324 communities on bedrock within the Upper Fowey and Pont Pill MCZ.

Taxa	R3	R6	R7	R11	R18	R24
Porifera			0.2			
Actinia equina		0.4				
Dynamena pumila		1	0.6			
Austrominius modestus	3.2	0.2		0.4	5.6	3
Gammaridae	6.8	7.4	3.2			4
Semibalanus balanoides	0.4	17	0.8			
Carcinus maenas juv.	2.6	0.2	1		0.4	1
Anurida maritima		8				
Magallana gigas			0.6			
Patella		1	0.2			0.2
Littorina littorea		0.6	0.6			0.4
Littorina obtusata		1.6	1.2			
Mytilus edulis		0.4	0.6			
Cladophora	0.2	1.2				
Ulva intestinalis	6					
Ascophyllum nodosum	81	91	73	57	92	88
Fucus ceranoides				9.4		
Fucus vesiculosus		3		6	2	5.6
Vertebrata lanosa	15	13	7			
Catenella caespitosa	0.4					5
Caulacanthus ustulatus			0.6			
Mastocarpus stellatus		2.8	1			

Plate 5. Photograph of the A1.324 communties on mixed sediments at Station R16 with the Upper Fowey and Pont Pill MCZ.

Plate 6. Photograph of the A1.324 communties on mixed sediments at Station R23 within the Upper Fowey and Pont Pill MCZ.

Plate 7. Photograph of the A1.324 communties on bedrock at Station R7 within the Upper Fowey and Pont Pill MCZ.

Plate 8. Photograph of the A1.324 communties on bedrock at Station R24 Upper Fowey and Pont Pill MCZ.

The A1.324 communities observed within the Upper Fowey and Pont Pill MCZ in 2018 closely resemble those described in the EUNIS classification[3]. The number of characteristic taxa sampled was, however, highly variable between stations sampled both on mixed substrata and on rock. The richest communities were found on rock within the lower reaches of the Pont Pill (stations R6 and R7). INNS recorded included Pom Pom weed *Caulacanthus ustulatus* which was present at occasional abundance at two of the twelve stations sampled, and 3 individuals of *Magallana gigas* which were attached to rock at station R7 in the Pont Pill.

The mean Bray-Curtis similarity between the community data gathered from the six stations sampled on rock was 58%, whilst that between the stations sampled on mixed substrates was lower at 50%.

Ascophyllum nodosum was the highest contributing taxa to the community similarity in both groups of data contributing 35.7% and 45.4% to the A1.324 communities on mixed sediment and rock respectively (Tables 7 and 8). The presence and abundance of the second principal characterising species *Fucus vesiculosus* contributed substantially less, just 13% and 3% in mixed sediment and rock communities respectively.

Table 7. Taxa contributions to community similarities within the A1.324 Biotope on mixed sediments within the Upper Fowey and Pont Pill MCZ.

Taxa	Mean Abundance per Quadrat	Mean Similarity	% Contribution	Cumulative % Contribution
Ascophyllum nodosum	6.3	35.7	72	72
Fucus vesiculosus	2.4	6.7	13	85
Gammaridae	1.4	3.7	7	92
Vertebrata lanosa	1.0	1.5	3	95
Littorina littorea	0.5	0.6	1	96
Austrominius modestus	0.4	0.5	1	97
Fucus ceranoides	0.5	0.5	1	98
Littorina obtusata	0.3	0.2	0	99
Carcinus maenas juv.	0.2	0.2	0	99

Table 6. Taxa contributions to community similarities within the A1.324 Biotope on bedrock within the Upper Fowey and Pont Pill MCZ.

Taxa	Mean Abundance per Quadrat	Mean Similarity	% Contribution	Cumulative % Contribution
Ascophyllum nodosum	8.9	45.4	78	78
Vertebrata lanosa	1.6	2.8	5	83
Gammaridae	1.3	2.4	4	87
Austrominius modestus	0.9	1.9	3	90
Fucus vesiculosus	1.0	1.8	3	93
Carcinus maenas juv.	0.6	1.2	2	95
Semibalanus balanoides	0.8	0.5	1	96
Fucus ceranoides	0.5	0.5	1	97
Littorina obtusata	0.4	0.4	1	98
Dynamena pumila	0.6	0.3	1	98
Mastocarpus stellatus	0.4	0.3	0	99
Ulva intestinalis	0.4	0.3	0	99

A1.326 – *Fucus serratus* and large *Mytilus edulis* on variable salinity lower eulittoral rock

The EUNIS classification[3] categorises the A1.326 Biotope as areas of:

"Very sheltered lower eulittoral rock or mixed substrata subject to variable salinity, which support an impoverished community dominated by the wrack [Fucus serratus]. The hydroid [Dynamena pumila] can form colonies on the Fucus serratus and clumps of large individuals of the mussel [Mytilus edulis] may be present on the bedrock beneath. The canopy of [Fucus serratus] is not usually as dense as in the other [Fucus serratus] dominated biotopes due the presence of the wracks [Ascophyllum nodosum] and [Fucus vesiculosus], which are better

adapted to the variable salinity. A few red seaweeds are present which includes the species [Mastocarpus stellatus], [Chondrus crispus] and coralline crusts. Underneath the canopy is a sparse fauna consisting of barnacles [Semibalanus balanoides], [Balanus crenatus] and [Austrominius modestus], the limpet [Patella vulgate] or the occasional presence of the winkles [Littorina obtusata] and [Littorina mariae] and the crab [Carcinus maenas]. The tube-forming polychaetes [Pomatoceros triqueter] or spirorbid polychaetes can be found."

The A1.326 Biotope was limited to one area of the MCZ; a stretch of shore approximately 350 m long adjacent to Colvithick Wood at the southern end of the Upper Fowey MCZ boundary (Figure 12). At that location the *Fucus serratus* was limited to the extreme low water zone where it transitioned from *Fucus vesiculosus* communities (A1.324) on the mid shore. The presence of *Fucus Serratus* along that stretch of shore was patchy and interspersed with mixed sediments and/or areas of *Ulva intestinalis* with frequent abundance of *Fucus vesiculosus* (Plate 9). Due to their very limited extent, the A1.326 communities were not included within the quantitative sampling survey phase. The communities observed during the Phase I survey were similar to those described in the EUNIS classification[3], the only difference being the absence of a red algae under the main fucoid canopy, probably as a result of the high freshwater influence which the Biotope is exhibited to next to the main channel.

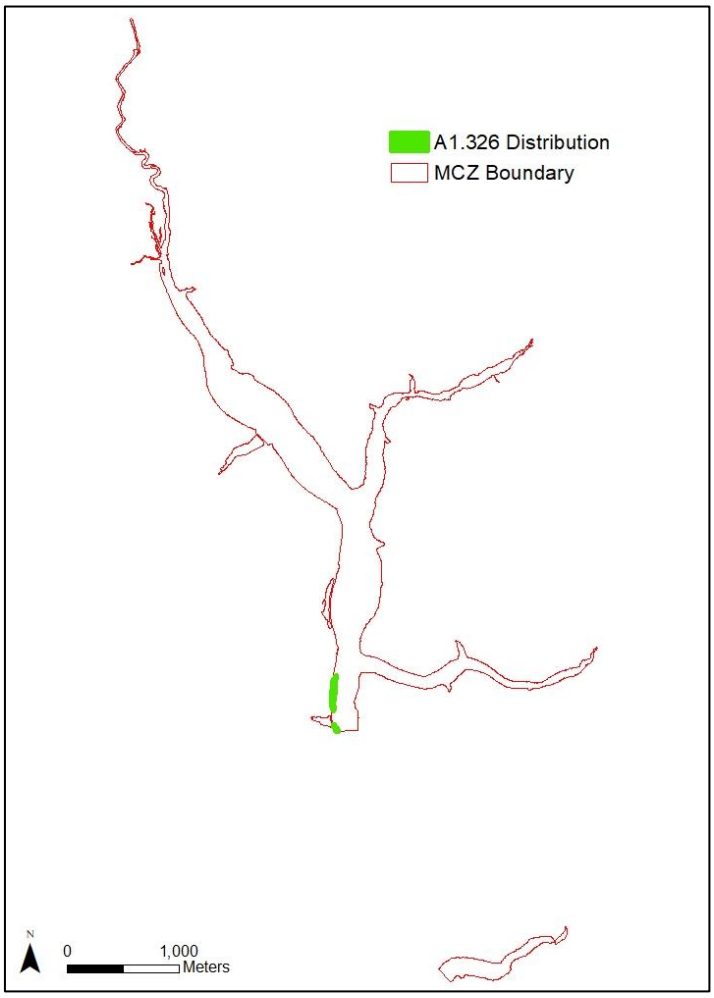

Figure 12. Map of the distribution of the A1.326 communities within the Upper Fowey and Pont Pill MCZ.

Plate 9. Photograph of the A1.326 communties within the Upper Fowey and Pont Pill MCZ.

A1.327 - *Fucus ceranoides* on reduced salinity eulittoral rock

This EUNIS Biotope[3] is described as:

"*Very sheltered to extremely sheltered bedrock and stable boulders in the eulittoral zone that are subject to reduced salinity and characterised by the wrack [Fucus ceranoides]. Species richness is typically low in this biotope. The green seaweeds [Ulva intestinalis] and [Ulva lactuca] may be present together with the crab [Carcinus maenas] and the occasional barnacle [Austrominius modestus] and [Semibalanus balanoides].*"

The extent and distribution of the A1.327 Biotope is limited to the mid-upper reaches of the Fowey estuary and its tributaries where the freshwater influence is greatest (Figure 13). Within the main Fowey river channel the Biotope starts where the stable mixed substrates begin at Milltown, and extends down as far as St Winnow where the *Fucus ceranoides* communities become restricted to banks in the centre of the main channel. Within the River Lerryn *Fucus ceranoides* is found between Lerryn and Notts Mill Creek, and in Penpoll and Pont Pill creeks it is restricted to the top 800 m and 250 m respectively. Photographs of the Biotope in the Upper Fowey and Pont Pill are shown in Plates 10 and 11 respectively. The width of shore over which the A1.327 communities stretched ranged between 0.5 and 7 m.

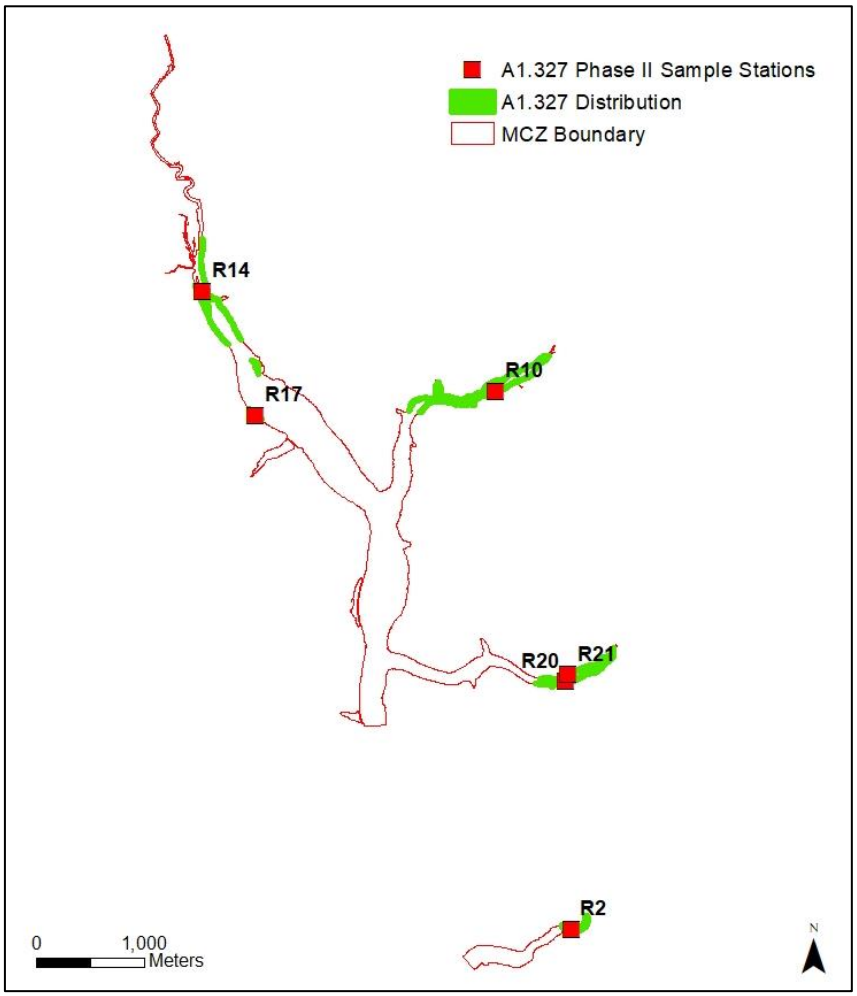

Figure 13. Map of the distribution of the A1.327 communities within the Upper Fowey and Pont Pill MCZ, and the location of the Phase II sampling stations within the A1.327 (on bedrock) Biotope.

Plate 10. Photograph of the A1.327 Biotope within the Upper Fowey and Pont Pill MCZ at Station R17.

Plate 11. Photograph of the A1.327 Biotope within the Upper Fowey and Pont Pill MCZ at Station R2.

The A1.327 communities within the MCZ are accurately described by the EUNIS description[3] of the Biotope, this is represented by the data collected from quadrats in Table 9 which shows very low species diversity. Not surprisingly, the presence of *Fucus ceranoides* almost exclusively accounted for the similarities between the communities sampled (Table 10).

Table 7. Mean taxa abundance within quadrats at stations within the A1.327 Biotope within the Upper Fowey and Pont Pill MCZ.

Transect:	R2	R1	R14	R17	R2	R21
Gammaridae			0.8	0.4	0.2	3.4
Carcinus maenas juv.			0.4	0.4		
Ulva intestinalis	0.8					
Ascophyllum nodosum	2			2		
Fucus ceranoides	79	1	72	71	34	82
Fucus vesiculosus					1	

Table 8. Taxa contribution in the A1.327 communities derived from quadrat data within the Upper Fowey and Pont Pill MCZ.

Taxa	Mean Abundance per Quadrat	Mean Similarity	% Contribution	Cumulative % Contribution
Fucus ceranoides	8.4	80.3	99	99
Gammaridae	0.4	0.5	1	100
Carcinus maenas juv.	0.1	0.1	0	100
Ascophyllum nodosum	0.2	0.1	0	100
Ulva intestinalis	0.1	0.0	0	100

4.1.2 Statistical Analysis of Flora and Fauna in Littoral Rock Habitat Types

The results of the univariate analysis for each transect and the mean diversity indices for each habitat type have been incorporated into Table 9.

The often patchy nature of littoral rock communities at the scale of sampling has led to variable univariate indices both within and between habitat types.

Table 9. Univariate community analysis of littoral rock communities in the Upper Fowey and Pont Pill MCZ.

Habitat Type	Station	Total no. taxa per station (x 3 Quadrats) S	Mean Abundance per 0.25 m^2 N	Margelef's Species Richness d	Pielou's Eveness J'	Shannon Wiener Index H'(loge)	Simpson Diversity Index 1-Lambda'
A1.321	R4	9	123	1.66	0.64	1.40	0.68
	R9	7	88	1.34	0.75	1.46	0.71
	R13	5	94	0.88	0.71	1.14	0.61
	R26	6	86	1.12	0.67	1.21	0.65
	R29	8	101	1.52	0.88	1.82	0.82
	R30	4	86	0.67	0.59	0.82	0.42
	Mean	***7***	***96***	***1.20***	***0.71***	***1.31***	***0.65***
A1.323	R1	6	119	1.05	0.46	0.83	0.41
	R5	15	139	2.84	0.53	1.43	0.61
	R8	11	76	2.31	0.42	1.01	0.46
	R12	6	76	1.16	0.22	0.40	0.17
	R15	5	73	0.93	0.34	0.55	0.29
	R28	7	83	1.36	0.82	1.60	0.77
	Mean	***8***	***94***	***1.61***	***0.47***	***0.97***	***0.45***
A1.324 on mixed	R16	5	60	0.98	0.74	1.19	0.64
	R19	7	89	1.34	0.29	0.57	0.24
	R22	3	33	0.57	0.25	0.27	0.12
	R23	13	62	2.91	0.66	1.69	0.74
	R25	6	97	1.09	0.59	1.06	0.60
	R27	7	85	1.35	0.56	1.09	0.55
	Mean	***7***	***71***	***1.37***	***0.51***	***0.98***	***0.48***
A1.324 on bedrock	R3	9	116	1.68	0.49	1.07	0.49
	R6	16	158	2.96	0.56	1.56	0.64
	R7	14	91	2.89	0.33	0.88	0.35
	R11	4	73	0.70	0.50	0.69	0.37
	R18	4	100	0.65	0.24	0.34	0.15
	R24	8	107	1.50	0.36	0.76	0.32
	Mean	***9***	***108***	***1.73***	***0.42***	***0.88***	***0.39***
A1.327	R2	3	82	0.45	0.15	0.17	0.07
	R10	1	100	0.00	-	0.00	0.00
	R14	3	73	0.47	0.09	0.09	0.03
	R17	4	74	0.70	0.14	0.19	0.07
	R20	3	35	0.56	0.15	0.16	0.07
	R21	2	85	0.22	0.24	0.17	0.08
	Mean	***3***	***75***	***0.40***	***0.15***	***0.13***	***0.05***

Two trends in the univariate indices are usually apparent in small estuarine systems such as the Fowey estuary. The first is that generally speaking, the lower shore Habitat types usually exhibit greater species diversity and richness. 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 those species that are tolerant of desiccation and temperature stress (as well

as salinity stress) can survive. However, the diversity values for the A1.321 Biotope (*Pelvetia canaliculata* on sheltered variable salinity littoral fringe rock) and the A1.327 (*Fucus ceranoides* on reduced salinity littoral rock) (which are generally found on the upper and lower shore respectively within the study area) contradicts this usual trend, whilst the diversity and richness between the mid shore Habitat types are similar (Table 9). The reason for this is likely to be associated with the fact that only the upper Fowey and Pont Pill were included within the study area, and therefore the stresses imposed on fauna and flora from the freshwater input from the river channels has clearly had a greater influence on community composition at the majority of stations than that of desiccation and temperature stress. Had the lower estuary (e.g. down as far as Polruan and Fowey town) been included in the study area, then the less variable/higher salinity in that part of the estuary would have facilitated colonisation by a greater number of taxa on the lower shore producing more usual trends in univariate statistics with shore height. The higher diversity of the upper shore community data may also be associated with the high degree of shading of the mid-upper littoral zone by the wooded banks that are present throughout much of the study area, thus alleviating temperature and desiccation stress. In contrast, the high presence of muddy sediments on the lower shore and therefore siltation/smothering is likely to be a significant influence resulting in reduced diversity of epifaunal species on the lower shore.

Due to the influence of freshwater, the richness and diversity of communities would also usually be expected to become diminished geographically higher in the estuary. However, no such trends are evident in the number of taxa/species richness data within the MCZ (R = 0.14). However, the littoral rock species diversity data that has been gleaned from within the MCZ follow a long established pattern along the estuarine salinity gradient described by Carriker[7]; a significant upward trend in diversity is apparent with distance down the estuary (R = 0.45, P = <0.05). The geographical distribution of the number of taxa and species diversity at stations within the MCZ in 2018 is represented in Figures 14 and 15 respectively.

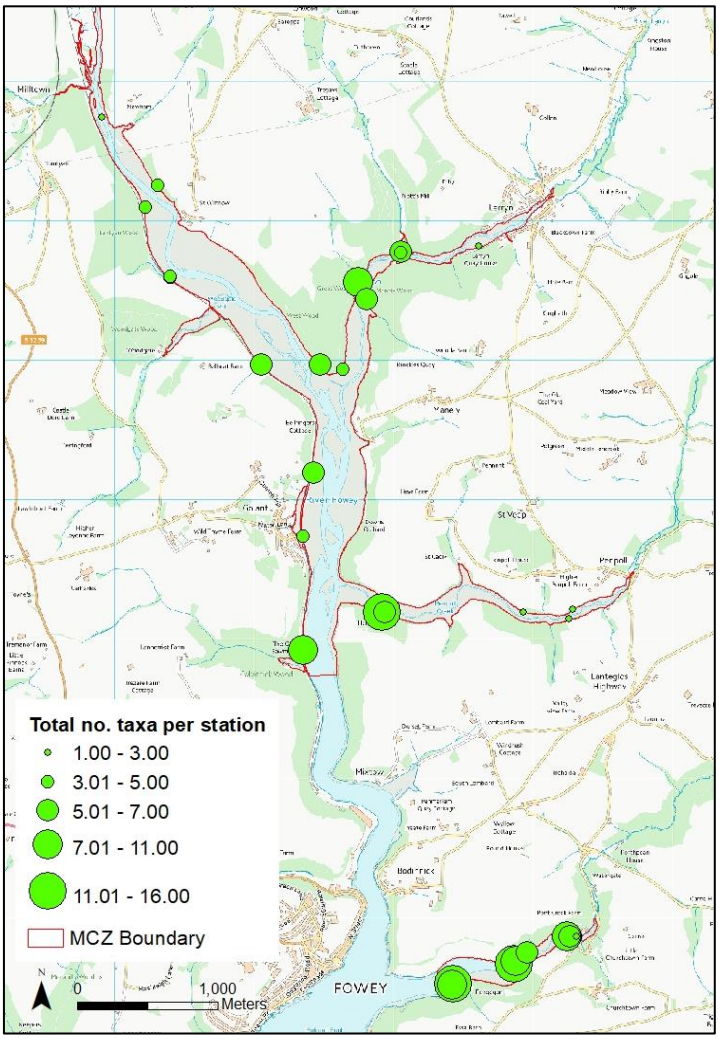

Figure 14. Geographical representation of the total number of taxa recorded at stations within the Upper Fowey and Pont Pill MCZ.

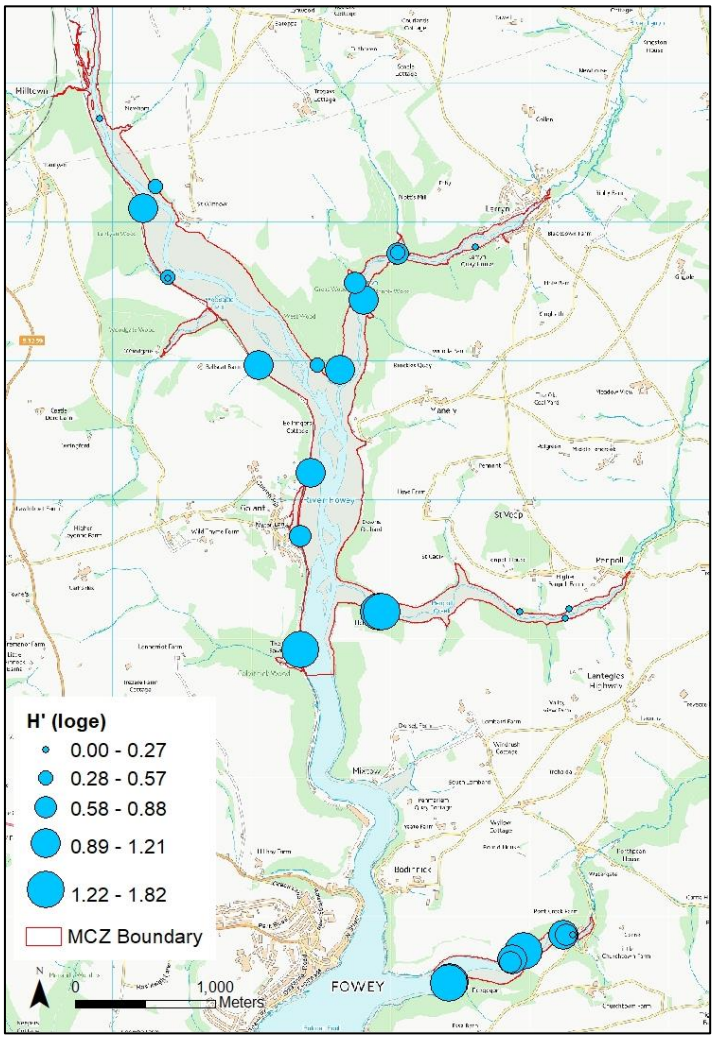

Figure 15. Geographical representation of the species diversity (Shannon Weiner) at stations within the Upper Fowey and Pont Pill MCZ.

Community analysis in PRIMER[8] used the multivariate Bray-Curtis similarity statistic and MDS to assess the communities at each transect. The MDS plot in Figure 16 represents the data recorded from quadrats (within each Habitat type) in two dimensions, where the distances between points represent the similarities between the faunal communities (i.e. the closer together the points the more similar the sampled communities).

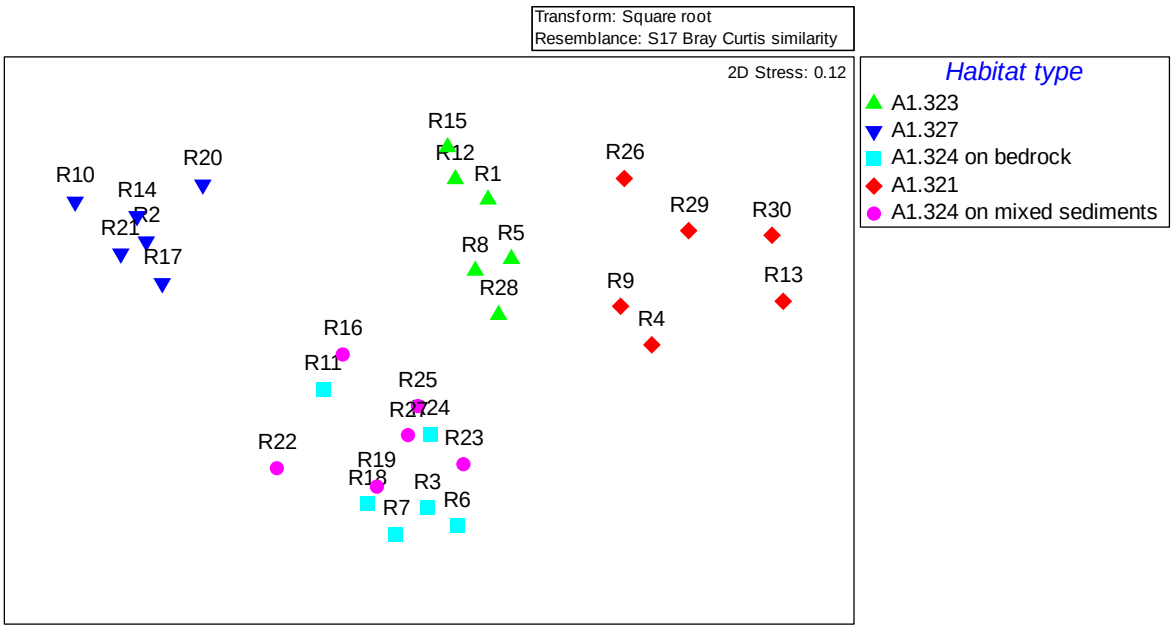

Figure 16. Two dimensional MDS plot of all habitat type communities sampled using quadrats within the Upper Fowey and Pont Pill MCZ.

The plot in Figure 16 demonstrates a reasonably good similarity and distinct grouping of stations within discrete Habitat types. Not surprisingly there is some cross-over of stations within the A1.324 Biotope. Some habitat types do however demonstrate better mean Bray-Curtis similarity values than others. The A1.327 Biotope for example generated the highest value of 81% whilst the A1.321 Biotope generated the lowest value of just 49%. The stronger similarities observed within the A1.327 Biotope are as a consequence of the strong freshwater influence within those communities and the subsequent low diversity and high dominance by the freshwater tolerant algae *Fucus ceranoides*. The weaker similarity value which has been generated from the data collected within the A1.321 Biotope is likely to be associated with environmental variables such as variable shading, substrate topography and complexity (e.g. sea wall/natural rock) as well as shore aspect and other geographic variables.

4.2 Extent and Distribution of Littoral Sediment Habitat Types

A total of twelve littoral sediment Habitat types were recorded and mapped within the Upper Fowey and Pont Pill MCZ. Seven were classified to EUNIS level 5[3] whilst it was possible to classify five of these further to EUNIS level 6. An additional freshwater Habitat type characterised solely by the presence of the oligochaete *Limnodrilus hoffmeisteri* was also identified at the very upper end of the study area.

The twelve sediment Habitat types that were identified fall within one of three EUNIS level 3 categories, these were: littoral sands and muddy sands (A2.2), littoral mud (A2.3) and littoral mixed sediments (A2.4). The sediments with a substantial sandy element were restricted to the lower shore in/adjacent to the main Fowey river channel, whilst those dominated by mud were found higher in the estuary, on the mid and upper shores of the mid estuary and throughout the Lerryn, Penpoll and Pont Pill tributaries. Mixed sediments were mostly restricted to localised areas of scour in the mid-upper Fowey estuary and at the head of the Lerryn.

The twelve habitat types that were identified in total are listed below; eight of these Habitat types were subject to Phase II sampling. The four habitat types that were not selected for

inclusion within the Phase II survey were found to account for only a very limited area of the littoral sediments within the MCZ and are annotated with a '*' below:

- A2.221* Barren littoral coarse sand
- A2.2231 *Scolelepis* spp. in littoral mobile sand
- A2.231 Polychaetes in littoral fine sand
- A2.311 *Nephtys hombergii*, *Limecola balthica* and *Streblospio shrubsolii* in littoral sandy mud
- A2.313 *Hediste diversicolor*, *Limecola balthica* and *Scrobicularia plana* in littoral sandy mud
- A2.321 *Nephtys hombergii* and *Streblospio shrubsolii* in littoral mud
- A2.3222 *Hediste diversicolor* and *Corophium volutator* in littoral mud
- A2.325* Saltmarsh creeks
- A2.4112 *Hediste diversicolor* and *Scrobicularia plana* in littoral gravelly mud
- A2.4114 *Hediste diversicolor*, cirratulids and *Tubificoides* spp. in littoral gravelly sandy mud
- A2.4115 *Hediste diversicolor* and *Corophium volutator* in littoral gravelly sandy mud
- A2.421* Cirratulids and *Cerastoderma edule* in littoral mixed sediment

The extent and distribution of all twelve Habitat types (plus the freshwater community found at the upper estuarine extreme) are shown in Figures 17 to 21 in relation to the Phase II sampling stations (the coordinates of each of the Phase II stations are provided in Appendix II). Littoral sediment communities were found throughout the MCZ up as far as 1km North of Milltown. There were distributional patterns to Habitat types related to the degree of marine influence (lower, mid and upper estuary) as well as some zonation relating to shore height. The effects of shore height were most evident in the mid estuary between Colvthick Wood and St Minnows.

A detailed description of the biotic and abiotic components of each of the littoral sediment Habitat types that were sampled during the Phase II survey is provided in section 4.4.2 together with maps of the distribution of each individual Habitat type in relation to the Phase II sampling stations. Distribution maps and broad descriptions (taken from the EUNIS classification[3]) of the Habitat types not included within the Phase II survey are also provided.

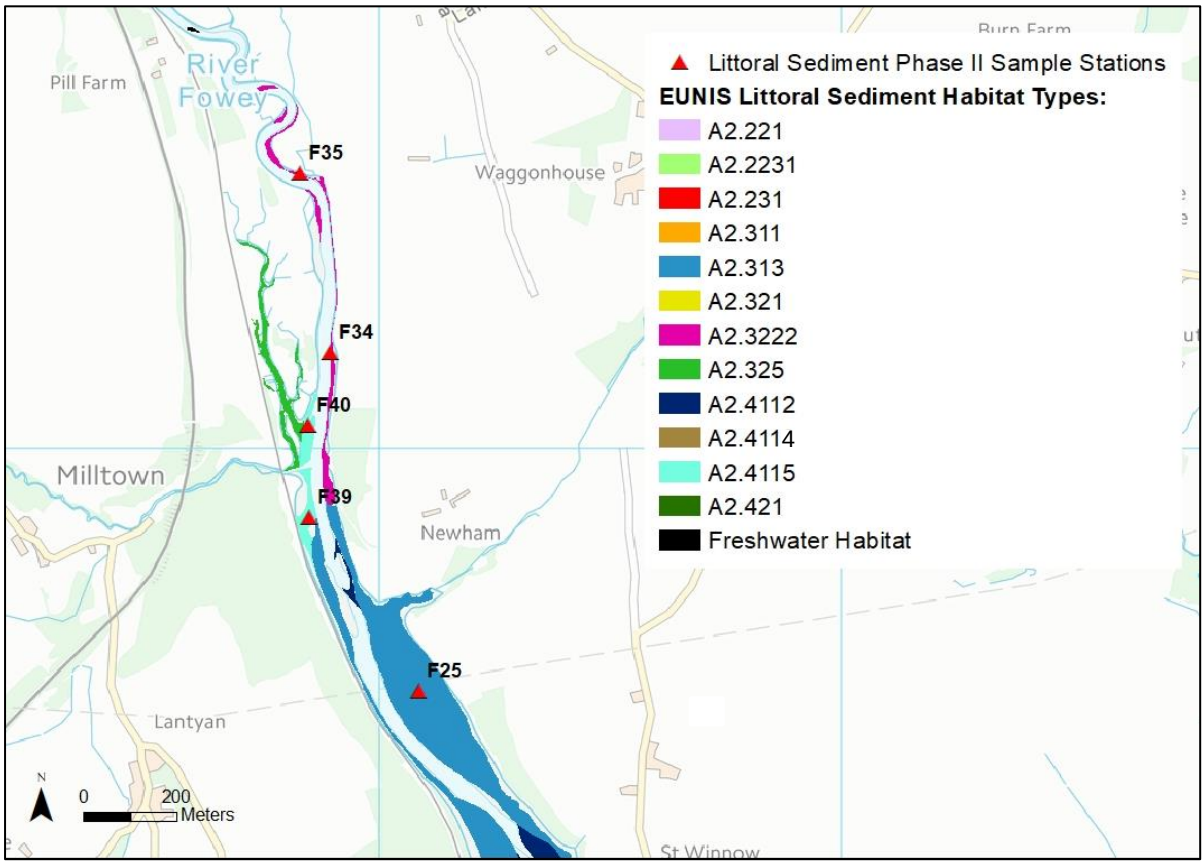

Figure 17. Extent and distribution of littoral sediment communities within the Upper Fowey and Pont Pill MCZ – 1 km north of Milltown to St Winnow

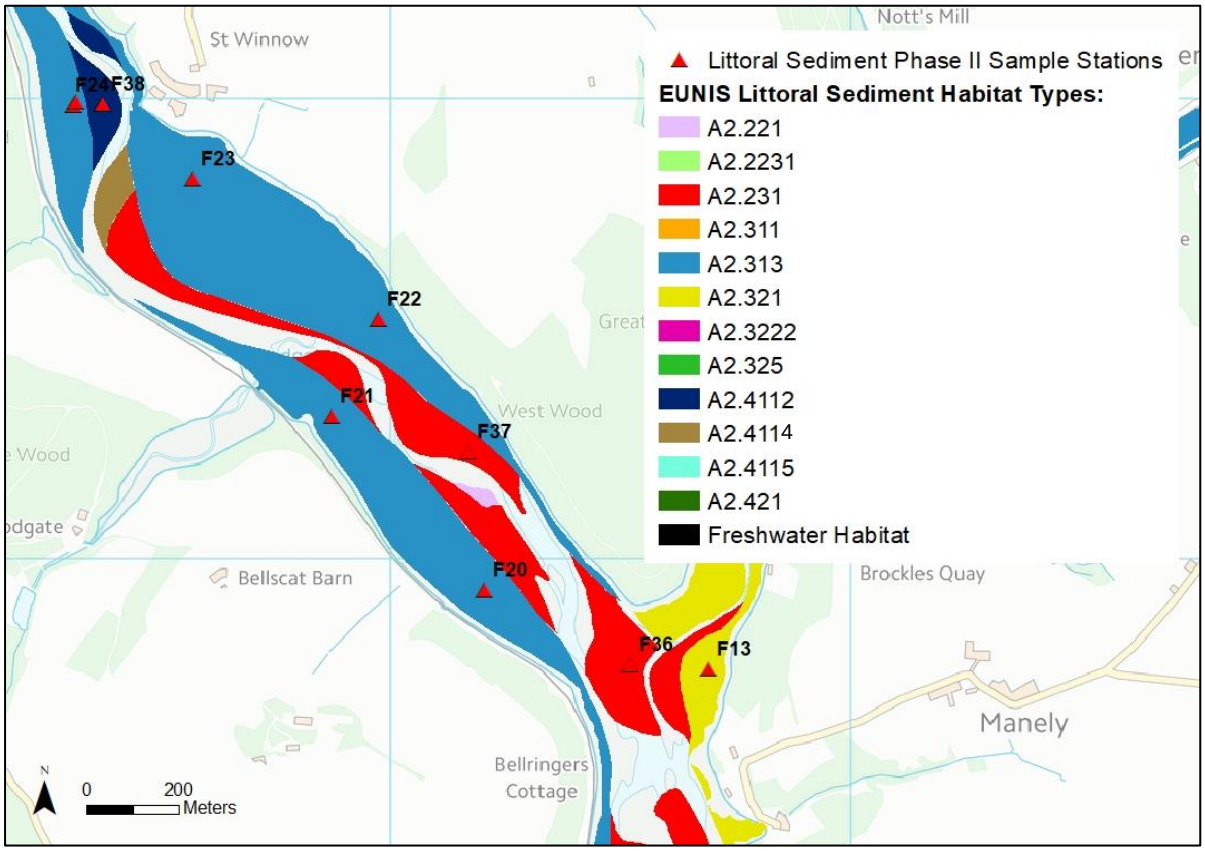

Figure 18. Extent and distribution of littoral sediment communities within the Upper Fowey and Pont Pill MCZ – St Winnow to Manley.

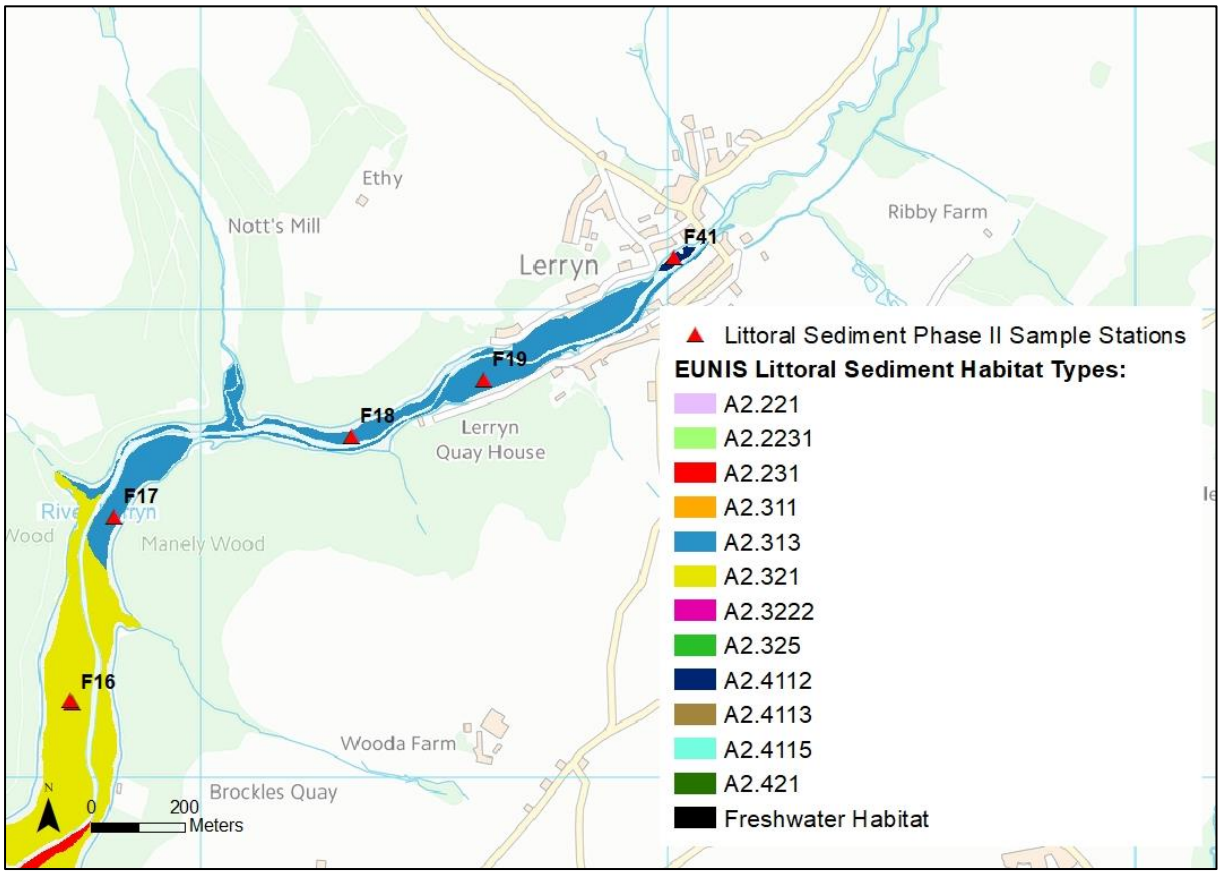

Figure 19. Extent and distribution of littoral sediment communities within the Upper Fowey and Pont Pill MCZ – River Lerryn.

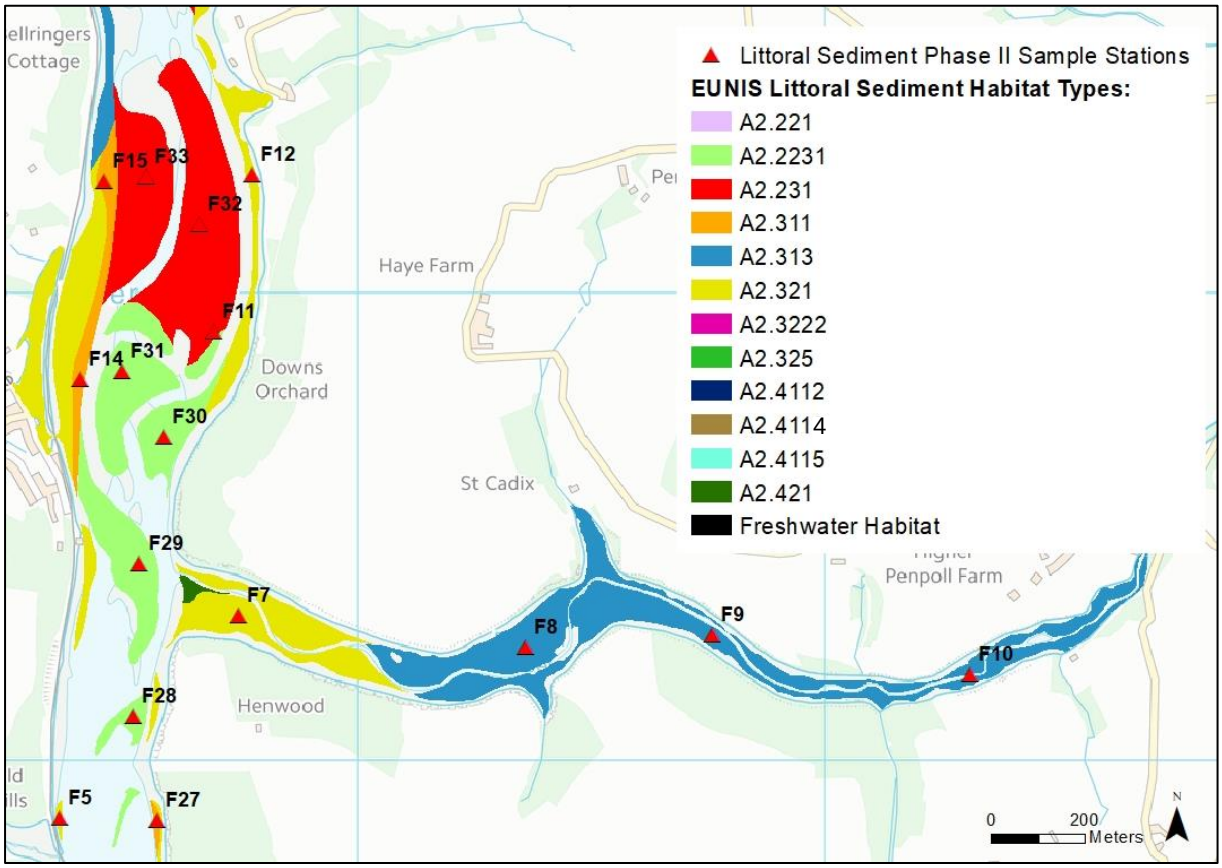

Figure 20. Extent and distribution of littoral sediment communities within the Upper Fowey and Pont Pill MCZ – Manely to Colvthick Wood.

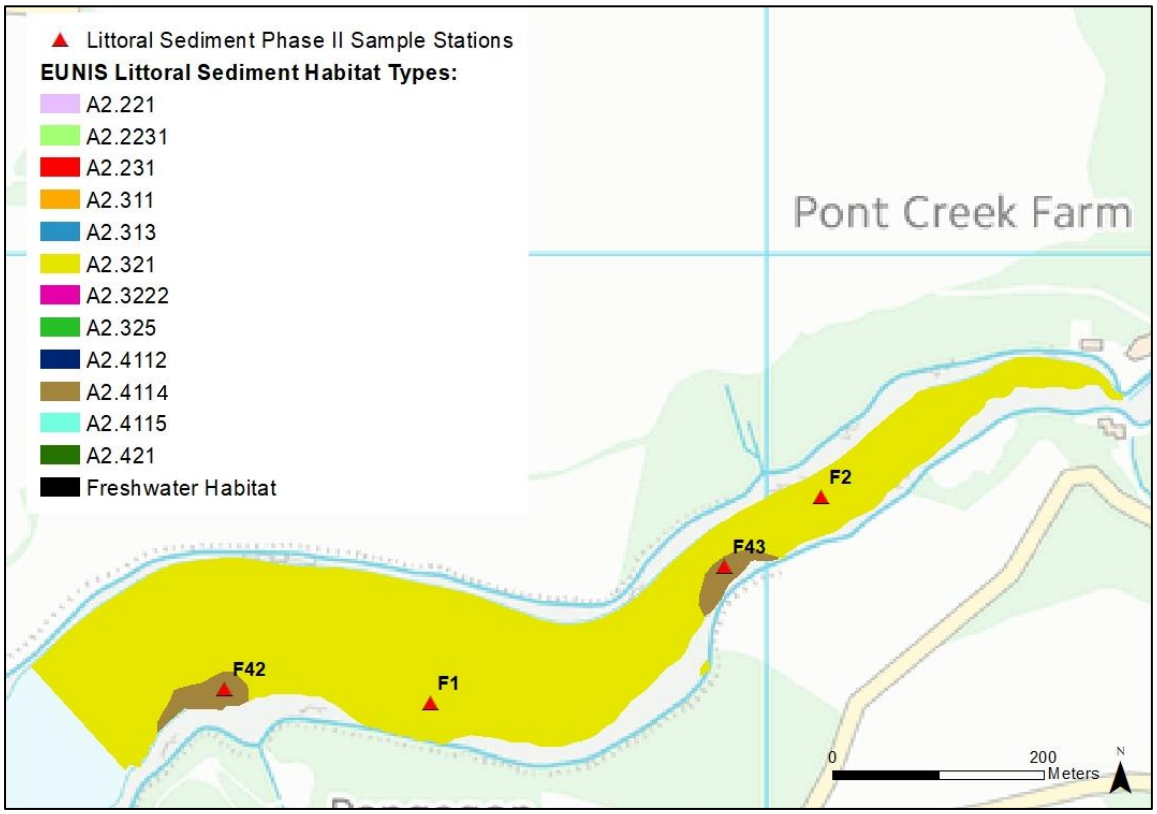

Figure 21. Extent and distribution of littoral sediment communities with the Upper Fowey and Pont Pill MCZ – Pont Pill

4.2.1 Particle Size Analysis

The particle size distributions (percentage distribution of sediments by weight) at each sampling station has been summarised following the Wentworth Scale[9] (although the silt fractions have been amalgamated for clarity) (Table 10).

The overall degree of similarity in the mean sediment particle size between each station has been determined using PRIMER 6[8] 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 all Habitat types that were sampled. The sediments within the A2.311, A2.313, A2.321 and A2.3222 Habitat types were mostly dominated by silt with smaller proportions of very fine sand and less than 5% clay. The A2.4112 and A2.4115 Sub-biotopes had more variable sediment granulometry with sediments ranging from being silt dominated to those being characterised by larger proportions of granules and pebbles. The sediments in the A2.2231, A2.231, and A2.4114 Habitat types were set to the left of the plot due to larger fractions of sand particles.

Table 10. Particle size analysis results (Wentworth Scale) from sediments within the Upper Fowey and Pont Pill MCZ.

Habitat type	Station	Clay	Silt	Very fine sand	Fine sand	Medium sand	Coarse sand	Very coarse sand	Granules	Pebbles
		<3.91 µm	3.91 to 62.5 µm	62.5 to 125 µm	125 to 250 µm	250 to 500 µm	500 to 1000 µm	1000 to 2000 µm	2000 to 4000 µm	>4000 µm
A2.2231	F28	0.0	0.0	0.0	0.0	2.6	24.0	35.2	31.4	6.7
	F29	0.0	0.0	0.0	0.3	10.9	40.1	35.3	12.6	0.8
	F30	0.0	0.9	0.2	5.5	18.6	14.4	17.1	30.5	12.9
	Mean	***0.0***	***0.3***	***0.1***	***1.9***	***10.7***	***26.1***	***29.2***	***24.8***	***6.8***
A2.231	F11	0.4	5.8	10.0	43.1	32.7	6.9	0.5	0.3	0.3
	F31	0.2	5.4	2.2	10.7	27.7	35.6	10.1	6.4	1.7
	F32	0.3	4.7	9.2	40.6	35.6	9.0	0.3	0.1	0.2
	F33	0.0	1.6	1.5	27.0	35.3	8.4	10.8	10.8	4.6
	F36	0.0	1.6	1.0	19.9	41.9	21.5	8.9	3.6	1.6
	F37	0.0	0.7	0.1	8.3	33.2	26.7	15.3	12.2	3.6
	Mean	***0.1***	***3.3***	***4.0***	***24.9***	***34.4***	***18.0***	***7.6***	***5.6***	***2.0***
A2.311	F14	6.2	56.6	19.2	9.6	4.4	0.9	1.7	1.0	0.3
	F15	2.4	38.9	21.9	14.8	9.3	6.1	1.1	1.4	4.2
	F27	4.0	50.4	23.9	13.4	5.6	2.7	0.1	0.0	0.1
	Mean	***4.2***	***48.6***	***21.7***	***12.6***	***6.4***	***3.2***	***1.0***	***0.8***	***1.5***
A2.313	F8	3.9	50.3	23.5	11.8	4.0	0.5	1.3	1.8	2.9
	F9	3.6	55.2	20.3	11.7	5.9	2.7	0.2	0.1	0.1
	F10	4.8	58.5	17.6	8.2	3.6	0.7	0.7	0.8	5.0
	F17	2.7	53.2	20.8	12.2	6.2	3.7	0.3	0.3	0.7
	F18	3.7	52.1	20.6	11.2	5.8	3.9	0.5	0.7	1.6
	F19	4.6	73.5	16.8	4.7	0.4	0.0	0.0	0.0	0.1
	F20	2.8	54.0	21.6	12.0	6.8	2.6	0.0	0.0	0.1
	F21	2.4	48.5	24.6	13.0	6.5	3.8	0.3	0.2	0.7
	F22	2.1	42.8	24.8	15.0	8.1	6.1	0.1	0.3	0.6
	F23	3.5	54.8	19.9	12.6	6.4	1.3	0.2	0.3	0.9
	F24	2.4	44.4	26.4	16.5	6.9	2.6	0.2	0.2	0.5
	F25	2.6	53.0	24.9	10.9	5.7	2.4	0.1	0.2	0.2
	Mean	***3.3***	***53.4***	***21.8***	***11.6***	***5.5***	***2.5***	***0.3***	***0.4***	***1.1***
A2.321	F1	2.9	47.6	21.8	10.8	4.7	2.7	1.4	1.9	6.1
	F2	2.6	47.8	18.3	16.5	9.0	2.7	0.9	0.5	1.8
	F5	3.9	53.9	21.4	12.7	5.8	2.0	0.0	0.1	0.2
	F7	2.8	41.3	20.3	11.2	5.3	3.6	3.3	4.5	7.7
	F12	2.8	45.4	26.0	15.1	6.7	3.3	0.2	0.1	0.4
	F13	2.8	45.7	22.5	13.2	7.6	4.3	1.3	1.3	1.4
	F16	2.5	47.4	26.3	14.6	5.9	2.7	0.1	0.2	0.1
	Mean	***2.9***	***47.0***	***22.4***	***13.4***	***6.4***	***3.0***	***1.0***	***1.2***	***2.5***
A2.3222	F34	4.9	56.5	25.6	11.9	0.2	0.0	0.4	0.3	0.3
	F35	3.2	53.7	21.0	10.9	5.9	2.1	0.7	0.6	2.0
	Mean	***4.0***	***55.1***	***23.3***	***11.4***	***3.0***	***1.0***	***0.5***	***0.5***	***1.1***
A2.4112	F38	0.8	13.6	12.2	14.6	12.6	8.3	6.5	10.6	20.8
	F41	4.5	61.1	14.9	7.8	3.6	2.3	2.4	0.6	2.0
	Mean	***2.7***	***37.4***	***13.5***	***11.2***	***8.1***	***5.3***	***4.5***	***5.6***	***11.4***
A2.4114	F42	2.0	20.6	7.6	8.1	10.5	12.4	22.1	13.9	2.8
	F43	1.5	14.4	3.8	2.6	3.0	3.6	13.7	20.9	36.4
	Mean	***1.8***	***17.5***	***5.7***	***5.4***	***6.8***	***8.0***	***17.9***	***17.4***	***19.6***
A2.4115	F39	3.6	49.9	20.6	12.3	7.7	3.9	0.6	0.7	0.8
	F40	2.1	26.4	11.7	8.2	5.2	3.9	8.6	16.0	18.1
	Mean	***2.8***	***38.1***	***16.1***	***10.2***	***6.4***	***3.9***	***4.6***	***8.4***	***9.4***

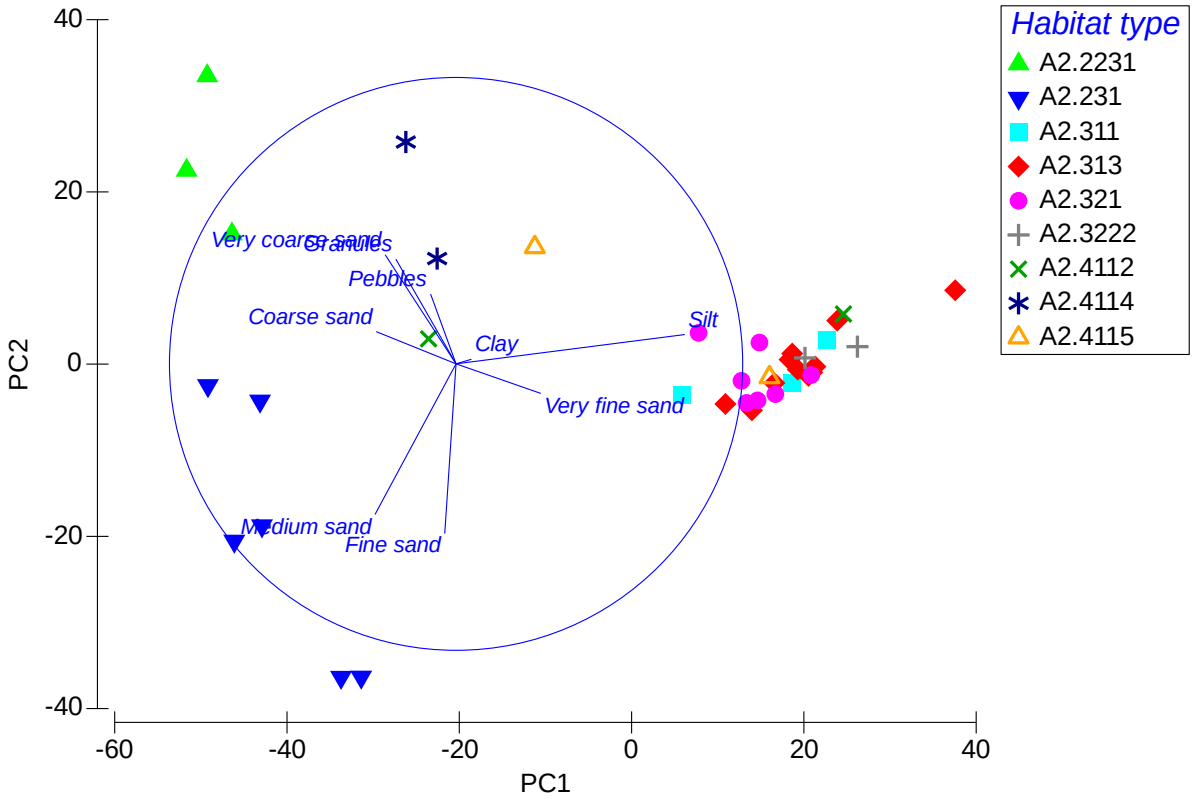

Figure 22. Principal component analysis (PCA) of station sediment granulometry similarities.

4.2.2 Littoral Sediment Habitat Type Descriptions

A2.221 - Barren littoral coarse sand

The A2.221 Biotope is described within the EUNIS classification[3] as:

'Freely-draining sandy beaches, particularly on the upper and mid shore, which lack a macrofaunal community due to their continual mobility. Trial excavations are unlikely to reveal any macrofauna in these typically steep beaches on exposed coasts. Oligochaetes, probably mainly enchytraeids, and the isopod [Eurydice pulchra] may be found in extremely low abundances. Burrowing amphipods ([Bathyporeia] spp.) may be present on very rare occasions. Occasionally, other species may be left behind in low abundance by the ebbing tide.'

The small area within the main channel near Woodgate was mapped as A2.221 based on the sediment character and the absence of observed fauna during a spade inspection (Figure 23). These attributes fit closely with the EUNIS description of the Biotope, but the estuarine location is less usual. Within the Upper Fowey and Pont Pill MCZ the absence of fauna is attributable to sediment mobility resulting from tidal currents and river flow rather than wave exposure. It is likely that the small area is ephemeral and may come and go depending upon rainfall and subsequent flow in the main channel.

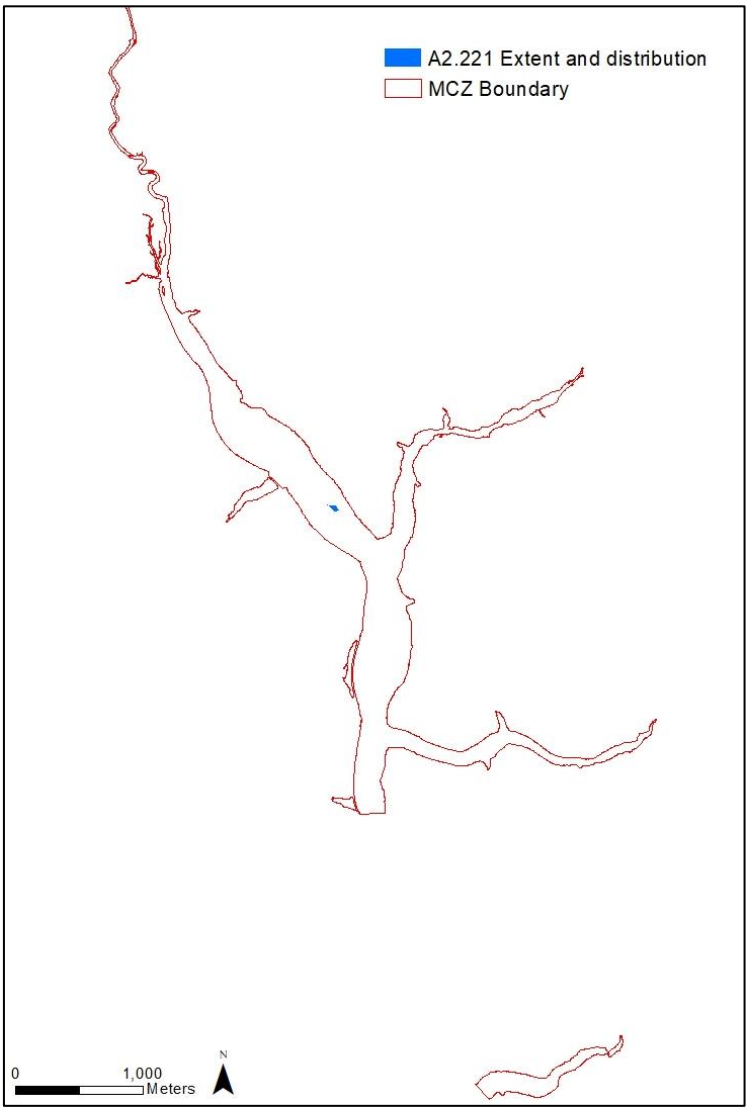

Figure 23. Map of the extent and distribution of the A2.221 Biotope within the Upper Fowey and Pont Pill MCZ.

A2.2231 - *Scolelepis* spp. in littoral mobile sand

The EUNIS description[3] of the A2.2231 Sub-biotope is as follows:

'Exposed and moderately exposed shores of fully marine mobile clean sand, with particle sizes ranging from coarse to very fine. The sediment is not always well sorted, and may contain a subsurface layer of gravel or shell debris. Usually no anoxic layer is present. The mobility of the sediment leads to a species-poor community, dominated by the polychaetes [Scolelepis squamata] and [Scolelepis foliosa]. The amphipod [Bathyporeia pilosa] may be present. Further species that may be present in this sub-biotope include the amphipods [Bathyporeia pelagica] and [Haustorius arenarius], and the isopod [Eurydice pulchra]. The lugworm [Arenicola marina] may also occur.'

The A2.2231 communities were found to occupy the extreme lower shore banks within the main channel at the southern extent of the upper MCZ boundary adjacent to, and south of Golant (Figure 24, Plate 12).

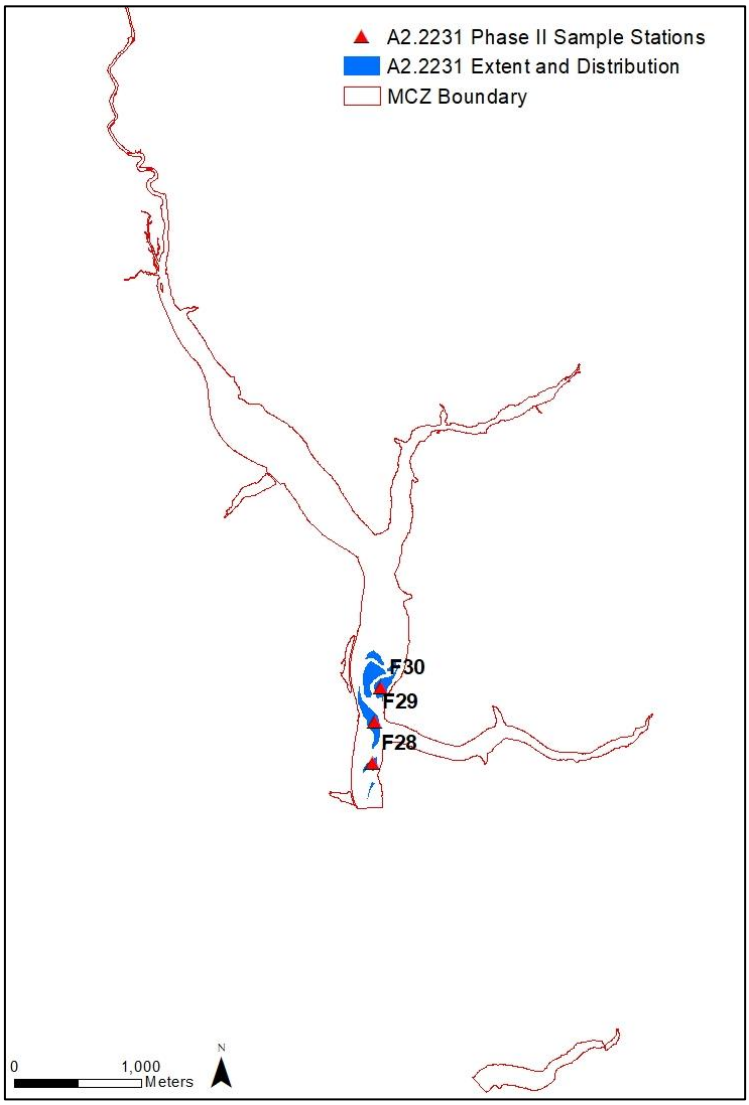

Figure 24. Map of the extent and distribution of the A2.2231 Sub-biotope within the Upper Fowey and Pont Pill MCZ.

Plate 12. Photograph of the A2.2231 Sub-biotope within the Upper Fowey and Pont Pill MCZ at Phase I station S14.

The A2.2231 communities in the Upper Fowey and Pont Pill MCZ largely correspond with the EUNIS description[3] (Table 11), there are some discrepancies, however, in both the biological and physical attributes. Most notably, amphipods were absent and juvenile mussel spat (*Mytilus edulis*) were common, although the numbers of mussels are likely to represent a temporary recruitment. Species diversity was higher than would usually be expected (between

11 and 14 taxa were recorded at each station), but it is thought that a number of species were probably washed into these lower shore banks from more stable Habitat types found higher in the estuary and/or higher on the shore.

The occurrence of the A2.2231 Sub-biotope within an estuarine system is unusual as the communities are usually found in fully marine conditions. Interstitial salinity data was collected at the three stations sampled within the Sub-biotope, and this ranged from 20 to 29 ppt. The sediments also contained a larger grain size fraction than expected, and although dominated by coarse and very coarse sands, gravel and pebbles were also present (Table 10).

The mean similarity between the benthic faunal communities present at each station was just 34%. The main characterising species *Scolelepis squamata* was present at all three stations but contributed just 7% to the community similarity (Table 12). Juvenile mussels contributed the most to community similarity (21%), whilst *Ophelia rathkei* and nemerteans, which are likely to have washed in from the adjacent fine sand communities (A2.231) each accounted for 13% of the community similarity.

Table 11. Mean taxa abundance at stations within the A1.2231 Sub-biotope.

Taxa	Mean Abundance per 0.01m^2 Core		
	Station		
	F28	F29	F30
Nematoda	1.7	2.5	
Lekanesphaera levii	2.2	8.3	0.6
Cyprideis torosa		0.6	
Capitella agg.			1.2
Ophryotrocha	0.6		0.0
Mediomastus fragilis			1.2
Nephtys cirrosa		0.6	
Ophelia rathkei	0.6	1.9	3.3
Pisione remota	1.5		
Protodriloides chaetifer	1.2	1.2	0.6
Enchytraeidae			1.0
Tubificoides pseudogaster agg.	0.6		
Spisula juv.	0.6		
Cerastoderma edule juv.	0.6	1.3	0.8
Mytilus edulis juv.	22.7	4.0	0.8
Peringia ulvae	0.8	0.8	0.0
Hediste diversicolor		0.6	0.0
Nemertea	1.2	1.0	1.3
Lepidochitona cinerea	0.6	0.6	
Scolelepis squamata	0.8	0.6	0.6
Dolichopodidae larva		0.6	0.6

Table 12. Taxa contribution within the A1.2231 communities derived from core data.

Taxa	Mean Abundance per Quadrat	Mean Similarity	% Contribution	Cumulative % Contribution
Mytilus edulis juv.	9.2	7	21	21
Ophelia rathkei	1.9	5	15	35
Nemertea	1.2	5	13	49
Lekanesphaera levii	3.7	4	13	61
Protodriloides chaetifer	1.0	3	9	71
Cerastoderma edule juv.	0.9	3	9	79
Scolelepis squamata	0.7	3	7	87
Nematoda	1.4	2	6	92

A2.231 - Polychaetes in littoral fine sand

The A2.231 Biotope is described[3] as:

'Moderately exposed or sheltered beaches of medium and fine, usually clean, sand, though the sediment may on rare occasions contain a small silt and clay fraction. The sediment is relatively stable, remains damp throughout the tidal cycle, and contains little organic matter. It is often rippled and typically lacks an anoxic sub-surface layer. Where an anoxic layer is present, it occurs at a depth below 10 cm and tends to be patchy. The biotope occurs mainly on the lower part of the shore, and relatively frequently on the mid shore. It is only rarely present above mid shore level, except where coastal defences cause backwash onto the upper shore. Conditions are usually fully marine, though the biotope can also occur in open lower estuarine conditions. The infaunal community is dominated by a range of polychaete species such as [Nephtys cirrosa], [Paraonis fulgens], [Spio] spp., [Pygospio elegans], [Ophelia rathkei] and [Scoloplos armiger]. [Arenicola marina] casts may be present on the sediment surface. The amphipods [Bathyporeia] spp. and [Pontocrates arenarius] frequently occur, and nemerteans are often present.'

The A2.231 Biotope was found on the extreme lower shore banks in the main channel between Golant and St Winnow (Figure 25). Plate 13 shows the typical appearance of the Biotope in the MCZ.

Plate 13. Photograph of the A2.231 Biotope within the Upper Fowey and Pont Pill MCZ at Phase I station S15.

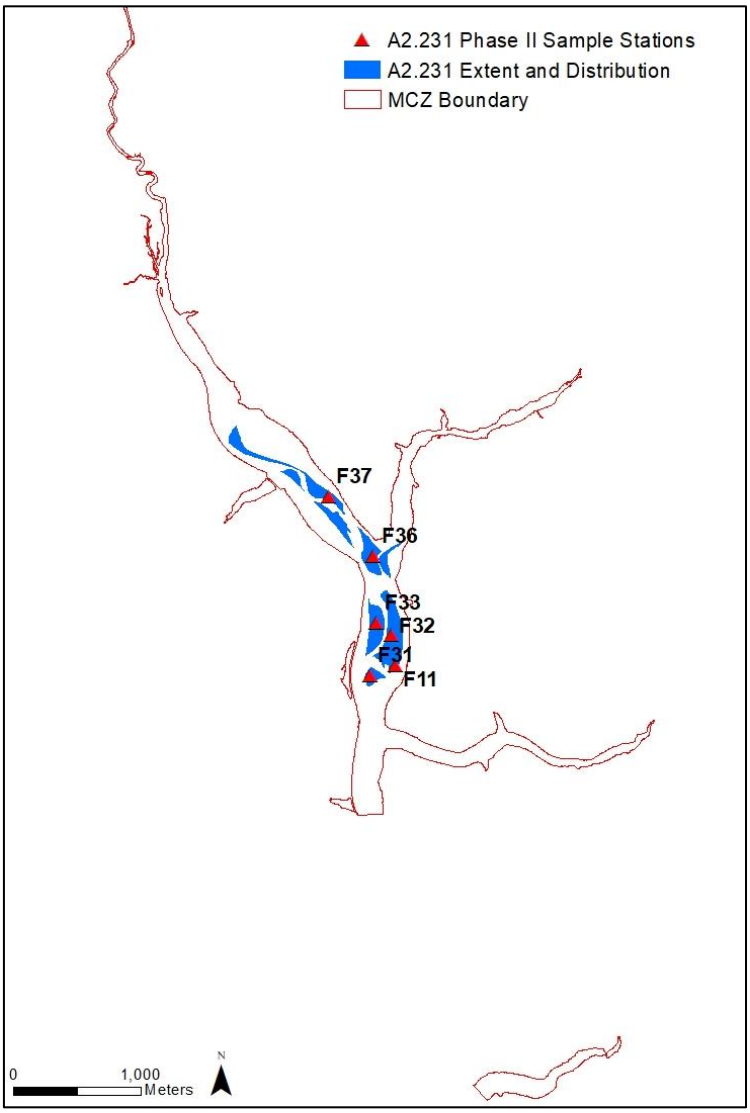

Figure 25. Map of the extent and distribution of the A2.231 Biotope within the Upper Fowey and Pont Pill MCZ.

These banks are more stable than those found in the channel lower in the estuary and therefore generally support a greater number of taxa; between 11 and 22 taxa were captured in three cores at each station (Table 13).

The sediments within the A2.231 Biotope were mostly characterised by fractions of fine and medium sands, although small proportions of gravel and pebbles were also present at a few stations. Clay was almost entirely absent and proportions of silt never exceeded 6%. The interstitial salinity ranged from 34 ppt at F11 (furthest downstream) to 14 ppt (at the upper estuarine limit of the Biotope).

The faunal component of the A2.231 Biotope corresponded reasonably well with the communities described in the EUNIS description[3]. Many of the polychaetes listed as characterising were present in at least a proportion of the cores, although as was observed in the A2.2231 lower in the estuary amphipods were again absent, whilst juvenile bivalves were common (Table 13). A number of other taxa which are not described as characterising for the Biotope were also present, although these were in low numbers not consistently sampled. These included taxa such as oligochaetes, cirratulids and phyllodocidae.

At 43% the mean Bray-Curtis similarity between the benthic faunal communities at stations within this Biotope was relatively low. SIMPER analysis determined that spionid polychaete species collectively contributed 43% to the overall community similarity. Juvenile cockles (*Cerastoderma edule*) ranked the top single contributing species alongside the spionid *Pygospio elegans*, each accounting for 19% of community similarity. The juvenile cockles may represent a temporary recruitment event.

Table 13. Mean taxa abundance at stations within the A2.231 Biotope within the Upper Fowey and Pont Pill MCZ.

Taxa	Mean Abundance per 0.01m^2 Core					
	Station					
	F11	F31	F32	F33	F36	F37
Nematoda		1.0				
Nemertea		0.8				1.2
Crangonidae	0.6					
Cyathura carinata					0.6	
Lekanesphaera levii			0.6	0.6	0.6	0.8
Capitella agg.		2.2	0.8	0.6	1.8	
Tharyx Type A	0.6	1.9	0.6			
Microphthalmus					0.6	
Ampharete cf. acutifrons						
Melinna palmata		0.6				
Arenicola marina		1.0				
Heteromastus filiformis		0.6		0.6		0.6
Mediomastus fragilis		1.8		0.0		
Glycera tridactyla		0.6		0.6		
Hediste diversicolor					1.2	
Nephtys hombergii	1.6	1.3	2.0	1.6	1.0	
Eteone longa agg.		0.6	0.6			1.0
Phyllodoce mucosa		0.6				
Aricidea minuta		3.2		0.6		
Pygospio elegans	4.0	3.9	11.2	8.4	2.2	
Spio martinensis	3.3	2.0	1.0	3.8	6.1	
Streblospio shrubsolii	1.0	1.4	1.4	2.3	4.9	1.4
Enchytraeidae	0.0	1.5				1.8
Clitellio arenarius					0.8	
Tubificoides benedii	0.6				1.4	
Tubificoides pseudogaster agg.				0.6	2.6	1.3
Tellinoidea juv.	0.8	1.2	3.7			
Tellinoidea		1.3	3.9			
Cerastoderma edule					0.6	
Cerastoderma edule juv.	0.8	5.8	8.9	3.2	2.4	3.4
Mya arenaria juv.		1.3	2.2	1.0	0.6	1.4
Mytilus edulis juv.						1.0
Scrobicularia plana juv.				0.6		
Peringia ulvae	2.8	2.4	6.0	1.2	0.8	1.8

Table 14. Taxa contribution within the A2.231 communities derived from core data within the Upper Fowey and Pont Pill MCZ.

Taxa	Mean Abundance per Quadrat	Mean Similarity	% Contribution	Cumulative % Contribution
Cerastoderma edule juv.	4.1	8	19	19
Pygospio elegans	5.0	8	19	39
Peringia ulvae	2.5	5	13	52
Spio martinensis	2.7	5	12	63
Streblospio shrubsolii	2.1	5	12	75
Nephtys hombergii	1.3	3	7	82
Mya arenaria juv.	1.1	2	5	87
Capitella agg.	0.9	1	2	89
Lekanesphaera levii	0.4	1	2	91

A2.311 - *Nephtys hombergii*, *Limecola balthica* and *Streblospio shrubsolii* in littoral sandy mud

The EUNIS classification system[3] describes the A2.311 Biotope as:

'Soft mud with a fine sand fraction, in variable salinity conditions, typically close to the head of estuaries. The infauna is dominated by the polychaete worm [Streblospio shrubsolii], the polychaete [Nephtys hombergii], oligochaetes of the genus [Tubificoides], and the Baltic tellin [Limecola balthica]. The ragworm [Hediste diversicolor] and the spire shell [Peringia ulvae] are often common or abundant.'

The A2.311 communities were limited to the mid-lower shore adjacent to Golant, and in a small area on the eastern side just above the southern MCZ boundary (Figure 26.). In both locations A2.311 Biotope was found on the lower shore periphery of the A.321 Biotope, and slightly higher on the shore than sandier sediments (A2.2231 and A2.231).

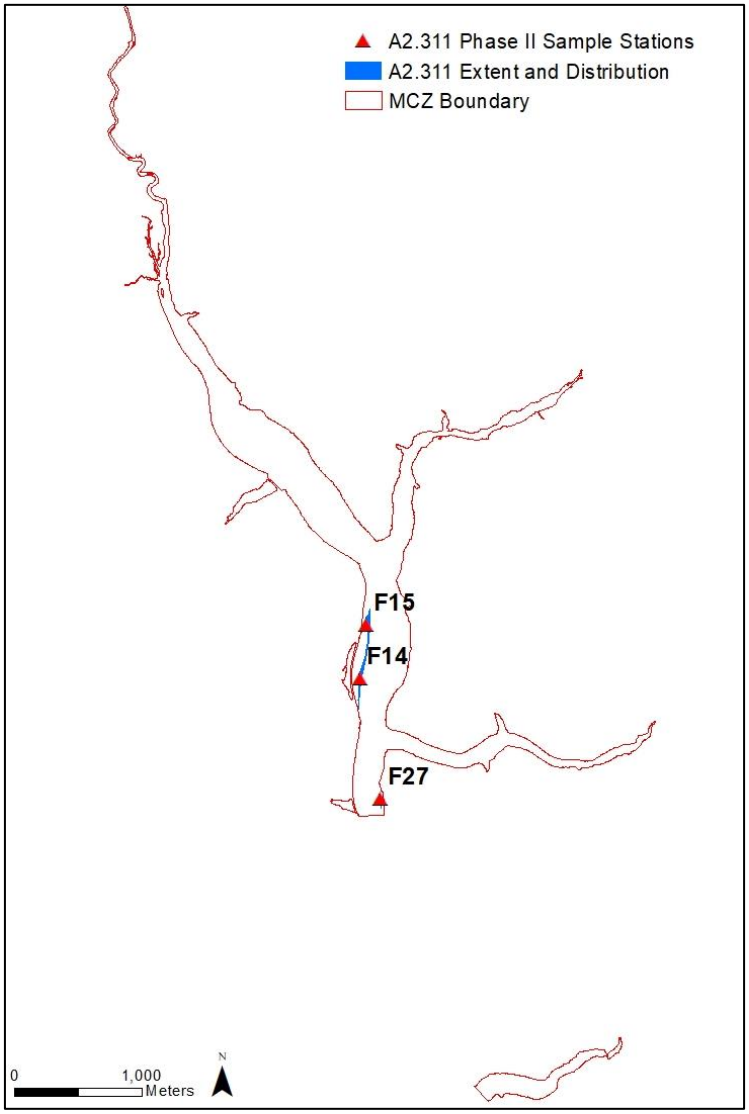

Figure 26. Map of the extent and distribution of the A2.311 Biotope within the Upper Fowey and Pont Pill MCZ.

In accordance with the EUNIS description, the sediments within the A2.311 Biotope were mostly characterised by large proportions of silt (39-57 %) with smaller proportions of very

fine-fine sand (10-20%), although both smaller and larger particle size ranges were present in small quantities (Table 10).

The faunal component of the A2.311 Biotope corresponded well with the communities described in the EUNIS description[3]. All of the species listed as principally characterising for the Biotope were present at all stations, and secondary characterising species such as *Limecola balthica* and *Hediste diversicolor* were present at two of the three stations (Table 15). Between 12 and 17 taxa were recorded at the stations sampled within the A2.311 Biotope, it is thought likely that the greater number of taxa at stations F14 and F15 represent transitioning with muddier Habitat types higher in the estuary.

Table 15. Mean taxa abundance at stations within the A2.311 Biotope within the Upper Fowey and Pont Pill MCZ.

Taxa	Mean Abundance per 0.01m^2 Core		
	Station		
	F14	F15	F27
Carcinus maenas juv.		0.6	
Tharyx Type A			1.2
Alkmaria romijni		2.1	
Ampharete cf. acutifrons	0.6		1.0
Melinna palmata	0.6		
Heteromastus filiformis	0.6	1.4	0.6
Nephtys hombergii	1.2	2.4	2.0
Manayunkia aestuarina		1.5	1.4
Pygospio elegans	1.7	3.1	3.5
Streblospio shrubsolii	0.6	4.8	2.8
Tubificoides benedii	1.7	13.8	2.2
Tubificoides pseudogaster agg.		4.6	2.9
Tellinoidea juv.	0.8	1.0	
Tellinoidea	1.3		
Cerastoderma edule juv.	0.8	0.6	0.6
Mytilus edulis juv.	0.8		
Scrobicularia plana	0.8		
Alderia modesta		0.8	
Peringia ulvae	4.9	5.9	1.3
Hediste diversicolor	1.2	0.6	
Baltidrilus costatus	0.6		
Limecola balthica	0.6	0.6	0.6
Chironomidae larva	0.6		
Decapoda megalopa		0.6	

The mean similarity between the benthic faunal communities present at each station The mud snail *Peringia ulvae* which is almost ubiquitous throughout the MCZ most (19%) to community similarity (

Table 16). The spionid *Pygospio elegans* and estuarine oligochaete *Tubificoides benedii* also contributed significantly, whilst the main characterising species *Nephtys hombergii*, *Streblospio shrubsolii* and *Limecola balthica* each contributed 11%, 10% and 5% respectively.

Table 16. Taxa contribution within the A2.311 communities derived from core data within the Upper Fowey and Pont Pill MCZ.

Taxa	Mean Abundance per Quadrat	Mean Similarity	% Contribution	Cumulative % Contribution
Peringia ulvae	4.1	9	19	19
Pygospio elegans	2.8	8	17	35
Tubificoides benedii	5.9	7	15	51
Nephtys hombergii	1.9	5	11	62
Streblospio shrubsolii	2.7	5	10	71
Tubificoides pseudogaster agg.	2.5	3	6	78
Cerastoderma edule juv.	0.7	2	5	82
Heteromastus filiformis	0.9	2	5	87
Limecola balthica	0.6	2	5	92

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

The A2.313 Biotope is described as:

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

Within the Upper Fowey and Pont Pill MCZ the A2.313 Biotope was the most widespread littoral sediment Habitat type mapped. It was found to occupy the muddy banks either side of the Fowey upstream of Golant, and those in the upper two thirds of the Lerryn and Penpoll Creeks (Figure 28). Plate 14 shows the typical appearance of the Biotope within the MCZ. Within the creeks the A2.313 Biotope accounted for the communities at all tidal heights where it was present. Within the main Fowey channel this was also the case except where tidal scouring had removed the silts and clays from the sediments exposing sandy and/or gravelly banks on the extreme lower shore.

Plate 14. Photograph of the A2.313 Biotope within the Upper Fowey and Pont Pill MCZ at Phase I station S19.

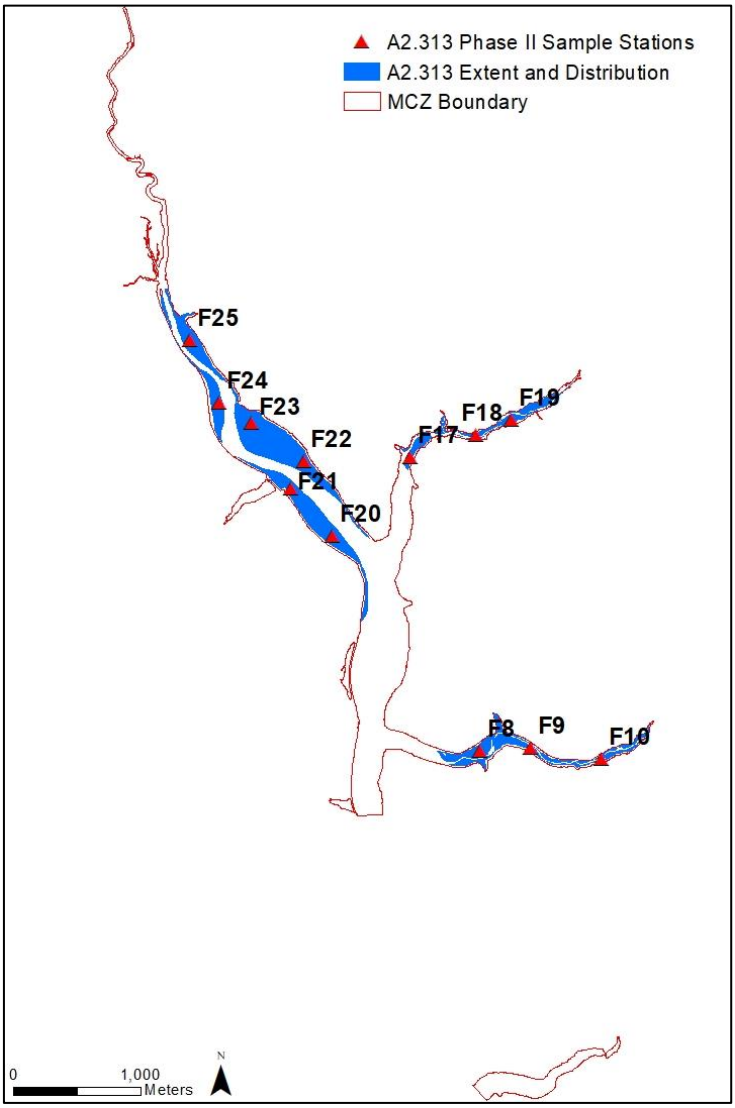

Figure 27. Map of the extent and distribution of the A2.313 Biotope within the Upper Fowey and Pont Pill MCZ.

The abiotic characteristics of the A2.313 Biotope observed within the MCZ were largely consistent with the EUNIS description[3] of the Biotope. Sediments were mostly silt (53% on average) with smaller proportions very fine-fine sand (average content of 22%) (Table 10).

The faunal component of this Habitat type resembled the communities described in the EUNIS description[3] well. All of the main characterising species were present in at least a proportion of the cores (Table 17). Almost every secondary characterising species listed was also present. These included the spionids *Streblospio* spp., *Pygospio elegans*, the gastropod *Peringia ulvae,* tubificid oligochaetes and juveniles cockles (*Cerastoderma edule*). A number of other taxa which are not described as characterising the Biotope were also present consistently in low numbers. These included the capitellid *Heteromastus filiformis*, and the brackish water sabellid *Manayunkia aestuarina*. Most significantly, the tentacled lagoon worm *Alkmaria romijni* was present at 11 of the 12 stations that were sampled within the Biotope. This species is a SOCI and considered nationally scarce. The abundance of the species was greatest at stations F23 and F24 adjacent to St Winnow.

Between 10 and 17 taxa were sampled within the A2.313 Biotope. The mean Bray-Curtis similarity between the benthic faunal communities at stations was 51%. SIMPER analysis determined that the estuarine oligochaete *Tubificoides benedii* contributed 16% to community similarity and was matched by the spionid *Streblospio shrubsolii* (

Table 18). The main characterising species *Hediste diversicolor* and (juvenile) *Scrobicularia plana* contributed just 4% and 3% respectively to the community similarities. However, the adults of *Scrobicularia plana* often burrow beyond 15cm (the depth of the core) and as a result this species is likely to be underrepresented by the quantitative data. Furthermore, *Scrobicularia plana* are also quite large comparatively and therefore fewer individuals would be expected in cores than smaller taxa such as oligochaetes.

Table 17. Mean taxa abundance at stations within the A2.313 Biotope within the Upper Fowey and Pont Pill MCZ.

Taxa	Mean Abundance per 0.01m^2 Core											
	Station											
	F8	F9	F10	F17	F18	F19	F20	F21	F22	F23	F24	F25
Nematoda									0.6			
Copepoda								0.6				0.6
Carcinus maenas juv.		0.6	0.6					1.3			0.6	
Cyathura carinata			0.6		2.5	3.3					1.4	2.4
Tharyx Type A				2.4				2.2	1.2			
Nephtys juv.	0.6											
Alkmaria romijni	1.2		0.6	1.7	0.8	3.9	2.5	4.7	1.3	7.8	8.4	2.7
Melinna palmata	0.6											
Arenicola marina		0.6										
Heteromastus filiformis			2.6	4.0	0.6	0.6	2.0	2.6	4.2	3.1	9.0	
Hediste diversicolor		1.7	2.6	0.8	2.3	3.1			0.6		1.7	3.1
Nephtys hombergii	3.1	1.0	1.3	1.4			2.8	1.7	1.7	1.6		
Eteone longa agg.											0.6	
Manayunkia aestuarina	0.8	1.0		0.6	0.8		1.8	0.8	1.0	0.8	0.8	1.0
Polydora cornuta		0.6									1.0	
Pygospio elegans	4.5	5.9	1.7	5.6	1.9	2.1	8.2	5.1	4.9	4.2	8.5	0.6
Streblospio shrubsolii	0.8	2.4	1.6	5.8	4.7	4.4	4.4	3.1	5.9	5.5	5.7	4.1
Paranais litoralis		0.6		1.2	1.8		0.6	0.6	1.2			0.8
Spirobranchus lamarcki											0.6	
Baltidrilus costatus					3.3	4.2						3.1
Enchytraeidae					0.8							
Tubificoides benedii	0.6	7.7	1.0	12.5	5.4	2.6	16.7	11.9	20.3	3.6	3.4	0.6
Tubificoides pseudogaster agg.		2.0	3.3	3.0	8.3	3.4	4.9	4.8	2.4	3.7	10.1	3.8
Tellinoidea juv.	1.0	1.6	0.6	1.2		0.6	1.4	1.8	1.4		0.8	
Tellinoidea		1.2					0.6	0.6		0.6	1.4	
Cerastoderma edule juv.							0.6					
Scrobicularia plana		1.0	0.8	0.8	1.0	1.3	0.8			1.5	1.3	1.0
Peringia ulvae	3.5	2.4	1.5	1.0	1.0	2.0	3.6	8.9	2.0	4.4	7.4	
Limecola balthica				0.6			1.0		0.6			
Diptera pupa					0.6							
Dolichopodidae larva					0.6							

Table 18. Taxa contribution within the A2.313 communities derived from core data within the Upper Fowey and Pont Pill MCZ.

Taxa	Mean Abundance per Quadrat	Mean Similarity	% Contribution	Cumulative % Contribution
Tubificoides benedii	7.2	8	16	16
Streblospio shrubsolii	4.0	8	16	31
Pygospio elegans	4.4	8	15	46
Tubificoides pseudogaster agg.	4.1	7	14	60
Peringia ulvae	3.1	4	9	69
Alkmaria romijni	3.0	4	7	76
Heteromastus filiformis	2.4	2	5	80
Hediste diversicolor	1.3	2	4	84
Nephtys hombergii	1.2	2	3	87
Manayunkia aestuarina	0.8	1	3	90
Scrobicularia plana	0.8	1	3	93

A2.321 - *Nephtys hombergii* and *Streblospio shrubsolii* in littoral mud

Within the EUNIS classification[3] the A2.321 Biotope is described as:

'Soft wet mud with a fine sand fraction, on the mid and lower shore of sheltered estuaries, usually with an anoxic layer present within the first 5 cm of the sediment. The infauna is relatively poor, dominated by the polychaetes [Nephtys hombergii], [Streblospio shrubsolii], and [Aphelochaeta marioni]. The oligochaete [Tubificoides benedii] is also characterising for this biotope, and [Hediste diversicolor] may be common.'

This Biotope was found to encompass almost all of the littoral sediments within the Pont Pill (the only exception being small areas of mixed sediments), and those at the lower extent of the Lerryn and Penpoll Creeks. The muddy upper shore banks on both the eastern and western sides of the Fowey adjacent to Golant (and further south on the western bank) also supported these polychaete dominated communities (Plate 15, Figure 28).

Plate 15. Photograph of the A2.321 Biotope within the Upper Fowey and Pont Pill MCZ at Phase I station S13.

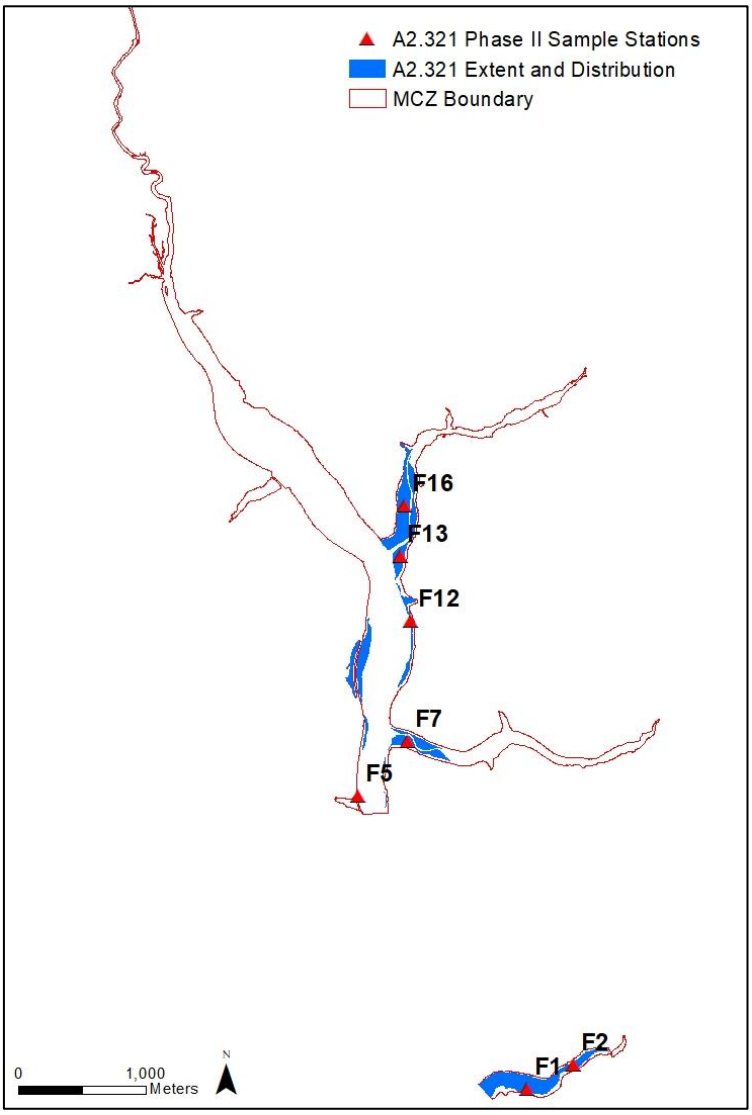

Figure 28. Map of the extent and distribution of the A2.321 Biotope within the Upper Fowey and Pont Pill MCZ.

Both the abiotic and biotic attributes of the A2.321 Biotope in the Upper Fowey and Pont Pill MCZ correspond with the EUNIS description[8]. The sediment granulometry is dominated by silt (average 47%) with smaller proportions of very fine-fine sand fractions (average 22% and 13% respectively) (Table 10).

The two main characterising species (*Nephtys hombergii* and *Streblospio shrubsolli*) were present at all stations (Table 19). *Tubificoides pseudogaster*, which is often found to occupy the same ecological niche alongside *Tubficoides benedii*, was found at all stations, whilst the main characterising Tubificid *Tubificoides benedii* was sampled at four of the seven stations. The SOCI *Alkmaria romijni* was found in both stations that were sampled within Lerryn Creek.

The number of taxa recorded from stations was variable and ranged from 6 (at station F12) to 15 (at station F16). The Bray-Curtis analysis determined that the sampled A2.321 communities were, on average, 47% similar. It is thought that part of the community variability is attributable to the geographic spread of the communities within the MCZ (which are spread over 5 km) from the Pont Pill to the Lerryn Creek. However, the fauna data from station F7 is also thought to represent broad transitioning of the A2.231 communities with the A2.421 Biotope lower on the shore. Similarly, station F16 is likely to represent the start of transitioning to the A2.313 communities higher in the Lerryn Creek.

Those species which provided the highest percentage contribution to similarity are listed in Table 20. The oligochaete Tubificoides pseudogaster accounted for the largest proportion of the similarity between stations (22%). The main characterising species *Nephtys hombergii* and *Streblospio shrubsolii* followed, accounting for 19% and 17% of the total community similarity respectively.

Table 19. Mean taxa abundance at stations within the A2.321 Biotope with the Upper Fowey and Pont Pill MCZ.

Taxa	Mean Abundance per 0.01m^2 Core						
	Station						
	F1	F2	F5	F7	F12	F13	F16
Nematoda	0.6						
Capitella agg.	0.6						
Nephtys juv.		0.6					
Alkmaria romijni						1.0	3.5
Ampharete cf. acutifrons	0.6	1.0		2.2			
Heteromastus filiformis		0.6					1.0
Nephtys hombergii	2.1	1.4	1.7	1.3	2.0	1.3	1.4
Manayunkia aestuarina			0.8	1.3			1.9
Pygospio elegans		0.6	1.4	4.0	1.0	4.3	8.9
Streblospio shrubsolii	0.8	1.4	1.6	1.8	1.8	3.9	2.4
Paranais litoralis							1.2
Tubificoides benedii	1.9		0.6			5.4	2.9
Tubificoides pseudogaster agg.	0.6	2.6	1.2	6.6	2.6	5.4	4.0
Tellinoidea juv.				1.7		0.6	1.2
Tellinoidea	0.6					0.6	0.6
Cerastoderma edule juv.		0.6	1.2				
Mytilus edulis juv.					0.6		
Scrobicularia plana							0.6
Abra tenuis			0.6				
Peringia ulvae	0.6	5.4	1.2	1.6	1.5	1.5	6.1
Hediste diversicolor	1.2	0.8	0.6	1.2			0.6
Jaera albifrons agg.		0.8					
Decapoda megalopa	0.6		0.6			0.6	0.6

Table 20. Taxa contribution within the A2.321 communities derived from core data within the Upper Fowey and Pont Pill MCZ.

Taxa	Mean Abundance per Quadrat	Mean Similarity	% Contribution	Cumulative % Contribution
Tubificoides pseudogaster agg.	3.3	10	22	22
Nephtys hombergii	1.6	9	19	40
Streblospio shrubsolii	2.0	8	17	58
Peringia ulvae	2.6	7	16	73
Pygospio elegans	2.9	5	11	85
Hediste diversicolor	0.6	2	4	89
Tubificoides benedii	1.6	2	4	93

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

The EUNIS description[3] of this Sub-biotope reads:

'Sheltered estuarine shores of sandy mud, which may become firm and compacted if present in the upper shore where there is more time for drainage between high tides. An anoxic layer is usually present within the first 5 cm of the sediment. The infauna is very sparse, usually only the ragworm [Hediste diversicolor] and the amphipod [Corophium volutator] are present in any abundance. Occasionally, oligochaetes or the spire shell [Peringia ulvae] may be present.

[Corophium multisetosum] may also be found."

The A2.3222 Sub-biotope was found only in the upper reaches of the main Fowey channel (Figure 29). There, *Hediste diversicolor* and *Corophium volutator* communities occupied the compact muddy banks (Plate 16) which stretched from Milltown to Pill Farm over a length of approximately 1 km (Figure 29). At the upper extent of the A2.3222 Sub-biotope communities quickly transitioned to those representing freshwater conditions and were solely dominated by the most common and salt tolerant freshwater oligochaete *Limnodrilus hoffmeisteri*.

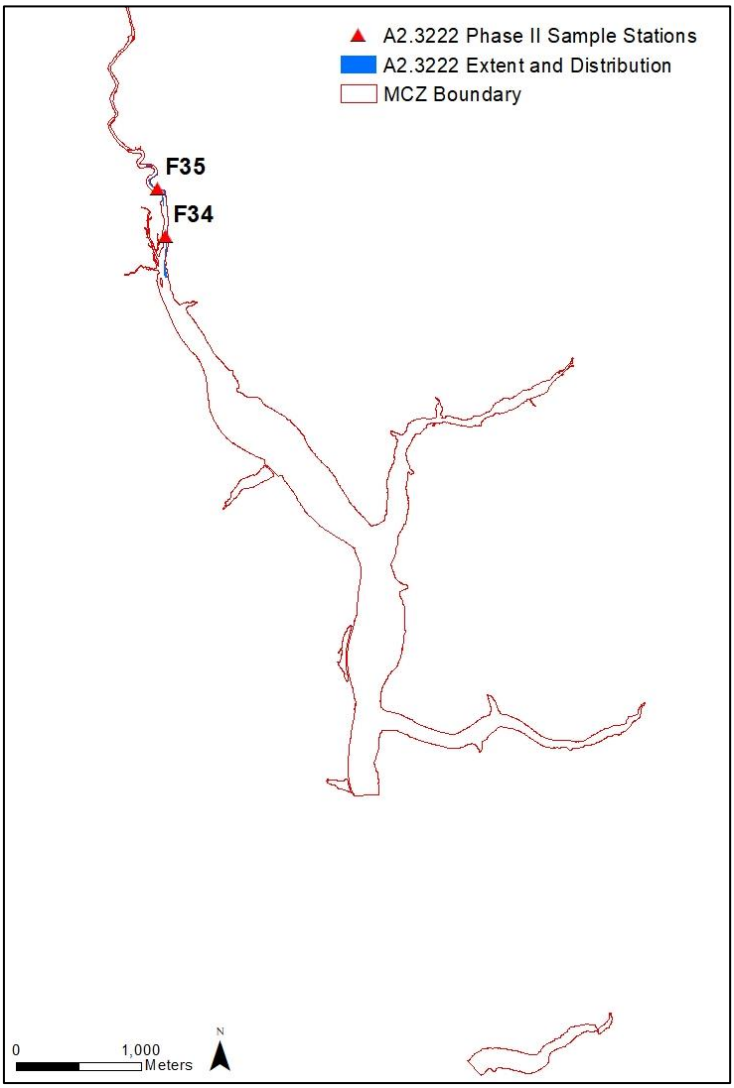

Figure 29. Map of the extent and distribution of the A2.3222 Sub-biotope within the Upper Fowey and Pont Pill MCZ.

Plate 16. Photograph of the A2.3222 Sub-biotope within the Upper Fowey and Pont Pill MCZ at Phase I station S28.

The sediments were composed, on average, of 55% silt with 21% and 11% very fine and fine sand respectively, fitting with the A2.3222 EUNIS description[3] of 'sandy mud'.

The faunal communities also corresponded well with the those described in the EUNIS classification[3] (Table 21). Ten taxa were sampled at both stations (Table 22). The main characterising species *Corophium volutator* and the polychaete *Hediste diversicolor* were present at both stations sampled, although in low abundance, probably because of the compact nature of the sediments. A number of non-characterising brackish/freshwater species that were sampled included the isopod *Cyathura carinata* and three species of oligochaetes which are typical of low and/or limited salinity ranges. The spionid *Pygospio elegans* was also common.

At 63%, the mean Bray-Curtis similarity between the benthic faunal communities at stations within this Sub-biotope was the highest of all the littoral sediment communities sampled. SIMPER analysis in PRIMER 6[8] determined that the oligochaete *Baltidrilus costatus* (which occupies a distinct niche in mid-range salinities in the intertidal but is not particular about sediment type[10]) contributed the most (31%) to community similarities (Table 22). The abundance of insect larvae contributed the second highest percentage to community similarities, whilst the main characterising species *Corophium volutator* and *Hediste diversicolor* contributed 16% and 7% respectively.

Table 21. Mean taxa abundance at stations within the A2.3222 Sub-biotope within Upper Fowey and Pont Pill MCZ.

Taxa	Mean Abundance per 0.01m^2 Core	
	Station	
	F34	F35
Nematoda	0.6	
Corophium volutator	1.8	2.0
Cyathura carinata	0.8	1.2
Pygospio elegans	0.8	0.6
Enchytraeidae	0.6	0.6
Tubificoides pseudogaster agg.	1.3	2.9
Peringia ulvae		1.0
Hediste diversicolor	0.8	1.0
Acari	1.0	
Monopylephorus irroratus		0.8
Baltidrilus costatus	3.5	9.6
Dolichopodidae larva	3.6	2.1

Table 22. Taxa contribution within the A2.3222 communities derived from core data within the Upper Fowey and Pont Pill MCZ.

Taxa	Mean Abundance per Quadrat	Mean Similarity	% Contribution	Cumulative % Contribution
Baltidrilus costatus	6.5	19	31	31
Dolichopodidae larva	2.8	11	18	49
Corophium volutator	1.9	10	16	65
Tubificoides pseudogaster agg.	2.1	7	11	76
Cyathura carinata	1.0	4	7	83
Hediste diversicolor	0.9	4	7	90
Enchytraeidae	0.6	3	5	95

A2.325 - Saltmarsh creeks

These communities are broadly described by the EUNIS classification[3] as:

'Upper estuarine sandy mud and mud shores, in areas with significant freshwater influence. Littoral mud typically forms mudflats, though dry compacted mud can form steep and even vertical structures, particularly at the top of the shore adjacent to saltmarshes. Little oxygen penetrates these cohesive sediments, and an anoxic layer is often present within millimetres of the sediment surface. The upper estuarine mud communities support few infaunal species and are principally characterised by a restricted range of polychaetes and oligochaetes.'

The extent and distribution of these communities within the MCZ is very limited as are the saltmarsh habitats they are associated with. They are only found adjacent to St Winnow in the upper reaches of estuary (Figure 30). Consequently these communities were not subject to Phase II sampling, but direct observations of the abiotic and biotic features in the field during the Phase I survey were consistent with the EUNIS description[3].

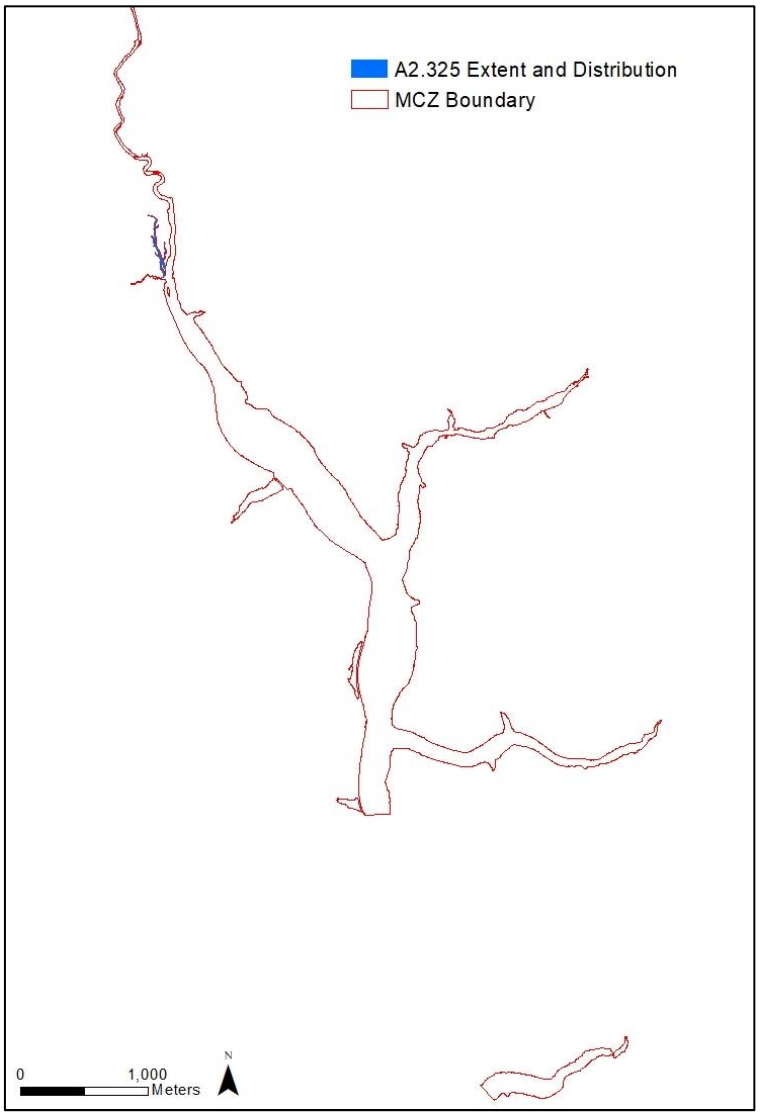

Figure 30. Map of the extent and distribution of the A2.325 Biotope within the Upper Fowey and Pont Pill MCZ.

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

Within the EUNIS classification[3] the A2.4112 Sub-biotope is described as:

'Extremely sheltered gravelly mud on the mid and lower shore, containing little sand with occasional cobbles. The infaunal community includes the ragworm [Hediste diversicolor] and the peppery furrow shell [Scrobicularia plana], as well as a range of polychaetes, oligochaetes, and molluscs. Given the low sample numbers for this biotope, more records are needed to confirm the characterising species list.'

This Sub-biotope was limited to the lowest shore banks between St. Winnow and Newham, and at the very upper limit of Lerryn Creek (Figure 32). Within the main Fowey channel these areas of gravelly mud were found on the lower periphery of littoral mud communities that were also characterised by the bivalve *Scrobicularia plana* (A2.313). The distinction between the A2.313 and A2.4112 Habitat types has been made based almost entirely on the sediment character, as those sediments within the A2.4112 contain a more substantial gravel and pebble component (as a result of tidal scour in the main channel) which is all but absent within the A2.313 Biotope. At station F41 within Lerryn Creek, the lower proportion of mud (sum of

silt and clay) is likely to be attributable to periodic scour from the River Lerryn. Photographs of the Sub-biotope in the upper Lerryn are shown in Plate 17.

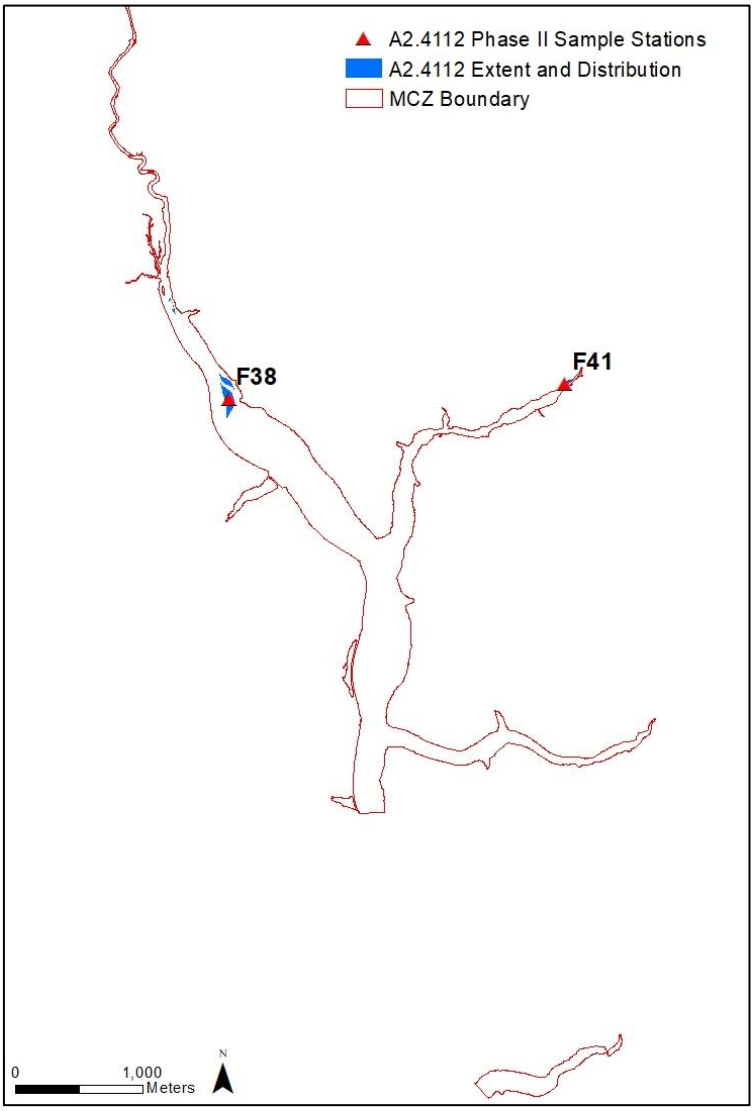

Figure 31. Map of the extent and distribution of the A2.4112 Sub-biotope within the Upper Fowey and Pont Pill MCZ.

Plate 17. Photograph of the A2.4112 Sub-biotope within the Upper Fowey and Pont Pill MCZ at Phase I station S20.

Based on observations in the field, the physical and faunal attributes of the Sub-biotope within the Upper Fowey and Pont Pill MCZ correspond with the EUNIS classification[3]. The sediment character at the two stations sampled were, however, variable (Table 10). The upper reaches of Lerryn Creek were observed to contain a substantial gravel and pebble component during the Phase I survey, However, since the mud component overlaid the gravel, it is thought that the larger grain size fractions may not have been accurately represented by the sampling (i.e. core captured soft surface sediments only). Alternatively, the mud and gravel/pebble may have mosaicked and a more muddy area was sampled.

The faunal component of the A2.4112 Sub-biotope corresponded reasonably well with the communities described in the EUNIS description[3]. With the exception of *Scrobicularia plana*, the main characterising species were present in the cores (Table 23). However, the adults of *Scrobicularia plana* often burrow beyond 15 cm (the depth of the core) and as a result this species is often underrepresented by the quantitative core data. The number of taxa sampled at each of the two stations sampled was 11 and 14, and included five species of oligochaetes as well as a few individuals of other low/variable salinity tolerant taxa including *Cyathura carinata*, *Manayunkia aestuarina* and *Corophium volutator*.

At 30% the mean Bray-Curtis similarity between the benthic faunal communities at within this Biotope was the lowest of all the littoral sediment communities sampled. surprising given the geographical disconnection of the sampled communities within and the different environmental conditions that exist between the upper Lerryn Creek Fowey channel. The estuarine isopod *Cyathura carinata* contributed the most (39%) to community similarity (

Table 24). The main characterising species *Hediste diversicolor* was the second highest species contributing to the similarity observed (18%).

Table 23. Mean taxa abundance at stations within the A2.4112 Sub-biotope within the Upper Fowey and Pont Pill MCZ.

Taxa	Mean Abundance per 0.01m^2 Core	
	Station	
	F38	F41
Nematoda	1.0	
Gammaridae juv.	1.2	
Corophium volutator		0.6
Collembola	0.6	
Cyathura carinata	4.4	3.3
Cyprideis torosa		2.3
Manayunkia aestuarina		0.8
Pygospio elegans	7.1	
Streblospio shrubsolii	1.2	2.8
Paranais litoralis		1.0
Enchytraeidae	4.3	
Tubificoides benedii	0.6	
Tubificoides pseudogaster agg.	3.7	
Tellinoidea		1.0
Cerastoderma edule juv.	1.2	
Peringia ulvae	0.6	2.0
Hediste diversicolor	1.5	6.8
Baltidrilus costatus	1.3	3.9
Dolichopodidae larva	2.0	0.6

Table 24. Taxa contribution within the A2.313 communities derived from core data within the Upper Fowey and Pont Pill MCZ.

Taxa	Mean Abundance per Quadrat	Mean Similarity	% Contribution	Cumulative % Contribution
Cyathura carinata	3.8	12	39	39
Hediste diversicolor	4.2	6	18	57
Baltidrilus costatus	2.6	5	15	73
Streblospio shrubsolii	2.0	4	14	86
Dolichopodidae larva	1.3	2	7	93

A2.4114 *Hediste diversicolor*, cirratulids and *Tubificoides* spp. in littoral gravelly sandy mud

The EUNIS classification[3] describes the A.4114 Sub-biotope as:

'Sheltered gravelly sandy mud, subject to variable salinity. The infaunal community consists of the ragworm [Hediste diversicolor], [Pygospio elegans], [Streblospio shrubsolii], and cirratulid polychaetes such as [Tharyx killariensis]. Nematodes and oligochaetes occur, as well as the bivalve [Limecola balthica]. Given the low sample numbers for this biotope, more records are needed to confirm the characterising species list.'

This Sub-biotope is limited to small discrete areas of muddy littoral sediments which are essentially characterised by a larger gravel component as a result of localised effects of tidal scour. These areas were observed adjacent to littoral rock outcrops in Pont Pill Creek, and on an extreme lower shore bank which protrudes out into the freshwater flow of the main Fowey channel, adjacent to St Winnow (Plate 18, Figure 32).

Plate 18. Photograph of the A2.4114 Sub-biotope within the Upper Fowey and Pont Pill MCZ at Phase I station S24.

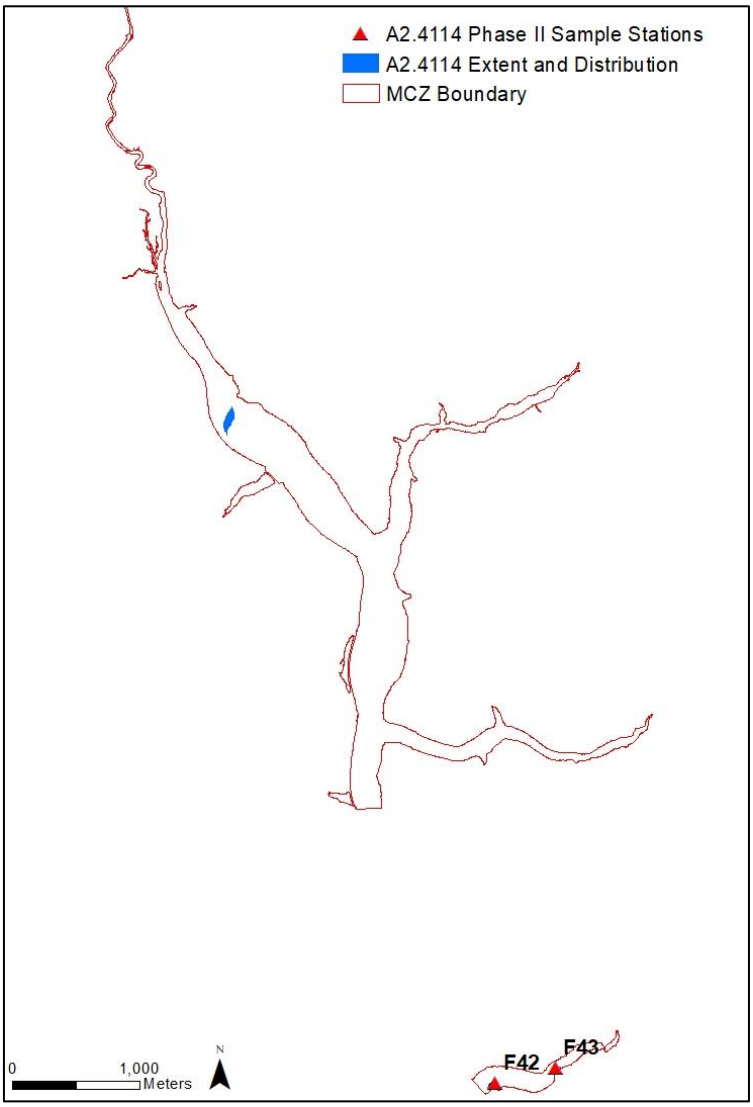

Figure 32. Map of the extent and distribution of the A2.4114 Sub-biotope within the Upper Fowey and Pont Pill MCZ.

The sediment character at the two stations was broadly consistent, with silt, coarse sand, gravel and pebbles accounting for the dominant fractions (Table 10. Particle size analysis results (Wentworth Scale) from sediments within the Upper Fowey and Pont Pill MCZ. The A2.4114 faunal communities recorded within the MCZ fit closely with those described in the EUNIS classification[3]. With the exception of the bivalve *Limecola balthica* all of the species listed as characterising for the Sub-biotope were sampled at both stations (Table 25). Tharyx Type 'A' represented the cirratulid component of the communities. 23 taxa were sampled in total at each of the two stations within Pen Poll, although the species present varied between stations resulting in 44% community similarity. Additional species collected at both stations that are not considered characterising included nematodes, the capitellid polychaete *Hetermastus filiformis,* and juvenile bivalves including Tellinoidea and the cockle *Cerastoderma edule*.

With the exception of *Tubificoides* species which collectively contributed 17%, none of the main characterising species contributed more than 6% to the similarity of the communities that were sampled at each station (Table 26).

Table 25. Mean taxa abundance at stations within the A2.4114 Sub-biotope within the Upper Fowey and Pont Pill MCZ.

Taxa	Average Abundance per 0.01m^2 Core	
	Station	
	F42	F43
Nematoda	9.3	9.8
Cyathura carinata		4.7
Capitella agg.	2.2	
Tharyx Type A	12.2	1.3
Ampharete cf. acutifrons	2.1	
Heteromastus filiformis	6.1	4.0
Mediomastus fragilis	7.1	
Glycera tridactyla	0.6	
Nephtys hombergii	0.8	
Eteone longa agg.	1.6	
Manayunkia aestuarina		1.3
Aonides oxycephala	0.8	
Polydora cornuta		0.6
Pseudopolydora paucibranchiata	2.4	
Pygospio elegans	3.6	1.7
Spio martinensis	0.6	
Streblospio shrubsolii	1.4	2.7
Enchytraeidae		4.7
Tubificoides benedii	5.7	3.0
Tubificoides pseudogaster agg.	2.3	7.7
Tellinoidea juv.	1.6	1.5
Tellinoidea		1.3
Cerastoderma edule juv.	3.3	2.5
Mya arenaria juv.		0.6
Scrobicularia plana juv.	2.2	
Peringia ulvae	2.4	2.3
Hediste diversicolor	1.2	5.5
Nemertea		0.8
Jaera albifrons agg.		0.6
Malacoceros tetracerus	0.6	3.0
Phyllodoce mucosa	1.2	
Baltidrilus costatus		6.6
Clitellio arenarius		3.2
Decapoda megalopa		1.2

Table 26. Taxa contribution within the A2.4114 communities derived from core data within the Upper Fowey and Pont Pill MCZ.

Taxa	Mean Abundance per Quadrat	Mean Similarity	% Contribution	Cumulative % Contribution
Nematoda	9.6	13	30	30
Heteromastus filiformis	5.1	6	13	43
Tubificoides benedii	4.4	4	10	52
Cerastoderma edule juv.	2.9	4	8	60
Peringia ulvae	2.3	3	7	68
Tubificoides pseudogaster agg.	5.0	3	7	75
Pygospio elegans	2.7	2	6	81
Tellinoidea juv.	1.6	2	5	86
Streblospio shrubsolii	2.1	2	5	90

A2.4115 - *Hediste diversicolor* and *Corophium volutator* in littoral gravelly sandy mud

Described by the EUNIS classification[3] as:

'Extremely sheltered gravelly sandy mud, subject to variable or reduced salinity. The infaunal community consists of the ragworm [Hediste diversicolor], [Streblospio shrubsolii], [Capitella capitata] and [Manayunkia aestuarina]. Oligochaetes and [Corophium volutator] are abundant. It is probable that there are broad transition areas between this biotope and the corresponding muddy sediment biotope A2.3222. The boundaries may be very indistinct, with this unit present in patches of gravelly mud on areas of mudflat, where the main biotope is A2.3222. Given the low sample numbers for this biotope, more records are needed to confirm the characterising species list.'

This Sub-biotope was limited to a 500 m stretch of mud bank on the upper estuarine western side of the MCZ, adjacent to Milltown (Figure 33). Pictures of this area are show in Plate 19.

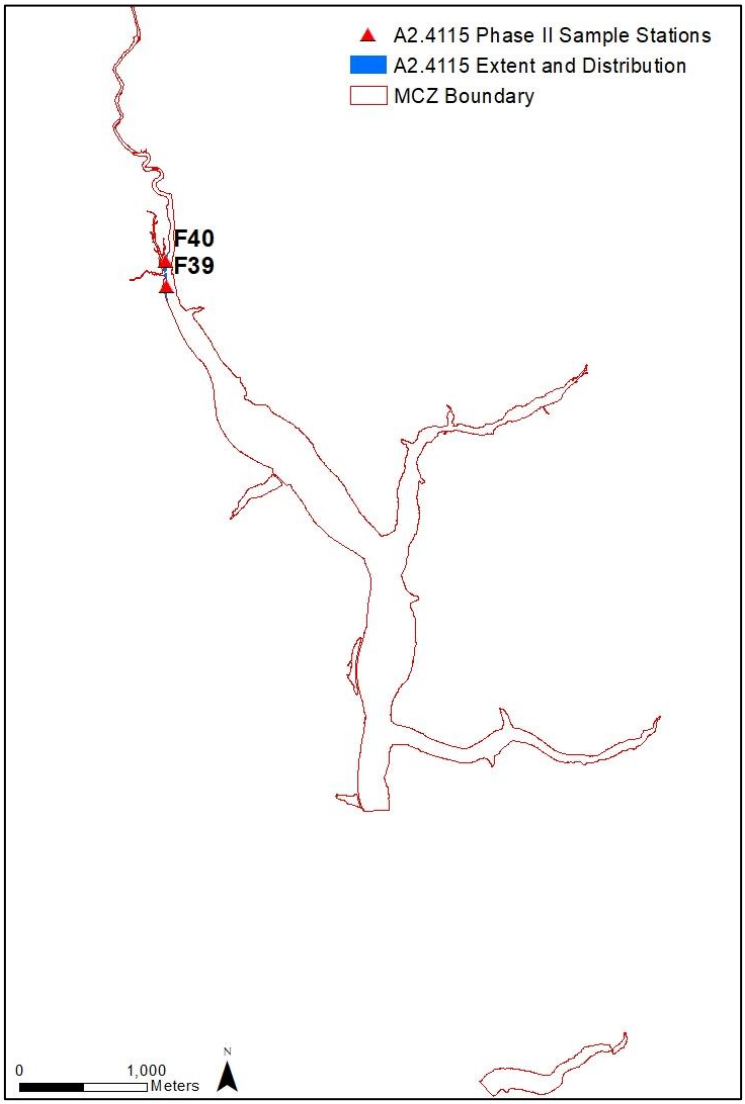

Figure 33. Map of the extent and distribution of the A2.4115 Sub-biotope within the Upper Fowey and Pont Pill MCZ.

Plate 19. Photograph of the A2.4115 Sub-biotope within the Upper Fowey and Pont Pill MCZ at Phase I station S1.

The abiotic characteristics of the A2.4115 Sub-biotope fit with the broad EUNIS description, but due to varying proportions of silt, gravel and pebbles, the sediments were found to be variable between stations (Table 10).

The fauna captured at the two stations closely resembled the Habitat type description. The only characterising species that was absent from both stations was the polychaete *Capitella capitata* agg. (Table 27). 9 taxa were sampled at each of the stations.

At 55% the mean Bray-Curtis similarity between the benthic faunal communities at stations within this Habitat type was relatively high, but given the close geographical distance between the sample stations it could have been expected that the similarity would be higher. However, during Phase I observations station F39 was thought to be in a transitional area between A2.4115 and A2.313, which may have contributed to the observed variability in community structure.

The oligochaete *Baltidrilus costatus* (which occupies a distinct niche in mid-range salinities[10]) contributed 38% to the community similarity (Table 28), whilst the main characterising species *Hediste diversicolor* and *Corophium volutator* contributed 27% and 7% respectively.

Table 27. Mean taxa abundance at stations within the A2.4115 Sub-biotope within the Upper Fowey and Pont Pill MCZ.

Taxa	Average Abundance per 0.01m^2 Core	
	Station	
	F39	F40
Gammaridae juv.		0.6
Corophium volutator	0.8	1.5
Carcinus maenas juv.	0.8	
Cyathura carinata	2.3	2.7
Manayunkia aestuarina	0.6	
Streblospio shrubsolii	4.6	0.8
Enchytraeidae		0.6
Tubificoides pseudogaster agg.	0.8	
Tellinoidea	1.2	
Cerastoderma edule juv.		0.6
Hediste diversicolor	8.1	3.0
Baltidrilus costatus	4.4	4.3
Dolichopodidae larva	0.0	3.5

Table 28. Taxa contribution within the A2.4115 communities derived from core data with the Upper Fowey and Pont Pill MCZ.

Taxa	Mean Abundance per Quadrat	Mean Similarity	% Contribution	Cumulative % Contribution
Baltidrilus costatus	4.3	21	38	38
Hediste diversicolor	5.6	15	27	65
Cyathura carinata	2.5	11	21	85
Corophium volutator	1.2	4	7	93

A2.421 - Cirratulids and *Cerastoderma edule* in littoral mixed sediment

This Biotope is defined by the EUNIS classification[3] as:

'Sheltered mixed sediments, usually subject to variable salinity conditions. Banks of shell may be present. The infauna is very diverse, dominated by a range of polychaetes including [Exogone naidina], [Sphaerosyllis taylori], [Pygospio elegans], [Chaetozone gibber], [Cirriformia tentaculata], [Aphelochaeta marioni], [Capitella capitata], [Mediomastus fragilis], and [Melinna palmata]. The oligochaetes [Tubificoides benedii] and [T. pseudogaster] are abundant, as is the cockle [Cerastoderma edule]. A large range of amphipods may occur, including [Melita palmata], [Microprotopus maculatus], [Aora gracilis] and [Corophium volutator]. The bivalves [Abra alba] and [A. nitida] may occur. The barnacle [Elminius modestus] can be abundant where the sediment has stones on the surface. Epifaunal algae may occur attached to stable cobbles on the sediment surface.'

This Biotope is extremely limited in extent and distribution within the MCZ. No quantitative data is available as the area was not included within the Phase II surveys. The Habitat type was identified during the Phase I survey and, given its location at the Penpoll confluence with the main channel, is likely to alter both in character and extent depending upon the dynamic estuarine processes.

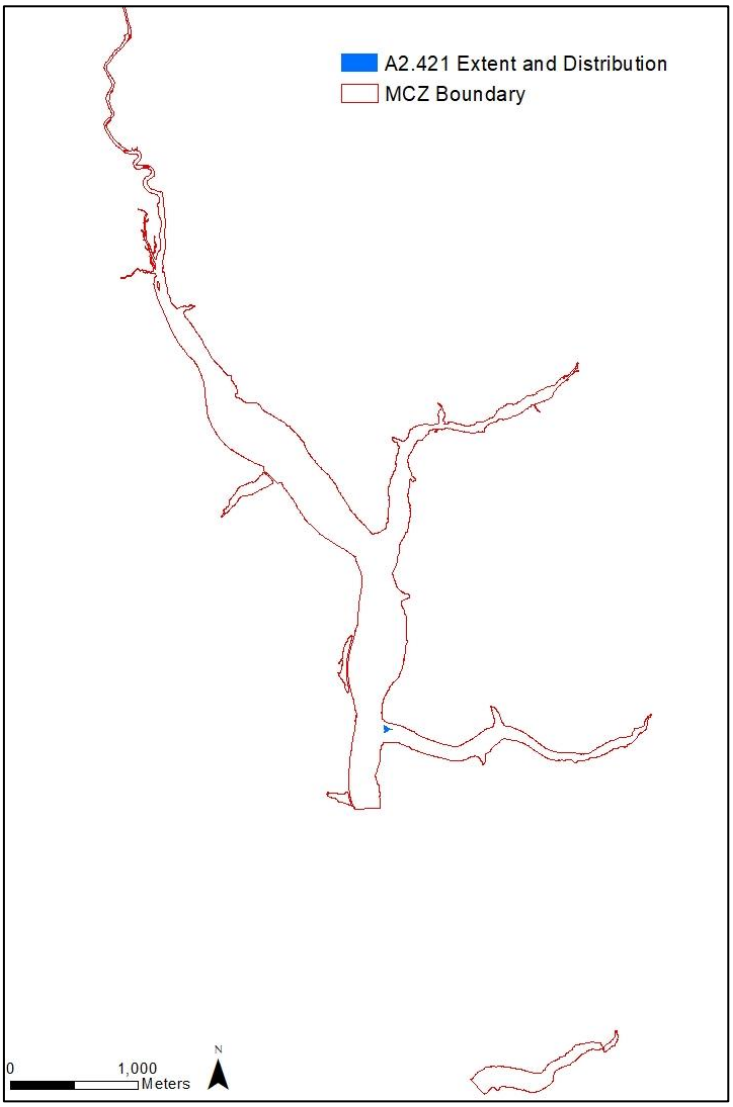

Figure 34. Map of the extent and distribution of the A2.421 Biotope within the Upper Fowey and Pont Pill MCZ.

4.2.3 Statistical Analysis of Flora and Fauna in Littoral Sediment Habitat Types

The results of the univariate analysis for each transect and the mean diversity indices for each habitat type have been incorporated into Table 29.

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Table 29. Univariate community analysis of littoral sediment faunal communities in the Upper Fowey and Pont Pill MCZ.

Habitat Type	Station	Total No. Taxa per Station S	Average Number of Individuals per Station N	Margalef's Species Richness d	Pielou's Evenness J'	Shannon Wiener Index H'(log10)	Simpson Diversity Index 1-Lambada'
A2.2231	F28	14	36	3.6	0.6	1.5	0.6
	F29	14	24	4.1	0.8	2.2	0.9
	F30	11	12	4.1	0.9	2.2	0.9
	Mean	***13***	***24***	***4***	***1***	***2***	***1***
A2.231	F11	11	17	3.6	0.9	2.1	0.9
	F31	22	37	5.8	0.9	2.9	1.0
	F32	13	43	3.2	0.8	2.1	0.9
	F33	14	26	4.0	0.8	2.2	0.9
	F36	16	28	4.5	0.9	2.4	0.9
	F37	11	16	3.6	1.0	2.3	0.9
	Mean	***15***	***28***	***4***	***1***	***2***	***1***
A2.311	F14	17	19	5.4	0.9	2.6	0.9
	F15	16	44	4.0	0.8	2.3	0.9
	F27	12	20	3.7	0.9	2.3	0.9
	Mean	***15***	***28***	***4***	***1***	***2***	***1***
A2.313	F8	10	17	3.2	0.9	2.0	0.9
	F9	15	30	4.1	0.9	2.3	0.9
	F10	13	19	4.1	0.9	2.4	0.9
	F17	16	43	4.0	0.8	2.3	0.9
	F18	17	37	4.4	0.9	2.5	0.9
	F19	12	31	3.2	0.9	2.3	0.9
	F20	15	52	3.5	0.8	2.2	0.9
	F21	15	51	3.6	0.9	2.3	0.9
	F22	15	49	3.6	0.8	2.1	0.8
	F23	11	37	2.8	0.9	2.2	0.9
	F24	17	63	3.9	0.8	2.4	0.9
	F25	12	24	3.5	0.9	2.3	0.9
	Mean	***14***	***38***	***4***	***1***	***2***	***1***
A2.321	F1	11	10	4.3	0.9	2.2	1.0
	F2	11	16	3.6	0.9	2.1	0.9
	F5	11	11	4.1	1.0	2.3	1.0
	F7	9	22	2.6	0.9	2.0	0.9
	F12	6	10	2.2	0.9	1.7	0.9
	F13	10	25	2.8	0.9	2.0	0.9
	F16	15	37	3.9	0.9	2.3	0.9
	Mean	***10***	***19***	***3***	***1***	***2***	***1***
A2.3222	F34	10	15	3.3	0.9	2.1	0.9
	F35	10	22	2.9	0.8	1.8	0.8
	Mean	***10***	***19***	***3***	***1***	***2***	***1***
A2.4112	F38	14	30	3.8	0.9	2.3	0.9
	F41	11	25	3.1	0.9	2.1	0.9
	Mean	***13***	***28***	***3***	***1***	***2***	***1***
A2.4114	F42	23	71	5.2	0.9	2.8	0.9
	F43	23	71	5.2	0.9	2.9	0.9
	Mean	***23***	***71***	***5***	***1***	***3***	***1***
A2.4115	F39	9	24	2.5	0.8	1.8	0.8
	F40	9	18	2.8	0.9	1.9	0.9
	Mean	***9***	***21***	***3***	***1***	***2***	***1***

As described for the littoral rock habitat types in Section 4.2.1, estuarine environmental variables are expected to drive two trends in community univariate indices from an estuarine system such as the Fowey estuary. The first is that the lower shore Habitat types usually exhibit greater species diversity and richness than those on the upper shore.

However, the richness and diversity values derived from the littoral sediment fauna data in the Fowey estuary do not evidently follow this trend. Communities that were sampled on the lower or lower to mid shore (A2.2231, A2.231, A2.321, A2.311 and A2.4112) on average, support similarly rich and diverse communities to those sampled on the mid and upper shores (AA2.313, A2.3222 and A2.4115). An exception to this was the small areas of muddy gravel communities that were mapped within the Pont Pill. These mid-upper shore communities were the most rich and diverse of all the sediment Habitat types sampled. The reasons for this are probably to be attributable to the likely less variable salinity at that location lower in the estuary, and distribution higher on the shore away from the freshwater influence of the Pont Pill tributary (although salinity data was not collected within the Habitat type).

The richness and diversity of communities would usually be expected to be greatest at the seaward extent of the study area in correspondence with the estuarine salinity gradient[7]. The total taxa, richness and diversity indices from each of the stations sampled within the Fowey estuary have been considered individually, irrespective of the Habitat type assigned, and plotted in Figure 35. No obvious trends were evident in the number of taxa or species diversity with distance down the estuary (this observation was corroborated by correlation coefficients of R = 0.12 and R = 0.02 respectively). The only trend found to exist was an increase in the Shannon Weiner diversity index with distance down the estuary, although this trend was weak, it was found to be significant (R = 0.243, P = <0.05).

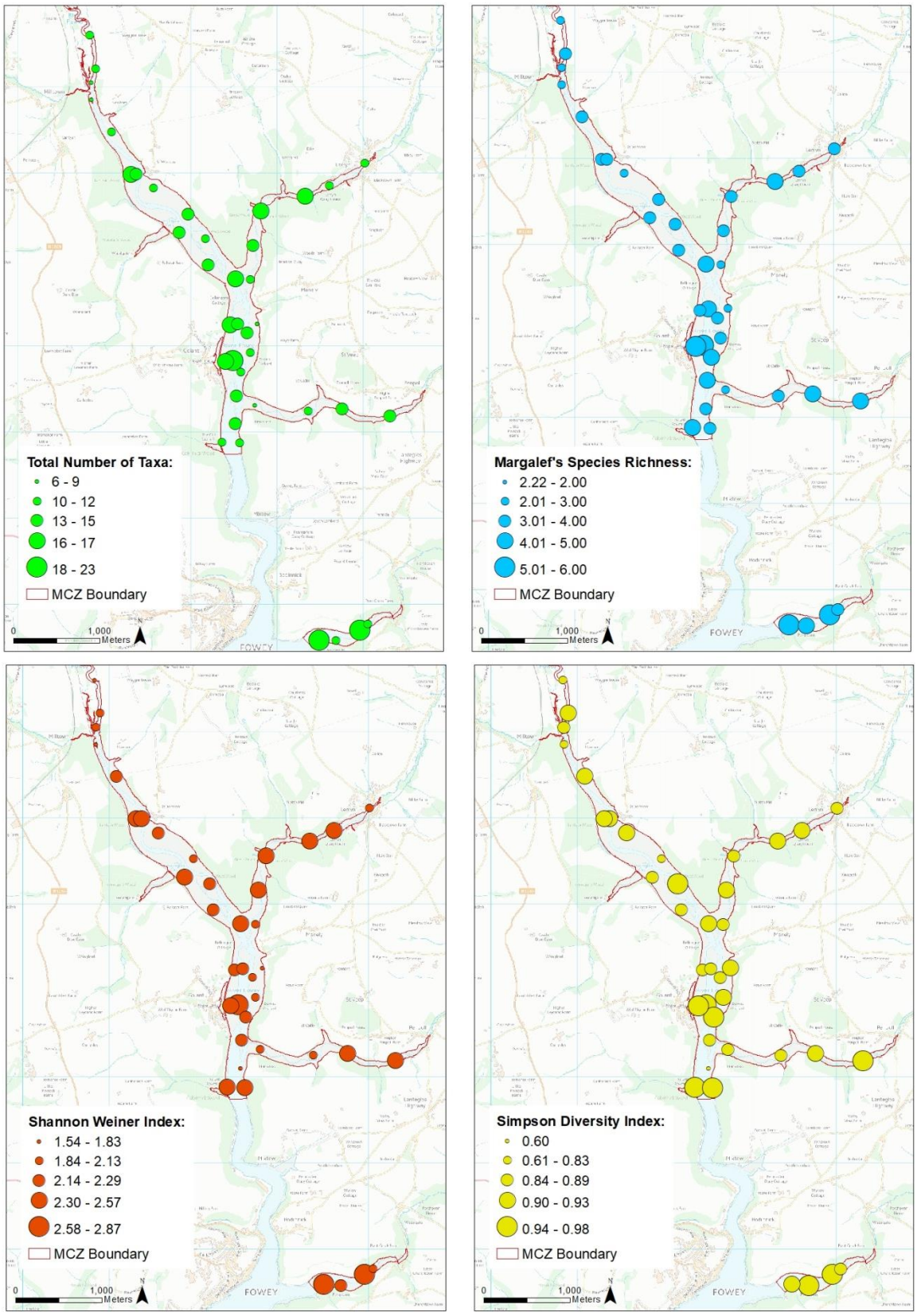

Figure 35. Geographical representation of the number of taxa, richness and diversity indices at littoral sediment stations within the Upper Fowey and Pont Pill MCZ.

Community analysis in PRIMER[8] used the multivariate Bray-Curtis similarity statistic and MDS to assess the communities at each station. The MDS plot in Figure 35 represents the sample stations (within each Habitat type) in two dimensions, where the distances between

points represent the similarities between the faunal communities at those stations (i.e. the closer together two stations are on the plot, the more similar their community structure).

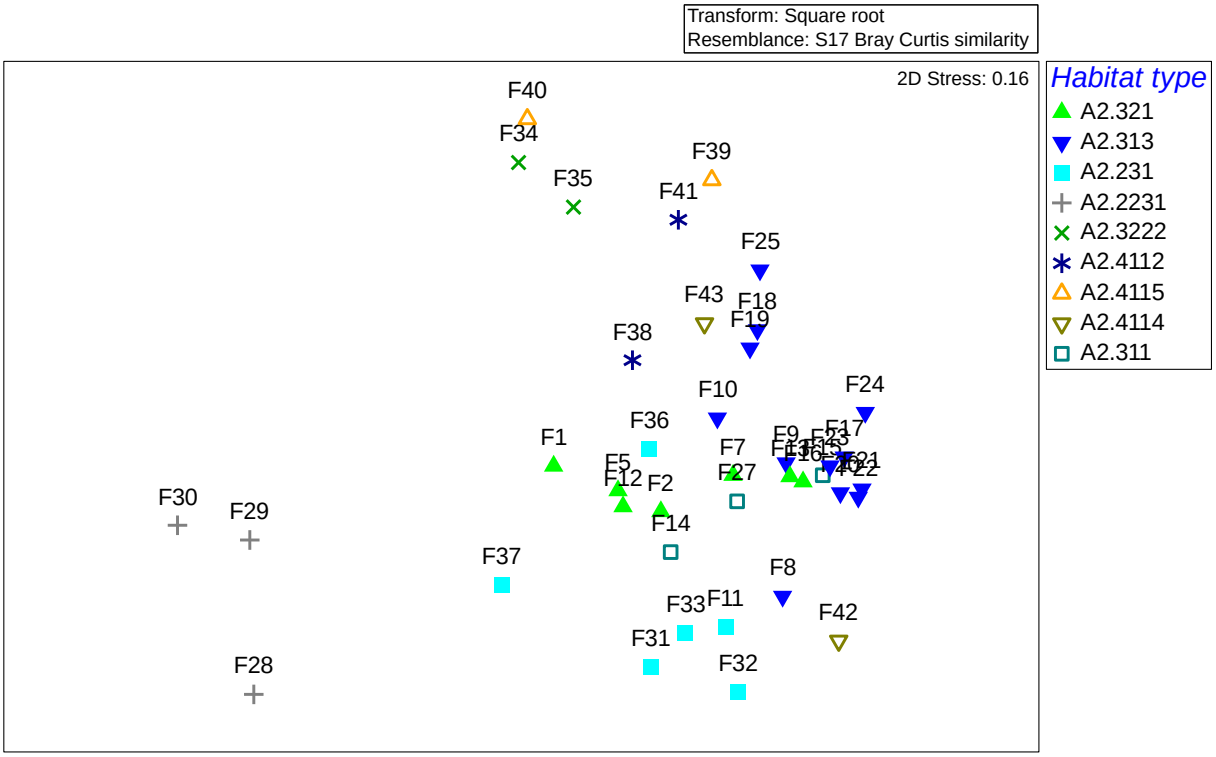

Figure 36. Two dimensional MDS plot of all littoral sediment communities sampled within the Upper Fowey and Pont Pill MCZ.

The plot generally demonstrates relatively good grouping of stations from the same littoral sediment Habitat types. However, the mean Bray-Curtis similarities within the habitat types were generally relatively low. This is probably a result of the broad range of environmental variables such as salinity range, tidal regime and tidal scour, to which the communities are exposed to between the mid and upper regions of the estuary.

Communities within some habitat types were however more similar than others. The A2.3222 Sub-biotope (*Hediste diversicolor* and *Corophium volutator* in littoral mud), for example, had the highest overall mean Bray-Curtis of 63% whilst the A2.4112 Sub-biotope (*Hediste diversicolor* and *Scrobicularia plana* in littoral gravelly mud) has the lowest value at 30%.

The low similarity value between communities within the A2.4112 Sub-biotope is not surprising. The two stations that were sampled within the Habitat type were geographically separated between the upper Lerryn Creek and main Fowey channel. Although the main characterising species were present at each of the stations, the environmental conditions in these two discrete areas of the estuary are likely to be very variable. The sediment granulometry was also found to be inconsistent between the two stations. It is well documented that the particle size distribution of the sediment has an effect on the community structure of benthic communities[11]. Variable sediment granulometry is therefore likely to be a contributing factor in the differences observed between the communities in the A2.4112 Sub-biotope.

Conversely, the high community similarity within the A2.3222 communities is likely to be attributable to the close proximity of the samples to each other in the estuary and almost identical sediment composition.

4.3 Sediment Contaminant Analysis

Additional samples were taken at 4 of the 43 stations for contaminant analysis; the location of these stations is shown in 38.

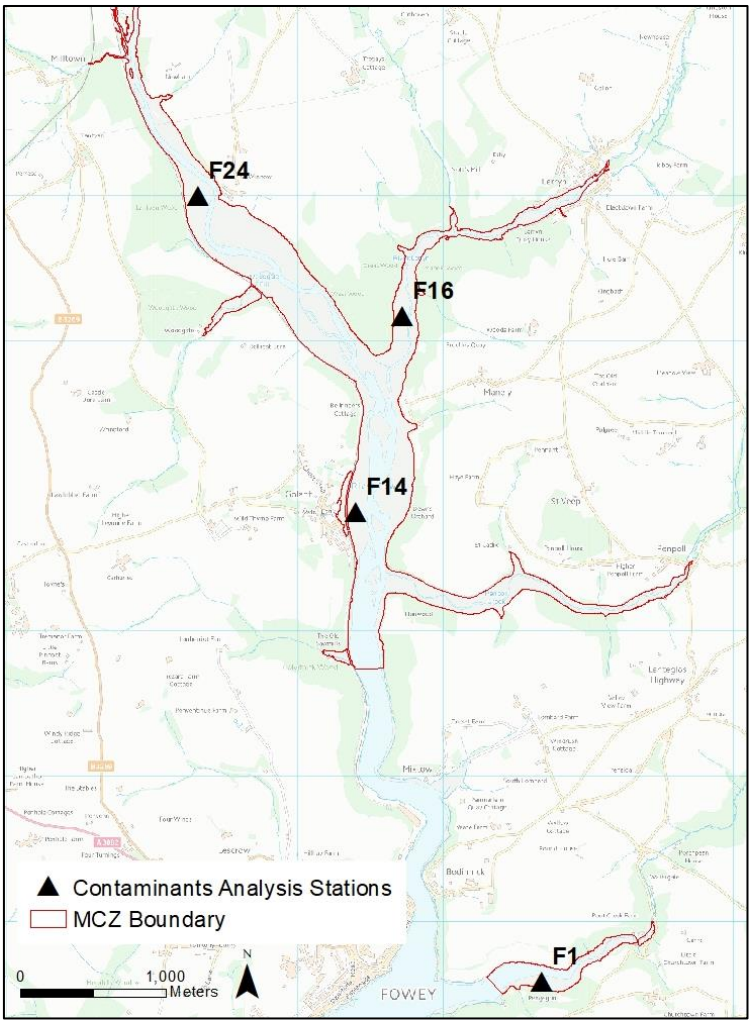

Figure 37. Location of samples collected for sediment contaminant analysis within the Upper Fowey and Pont Pill MCZ.

The results of the analysis are summarised in Table 30. In the absence of quantified Environmental Quality Standards (EQS) for marine sediment quality, three sediment quality guidance criteria have been used here to give context to, and describe the baseline marine sediment quality conditions within the Upper Fowey and Pont Pill MCZ. These guidance thresholds are usually used to assess whether marine ecosystems would be at risk from the likely concentrations of contaminants should they be distributed into the water column during dredging or development projects. The two guidelines used are CEFAS's guideline Action Levels[12] (ALs) for the disposal of dredged material, and the Canadian Sediment Quality Guidelines (CCME)[13] for the protection of aquatic life.

CEFAS's ALs are used as part of a weight of evidence approach to decision making. They are not a pass or fail criteria, but thresholds for consideration. If concentrations are below AL 1, then sediments are usually considered not to pose a risk. If concentrations fall between AL 1 and AL 2 then further assessment is usually required before such sediments can be disturbed or disposed of at sea. If concentrations exceed AL 2 then dredged material, for example, may not be considered suitable for disposal at sea.

The Canadian ISQG Threshold Effect Levels (TELs) and Probable Effect Levels (PELs) are indicators of sediment quality based on biological effects. The ISQG is the concentration that may affect certain sensitive species), whilst the Probable Effect Level (PEL) is the level at which adverse biological effects are likely to occur.

Most significantly in terms of this assessment however are the OSPAR Environment Assessment Criteria (EAC) or Effects Range Low (ERL) thresholds[15]. Similar to the Canadian ISQGs, 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.

Table 30. Results of sediment contaminant analysis within the Upper Fowey and Pont Pill MCZ.

Analyte	Units	Station				CEFAS Action Level 1	CEFAS Action Level 2	CCME Guidelines ISQG Level	CCME Guidelines PEL Level	OSPAR ERL	OSPAR EAC
		F1	F14	F16	F24						
Mercury	mg/kg	0.115	0.074	0.062	0.0794	0.3	3	0.13	0.7	0.15	-
Aluminium, HF Digest		74200	75500	73400	76400	-	-	-	-	-	-
Iron, HF Digest		28700	27400	29100	32000	-	-	-	-	-	-
Arsenic, HF Digest		26.1	35.5	49	62.5	20	100	7.24	41.6	-	-
Cadmium, HF Digest		0.33	0.45	0.38	0.65	0.4	5	0.7	4.2	1.2	-
Chromium, HF Digest		79.2	67.8	69.7	71.4	40	400	52.3	160	-	-
Copper, HF Digest		73.5	103	119	150	40	400	18.7	108	-	-
Lead, HF Digest		55.9	51.4	46.1	62.1**	50	500	30.2	112	47	-
Nickel, HF Digest		31.5	28.8	30.7	31.7	20	200	-	-	-	-
Zinc : HF Digest		169	191	184	233	130	800	124	271	-	-
Hexachlorobenzene	ug/kg	0.1	0.1	0.1	0.1	-	-	-	-	-	-
Hexachlorobutadiene		0.1	0.1	0.1	0.1	-	-	-	-	-	-
Benzo(a)anthracene		947	342**	134	354**	-	-	74.8	693	261	-
Benzo(a)pyrene		609	242	97.9	252	-	-	88.8	763	430	-
Chrysene + Triphenylene		940	325	130	343	-	-	108	846	384	-
Fluoranthene		1820	642**	215	643**	-	-	113	1494	600	-
Indeno(1,2,3-c,d)pyrene		626	237	95.8	243	-	-	-	-	240	-
Naphthalene		48.4	21.3	11.5	18.8	-	-	34.6	391	160	-
Phenanthrene		736	228	65.8	196	-	-	86.7	544	240	-
Hexabromodiphenyl ether {PBDE 153}		0.02	0.02	0.02	0.02	-	-	-	-	-	-
Hexabromodiphenyl ether {PBDE 154}		0.02	0.02	0.02	0.02	-	-	-	-	-	-
Pentabromodiphenyl ether{PBDE 99}		0.05	0.05	0.05	0.05	-	-	-	-	-	-
Pentabromodiphenyl ether {PBDE 100}		0.02	0.02	0.02	0.02	-	-	-	-	-	-
Tetrabromodiphenyl ether {PBDE 47}		0.07	0.07	0.07	0.07	-	-	-	-	-	-
PCB - 028		0.1	0.1	0.1	0.1	-	-	-	-	-	1.7
PCB - 052		0.1	0.1	0.1	0.1	-	-	-	-	-	2.7
PCB - 101		0.2	0.2	0.1	0.2	-	-	-	-	-	3
PCB - 118		0.3	0.2	0.2	0.3	-	-	-	-	-	0.6
PCB - 138		0.2	0.3	0.2	0.3	-	-	-	-	-	7.9
PCB - 153		0.4	0.3	0.2	0.4	-	-	-	-	-	40
PCB - 180		0.2	0.1	0.1	0.3	-	-	-	-	-	12
PCB's - Sum of ICES		1.3	1.1	0.8	1.5	10	-	16	55	16	55
Tributyl Tin		14.9	7.18	5.57	10.1	100	1,000	-	-	-	-

Levels within ISQG and CEFAS Action Level 1

Levels over the ISQG or CEFAS Action Level 1

\- No thresholds available

Levels over the PEL or CEFAS Action Level 2

** Levels exceeding ERL or EAC

The ISQG[13] and /or the UK's CEFAS Action Level 1 limit[12] for arsenic (As), chromium (Cr), copper (Cu), lead (Pb), nickel (Ni) and zinc (Zn) exceeded at all four stations sampled (F1, F14, F16 and F24). At stations F16 and F24 however, the concentrations of As and Cu were found to be elevated above the PEL threshold. Cadmium (Cd) was also slightly elevated above the CEFAS Action Level 1 at stations F14 and F24. Pb also exceeded the OSPAR ERL at station F24.

The ISQGs for a number of Polycyclic Aromatic Hydrocarbons (PAHs) (including benzo(a) anthracene, benzo(a)pyrene, chrysene/triphenylene and fluoranthene) were also exceeded to varying degrees at all stations. The levels of benzo(a) anthracene and fluoranthene were greatest at stations F14 and F24 and consequently the ERL as well as the ISQG at those stations were exceeded. The ISQG for naphthalene was exceeded on at station F1, whilst that for phenanthrene was exceeded at stations F14 and F24. However, at station F1 in Pont Pill Creek levels of benzo(a) anthracene, chrysene/triphenylene, fluoranthene and phenanthrene were such that the PEL was also exceeded.

The marginal ISQG and/or CEFAS action level 1 exceedances in the metalloids (i.e. As) or trace metals concentrations (e.g. Cd, Cr, Pb, Ni and Zn) are likely to be at least partially attributable to the natural geology and soils found in the catchment[14], particularly as levels were similar at all four stations which were distributed throughout the MCZ. However, the higher levels of As and Cu are probably associated with the historically very active Cu and china clay mining within the catchment. Cu was also historically used in antifouling and remain the most common active ingredient in modern antifouling products. The Fowey estuary is navigable from the mouth to seven miles up-stream to Lostwithiel at the upper limit of Tidal Navigation. The estuary continues to provide a deep water commercial harbour for the export of china clay and the handling of other cargoes both for export and import. In addition the harbour provides a safe haven for in excess of 1,550 resident pleasure craft and 7,000 – 8,000 visiting vessels[14].

The reason for the elevated levels of PAHs in Pont Pill Creek is not known. PAHs urban run-off from nearby roads is the most usual contributing factor responsible for elevated levels in PAHs within non-industrialised catchments. However, given the absence of significant road networks in that localised area, it is unlikely that run-off is the source. It is therefore most probable that historical shipping activity and historical industry are the main contributors. Despite its tidal location, the quay became important for trade between farms of this area and other coastal communities. Imports were roadstone, bricks, coal, manure and flour; exports were grain and logs [16].

It is well documented that sediment contamination concentrations are often inversely related to grain size because of the different adsorption potential associated with the surface of clays, silts and organic matter[17]. However, given that both the clay and silt fractions were very similar between stations (Figure 38), the variability in contamination levels that has been observed between stations cannot be explained by the sediment character.

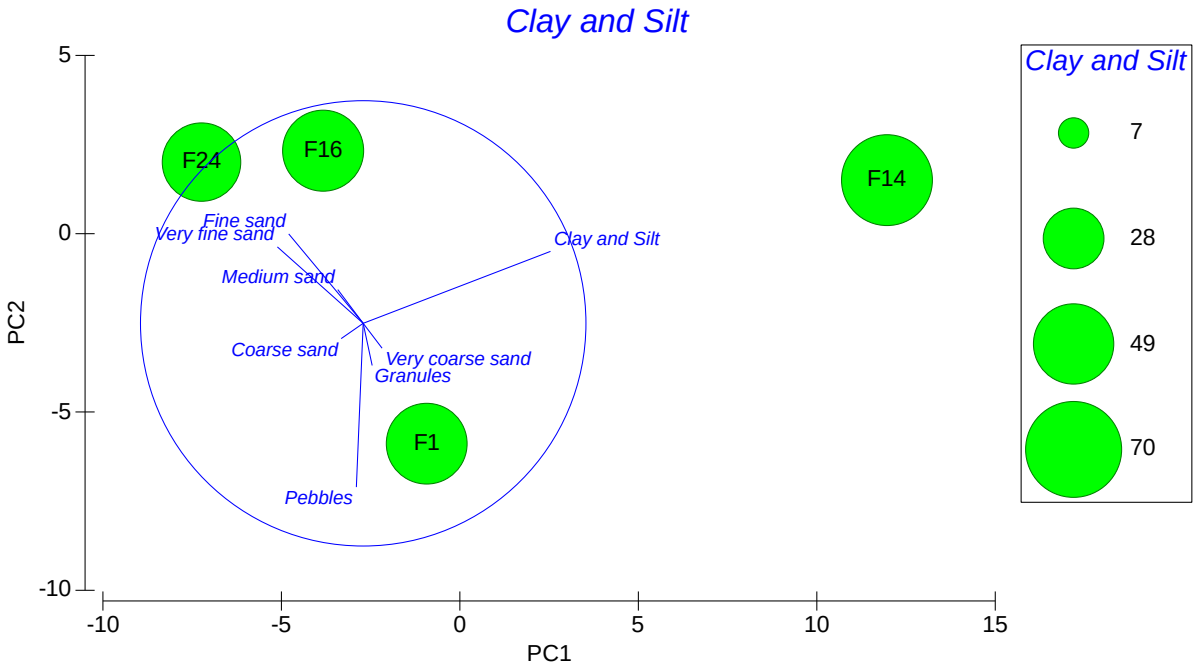

Figure 38. PCA plot of particle size at stations sampled for contaminants within the Upper Fowey and Pont Pill MCZ.

4.4 Habitats/species of conservation importance

The tentacled lagoon worm *Alkmaria romijni* was the only SOCI that was identified within the study area. This species is considered nationally scarce, and as such, are protected under Schedule 5 of the Wildlife and Countryside Act 1981. The abundance and distribution of the species within littoral sediments of the Upper Fowey and Pont Pill MCZ has been represented geographically in Figure 37.

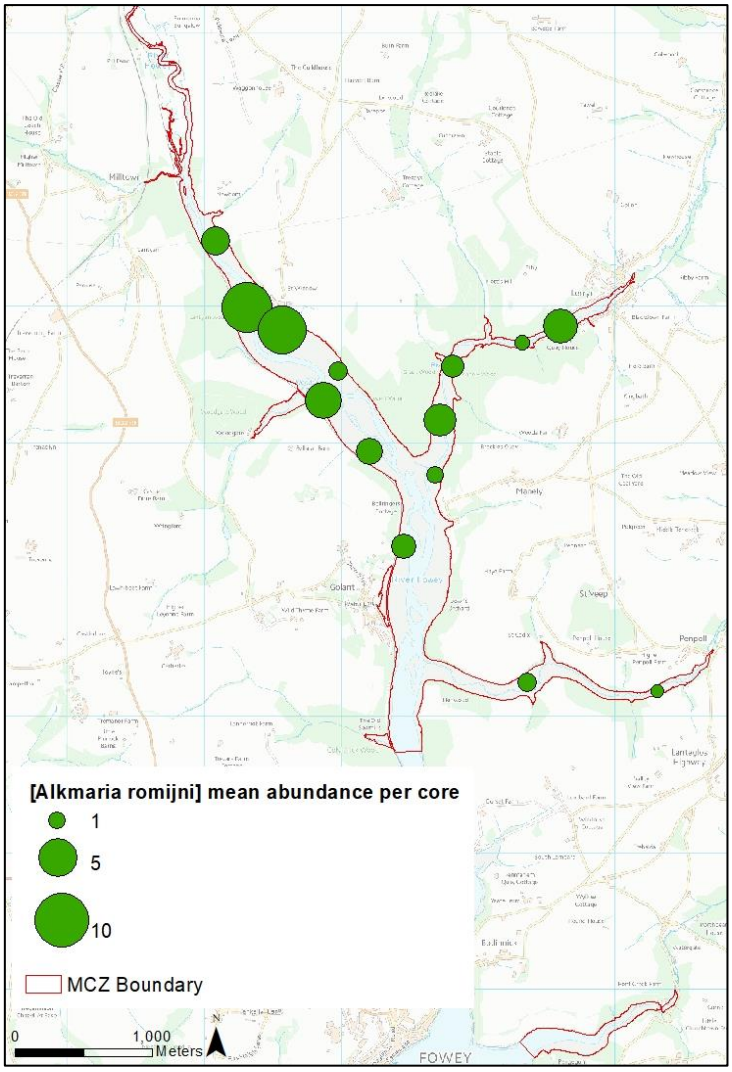

Figure 39. Geographical representation of the abundance and distribution of the SOCI *Alkmaria romijni* with the Upper Fowey and Pont Pill MCZ.

4.5 Invasive Non Native Species

The INNS red algae *Caulacanthus* spp. (Plate 20) was frequently observed in SACFOR abundances ranging from 'rare' to 'abundant' (Figure 40). The Australasian barnacle *Austrominius modestus* was also frequently encountered (although only in 'rare' to 'occasional' abundances) on rock throughout the study area (Figure 41).

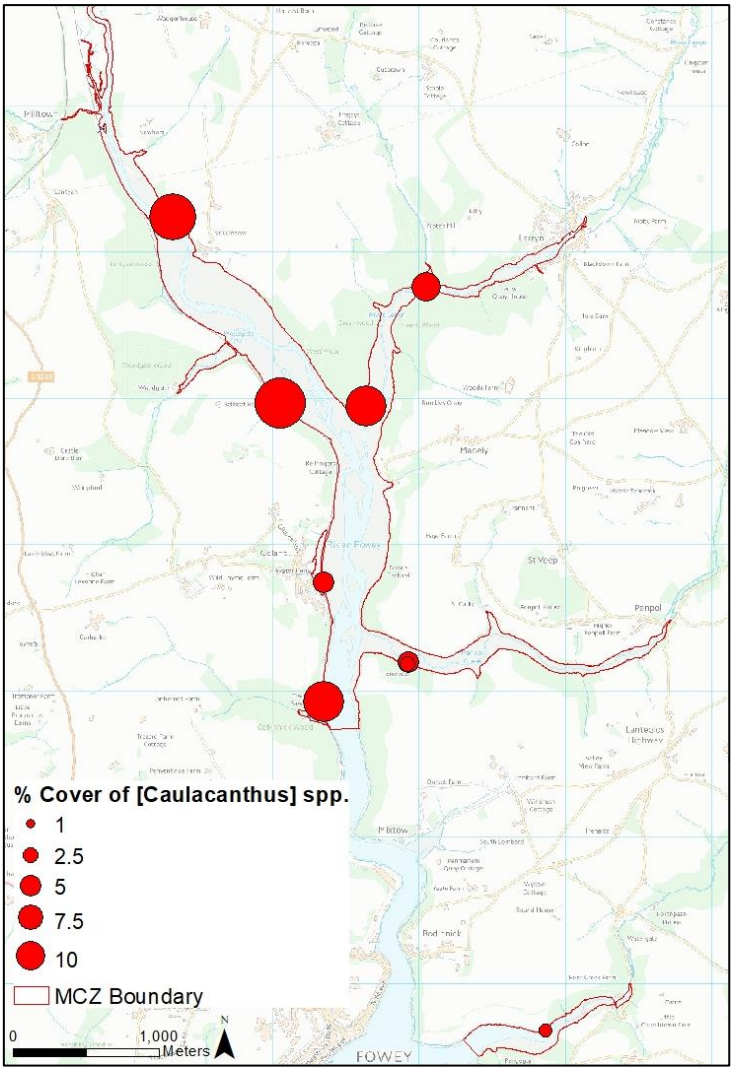

Figure 40. Geographical representation of the abundance and distribution of the INNS *Caulacanthus* spp. within the Upper Fowey and Pont Pill MCZ.

Plate 20. *Caulacanthus* spp. in Pont Pill Creek (within the Upper Fowey and Pont Pill MCZ).

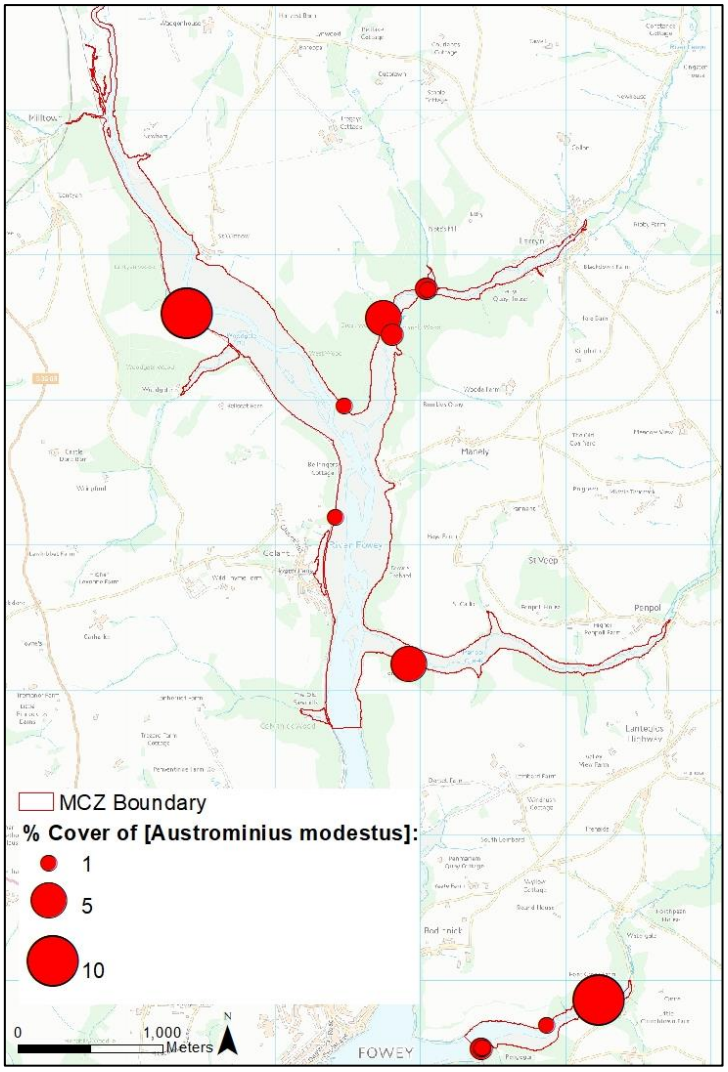

Figure 41. Geographical representation of the abundance and distribution of the INNS *Austrominius modestus* within the Upper Fowey and Pont Pill MCZ.

The Pacific oyster *Magallana gigas* (Plate 21) was also observed within the upper reaches of the Fowey estuary between the southern boundary of the MCZ and Golant in 'common' to 'rare' abundances (Figure 42). Within the Pont Pill individuals of Pacific oyster were found in much higher densities, particularly at the western end where up to 25 individuals per square metre were observed in patches, mostly along the littoral rock/littoral sediment interface. An objective of this study was to determine the percentage of littoral area where the community has been significantly altered by Pacific oyster abundance. For the purposes of this study 'significant alteration of community' has been defined as those areas where the number of individual oysters equate to 'Abundant' according to the SACFOR scale. The total area of littoral rock and littoral sediment mapped within the MCZ in 2018 equates to 23 ha and 132 ha respectively. The total littoral communities considered to be significantly altered was limited to Pont Pill Creek (Figure 37) and the area calculated to be 0.187 ha in total (0.015 ha of littoral sediments and 0.172 ha of interface between littoral rock and littoral sediment that could not practically be separated). The affected area therefore represents less than 1% of the littoral habitats within the MCZ.

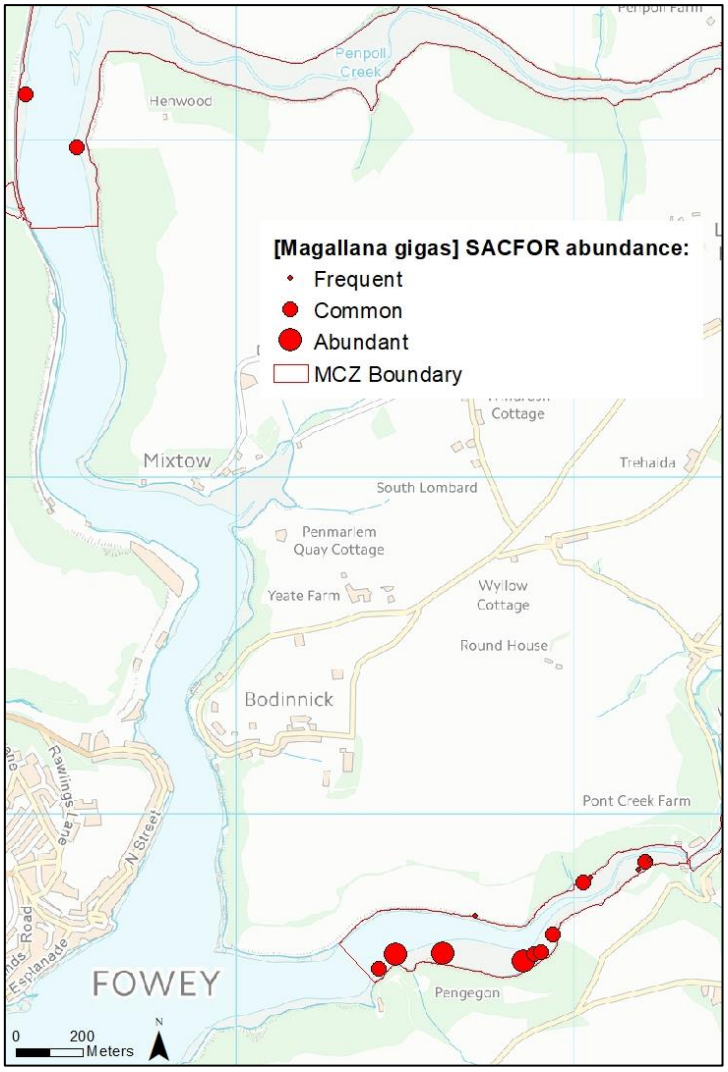

Figure 42. Geographical representation of point data relating to the abundance and distribution of the INNS *Magallana gigas* in the wider Upper Fowey and Pont Pill MCZ.

Plate 21. *Magallana gigas* within the Upper Fowey and Pont Pill MCZ: Pont Pill Creek (left), main Fowey channel near Henwood at rock station R43 (right).

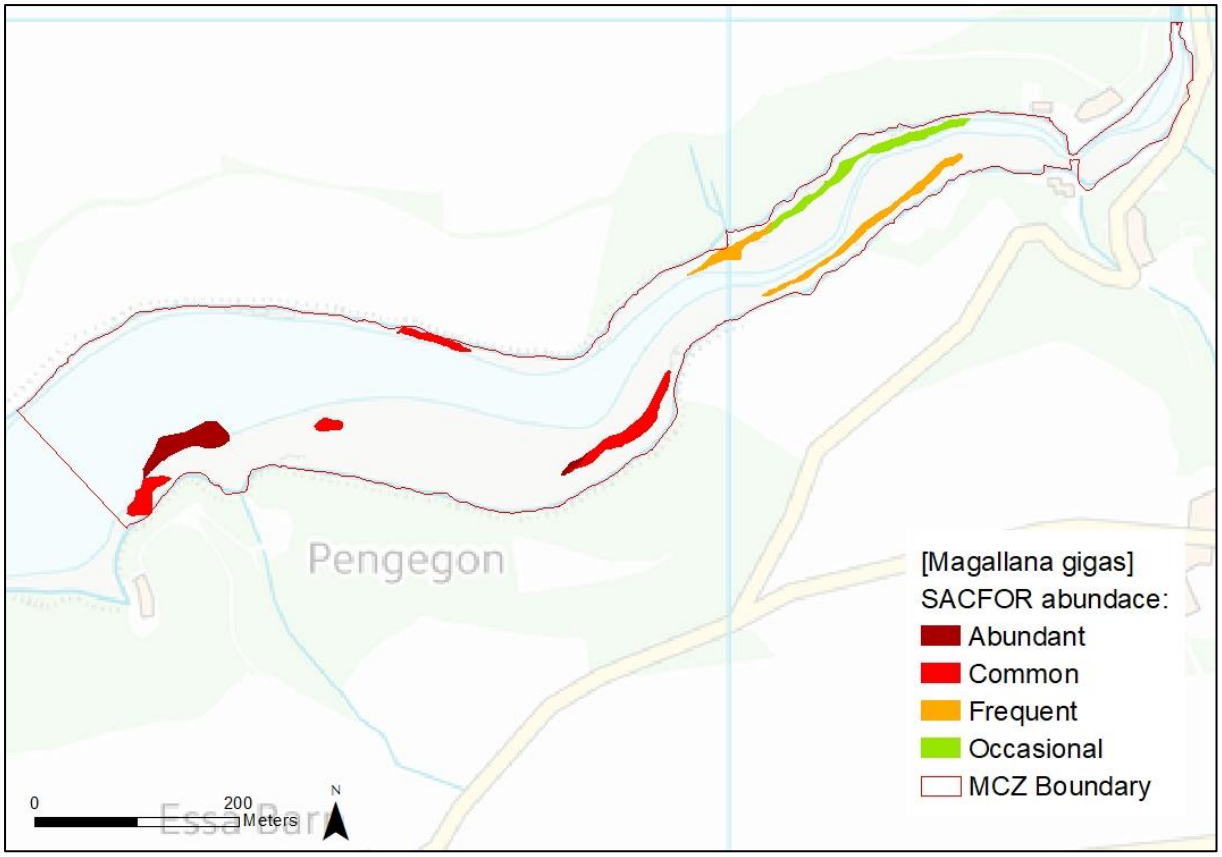

Figure 43. SACFOR abundance of *Magallana gigas* within the Upper Fowey and Pont Pill MCZ. Those areas where the INNS species has been mapped as 'abundant' also represents those communities considered to be 'significantly affected'.

4.6 Anthropogenic activity

A number of types of anthropogenic activity were identified during the course of the Phase I surveys within the MCZ. The types and locations of these observations are mapped in (Figure 44). Most commonly observed and widespread was propeller scarring of the mudflats (Plate 13), but baiting digging (Plate 14) and placement of peeler crab traps was also evident (Plate 15).

Old wooden wrecks were noted sitting on the mud banks on the southern bank of the Pont Pill. The presence of these are likely to represent an enhancement to littoral communities rather than impoverishment however, as the three dimensional structure provides a greater area of intertidal habitat as well as additional niches and habitat complexity for species to colonise.

No activities with the potential to result in a breach of the conservation objectives for any of the habitats or species of conservation importance were identified.

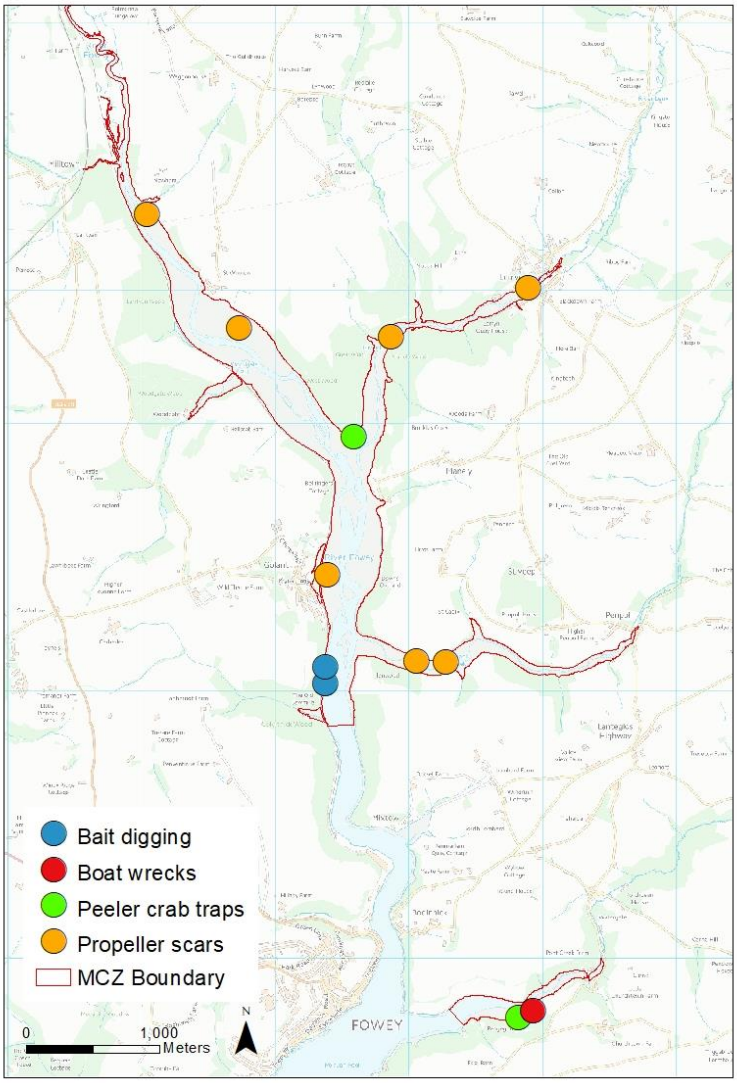

Figure 44. Locations of anthropogenic activities within the Upper Fowey and Pont Pill MCZ.

Plate 13. Propeller scars on mudflats in the upper Lerryn Creek within the Upper Fowey and Pont Pill MCZ.

Plate 14. Evidence of bait digging in the main Fowey estuary adjacent to Golant (within the Upper Fowey and Pont Pill MCZ).

Plate 15. Photograph of peeler crab traps in Pont Pill Creek within the Upper Fowey and Pont Pill MCZ.

4.7 Opportunistic Macroalgae extent and distribution

The extent and distribution of opportunistic algal mats within the Upper Fowey and Pont Pill MCZ have been mapped. The results have been presented in Figure 45. No macroalgae was observed within Pont Pill Creek. In the upper Fowey estuary a number of mats dominated by *Chaetomorpha* spp. were found distributed between Henwood and St Winnow in the main Fowey channel, and in the lower reaches of the Lerryn and Penpoll Creeks. Where present the macroalgae mats were was found to cover more than 15% of the sediment surface.

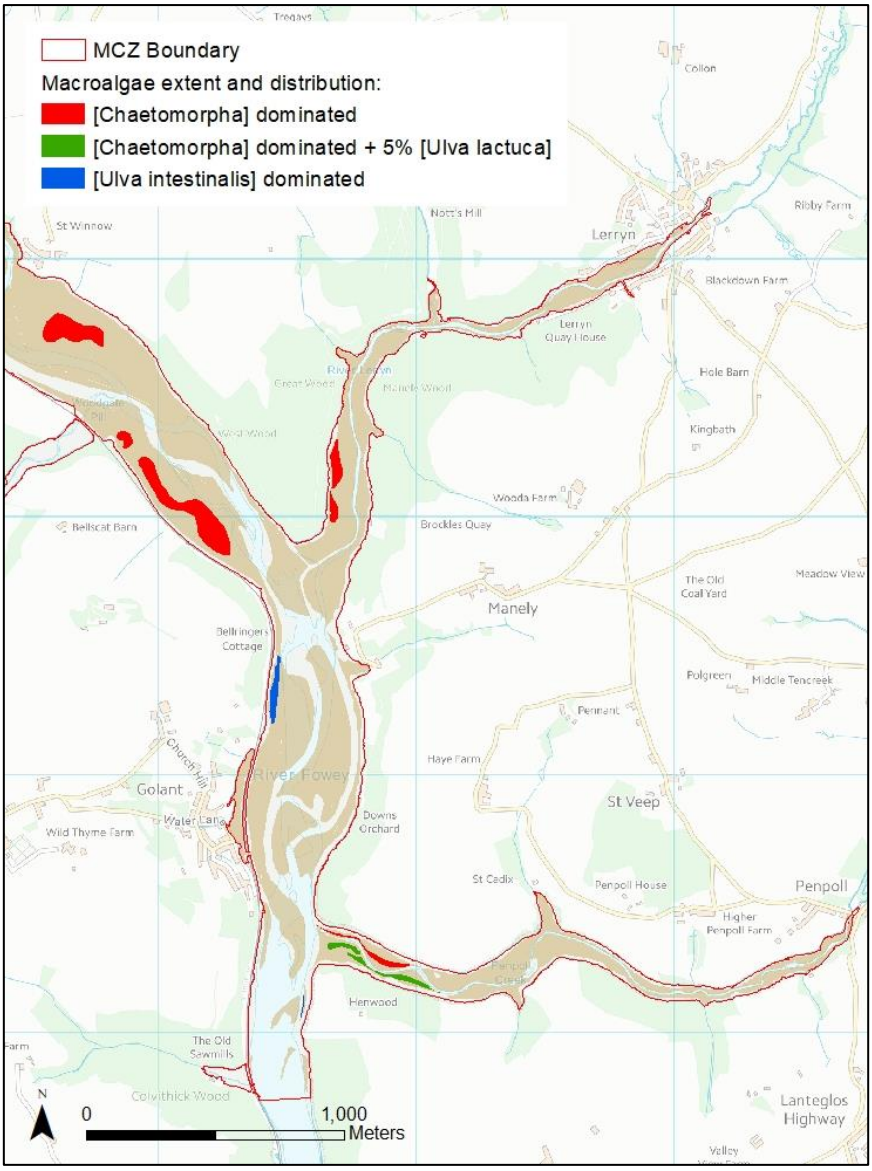

Figure 45. Extent and distribution of macroalgal mats in the Upper Fowey and Pont Pill MCZ.

5. DISCUSSION

5.1 MCZ Preliminary Condition Assessment

Due to a lack of previous relevant studies, the ability to make temporal comparisons of the attributes of the littoral rock and sediment communities in the Upper Fowey and Pont Pill MCZ has been limited. The attributes which have been address (Table 31) have been selected by Natural England as specific objectives of this study.

Table 31. Condition recommendation of attributes that, subject to natural change, contribute to defining the condition of the mudflats and sandflats feature of the Upper Fowey and Pont Pill MCZ.

Feature / Sub-feature	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 suitable baseline data exists with which to compare current results. Consequently it has not been possible to make temporal comparisons of the extent and distribution of the littoral rock communities in the MCZ. The condition of this attribute is therefore **unknown**$^{\Delta}$.
Littoral sediment: Presence and spatial distribution of biological communities	Restore/Maintain the presence and spatial distribution of (subfeature) communities, according to the map.	No suitable baseline data exists with which to compare current results. Consequently it has not been possible to make temporal comparisons of the extent and distribution of the littoral sediment communities in the MCZ. The condition of this attribute is therefore **unknown**$^{\Delta}$.
Structure of littoral rock and littoral sediment habitats: non-native species and pathogens	Reduce the introduction and spread of non-native species and pathogens, and their impacts	Three species of INNS were identified to be present within the MCZ, there were *Caulacanthus* spp., *Magallana gigas* and *Austrominius modestus*. Given that no previous comparable data relating to these species within the MCZ exists, it has not been possible to determine whether their extent and/or distribution has changed temporally. The condition of this attribute is therefore **unknown**$^{\Delta}$.
Structure of littoral rock: 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 littoral rock communities within the MCZ. The condition of this attribute is therefore **unknown**$^{\Delta}$.

$^{\Delta}$ *This study provides the baseline for future condition assessment of these attributes.*

Feature / Sub-feature	Target	Condition Recommendation
Structure of littoral sediment habitats: 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 littoral sediment communities within the MCZ. The condition of this attribute is therefore **unknown**[Δ].
Structure of littoral sediment habitats**:** sediment composition and distribution.	Maintain the existing distribution of sediment composition types across the feature.	No suitable baseline data exists with which to compare current results. Consequently it has not been possible to make temporal comparisons of the sediment composition and distribution within the MCZ. The condition of this attribute is therefore **unknown**[Δ].
Structure of littoral sediment habitats**:** 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 littoral sediments of the MCZ. The condition of this attribute is therefore **unknown**[Δ].
Supporting processes of littoral sediment habitats**:** sediment contaminants.	Reduce surface sediment contaminants (<1cm from the surface) to below the OSPAR Environment Assessment Criteria (EAC) or Effects Range Low (ERL) threshold.	The OSPAR Effects Range Low (ERL) threshold for lead was breached at one station, whilst that for the Polycyclic Aromatic Hydrocarbon (PAH) compounds benzo(a)anthracene and fluoranthene was exceeded at two stations. This condition of this attribute is therefore **unfavourable**.

[Δ] *This study provides the baseline for future condition assessment of these attributes.*

Feature / Sub-feature	Target	Condition Recommendation
Structure of littoral rock habitats: 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.	No comparable baseline data exists. Consequently it has not been possible to make temporal comparisons of zonation patterns in the littoral rock communities within the MCZ. The condition of this attribute is therefore **unknown**[Δ].
Structure of littoral rock habitats: 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.	No comparable baseline data exists. Consequently it has not been possible to make temporal comparisons of zonation patterns in the littoral sediment communities within the MCZ. The condition of this attribute is therefore **unknown**[Δ].

[Δ] *This study provides the baseline for future condition assessment of these attributes.*

5.2 Evaluation of methods

The protocol used in this assessment was tailored to fulfil the aims of the project in the most efficient way possible using standard methods. To achieve this, access was gained using a hovercraft. Since no previous relevant surveys within the study area were available, it has not been possible to assess temporal changes in the littoral rock or littoral sediment communities. It can be said, however, that the distribution and community composition of the habitats observed during this study were typical of an estuarine site of this nature. The output from this study will provide a baseline from which a change in the condition of the attributes can be measured within any future condition assessments.

Although the data collected within the littoral sediment habitats is sufficiently detailed to enable statistical comparison with compatible future data, there are opportunities to enhance future surveys to enable more robust statistical comparisons to be made. This could be achieved by placing more emphasis on the collection of fully quantitative fauna data to increase the number of replicates in some of the habitat types that are less well represented. If any species or habitats are a cause for concern, the sampling effort could be tailored to investigate these further. The statistical robustness of the data and the subsequent power to detect change is largely determined by the number of replicate stations sampled, but is also dependant on factors such as the survey design. The corollary of this is that with low replication the potential for an erroneous indication of temporal change is increased, since a lower sampling effort may not result in the data set being representative of the community structure actually present. It is important to note that increasing the number of fully quantitative sample stations is not the same as increasing the number of replicates at each station as these replicates are pseudo-replicates and only assess sampling variability. For example, the replication within those habitat types that were limited in extent and distribution (e.g. A2.2231, A2.311, A2.3222, A2.4112, A2.4114 and A2.4115) could be increased to at least three (where only two stations were sampled) or preferably 5 stations in each Habitat type.

It should be noted that as long as future surveys re-visit the same sample stations that were used in this study, any directional change over time at the stations should become apparent when using multivariate analysis methods, even in Habitat types in which there was very little replication. Therefore, the limitations brought about by the low replication may be mitigated to some degree by treating stations as sentinel stations.

Depending on the frequency of future surveys, it is proposed that the increase in effort towards fully quantitative faunal sampling could be offset to some degree by reducing the effort spent on Phase I habitat mapping. Rather than providing 100% coverage, future assessments could focus more on verifying the habitat type boundaries delineated in the previous assessment to ensure that there have not been any substantial changes. This is considered a suitable method because unless there are large changes in the natural or anthropogenic factors affecting the MCZ, changes in the distribution of habitats are only likely to be minor in the short term for the majority of habitat types.

5.3 Recommendations for Future Condition Assessment

In order to carry out future condition assessments the results presented here should be used as a baseline from which to compare the attributes and targets outlined in Table 31.

As discussed in Section 5.2, the number of stations within each habitat type should ideally be increased to a minimum of three and preferably five stations where relevant. This would

increase the likelihood that the samples reflect the actual community structure within each habitat type and that factors affecting them would be detected. There are a number of ways that this could be achieved without greatly altering the overall sampling effort and could include a reduction in the emphasis on the Phase 1 habitat mapping as discussed above or potentially by moving some stations from Habitat types with a much greater level of replication (although this would weaken the power to detect change in these habitats).

It is considered that it is essential to re-visit the same sample stations (+/- 10m). Not only will this minimise the potential for an erroneous indication of temporal change as a function of different sampling locations, but this will also, over time, enable any directional changes in communities at stations to be identified if they occur.

In order to eliminate the introduction of variability in estuarine communities as a result of seasonal fluctuations, future sampling for the purposes of condition monitoring should be carried out at the same time of year as this study. Seasonal variability may otherwise indicate temporal changes in communities where none exist.

The distribution, extent and variety of biotopes will be most efficiently compared using GIS software to map and measure the attributes area.

It is recommended that attributes such as redox is determined using a redox meter at each Phase II sediment station. Interstitial salinity should also be measured consistently at each station (interstitial salinity was measured at only a few stations and methods varied e.g. sometimes water in adjacent channels was sampled whilst at other times the salinity at the precise sampling point was measured). This will provide objective data from which more robust conclusions can be drawn.

In any future monitoring particular emphasis should be placed on faunal and floral community structures using a combination of univariate and multivariate statistics. Such an approach is the most effective method of showing any temporal changes caused by natural or anthropogenic factors. By plotting community data from this survey alongside future survey data, temporal trends in community assemblages should become apparent. Any directional changes in these plots could indicate anthropogenic stressors (particularly if the changes are not reflected at other stations within a habitat type) or natural changes caused, for example, by changing weather patterns.

By implementing these recommendations, a comparison of results from future studies will provide a sound foundation from which to base scientifically robust conclusions regarding any temporal changes that may be observed within the MCZ. However, estuarine littoral sediment communities are known to be influenced by the morphological evolution of the estuary and its naturally dynamic nature. As such, the gross distribution of habitats and species can be expected to change over time naturally at least to some extent. Therefore, depending upon the specific aims of any future monitoring, it may be necessary to discern whether any changes observed (e.g. loss in extent of a particular Habitat type) are attributable to anthropogenic factors as opposed to natural factors. If it is not possible to derive the information to make such distinctions from the data available, then further work outside the remit of the initial condition monitoring may be necessary.

6. REFERENCES

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

[2] Davies, J., Baxter, J., Bradley, M., Conner, D., Khan, J., Murray, E., Sanderson, W., Turnbull, C. & Vincent, M., (2001), Marine Monitoring Handbook, 40 pp, ISBN 1 85716 550 0 [online]. URL: http://jncc.defra.gov.uk/page-2240 [Accessed January 2019].

[3] European Environment Agency. EUNIS Habitat types [Online]. Available: http://eunis.eea.europa.eu/habitats.jsp [Accessed 1 June 2018]

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

[5] JNCC (2004). Common Standards Monitoring Guidance for Littoral Rock and Inshore Sublittoral Rock Habitats (Reefs). Version August 2004, Updated from (February 2004). JNCC. ISSN 1743-8160 [Online]. URL: http://jncc.defra.gov.uk/page-2236 [Accessed January 2019]

[6] JNCC (2004). Common Standards Monitoring Guidance for Littoral Sediment Habitats. Version August 2004, Updated from (February 2004). JNCC. ISSN 1743-8160 (online) URL: http://jncc.defra.gov.uk/PDF/CSM_marine_littoral_sediment.pdf [Accessed October 2018].

[7] Carriker, M. R. (1967). Ecology of estuarine benthic invertebrates, a perspective. In: Lauff, G. H. (ed.) Estuaries. American Association for the Advancement of Science, Washington D.C., p. 442-487.

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

[9] Wentworth, C.K. (1929). Method of computing mechanical composition types in sediment. Geol. Soc. America Bull., 40, 771-790.

[10] Worsfold, T., (2003). Introduction to Oligochaetes. Report to the NMBAQC 2003 taxonomic workshop participants - Dove Marine Laboratory. Unicomarine Report NMBAQC olig03, 22pp, November 2003.

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

[12] Cefas (1994). Guideline Action Levels for the disposal of dredged materials at sea.[Online] .Available: www.pla.co.uk/display_fixedpage.cfm/id/2467/site/environment [Accessed Jan 2019]

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

[14] Fowey Harbour Commissioners (n.d) An aerial trip through the Fowey Estuary [Online] URL: https://www.foweyharbour.co.uk/assets/file/pdfs/Downloads/aerial%20views%20of%20estuary.pdf [Accessed Jan 2019]

[15] OSPAR (2010) Agreement on CEMP Assessment Criteria for the QSR 2010 Agreement number: 2009-2 [Online] URL: https://qsr2010.ospar.org/media/assessments/p00390_supplements/09-02e_Agreement_CEMP_Assessment_Criteria.pdf [Accessed January 2019]

[16] Fowey Harbour Heritage Society (n.d) Pont Pill. [Online] URL: http://foweyharbourheritage.org.uk/heritage/places/pont-pill/ [Accessed Jan 2019]

[17] Klamer, J., Hegeman, W. and Smedes, M. (1990). Comparison of grain size correction procedures for organic micropollutants and heavy metals in marine sediments. Hydrobiologia 208, 213-20.

7. GLOSSARY

Abundance	Total number of all animals (individuals) in a sample
Biotope	EUNIS Level 5 habitat
Bray-Curtis similarity	Statistic that compares the similarity of the community structure between samples
BSH	Broad scale habitat
CCME	Canadian Council of Ministers of the Environment
Community	A collection of fauna (or flora) cohabiting in and characteristic of an area of the environment
Community analysis	Statistical technique used to identify areas with a similar biological community
Diversity	The range of animals (taxa) in a sample
FOCI	Feature of Conservation Importance
Habitat type	Collective term for all EUNIS levels of habitat
HOCI	Habitat of Conservation Importance
Infauna	Animals that live within the sediment
MDS	Multi-Dimensional Scaling, a statistical manipulation used to identify groups of distinct fauna (communities).
Multivariate Statistics	Statistics which can be applied to a complete taxa abundance data matrix without any loss of information i.e. not requiring reduction of the data to a single number or index
Margalef's species richness	A measure of the variety of species present.
Pielou's evenness	A measure of how evenly the total number of individuals is distributed between the species present

Shannon Wiener diversity index	An index (single number) of fauna diversity, increases with fauna diversity
Simpson's diversity index	An index of fauna diversity, increases with fauna diversity
SOCI	Species of Conservation Importance
STW	Sewage Treatment Works
Sub-biotope	EUNIS Level 6 habitat
Taxon	A grouping of the fauna, may be a species or, if different species are indistinguishable, it may be based on a higher taxonomic group such as the genus, family or phylum
Univariate	Statistics that describe the fauna in terms of a single number
Wentworth scale	Recognised 12 band scale of sediment particle size
A1.1131	*Semibalanus balanoides*, *Patella vulgata* and *Littorina* spp. on exposed to moderately exposed or vertical sheltered eulittoral rock
A1.221	*Mytilus edulis* and *Fucus vesiculosus* on moderately exposed mid eulittoral rock
A1.321	*Pelvetia canaliculata* on sheltered variable salinity littoral fringe rock
A1.323	*Fucus vesiculosus* and barnacle mosaics on moderately exposed mid eulittoral rock
A1.324	*Ascophyllum nodosum* and *Fucus vesiculosus* on variable salinity mid eulittoral rock
A1.326	*Fucus serratus* and large *Mytilus edulis* on variable salinity lower eulittoral rock
A1.327	*Fucus ceranoides* on reduced salinity eulittoral rock
A2.221	Barren littoral coarse sand
A2.2231	*Scolelepis* spp. in littoral mobile sand
A2.231	*Polychaetes* in littoral fine sand
A2.311	*Nephtys hombergii*, *Limecola balthica* and *Streblospio shrubsolii* in littoral sandy mud
A2.313	*Hediste diversicolor*, *Limecola balthica* and *Scrobicularia plana* in littoral sandy mud

A2.321	*Nephtys hombergii* and *Streblospio shrubsolii* in littoral mud
A2.3222	*Hediste diversicolor* and *Corophium volutator* in littoral mud
A2.325	Saltmarsh creeks
A2.4112	Hediste diversicolor and *Scrobicularia plana* in littoral gravelly mud
A2.4114	*Hediste diversicolor*, cirratulids and *Tubificoides* spp. in littoral gravelly sandy mud
A2.4115	*Hediste diversicolor* and *Corophium volutator* in littoral gravelly sandy mud
A2.421	Cirratulids and *Cerastoderma edule* in littoral mixed sediment

APPENDIX I

Littoral Rock Phase II Quadrat Coordinates (OSGB 1936 BUG) and zone widths:

East	North	Station	Habitat types (upper to lower shore)							
			Zone 1	Width (m)	Zone 2	Width (m)	Zone 3	Width (m)	Zone 4	Width (m)
213706	51698	r1	A1.321	0.5	A1.323	0.6	A1.324	1	A1.324 - A1.113 - A1.324	2
213422	51540	r2a	A1.321	0.5	A1.323	0.5	A1.324	0.7	A1.324	0.7
213537	51573	r2b	A1.321	0.1	A1.323	0.5	A1.324		A1.324	4
214168	51896	r3a	A1.323	0.25	A1.324	4	A1.327		A1.327	6
214231	51862	r3b	A1.321	0.2	A1.323	1	A1.324		A1.324	2.5
214114	51774	r4a	A1.323	3	A1.324	5				
213988	51710	r4b	A1.321	0.1	A1.323	0.2	A1.324		A1.324	4 - 6
213902	51591	r5	A1.323	0.5	A1.324	20 - 25				
212366	53890	r6	A1.321	0.3	A1.324	5				
212374	54078	r7	A1.321	0.25	A1.324	10	A1.326		A1.326	10
212360	54730	r8	A1.321	1	A1.324	4				
212429	55186	r9	A1.324	1						
212447	55620	r10	A1.321	0.5	A1.324	5.5				
212051	55977	r11	A1.321	0.25	A1.323	0.5	A1.324		A1.324	2
211821	56310	r12	A1.323	3						
211256	56865	r13	A1.323	5	A1.324	3				
211223	57094	r14	A1.323	3	A1.324	2.5				
210950	57549	r15	A1.327	1.5						
210903	58206	r16	A1.327	7						
210910	57747	r17	A1.327	2 to 4						
211304	57237	r18	A1.323	0.6	A1.324	8				
211722	56834	r19	A1.323	6						
212051	56494	r20	A1.321	0.1	A1.323	1.5	A1.324		A1.324	1 - 4
212391	56049	r21	A1.321	0.6	A1.323	0.7	A1.324		A1.324	3
212634	55932	r22	A1.321	0.6	A1.323	2 - 3	A1.324		A1.324	6
212688	56314	r23	A1.323	5	A1.324	2 - 3				
212747	56568	r24	A1.323	0.6	A1.324	0.75 - 1				
213304	56751	r25	A1.323	0.4	A1.327	2.5				
213713	56960	r26	A1.327	0.75						
214004	57103	r27	A1.327	2.5						
213603	56823	r28	A1.327	2 - 3						
213051	56780	r29	A1.323	0.75	A1.324	0.7	A1.327		A1.327	0.25
212808	56424	r30	A1.323	2.5	A1.324	3 - 5				
212686	55632	r31	A1.323	2.5	A1.324	4				
212795	55217	r32	A1.324	5						
212624	54646	r33	A1.323	0.4	A1.324	4 - 6				
212894	54323	r34	A1.323	3	A1.324	3				
213366	54320	r35	A1.324	3.5						
213922	54193	r36	A1.323	0.5	A1.324	2 - 4				
214304	54209	r37	A1.327	5						
214681	54424	r38	A1.327	0.5						
214239	54153	r39	A1.327	4.5						
213803	54219	r40	A1.323	0.75	A1.324	0 - 3				
213403	54171	r41	A1.324	2 - 5						
212910	54206	r42	A1.323	0 - 0.5	A1.324	2 - 10				
212551	53983	r43	A1.324	15						
213184	56736	r44	A1.323	0.2	A1.327	5				

APPENDIX II

Littoral Sediment Phase II Sample Station Coordinates (OSGB 1936 BUG):

Habitat Type	Station	East	North
A2.2231	F28	212521	54094
	F29	212534	54420
	F30	212585	54692
A2.231	F11	212693	54915
	F31	212496	54831
	F32	212660	55146
	F33	212547	55249
	F36	212521	55770
	F37	212170	56234
A2.311	F14	212406	54816
	F15	212457	55238
	F27	212571	53872
A2.313	F8	213361	54242
	F9	213760	54267
	F10	214312	54184
	F17	212817	56556
	F18	213325	56730
	F19	213607	56849
	F20	212206	55933
	F21	211873	56309
	F22	211976	56521
	F23	211571	56826
	F24	211313	56986
	F25	211087	57477
A2.321	F1	213683	51576
	F2	214052	51771
	F5	212364	53877
	F7	212746	54310
	F12	212775	55254
	F13	212691	55762
	F16	212726	56160
A2.3222	F34	210896	58209
	F35	210831	58595
A2.4112	F38	211374	56989
	F41	214015	57112
A2.4114	F42	213489	51589
	F43	213961	51705
A2.4115	F39	210850	57852
	F40	210848	58051