Thurrock Flexible Generation Plant

Environmental Statement Volume 6
Appendix 17.4: Third Party Survey Reports

Date: November 2019

Environmental Impact Assessment

Environmental Statement

Volume 6

Appendix 17.4

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Table of Contents

Summary

This appendix presents third-party ecological survey reports that have informed the assessment in Volume 3, Chapter 17: Marine Environment.

1. APEM (2018) Tilbury Energy Centre Subtidal and Intertidal Fish Survey Report. Preliminary Environmental Information Report: Appendix 10.7. APEM Scientific Report P00001435 WP4-5 prepared for RWE Generation UK.

Tilbury Energy Centre Marine Ecology Surveys

Preliminary Environmental Information Report: Appendix 10.7

APEM Subtidal and Intertidal Fish Survey Report

RWE Generation UK

APEM Ref P00001435: WP4-5

December 2018

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Client: **RWE Generation UK**

Project reference: **P00001435: WP4/5**

Date of issue: **December 2018**

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Revision and Amendment Register

Version Number	Date	Section(s)	Page(s)	Summary of Changes	Approved by
1.0	16/11/2018	All	All	Document creation	DH
2.0	20/12/2018	2.5.1.4, 2.5.3	8, 11, 14	RWE comment changes	MH

Contents

List of Figures

List of Tables

Executive Summary

APEM Ltd was commissioned to undertake a series of marine ecology surveys to inform an Ecological Impact Assessment for the proposed Tilbury Energy Centre (TEC) on behalf of RWE Generation UK. This report presents data from the four seasonal subtidal and intertidal fish surveys conducted as part of the overall programme (May 2017 (spring), August 2017 (summer), October 2017 (autumn) and February 2018 (winter)). The objective of the agreed survey programme was to characterise the assemblages of fish present in the subtidal and intertidal zone within the survey area based on quarterly sampling.

Subtidal sampling was conducted using a beam trawl, an otter trawl and a pelagic trawl. Two stations (500 m length transects), were surveyed in the Thames Estuary channel, with five replicate tows at each using each gear type (total of 10 x 500 m replicate trawls per gear type per survey). These transects were consistent with those sampled previously at Tilbury Power Station for a previous proposed biomass power station to facilitate comparison of data with previous surveys at the site (RWE nPower 2012, unpublished data).

Intertidal sampling was undertaken using fyke, seine and push nets. Three stations were selected for seine netting (two on the north bank near the current Tilbury power station and one on the south bank). A further five stations were targeted for push netting, three on the north bank and two on the south bank (each push net transect was 100 m in length). The original design for the fyke net sampling targeted four stations located on the north shore of the Thames in the vicinity of a proposed cooling water intake location (F1-4). These fyke nets were set to sample at a range of shore heights (lower shore, mid shore and upper shore) as agreed through consultation with the Environment Agency (EA). Additional fyke net locations (F5-F8) were added in November and December to the east of the jetty due to the consideration of additional options for intake structure locations.

Raw catch data were converted to Catch Per Unit Effort (CPUE) for all gears except the seine net catch due to the small area sampled. Multivariate data analysis was carried out on the subtidal and intertidal fish data to investigate differences in fish assemblages across sample sites and surveys.

Across all subtidal survey gear types 18,036 fish representing 34 species were caught. The most abundant species was the sand goby complex (sand goby and Lozano's goby) with 13,099 individuals caught. The highest catches of sand goby complex were in the August and October surveys. European smelt was the second most abundant species with 1,465 individuals caught across all subtidal gear types. A total of 24 invertebrate taxa were caught in the subtidal trawl samples, with highest numbers of taxa and individuals recorded during the August survey. The brown shrimp *Crangon crangon* was the most abundant invertebrate taxon for all four subtidal surveys.

Across all intertidal survey methods 1,364 fish representing 13 species were recorded. There was considerable variation in the abundance of fish caught by gear and by season with fyke nets sampling the greatest number of species, and the highest number of fish was caught via push netting. The fish species recorded in highest numbers during the intertidal

surveys were common goby and European seabass. Common goby were primarily caught in the push nets and were caught in greatest numbers in August and October. European seabass were mainly caught in fyke nets and were caught in greatest abundance during the October and February surveys. European seabass was the dominant species in seine net catches in May and February, with common goby the most abundant species in seine net samples in August and October. Other species with over 50 individuals recorded were European smelt, European flounder and sand goby. A total of ten invertebrate taxa were recorded across all intertidal fish surveys and invertebrate catches were generally low. The shore crab *Carcinus maenas*, was the most abundant invertebrate species captured intertidally, followed by the brown shrimp *Crangon crangon*.

The species captured are characteristic of previous studies conducted within the Thames Estuary by the Environment Agency and RWE, as well as historic impingement monitoring at the site of the Tilbury B Power Station (Jacobs, 2012). Species captured include a range of protected and commercially important fish species, including European eel, European smelt, river lamprey, European seabass, Dover sole and Atlantic herring. The highest number of species caught was during the October 2017 survey, where 26 species were captured in the subtidal trawls, followed by the May 2017 survey with 21 species captured in the subtidal trawls. A larger number of species present within the estuary during these months may be indicative of periods of overlap between species which seasonally migrate into or out of the estuary for the summer or winter, as well as the presence of larger juveniles as they grow and mature in the Thames Estuary nursery ground after spawning.

1. Introduction

1.1 Project background

APEM Ltd was commissioned to undertake a series of marine ecology surveys to inform an Environmental Impact Assessment for the proposed Tilbury Energy Centre (TEC) on behalf of RWE Generation UK. The overall survey programme provides site-specific data for plankton (phyto-, zoo- and ichthyo-), fish (intertidal and subtidal), benthos (intertidal and subtidal), saltmarsh, sediment chemistry and water chemistry.

This report presents data from the four seasonal subtidal and intertidal fish surveys conducted as part of the overall programme (May 2017 (spring), August 2017 (summer), October 2017 (autumn) and February 2018 (winter)). An extra four fyke netting stations were also added in November/December due to consideration of additional intake location options.

1.2 Survey Objectives

The objective of the agreed survey programme was to characterise the assemblages of fish present in the subtidal and intertidal zone within the survey area based on quarterly sampling between May 2017 and February 2018. Samples were collected using a best practice multi-method approach to characterise the range of species and life stages utilising different parts of the water column (WFD-UKTAG 2014). Subtidal fish were sampled via beam, otter and pelagic trawling, while fish in intertidal areas were sampled using fyke, seine and push netting.

2. Methodology

2.1 Survey permissions

A Temporary River Works Licence (TRWL) was issued by the Port of London Authority (PLA; reference A2/40/116) and the PLA also granted permission to use their jetty at Gravesend. A dispensation letter for the surveys was provided by the Kent and Essex Inshore Fisheries and Conservation Authority (KEIFCA). Authorisation was obtained from the Environment Agency (EA) to use the intertidal and subtidal fishing gears under Section 27A of the Salmon and Freshwater Fisheries Act 1975.

Access for the intertidal surveys was through the existing power station at Tilbury and permission to access the foreshore was granted by RWE Generation UK.

2.2 Survey timings

Sampling commenced in May 2017 and was conducted quarterly until February 2018. The dates of surveys and times and heights of high and low water are provided in Table 1. Fyke stations 5 & 6 only were sampled in November, and only Fyke stations 7 & 8 were sampled in December (see Section 2.4.2).

Table 1: Dates and tidal information for subtidal and intertidal fish surveys. BST = British Summer Time.

<table>
<tr><th rowspan="2">Month</th><th rowspan="2">Survey Type</th><th rowspan="2">Date</th><th colspan="2">Low Tide</th><th colspan="2">High Tide</th></tr>
<tr><th>Time (BST</th><th>Height (m)</th><th>Time (BST)</th><th>Height (m)</th></tr>
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<tr><td>04/05/2017</td><td>14:11</td><td>1.5</td><td>08:12</td><td>5.9</td></tr>
<tr><td rowspan="3">Intertidal
(fyke stations 1 to 4)</td><td rowspan="2">10/05/2017</td><td>07:49</td><td>0.6</td><td>13:54</td><td>6.3</td></tr>
<tr><td>20:14</td><td>0.8</td><td>-</td><td>-</td></tr>
<tr><td>11/05/2017</td><td>08:21</td><td>0.6</td><td>14:26</td><td>6.4</td></tr>
<tr><td rowspan="5">August 2017</td><td rowspan="2">Subtidal</td><td>31/07/2017</td><td>13:04</td><td>1.4</td><td>07:24</td><td>5.7</td></tr>
<tr><td>01/08/2017</td><td>13:58</td><td>1.6</td><td>08:14</td><td>5.5</td></tr>
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(fyke stations 1 to 4)</td><td>07/08/2017</td><td>07:49</td><td>1.0</td><td>13:55</td><td>6.2</td></tr>
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<tr><td>21:01</td><td>0.8</td><td>-</td><td>-</td></tr>
<tr><td rowspan="6">October 2017</td><td rowspan="3">Subtidal</td><td>23/10/2017</td><td>09:59</td><td>0.8</td><td>15:54</td><td>6.5</td></tr>
<tr><td>24/10/2017</td><td>10:22</td><td>1.0</td><td>16:28</td><td>6.3</td></tr>
<tr><td>25/10/2017</td><td>10:45</td><td>1.1</td><td>17:01</td><td>6.0</td></tr>
<tr><td rowspan="3">Intertidal
(fyke stations 1 to 4)</td><td>17/10/2017</td><td>06:01</td><td>1.1</td><td>12:09</td><td>6.1</td></tr>
<tr><td rowspan="2">18/10/2017</td><td>06:54</td><td>0.9</td><td>12:57</td><td>6.3</td></tr>
<tr><td>19:35</td><td>0.5</td><td>-</td><td>-</td></tr>
<tr><td rowspan="2">November 2017</td><td rowspan="2">Intertidal
(fyke stations 5 & 6)</td><td rowspan="2">07/11/2017</td><td>10:06</td><td>0.5</td><td>15:53</td><td>6.9</td></tr>
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<tr><td>December 2017</td><td>Intertidal
(fyke stations 7 & 8)</td><td>05/12/2017</td><td>09:10</td><td>0.5</td><td>14:53</td><td>7.0</td></tr>
<tr><td rowspan="7">February 2018</td><td rowspan="2">Subtidal</td><td>19/02/2017</td><td>10:28</td><td>0.5</td><td>16:24</td><td>6.4</td></tr>
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<tr><td rowspan="2">02/02/2018</td><td>09:45</td><td>0.2</td><td>15:23</td><td>6.9</td></tr>
<tr><td>21:51</td><td>0.5</td><td>-</td><td>-</td></tr>
</table>

2.3 Survey vessel

The subtidal fish surveys were conducted using the survey vessel INA K (Figure 1). INA K is a 16.7 m ex-fishing vessel built in 1961 which is now used as a fisheries research and survey vessel operating out of Hole Haven Marina at Canvey Island. Daily survey operations mobilised from the PLA jetty at Denton Wharf on the South Bank of the Thames at Gravesend, opposite Tilbury Power Station.

Figure 1: The survey vessel INA K used during the subtidal fish trawl surveys. Photograph © Charlie McNeilly.

2.4 Survey Design

The overall survey design was separated into subtidal and intertidal elements, with three sampling gears selected for each component (Figure 2).

2.4.1 Subtidal survey

Sampling was conducted using a beam trawl, an otter trawl and a pelagic trawl. Two stations (transects 500 m in length), were surveyed along the Thames channel (Figure 2), with five replicate tows at each using each gear type (total of 10 x 500 m replicate trawls per gear type per survey). Thermal modelling indicated potential temperature changes along the north bank of the Thames estuary and the northern transect was located within the zone of a potential >2ºC increase above background temperature levels with an operating power station (based on 98th percentile temperature rise at the water surface, average surface loss, average river flow).. The southern transect was located just outside the boundary of this zone. These transects were consistent with those sampled previously at Tilbury Power Station for a previous proposed biomass power station (RWE nPower 2012, unpublished data) to facilitate comparison of data with previous surveys at the site.

2.4.2 Intertidal survey

Intertidal sampling was undertaken using fyke, seine and push nets. Three stations were selected for seine netting (two on the north bank near the current Tilbury power station and one on the south bank), (Figure 2). A further five stations were targeted for push netting, with three on the north bank and two on the south bank (each push net transect was 100 m in length), (Figure 2). The original design for the fyke net sampling targeted four station locations on the north shore of the Thames in the vicinity of a proposed cooling water intake location (F1-4). These fyke nets were set to sample at a range of shore heights (lower shore, mid shore and upper shore) as agreed following consultation with the Environment Agency (EA). Additional fyke net locations (F5-F8) were added in November and December to the east of the jetty due to the consideration of additional options for intake structure locations (Figure 2). All station coordinates are provided in Appendix 1.

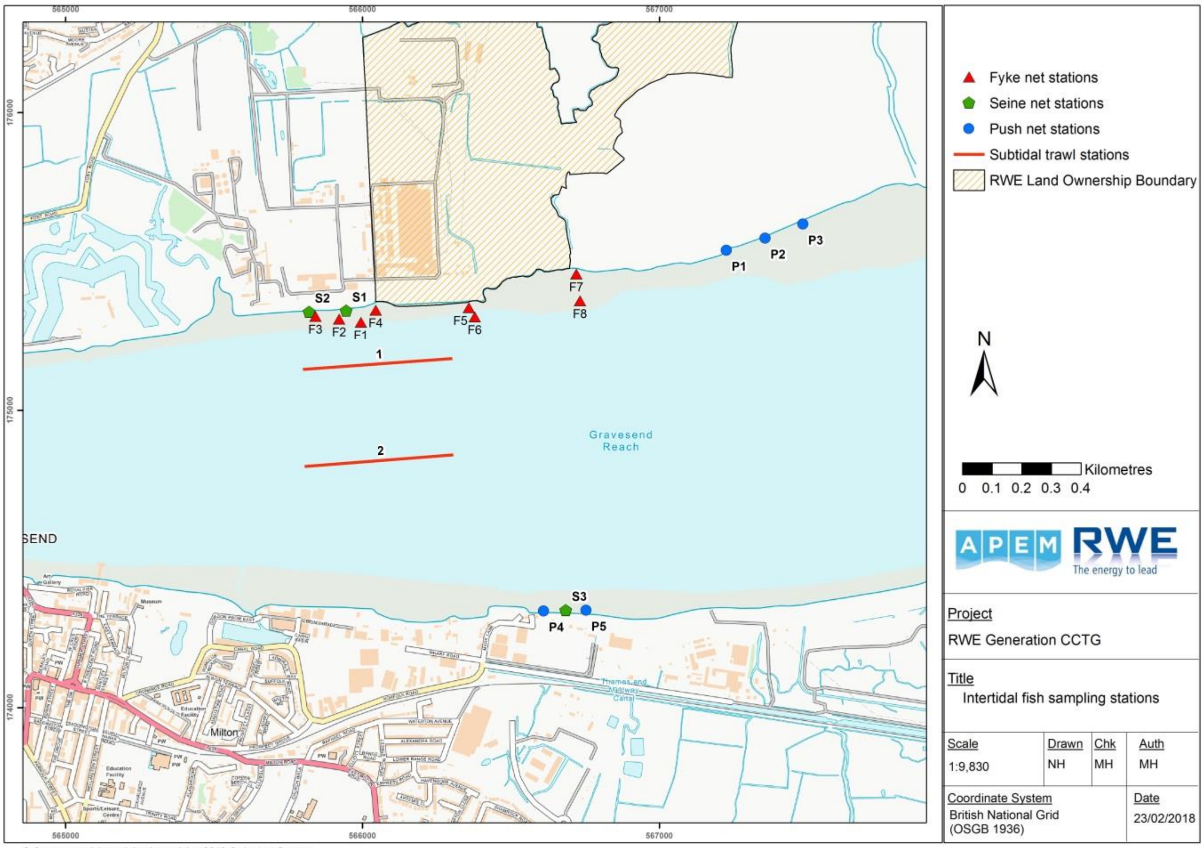

Figure 2: Intertidal (fyke, seine and push net) and subtidal (beam, otter and pelagic trawls) fish survey locations.

2.5 Survey methodology

2.5.1 Subtidal survey

Methods employed for surveys were compliant with the transitional (estuarine) fish Water Framework Directive (WFD) sampling methodology (WFD-UKTAG 2014).

2.5.1.1 *Beam trawling*

The beam trawl was a 1.5 m wide beam frame with a 22 mm mesh nylon body and a 5 mm sq. mesh (knot to knot) liner in the cod-end to allow sampling of small size classes. The belly of the trawl was covered with a chafer net for protection and the trawl was fitted with a 6 mm chain footrope with rubber discs and a single tickle chain to optimise fishing efficiency. Beam trawls are lightweight with a fixed entrance which makes them particularly suitable for sampling the small benthic fish assemblage e.g. juvenile flatfish. Trawl speeds ranged from 0.3 to 2.2 knots, depending on the strength of the tidal currents.

2.5.1.2 *Otter trawling*

Samples were acquired using an otter trawl (similar to the CEFAS Bass design (Pickett *et al*. 2002)) with an 11 m headline and an 80 mm mesh nylon body, reducing to 50 mm at the mid-point and a mesh of 5 mm in the cod-end. The doors for the otter trawl were 1 m in length. The high-opening otter trawl is particularly well suited to capturing larger, more mobile fish living both on and above the seabed, including some demersal species. Trawl speed ranged from 0.8 to 3.2 knots, depending on the strength of the tidal currents.

Figure 3: Otter trawl retrieval aboard the survey vessel INA K. Photograph © APEM Ltd.

2.5.1.3 Pelagic trawling

The pelagic trawl had a 12 m headline and 12 m side ropes, and due to the shape of the net when being dragged the fishing circle was approximately 7 m in diameter. The net was constructed of an 80 mm mesh narrowing to 6 mm on the sleeve at the narrowest point. The pelagic trawl targetted species within the mid-waters of the estuary (e.g. Atlantic herring and European smelt), which generally avoid the estuary bed. Trawl speeds ranged from 0.5 to 2.3 knots, depending on the strength of the tidal currents.

2.5.1.4 Sample recovery and validity

The catch of each trawl was recovered into a fish crate, where it was photographed and a visual description of the catch was recorded. The nets were then checked for any remaining epifauna and fish and the cod-end refastened, prior to redeployment at the next station.

Upon recovery of the trawls the mesh panels and the cod-end integrity were inspected to ensure no damage was sustained during the sampling and if damage was noted it was repaired on site. At the same time the trawl shoes (beam trawl), otter doors (otter trawl) and ground rope were inspected for signs of wear, evidence of contact with the seabed (mud or bottom debris with the catch) and effective operation of the gear (e.g. noting if there was any large debris blocking the net). If there was any evidence that the trawl did not deploy correctly samples were rejected and the trawl was re-run. This was only required on three occasions.

Before accepting any sample, the field team leader ensured the integrity of the sample gear and the completeness of haul information and water quality records. A field data log was compiled recording the following:

- Date and time (GMT);
- Tidal state and water depth;
- Weather conditions;
- Start position and end position of trawl (GPS waypoint);
- Start heading, direction of travel and orientation; and
- Duration of trawl.

2.5.2 Intertidal survey

2.5.2.1 Fyke netting

Fyke nets are a sequence of conical shaped nets fitted within each other held open by a series of rigid hoops which progressively reduce in size, before terminating in a cod end. To further enhance fishing efficacy a leader was fitted to the entrance hoop, which was then angled into the flow to guide fish into the trap. Stakes were used to hold the fykes in position and to prevent the net from becoming dislodged in strong currents and surf. Fyke nets were deployed at low water and coordinates recorded using a handheld GPS unit.

At each survey station, fyke nets were set in pairs (double fykes) and positioned facing both upstream and downstream to catch fish and other mobile fauna ascending the estuary with the flooding tide and descending the estuary with the ebb (each pair representing one sample), (Figure 3). Fyke nets were deployed at low water.

To retrieve samples the field teams followed the ebb tide out until the net was exposed.

Figure 4: Fyke nets deployed on the north shore of the Thames Estuary near the Tilbury Energy Centre site. Photograph © APEM Ltd.

2.5.2.2 Seine netting

Seine netting was undertaken using a micromesh seine net (length 25 m, depth 2.5 m, mesh size of 3 mm). The net was set by wading in an arc at mid-tide to trap any fish present. Two seine deployments were conducted at adjacent but not overlapping locations at each of the three sample stations. Coordinates were recorded using a handheld GPS unit.

2.5.2.3 Push netting

The push net was designed based on the Riley push net and had three distinct parts: the upper and the lower part, and the bag (Riley 1971). The net had a weighted headline to ensure that it touched the sea bottom during fishing operation and a set of three tickler chains. The frame consisted of two poles attached to a handle at one end and iron skis to slide along the seabed. Floats were also attached near the skis to prevent them from getting stuck in the mud (Figure 4).

The push net was operated by two field scientists. The target species (typically epibenthic fauna such as shrimps as well as small fish) were collected by pushing the net along the transect to be sampled. A handheld GPS unit was used to record the start and end coordinates of each transect.

Figure 5: APEM field scientists in parallel operating push net. Photograph © APEM Ltd.

2.5.3 Sample processing

Once validated, each fish sample was cleared of large debris and the total catch was photographed.

For both subtidal and intertidal surveys up to 50 individuals per species in each sample were measured (total length mm) and returned to the water. Where the total catch for a species in one sample was larger than 50 individuals a representative size-structured subsample of 50 fish was measured and the rest were counted to provide total abundance in the catch. Voucher specimens for young of the year (YOY) fish that could not be identified in the field were preserved in formaldehyde solution (4%) and taken to the laboratory for identification to species level. These specimens along with field photographs of larger fish were retained for Analytical Quality Control purposes.

To provide added value, all invertebrates present in the sample were enumerated and identified to species level where practical, or the next lowest taxonomic level possible.

A processing data log was compiled recording the following data and metadata fields:

- Sample unique ID code;
- Start position (GPS waypoint) and gear type;
- Corresponding photograph and water quality log entry;
- Species identity and abundance;
- Sub-sampling factors if applicable;
- ID of samples/pictures taken for Quality Assurance (QA) if applicable;
- Length distribution by species:
    - Finfish: total individual length to centimetres below (or millimetres for smaller individuals); and
    - Rays: wing width and total length to centimetres below (or millimetres for smaller individuals).
- Invertebrate identification and abundance.

Correct speciation of sand gobies in the ‘sand goby complex’, which includes both sand goby *Pomatoschistus minutus* and Lozano’s goby *Pomatoschistus lozanoi* (Webb 1980), can be problematic and requires microscopic examination of the head of each individual. *P. lozanoi* is also suspected to interbreed with *P. minutus* in their natural habitat (Webb 1980). Microscope examination of goby individuals was not conducted for the May 2017 and August 2017 surveys (this is common practice for subtidal trawls catching very large numbers of individuals). *P. lozanoi* individuals were absent from ichthyoplankton trawl samples in May, June and July (APEM 2018) so may have been absent from the May and August subtidal trawls (*P. minutus* individuals were in the ichthyoplankton samples collected during these months). The presence of *P. lozanoi* was noted in the ichthyoplankton each month from August 2017 to March 2018 (with the exception of November), (APEM 2018). Consequently, a decision was made to conduct sub-sample laboratory identification (~quarter of the sand goby complex catch) to differentiate between *P. minutus* and *P. lozanoi* individuals for the October 2017 and February 2018 surveys. It was found that *P. lozanoi* individuals constituted 28.4% of the sand goby complex sub-sample in October and 73.7% of the catch sub-sample in February. As the species were not differentiated in the May and August trawl samples, for the purposes of data recording and analyses these species have been grouped together as ‘sand goby complex’ for the subtidal catches. This approach of not differentiating between *P. minutus* and *P. lozanoi* is a frequently applied approach for fish data characterisation surveys to inform ecological assessments due primarily to the difficulties of *in situ* identification. Due to the lower catches during the intertidal sampling, microscopic examination was conducted to indicate that all individuals caught were *P. minutus* with no *P. lozanoi* recorded.

2.5.4 Water sampling

At each fish sampling station (subtidal stations and intertidal seine and push net stations) the following water quality parameters were recorded from the surface waters using a calibrated YSI Professional Plus handheld multiparameter probe:

- temperature;
- pH;
- dissolved oxygen concentration and saturation;
- salinity;
- conductivity.

2.6 Data analysis

2.6.1 Catch per Unit Effort (CPUE)

Raw catch data were converted to Catch Per Unit Effort (CPUE) for all gears except the seine net catch due to the small area sampled. CPUE for the beam trawl data was expressed as the number of fish caught per 100 m^2 of sea bed trawled. As the width of the otter and pelagic nets can vary throughout each tow, and due to variation in tidal currents, catches were not determined by volume of water trawled and CPUE for otter and pelagic trawls was expressed as the number of fish caught per 100 m trawled.

Fyke nets were set at different shore heights and were submerged for different lengths of time. Consequently the amount of time a fyke net was submerged for each deployment was used to calculate the number of fish caught per hour of deployment. Push net CPUE was expressed as the number of fish caught per 10 m^2 of sea bed.

2.6.2 Multivariate analysis

Multivariate data analysis was carried out on the subtidal and intertidal fish data to investigate differences in fish assemblages across sample sites and surveys. Multivariate analyses were carried out using PRIMER (Clarke & Warwick 2001, Clarke & Gorley 2006).

For the subtidal fish and push net analyses, raw abundance data were used due to the standardisation of transect length across surveys. Sample similarity calculations using raw abundance data can easily be dominated by a few highly abundant taxa (Clarke and Warwick 2001), thus masking the influence of less abundant species. Data transformations were therefore carried out on the subtidal data matrices prior to the calculation of Bray-Curtis similarity to reduce the influence of the most numerically dominant taxa, following the recommendations in Clarke & Gorley (2006). As abundances ranged from single figures up to hundreds of individuals a square root transformation was used (Clarke & Gorley 2006).

For the intertidal fyke net data analysis was carried out on CPUE data due to considerable differences in the effort (period nets were submerged) for each sample. A Bray-curtis similarity matrix was created for further analyses.

2.6.2.1 Ordination Analyses using non-Metric Multidimensional Scaling

Non-metric multidimensional scaling (MDS) is a type of ordination method which creates a 2- or 3-dimensional ‘map’ or plot of the samples from the resemblance matrix. The plot generated is a representation of the dissimilarity of the samples, with distances between the samples indicating the extent of the dissimilarity. For example, samples that are more dissimilar are further apart on the MDS plot.

Each MDS plot provides a stress value which is a broadscale indication of the usefulness of plots, with a general guide indicated below (Clarke 1993):

- <0.05 Almost perfect representation of rank similarities;
- 0.05 to <0.1 good representation;
- 0.1 to <0.2 still useful;
- 0.2 to <0.3 should be treated with caution;
- >0.3 little better than random points.

2.6.2.2 ANOSIM

Analysis of similarities (ANOSIM) is a non-parametric permutational test used to determine if the similarity between predefined groups is greater than or equal to the similarity within the groups. The test statistic R is calculated between the values -1 to 1, a positive value close to 1 suggests more similarity within groups than between groups and a value close to zero suggests no difference between groups.

2.6.2.3 SIMPER analysis

Where differences between groups of samples were found, SIMPER analysis was used to determine which taxa were principally responsible for the differences between the statistically distinct groups of stations.

3. Results

3.1 Fish species abundance and diversity

3.1.1 Subtidal surveys

Across all gear types a total of 18,036 fish representing 34 species were caught during the subtidal fish surveys (Table 2). The most abundant species was the sand goby complex[1] with 13,099 individuals caught (this represented 73% of the total fish count and 12% of individuals were caught in beam trawls, 37% in otter trawls and 51% in pelagic trawls). The highest catches of sand goby complex were in the August and October surveys (5,874 and 6,003 individuals, respectively) with only fifteen individuals caught in May and 1,207 individuals caught in February. European smelt was the second most abundant species with 1,465 individuals caught across all gear types (3% in beam trawls, 43% in Otter trawls and 54% in pelagic trawls). The majority of smelt were caught during the May survey (978 individuals), with catches in August, October and February being 180, 90 and 217 individuals, respectively. The third most abundant species was Dover sole, with 791 individuals caught across all three gear types (36% in beam trawls, 62% in otter trawls and 2% in pelagic tralws). Most sole were caught during the May survey (567 individuals), with successively lower catches of 136, 69 and 19 in the August, October and February surveys, respectively. Sand goby complex catch was more than twice as high at Station 2 in the mid channel (8,981 individuals) than at Station 1 nearer the north bank (4,118 individuals), for European smelt there was little difference in the catch between stations (768 individuals at Station 1 and 697 individuals at Station 2), while for Dover sole catch was far higher at Station 1 (702 individuals) than at Station 2 (89 individuals).

Other species with over 300 individuals caught were Atlantic herring, whiting and European sprat (each with similar catch across stations) and European flounder (two times greater catch at Station 1). Less than ten individuals were caught for sixteen species across all surveys and for six of those species only one individual was caught.

Overall, species richness of the catch was greatest for the otter trawls with 29 species represented, 28 species were caught in the beam trawls and 21 species in the pelagic trawls. The highest number of species caught was during the October survey (26 species), followed by May (21 species), August (18 species) and February (18 species).

3.1.1.1 Catch per Unit Effort

The CPUE units vary across the different sampling techniques. Beam trawls are rigid structures with a defined width and it is possible to estimate the area of seabed covered when trawling over a given distance, consequently a unit of individuals per m^2 can be calculated. For the otter and pelagic trawls the shape of the net opening can vary during the

[1] This species complex comprised individuals of both *Pomatoschistus minutus* and *P. lozanoi*.

trawl, current speeds vary and it is very difficult to estimate the volume of water sampled, consequently the CPUE for these methods has been based on distance trawled. For beam trawls the August survey had the highest CPUE with a total of 17.2 fish caught 100 m^{-2}. CPUE for May and October was considerably lower with 3.5 and 7.1 fish 100 m^{-2} respectively and the lowest catch rate was in February with 1.7 fish 100 m^{-2} (Table 3). This was primarily due to high catch rates of sand goby complex in August (14.8 ind. 100 m^{-2}) and the only other species with beam trawl catch rates greater than one individual 100 m^{-2} were sand goby complex in October (4.1 ind. 100 m^{-2}) and February (1.2 ind. 100 m^{-2}) and Dover sole in May (2.9 ind. 100 m^{-2}).

The highest catch rate for otter trawls was in August (64.1 fish caught 100 m^{-1}) compared to 21.8 and 41.6 fish 100 m^{-1} in May and October respectively and again the lowest catch rate was in February, with 18.3 individuals 100 m^{-1} (Table 13). The highest CPUE was for sand goby complex in August (56 ind. 100 m^{-1}), October (29.5 ind. 100 m^{-1}) and February (12.3 ind. 100 m^{-1}). The other species caught in numbers greater than one individual 100 m^{-1} were Dover sole in May (6.9 ind. 100 m^{-1}) and August (1.9 ind. 100 m^{-1}); European smelt in May (7.2 ind. 100 m^{-1}), August (2.5 ind. 100 m^{-1}) and February (2.2 ind. 100 m^{-1}); whiting in May (3.5 ind. 100 m^{-1}) and October (2.3 ind. 100 m^{-1}); flounder in May (2.0 ind. 100 m^{-1}), August (1.5 ind. 100 m^{-1}) and October (2.7 ind. 100 m^{-1}); sprat in February (1.36 ind. 100 m^{-1}); lesser sandeel in August (1.04 ind. 100 m^{-1}); and plaice in October (1.06 ind. 100 m^{-1}).

The highest CPUE for pelagic trawls was during the October survey (95.66 ind. 100 m^{-1}). This was primarily due to high numbers of individuals in the sand goby complex (84.38 ind. 100 m^{-1}) during this survey. Catches of sand goby complex were also high in August (39.36 ind. 100 m^{-1}) and February (10.08 ind. 100 m^{-1}). The only other fish species with catch rates above one individual 100 m^{-1} were European smelt in May (11.96 ind. 100 m^{-1}), October (1.08 ind. 100 m^{-1}) and February (2.04 ind. 100 m^{-1}); herring in October (5.38 ind. 100 m^{-1}) and February (2.74 ind. 100 m^{-1}); sprat in October (1.42 ind. 100 m^{-1}) and February (2.26 ind. 100 m^{-1}); transparent goby in May (1.3 ind. 100 m^{-1}) and whiting in October (1.32 ind. 100 m^{-1}) (Table 3).

Table 2: Subtidal survey catch data across all surveys and gear types.

Common name	Species	May 17				August 2017				October 2017				February 2018				Overall total
		Beam	Otter	Pelagic	Total	Beam	Otter	Pelagic	Total	Beam	Otter	Pelagic	Total	Beam	Otter	Pelagic	Total	
Atlantic herring	***Clupea harengus***	1	30	8	**39**	0	8	48	**56**	10	53	269	**332**	6	21	137	**164**	591
Atlantic horse mackerel	***Trachurus trachurus***	0	0	0	**0**	0	0	0	**0**	1	3	0	**4**	0	0	0	**0**	4
Bib/pouting	***Trisopterus luscus***	2	21	3	**26**	0	2	0	**2**	1	33	1	**35**	2	8	1	**11**	74
Black goby	***Gobius niger***	0	1	0	**1**	0	0	0	**0**	4	0	1	**5**	2	1	0	**3**	9
Brill	***Scophthalmus rhombus***	0	0	0	**0**	0	0	0	**0**	0	1	0	**1**	0	0	0	**0**	1
Common goby	***Pomatoschistus microps***	0	0	0	**0**	54	24	1	**79**	35	27	25	**87**	2	2	0	**4**	170
Common sea snail	***Liparis liparis***	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	1	0	0	**1**	1
Conger eel	***Conger conger***	0	0	0	**0**	0	1	0	**1**	0	0	0	**0**	0	0	0	**0**	1
Dab	***Limanda limanda***	0	0	0	**0**	0	0	0	**0**	14	12	1	**27**	0	1	0	**1**	28
Dover sole	***Solea solea***	216	343	8	**567**	33	96	7	**136**	28	41	0	**69**	7	12	0	**19**	791
European anchovy	***Engraulis encrasicolus***	0	0	0	**0**	0	0	2	**2**	1	8	39	**48**	0	0	0	**0**	50
European flounder	***Platichthys flesus***	9	102	26	**137**	14	77	17	**108**	19	134	4	**157**	2	28	2	**32**	434
European plaice	***Pleuronectes platessa***	2	1	1	**4**	0	0	0	**0**	42	53	0	**95**	0	0	0	**0**	99
European seabass	***Dicentrarchus labrax***	1	0	0	**1**	0	3	4	**7**	0	0	2	**2**	0	17	13	**30**	40
European smelt	***Osmerus eperlanus***	20	360	598	**978**	21	127	32	**180**	3	33	54	**90**	4	111	102	**217**	1,465
European sprat	***Sprattus sprattus***	1	1	11	**13**	0	1	29	**30**	7	29	71	**107**	7	68	113	**188**	338
Five-bearded rockling	***Ciliata mustela***	0	0	0	**0**	0	1	0	**1**	0	0	0	**0**	0	0	0	**0**	1
Greater pipefish	***Syngnathus acus***	0	1	1	**2**	0	1	0	**1**	1	0	0	**1**	0	0	0	**0**	4
Lesser sandeel	***Ammodytes tobianus***	0	2	0	**2**	64	52	4	**120**	49	28	0	**77**	1	1	0	**2**	201
Lesser weever	***Echiichthys vipera***	3	4	0	**7**	0	0	0	**0**	0	1	0	**1**	0	0	0	**0**	8
Lesser/Nilsson's pipefish	***Syngnathus rostellatus***	0	0	0	**0**	0	0	0	**0**	2	0	0	**2**	0	0	0	**0**	2
Pogge/hooknose	***Agonus cataphractus***	0	4	0	**4**	0	0	0	**0**	2	3	0	**5**	0	2	0	**2**	11
Poor cod	***Trisopterus minutus***	0	0	0	**0**	0	1	0	**1**	0	1	0	**1**	0	0	0	**0**	2
River lamprey	***Lampetra fluviatilis***	1	2	2	**5**	0	3	0	**3**	0	0	0	**0**	0	0	0	**0**	8
Sand goby complex	***Pomatoschistus minutus/lozanoi***	1	10	4	**15**	1,106	2,800	1,968	**5,874**	309	1,475	4,219	**6,003**	87	616	504	**1,207**	13,099
Short-spined sea scorpion	***Myoxocephalus scorpius***	0	0	0	**0**	1	0	0	**1**	0	0	0	**0**	0	0	0	**0**	1
Striped red mullet	***Mullus surmuletus***	0	1	0	**1**	0	0	0	**0**	1	8	7	**16**	0	0	0	**0**	17
Thin lipped grey mullet	***Chelon ramada***	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	1	1	1	**3**	3
Thornback ray	***Raja clavata***	0	1	0	**1**	0	0	0	**0**	1	1	0	**2**	0	0	0	**0**	3
Three-spined stickleback	***Gasterosteus aculeatus***	1	0	0	**1**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	1
Transparent goby	***Aphia minuta***	0	10	65	**75**	0	0	0	**0**	1	6	24	**31**	1	1	3	**5**	111
Tub gurnard	***Chelidonichthys lucerna***	0	20	3	**23**	0	9	0	**9**	0	14	0	**14**	0	0	0	**0**	46
Whiting	***Merlangius merlangus***	8	174	25	**207**	0	0	0	**0**	3	117	66	**186**	3	23	3	**29**	422
Total		266	1,088	755	2,109	1,293	3,206	2,112	6,611	534	2,081	4,783	7,398	126	913	879	1,918	**18,036**

Table 3: Catch Per Unit Effort by gear type.

Species	Beam				Otter				Pelagic			
	CPUE (ind. 100 m^{-2})				CPUE (ind. per 100 m^{-1})				CPUE (ind. 100 m^{-1})			
	May	Aug	Oct	Feb	May	Aug	Oct	Feb	May	Aug	Oct	Feb
Atlantic herring	0.013	0	0.13	0.080	0.60	0.16	1.06	0.42	0.16	0.96	5.38	2.74
Atlantic horse mackerel	0	0	0.013	0	0	0	0.06	0	0	0	0	0
Bib/pouting	0.027	0	0.013	0.027	0.42	0.040	0.66	0.16	0.060	0	0.020	0.020
Black goby	0	0	0.053	0.027	0.02	0	0	0.020	0	0	0.020	0
Brill	0	0	0	0	0	0	0.020	0	0	0	0	0
Common goby	0	0.72	0.47	0.027	0	0.48	0.54	0.040	0	0.020	0.50	0
Common sea snail	0	0	0	0.013	0	0	0	0	0	0	0	0
Conger eel	0	0	0	0	0	0.020	0	0	0	0	0	0
Dab	0	0	0.19	0	0	0	0.24	0.020	0	0	0.020	0
Dover sole	2.88	0.44	0.37	0.093	6.86	1.92	0.82	0.24	0.16	0.14	0	0
European anchovy	0	0	0.013	0	0	0	0.16	0	0	0.040	0.78	0
European flounder	0.12	0.19	0.25	0.027	2.040	1.54	2.68	0.56	0.52	0.34	0.080	0.040
European plaice	0.027	0	0.56	0	0.020	0	1.060	0	0.020	0	0	0
European seabass	0.013	0	0	0	0	0.060	0	0.34	0	0.080	0.040	0.26
European smelt	0.27	0.28	0.040	0.053	7.20	2.54	0.66	2.22	11.96	0.64	1.080	2.040
European sprat	0.013	0	0.093	0.093	0.020	0.020	0.58	1.36	0.22	0.58	1.42	2.26
Five-bearded rockling	0	0	0	0	0	0.020	0	0	0	0	0	0
Greater pipefish	0	0	0.013	0	0.020	0.020	0	0	0.020	0	0	0
Lesser sandeel	0	0.85	0.65	0.013	0.040	1.040	0.56	0.020	0	0.080	0	0
Lesser weever	0.040	0	0	0	0.080	0	0.020	0	0	0	0	0
Lesser/Nilsson's pipefish	0	0	0.027	0	0	0	0	0	0	0	0	0
Pogge/hooknose	0	0	0.027	0	0.080	0	0.060	0.040	0	0	0	0
Poor cod	0	0	0	0	0	0.020	0.020	0	0	0	0	0
River lamprey	0.013	0	0	0	0.040	0.060	0	0	0.040	0	0	0
Sand goby complex	0.013	14.75	4.12	1.16	0.20	56.00	29.50	12.32	0.080	39.360	84.38	10.080
Short-spined sea scorpion	0	0.013	0	0	0	0	0	0	0	0	0	0
Striped red mullet	0	0	0.013	0	0.020	0	0.16	0	0	0	0.14	0
Thin-lipped grey mullet	0	0	0	0.013	0	0	0	0.020	0	0	0	0.020
Thornback ray	0	0	0.013	0	0.020	0	0.020	0	0	0	0	0
Three-spined stickleback	0.013	0	0	0	0	0	0	0	0	0	0	0
Transparent goby	0	0	0.013	0.013	0.20	0	0.12	0.020	1.30	0	0.48	0.060
Tub gurnard	0	0	0	0	0.40	0.18	0.28	0	0.060	0	0	0
Whiting	0.11	0	0.040	0.040	3.48	0	2.34	0.46	0.50	0	1.32	0.060
Total	**3.55**	**17.24**	**7.12**	1.68	**21.76**	**64.12**	**41.62**	**18.26**	**15.10**	**42.24**	**95.66**	**17.58**

3.1.2 Intertidal surveys

To enable a comparison of the fyke net data across sampling events, only data for fyke net Stations 1 to 4 (the stations which were sampled during all surveys) were considered for the overall comparison between sampling gears (Table 4). Across all survey methods (and considering fyke net Stations 1 to 4) a total of 13 species[2] and 1364 individuals were recorded (Table 1). There was considerable variation in the abundance of fish caught by gear and by season with fyke nets sampling the greatest number of species (11 species), and the highest number of fish was caught via push netting (mainly due to high catches of common goby in August and October).

The fish species recorded in highest numbers during the intertidal surveys were common goby (572 individuals, representing 42% of the total catch) and European seabass (479 individuals, representing 35% of the catch). Common goby were primarily caught in the push nets (88% of the common goby catch) and were caught in greatest numbers in August and October with only six individuals caught in May and two in February. European seabass were mainly caught in fyke nets (69% of the seabass catch) and the highest numbers were caught during the October and February surveys (151 to 157 individuals) with fewer individuals caught in the May and August surveys (81 to 90 individuals). European seabass was the dominant species in seine net catches in May and February, with common goby the most abundant species in seine net samples in August and October (Table 4). Other species with over 50 individuals recorded were European smelt, European flounder and sand goby.

Within the extra fyke nets deployed at Stations 5 to 8 a further three species were recorded (small spotted catshark, grey gurnard and red gurnard; each represented by one individual) (Table 5), so the total number of species recorded across all intertidal surveys was 16. The catch at fyke net stations 5 to 8 was dominated by Europen seabass with a total of 563 individuals caught (with highest numbers of seabass caught at Stations 7 and 8 in December). The second most abundant fish species at these extra fyke net stations was European smelt (177 individuals recorded, with 121 of these recorded at Station 7 in February 2018). The only other species with more than ten individuals recorded at these extra stations were whiting (35 individuals) and European flounder (15 individuals).

3.1.2.1 Catch Per Unit Effort

Fyke nets sampled for a variable amount of time depending on tidal height during the survey and the height of the Station on the shore (generally soak time was between 5 and 9 hours). Therefore, the fyke net catches were converted into a CPUE of number of individuals caught per hour (Table 6).

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[2] Microscope ID confirmed that all sand goby individuals recorded in the intertidal samples were sand goby with no Lozano's goby in the samples.

CPUE data indicate that catch rates were similar at the lower and lower mid sites, but were generally 1.5 to 4 times greater at the upper mid to upper shore stations. The species with the highest catch rate was European seabass and this species was caught in very high numbers at Stations 7 and 8 in December (with over 35 fish caught per hour at both stations compared to 5.44 seabass per hour in Oct/Nov surveys on the mid upper shore which was the next highest CPUE). In addition, CPUE for European smelt was highest for the December and February surveys (5.17 and 7.71 fish per hour on the upper shore, respectively, compared to the next highest record of 1.64 per hour in the May survey) (Table 6). As the December fyke netting was carried out at Stations 7 and 8 for the first time both location and time of year could have resulted in the high CPUEs for European seabass and European smelt for this survey. In February 2018 across all fyke net stations, however, catches of European seabass and smelt at Station 7 were considerably greater than at each of the other fyke net stations indicating station location was likely a key factor.

For the push netting the highest catch rates were in August at both the Tilbury and Gravesend sites (Table 7) with 8.09 and 8.68 fish 10 m^{-2} at Tilbury and Gravesend respectively (due to high numbers of common goby caught during these months). The second highest catch was in October, again due to high numbers of common goby. The second most abundant species caught was European seabass, with CPUE ranging from 0.02 to 0.69 individuals 10 m^{-2} across surveys.

Table 4: Intertidal survey catch data across all surveys and gear types. Fyke net data are for Stations 1-4.

Common name	Species	May 17				August 17				October 17				February 18				Overall total
		Fyke	Push	Seine	Total	Fyke	Push	Seine	Total	Fyke	Push	Seine	Total	Fyke	Push	Seine	Total	
Atlantic herring	*Clupea harengus*	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	4	4
Bib/Pouting	*Trisopterus luscus*	1	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1	2
Black goby	*Gobius niger*	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	1
Common goby	*Pomatoschistus microps*	0	6	0	6	0	251	36	287	0	245	31	276	0	2	1	3	572
Dover sole	*Solea solea*	5	0	1	6	14	0	0	14	0	0	0	0	0	0	0	0	20
European eel	*Anguilla anguilla*	0	0	0	0	5	0	0	5	1	0	0	1	0	0	0	0	6
European flounder	*Platichthys flesus*	21	3	2	26	22	2	4	28	19	0	0	19	17	0	0	17	90
European seabass	*Dicentrarchus labrax*	54	18	18	90	37	41	3	81	133	4	14	151	108	36	13	157	479
European smelt	*Osmerus eperlanus*	23	0	8	31	3	0	0	3	4	0	0	4	34	0	2	36	74
European sprat	*Sprattus sprattus*	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	12	12
Sand goby	*Pomatoschistus minutus*	0	0	0	0	1	5	0	6	0	54	6	60	1	1	0	2	68
Thin lipped grey mullet	*Chelon ramada*	1	2	1	4	0	0	0	0	0	17	0	17	1	0	1	2	23
Whiting	*Merlangius merlangus*	1	0	0	1	0	0	0	0	4	0	0	4	8	0	0	8	13
Grand Total		106	29	30	**165**	82	300	43	**425**	161	320	51	**532**	186	39	17	**242**	**1364**

Table 5: Catch data for fyke net Stations 5-8.

Common name	November 17		December 17		February 2018				Overall total
	Station 5	Station 6	Station 7	Station 8	Station 5	Station 6	Station 7	Station 8	
Atlantic herring	0	0	1	0	0	0	1	1	3
Bib/Pouting	0	0	0	0	0	1	0	0	1
European eel	0	1	0	0	0	0	0	0	1
European plaice	0	0	0	0	0	0	1	1	2
European seabass	52	32	184	161	18	11	78	27	563
European smelt	2	1	25	7	3	5	121	13	177
European sprat	0	0	0	0	1	3	3	2	9
European flounder	1	0	5	3	1	0	2	3	15
Five-bearded rockling	0	0	0	0	0	1	0	0	1
Grey gurnard	0	0	0	1	0	0	0	0	1
Small spotted catshark	0	1	0	0	0	0	0	0	1
Red gurnard	0	0	0	1	0	0	0	0	1
Sand goby	0	0	1	0	0	1	0	0	2
Thin lipped grey mullet	0	0	0	0	0	0	1	0	1
Whiting	8	2	2	9	1	5	3	5	35
Grand Total	63	37	218	182	24	27	210	52	**813**

Table 6: Fyke netting Catch Per Unit Effort. Fish catch has been standardised to number caught per hour. Table shows catch for each survey season and for each shore height that nets were set (U = upper shore, UM = upper mid shore, LM = lower mid shore and L = lower shore).

Species	May 17				August 17				Oct/Nov 17				Dec 17		Feb 18			
	L	LM	UM	U	L	LM	UM	U	L	LM	UM	U	L	U	L	LM	UM	U
Atlantic herring	0	0	0	0	0	0	0	0	0	0	0	0	0	0.21	0.13	0.11	0.00	0.11
Bib/Pouting	0	0	0.16	0	0	0	0	0	0	0	0	0	0	0	0.04	0	0.16	0
Dover sole	0.25	0.13	0.33	0.00	0.35	0.38	0	1.35	0.11	0	0.12	0.07	0	0	0	0	0	0
European eel	0	0	0	0	0.12	0	0.30	0.34	0.11	0	0	0	0	0	0	0	0	0
European flounder	0.12	0.40	0.82	2.18	0.46	0.51	0.90	1.35	0.11	0.34	0.99	0.49	0.65	1.03	0.29	0	0.80	0.61
European plaice	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.04	0	0	0.06
European seabass	0.87	1.89	2.47	3.27	0.58	0.25	2.70	2.03	3.62	3.96	5.44	5.20	35.13	38.07	1.89	2.13	2.72	8.86
European Smelt	0.37	0.67	0.99	1.64	0	0.13	0.15	0.17	0.11	0.11	0	0.28	1.53	5.17	0.88	0.67	1.44	7.71
European sprat	0	0	0	0	0	0	0	0	0	0	0.25	0	0	0	0.38	0.22	0.16	0.50
Five-bearded rockling	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.04	0	0	0
Grey gurnard	0	0	0	0	0	0	0	0	0	0	0	0	0.22	0	0	0	0	0
Small spotted catshark	0	0	0	0	0	0	0	0	0.06	0	0	0	0	0	0	0	0	0
Red gurnard	0	0	0	0	0	0	0	0	0	0	0	0	0.22	0	0	0	0	0
Sand goby	0	0	0	0	0	0	0.15	0	0	0	0	0	0.21	0	0.08	0	0	0
Thin lipped grey mullet	0.12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.11
Whiting	0	0	0.16	0	0	0	0	0	0.17	0.34	0	0.55	1.96	0.41	0.51	0.22	0.64	0.22
Total	1.73	3.10	4.93	7.09	1.50	1.27	4.20	5.24	4.31	4.75	6.80	6.59	39.71	45.10	4.29	3.37	5.92	18.17

Table 7: Push netting Catch per Unit Effort. Fish catch has been standardised to individuals caught 10 m^{-2}.

Species	CPUE (ind. 10 m^{-2})							
	Tilbury				Gravesend			
	May	Aug	Oct	Feb	May	Aug	Oct	Feb
Black goby	0	0	0	0	0	0.03	0	0
Common goby	0.13	7.40	5.87	0.04	0	8.03	3.70	0
European flounder	0	0	0	0	0.10	0.07	0	0
European seabass	0.24	0.69	0.02	0.44	0.23	0.37	0.10	0.53
Sand goby	0	0	0	0	0	0.17	1.80	0.03
Thin lipped grey mullet	0.04	0	0.36	0	0	0	0.03	0
Total fish 10 m^{-2}	**0.42**	**8.09**	**6.24**	**0.49**	**0.33**	**8.68**	**5.63**	**0.57**

3.2 Species of conservation and commercial importance

A number of species of conservation and commercial importance were recorded during the surveys as shown in Table 8.

Table 8: Protected and commercially important fish species sampled during the Tilbury Energy Centre surveys. Commercial importance is defined at the population level, rather than whether a specific commercial fishery exists for the species in the Thames. CR = Critically Endangered, VU = Vulnerable, NT = Near Threatened, LC = Least Concern, NE = Not Evaluated.

Group	Species	Bern Convention	OSPAR	Habitats Directive	EC Cites	Global Red list status	NERC Section 41 list	Recreational or commercial fishery	Number of individuals caught across all TEC surveys
Anadromous / Catadromous (migratory)	European eel		OSPAR		Appendix II	CR	Yes	Recreational	7
	European smelt					LC	Yes	Commercial	1716
	River lamprey	Appendix III		Annex II* & V		LC	Yes	None	8
Marine migrant bony	Atlantic cod		OSPAR			VU	Yes	Commercial	
	Atlantic herring					LC	Yes	Commercial	598
	Brill					NE		Commercial	1
	Common dab					LC		Commercial	28
	Dover sole					DD	Yes	Commercial	811
	European anchovy					LC		Commercial	50
	European plaice					LC	Yes	Commercial	101
	European seabass					LC		Commercial & recreational	1082
	European sprat					NE		Commercial	359
	European whiting					LC	Yes	Commercial	470
	Poor cod					NE		Commercial	74
Marine straggler bony fish	Conger eel					LC		Recreational	1
	Lesser sandeel					DD	Yes	None	201
	Red mullet					NE		Commercial	17
	Scad/horse mackerel					VU	Yes	None	4
Estuarine bony fish	Common goby	Appendix III				LC		None	742
	European flounder					LC		Commercial	539
	Sand goby	Appendix III				NE		None	13,169*
	Thin-lipped grey mullet					NE		Commercial	27
Elasmobranchs	Thornback Ray		OSPAR			NT		Commercial	3
	Small spotted catshark					LC		None	1

* the number indicated is for sand goby complex (sand and Lozano's goby) but only sand goby is protected.

3.3 Multivariate analysis

3.3.1 Subtidal surveys

3.3.1.1 Beam trawls

There was a clear separation of the May 2017 beam trawl data from the other beam trawl survey data on the MDS plot (Figure 6), and some overlap was evident between the August and October 2017 samples.

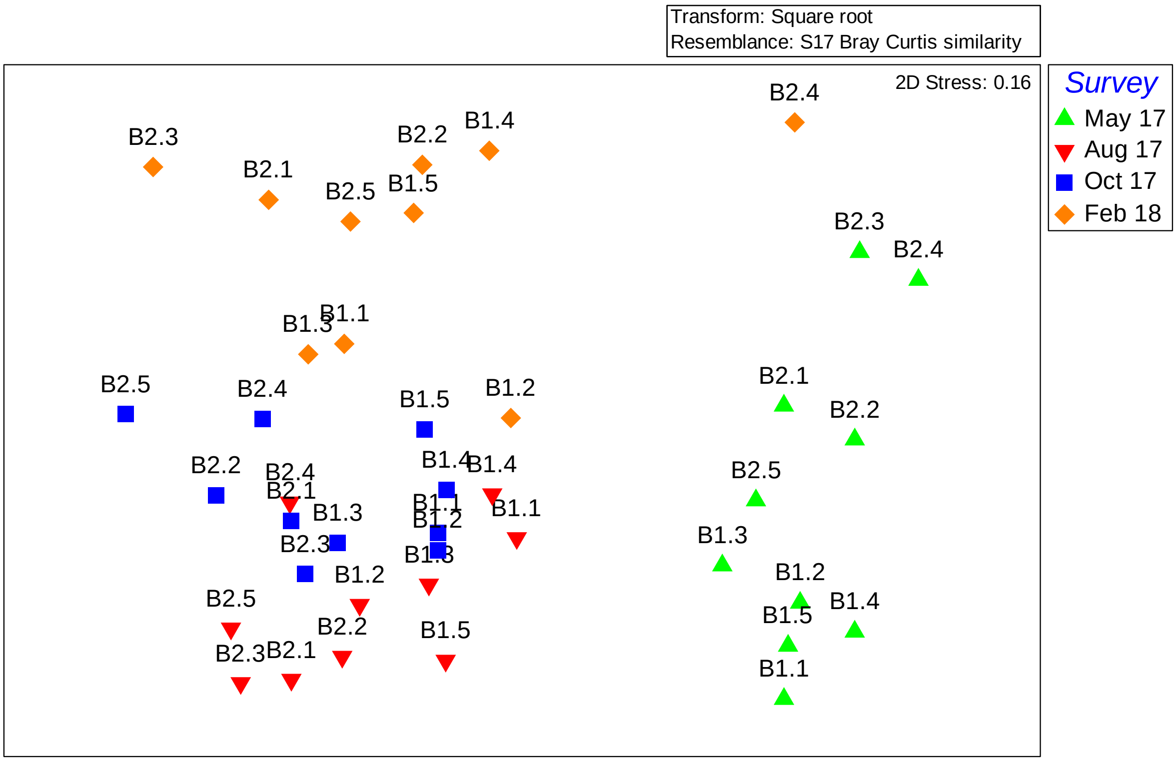

Figure 6: Multidimensional Scaling ordination plot based on the square root transformed beam trawl fish catch data across all surveys.

A global ANOSIM test gave an R value of 0.666, indicating that there were differences in the fish assemblages recorded across surveys and this result was statistically significant (P<5%). Examination of the pairwise tests indicated large differences between May and the other surveys, particularly between May and October, and confirmed the smallest difference was between August and October.

Outputs of SIMPER analysis indicating the main species contributing to within-group similarity and similarity/dissimilarity between groups are provided in Appendix 2. Within-group similarity was highest for the August 2017 survey and lowest for the February 2018 survey. Differences between surveys were primarily driven by changes in abundance of gobies in the sand goby complex for all comparisons except the comparison between May

2017 and February 2018, for which dissimilarity was primarily due to differences in numbers of Dover sole. Numbers of individuals in the sand goby complex were much lower in the May 2017 survey compared to the later surveys, whereas Dover sole numbers were higher in May 2017 than in subsequent surveys.

3.3.1.2 Otter trawls

The MDS plot for the otter trawl catch data indicated that the data for the May 2017 and October 2017 surveys were grouped separately to each other and the other two surveys (Figure 7). The data for the August 2017 and February 2018 surveys had more overlap, but also had a wider distribution across the plot, indicating more variability between replicates.

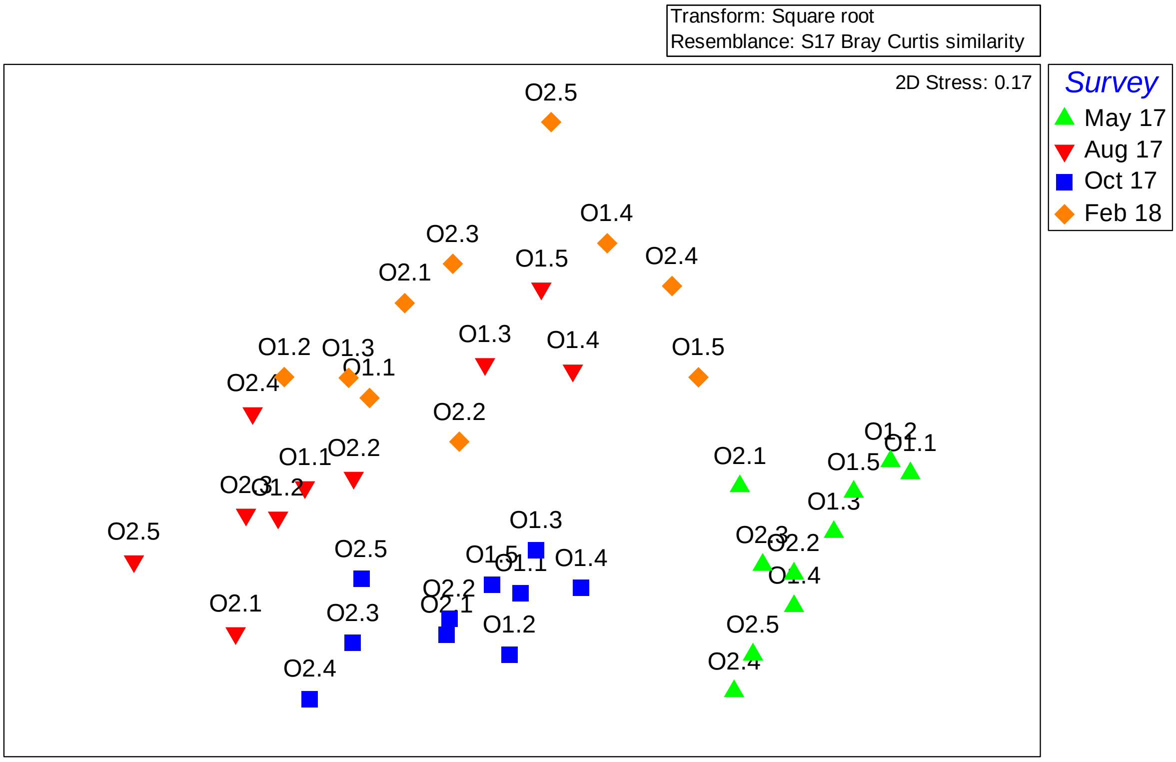

Figure 7: **Multidimensional Scaling ordination plot based on the square root transformed otter trawl fish catch data across all surveys.**

The results of the ANOSIM test indicated a high global R value of 0.782, which indicates significant (p<5%) seasonal differences in catch data. As with the beam trawls, the pairwise tests indicated the largest differences were between May 2017 and the subsequent surveys and the smallest differences were between the August 2017 and February 2017 surveys.

The SIMPER results for within-group similarity indicated that again abundances of gobies in the sand goby complex had the highest contribution to within-group similarity across replicates for the August 2017, October 2017 and February 2018 surveys (see Appendix 2).

The greatest contribution to similarity across replicates in the May 2017 otter trawl survey was European smelt with the highest numbers of this species recorded during this survey.

The results of the SIMPER analysis indicated that changes in abundances of gobies in the sand goby complex were the main driver of differences between surveys in all comparisons, with lowest abundances of these species (sand goby/Lozano's goby) in May 2017 and highest numbers in August 2017.

3.3.1.3 Pelagic trawls

The MDS plot for the pelagic trawl data indicated clear separation of samples from each season, but with a very pronounced gap between May 2017 and the other surveys, indicating a large difference in catches obtained during the May 2017 survey (Figure 8).

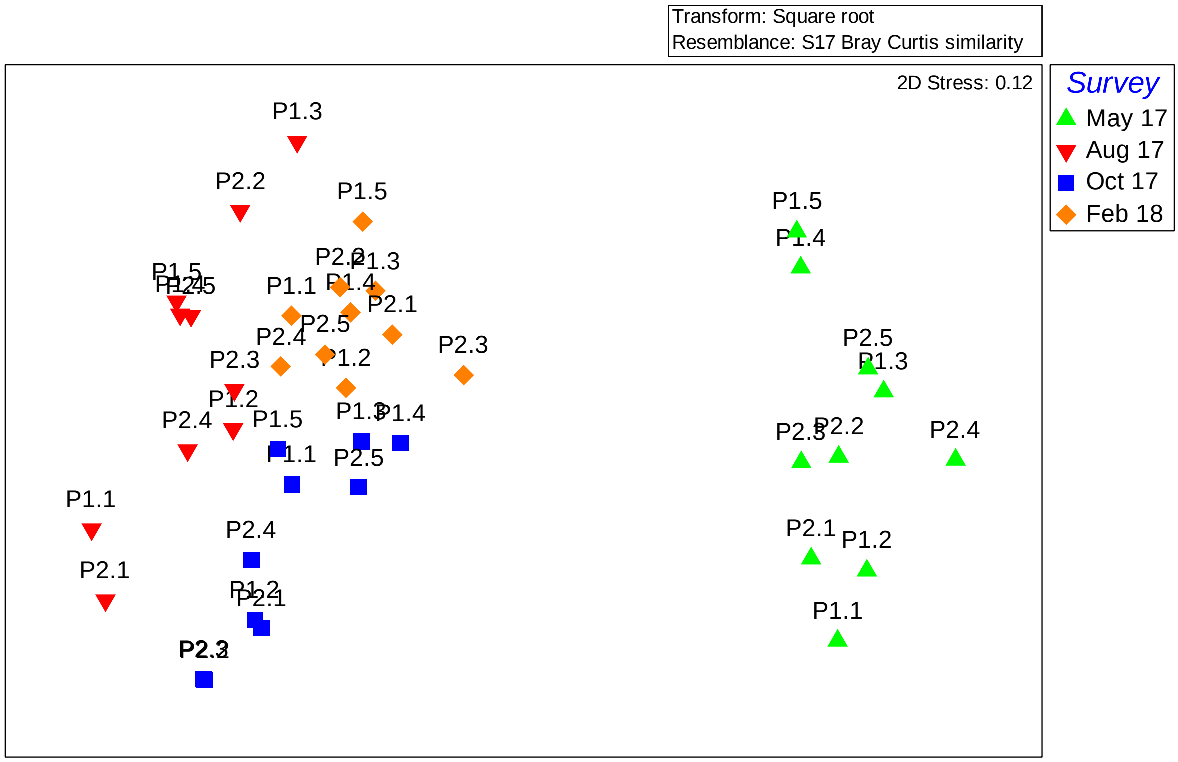

Figure 8: Multidimensional Scaling ordination plot based on the square root transformed pelagic trawl fish catch data across all surveys.

The results of the ANOSIM test show similar results to the tests on the beam and otter trawl data, with a high R value of 0.76 (p<5%) indicating clear seasonal differences and pairwise tests indicating the greatest differences were between the May 2017 survey and subsequent surveys.

The SIMPER results indicated that abundance of gobies in the sand goby complex had the highest contribution to within-group similarity across replicates for the August 2017, October

2017 and February 2018 surveys, followed by abundance of Atlantic herring (Appendix 2). In the May 2017 survey the highest contributor to within-group similarity across replicates was European smelt followed by transparent goby.

As with the otter trawls, the abundance of gobies in the sand goby complex had the highest contributions to dissimilarity for all seasonal comparisons with lowest abundances in the May 2017 survey and highest in the October 2017 survey.

3.3.2 *Intertidal surveys*

3.3.2.1 Fyke netting

Multivariate analysis of fyke netting samples was carried out for stations F1 to F4 since these were the only stations sampled during all four surveys. The MDS plot indicated a wide separation from the other samples of the lower shore station data from May, August and February and the mid shore station data from August (Figure 9). The May and February samples indicated a similar distribution of samples from different shore heights, but with wider separation of the February data for the upper shore station (F4) from the other samples.

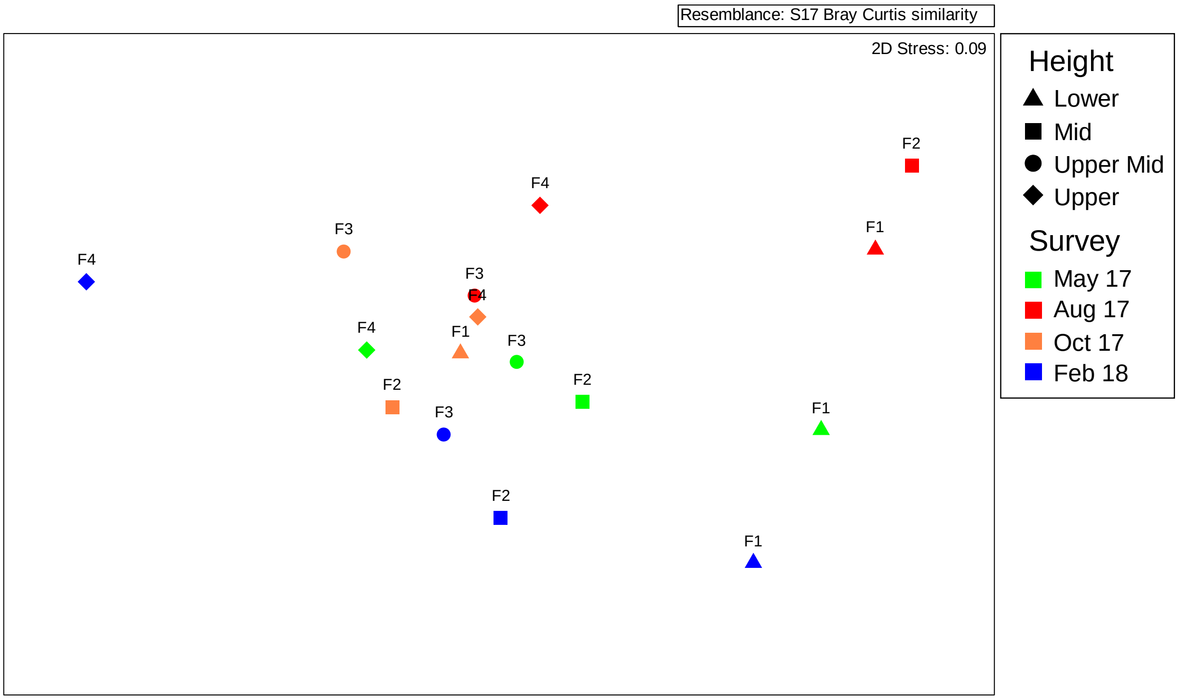

Figure 9: Multidimensional Scaling ordination plot based on the untransformed CPUE Fyke netting catch data for consistently sampled stations across all surveys. Shore heights are distinguished by different symbols and survey months by colours.

Despite the fact that fish abundances in catches tended to be greater on the upper shore sites (Table 6), the results of the two-way ANOSIM test data found no significant differences between shore heights (R=0; p>5%). The test also found differences between surveys were very small (R=0.133) and not significant (p>5%). As such, the null hypothesis of 'no differences between groups' must be accepted in both cases.

3.3.2.2 Push netting

The MDS plot for push net samples indicated a clear separation between the May and August survey data and the October 2017 and February 2018 data (Figure 10). The October and February surveys were also separated from each other, whereas there was more overlap between the May and August samples. There was no apparent separation of samples between the Tilbury and Gravesend sites.

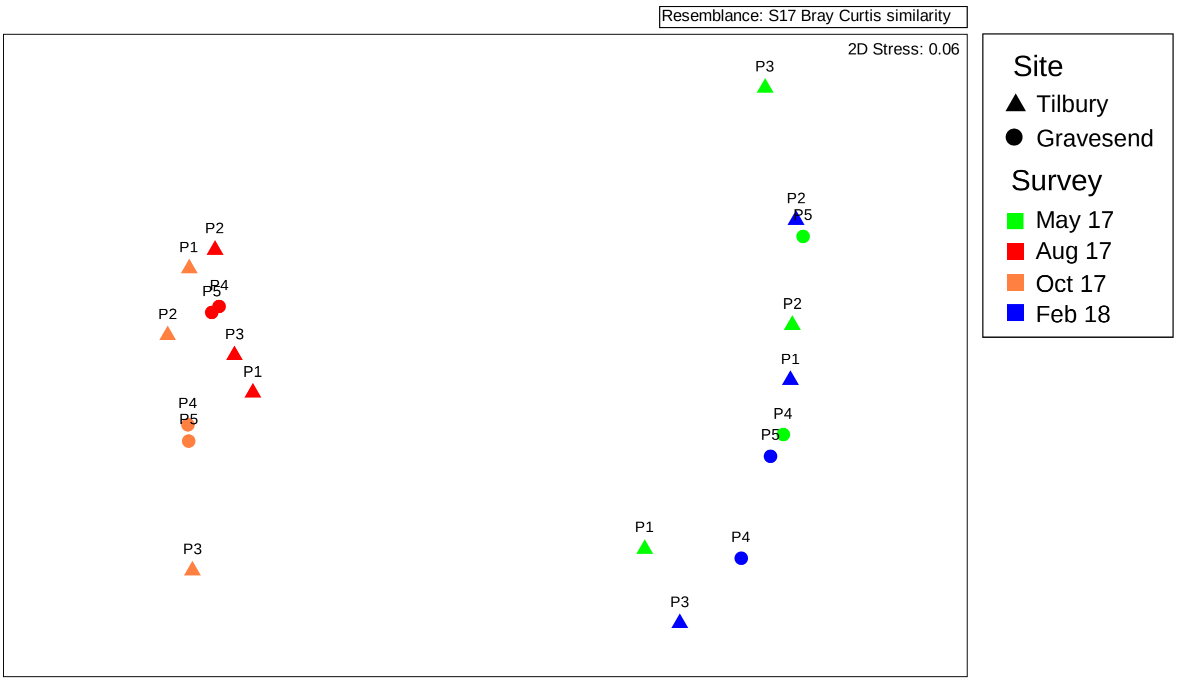

Figure 10: Multidimensional Scaling ordination plot based on the untransformed CPUE Push net catch data across all surveys. The two different sites are distinguished by different symbols and survey months by colours.

The two-way ANOSIM test found that there were significant differences between surveys (R=0.673, p<5%). The pairwise tests indicated that differences between May and February and between August and October were not significant (p>5%) but all other pairings were significant with large R values (R>0.9 in all cases, p<5%). The results confirmed that there were no significant differences in the data collected at the Tilbury and Gravesend sampling sites (R=-0.083, p>5%).

SIMPER analysis indicated that the relative abundance of common gobies was the predominant factor driving differences between surveys, accounting for more than 70% dissimilarity between surveys for almost all comparisons. The only exception was the comparison between May and February, where the differences were driven mainly by the abundance of European seabass.

3.3.2.3 Seine netting

The MDS plot indicated a general separation of the May and February samples from the August and October samples (Figure 11). The August samples had the widest dispersion of samples across the plot, suggesting a high degree of heterogeneity between samples, driven by low number of individuals in most samples.

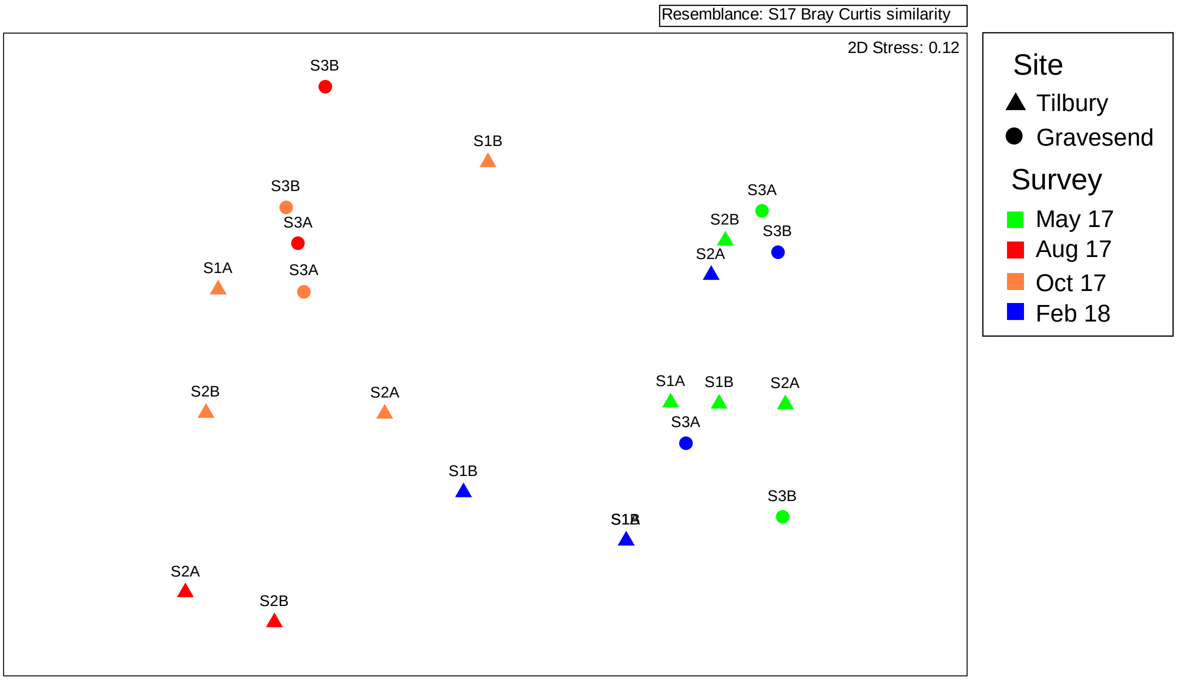

Figure 11: Multidimensional Scaling ordination plot based on the untransformed Seine net catch data across all surveys. The two different sites are distinguished by different symbols and survey months by colours.

The two-way ANOSIM test indicated that there were significant differences between surveys (R=0.537, p<5%). The pairwise tests indicated that differences between May and February and between August and October were not significant (p>5%) but all other pairings were significantly different (P<5%), with the largest difference between the May and October surveys (R=0.954). The results of the two-way test showed no significant differences between seine net samples collected at Tilbury and Gravesend sites (R=0.082, p>5%).

SIMPER analysis indicated that the relative abundance of common gobies was the predominant factor driving differences between surveys for all but one seine netting comparison. For the comparison between May and February the abundance of European seabass was the most important contributor to differences, and this was the second most important species (after common goby) in all other comparisons.

3.4 Fish length data

3.4.1 Subtidal surveys

The length range of fish caught during subtidal surveys (across beam, otter and pelagic trawls) is provided in Table 9.

Table 9: Length ranges of fish caught during subtidal surveys. NA = Not applicable.

Species	Fish Length (mm TL)				
	May	Aug	Oct	Feb	All surveys
Atlantic herring	29-152	54-112	49-164	25-306	25-306
Atlantic horse mackerel	NA	NA	85-130	NA	85-130
Bib/pouting	28-220	121-124	136-228	111-248	28-228
Black goby	65	NA	35-37	45-89	35-89
Brill	NA	NA	323	NA	323
Common goby	NA	15-75	27-50	42-47	15-75
Common sea snail	NA	NA	NA	106	106
Conger eel	NA	540	NA	NA	540
Dab	NA	NA	47-159	187	47-187
Dover sole	70-393	40-398	62-372	60-318	40-398
European anchovy	NA	54-67	66-114	NA	54-114
European flounder	83-343	39-343	60-323	70-327	39-343
European plaice	33-98	NA	55-225	NA	33-225
European seabass	380	33-150	85-102	60-205	33-380
European smelt	69-215	105-225	100-217	80-265	69-265
European sprat	46-112	26-81	47-108	35-143	26-143
Five-bearded rockling	NA	94	NA	NA	94
Greater pipefish	78-90	282	185	NA	78-282
Lesser sandeel	85-92	46-146	53-145	74-81	46-146
Lesser weever	95-135	NA	125	NA	95-135
Lesser/Nilsson's pipefish	NA	NA	72-85	NA	72-85
Pogge/hooknose	75-94	NA	54-111	117-119	54-119
Poor cod	NA	90	110	NA	90-110
River lamprey	135-180	157-198	NA	NA	135-198
Sand goby complex	24-85	12-78	26-189	29-84	12-189
Short-spined sea scorpion	NA	111	NA	NA	111
Striped red mullet	129	NA	91-412	NA	91-412
Thin-lipped grey mullet	NA	NA	NA	127-150	127-150
Thornback ray	425	NA	92-465	NA	92-465
Three-spined stickleback	43	NA	NA	NA	43
Transparent goby	26-65	NA	30-42	30-37	26-65
Tub Gurnard	107-493	150-260	237-327	NA	107-493
Whiting	108-390	NA	91-317	139-246	91-390

Length-frequency distribution data are provided below for the following key species: common goby, sand goby complex, Dover sole, flounder, plaice, European smelt, seabass, herring, whiting, sprat and lesser sand eel. It was considered that a minimum of ten individuals for a species were required to plot length frequency histograms.

Common goby individuals were larger and more abundant in October 2017 than in August 2017, with no individiduals caught in May 2017 and a few large individuals recorded in February 2018. For the sand goby complex individuals were present in very low numbers in May 2017 with high numbers in August 2017, October 2017 and February 2018 with largest mean size in October 2017 (Figure 12). For Dover sole peak abundance was in May 2017 dominated by juveniles (~80 to 120 mm TL). Relatively lower numbers of juveniles and adults were present in August and October 2017, with a small number of juveniles recorded in Febuary 2018. The size range of flounder was relatively consistent across the year with a smaller juvenile cohort present in August and October 2017 (Figure 13).

European plaice were primarily recorded in October 2017 with the size range of individuals present representing juveniles and adults. The smelt catch in May was dominated by juveniles (~20 to 125 mm TL) with lower numbers of individuals and a gradual increase in mean length in the August, October and February surveys (Figure 14). Seabass catch in subtidal samples was highest in February with juveniles and adults represented, but far more seabass were sampled during the intertidal survey than the subtidal survey (see Section 3.4.2), (Figure 15).

The size cohorts of Atlantic herring increased across the year with a small number of juveniles recorded in May 2017 (~20 to 30 mm TL), larger juveniles (mean size of ~100 mm) present in August and numbers of similar size individuals increasing greatly in October 2017. In Febuary 2018 small numbers of individuals were sampled across the full size range from ~20 mm to 300 mm (Figure 15).

For whiting a wide range of fish sizes were recorded in May 2017 with a peak around 180 mm TL, no individuals were recorded in August and individuals caught in October were larger than in May with peak numbers of fish in the size range of 230-270 mm TL and small numbers of fish in the range of 140 to 250 mm TL in February 2018. The majority of sprat were recorded in October 2017 and February 2018 with most individuals between 50 and 100 mm TL (Figure 16).

Sandeel was recorded in highest numbers in August and October 2017 with individuals ranging from 50 to 150 mm TL, only two individuals were recorded in May 2017 and February 2018 (Figure 17).

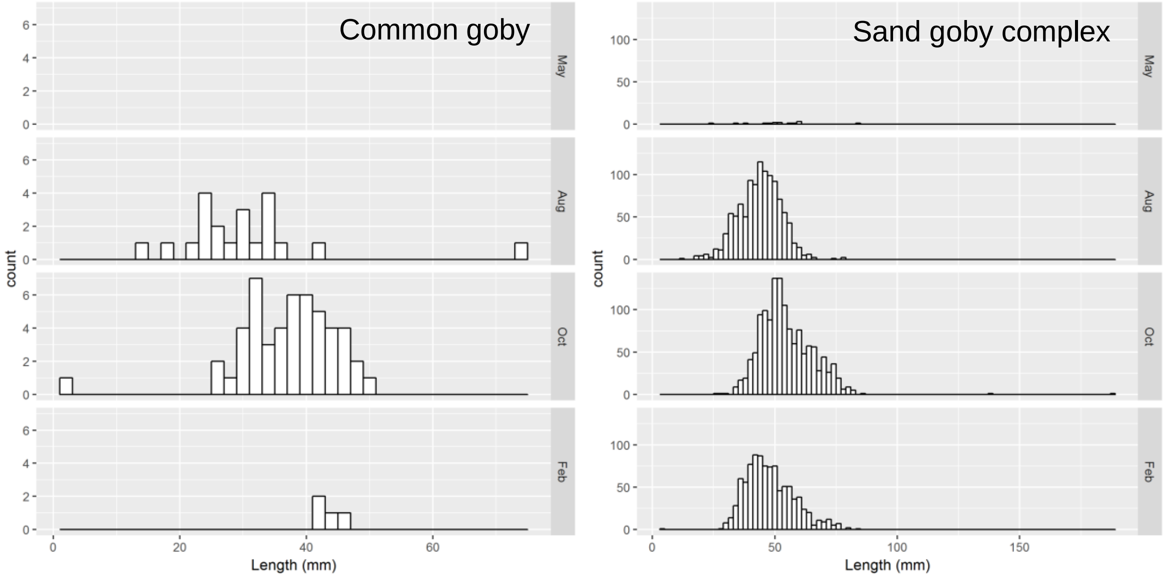

Figure 12: Total length (mm) - frequency histograms for common goby and sand goby complex from subtidal sampling (across beam, otter and pelagic trawls) during different surveys.

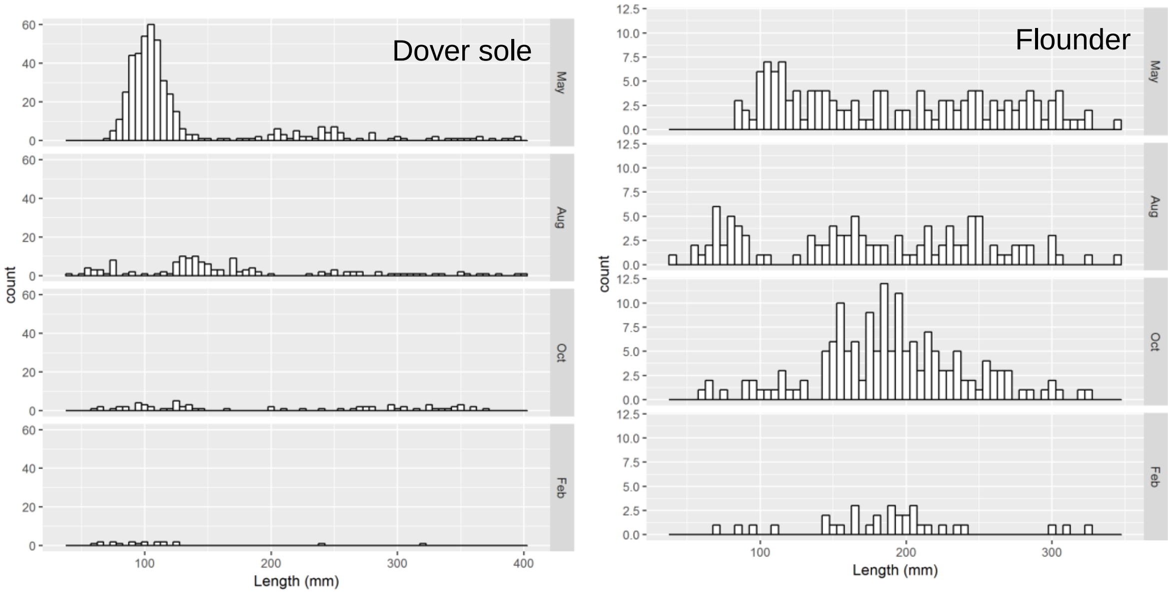

Figure 13: Total length (mm) - frequency histograms for Dover sole and flounder complex from subtidal sampling (across beam, otter and pelagic trawls) during different surveys.

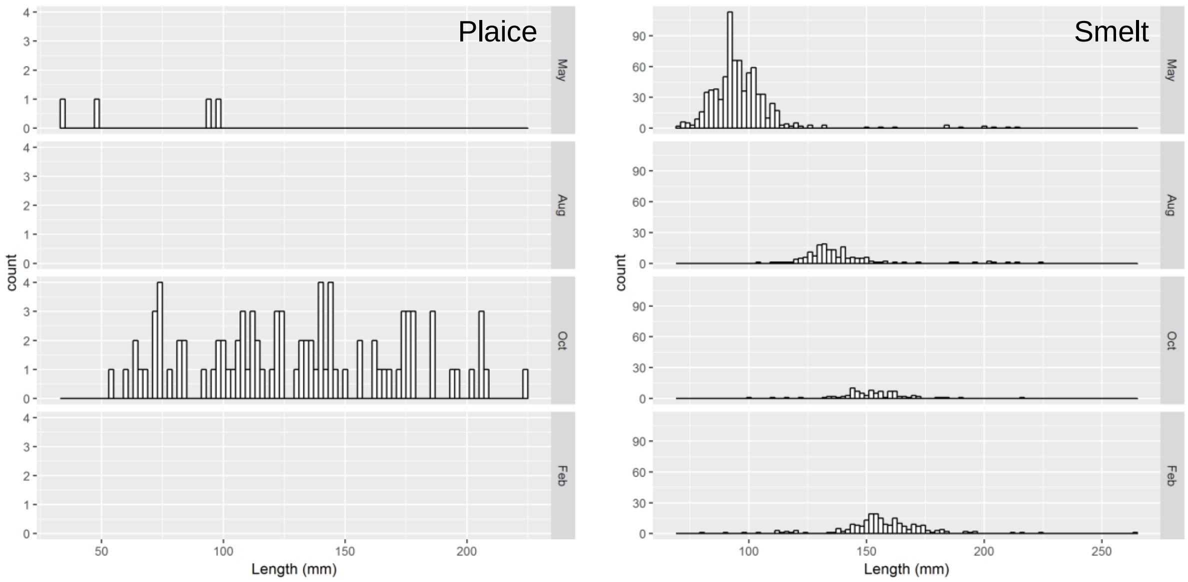

Figure 14: Total length (mm) - frequency histograms for plaice and smelt from subtidal sampling (across beam, otter and pelagic trawls) during different surveys.

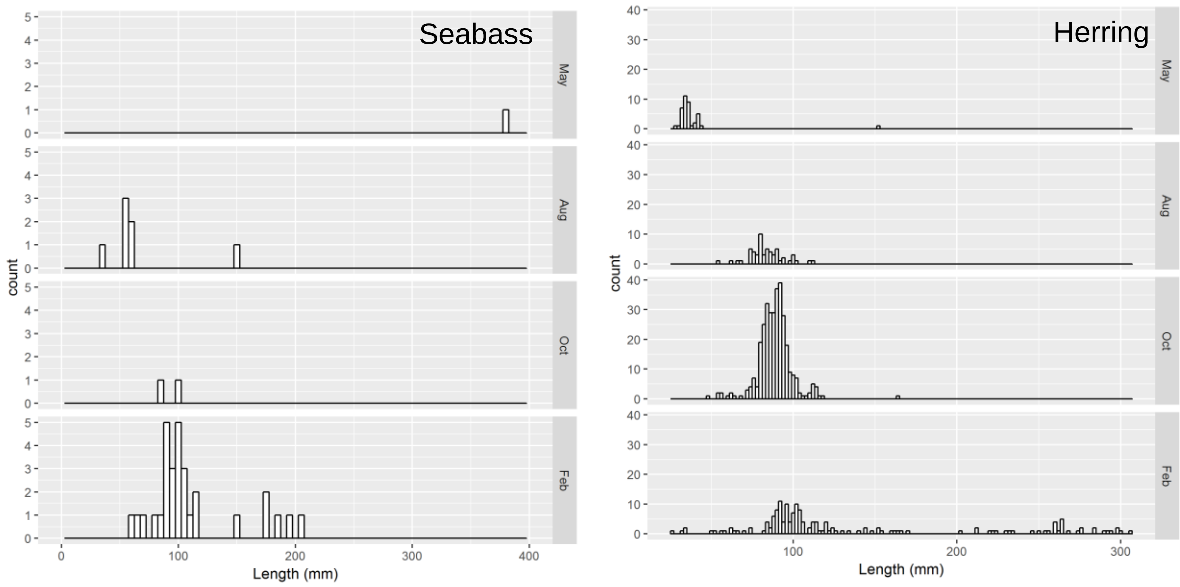

Figure 15: Total length (mm) - frequency histograms for seabass and herring from subtidal sampling (across beam, otter and pelagic trawls) during different surveys.

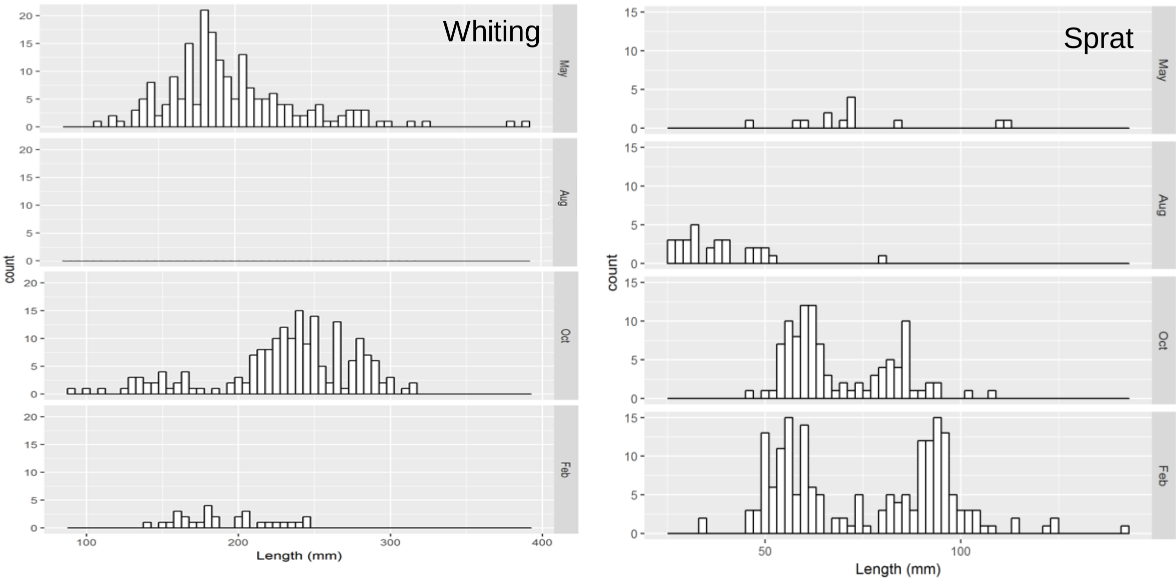

Figure 16: Total length (mm) - frequency histograms for whiting and sprat from subtidal sampling (across beam, otter and pelagic trawls) during different surveys.

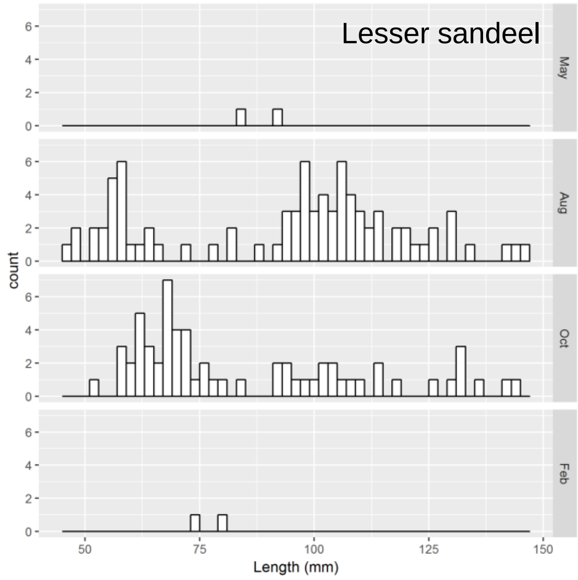

Figure 17: Total length (mm) - frequency histograms for lesser sandeel from subtidal sampling (across beam, otter and pelagic trawls) during different surveys.

3.4.2 Intertidal surveys

The length range of fish caught during intertidal surveys (across fyke, push and seine netting) is provided in Table 10.

Table 10: Length ranges of fish caught during intertidal surveys. NA = Not applicable.

Species	Fish length range (mm TL)					
	May	Aug	Oct	Dec	Feb	All surveys
Atlantic herring	NA	NA	NA	90	75-225	90
Bib/pouting	193	NA	NA	NA	163-172	163-193
Black goby	NA	34	NA	NA	NA	34
Common goby	48-70	11-60	15-80	NA	31-44	11-80
Dover sole	87-284	118-290	80-193	NA	NA	80-290
European eel	NA	300-510	310-590	NA	NA	300-590
European flounder	47-288	46-286	61-314	76-282	48-284	46-314
European plaice	NA	NA	NA	NA	108-109	108-109
European seabass	65-618	9-230	34-338	48-235	57-204	9-618
European smelt	63-221	175-194	93-190	108-202	79-184	63-221
European sprat	NA	NA	76-82	NA	64-204	76-204
Five-bearded rockling	NA	NA	NA	NA	184	184
Grey gurnard	NA	NA	NA	104	NA	104
Small-spotted catshark	NA	NA	505	NA	NA	505
Red gurnard	NA	NA	NA	99	NA	99
Sand goby	NA	36-70	35-78	82	70-85	35-85
Thin lipped grey mullet	23-491	NA	16-25	NA	122-145	16-491
Whiting	242	NA	142-285	121-280	111-285	111-285

The length-frequency distribution of the following species are provided below for common goby, sand goby, Dover sole, European flounder, European smelt, European seabass and whiting. Other species were not captured in sufficient numbers to develop length-frequency distributions.

No common gobies were recorded in May 2017 and in August 2017 a small number of individuals were caught including juveniles and adults. Peak abundance was in October/November 2017 with individuals recorded across the the full size range, and a very small number of larger individuals were recorded in December 2017 and February 2018 (Figure 18).

Sand gobies were most abundant in August and October/November 2017 with a larger size cohort in October/November 2017. No individuals were recorded in December 2017 with very low numbers of individuals present in February 2018 (Figure 18).

For Dover sole, a wide size range of individuals were present in small numbers in May, August and October/November 2017. No Dover sole were recorded in December 2017 or February 2018. European flounder were present throughout the year with the highest abundance recorded in May 2017 and the lowest abundance recorded in December 2017. For flounder a wide range of fish sizes were recorded each month although most were ~50mm-180 mm TL (Figure 19).

European smelt were caught in small numbers in May, August, October/November and December 2017, with a larger juvenile cohort present in May 2017. Smelt were most abundant in February 2018 with individuals sampled ranging from ~75 mm to 180 mm TL (Figure 20). European seabass were present in relatively high numbers across all sampling months with most individuals between the size of ~50 mm to 150 mm TL. The lowest number of seabass was recorded in August 2018 when a smaller size juvenile cohort was present compared to the other months (mainly ≤100 mm TL) (Figure 20).

For whiting, relatively low numbers of individuals were recorded in October/November 2017, December 2017 and February 2018 across a wide range of sizes. One whiting individual was recorded present in May 2017 and no individuals were recorded in August 2017 (Figure 21).

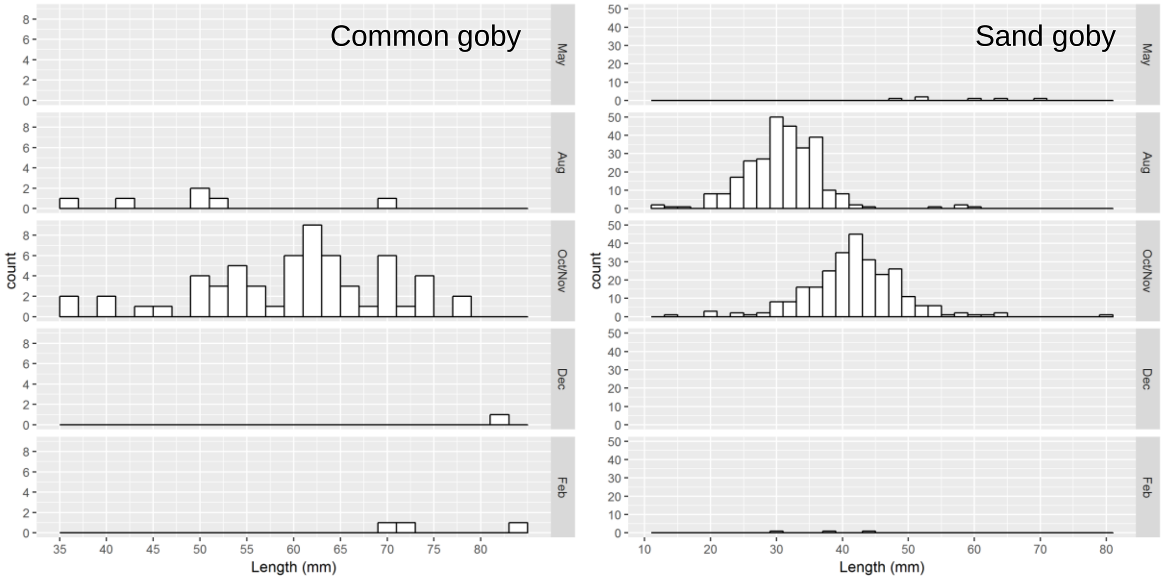

Figure 18: Total length (mm) - frequency histograms for common goby and sand goby from intertidal sampling (across fyke, seine and push nets) during different surveys.

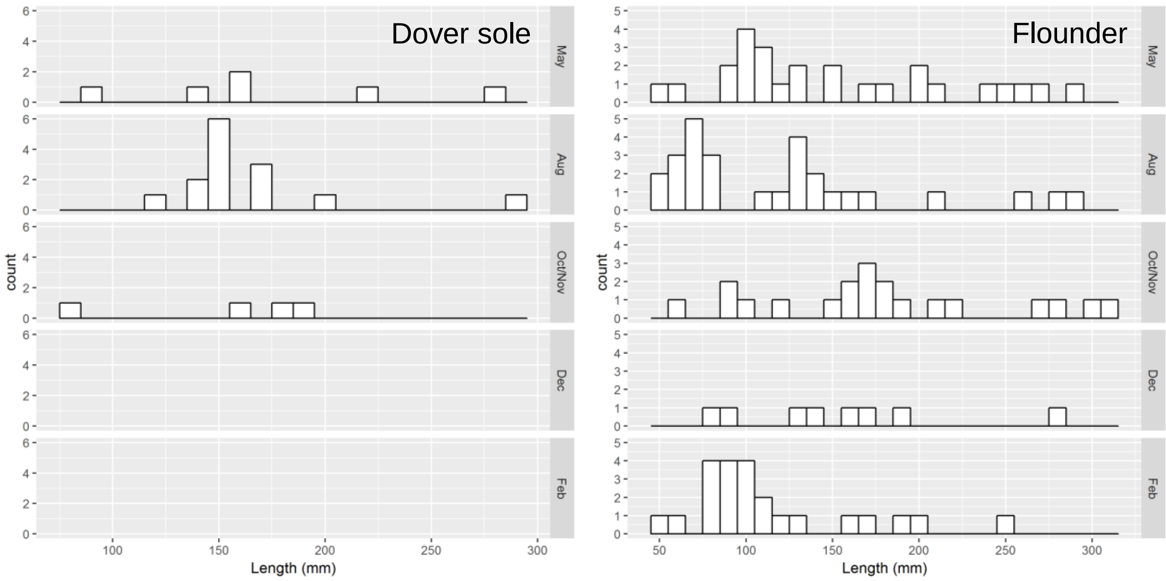

Figure 19: Total length (mm) - frequency histograms for Dover sole and European flounder from intertidal sampling (across fyke, seine and push nets) during different surveys.

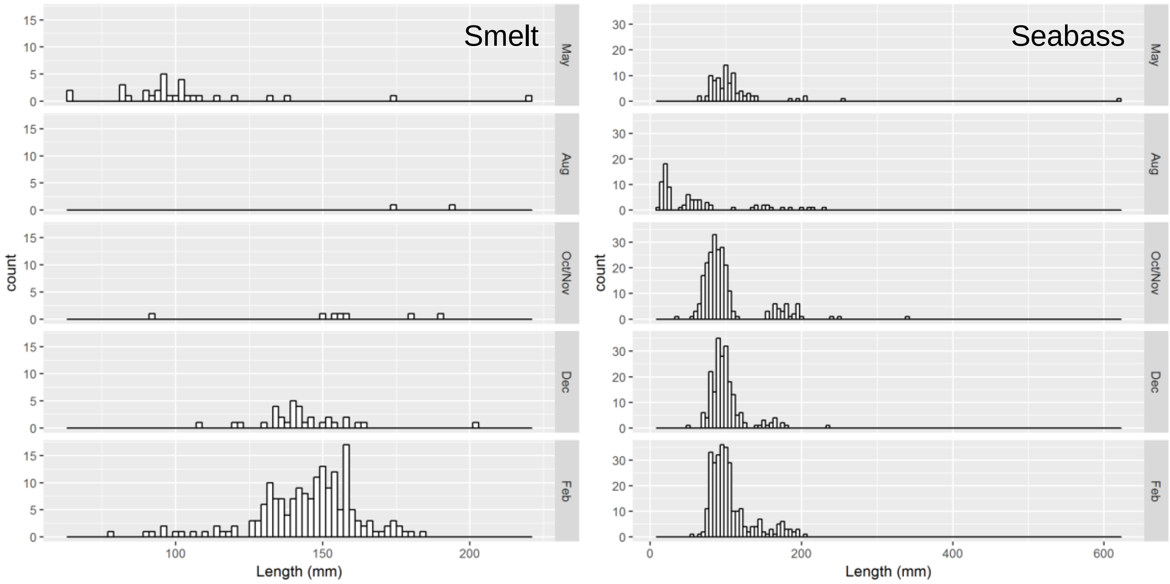

Figure 20: Total length (mm) - frequency histograms for European smelt and European seabass from intertidal sampling (across fyke, seine and push nets) during different surveys.

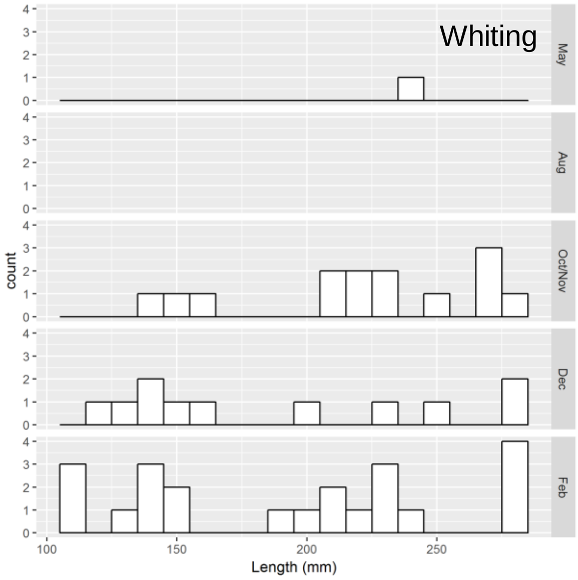

Figure 21: Figure: Total length (mm) - frequency histograms for whiting from intertidal sampling (across fyke, seine and push nets) during different surveys.

3.5 Invertebrate catch data

3.5.1 Subtidal invertebrate catch

A total of 22 invertebrate taxa were caught in the subtidal trawls samples, with highest numbers of taxa and individuals recorded in the August survey (Table 11). The brown shrimp *Crangon crangon* was the most abundant invertebrate taxon in all four surveys which is a commercially important invertebrate species.

Table 11: Invertebrate abundance in subtidal trawl surveys.

Common name	Species	May	Aug	Oct	Feb
Anemone	Actiniaria	6	15	12	0
European common squid	*Alloteuthis subulata*	0	1	0	0
Moon jellyfish	*Aurelia aurita*	0	216	0	0
Piddock	*Barnea*	0	4	1	0
Shore crab	*Carcinus maenas*	353	920	235	21
Brown shrimp	*Crangon crangon*	5100	57312	13548	2346
Comb jellies	Ctenophora	1635	234	73	0
Chinese mitten crab	*Eriocheir sinensis*	61	6	1	1
Gammarid shrimp	Gammaridae	4	37	0	12
Swimming crab	*Liocarcinus*	0	11	0	0
Baltic tellin	*Macoma balthica*	0	4	4	0
Spider crab	*Macropodia*	0	13	1	0
Opossum shrimp	Mysidae	174	1216	460	1644
Velvet swimming crab	*Necora puber*	1	0	0	0
Nereid polychaete	Nereididae		9	4	0
Palaemonid shrimp	*Palaemon*	280	0	0	0
Oriental shrimp	*Palaemon macrodactylus*	255	1757	1104	325
Common prawn	*Palaemon serratus*	9	11	25	0
Pink shrimp	*Pandalus montagui*		0	6	4
Pasiphaeid shrimp	Pasiphaeidae	1	0	0	0
European common cuttlefish	*Sepia officinalis*	0	5	0	0
Terebellid polychaete	Terebellidae	0	0	5	0

High numbers of the invasive oriental prawn *Palaemon macrodactylus* were recorded in the subtidal trawls. This non-native species was first recorded in the UK in 1992 and was abundant in the Thames by 2006 (Worsfold & Ashelby, 2008). All suspected *P. macrodactylus* specimens were returned to the laboratory for identification confirmation. The invasive Chinese mitten crab *Eriocheir sinensis* was also recorded in all four surveys, although highest abundances were recorded in the May 2017 trawls. All mitten crabs were euthanised on site and disposed of in accordance with the Wildlife and Countryside Act 1981. No mitten crabs were released back into the Thames.

3.5.2 Intertidal invertebrate catch

A total of ten taxa were recorded across all intertidal fish surveys and intertidal invertebrate catches were generally low (Figure 12). The shore crab, *Carcinus maenas*, was the most abundant invertebrate species, followed by the brown shrimp, *C. crangon*.

Table 12: Invertebrate abundance in intertidal trawl surveys.

Common name	Species	May	Aug	Oct	Dec	Feb
Brown Shrimp	*Crangon crangon*	9	8	12	0	8
Comb Jellies	Ctenophora	15	0	0	0	2
Common prawn	*Palaemon serratus*	0	1	7	0	0
Corophid	Corophiidae	0	1	0	0	0
Decapod megalopa	Decapoda	0	2	0	0	0
Moon jellyfish	*Aurelia aurita*	0	1	0	0	0
Opossum Shrimp	Mysidae	1	6	0	0	0
Oriental shrimp	*Palaemon macrodactylus*	0	1	0	0	0
Palaemonid shrimp	*Palaemon*	1	0	0	0	1
Shore Crab	*Carcinus maenas*	16	15	16	1	0

3.6 Water Quality data

Water temperature was consistent within each seasonal survey with a maximum within-survey variation of 2.6 °C during the May 2017 subtidal trawling (Tables 13 & 14). Mean water temperature for each survey was highest in August 2017 (high of 19.84°C during beam trawling) and lowest in February (lowest was 5.57 °C during beam trawling), (Figures 22 & 23). Salinity ranged from 12.74 to 25.98, with the lowest salinities recorded during the subtidal trawling in February 2018. Dissolved oxygen (DO) concentration ranged from 6.44 to 11.37 mg l^{-1} with highest concentrations during the February 2018 surveys and pH values varied little between and during surveys (Tables 13 & 14). The full water quality data set is provided in Appendix 3.

Table 13: Mean water quality parameters measured during subtidal fish surveys, May 2017 to February 2018.

Survey	Temp (°C)	DO (%)	DO (mg/l)	Specific conductance (S/cm)	Salinity	pH
May 2017 - Pelagic trawl	12.75	73.37	6.87	31836.20	19.86	7.77
May 2017 - Beam trawl	11.89	79.11	7.46	34339.36	21.56	7.82
May 2017 - Otter trawl	11.70	82.21	7.75	35095.00	22.08	7.75
August 2017 - Pelagic trawl	19.48	84.01	6.78	34273.60	21.59	7.72
August 2017 - Beam trawl	19.84	83.36	6.74	31578.50	19.71	7.69
August 2017 - Otter trawl	19.78	87.73	7.08	33280.20	20.89	7.73
October 2017 - Pelagic trawl	14.16	91.74	8.35	33100.40	20.75	7.81
October 2017 - Beam trawl	14.11	93.80	8.26	39279.50	25.06	7.90
October 2017 - Otter trawl	14.39	92.39	8.22	35334.60	22.30	7.85
February 2017 - Pelagic trawl	6.16	86.97	10.36	21433.10	12.74	7.85
February 2017 - Beam trawl	5.57	90.34	9.99	32475.60	19.85	7.92
February 2017 - Otter trawl	5.93	84.68	9.92	23432.30	13.97	7.87

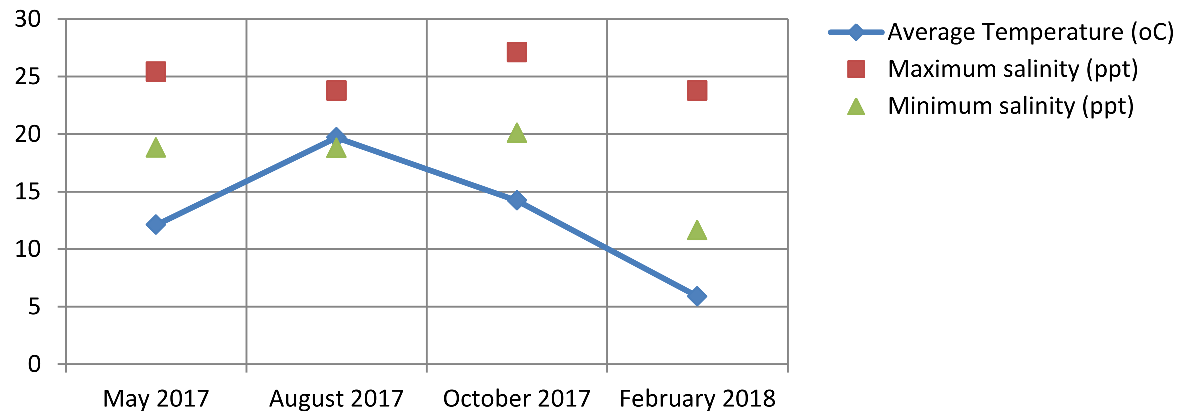

Figure 22: Average temperature with minimum and maximum salinity recorded during each subtidal fish survey, May 2017 to February 2018.

Table 14: Mean water quality parameters measured during intertidal fish surveys, May 2017 to February 2018 (NB pH recording was not functioning correctly during the October 2017 push netting survey and so no data was obtained).

Survey	Temp (oC)	DO (%)	DO (mg/l)	Specific conductance (S/cm)	Salinity	pH
May 2017 - Seine netting	13.13	94.77	8.74	29108.67	23.89	8.03
May 2017 - Push netting	13.70	95.36	8.49	27718.20	22.42	7.96
August 2017 - Seine netting	19.28	82.42	6.50	35640.17	25.61	7.85
August 2017 - Push netting	19.34	79.50	6.44	33402.40	23.72	7.72
October 2017 - Seine netting	14.62	80.04	6.94	32767.33	25.98	7.66
October 2017 - Push netting	14.38	80.42	6.94	32409.40	24.61	7.74
February 2018 - Seine netting	6.42	105.50	11.37	18918.00	19.18	8.31
February 2018 - Push netting	6.54	103.52	11.19	20679.20	19.19	8.47

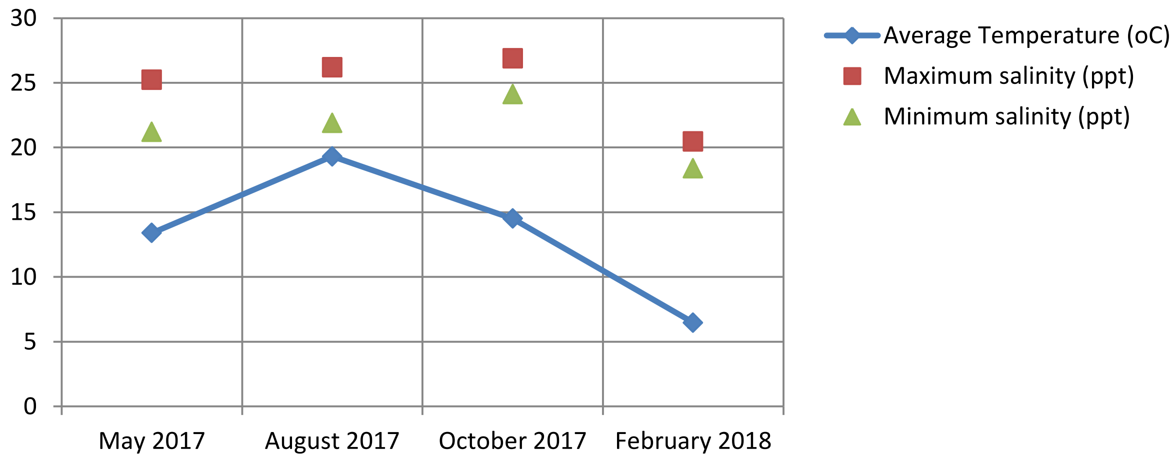

Figure 23: Average temperature with minimum and maximum salinity recorded during each intertidal fish survey, May 2017 to February 2018.

4. Summary and discussion

A subtidal fish survey was conducted in May, August, October 2017 and February 2018 using beam, otter and pelagic trawls for the TEC project. Intertidal sampling was conducted during the same months, with sampling at some additional stations in November and December 2017.

A total of 34 species were recorded across all gears during the subtidal trawling, and 16 species were recorded across all of the intertidal surveys. The species captured are characteristic of previous studies conducted within the Thames Estuary by the Environment Agency and RWE, as well as historic impingement monitoring at the site of the Tilbury B Power Station (RWE nPower 2012).

Species captured included European eel and river lamprey which are species of international conservation importance and European smelt which is a key protected species in the Thames Estuary. In addition may species of commercial importance were caught including European seabass, Dover sole and Atlantic herring, and a number of the commerical species are species of principal importance for biodiversity listed on the Section 41 list under the NERC Act.

Across the subtidal trawls the highest number of species was recorded in October 2017 (26 species) followed by the May 2017 survey (21 species), August 2017 survey (18 species) and February 2018 survey (17 species). A larger number of species may be present in the estuary in October due to overlap between species which seasonally migrate into or out of the estuary for the summer or winter, as well as the presence of larger juveniles of some species as they grow and mature in the Thames Estuary nursery ground after spawning. The number of species recorded in intertidal habitats, however, was relatively consistent with eight species recorded in May, August and October 2017 and ten species recorded in February 2018 (only including fyke stations 1-4 for comparative purposes).

Sand goby complex was the species caught in greatest numbers during the subtidal trawling, dominating the catches during each survey period apart from the spring surveys in May 2017. Of the 18,036 fish caught subtidally, 13,099 individuals belonged to the sand goby complex. The second most abundant species across all subtidal surveys was European smelt (1,465 individuals recorded in total) and individuals were predominantly juveniles. European smelt is known to reside within the Thames Estuary throughout the year from the juvenile stage through to maturity, seeking deeper, cooler water in the summer (Power & Attrill 2007), and a high abundance of this species was expected, with a skew towards the juvenile age-classes. Other species with hundreds of individuals caught included Dover sole, Atlantic herring, whiting, European flounder and European sprat.

The lower Thames Estuary is considered to be an important spawning ground and nursery area for Dover sole. The highest number of Dover sole were caught in the subtidal trawling in May 2017, which corresponds with the spawning period of this species in the Thames Estuary and with the migratory period as individuals move from deeper water into shallower water for the summer. Very few individuals were recorded during the winter, which is consistent with the understanding that this species seeks deeper waters at this time of year. Seasonally elevated numbers of clupeids (European sprat and Atlantic herring) were also caught during the winter, which corresponds with individuals utilising their nursery, spawning and wintering grounds near the coast, before moving back into deeper waters to feed in the summer.

Common goby was the species caught in greatest numbers during the intertidal netting (total of 572 individuals when including fyke stations 1-4 only). This species dominated the catches during the August and October 2017 survey periods, but was present in very low numbers during the May 2017 and February 2018 survey periods. This is expected as goby species spawn in the spring (Munk & Nielsen 2005), with adults generally dying after spawning. The results of icthyoplankton trawls conducted each month between May 2017 and April 2018 indicate that in June, July and August 2017 the number of common goby larvae in the water column was relatively high compared to other species which is consistent with higher numbers of juveniles caught in push and seine nets in August and October (APEM 2018). European seabass had the second highest abundance during the intertidal sampling (479 individuals when including fyke stations 1-4 only). This species was captured year-round, with the highest numbers recorded during the autumn and winter. The Thames Estuary is a nursery ground for European seabass with spawning occuring in the English Channel from February to June (ICES 2001). Therefore, 0-group and 1-group individuals are expected to be present in the Thames Estuary year-round and as they occupy the littoral zone abundances are expected to be higher within the intertidal samples than the subtidal samples. The size at maturity for sea bass in UK waters is estimated to be between 310-350 mm for males and 400 – 450 mm for females (95% confidence limit), (Pawson & Pickett 1996). Therefore only two of the individuals captured were likely to be mature and the population captured throughout the year both intertidally and subtidally consisted almost entirely of juveniles. The very high numbers of seabass individuals recorded in fyke nets at Stations 7 and 8 in December 2017 could partly be related to the habitat present at these stations (with the intertidal zone extending over a far greater distance than at the other stations), and to the time of the sampling as no other stations were sampled in December.

Invertebrate catches peaked during the summer, with very large abundances of brown shrimp dominating the August 2017 and October 2017 subtidal trawling catches. This was the only commercially important invertebrate caught in high numbers during the subtidal and intertidal surveys. Invasive non-native invertebrate species, such as the oriental shrimp and Chinese mitten crab, were also captured in during the surveys.

5. References

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APPENDICES

Appendix 1 Sampling positions

Subtidal Sampling Positions (all gear types)

Transect	Station	NGR	Latitude	Longitude
1	West	TQ6580075137	51.450944	0.384743
1	East	TQ6630375173	51.45112	0.391992
2	West	TQ6580574810	51.448005	0.384661
2	East	TQ6630674849	51.448209	0.391883

Intertidal Sampling Positions

Gear	Station	Location	NGR	Latitude	Longitude
Fyke	F1	Station furthers west	TQ6577775298	51.452397	0.38448729
Fyke	F2	Second station to the west.	TQ6588575301	51.452393	0.38604159
Fyke	F3	Second station to the east.	TQ6600675306	51.452402	0.38778376
Fyke	F4	Station near east end of jetty	TQ6608675319	51.452496	0.38894015
Fyke	F5	Current outfall (upper)	TQ6635975344	51.45264	0.39287726
Fyke	F6	Current outfall (lower)	TQ6637975313	51.452356	0.39315027
Fyke	F7	Option 7 intake location (upper)	TQ6666375461	51.453602	0.39730345
Fyke	F8	Option 7 intake location (lower)	TQ6672675355	51.452631	0.3981594
Seine	S1	North bank western-most station	TQ6594575334	51.452672	0.38691978
Seine	S2	North bank eastern-most station	TQ6582075330	51.452672	0.38512056
Seine	S3	South bank station	TQ6668574327	51.443408	0.39708604
Push	P1	North bank station closest to development	TQ6722675537	51.454119	0.40543465
Push	P2	North bank central station	TQ6735775578	51.454448	0.40733768
Push	P3	North bank eastern-most station	TQ6661074324	51.443403	0.39600644
Push	P4	South bank western-most station	TQ6675374327	51.443388	0.39806359
Push	P5	South bank eastern-most station	TQ6748475625	51.454833	0.40918606

Appendix 2 SIMPER values

Subtidal trawls

Beam Trawls

Test	R Statistic	Significance (%)	Possible Permutations	Actual Permutations	Number ≥ observed
Global test	**0.666**	**0.1**	**Very large**	**999**	**0**
Pairwise tests:					
May 17, Aug 17	0.876	0.1	92378	999	0
May 17, Oct 17	0.901	0.1	92378	999	0
May 17, Feb 18	0.786	0.1	92378	999	0
Aug 17, Oct 17	0.423	0.1	92378	999	0
Aug 17, Feb 18	0.612	0.1	92378	999	0
Oct 17, Feb 18	0.598	0.1	92378	999	0

SIMPER results for within group similarity:

May 17 Average similarity 47.74 Species	Mean Abundance	Mean Similarity	Sim/SD	Contribution %	Cumulative %
Solea solea	3.94	29.07	2.57	60.90	60.90
Osmerus operlanus	1.45	10.49	1.15	21.98	82.88
Merlangius merlangus	0.68	4.57	0.66	9.57	92.45
Aug 17 Average similarity 60.29 Species	**Mean Abundance**	**Mean Similarity**	**Sim/SD**	**Contribution %**	**Cumulative %**
Pomatoschistus minutus complex	9.56	39.38	2.69	65.31	65.31
Pomatoschistus microps	1.91	6.49	1.01	10.76	76.08
Solea solea	1.42	4.98	0.81	8.25	84.33
Platichthys flesus	1.01	4.37	1.17	7.24	91.57
Oct 17 Average similarity 57.58 Species	**Mean Abundance**	**Mean Similarity**	**Sim/SD**	**Contribution %**	**Cumulative %**
Pomatoschistus minutus complex	5.38	26.68	3.99	46.34	46.34
Pleuronectes platessa	1.82	7.42	1.61	12.89	59.23
Solea solea	1.37	4.51	1.12	7.84	67.07
Pomatoschistus microps	1.47	4.46	0.87	7.75	74.82
Ammodytes tobianus	1.63	4.21	0.61	7.31	82.13
Limanda limanda	0.96	3.17	0.89	5.5	87.63
Feb 18 Average similarity 38.63 Species	**Mean Abundance**	**Mean Similarity**	**Sim/SD**	**Contribution %**	**Cumulative %**
Pomatoschistus minutus complex	2.61	30.19	1.68	78.13	78.13
Clupea harengus	0.48	2.45	0.37	6.33	84.46
Sprattus sprattus	0.51	2.08	0.38	5.39	89.85

SIMPER results for between-group similarity

May 17 & Aug 17 Average dissimilarity 78.87 Species	Mean Abundance May 17	Mean Abundance Aug 17	Mean Similarity	Sim/SD	Contribution %	Cumulative %
Pomatoschistus minutus complex	0.1	9.56	36.87	2.79	46.75	46.75
Solea solea	3.94	1.42	10.81	1.35	13.71	60.45
Pomatoschistus microps	0	1.91	7.88	1.36	10	70.45
Ammodytes tobianus	0.1	1.61	6.22	0.83	7.89	78.34
Osmerus eperlanus	1.45	1.05	4.79	1.22	6.08	84.42
May 17 & Oct 17 Average dissimilarity 79.50 Species	**Mean Abundance May 17**	**Mean Abundance Oct 17**	**Mean Similarity**	**Sim/SD**	**Contribution %**	**Cumulative %**
Pomatoschistus minutus complex	0.1	5.38	21.31	3.59	26.8	26.8
Solea solea	3.94	1.37	10.61	1.26	13.35	40.15
Ammodytes tobianus	0.1	1.63	6.6	1.03	8.31	48.45
Pleuronectes platessa	0.3	1.82	6.55	1.57	8.23	56.69
Pomatoschistus microps	0	1.47	5.92	1.28	7.44	64.13
Osmerus eperlanus	1.45	0.3	5.04	1.5	6.34	70.47
Aug 17 & Oct 17 Average dissimilarity 51.05 Species	**Mean Abundance Aug 17**	**Mean Abundance Oct 17**	**Mean Similarity**	**Sim/SD**	**Contribution %**	**Cumulative %**
Pomatoschistus minutus complex	9.56	5.38	14.08	1.46	27.58	27.58
Ammodytes tobianus	1.61	1.63	5.71	1.14	11.18	38.76
Pleuronectes platessa	0	1.82	5.55	1.86	10.88	49.63
Pomatoschistus microps	1.91	1.47	4.42	1.33	8.66	58.29
Solea solea	1.42	1.37	3.67	1.29	7.18	65.47
Limanda limanda	0	0.96	2.93	1.32	5.73	71.2
Osmerus eperlanus	1.05	0.3	2.89	1.1	5.66	76.86
Platichthys flesus	1.01	1.03	2.77	1.4	5.43	82.3
May 17 & Feb 18 Average dissimilarity 83.75 Species	**Mean Abundance May 17**	**Mean Abundance Feb 18**	**Mean Similarity**	**Sim/SD**	**Contribution %**	**Cumulative %**
Solea solea	3.94	0.42	24.29	1.75	29	29
Pomatoschistus minutus complex	0.1	2.61	18.29	1.9	21.84	50.84
Osmerus eperlanus	1.45	0.34	9.18	1.41	10.96	61.79
Merlangius merlangus	0.68	0.24	5.26	1.03	6.28	68.07
Platichthys flesus	0.64	0.2	4.46	0.96	5.32	73.39
Aug 17 & Feb 18 Average dissimilarity 79.50 Species	**Mean Abundance Aug 17**	**Mean Abundance Feb 18**	**Mean Similarity**	**Sim/SD**	**Contribution %**	**Cumulative %**
Pomatoschistus minutus complex	9.56	2.61	29.77	1.83	42.89	42.89
Pomatoschistus microps	1.91	0.2	8.2	1.32	11.82	54.72
Ammodytes tobianus	1.61	0.1	6.86	0.83	9.89	64.6
Solea solea	1.42	0.42	6.64	1.14	9.57	74.17
Platichthys flesus	1.01	0.2	4.43	1.26	6.39	80.56
Osmerus eperlanus	1.05	0.34	4.39	1.08	6.32	86.88
Oct17 & Feb 18 Average dissimilarity 79.50 Species	**Mean Abundance Oct 17**	**Mean Abundance Feb 18**	**Mean Similarity**	**Sim/SD**	**Contribution %**	**Cumulative %**
Pomatoschistus minutus complex	5.38	2.61	13.3	1.65	19.84	19.84
Pleuronectes platessa	1.82	0	8.17	1.88	12.19	32.03
Ammodytes tobianus	1.63	0.1	7.29	1.04	10.87	42.9
Pomatoschistus microps	1.47	0.2	6.15	1.28	9.18	52.08
Solea solea	1.37	0.42	5.42	1.3	8.08	60.16
Platichthys flesus	1.03	0.2	4.34	1.17	6.47	66.62
Limanda limanda	0.96	0	4.3	1.33	6.42	73.04

Otter Trawls

Test	R Statistic	Significance (%)	Possible Permutations	Actual Permutations	Number ≥ observed
Global test	**0.782**	**0.1**	**Very large**	**999**	**0**
Pairwise tests:					
May 17, Aug 17	0.903	0.1	92378	999	0
May 17, Oct 17	0.945	0.1	92378	999	0
May 17, Feb 18	0.897	0.1	92378	999	0
Aug 17, Oct 17	0.669	0.1	92378	999	0
Aug 17, Feb 18	0.529	0.1	92378	999	0
Oct 17, Feb 18	0.764	0.1	92378	999	0

SIMPER results for within-group similarity

May 17 **Average similarity 63.97** **Species**	**Mean Abundance**	**Mean Similarity**	**Sim/SD**	**Contribution %**	**Cumulative %**
Osmerus eperlanus	5.38	16.68	3.04	26.07	26.07
Solea solea	5.08	13.76	1.65	21.51	47.58
Merlangius merlangus	3.74	11.28	2.65	17.64	65.22
Platichthys flesus	3.08	10.84	4.02	16.94	82.16
Trisopterus luscus	1.4	5.05	3.86	7.89	90.05
Aug 17 **Average similarity 62.10** **Species**	**Mean Abundance**	**Mean Similarity**	**Sim/SD**	**Contribution %**	**Cumulative %**
Pomatoschistus minutus complex	14.62	32.34	2.85	52.08	52.08
Osmerus eperlanus	3.34	9.25	2.89	14.89	66.98
Platichthys flesus	2.67	8.33	2.86	13.42	80.4
Solea solea	2.7	7.15	1.13	11.51	91.9
Oct 17 **Average similarity 68.94** **Species**	**Mean Abundance**	**Mean Similarity**	**Sim/SD**	**Contribution %**	**Cumulative %**
Pomatoschistus minutus complex	10.72	21.86	4.61	31.7	31.7
Merlangius merlangus	3.38	8.81	5.79	12.78	44.48
Platichthys flesus	3.42	7.64	3.03	11.08	55.56
Pleuronectes platessa	2.21	5.23	3.06	7.58	63.14
Solea solea	1.85	4.14	1.56	6.01	69.15
Clupea harengus	2.02	3.87	1.73	5.61	74.76
Osmerus eperlanus	1.66	3.65	1.85	5.29	80.05
Trisopterus luscus	1.67	3.55	1.74	5.15	85.2
Feb 18 **Average similarity 63.04** **Species**	**Mean Abundance**	**Mean Similarity**	**Sim/SD**	**Contribution %**	**Cumulative %**
Pomatoschistus minutus complex	6.68	19.99	1.78	31.71	31.71
Osmerus eperlanus	3.26	14.99	4.33	23.78	55.49
Sprattus sprattus	2.4	9.38	2.56	14.88	70.37
Platichthys flesus	1.5	5.97	3.72	9.47	79.84
Clupea harengus	1.36	5.48	1.8	8.69	88.54

SIMPER results for between group similarity

May 17 & Aug 17 Average dissimilarity 63.37 Species	Mean Abundance May 17	Mean Abundance Aug 17	Mean Similarity	Sim/SD	Contribution %	Cumulative %
Pomatoschistus minutus complex	0.67	14.62	24.93	2.35	39.35	39.35
Merlangius merlangus	3.74	0	7.45	1.96	11.75	51.1
Solea solea	5.08	2.7	6.33	1.35	9.99	61.09
Osmerus eperlanus	5.38	3.34	5.26	1.05	8.31	69.4
May 17 & Oct 17 Average dissimilarity 57.29 Species	**Mean Abundance May 17**	**Mean Abundance Oct 17**	**Mean Similarity**	**Sim/SD**	**Contribution %**	**Cumulative %**
Pomatoschistus minutus complex	0.67	10.72	16.49	2.35	28.78	28.78
Osmerus eperlanus	5.38	1.66	6.44	1.42	11.24	40.02
Solea solea	5.08	1.85	5.77	1.23	10.07	50.09
Pleuronectes platessa	0	2.21	3.81	3.21	6.65	56.74
Clupea harengus	1.04	2.02	2.88	1.49	5.03	61.77
Aug 17 & Oct 17 Average dissimilarity 48.99 Species	**Mean Abundance Aug 17**	**Mean Abundance Oct 17**	**Mean Similarity**	**Sim/SD**	**Contribution %**	**Cumulative %**
Pomatoschistus minutus complex	14.62	10.72	12.32	1.41	25.15	25.15
Merlangius merlangus	0	3.38	5.48	4.66	11.19	36.34
Pleuronectes platessa	0	2.21	3.61	2.83	7.37	43.71
Osmerus eperlanus	3.34	1.66	2.77	1.51	5.66	49.37
Solea solea	2.7	1.85	2.65	1.63	5.41	54.78
Ammodytes tobianus	1.65	1.13	2.58	1.19	5.26	60.04
Clupea harengus	0.67	2.02	2.51	1.28	5.12	65.15
Trisopterus luscus	0.2	1.67	2.45	1.86	5	70.16
May 17 & Feb 18 Average dissimilarity 61.00 Species	**Mean Abundance May 17**	**Mean Abundance Feb 18**	**Mean Similarity**	**Sim/SD**	**Contribution %**	**Cumulative %**
Pomatoschistus minutus complex	0.67	6.68	13.21	1.58	21.66	21.66
Solea solea	5.08	0.81	10.22	1.42	16.76	38.41
Merlangius merlangus	3.74	1.1	6.34	1.43	10.4	48.81
Osmerus eperlanus	5.38	3.26	5.69	0.99	9.32	58.13
Sprattus sprattus	0.1	2.4	5.39	2.23	8.84	66.97
Platichthys flesus	3.08	1.5	4.07	1.86	6.67	73.64
Aug 17 & Feb 18 Average dissimilarity 50.87 Species	**Mean Abundance Aug 17**	**Mean Abundance Feb 18**	**Mean Similarity**	**Sim/SD**	**Contribution %**	**Cumulative %**
Pomatoschistus minutus complex	14.62	6.68	18.83	1.52	37.03	37.03
Solea solea	2.7	0.81	5.1	1.3	10.02	47.04
Sprattus sprattus	0.1	2.4	5.09	1.97	10.01	57.05
Ammodytes tobianus	1.65	0.1	3.31	0.97	6.51	63.57
Platichthys flesus	2.67	1.5	3.09	1.45	6.08	69.65
Merlangius merlangus	0	1.1	2.55	0.98	5.01	74.65
Oct17 & Feb 18 Average dissimilarity 50.24 Species	**Mean Abundance Oct 17**	**Mean Abundance Feb 18**	**Mean Similarity**	**Sim/SD**	**Contribution %**	**Cumulative %**
Pomatoschistus minutus complex	10.72	6.68	10.83	1.3	21.55	21.55
Merlangius merlangus	3.38	1.1	4.21	2.07	8.37	29.92
Pleuronectes platessa	2.21	0	4.15	3.01	8.27	38.19
Platichthys flesus	3.42	1.5	3.89	1.47	7.74	45.93
Osmerus eperlanus	1.66	3.26	3.03	1.77	6.03	51.96
Sprattus sprattus	1.34	2.4	2.81	1.27	5.6	57.56
Solea solea	1.85	0.81	2.54	1.34	5.05	62.61

Pelagic Trawls

Test	R Statistic	Significance (%)	Possible Permutations	Actual Permutations	Number ≥ observed
Global test	**0.76**	**0.1**	**Very large**	**999**	**0**
Pairwise tests:					
May 17, Aug 17	0.996	0.1	92378	999	0
May 17, Oct 17	0.997	0.1	92378	999	0
May 17, Feb 18	0.984	0.1	92378	999	0
Aug 17, Oct 17	0.551	0.1	92378	999	0
Aug 17, Feb 18	0.636	0.1	92378	999	0
Oct 17, Feb 18	0.749	0.1	92378	999	0

SIMPER results for within-group similarity

May 17 Average similarity 60.01 Species	Mean Abundance	Mean Similarity	Sim/SD	Contribution %	Cumulative %
Osmerus eperlanus	7.27	38.68	3.71	64.46	64.46
Aphia minuta	1.97	6.91	1.03	11.51	75.97
Sprattus sprattus	0.92	4.34	1.15	7.23	83.19
Aug 17 Average similarity 64.39 Species	**Mean Abundance**	**Mean Similarity**	**Sim/SD**	**Contribution %**	**Cumulative %**
Pomatoschistus minutus complex	12.75	46.63	3.83	72.43	72.43
Clupea harengus	1.91	6.56	1.36	10.19	82.62
Osmerus eperlanus	1.52	5.51	1.19	8.56	91.18
Oct 17 Average similarity 68.06 Species	**Mean Abundance**	**Mean Similarity**	**Sim/SD**	**Contribution %**	**Cumulative %**
Pomatoschistus minutus complex	17.8	30.63	2.56	45.01	45.01
Clupea harengus	4.96	11.53	3.45	16.94	61.95
Merlangius merlangus	2.52	6.59	3.84	9.69	71.64
Sprattus sprattus	2.49	5.22	3.37	7.67	79.31
Osmerus eperlanus	2.18	4.92	5.04	7.23	86.54
Engraulis encrasicolus	1.83	3.98	3.73	5.85	92.39
Feb 18 Average similarity 78.16 Species	**Mean Abundance**	**Mean Similarity**	**Sim/SD**	**Contribution %**	**Cumulative %**
Pomatoschistus minutus complex	6.87	31.15	5.05	39.85	39.85
Clupea harengus	3.54	15.64	3.42	20.01	59.86
Sprattus sprattus	3.27	15.41	4.65	19.71	79.57
Osmerus eperlanus	3	12.65	5.62	16.19	95.76

SIMPER results for between group similarity

May 17 & Aug 17 Average dissimilarity 79.34 Species	Mean Abundance May 17	Mean Abundance Aug 17	Mean Similarity	Sim/SD	Contribution %	Cumulative %
Pomatoschistus minutus complex	0.4	12.75	34.55	3.24	43.55	43.55
Osmerus eperlanus	7.27	1.52	16.89	2.22	21.29	64.84
Aphia minuta	1.97	0	5.9	1.2	7.44	72.28
Clupea harengus	0.68	1.91	4.56	1.09	5.74	78.03
May 17 & Oct 17 Average dissimilarity 74.78 Species	**Mean Abundance May 17**	**Mean Abundance Oct 17**	**Mean Similarity**	**Sim/SD**	**Contribution %**	**Cumulative %**
Pomatoschistus minutus complex	0.4	17.8	31.74	2.49	42.45	42.45
Osmerus eperlanus	7.27	2.18	10.71	1.73	14.33	56.77
Clupea harengus	0.68	4.96	8.65	2.59	11.57	68.34
Aug 17 & Oct 17 Average dissimilarity 47.49 Species	**Mean Abundance Aug 17**	**Mean Abundance Oct 17**	**Mean Similarity**	**Sim/SD**	**Contribution %**	**Cumulative %**

Pomatoschistus minutus complex	12.75	17.8	17.55	1.48	36.94	36.94
Clupea harengus	1.91	4.96	5.66	1.8	11.92	48.87
Merlangius merlangus	0	2.52	4.85	3.43	10.21	59.07
Sprattus sprattus	0.8	2.49	4.05	2.34	8.52	67.6
Engraulis encrasicolus	0.2	1.83	3.02	2.22	6.35	73.95
Pomatoschistus microps	0.1	1.35	2.51	1.63	5.29	79.23
May 17 & Feb 18 Average dissimilarity 67.79 Species	**Mean Abundance May 17**	**Mean Abundance Feb 18**	**Mean Similarity**	**Sim/SD**	**Contribution %**	**Cumulative %**
Pomatoschistus minutus complex	0.4	6.87	19.56	3.55	28.85	28.85
Osmerus eperlanus	7.27	3	12.85	1.76	18.95	47.8
Clupea harengus	0.68	3.54	8.91	2.07	13.14	60.94
Sprattus sprattus	0.92	3.27	7.31	2.22	10.78	71.72
Aphia minuta	1.97	0.3	5.38	1.18	7.93	79.65
Aug 17 & Feb 18 Average dissimilarity 42.50 Species	**Mean Abundance Aug 17**	**Mean Abundance Feb 18**	**Mean Similarity**	**Sim/SD**	**Contribution %**	**Cumulative %**
Pomatoschistus minutus complex	12.75	6.87	15.86	1.49	37.32	37.32
Sprattus sprattus	0.8	3.27	7.97	2.08	18.74	56.06
Clupea harengus	1.91	3.54	5.06	1.41	11.91	67.97
Osmerus eperlanus	1.52	3	4.24	1.36	9.97	77.94
Platichthys flesus	1.13	0.14	2.89	1.57	6.79	84.73
Dicentrarchus labrax	0.4	0.94	2.12	1.25	4.99	89.72
Oct17 & Feb 18 Average dissimilarity 43.94 Species	**Mean Abundance Oct 17**	**Mean Abundance Feb 18**	**Mean Similarity**	**Sim/SD**	**Contribution %**	**Cumulative %**
Pomatoschistus minutus complex	17.8	6.87	18.22	1.3	41.46	41.46
Merlangius merlangus	2.52	0.17	4.55	2.83	10.35	51.81
Clupea harengus	4.96	3.54	3.61	1.61	8.21	60.02
Engraulis encrasicolus	1.83	0	3.35	3.65	7.63	67.65
Pomatoschistus microps	1.35	0	2.64	1.79	6	73.65
Sprattus sprattus	2.49	3.27	2.5	1.05	5.69	79.34
Osmerus eperlanus	2.18	3	2.42	1.11	5.51	84.85

Intertidal netting

Push netting

May 17 Average similarity: 39.10 Species	Mean Abundance	Mean Similarity	Sim/SD	Contribution %	Cumulative %
European sea bass	0.24	37.1	2.86	94.88	94.88
Aug 17 Average similarity: 78.14 Species	**Mean Abundance**	**Mean Similarity**	**Sim/SD**	**Contribution %**	**Cumulative %**
Common Goby	7.65	73.44	7.37	93.99	93.99
Oct 17 Average similarity: 55.78 Species	**Mean Abundance**	**Mean Similarity**	**Sim/SD**	**Contribution %**	**Cumulative %**
Common Goby	5	53.51	4.08	95.93	95.93
Feb 18 Average similarity: 54.22 Species	**Mean Abundance**	**Mean Similarity**	**Sim/SD**	**Contribution %**	**Cumulative %**
European sea bass	0.48	54.22	2.84	100	100

SIMPER results for between-group similarity

May 17 & Aug 17 Average dissimilarity = 92.58 Species	Mean Abundance May 17	Mean Abundance Aug 17	Mean Similarity	Sim/SD	Contribution %	Cumulative %
Common Goby	0.08	7.65	86.01	11.04	92.9	92.9
May 17 & Oct 17 Average dissimilarity 57.29 Species	**Mean Abundance May 17**	**Mean Abundance Oct 17**	**Mean Similarity**	**Sim/SD**	**Contribution %**	**Cumulative %**
Common Goby	0.08	5	76.22	4.76	80.17	80.17
Sand Goby	0	0.72	11.18	0.73	11.76	91.93
Aug 17 & Oct 17 Average dissimilarity = 37.62 Species	**Mean Abundance Aug 17**	**Mean Abundance Oct 17**	**Mean Similarity**	**Sim/SD**	**Contribution %**	**Cumulative %**
Common Goby	7.65	5	26.8	1.47	71.24	71.24
Sand Goby	0.07	0.72	5.16	0.73	13.71	84.95
European sea bass	0.56	0.05	4.01	1.16	10.66	95.61
May 17 & Feb 18 Average dissimilarity = 52.41 Species	**Mean Abundance May 17**	**Mean Abundance Feb 18**	**Mean Similarity**	**Sim/SD**	**Contribution %**	**Cumulative %**
European sea bass	0.24	0.48	34.73	1.51	66.26	66.26
Common Goby	0.08	0.03	7.45	0.6	14.21	80.47
Flounder	0.04	0	5.34	0.71	10.18	90.65
Aug 17 & Feb 18 Average dissimilarity = 90.94 Species	**Mean Abundance Aug 17**	**Mean Abundance Feb 18**	**Mean Similarity**	**Sim/SD**	**Contribution %**	**Cumulative %**
Common Goby	7.65	0.03	85.3	11.48	93.8	93.8
Oct17 & Feb 18 Average dissimilarity = 97.40 Species	**Mean Abundance Oct 17**	**Mean Abundance Feb 18**	**Mean Similarity**	**Sim/SD**	**Contribution %**	**Cumulative %**
Common Goby	5	0.03	75.31	4.95	77.32	77.32
Sand Goby	0.72	0.01	11.03	0.74	11.32	88.64
European sea bass	0.05	0.48	8.11	1.12	8.32	96.96

Seine netting

May 17 Average similarity: 50.08 Species	Mean Abundance	Mean Similarity	Sim/SD	Contribution %	Cumulative %
European sea bass	3	39.45	2.04	78.78	78.78
European Smelt	1.33	9.74	0.63	19.44	98.22
Aug 17 Average similarity: 19.72 Species	**Mean Abundance**	**Mean Similarity**	**Sim/SD**	**Contribution %**	**Cumulative %**
Common Goby	7.2	16.08	0.7	81.53	81.53
European sea bass	0.6	3	0.51	15.2	96.73
Oct 17 Average similarity: 55.99 Species	**Mean Abundance**	**Mean Similarity**	**Sim/SD**	**Contribution %**	**Cumulative %**
Common Goby	5.17	51.31	2.9	91.64	91.64
Feb 18 Average similarity: 44.71 Species	**Mean Abundance**	**Mean Similarity**	**Sim/SD**	**Contribution %**	**Cumulative %**
European sea bass	2.6	44.71	2.66	100	100

SIMPER results for between group similarity

May 17 & Aug 17 Average dissimilarity = 86.56 Species	Mean Abundance May 17	Mean Abundance Aug 17	Mean Similarity	Sim/SD	Contribution %	Cumulative %
Common Goby	0	7.2	34.07	1.15	39.36	39.36
European sea bass	3	0.6	28.64	1.16	33.09	72.44
European Smelt	1.33	0	14.67	0.86	16.95	89.39
Flounder	0.33	0.8	6.04	0.87	6.98	96.37
May 17 & Oct 17 Average dissimilarity = 87.11 Species	**Mean Abundance May 17**	**Mean Abundance Oct 17**	**Mean Similarity**	**Sim/SD**	**Contribution %**	**Cumulative %**
Common Goby	0	5.17	41.26	3	47.37	47.37
European sea bass	3	2.33	24.47	1.43	28.09	75.46
European Smelt	1.33	0	10.75	0.95	12.34	87.79
Sand Goby	0	1	5.92	0.56	6.8	94.59
Aug 17 & Oct 17 Average dissimilarity = 68.20 Species	**Mean Abundance Aug 17**	**Mean Abundance Oct 17**	**Mean Similarity**	**Sim/SD**	**Contribution %**	**Cumulative %**
Common Goby	7.2	5.17	45.91	2.32	67.32	67.32
European sea bass	0.6	2.33	12.47	0.65	18.28	85.6
Sand Goby	0	1	5.85	0.53	8.57	94.17
May 17 & Feb 18 Average dissimilarity = 51.42 Species	**Mean Abundance May 17**	**Mean Abundance Feb 18**	**Mean Similarity**	**Sim/SD**	**Contribution %**	**Cumulative %**
European sea bass	3	2.6	23.35	1.31	45.41	45.41
European Smelt	1.33	0.4	16.32	1.05	31.74	77.15
Thin Lipped Grey Mullet	0.17	0.2	3.97	0.61	7.72	84.86
Flounder	0.33	0	3.23	0.67	6.29	91.15
Aug 17 & Feb 18 Average dissimilarity = 78.85 Species	**Mean Abundance Aug 17**	**Mean Abundance Feb 18**	**Mean Similarity**	**Sim/SD**	**Contribution %**	**Cumulative %**
Common Goby	7.2	0.2	37.64	1.2	47.73	47.73
European sea bass	0.6	2.6	28.29	1.12	35.88	83.62
Flounder	0.8	0	6.1	0.66	7.74	91.36
Oct17 & Feb 18 Average dissimilarity = 81.40 Species	**Mean Abundance Oct 17**	**Mean Abundance Feb 18**	**Mean Similarity**	**Sim/SD**	**Contribution %**	**Cumulative %**
Common Goby	5.17	0.2	45.83	2.8	56.31	56.31
European sea bass	2.33	2.6	24.14	1.3	29.66	85.96
Sand Goby	1	0	6.54	0.56	8.03	93.99

Appendix 3 Water Quality data

Subtidal trawls

Survey	Transect	Rep.	Gear type	Temp (°C)	DO (%)	DO (Mg/l)	Specific conductance (S/cm)	Cond. (S)	Salinity	pH
May-17	1	1.1	Pelagic trawl	12.6	73.5	6.81	34637	26670	21.78	8.06
May-17	2	2.1	Pelagic trawl	12.3	84.2	7.99	33211	25160	20.79	7.79
May-17	1	1.2	Pelagic trawl	14	64.1	5.83	32421	25599	20.27	7.76
May-17	2	2.2	Pelagic trawl	13.1	77.1	7.3	31897	24668	19.9	7.75
May-17	1	1.3	Pelagic trawl	12.7	77.1	7.23	31452	24082	19.59	7.74
May-17	2	2.3	Pelagic trawl	12.5	63.9	6.02	31395	23898	19.55	7.73
May-17	1	1.4	Pelagic trawl	13	76.6	7.11	31088	23969	19.35	7.76
May-17	2	2.4	Pelagic trawl	12.4	74.3	6.97	31043	23528	19.3	7.73
May-17	1	1.5	Pelagic trawl	12.7	73.6	6.87	30320	23183	18.82	7.7
May-17	2	2.5	Pelagic trawl	12.2	69.3	6.58	30898	23367	19.2	7.72
May-17	2	2.1	1.5m beam trawl	12	71.8	6.73	35109	36393	22.09	7.86
May-17	1	1.1	1.5m beam trawl	12.1	68.8	6.45	35352	26621	22.26	7.81
May-17	2	2.2	1.5m beam trawl	12.1	76.6	7.14	35412	26699	22.3	8.24
May-17	1	1.2	1.5m beam trawl	12.5	65.6	6.08	35484	26996	22.36	7.8
May-17	2	2.3	1.5m beam trawl	11.4	87	8.13	39357	29103	25.03	7.71
May-17	1	1.3	1.5m beam trawl	11.7	86.9	8.22	33841	25256	21.21	7.77
May-17	2	2.4	1.5m beam trawl	11.5	84.1	8	34122	25346	21.4	7.76
May-17	1	1.4	1.5m beam trawl	11.6	82.3	7.83	33760	25109	21.15	7.76
May-17	2	2.5	1.5m beam trawl	12	86.6	8.21	32314	24291	20.17	7.73
May-17	1	1.5	1.5m beam trawl	11.7	85.1	8.14	31708	23668	19.76	7.79
May-17	1	1.1	Otter trawl	11.9	79.3	7.5	31488	23596	19.6	7.73
May-17	2	2.1	Otter trawl	11.7	80.9	7.75	31672	23617	19.7	7.75
May-17	1	1.2	Otter trawl	11.9	78.5	7.4	31179	23361	19.38	7.78
May-17	2	2.2	Otter trawl	11.6	83	7.91	33425	24851	20.92	7.78
May-17	1	1.3	Otter trawl	11.7	91.2	8.62	34360	25693	21.57	7.57
May-17	2	2.3	Otter trawl	11.7	76.7	7.24	35218	26252	22.16	7.82
May-17	2	2.4	Otter trawl	11.6	88	8.23	39905	29674	25.42	7.61
May-17	1	1.4	Otter trawl	11.6	87.6	8.11	39699	29532	25.27	7.78
May-17	2	2.5	Otter trawl	11.7	81.6	7.61	38043	28379	24.12	7.83
May-17	1	1.5	Otter trawl	11.6	75.3	7.12	35961	26741	22.67	7.81
Aug-17	2	2.1	Pelagic trawl	19.24	85.8	6.88	37326	33217	23.71	7.71
Aug-17	1	1.1	Pelagic trawl	19.25	88.8	7.12	37435	33332	23.78	7.74

Survey	Transect	Rep.	Gear type	Temp (°C)	DO (%)	DO (Mg/l)	Specific conductance (S/cm)	Cond. (S)	Salinity	pH
Aug-17	2	2.2	Pelagic trawl	19.28	87.7	7.03	37370	33282	23.74	7.76
Aug-17	1	1.2	Pelagic trawl	19.38	85.6	6.92	34760	31047	21.92	7.74
Aug-17	2	2.3	Pelagic trawl	19.69	82.8	6.67	33489	30100	21.04	7.72
Aug-17	1	1.3	Pelagic trawl	19.58	83	6.69	33938	30432	21.34	7.71
Aug-17	2	2.4	Pelagic trawl	19.48	84.7	6.87	33196	29704	20.83	7.72
Aug-17	1	1.4	Pelagic trawl	19.62	80.5	6.53	32281	28956	20.21	7.69
Aug-17	2	2.5	Pelagic trawl	19.55	79.2	6.47	31601	28301	19.73	7.68
Aug-17	1	1.5	Pelagic trawl	19.68	82	6.66	31340	28166	19.55	7.69
Aug-17	2	2.1	Beam trawl	20.49	80.4	6.46	30830	28183	19.2	7.67
Aug-17	1	1.1	Beam trawl	19.84	85.6	6.86	30237	27272	18.8	7.68
Aug-17	2	2.2	Beam trawl	19.85	80.4	6.56	30502	27505	18.98	7.67
Aug-17	1	1.2	Beam trawl	19.81	85.1	6.81	30615	27583	19.01	7.67
Aug-17	2	2.3	Beam trawl	19.74	81.1	6.62	30865	27763	19.22	7.68
Aug-17	1	1.3	Beam trawl	19.83	84.5	6.86	30970	27913	19.3	7.7
Aug-17	2	2.4	Beam trawl	19.69	84	6.83	31702	28494	19.8	7.7
Aug-17	1	1.4	Beam trawl	19.82	82.5	6.68	31952	28791	19.97	7.7
Aug-17	2	2.5	Beam trawl	19.62	85	6.85	33740	30270	21.21	7.73
Aug-17	1	1.5	Beam trawl	19.67	85	6.83	34372	30874	21.64	7.74
Aug-17	1	1.1	Otter trawl	19.51	84.7	6.76	35746	32006	22.61	7.75
Aug-17	2	2.1	Otter trawl	19.57	84.5	6.79	35059	31436	22.12	7.74
Aug-17	1	1.2	Otter trawl	19.51	89.2	7.15	36147	32350	22.88	7.77
Aug-17	2	2.2	Otter trawl	19.81	88.8	7.17	33124	29849	20.78	7.74
Aug-17	1	1.3	Otter trawl	19.81	90	7.25	33817	30456	21.24	7.74
Aug-17	2	2.3	Otter trawl	19.87	88.9	7.17	32947	29721	20.66	7.73
Aug-17	1	1.4	Otter trawl	20.09	89.4	7.21	32126	29119	20.09	7.72
Aug-17	2	2.4	Otter trawl	19.96	88.6	7.17	31795	28744	19.87	7.71
Aug-17	1	1.5	Otter trawl	19.81	87.5	7.12	31406	28299	19.6	7.71
Aug-17	2	2.5	Otter trawl	19.87	85.7	6.98	30635	27633	19.07	7.69
Oct-17	2	2.1	Pelagic trawl	14.05	91.8	8.91	34111	26979	21.44	7.77
Oct-17	1	1.1	Pelagic trawl	14.08	91.1	8.23	33695	26665	21.16	7.8
Oct-17	2	2.2	Pelagic trawl	14.11	91.7	8.28	33338	26401	20.91	7.8
Oct-17	1	1.2	Pelagic trawl	14.12	91.8	8.29	33215	26311	20.83	7.82
Oct-17	2	2.3	Pelagic trawl	14.15	91.5	8.28	32627	25868	20.42	7.82
Oct-17	1	1.3	Pelagic trawl	14.18	91.4	8.27	32645	25900	20.44	7.82
Oct-17	2	2.4	Pelagic trawl	14.21	92.4	8.37	32162	25532	20.1	7.82
Oct-17	1	1.4	Pelagic trawl	14.21	92.1	8.33	32508	25806	20.34	7.82
Oct-17	2	2.5	Pelagic trawl	14.23	91.8	8.28	32917	26147	20.62	7.83
Oct-17	1	1.5	Pelagic trawl	14.25	91.8	8.25	33786	26851	21.22	7.84
Oct-17	1	1.1	Beam trawl	14.2	92.2	8.23	34964	27756	22.04	7.84
Oct-17	2	2.1	Beam trawl	14.14	92.4	8.17	38023	30135	24.17	7.88

Survey	Transect	Rep.	Gear type	Temp (°C)	DO (%)	DO (Mg/l)	Specific conductance (S/cm)	Cond. (S)	Salinity	pH
Oct-17	1	1.2	Beam trawl	14.19	92.9	8.24	37464	29724	23.78	7.88
Oct-17	1	1.3	Beam trawl	14.24	92.9	8.21	37862	30085	24.06	7.89
Oct-17	2	2.2	Beam trawl	14.05	94.6	8.29	40732	32216	26.07	7.91
Oct-17	1	1.4	Beam trawl	14.31	94.4	8.34	37648	29961	23.91	7.9
Oct-17	2	2.3	Beam trawl	13.99	95.1	8.3	42112	33262	27.05	7.93
Oct-17	1	1.5	Beam trawl	14.03	94.6	8.27	41243	32604	26.44	7.92
Oct-17	2	2.4	Beam trawl	13.95	94.6	8.25	42187	33286	27.1	7.93
Oct-17	2	2.5	Beam trawl	14.03	94.3	8.27	40560	32067	25.95	7.91
Oct-17	1	1.1	Otter trawl	14.39	92.9	8.22	36792	29335	23.29	7.86
Oct-17	2	2.1	Otter trawl	14.39	93.8	8.28	37489	29898	23.8	7.88
Oct-17	1	1.2	Otter trawl	14.34	91.1	8.01	38512	30676	24.51	7.88
Oct-17	2	2.2	Otter trawl	14.23	94	8.23	40040	31797	25.58	7.9
Oct-17	1	1.3	Otter trawl	14.37	92.4	8.28	33938	27045	21.33	7.83
Oct-17	2	2.3	Otter trawl	14.36	88.8	7.99	33169	26430	20.8	7.82
Oct-17	1	1.4	Otter trawl	14.43	92.6	8.33	32965	26310	20.66	7.83
Oct-17	1	1.5	Otter trawl	14.36	92.1	8.19	32684	26646	20.47	7.82
Oct-17	2	2.4	Otter trawl	14.51	92.9	8.32	33658	26911	21.14	7.83
Oct-17	2	2.5	Otter trawl	14.56	93.3	8.32	34099	27299	21.44	7.84
Feb-17	1	1.1	Pelagic trawl	5.7	85.3	9.82	23605	14915	14.14	7.79
Feb-17	2	2.1	Pelagic trawl	5.8	76.4	10.79	22336	14141	13.31	7.84
Feb-17	1	1.2	Pelagic trawl	5.8	89.1	10.41	22170	14049	13.21	7.86
Feb-17	2	2.2	Pelagic trawl	5.8	87.6	10.15	21355	13537	12.69	7.86
Feb-17	1	1.3	Pelagic trawl	6.9	99.8	12.06	21046	13365	12.49	7.84
Feb-17	2	2.3	Pelagic trawl	6.9	83.1	9.53	20447	12987	12.1	7.87
Feb-17	1	1.4	Pelagic trawl	6	87.7	10.36	19692	12535	11.63	7.86
Feb-17	2	2.4	Pelagic trawl	5.9	84.7	9.81	20949	13294	12.43	7.85
Feb-17	1	1.5	Pelagic trawl	6.9	90.4	10.72	21142	13415	12.55	7.84
Feb-17	2	2.5	Pelagic trawl	5.9	85.6	9.92	21589	13712	12.84	7.85
Feb-17	1	1.1	Beam trawl	5.8	89	9.8	24394	15426	14.65	7.85
Feb-17	2	2.1	Beam trawl	5.7	88.2	10.27	26493	16716	16.02	7.86
Feb-17	1	1.2	Beam trawl	5.7	98.4	11.59	29027	18277	17.27	7.85
Feb-17	2	2.2	Beam trawl	5.6	84.1	9.45	28966	18264	17.66	7.91
Feb-17	1	1.3	Beam trawl	5.6	96.1	10.33	31925	20096	19.63	7.92
Feb-17	2	2.3	Beam trawl	5.5	88.6	9.62	35752	22418	22.2	7.94
Feb-17	1	1.4	Beam trawl	5.4	88.4	9.56	36303	22737	22.57	7.95
Feb-17	2	2.4	Beam trawl	5.4	95.2	10.41	37757	23592	22.32	7.94
Feb-17	1	1.5	Beam trawl	5.5	87	9.35	38060	23857	23.78	8
Feb-17	2	2.5	Beam trawl	5.5	88.4	9.53	36079	22620	22.42	7.99
Feb-17	1	1.1	Otter trawl	5.9	82.1	9.41	22296	14170	13.3	7.9
Feb-17	2	2.1	Otter trawl	6	85.6	9.84	21333	13589	12.68	7.89

Survey	Transect	Rep.	Gear type	Temp (°C)	DO (%)	DO (Mg/l)	Specific conductance (S/cm)	Cond. (S)	Salinity	pH
Feb-17	1	1.2	Otter trawl	6.1	87.1	9.86	20623	13167	12.23	7.86
Feb-17	2	2.2	Otter trawl	6	83.4	9.63	20191	12877	11.95	7.87
Feb-17	1	1.3	Otter trawl	6	81.5	9.37	20975	13374	12.45	7.85
Feb-17	2	2.3	Otter trawl	6	84.3	9.74	21891	13942	13.04	7.87
Feb-17	1	1.4	Otter trawl	5.9	86.2	11.74	24116	15307	14.4	7.78
Feb-17	2	2.4	Otter trawl	5.8	97.2	11.77	26301	14442	15.18	7.83
Feb-17	1	1.5	Otter trawl	5.8	81.6	9.12	28123	17822	17.1	7.93
Feb-17	2	2.5	Otter trawl	5.8	77.8	8.68	28474	18016	17.33	7.93

Intertidal netting

Survey	Sample	Rep.	Gear	Temp (°C)	DO (%)	DO (mg/l)	Specific conductance (S/cm)	Cond. (S)	Salinity	pH
May-17	Seine 1A	1A	Seine	12.5	95.2	8.67	38455	30056	25.13	8.08
May-17	Seine 1B	1B	Seine	13.4	99.4	8.88	39175	30452	24.99	8.09
May-17	Seine 2A	2A	Seine	12.7	98.8	9.91	39569	30328	25.24	8.06
May-17	Seine 2B	2B	Seine	12.7	95.4	8.65	39689	30404	25.21	8.04
May-17	Seine 3A	3A	Seine	13.8	91.3	8.26	33915	26669	21.3	7.91
May-17	Seine 3B	3B	Seine	13.7	88.5	8.05	34129	26743	21.44	7.98
May-17	Push Net 1	1	Push Net	14.6	94	8.45	33566	26620	21.2	7.96
May-17	Push Net 2	2	Push Net	13.5	100.5	9.08	36128	28220	22.83	8.03
May-17	Push Net 3	3	Push Net	13.1	97.02	8.87	37642	28757	23.82	8.01
May-17	Push Net 4	4	Push Net	13.5	95.5	8.02	35059	27329	22.08	7.87
May-17	Push Net 5	5	Push Net	13.8	89.8	8.04	35165	27665	22.18	7.95
Aug-17	Seine 1A	1A	Seine	19.5	83	6.49	39615	35419	25.26	7.89
Aug-17	Seine 1B	1B	Seine	19.9	90.7	7.13	38820	35007	24.85	7.91
Aug-17	Seine 2A	2A	Seine	19.1	79.9	6.3	40239	35773	25.74	7.9
Aug-17	Seine 2B	2B	Seine	19.6	81	6.35	39982	35846	25.63	7.91
Aug-17	Seine 3A	3A	Seine	18.8	79.2	6.32	40566	35774	25.96	7.72
Aug-17	Seine 3B	3B	Seine	18.8	80.7	6.43	40731	36022	26.2	7.79
Aug-17	Push Net 1	1	Push Net	19.9	81.6	6.54	34723	31240	21.89	7.81
Aug-17	Push Net 2	2	Push Net	19.5	79.2	6.29	37775	33811	24.03	7.84
Aug-17	Push Net 3	3	Push Net	19.2	77	6.56	38590	34220	24.6	7.86
Aug-17	Push Net 4	4	Push Net	19	79.6	6.37	38808	34308	24.05	7.69
Aug-17	Push Net 5	5	Push Net	19.1	80.1	6.43	37777	33433	24.04	7.4
Oct-17	Seine 1A	1A	Seine	14.6	80.1	6.98	41585	33334	26.21	7.46
Oct-17	Seine 1B	1B	Seine	14.5	73.9	6.47	40227	32195	25.69	7.49
Oct-17	Seine 2A	2A	Seine	14.6	82.9	7.13	41906	33555	26.88	7.84
Oct-17	Seine 2B	2B	Seine	14.6	81.06	7.02	41442	33342	26.01	7.84
Oct-17	Seine 3A	3A	Seine	14.7	80.1	6.94	39794	31932	25.41	7.56

Survey	Sample	Rep.	Gear	Temp (°C)	DO (%)	DO (mg/l)	Specific conductance (S/cm)	Cond. (S)	Salinity	pH
Oct-17	Seine 3B	3B	Seine	14.7	82.2	7.1	40212	32246	25.7	7.58
Oct-17	Push Net 1	1	Push Net	14.2	82	7.01	40245	32567	24.12	7.76
Oct-17	Push Net 2	2	Push Net	14.2	81.5	6.93	40735	32908	24.14	7.72
Oct-17	Push Net 3	3	Push Net	14.2	81.6	6.97	39736	33331	24.51	7.71
Oct-17	Push Net 4	4	Push Net	14.7	80.1	7.1	38428	30955	24.53	7.80
Oct-17	Push Net 5	5	Push Net	14.6	76.9	6.68	40216	32286	25.75	7.73
Feb-18	Seine 1A	1A	Seine	6.6	106.3	11.44	28532	18076	19.6	8.23
Feb-18	Seine 1B	1B	Seine	6.4	106.0	11.41	28964	18413	19.5	8.26
Feb-18	Seine 2A	2A	Seine	6.2	105.7	11.38	29396	18750	19.4	8.29
Feb-18	Seine 2B	2B	Seine	6.3	105.3	11.36	29828	19086	19.6	8.33
Feb-18	Seine 3A	3A	Seine	6.5	105.0	11.33	30260	19423	18.6	8.36
Feb-18	Seine 3B	3B	Seine	6.5	104.7	11.30	30692	19760	18.4	8.40
Feb-18	Push Net 1	1	Push Net	6.4	102.5	11.07	30767	19830	18.9	8.41
Feb-18	Push Net 2	2	Push Net	6.6	105.6	11.45	31529	20547	19.3	8.47
Feb-18	Push Net 3	3	Push Net	6.4	106.3	11.41	33114	21344	20.47	8.54
Feb-18	Push Net 4	4	Push Net	6.7	101.2	10.99	31679	20687	18.7	8.5
Feb-18	Push Net 5	5	Push Net	6.6	102.0	11.04	32836	20988	18.6	8.44

2. APEM (2019) Tilbury Energy Centre Saltmarsh Survey Report. Preliminary Environmental Information Report: Appendix 10.6. APEM Scientific Report P00001435 WP6 prepared for RWE Generation UK

Tilbury Energy Centre Marine Ecology Surveys

Preliminary Environmental Information Report: Appendix 10.6

APEM Saltmarsh Survey Report

RWE Generation UK

APEM Ref P00001435: WP6

February 2019

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Client: **RWE Generation UK**

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Revision and Amendment Register

Version Number	Date	Section(s)	Page(s)	Summary of Changes	Approved by
1.0	18/01/2018	All	All	Document creation	DH
2.0	12/08/2018	Exec Summ; 2.3; 2.4; 3.2.1	1, 3, 8	Addressing RWE Generation UK comments	MH
3.0	19/02/2018	Exec Summ; 2.4	1, 3	Addition of reference for NRW guidance	MH

Contents

APEM

List of Figures

List of Tables

Executive summary

APEM conducted a saltmarsh survey in the vicinity of the current Tilbury Power Station on the north bank of the Thames Estuary in August 2017. This survey was conducted as part of a wider programme of marine ecology surveys for the proposed Tilbury Energy Centre (TEC) on behalf of RWE Generation UK. The purpose of the survey was site characterisation to inform an Ecological Impact Assessment (EcIA) for the proposed TEC project.

The survey covered an area from west of the Tilbury Power Station to Coalhouse Fort in the east and the survey area selected was informed by previous thermal modelling outputs for a proposed power station plant at this location.

An initial broad walkover was conducted across the whole of the survey area to gain an understanding of the main saltmarsh species present and the pattern and scale of variation of the vegetation communities across the area. The main survey was then conducted following the National Vegetation Classification (NVC) protocol (Rodwell 2000 & 2006) which is considered the best practice approach for site characterisation surveys (NRW 2019).

A total of eight main NVC types and two sub-types were recorded across the survey area. The NVC type SM12a (Rayed *Aster tripolium* on salt-marshes) had the greatest extent covering just under a third of the saltmarsh area. Large areas of saltmarsh were also comprised of SM14a (*Halimione portulacoides* salt-marsh community) and SM24 (*Elymus pycnanthus* salt-marsh community).

The saltmarsh was reduced to a narrow band in several places with an associated drop in species richness and number of NVC types, and this was associated with areas of raised marsh and presence of the seawall at the landward[1] boundary. The most diverse saltmarsh was recorded within the eastern section of the survey area near Coalhouse Fort. The nationally scarce plant species Golden Samphire *Inula crithmoides* and Slender Hare's Ear *Bupleurum tenuissimum* were recorded during the survey.

This survey recorded broadly comparable vegetation types to those recorded during a previous survey in July 2007 for the proposed Tilbury Biomass Power Station project (RWE nPower 2011). Comparison of data with historic aerial imagery indicates notable accretion in the eastern marsh over the previous decade. In the mid and western sections of the saltmarsh in the vicinity of Tilbury Power Station extent has been stable with areas of accretion and erosion being small scale and localised.

[1] Note that in this report landward is used in the context of the upper shore limit of saltmarsh as opposed to further west of the TEC.

1. Introduction

1.1 Project background

APEM Ltd was commissioned to undertake a series of marine ecology surveys to inform an Environmental Impact Assessment for the proposed Tilbury Energy Centre (TEC) on behalf of RWE Generation UK. The overall survey programme has provided site-specific data for plankton (phyto-, zoo- and ichthyo-), fish (intertidal and subtidal), benthos (intertidal and subtidal), saltmarsh, sediment chemistry and water chemistry.

The report presents saltmarsh data from a survey conducted in August 2017.

1.2 Survey objectives

The objective of the agreed survey was to characterise the saltmarsh community present at, and in the vicinity of, the TEC site. The information obtained was to inform an Ecological Impact Assessment (EcIA) for the proposed TEC project.

2. Methodology

2.1 Survey permissions

Permission for the survey was obtained from the Port of London Authority. Permission was also obtained from the Coalhouse Fort Ranger to survey around Coalhouse Fort Park near the eastern boundary of the survey area.

2.2 Survey timings

Sampling was conducted by a team of two experienced field scientists during a spring low tide period between August 21st and 23rd.

Table 1: Tidal information for dates of saltmarsh survey. BST = British Summer Time.

Date	Tides	
	Time (BST)	Height (m)
21/08/2017	13:28	6.43
	19:47	0.33
22/08/2017	08:11	0.57
	14:17	6.70
23/08/2017	08:56	0.46
	15:01	6.84

2.3 Survey design

The extent of the saltmarsh survey was determined based on consideration of initial thermal modelling outputs for a previous proposed biomass power station at the Tilbury site (RWE nPower, unpublished data). The thermal discharge from that proposal was similar to that envisaged for the currently proposed TEC project. The thermal modelling indicated potential temperature changes along the north bank of the Thames estuary and the saltmarsh survey was selected to include, and where appropriate extend beyond, the zone of a potential >2ºC increase above background temperature levels with an operating power station (based on 98th percentile temperature rise at the Estuary bed). The saltmarsh area surveyed was also consistent with a previous survey at the Tilbury Power Station location to facilitate comparison of data across surveys (RWE npower 2011, unpublished data). Temperature changes from the mid channel to the southern shore were generally modelled to be <1ºC so it was considered that survey was not required on the southern bank. The area covered by the survey is indicated in Figure 1 which shows all locations at which records were taken, either for the quadrat sampling or for a target note (see methods for details). The coordinates of the western and eastern extent of the survey area are provided in Table 2.

Table 2: Coordinates for boundary points for survey area.

	Position		
	Latitude	Longitude	National Grid Reference
Western extent	51.451660	0.36620736	TQ 64510 75175
Eastern extent	51.470424	0.43773651	TQ 69410 77424

2.4 Survey methodology

An initial broad walkover was conducted across the whole of the survey area to gain an understanding of the main saltmarsh species present and the pattern and scale of variation of the vegetation communities across the area.

The main survey was then conducted following the National Vegetation Classification (NVC) protocol (Rodwell 2000 & 2006). This is currently considered to be the best practice methodology to apply for saltmarsh site characterisation surveys as the approach determines the distribution and extent of different NVC communities and other saltmarsh vegetation communities which characterise the site (NRW 2019). As many of the different NVC communities correspond to components of Annex I saltmarsh habitats protected under the EC Habitats Directive, the data obtained from NVC surveys can be interpreted to map Annex I saltmarsh habitats if required (NRW 2019). Aerial imagery (The GeoInformation Group, Map data © 2017 Google) was taken into the field as a visual guide during the survey and to map the extent of different NVC community types the locations of boundaries to community stands were sketched in the field onto the imagery. GPS coordinates were taken of key boundary locations where appropriate for subsequent GIS digitisation.

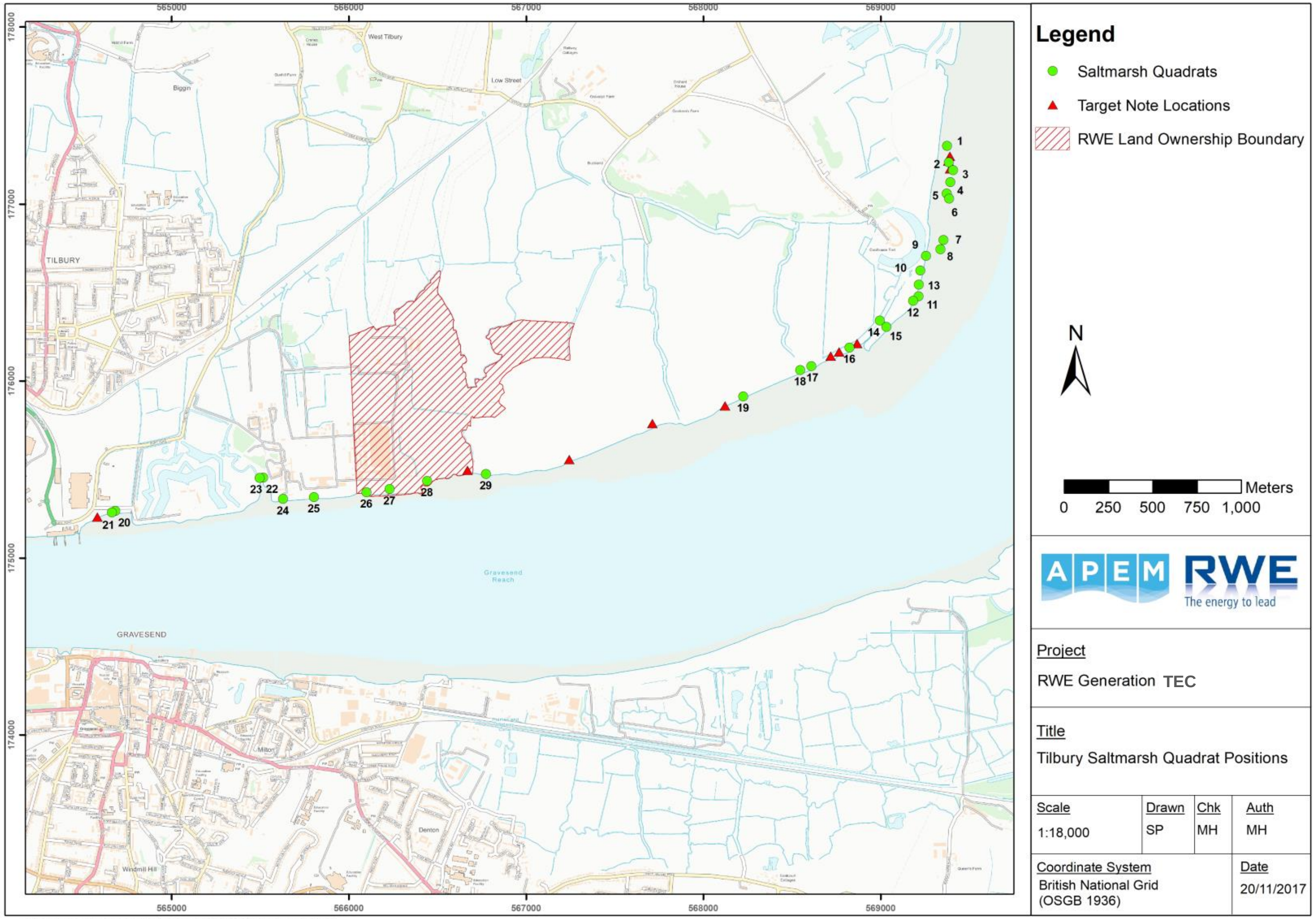

Figure 1: Map of the surveyed area around Tilbury Power Station showing all survey points.

To assess the composition of the vegetation within each distinct community, homogeneous stands of NVC types were delimited by the surveyors and within each NVC type up to five replicate 2 x 2 metre quadrats were deployed to obtain quantitative community data. Following standard NVC best practice the surveyors ensured that quadrats were placed within different vegetation stands to provide representative data across the entire surveyed area.

Within each quadrat, plant species were identified and abundance was recorded as percentage cover using the Domin scale (Rodwell 2006), (Table 3).

Table 3: The Domin Scale (after Dahl & Hadac 1941).

Cover	Domin score
91 - 100%	10
76 - 90%	9
51 - 75%	8
34 - 50%	7
26 - 33%	6
11 - 25%	5
4 - 10%	4
< 4% (many individuals)	3
< 4% (several individuals)	2
< 4% (few individuals)	1

All quadrat sample station locations were recorded using a handheld GPS unit (accurate to ±5 m). Target notes and coordinates were also recorded for any observed anthropogenic impacts, areas of erosion and/or ecological features such as pans and streams. These notes were made opportunistically, and should not be considered to represent comprehensive coverage of the survey area for the recorded features/observations.

Photos were taken of sampling locations and features of interest.

2.5 Data analysis

Communities were assigned an NVC type based on the recorded species list, percent coverage of different taxa and frequency of occurrence in replicate quadrats following Rodwell (2000).

The initial assessment was also supported by running the data through the MAVIS software (Smart 2017) which reports a range of potential NVC types using a matching coefficient. MAVIS is a program that analyses vegetation data using different types of classification system including the 'MATCH' calculations that were previously used for NVC analyses, Preston and Hill's (1997) biogeographic classification, the Countryside Vegetation System (CVS) and Ellenberg scores for light, fertility, wetness and pH. In line with Rodwell (2000) such vegetation keys and software were used as confirmation of a diagnosis and were not used in isolation to provide identifications.

3. Results

3.1 NVC communities

A total of seven main NVC types were recorded across the survey area and are described below (see Appendix 1 for a summary of species and NVC types in each quadrat). Images of each NVC community type are provided in Appendix 2 and a map of the distribution of each NVC type is provided in Appendix 3.

SM6 *Spartina anglica* salt-marsh community

This is a pioneer community of the seaward[2] edge of saltmarsh, defined by having few species and being dominated by *Spartina anglica*. Isolated patches of this community were found immediately to the west of Tilbury Fort, and to the southeast of the power station, but the most extensive areas were at Coalhouse Fort reserve.

SM10 Transitional low-marsh vegetation with *Puccinellia maritima*, annual *Salicornia* species and *Suaeda maritima*

This is another assemblage of few species and at the Tilbury saltmarsh there was a limited presence of *Puccinellia maritima*. This vegetation was recorded exclusively at Coalhouse nature reserve behind the pioneer zone. In the dynamic state of the low marsh this community is likely to be replaced by others as accretion progresses and the timeframes over which this occurs can vary considerably dependent on the rate of accretion. Accretion rate would primarily be driven by gradual sediment deposition during tidal inundation and available data suggests seaward accretion of the saltmarsh could be in the region of a few metres per year (see Section 3.2.1).

SM12 Rayed *Aster tripolium* on salt-marshes

Whilst there is some contention regarding possible habitat distinction between the ray and disc forms of *Aster tripolium*, all plants of this species observed at Tilbury saltmarsh were the rayed form. A small patch of this vegetation was situated immediately to the east of Tilbury Fort, with a larger area located to the east of Coalhouse Fort.

SM14 *Halimione portulacoides* salt-marsh community

This is a closed association in which *Halimione (Atriplex) portulacoides* is conspicuous as a bushy canopy up to 50 cm high or as a virtually prostrate carpet. In addition to the higher

[2] Note that in this report seaward is used in the context of the lower shore limit of saltmarsh as opposed to further east of the TEC.

plants filamentous algae was present in patches of this community at Tilbury saltmarsh. A small area of this community was found to the southeast of the power station, with a larger area in the Coalhouse nature reserve.

SM13 and SM14 *Puccinellia maritima* salt-marsh community and *Halimione portulacoides* salt-marsh community mosaic

This mixed community occurred predominantly at the seaward edge of the Tilbury Power Station wall, representing saltmarsh that was constricted in breadth and raised in height.

SM24 *Elymus pycnanthus* salt-marsh community

This vegetation is dominated by the stiff clumps of *Elytrigia atherica* and at the Tilbury site this vegetation formed a near continuous band at the landward edge of the saltmarsh which was interrupted at the Victorian landfill site.

SM26 *Inula crithmoides* on salt-marshes

This valued vegetation type was present within a few isolated patches on Tilbury saltmarsh. There was a small patch of this vegetation immediately to the west of Tilbury Fort, with extensive areas to the south and east of Coalhouse Fort.

3.2 Extent of saltmarsh

A total of 17.5 hectares of saltmarsh vegetation were recorded across the survey area (see Appendix 3). Across the survey area, NVC type SM12 had the greatest extent covering just under a third of the saltmarsh area (4.55 ha). Large areas of saltmarsh were also comprised of SM14 (3.63 ha) and SM24 (3.55 ha), (Table 1, Appendix 3). The saltmarsh was reduced to a narrow band in several places with an associated drop in species richness and number of NVC types. The most diverse saltmarsh was recorded within the eastern section of the survey area near Coalhouse Fort.

Table 3: Extent of each NVC type recorded across the Tilbury saltmarsh survey area.

NVC type	Area (m^2)	Area (Ha)
SM6	29,812.05	2.98
SM10	10,302.96	1.03
SM12	45,480.03	4.55
SM13-14 mosaic	13,419.62	1.34
SM14	36,319.96	3.63
SM24	35,549.91	3.55
SM26	37,65.47	0.38
TOTAL	**174,650**	**17.46**

3.2.1 *Changes in saltmarsh extent*

Comparison of the seaward border of saltmarsh (SM6 NVC community) to historical GoogleEarth imagery for sections of the survey area indicates changes in the seaward boundary of the saltmarsh over the last 13 years (Appendix 4). At the eastern section around Coalhouse Fort the marsh has accreted at an average rate of between 3 and 5 metres per year, i.e. a seaward advance of between 39 and 65 m between 2004 and 2017 (Appendix 4) replacing mudflat habitat. Within the mid and western sections of the survey area around Tilbury Power Station there has been little change in the seaward boundary during this period with some areas of small scale accretion (Appendix 4) and some localised evidence of erosion as indicated below.

3.3 Target notes

The locations at which target notes were taken are indicated in Figure 1 and Appendix 5. As they were taken when physical and ecological features of interest were encountered they do not represent a comprehensive account for the survey area, so have not been numbered individually.

A sea wall was present at the site along the foreshore from TQ 64510 75175 to TQ 66726 75523. Some saltmarsh erosion was evident, particularly in the western half of this site (e.g. TQ 64664 75257, TQ 66442 75435). Erosion could be influenced by a range of factors including presence of the sea wall (van der Wal & Pye 2004). The saltmarsh erosion, presence of the sea wall, and raising of the marsh where present, appear to have resulted in an artificially narrowed band of saltmarsh with a low number of NVC types and often with no pioneer community (SM6) present.

There was a low levee feature at the sea edge with a transitional pan behind (e.g. TQ 69391 77271, TQ 69393 77199). In addition, artificial gullies were noted which are associated with lateral erosion of the saltmarsh which is likely due to wave action generated by tidal movements and can be exacerbated by storm events (e.g. TQ 69383 77243), (van der Wal & Pye 2004).

There were several areas of washed-up litter (e.g. TQ 69374 77328, TQ 69337 76744) and litter leaching out of the Victorian landfill site (e.g. TQ 68123 75859, TQ 67714 75760). In addition there were old structures including a water tower and boat wrecks (e.g. TQ 66773 75474) to the east of the power station.

Blue-green algae was present at some locations although it was not abundant (e.g. TQ 69386 77030, TQ 69032 76305).

A small area of common reed *Phragmites australis* was recorded at the western extent of the saltmarsh to the west of Tilbury Fort (TQ 64582 752570), (Appendix 3, Map 1). This is a halophyte that can outcompete other plants leading to a reduction in local biodiversity (e.g. Able & Hagan 2001), but based on the extent recorded any local effects are expected to be limited at the time of survey.

3.4 Species of conservation or commercial importance

A total of 23 plant species were recorded within the surveyed area. The following are considered to be of particular ecological interest (see Appendix 5 for locations at which they were recorded):

Golden Samphire *Inula crithmoides*. This species is designated in the UK as Nationally Scarce (JNCC 2017). It is a perennial coastal species which is found growing on salt marsh or sea cliffs across western and southern Europe and the Mediterranean.

Slender Hare's Ear *Bupleurum tenuissimum*. This species is designated in the UK as Vulnerable and Nationally Scarce (JNCC 2017). It is primarily a colonist of thinly vegetated or disturbed coastal sites, including coastal banks, sea walls, drained estuarine marshes and the margins of brackish ditches.

In addition some notable fauna were recorded:

The sea aster mining bee *Colletes halophilus* has a restricted UK population and is associated with the margins of saltmarshes and other coastal habitats. It feeds on a limited number of plant species mainly from the Asteraceae family (encountered at Tilbury saltmarsh land border on Prickly Sow-thistle *Sonchus asper*). Sea aster *Aster tripolium* is particularly important, with the bee's emergence synchronised with the plant's flowering period.

Figure 2: Sea aster mining bee *Colletes halophilus* at Tilbury saltmarsh, August 2017.

The wasp spider *Argiope bruennichi* was first recorded in Britain in 1922 at Rye and is at its greatest abundance in the southeast and is widespread in the East Thames corridor (Harvey 2000). The species increased its range in the 1970's and is currently known to occur as far as central England.

Figure 3: Wasp spider *Argiope bruennichi* at Tilbury saltmarsh, August 2017.

In the northern part of the site around Coalhouse Fort there were bankside burrows and latrines suggesting the presence of water vole. Adders and rats were reported to occur here by the Coalhouse Fort ranger but were not observed during the survey.

4. Summary and discussion

Saltmarshes are intertidal areas of fine sediment that have been stabilised by vegetation (Boorman 2003). The UK Biodiversity Action Plan (since superseded by the UK Post-2010 Biodiversity Framework) defined the habitat as 'the upper, vegetated portions of intertidal mudflats, lying approximately between mean high water neap tides and mean high water spring tides' (UKBAP 2008). In addition to providing important habitats for a range of invertebrates, fish, mammals, and migratory, overwintering (e.g. dunlin, plover) and breeding (e.g. redshank) coastal birds, saltmarsh habitats can provide natural flood defences and are important for the management of coastal flood risk.

The saltmarsh at Coalhouse Fort is protected as part of the Mucking Flats and Marshes Site of Special Scientific Interest (SSSI) and the Thames Estuary and Marshes Special Protection Area (SPA) and Ramsar site (which also covers extensive areas on the south bank of the estuary to the east of Gravesend). The South Thames Estuary and Marshes SSSI forms extensive areas of grazing marsh, mudflats and saltmarsh extending for approximately 15 km along the south bank of the estuary from Gravesend in the west to the mouth of the Medway in the in the east.

The NVC scheme recognises 28 communities of vegetation (Rodwell 2000) and of these, eight main NVC types and two sub-types were recorded within the survey area at Tilbury. A total of 17.5 hectares of saltmarsh vegetation were recorded across the survey area, with NVC type SM12 having the greatest extent. The saltmarsh was reduced to a narrow band in several places with a corresponding drop in species richness and the number of NVC types present. The most diverse area of saltmarsh was within the eastern section of the survey area near Coalhouse Fort.

This survey recorded broadly comparable vegetation types to those recorded during a survey in July 2007 for the proposed Tilbury Biomass Power Station project (RWE nPower 2011). During the TEC–specific survey, two species were recorded that are designated in the UK as Vulnerable and Nationally Scarce (JNCC 2017a) (Golden samphire *I. crithmoides* and Slender Hare's Ear *Bupleurum tenuissimum*). Golden samphire was also recorded during the 2007 survey (RWE nPower 2011).

Stinking Goosefoot *C. vulvaria* is Nationally Scarce (JNCC 2017a) and has previously been reported to occur in this area east of the power station in the vicinity of Goshems Farm (Thurrock Council 2007), however, this species was not recorded during the TEC survey or the 2007 survey (RWE nPower 2011).

The NVC communities SM10 (Transitional low-marsh vegetation with *Puccinellia maritima*, annual *Salicornia* species and *Suaeda maritima*), SM12 (Rayed *Aster tripolium* on salt-marshes), SM13 (*Puccinellia maritima* salt-marsh community) and SM14 (*Halimione portulacoides* saltmarsh community) which were all recorded during the survey correspond to the EC Habitats Directive Annex I habitat Atlantic salt meadows (*Glauco-Puccinellietalia maritimae)* (Code 1330). The NVC community SM6 *Spartina anglica* salt-marsh community was also recorded which corresponds to the EC Habitats Directive Annex I habitat *Spartina* swards (*Spartinion maritimae*) (Code 1320).

Comparison of saltmarsh extent between the 2007 survey and the current survey was not possible as the RWE nPower (2011) report did not delimit boundaries of extent on the ground. Comparison of data with historic aerial imagery, however, indicates a notable difference in accretion rate within different sections of the saltmarsh with notable accretion in the eastern marsh and only very localised areas of accretion in the mid or western sections of the marsh along with some localised erosion. This suggests that the function of the mid and western areas of saltmarsh has been influenced by physical and environmental features in this location with the marsh being raised, with little or no pioneer (SM6) vegetation present, and a hard wall at the landward boundary resulting in a relatively consistent saltmarsh seaward boundary over recent years. A small area of common reed *P. australis* was recorded to the west of Tilbury Fort and this species was not recorded in the 2007 survey (RWE nPower 2011). This species can outcompete other species and future survey work could clarify if there are any increases in the extent of *P. australis* at this location.

This survey has characterised the saltmarsh currently present within the proposed project area at Tilbury in 2017 and these data can be compared with future NVC mapping data sets to identify changes in vegetation composition, zonation and extent of the saltmarsh over time.

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APPENDICES

Appendix 1 Domin scores for Tilbury saltmarsh species ordered by NVC communities and quadrats.

NVC community type	SM 6: *Spartina anglica* salt-marsh community				
Quadrat	q3	q4	q6	q15	q21
Domin					
Aster tripolium	9	5	2	8	
Phragmites australis					2
Salicornia europaea agg.	4	8		4	
Spartina anglica	9	5	10	7	10
Suaeda maritima				4	

NVC community type	SM 10: Transitional low-marsh vegetation with *Puccinellia maritima*,, annual *Salicornia* species and *Suaeda maritima*	
Quadrat	q5	q7
Domin		
Aster tripolium	4	5
Salicornia europaea agg.		6
Spartina anglica	8	3
Suaeda maritima	5	8

NVC community type	SM 12: Rayed Aster tripolium on salt-marshes				
Quadrat	q2	q8	q11	q12	q22
Domin					
Aster tripolium	6	4	7	8	9
Halimione (Atriplex) portulacoides		4			
Atriplex prostrata agg.	5		4	3	
Phragmites australis					2
Puccinellia maritima	3	7	4	4	6
Spartina anglica		5		3	
Suaeda maritima	8	2	5	4	4

NVC community type	SM 13 and SM 14 mosaic: *Puccinellia maritima / Halimione portulacoides* salt-marsh communities				
Quadrat	**q24**	**q25**	**q26**	**q27**	**q28**
Domin					
Armeria maritima				1	
Aster tripolium	6	6	5	4	5
Halimione (Atriplex) portulacoides	6	8	7	7	5
Elytrigia atherica	2				
Filamentous green algae				2	2
Inula crithmoides					2
Juncus gerardii			2		
Juncus maritimus				2	
Limonium vulgare	4	4	4		2
Plantago maritima		4	5	5	8
Puccinellia maritima	4		3	4	4
Spartina anglica	2	1		2	2
Suaeda maritima				5	
Triglochin maritimum	4	4		2	

NVC community type	SM 14: *Halimione portulacoides* salt-marsh community			
Quadrat	**q1**	**q13**	**q14**	**q29**
Domin				
Armeria maritima				1
Aster tripolium	5	7	2	7
Halimione (Atriplex) portulacoides		8	9	8
Atriplex prostrata agg.	5			
Filamentous green algae				2
Plantago maritima				4
Puccinellia maritima	5			
Salicornia europaea agg.				2
Spartina anglica	5	4		2
Suaeda maritima	5	5		2
Triglochin maritimum		1	4	

NVC community type	SM 24: *Elymus pycnanthus* salt-marsh community				
Quadrat	**q9**	**q10**	**q18**	**q19**	**q23**
Domin					
Armeria maritima					2
Artemisia vulgaris			1	1	
Aster tripolium	2			2	
Halimione (Atriplex) portulacoides	4			3	10
Atriplex prostrata agg.		2			
Beta vulgaris subsp.*maritima*		4	3		
Elytrigia atherica	10	9	9	9	5
Festuca rubra			2	1	
Lepidium latifolium			2	1	

NVC community type	SM 26: *Inula crithmoides* on salt-marshes		
Quadrat	**q16**	**q17**	**q20**
Domin			
Aster tripolium	4	4	
Atriplex littoralis			4
Haliminoe (Atriplex) portulacoides	9	8	9
Elytrigia atherica	5	5	4
Inula crithmoides	4	4	4
Lepidium latifolium		1	
Plantago maritima			2
Puccinellia maritima		5	
Spergularia marina	1	2	

Appendix 2 Representative photographs of each NVC type.

SM 6: *Spartina anglica* salt-marsh community (TQ 69386 77030)

SM 10: Transitional low-marsh vegetation with *Puccinellia maritima,* annual *Salicornia* species and *Suaeda maritima* (TQ 69355 76796)

SM 12: Rayed *Aster tripolium* on salt-marshes (TQ 65518 75454)

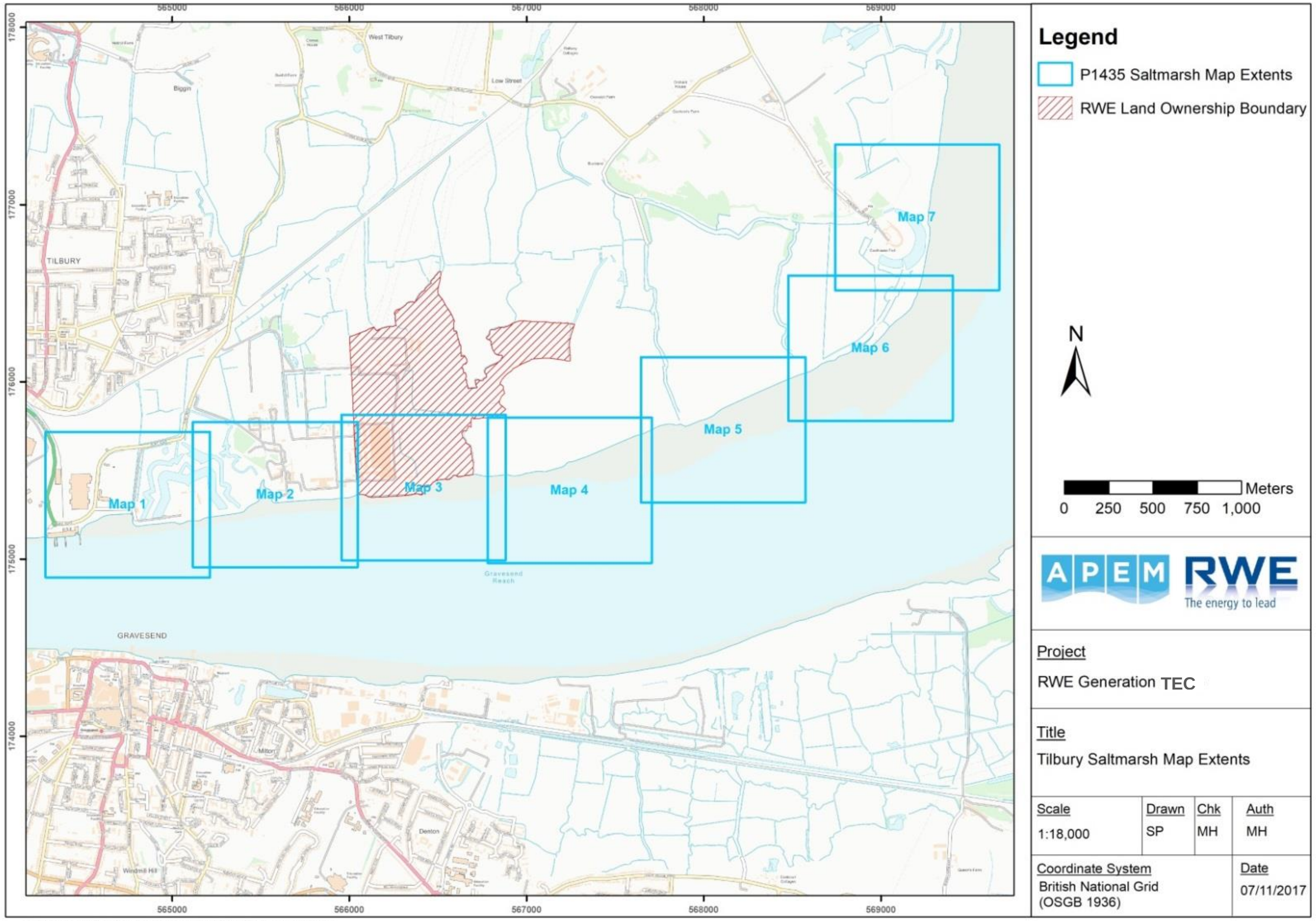
SM 13 and SM 14 mosaic: *Puccinellia maritima* / *Halimione portulacoides* salt-marsh communities (TQ 66442 75435)

SM 14: *Halimione portulacoides* salt-marsh community (TQ 68996 76340)

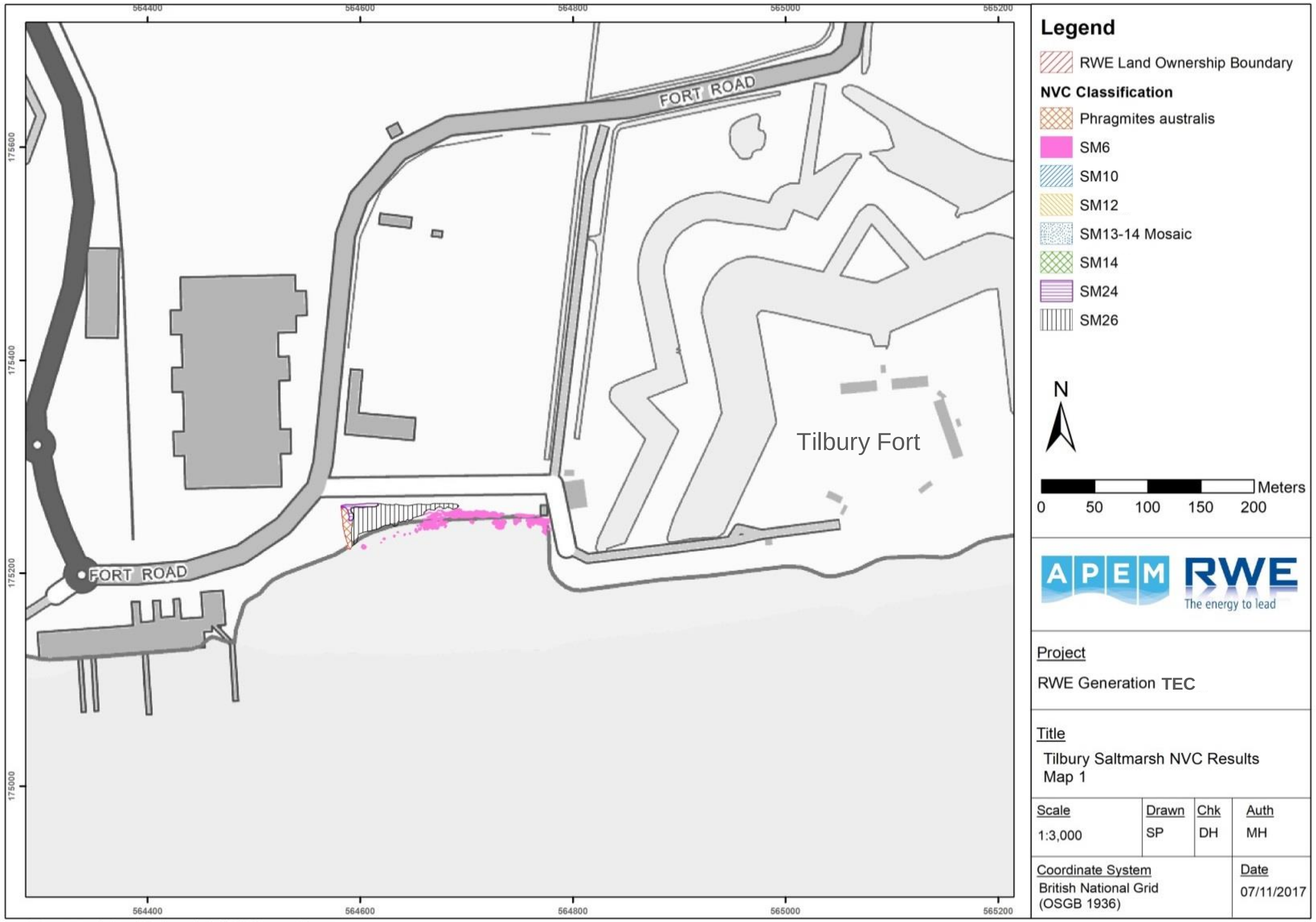
SM 24: *Elymus pycnanthus* salt-marsh community (TQ 68546 76062)

SM 26: *Inula crithmoides* on salt-marshes (TQ 64664 75257)

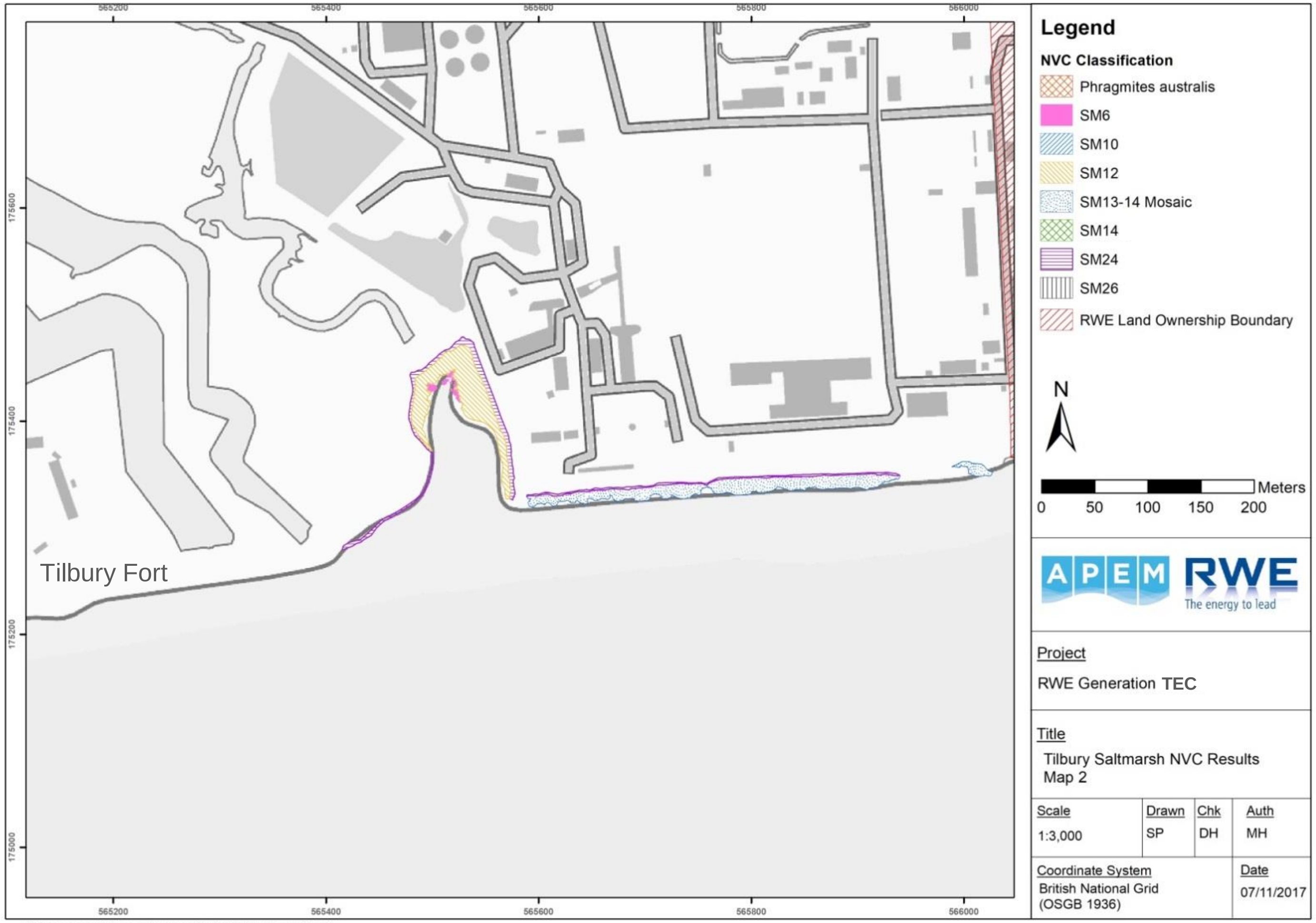
Appendix 3 Maps of extent of NVC communities across the survey area.



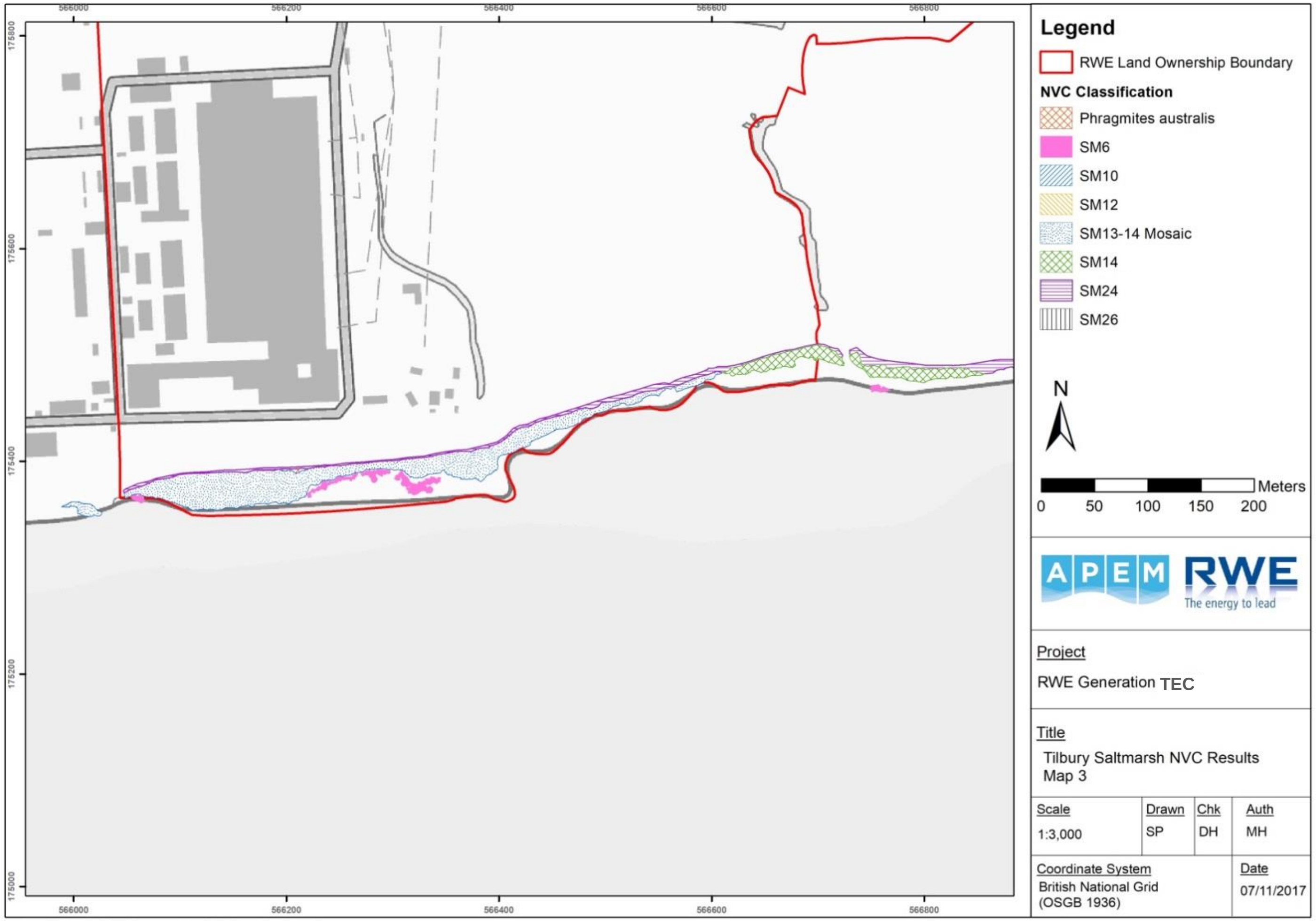
Map 1: West of Tilbury Fort.



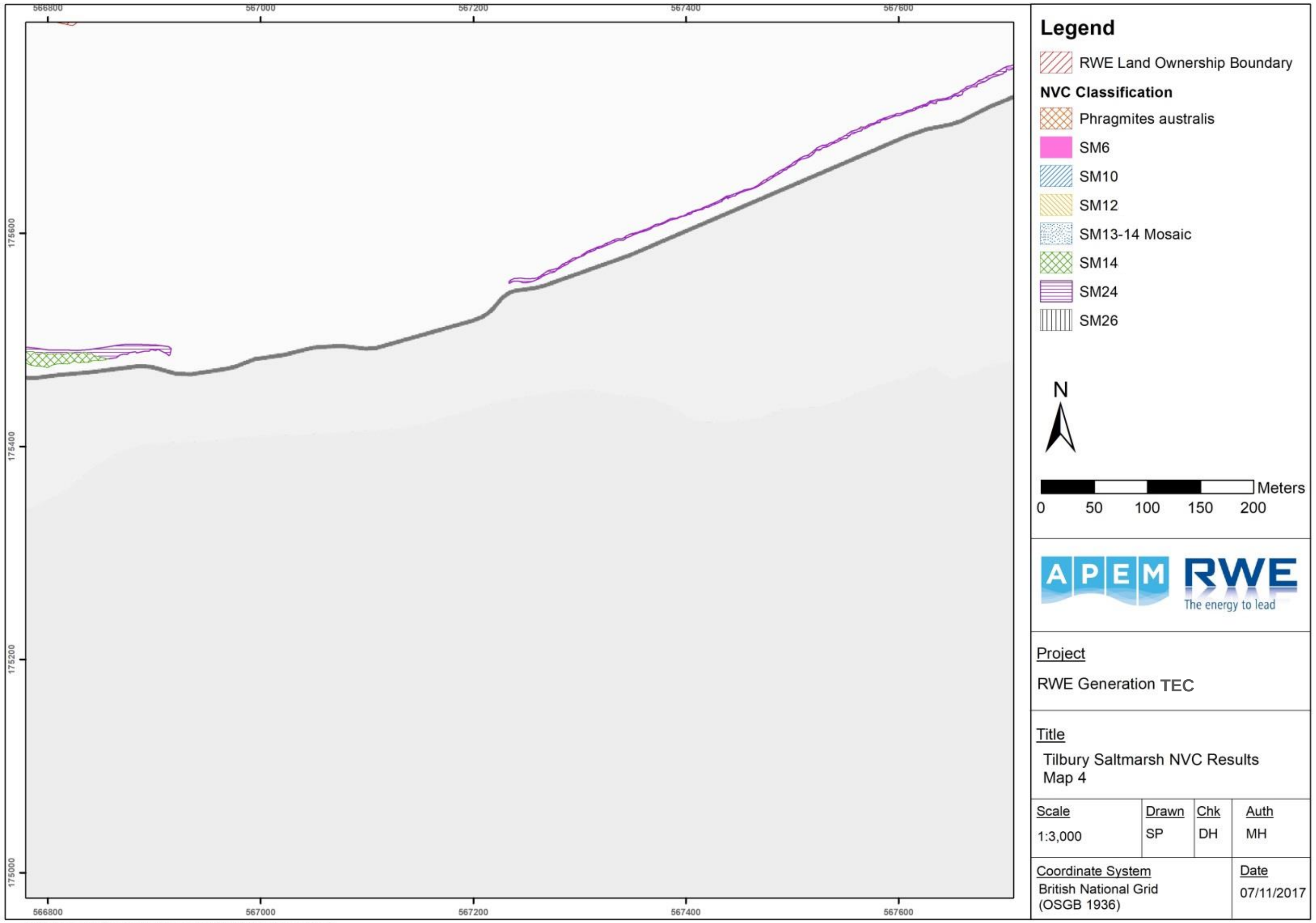
Map 2: East of Tilbury Fort and west of Tilbury Power Station.



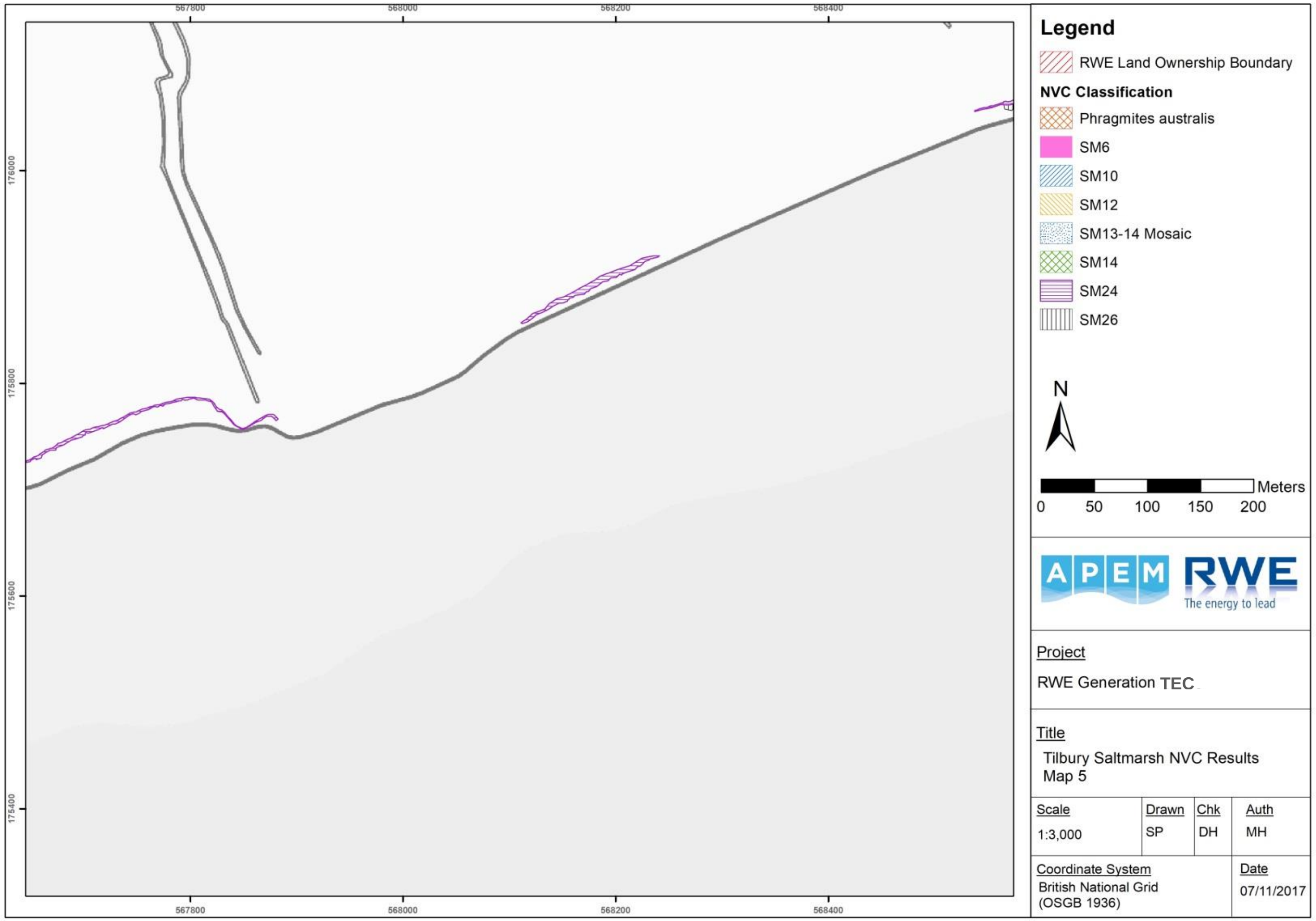
Map 3: In front and east of Tilbury Power Station.



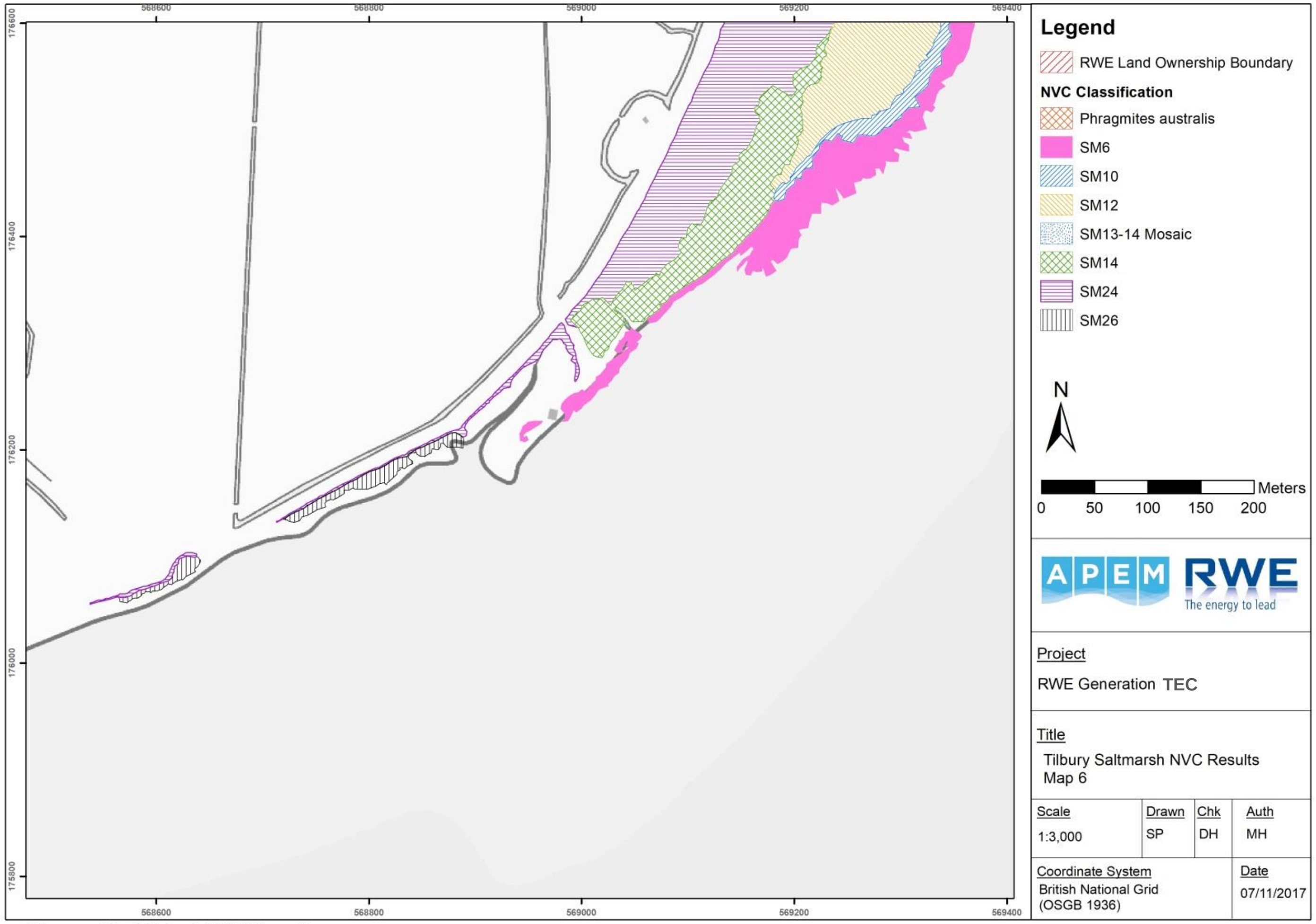
Map 4: Approximately 600 to 1,500 m east of Tilbury Power Station.



Map 5: Midway between Tilbury Power Station and Coalhouse Fort.



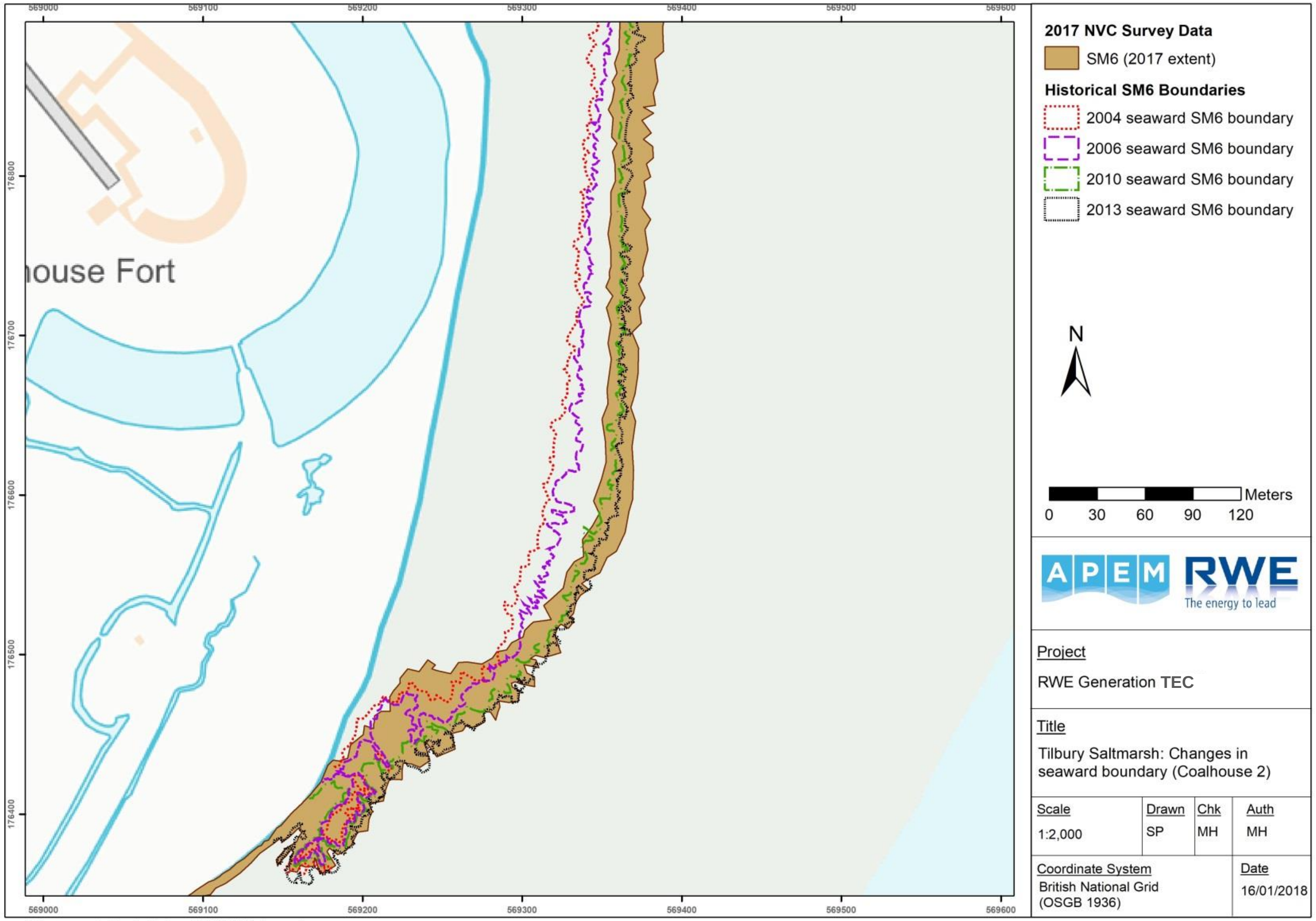
Map 6: South west of Coalhouse Fort.



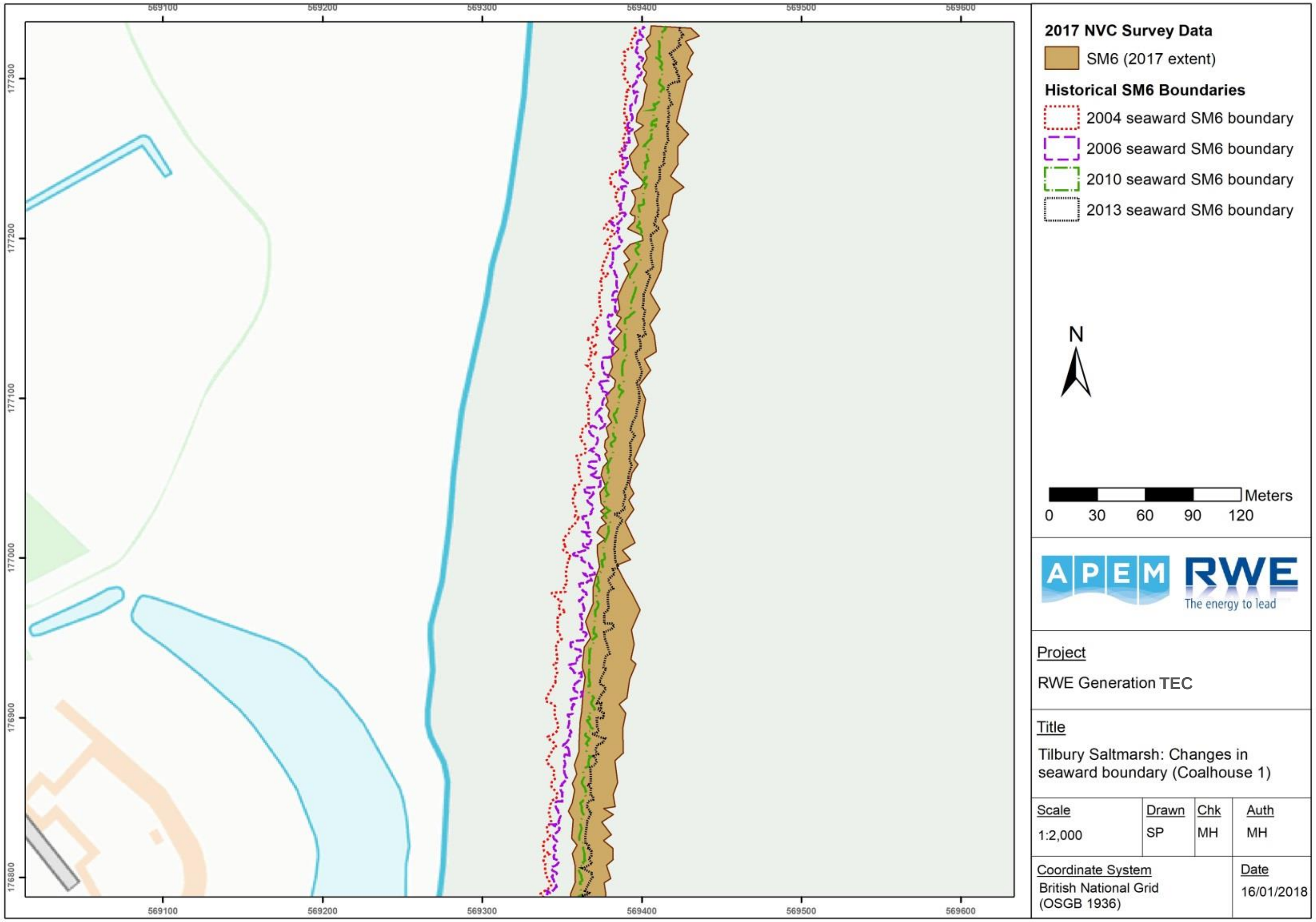
Map 7: In front and to north of Coalhouse Fort.

Appendix 4 Change in seaward boundary of the SM6 NVC community over time from Coalhouse Fort to east of Tilbury Fort.

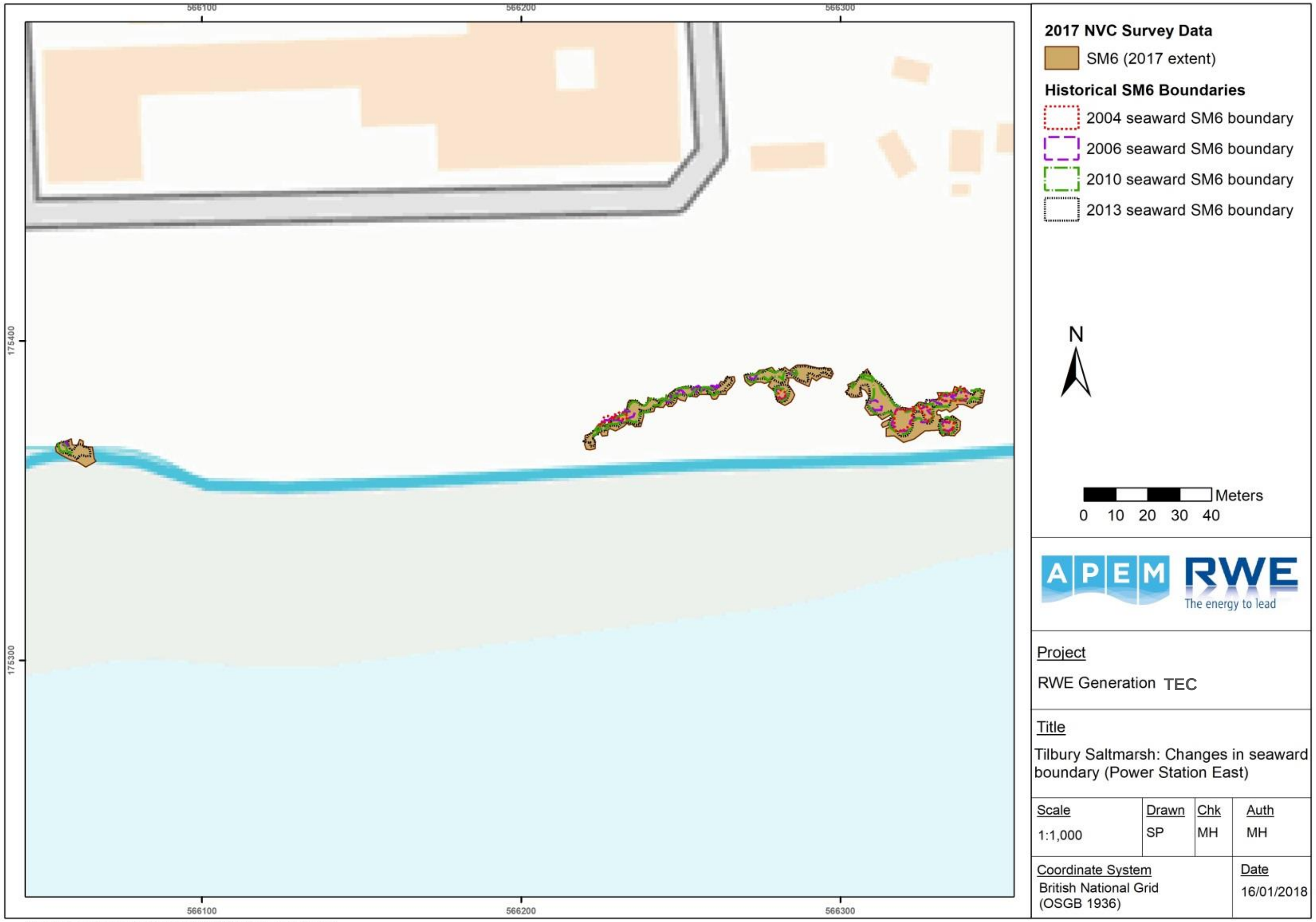
Coalhouse Fort (Figure 1)



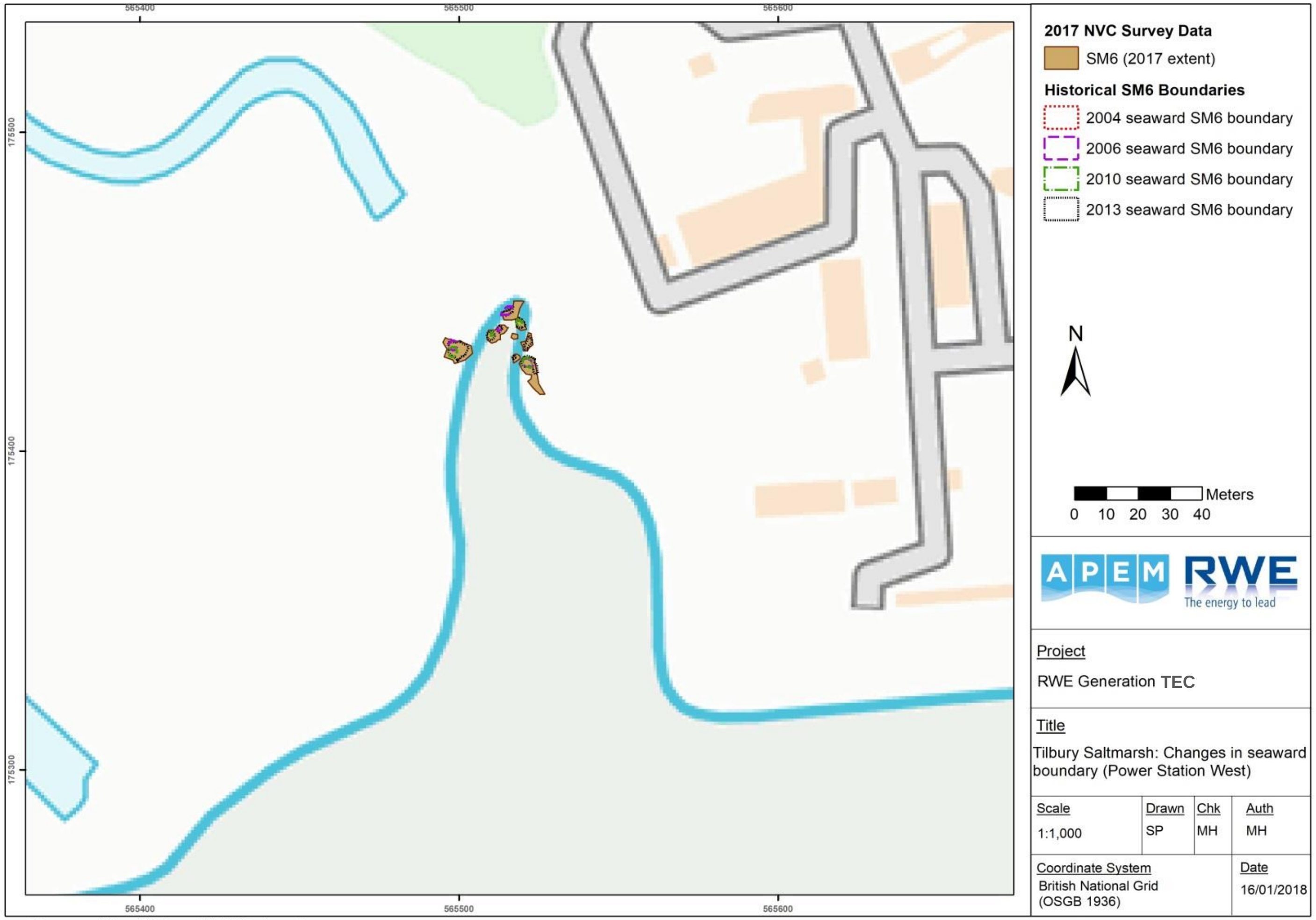
Coalhouse Fort (Figure 2)



Mid-section of saltmarsh in vicinity of eastern section of power station.



Section of saltmarsh to the west of the power station and east of Tilbury Fort.



Appendix 5 Details of all survey stop points (indicated in Figure 1) moving from west to east, including quadrats and point observations.

Grid Reference	NVC community	Quadrat	Sward height (m)	Point observations	Notable taxa
TQ 69374 77328	14a	1	1	Litter present	
TQ 69391 77271	-	-	-	Disturbed / transitional patch parallel to the sea edge.	
TQ 69383 77243	-	-		Disturbed / transitional patch parallel to the sea edge. Likely cause is the gully.	
TQ 69384 77235	12a	2	1.5		
TQ 69393 77199	-	-	-	Disturbed / transitional patch parallel to the sea edge. Likely a revegetating pan.	
TQ 69408 77190	6	3	1.2	Some deposition of *Fucus vesiculosus*.	
TQ 69394 77123	6	4	1	Disturbed / transitional patch behind levee.	
TQ 69373 77058	10	5	0.75		
TQ 69386 77030	6	6	1	Blue-green alga present.	
TQ 69355 76796	10	7	0.8		
TQ 69337 76744	12a	8	1.4	Litter present	
TQ 69256 76706	24	9	0.25		
TQ 69224 76624	24	10	0.3		large brown lizard: cf. *Zootoca vivipara*
TQ 69214 76477	12a	11	1		
TQ 69184 76452	12a	12	1.3		
TQ 69216 76543	14a	13	0.9	Raised area of archaeological site (rifle range) is evident.	
TQ 68996 76340	14a	14	1	Saltmarsh considerably narrower to the south of here.	Carder Bee: cf. *Bombus humilis*
TQ 69032 76305	6	15	1.2	Saltmarsh erosion by creek. Blue-green alga present. Some deposition of *Fucus vesiculosus*.	Slender Hare's Ear *Bupleurum tenuissimum* on path to N.
TQ 68869 76212	-	-	-	Eroded marsh edge and no pioneer community present. Litter present	

Grid Reference	NVC community	Quadrat	Sward height (m)	Point observations	Notable taxa
TQ 68824 76189	26	16	0.6	Raised marsh with no pioneer community present.	
TQ 68766 76164	-	-	-	Rubble by sea edge; no pioneer community present.	
TQ 68720 76140	-	-	-	Concrete reinforced bank. No saltmarsh.	
TQ 68610 76084	26	17	0.5		
TQ 68546 76062	24	18	0.5	Northern edge of Victorian landfill.	
TQ 68224 75913	24	19	0.4		Golden Samphire *Inula crithmoides*.
TQ 68123 75859	-	-	-	Litter from landfill.	
TQ 67714 75760	-	-	-	Litter from landfill.	
TQ 67245 75556	-	-	-	Litter from landfill.	
TQ 64683 75265	26	20	0.3	Some deposition of *Fucus vesiculosus*. Litter present.	Raptor: cf. Hen/Marsh Harrier, *Circus* sp.
TQ 64664 75257	6	21	1.1	Erosion from hard banking.	*Inula crithmoides*.
TQ 64582 75231	-	-	-	Apparently the westernmost extent of this site's saltmarsh.	
TQ 65518 75454	12a	22	1.5		
TQ 65497 75452	24	23	0.3		*Argiope bruennichi*.
TQ 65629 75333	14 and 13	24	0.5	Ducks and gulls congregating around sewage outflow. Some deposition of *Fucus vesiculosus*.	*Inula crithmoides*.
TQ 65804 75344	14 and 13	25	0.25	Some deposition of *Fucus vesiculosus*.	
TQ 66100 75371	14 and 13	26	0.2	Some deposition of *Fucus vesiculosus*.	*Inula crithmoides*.
TQ 66230 75389	14 and 13	27	0.25	Some deposition of *Fucus vesiculosus*. Blue-green alga present.	
TQ 66442 75435	14 and 13	28	0.25	Erosion evident and no pioneer zone. Some deposition of *Fucus vesiculosus*. Blue-green alga present.	*Inula crithmoides*.
TQ 66671 75496	-	-	-	Beach and rocks.	*Colletes halophilus*.
TQ 66773 75474	14a	29	0.4	Boat wreck.	

3. APEM, 2018, Tilbury Energy Centre Benthic Ecology Surveys, Preliminary Environmental Information Report Appendix 10.5, APEM Scientific Report P00001435: WP7-10. Prepared for RWE Generation UK

Tilbury Energy Centre Marine Ecology Surveys

Preliminary Environmental Information Report Appendix 10.5

APEM Subtidal and Intertidal Benthic Ecology Survey Report

RWE Generation UK

APEM Ref P00001435: WP7-10

August 2018

Dr Christopher Ashelby, Rachel Antill, Dr Marc Hubble

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Project reference: **P00001435 WP7-10**

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Revision and Amendment Register

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1.0	25/06/2018	All	All	Document creation	DH
2.0	16/08/2018	2.6.1; 2.7.1; 3.3.4.1	6, 9, 20, 21	Addressing RWE Generation UK comments	MH

Contents

List of Figures

List of Tables

Executive summary

APEM Ltd has been commissioned to undertake a series of marine ecology surveys to inform an Ecological Impact Assessment for the proposed Tilbury Energy Centre (TEC) on behalf of RWE Generation UK. This report presents intertidal and subtidal benthic ecology and sediment particle size and chemistry data from a survey conducted in May 2017.

The intertidal and subtidal survey extent was informed by previous thermal modelling outputs for a proposed power station plant at this location (RWE nPower 2012, unpublished data), with stations within and outside the area expected to be influenced by increases in temperature due to discharge of heated cooling water during operation of the TEC. Intertidal stations were located in the upper and mid intertidal zone along seven intertidal transects (total of 14 stations) from immediately west of Tilbury Fort to approximately 1.5 km east of the power station. Subtidal stations were located from the area adjacent to Tilbury Docks to approximately 2.5 km east of Tilbury B power station, generally focussed within the northern section of the channel with some stations in the mid channel (total of 14 stations).

Three replicate 0.01 m^2 core samples were collected at each intertidal sampling station for biotic analysis, and at each subtidal station biotic samples were collected using a 0.1 m^2 Day grab. Further samples were collected at each station for Particle Size Analysis (PSA) with chemistry samples collected at all of the intertidal sample stations, and seven of the subtidal stations as agreed with the Environment Agency (EA). Consultations were held with the EA to agree an appropriate chemical analysis suite ensuring inclusion of any chemicals that the EA have previously investigated, or are currently investigating locally (local Thames water quality and biota issues).

Sediment type within the intertidal zone was found to be relatively homogeneous with all except two stations classified as Sandy mud (the other two stations were classified as Slightly Gravelly Muddy Sand). This was also the case in the subtidal zone with eleven of the fourteen stations classified as Sandy mud (other stations were characterised as Gravel and Sand).

No benthic invertebrate species of conservation importance were recorded within any of the samples. Four non-native species were recorded during the intertidal survey (the American ostracod *Eusarsiella zostericola*, the polychaete *Hypereteone lighti*, the barnacle *Austrominius modestus* and the New Zealand mud snail *Potamopyrgus antipodarum*). *E. zostericola* and *H. lighti* were also recorded during the subtidal survey, along with the American piddock *Petricolaria pholadiformis* and the freshwater hydroid *Cordylophora caspia*. The records for *H. lighti* are the first known records for this species in the Thames Estuary and although it is non-native, this species (along with each of the other non-native species recorded during the surveys), is not considered to be 'invasive' as defined by the Great Britain Non-Native Species Secretariat (GB NNSS 2018).

The amphipod *Corophium volutator* was the most abundant taxon across the subtidal and intertidal samples while polychaete and oligochaete worms were the most abundant taxon groups. Density of invertebrates was highly variable across stations in the intertidal and subtidal zone, and biomass of intertidal invertebrates was dominated by annelids in the west section of the survey area with a greater proportional biomass of crustaceans at the more easterly stations. Intertidal assemblages were homogeneous with all except one station assigned the biotope '*Hediste diversicolor* and *Corophium volutator* in littoral mud', while subtidal assemblages were more heterogeneous with five biotopes assigned across the 14 stations (two of which were variants of more standard forms).

Chemistry analysis indicated that within the intertidal samples the only exceedance of Chemistry Action Level (cAL2) was for total PAH (tPAH) at two of the stations. The heavy metals with most exceedances of cAL1 in the intertidal samples were cadmium, chromium and mercury although there were also exceedances of cAL1 at a number of stations for lead, mercury and zinc, and exceedances of Probable Effect Levels (as defined by Canadian Sediment Quality guidelines) at some stations. Most of the PAHs in intertidal samples were found to exceed cAL1 concentrations and Probable Effect Levels were exceeded at all stations for six of the PAHs. Within the subtidal sample there was only one exceedance of cAL2 (again for tPAH). Cadmium and chromium were found to exceed cAL1 at six of the seven stations tested for chemistry with fewer exceedances for the other heavy metals although PEL was exceeded at one or two stations for Lead, Mercury and Zinc. The values for cAL1/PEL were exceeded for most PAHs at most stations.

Overall, both intertidal and subtidal assemblages were typical of those found throughout the length of the tidal Thames and are consistent with the assemblages recorded during other surveys in the area (e.g. RWE nPower 2011 (unpublished data), Port of Tilbury 2017).

1. Introduction

1.1 Project background

APEM Ltd has been commissioned to undertake a series of marine ecology surveys to inform an Environmental Impact Assessment for the proposed Tilbury Energy Centre on behalf of RWE Generation UK. The overall survey programme provides site-specific data for plankton (phyto-, zoo- and ichthyo-), fish (intertidal and subtidal), benthos (intertidal and subtidal), saltmarsh, sediment chemistry and water chemistry.

This report presents subtidal and intertidal benthic ecology and chemistry data which were obtained from a single survey conducted in May 2017.

1.2 Survey objectives

The objective of the survey was to characterise the subtidal and intertidal benthic assemblages present within the survey area in May 2017. Samples were analysed to provide data for biota, sediment/habitat type and concentrations of chemicals in the sediment. The information obtained was to inform an Ecological Impact Assessment (EcIA) for the proposed TEC project.

2. Methodology

2.1 Survey permissions

A Temporary River Works Licence (TRWL) was issued by the Port of London Authority (PLA; reference A2/40/116) and the PLA also granted permission to use their jetty at Gravesend. The works were exempt from a Marine Management Organisation (MMO) Marine Licence and an exemption form was completed.

Access for the intertidal surveys was through the existing power station at Tilbury and permission to access the foreshore was granted by RWE Generation UK.

2.2 Survey timings

The intertidal survey was conducted between the 30th and 31st May 2017 and the subtidal survey was conducted between 7th and 9th May 2017 with tide times provided in Table 1.

Table 1: Date and tidal information for the subtidal and intertidal survey days.

Survey	Date	Low tide		High Tide	
		Time (BST)	Height (m)	Time (BST)	Height (m)
Intertidal survey	30/05/2017	11:08	0.8	17:28	6.2
	31/05/2017	11:51	1.0	18.20	6.0
Subtidal survey	08/05/2017	06:34	0.7	12:39	6.3
		18:52	1.0	-	-
	09/05/2017	07:15	0.7	13:19	6.3
		19:35	0.9	-	-

2.3 Survey vessel

The subtidal sampling was conducted using the survey vessel INA K (Figure 1). INA K is a 16.7 m ex-fishing vessel built in 1961 and now used as a fisheries research and benthic survey vessel operating out of Hole Haven Marina at Canvey Island. Survey operations mobilised from the PLA jetty at Denton Wharf on the South Bank of the Thames at Gravesend, opposite Tilbury Power Station.

Figure 1: The survey vessel INA K used during the subtidal grab surveys. Photograph © Charlie McNeilly.

2.4 Survey design

The extent of the intertidal and subtidal surveys was determined based on consideration of initial thermal modelling outputs for a previous proposed biomass power station at the Tilbury site (RWE nPower 2012, unpublished data). The thermal discharge from that proposal was similar to that envisaged for the currently proposed TEC project. The thermal modelling indicated potential temperature changes along the north bank of the Thames estuary and the survey area was selected to include, and extend well beyond, the zone of a potential >2ºC increase above background temperature levels with an operating power station (based on 98th percentile temperature rise at the Estuary bed). Temperature changes from the mid channel to the southern shore were generally modelled to be <1ºC so it was considered that sampling was not required in the southern sections of the channel. Consultation was held with the Environment Agency (EA) in relation to survey design prior to commencement of survey work.

2.4.1 Intertidal survey

Intertidal survey stations were sampled on both the upper and mid shore after it was determined via an initial walkover that habitat type was very similar on the mid and lower shore sections of the intertidal zone (due to this observation and the short distance between mid and lower shore areas it was considered that data obtained for the mid shore would be sufficient to effectively characterise assemblages in the mid and lower intertidal zone). Intertidal core station locations are indicated in Figure 2 with coordinates provided in Appendix 1. Samples for chemical analysis were collected at all of the intertidal sample stations as agreed via consultation with the EA.

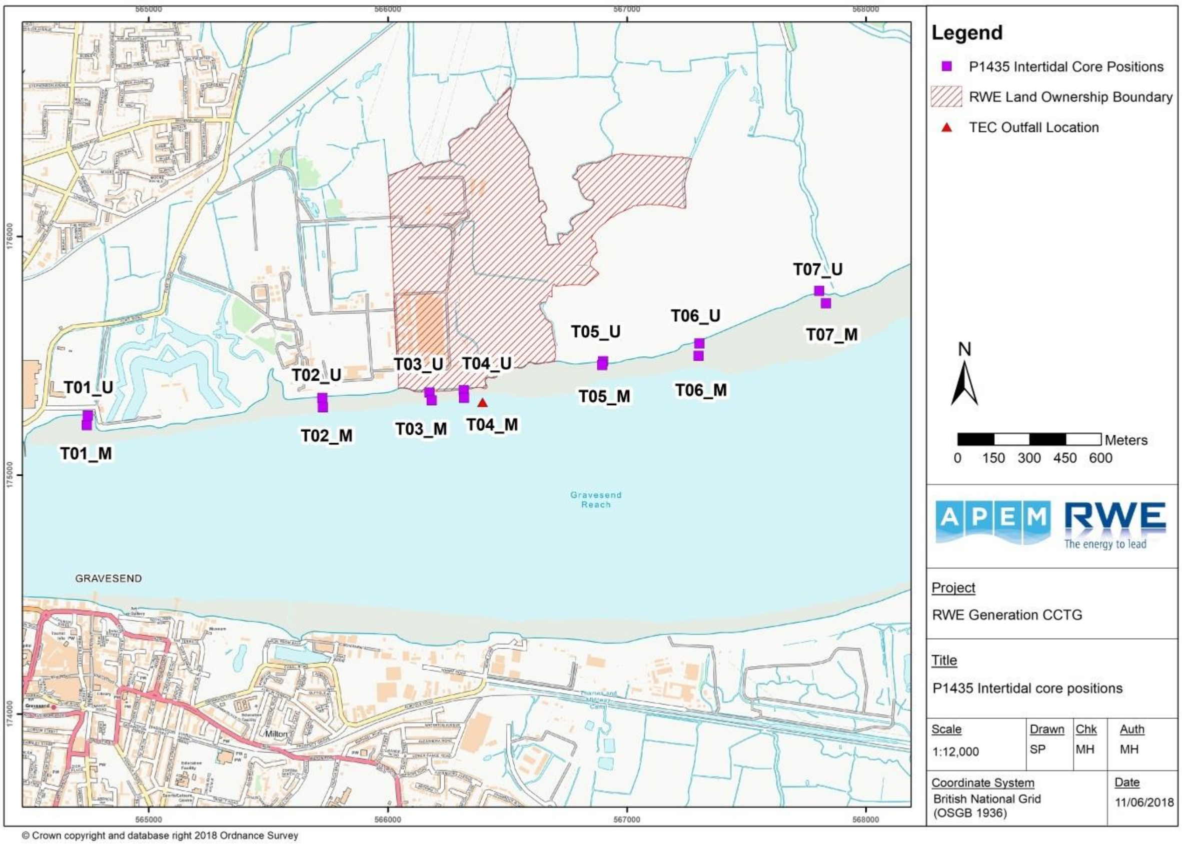

Figure 2: Intertidal core sampling locations.

2.4.2 Subtidal survey

Subtidal grab station locations are indicated in Figure 3, with coordinates provided in Appendix 1. Samples for chemical analysis were collected at seven of the benthic sample stations as agreed with the EA (Figure 3).

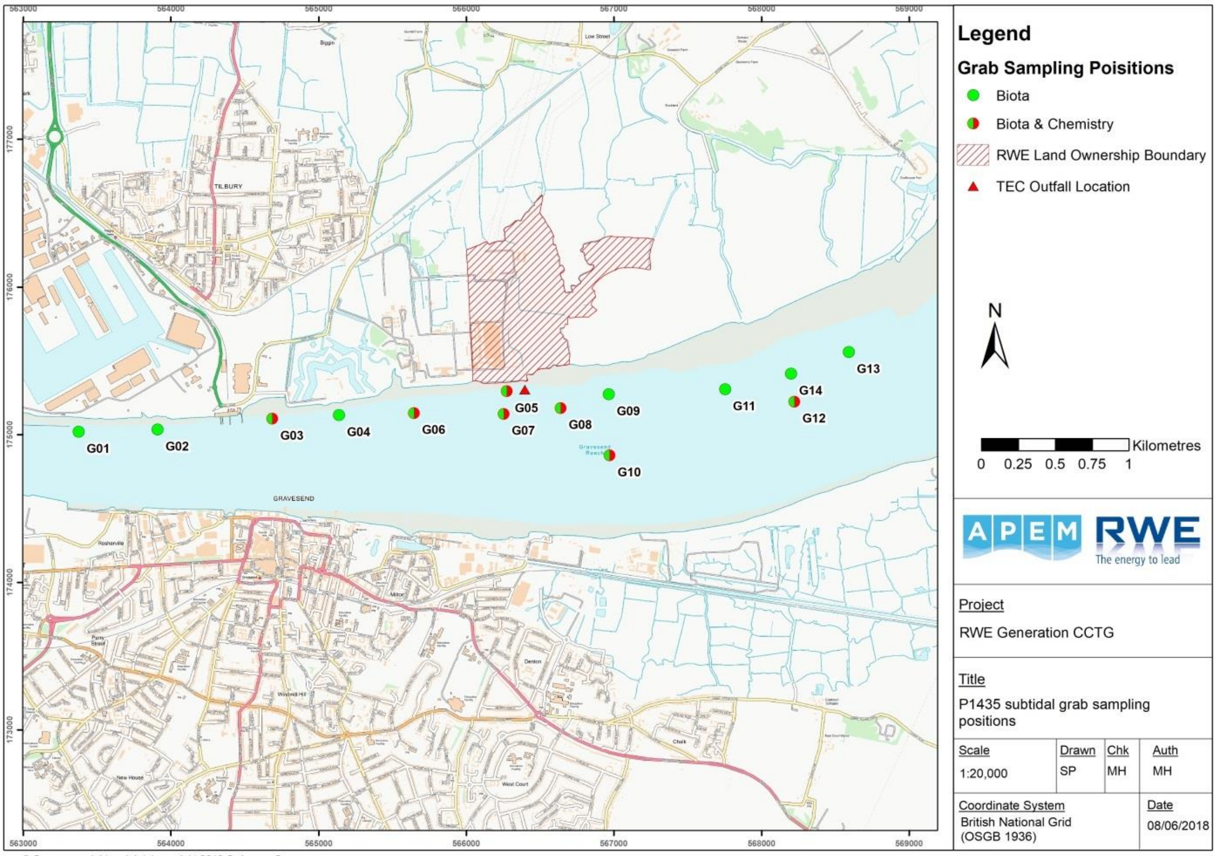

Figure 3: Subtidal benthic grab sampling locations.

2.5 Survey methodology

2.5.1 Intertidal survey

Intertidal core samples were taken following guidance within the Marine Monitoring Handbook (Dalkin & Barnett 2001) and UKTAG Water Framework Directive (WFD) guidance (WFD-UKTAG 2014).

Quantitative core samples were collected at each core station using a 0.01 m^2 hand held core pushed into the sediment to a depth of 15 cm (Dalkin & Barnett 2001). To ensure the data collected were WFD compatible three replicate cores were taken at each core sample station. Each sample was placed into a robust plastic bag and labelled before being transported to APEM's Marine Biolabs for analysis. Within 24 hours of collection, the biological core samples were sieved over a BS410 standard 0.5 mm mesh and preserved in buffered 4% formaldehyde solution.

Additional core samples were taken at each sample station for Particle Size Analysis (PSA) following WFD guidance (WFD-UKTAG 2014) and these samples were kept cool and transported to a third party laboratory for analysis within 24 hours. For chemical analyses 500 g of sediment was obtained using a plastic scoop for analysis of metals and 500 g was obtained using a metal scoop for analysis of organic compounds (e.g. Polycyclic Aromatic Hydrocarbons (PAHs) and Polychlorinated Biphenyls (PCBs)), with samples placed in labelled sterile containers provided by the processing laboratory. The chemical samples were frozen as soon as practicable following collection and were transported to a third party laboratory for analysis.

Notes were made at each station of the presence and extent of macroalgae, presence of surface features (e.g. casts, burrows), depth of anoxic layer and sediment characteristics (stability, firmness, surface relief). Anthropogenic impacts were also recorded where evident.

2.5.2 Subtidal survey

Grab samples were collected using a 0.1 m^2 Day grab, with three replicate grab samples taken at each station for biological analysis. All samples were assessed on retrieval for suitability. Where there was evidence of the grab not operating correctly or the sample volumes were low (<5 litres (Ware & Kenny 2011)) samples were rejected and another sampling attempt made. At each station up to four attempts were made to collect a valid sample. If a valid sample could not be collected after four attempts then a decision was made as to whether to relocate or abandon the station.

The grab sample was photographed prior to processing. Biological samples were processed in the field in accordance with the guidance provided in Cooper & Mason (2017). Samples were sieved using a 0.5 mm sieve and all material retained on the sieves was fixed with 4% buffered formaldehyde solution in seawater and placed in sample containers (labelled inside and outside) following guidance in Ware & Kenny (2011) and Davies *et al*. (2001). Once the sieved samples were labelled and preserved all apparatus and sieves were thoroughly cleaned to prevent cross-contamination before moving to the next station. The sample was securely stored prior to the deployment of the grab at the next sampling station to ensure a clear working area and prevent potential damage or contamination of the sample. The samples were then transported to APEM's Marine Biolabs for analysis.

A further replicate grab sample was taken at each station to obtain an appropriate sediment subsample of 500-1,000 ml for PSA which was transferred to a suitable container (labelled both internally and externally) and transported to a third party laboratory for analysis. In addition, at seven of the stations (Figure 3), samples were obtained for chemical analysis following the approach indicated for intertidal sediments.

At each benthic grab station the following water quality parameters were recorded from the surface waters using a calibrated YSI Professional Plus handheld multiparameter probe:

- temperature
- pH
- dissolved oxygen concentration and saturation
- salinity
- conductivity

2.6 Laboratory processing

2.6.1 Macrobiota

Sample analysis was conducted according to APEM's standard operating procedure for marine benthic sample analysis which is fully compliant with the North-East Atlantic Marine Biological Analytical Quality Control (NMBAQC) Scheme's Processing Requirement Protocol (PRP), (Worsfold *et al*. 2010).

To standardise the sizes of organisms and improve sorting efficiency, samples were sieved through a stack of sieves of 4.0, 2.0, 1.0 and 0.5 mm meshes in a fume cupboard following UKTAG guidance for benthic invertebrate sample analysis for transitional waters (WFD-UKTAG 2014). All biota retained in the sieves were then extracted under low power microscopes, identified and enumerated, where applicable.

Several samples required subsampling due to either large amounts of material or a high abundance of certain taxa. Where subsampling was undertaken it was conducted using the methodology outlined in the NMBAQC Scheme PRP (Worsfold *et al*. 2010) using a Quarteriser (Proudfoot *et al*. 2003). Abundance figures were corrected as required to account for any subsampling undertaken.

Taxa were identified to the lowest practicable taxonomic level (usually species), using appropriate taxonomic literature. For certain taxonomic groups (e.g. nemerteans, nematodes, and certain oligochaetes), higher taxonomic levels were used due to the widely acknowledged lack of appropriate identification tools for these groups. The NMBAQC Scheme's Taxonomic Discrimination Protocol (TDP) (Worsfold *et al*. 2010), which gives guidance on the most appropriate level to which different marine taxa should be identified, was adhered to for the laboratory analysis. Where required, specimens were also compared with material maintained within the laboratory reference collection. Nomenclature followed the World Register of Marine Species (WoRMS; WoRMS Editorial Board 2017), except where more recent published literature that had not yet been incorporated into the WoRMS list was known to exist

All samples were subject to internal quality assurance procedures and, following analysis, 10% of samples were subject to formal Analytical Quality Control (AQC). For archiving purposes, all samples were stored in 70% industrial denatured alcohol (IDA) solution. At least one example of each taxon recorded from the surveys was set aside for inclusion in APEM's in-house reference collection. This collection acts as a permanent record of the biota recorded.

2.6.2 Biomass estimations

Biomass analysis was conducted for the intertidal core samples to determine the biomass of different groups that could provide prey items for birds. The estimation of biomass was undertaken according to APEM's standard operating procedure and the NMBAQC Scheme guidance and TDP (Worsfold *et al*. 2010). APEM used a non-destructive biomass procedure that is fully compliant with the methods outlined in the Clean Seas Environmental Monitoring Programme (CSEMP) Green Book (CSEMP 2012). Animals were blotted dry before transfer to a tared analytical balance. Biomass values were recorded as blotted wet-weight, +/- 0.0001 g. Taxa weighing less than 0.0001 g were given a nominal weight of 0.0001 g. Barnacles, ascidians, cnidarians and non-countable taxa were not weighed.

Biomass was determined at major taxonomic group level and specimens set aside for inclusion in the reference collection were weighed separately with their weight being added to the relevant group. The major groups were defined as Annelida, Crustacea, Mollusca, Echinodermata and Others. Blotted wet-weight biomass values were converted to Ash-Free Dry-Weight values using the major group conversion factors published in Eleftheriou & Basford (1989).

2.6.3 Particle size analysis

PSA was performed in accordance with NMBAQC Scheme best practice guidance for PSA for supporting biological analysis (Mason 2016), with the modification that the wet separation was performed at 2.0 mm rather than 1.0 mm, to determine the ‘gravel’ to ‘sand and mud’ proportions by weight. A combination of dry sieving and laser diffraction was used due to the range of particle sizes present in the samples.

2.6.4 Sediment chemistry

A list of chemicals to be analysed was determined following consultation with the Environment Agency and RWE Generation UK (see Appendix 2). Chemical analyses were conducted according to UKAS accredited methods where appropriate by a Marine Management Organisation (MMO) approved laboratory.

2.7 Data analysis

2.7.1 Macrobiota

Before analysis, all data were checked for errors. Summary statistics were calculated and outlying values investigated to identify possible data transcription errors. As is standard practice, truncation of the biological data was undertaken before application of univariate and multivariate statistical analyses (see Table 3). Univariate and multivariate analyses were undertaken using the PRIMER software package (Clarke & Warwick 2001).

For analyses based on numbers of individuals, any non-countable taxa and fragments of individuals were also omitted from analysis.

Table 2: Details of data truncation performed prior to statistical analysis.

Dataset	Taxon / Records	Details of truncation performed
Intertidal	Fragments	Removed
	Coleoptera and Coleoptera (larvae)	Combined for analysis
	Scrobicularia plana and *Scrobicularia plana* (juv.)	Combined for analysis
Subtidal	Fragments	Removed
	Pleurobrachia pileus	Removed as not a benthic taxon
	Clupeidae	Removed as not a benthic taxon
	Coleoptera	Removed as not a subtidal or benthic taxon
	Neoamphitrite figulus and *Neoamphitrite figulus* (juv.)	Combined for analysis

Biological diversity within a community was assessed based on taxon richness (total number of taxa present) and evenness (considers relative abundances of different taxa). The following metrics were calculated:

- **Taxon richness:** The total number of taxa in a sample.
- **Density:** The number of individuals per unit area (e.g. per square metre).
- **Shannon-Wiener Diversity Index (*H'*(log_e)):** A widely used measure of diversity accounting for both the number of taxa present and the evenness of distribution of the taxa (Clarke & Warwick 2001).
- **Margalef's species richness (*d*):** A measure of the number of species present for a given number of individuals.
- **Pielou's Evenness Index (*J'*):** Represents the uniformity in distribution of individuals spread between species in a sample. The output range is from 0 to 1 with higher values indicating more evenness or more uniform distribution of individuals.
- **Simpson's Dominance Index (1-λ):** A dominance index derived from the probability of picking two individuals from a community at random that are from the same species. Simpson's dominance index ranges from 0 to 1 with higher values representing a more diverse community without dominant taxa.

Data for all replicates from a single station were averaged to provide mean values. Where mean values were calculated per station for a given metric, the standard deviation (SD) has been provided.

Multivariate analyses were conducted using resemblance (similarity) matrices. The particle size data resemblance matrix was calculated using Euclidean Distance following data normalisation and for both the intertidal and subtidal macrobiota data sets, the Bray-Curtis measure of similarity was used. Sample similarity calculations using raw abundance data can easily be dominated by a few highly abundant taxa (Clarke and Warwick, 2001), thus masking the influence of less abundant species. Data transformations were therefore carried out on both the intertidal and subtidal macrobenthic data matrices prior to the calculation of Bray-Curtis similarity to reduce the influence of the most numerically dominant taxa, following the recommendations in Clarke & Gorley (2006). For the subtidal data, where abundances ranged from single figures up to hundreds of individuals a square root transformation was used. For the intertidal data, where abundances ranged from single figures up to thousands of individuals a stronger fourth-root transformation was used (see Clarke & Gorley 2006).

2.7.1.1 Cluster Analysis

Cluster analysis was utilised to provide a visual representation of sample similarity in the form of a dendrogram. Cluster analysis was conducted in conjunction with a SIMPROF (similarity profile) test to determine whether groups of samples were statistically indistinguishable at the 5% significance level, or whether any trends in groupings were apparent. Black lines on the dendrogram indicate statistical distinctions between sampling stations, whilst red lines indicate that the samples were statistically inseparable.

2.7.1.2 Ordination Analyses using non-Metric Multidimensional Scaling

Non-metric multidimensional scaling (MDS) is a type of ordination method which creates a 2- or 3-dimensional ‘map’ or plot of the samples from the PRIMER resemblance matrix. The plot generated is a representation of the dissimilarity of the samples (or replicates), with distances between the replicates indicating the extent of the dissimilarity. For example, replicates that are more dissimilar are further apart on the MDS plot. No axes are present on the MDS plots as the scales and orientations of the plots are arbitrary in nature.

Each MDS plot provides a stress value which is a broad-scale indication of the usefulness of plots, with a general guide indicated below (Clarke & Warwick 2001):

- <0.05 Almost perfect representation of rank similarities;
- 0.05 to <0.1 Good representation;
- 0.1 to <0.2 Still useful;
- 0.2 to <0.3 Should be treated with caution;
- >0.3 Little better than random points.

2.7.1.3 SIMPER

Where differences between groups of samples were found, SIMPER analysis (in PRIMER) was used to determine which taxa were principally responsible for the differences between the statistically distinct groups of stations.

2.7.2 Particle size analysis

The PSA data were entered into GRADISTAT (Blott & Pye 2001) to produce sediment classifications, following Folk (1954), (Figure 4). Summary statistics were also calculated including mean particle size, sorting, skewness and kurtosis (following Blott & Pye 2001).

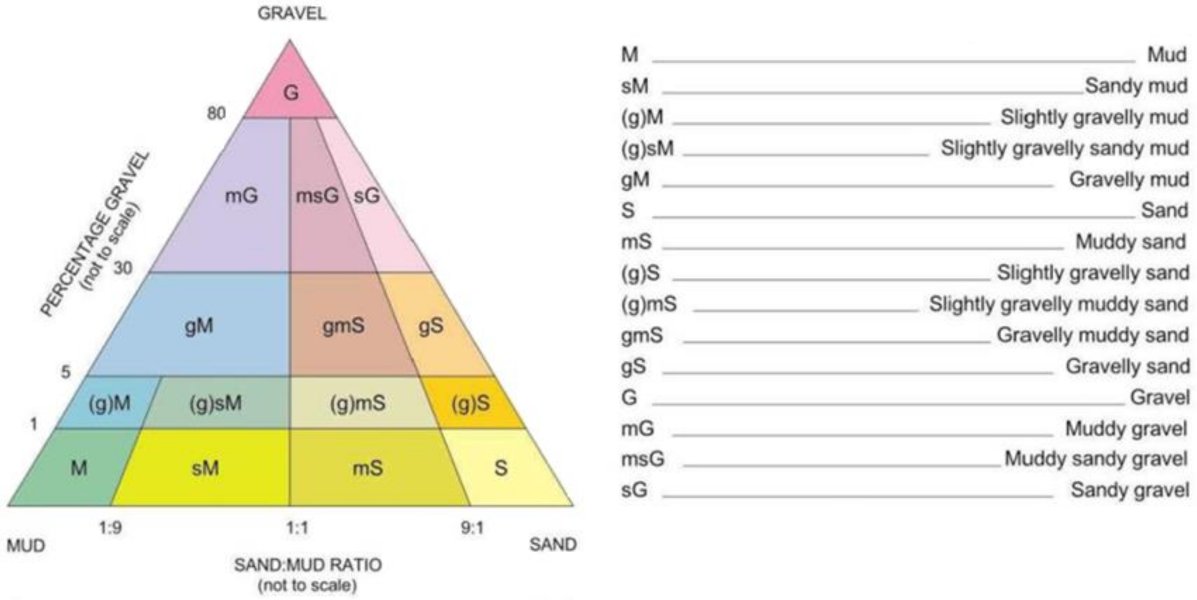

Figure 4: Folk sediment classification pyramid (Folk, 1954).

2.7.3 Biotope allocation

The invertebrate count data and PSA results, and outputs of the cluster analysis, SIMPROF and SIMPER analysis, were interpreted to allocate biotopes to each replicate sample. Biotopes were allocated following JNCC's National Marine Habitat Classification for Britain and Ireland: Version 04.05 (Connor *et al*. 2004). EUNIS codes corresponding to each biotope have also been provided (JNCC 2010, Parry 2015).

2.7.4 Sediment chemistry

The concentration of chemicals recorded at each station was compared against different environmental standards.

Where possible, chemical concentrations were assessed against Cefas Chemical Guideline Action Level concentrations (MMO 2015). The guidance defines Chemical Action Level 1 (cAL1) and Action Level 2 (cAL2) concentrations. Concentrations below cAL1 are of no concern, chemical levels between cAL1 and cAL2 generally would indicate further consideration would be required for disposal at sea, while dredged material with chemical levels above cAL2 is generally considered unsuitable for sea disposal (MMO 2015).

It should be noted action level concentrations (cAL1/cAL2) are only available in the UK for a sub-set of the chemicals on the Environmental Quality Standards Directive (EQSD) list for WFD assessment (EA 2016). For chemicals with no cAL1/cAL2 guidelines the Canadian Sediment Quality guidelines provide a Threshold Effect Level (TEL) (which is equivalent to the Interim Sediment Quality Guideline (ISQG) stated in the guidance) and a Probable Effect Level (PEL) which are chemical concentrations relating to potential biological effects as follows (CCME 2002):

- Below the TEL is the minimal effect range within which adverse biological effects rarely occur.
- Between the TEL and PEL is the possible effect range within which adverse biological effects occasionally occur.
- Above the PEL is the probable effect range within which adverse biological effects frequently occur.

In addition, for a number of chemicals there is a large difference between cAL1 and cAL2 values. Consequently, to provide further resolution where both cAL and Canadian Sediment Quality Guidelines were available, if cAL1 was exceeded, chemical levels in relation to TEL, PEL as well as cAL2, were also determined as appropriate.

Alternative standards for chemical concentrations are provided as part of the OSPAR Coordinated Environmental Monitoring Programme (CEMP) (OSPAR 2012). OSPAR (2012) provides Effects Range-Low (ERLs) for selected hazardous substances prioritised for action by OSPAR due to their risk to the marine environment (concentrations below the ERL rarely cause adverse effects in marine organisms while concentrations above the ERL will often cause adverse effects in some marine organisms). There were no chemicals assessed for which only OSPAR guidance was available, and following an approach agreed with the EA chemical concentrations have been assessed against cAL, TEL and PEL as indicated above, however, ERL values have also been provided for reference.

3. Results

A number of target sample stations toward the centre of the estuary channel could not be sampled due to the presence of cobbles and hard substrate which compromised operation of the grab. Consequently, a number of stations were relocated closer to the north bank resulting in the station array indicated in Figure 3.

3.1 Water quality measurements

Water temperature was consistent across the grab stations with just a 0.6°C variation between the minimum temperature (11.5°C at G12) and maximum temperature (12.1°C at G04), (Appendix 3). Salinity varied between 17.63 at station G01 to 25.42 at G05, and G01 also had the lowest pH with both salinity and pH influenced by the time of sampling in relation to time of high water. Dissolved Oxygen (DO) concentration was variable across stations ranging from 69.7% at G12 to 101.8% at station G08.

3.2 Particle size analysis

Photographs of the shoreline at each transect are provided in Figure 5, with photographs of intertidal sampling locations and grab samples in Appendices 4 and 5, respectively. Full PSA data for the subtidal and intertidal sediments are presented in Appendix 6 and summary data are provided in Table 3. Records of the presence of macroalgae, sediment characteristics, surface features and anthropogenic impacts at each station are provided in Appendix 7.

Table 3: Summary particle size data from each intertidal and subtidal sample station. U=Upper shore; M = Mid shore.

Station	Mean particle diameter (µm)	Gravel (%)	Sand (%)	Mud (%)	Folk classification	Sorting
Intertidal stations						
T01 - U	13.8	0.0	17.1	82.9	Sandy Mud	Very Poor
T01 - M	12.3	0.0	19.1	80.9	Sandy Mud	Very Poor
T02 - U	13.4	0.0	16.1	83.9	Sandy Mud	Very Poor
T02 - M	19.9	0.0	29.2	70.8	Sandy Mud	Very Poor
T03 - U	25.0	0.0	35.2	64.8	Sandy Mud	Very Poor
T03 - M	19.8	0.0	30.8	69.2	Sandy Mud	Very Poor
T04 - U	11.8	0.0	15.4	84.6	Sandy Mud	Very Poor
T04 - M	29.9	0.0	41.2	58.8	Sandy Mud	Very Poor
T05 - U	8.8	0.0	11.6	88.4	Sandy Mud	Very Poor
T05 - M	24.2	0.0	38.9	61.1	Sandy Mud	Very Poor
T06 - U	35.4	0.0	44.6	55.4	Sandy Mud	Very Poor
T06 - M	46.9	2.3	50.7	47.0	Slightly Gravelly Muddy Sand	Very Poor
T07 - U	26.7	3.3	31.6	65.1	Slightly Gravelly Sandy Mud	Very Poor
T07 - M	13.0	0.0	16.1	83.9	Sandy Mud	Very Poor
Subtidal stations						
G01	30.6	0.0	43.2	56.8	Sandy Mud	Very Poor
G02	40.1	0.0	49.7	50.3	Sandy Mud	Very Poor
G03	22.1	0.0	33.0	67.0	Sandy Mud	Very Poor
G04	18.1	0.0	27.6	72.4	Sandy Mud	Very Poor
G05	31.8	0.0	48.7	51.3	Sandy Mud	Very Poor
G06	13.4	0.0	14.6	85.4	Sandy Mud	Very Poor
G07	20.7	0.0	25.7	74.3	Sandy Mud	Very Poor
G08	14.0	0.0	13.2	86.8	Sandy Mud	Poor
G09	16.5	0.0	23.0	77.0	Sandy Mud	Very Poor
G10	28.6	0.0	38.1	61.9	Sandy Mud	Very Poor
G11	12.7	0.0	12.2	87.8	Sandy Mud	Very Poor
G12	19066.3	99.1	0.8	0.1	Gravel	Moderately Well
G13	162.6	0.0	95.9	4.1	Sand	Moderately Well
G14	209.6	0.0	96.6	3.4	Sand	Moderately Well

3.2.1 Intertidal sediments

Sediment at all of the intertidal stations was classified as Sandy mud, with the exception of T06 Mid and T07 Upper which were both classified as Slightly Gravelly Muddy Sand. At the Sandy mud stations the percentage of mud ranged from 55.4 to 88.4% and all sediments were considered to be 'very poorly' sorted.

3.2.2 Subtidal sediments

The sediment at G01 to G11 was classed as Sandy mud with the percentage of mud ranging from 50.3 to 87.8%, consistent with the intertidal samples. Sediment differed at the three sites at the eastern extent of the survey area and were classed as Sand at G13 and G14 and Gravel at G12 (Table 3). Sediments classified as Sandy mud were generally either 'very poorly' sorted with just G08 'poorly' sorted and the coarser sediments found at stations G12, G13 and G14 were 'moderately well' sorted.

3.3 Biotic data

3.3.1 Notable macrobenthic taxa

3.3.1.1 Intertidal survey

None of the intertidal infaunal species recorded were of conservation importance (e.g. protected under the Wildlife and Countryside Act 1981 (as amended), Habitats Directive or a Species of Principal Importance in England under Section 41 list of the NERC Act) and none were considered to be rare (i.e. those listed by Bratton 1991, Sanderson 1996, Betts 2001, Chadd & Extence 2004).

Four non-native species were recorded in the intertidal samples (the barnacle *Austrominius modestus*, the New Zealand mud snail *Potamopyrgus antipodarum*, the American ostracod *Eusarsiella zostericola* and polychaete *Hypereteone lighti*), (Appendix 8). *A. modestus* was recorded at T04 Mid and *P. antipodarum* was found at T01 Upper (*P. antipodarum* is primarily a freshwater species and is at the upper limit of its salinity range at Tilbury). Two individuals of *H. lighti* were recorded at T2 Mid and fifteen individuals of *E. zostericola* were recorded across T3 Mid, T4 Mid and T6 Mid (*H. lighti* and *E. zostericola* were also recorded in the subtidal samples). The *H. lighti* specimens from the current survey are the first known records of this species from the Thames Estuary.

Streblospio sp. was found in 29 of the core samples with the highest number recorded at T07 Upper. At least one species of the genus is considered non-native in the UK, however, *Streblospio* is taxonomically problematic and individuals were not identified to species in this study.

Two species considered to be cryptogenic (i.e. that are neither demonstrably native nor non-native) were recorded within the intertidal samples (Tharyx 'species A' and *Polydora cornuta*).

Figure 5: Views along shore from top of Transects 1 to 7 (T1-7).

3.3.1.2 Subtidal survey

In common with the intertidal samples, no species of conservation importance were encountered in the subtidal samples. Four species considered non-native to the UK were recorded from the grab samples (two of these *E. zostericola* and *H. lighti* were also recorded in the intertidal samples), (Appendix 9). Of these, *E. zostericola* was the most abundant being present in 17 of the replicates, with 111 individuals in total with the highest densities of this species recorded at station G03. *H. lighti* was recorded in five samples with a total of 23 individuals, the majority of which were recorded at station G04. The American piddock *Petricolaria pholadiformis* was recorded in eight replicate samples whilst the freshwater hydroid *Cordylophora caspia* was present in seven of the replicate samples. Spionid polychaetes of the genus *Streblospio* were abundant in the samples (182 individuals recorded in total). At least one species of the genus is considered non-native in the UK, however, as indicated above *Streblospio* individuals were not identified to species in this study.

Several species considered to be cryptogenic (i.e. that are neither demonstrably native nor non-native) were recorded within the subtidal samples (the polychaetes *Alitta succinea*, *Alitta virens*, *P. cornuta* and *Tharyx* 'species A' and the barnacle *Amphibalanus improvisus*).

3.3.2 Community summary statistics for macrobenthic assemblages

The complete benthic dataset for the intertidal and subtidal and samples is provided in Appendices 8 and 9.

3.3.2.1 Intertidal survey

Fifty-seven benthic taxa were identified from the 14 stations (42 intertidal core samples) and ten of the taxa recorded were non-countable. The mud shrimp *Corophium volutator* was the most abundant taxon, being present in every sample and having a total abundance of 12,915 individuals (43.7% of the total number of countable organisms recorded for the survey) and a mean density of 30,750 ± 48,521 individuals m^{-2}. The oligochaete *Tubificoides benedii* was also present in all samples, and nematode worms were present in all except one replicate at T03 Mid. Abundant taxa other than *C. volutator* were the oligochaete worms *T. benedii* (6,208 individuals in total; mean density of 14,781 ± 14,099 individuals m^{-2}) and *Baltidrilus costatus* (4,461 individuals; mean density of 10,621 ± 14,688 individuals m^{-2}), nematode worms (1,958 individuals; mean density of 4,662 ± 6,349 individuals m^{-2}) and ragworms *Hediste diversicolor* (1,097 individuals; mean density of 2,612 ± 4,955 individuals m^{-2}). Nine samples (the three replicates at T05 Mid and T06 Upper, two of the replicates at T07 Upper, and replicate C at the T07 Mid station) were numerically dominated by *C. volutator* whereas all other samples were dominated by annelid worms.

The lowest mean number of taxa was found at Station T04 Upper (10.3 taxa) and T05 Mid had the highest number of taxa (mean of 17.3 taxa), (see Table 4). The greatest density of individuals was found at T06 Upper with 233,500 ± 50,105 individuals m^{-2} whilst T03 Mid had the lowest density with 7,500 ± 6,322 individuals m^{-2}. Margalef's Species Richness varied from 1.5 at T01 Upper, T05 Upper and T07 Mid to 2.4 at T06 Mid. Pielou's Evenness varied from 0.3 at T02 Mid and T03 Upper (low evenness primarily influenced by large numbers of *T. benedii* in relation to other taxa) to 0.7 at T03 Mid, T04 Upper and T05 Upper (high evenness due to low or similarly high numbers of most taxa). The Shannon Wiener Diversity index also indicated low diversity at T03 Upper (value of 0.7), while the highest value was recorded at T06 Mid (value of 1.7). Simpson's dominance varied from 0.3 at T02 Mid and T03 Upper to 0.8 at T05 Upper and the lower values were largely influenced by low numbers of individuals for most taxa and high numbers of *T. benedii* relative to other taxa.

Table 4: Summary statistics for the intertidal stations.

Station	Mean no. taxa (number ± SD)	Mean density (individuals per m^2 ± SD)	Margalef's species richness (*d*)	Mean Pielou's Evenness (*J'*)	Mean Shannon Wiener Diversity (*H'*($\log_e$))	Mean Simpson's Dominance (1-λ)
T01-U	12.7 ± 2.5	77,900 ± 16,263	1.5 ± 0.4	0.6 ± 0	1.5 ± 0.2	0.7 ± 0
T01-M	15 ± 3	38,700 ± 2,722	2.1 ± 0.4	0.6 ± 0	1.6 ± 0	0.7 ± 0
T02-U	13 ± 1	41,433 ± 2,701	1.8 ± 0.2	0.5 ± 0.1	1.2 ± 0.3	0.6 ± 0.2
T02-M	13.3 ± 0.6	19,033 ± 2,892	2.1 ± 0.2	0.3 ± 0	0.8 ± 0.1	0.3 ± 0
T03-U	13 ± 3.6	34,400 ± 9,825	1.8 ± 0.6	0.3 ± 0.1	0.7 ± 0.2	0.3 ± 0.1
T03-M	10.7 ± 2.5	7,500 ± 6,332	2.2 ± 0.3	0.7 ± 0.1	1.6 ± 0.3	0.7 ± 0.1
T04-U	10.3 ± 1.5	22,733 ± 8,310	1.7 ± 0.2	0.7 ± 0	1.6 ± 0.1	0.7 ± 0
T04-M	14 ± 1.7	30,300 ± 7,692	2 ± 0.3	0.5 ± 0	1.2 ± 0.1	0.6 ± 0
T05-U	13.3 ± 2.1	120,233 ± 25,632	1.5 ± 0.2	0.7 ± 0	1.6 ± 0.1	0.8 ± 0
T05-M	17.3 ± 1.5	146,467 ± 94,404	2 ± 0.1	0.4 ± 0.1	1 ± 0.2	0.5 ± 0.1
T06-U	16.3 ± 3.1	233,500 ± 50,105	1.8 ± 0.3	0.5 ± 0	1.2 ± 0.2	0.5 ± 0.1
T06-M	16.7 ± 1.5	41,200 ± 16,743	2.4 ± 0.3	0.6 ± 0.1	1.7 ± 0.1	0.7 ± 0
T07-U	15.3 ± 1.2	116,700 ± 44,674	1.9 ± 0.2	0.6 ± 0	1.6 ± 0.1	0.7 ± 0
T07-M	11.3 ± 3.5	56,067 ± 31,614	1.5 ± 0.6	0.5 ± 0.1	1.3 ± 0.3	0.6 ± 0.1
Min	**10.3**	**7,500**	**1.5**	**0.3**	**0.7**	**0.3**
Max	**17.3**	**233,500**	**2.4**	**0.7**	**1.7**	**0.8**

3.3.2.2 Subtidal survey

Seventy-nine benthic taxa were identified across the 14 stations (42 replicate samples). Non-countable taxa (e.g. algae or colonial species such as bryozoans or hydroids) accounted for 17 of the taxa recorded. Among these the boring polychaete *Polydora cornuta* was the most frequently recorded taxon being present in 30 (71.4%) of the replicate samples. *C. volutator* was the most abundant taxon recorded with a total of 2,337 individuals (mean density of 556 ± 1,075 individuals m^{-2}), accounting for 35.6% of the total number of countable organisms, and 607 of these were recorded in sample G09A. Other abundant taxa were the polychaete worm *Tharyx* 'species A' (1,199 individuals; mean of 285 ± 963 individuals m^{-2}) and the oligochaete worm *T. benedii* (1,034 individuals; mean of 246 ± 438 individuals m^{-2}).

The lowest mean number of taxa was recorded at Station G12 (4.3 taxa) and G04 had the highest number of taxa (20.3 taxa), (Table 5). Station G04 also had the highest density of individuals with 4,420 ± 2,225 m^{-2} whilst G13 had the lowest density with just 166.7 ± 41.6 individuals m^{-2}. Margalef's Species Richness varied from 1.2 at Station G12 to 2.9 at Station G04 reflecting the large difference in the number of taxa at these stations. Pielou's Evenness varied from 0.4 at Station G04 (the low evenness value was primarily influenced by large numbers of *Tharyx* 'species A' and *C. volutator* in relation to other taxa) to 0.9 at Stations G01 and G14 (high evenness as most taxa were represented by just a few individuals). The Shannon Wiener Diversity indices indicated stations generally had low diversity ranging from a value of 1.1 at Station G12 to 1.9 at Station G11. Simpson's dominance values varied from 0.5 at Station G04 to 0.8 at Stations G01, G06, G11, G13 and G14 (higher values indicate a more diverse community without dominance by any one taxon).

Table 5: Summary statistics for the subtidal stations.

Station	Mean no. taxa (number ± SD)	Mean density (individuals per m^2 ± SD)	Margalef's species richness (*d*)	Mean Pielou's Evenness (*J'*)	Mean Shannon Wiener Diversity (*H'*(log$_e$))	Mean Simpson's Dominance (1-λ)
G1	7.3 ± 4.9	206.7 ± 155	1.5 ± 0.8	0.9 ± 0.2	1.2 ± 0.6	0.8 ± 0.3
G2	16 ± 2.6	2,896.7 ± 398.8	2.1 ± 0.4	0.6 ± 0.1	1.6 ± 0.2	0.7 ± 0.1
G3	16.7 ± 3.5	3,186.7 ± 1,752.3	2.5 ± 0.4	0.5 ± 0.1	1.4 ± 0.3	0.6 ± 0.1
G4	20.3 ± 2.3	4,420 ± 2,225	2.9 ± 0.8	0.4 ± 0.1	1.3 ± 0.5	0.5 ± 0.2
G5	16 ± 7.5	3,150 ± 1,011.3	2.1 ± 1	0.5 ± 0.1	1.3 ± 0.5	0.6 ± 0.2
G6	11 ± 3.5	1,413.3 ± 1,626.6	2 ± 0.8	0.8 ± 0	1.8 ± 0.2	0.8 ± 0
G7	9.7 ± 0.6	573.3 ± 225.5	1.9 ± 0.1	0.7 ± 0.1	1.5 ± 0.3	0.7 ± 0.1
G8	9 ± 2	566.7 ± 316.3	1.8 ± 0.5	0.6 ± 0.1	1.3 ± 0.3	0.6 ± 0.2
G9	18.7 ± 4	3,960 ± 3,550.7	2.8 ± 0.2	0.5 ± 0.2	1.4 ± 0.4	0.6 ± 0.2
G10	9 ± 1.7	236.7 ± 228.5	2.6 ± 0.9	0.7 ± 0.4	1.5 ± 0.8	0.7 ± 0.4
G11	15 ± 1	630 ± 311.9	2.7 ± 0.3	0.8 ± 0.1	1.9 ± 0.3	0.8 ± 0.1
G12	4.3 ± 1.5	180 ± 115.3	1.2 ± 0.3	0.8 ± 0.2	1.1 ± 0.1	0.7 ± 0.1
G13	12 ± 3	166.7 ± 41.6	2.8 ± 0.7	0.8 ± 0.1	1.8 ± 0.4	0.8 ± 0.1
G14	9.7 ± 5.1	243.3 ± 158.9	2.5 ± 0.7	0.9 ± 0.1	1.7 ± 0.4	0.8 ± 0.1
Min	**4.3**	**166.7**	**1.2**	**0.4**	**1.1**	**0.5**
Max	**20.3**	**4,420.0**	**2.9**	**0.9**	**1.9**	**0.8**

3.3.3 Biomass analysis

Faunal biomass was dominated by annelids at most stations from Transects 1 to 4 (T1 to T4), with an increase in the relative biomass of crustaceans from Transects 5 to 7 (T5 to T7) (Figure 6, Appendix 10)). Particularly high values for annelids were recorded at T01 Upper and T04 Upper which was largely influenced by high numbers of large ragworms *H. diversicolor* at these stations. Although the highest abundance of *H. diversicolor* was recorded at T05 Upper these were mostly juveniles and therefore did not have such a great influence on the biomass. At T05 Mid, T06 Upper, T07 Upper and T07 Mid crustaceans dominated the biomass. This was primarily influenced by the large numbers of *C. volutator* recorded at these sites but the particularly high value for T06 Upper was due to a juvenile shore crab *Carcinus maenas* in one of the samples. The high value for molluscs at T02 Upper is as a result of two large peppery furrow shells *Scrobicularia plana* in one of the replicates. The highest total biomass was found at T04 Upper whilst T03 Mid had the lowest total biomass.

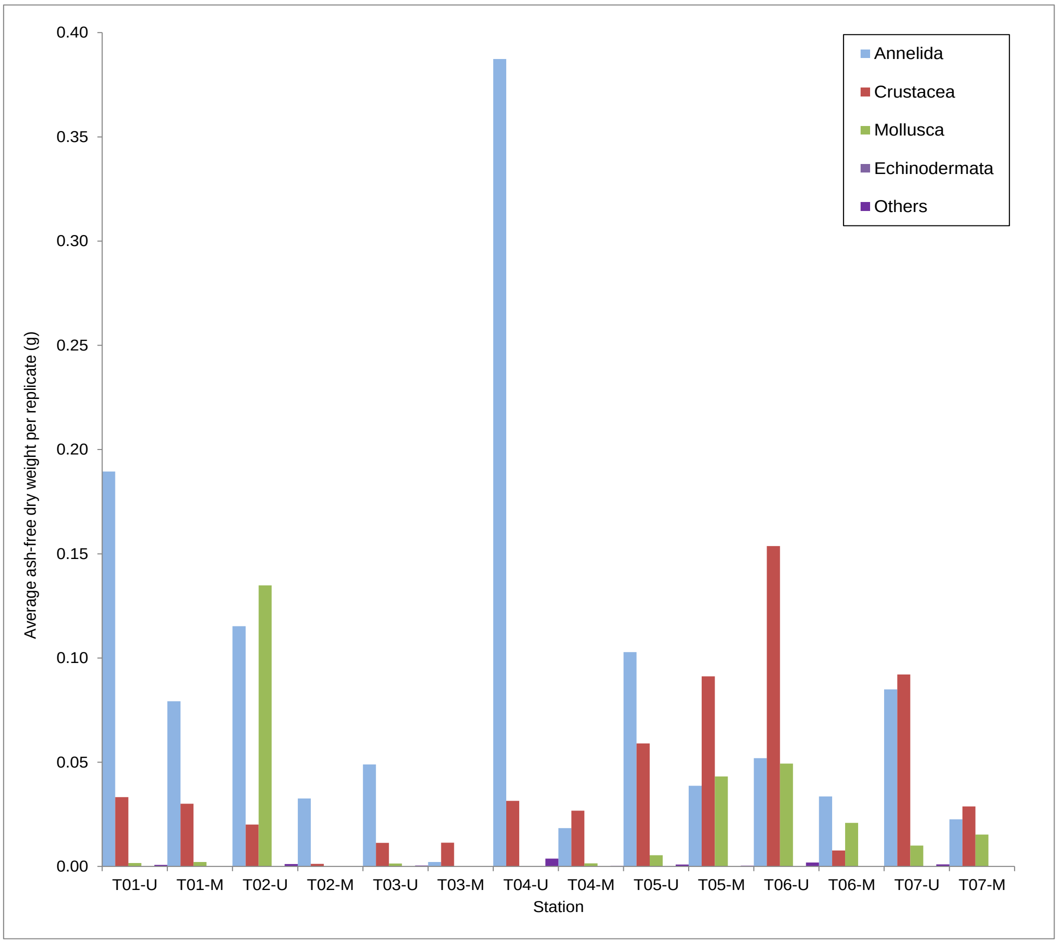

Figure 6: Average ash-free dry weight biomass in grams per replicate at each intertidal station. U = Upper shore, M = Mid shore.

3.3.4 Multivariate analyses

3.3.4.1 Intertidal survey

The SIMPROF test on the intertidal core samples identified nine cluster groups that could be statistically distinguished at the 5% significance level. These are differentiated on the cluster dendrogram (Figure 7) and MDS plot (Figure 8) with different symbols. The SIMPER results for the intertidal samples showed much lower values of dissimilarity between groups than the subtidal samples, with differences largely resulting from relative abundances of species between cluster groups rather than differences in species composition (Appendix 11).

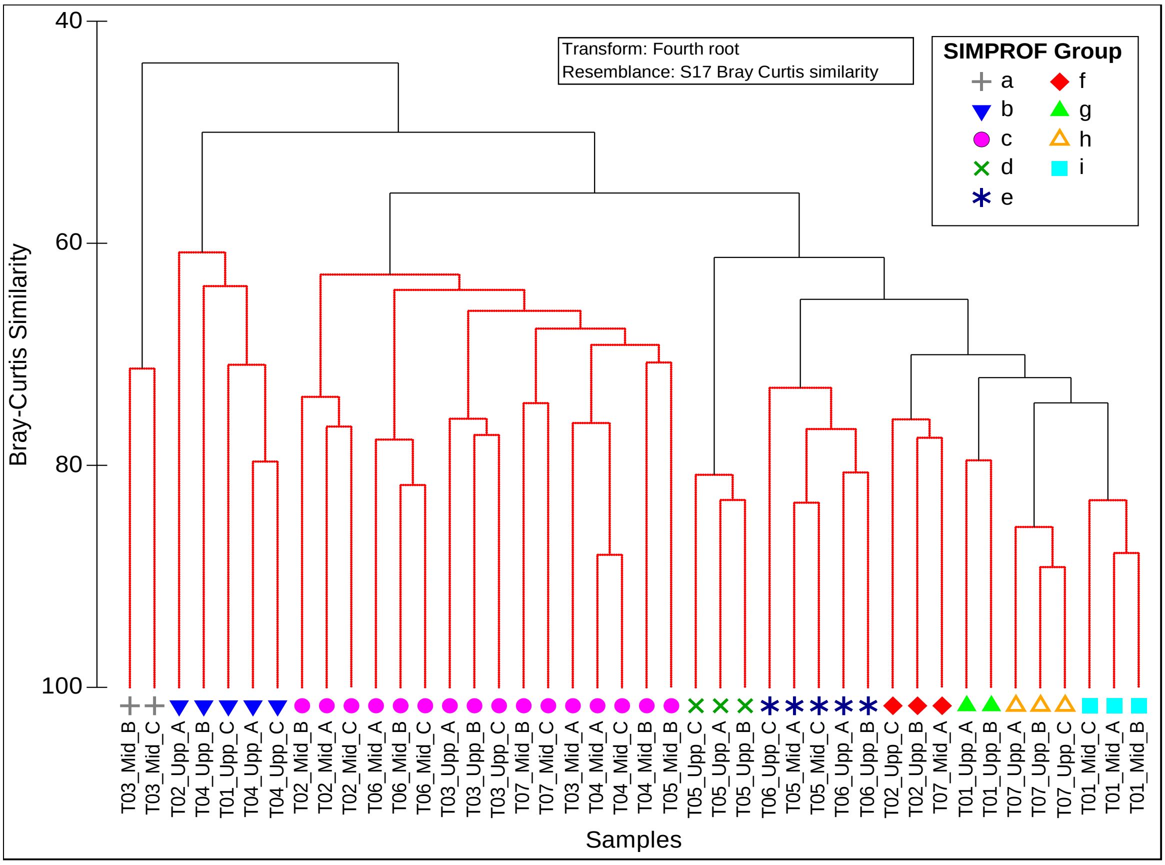

Figure 7: Cluster analysis dendrogram with SIMPROF for intertidal core invertebrate abundance. Black lines show groupings at ≥5%.

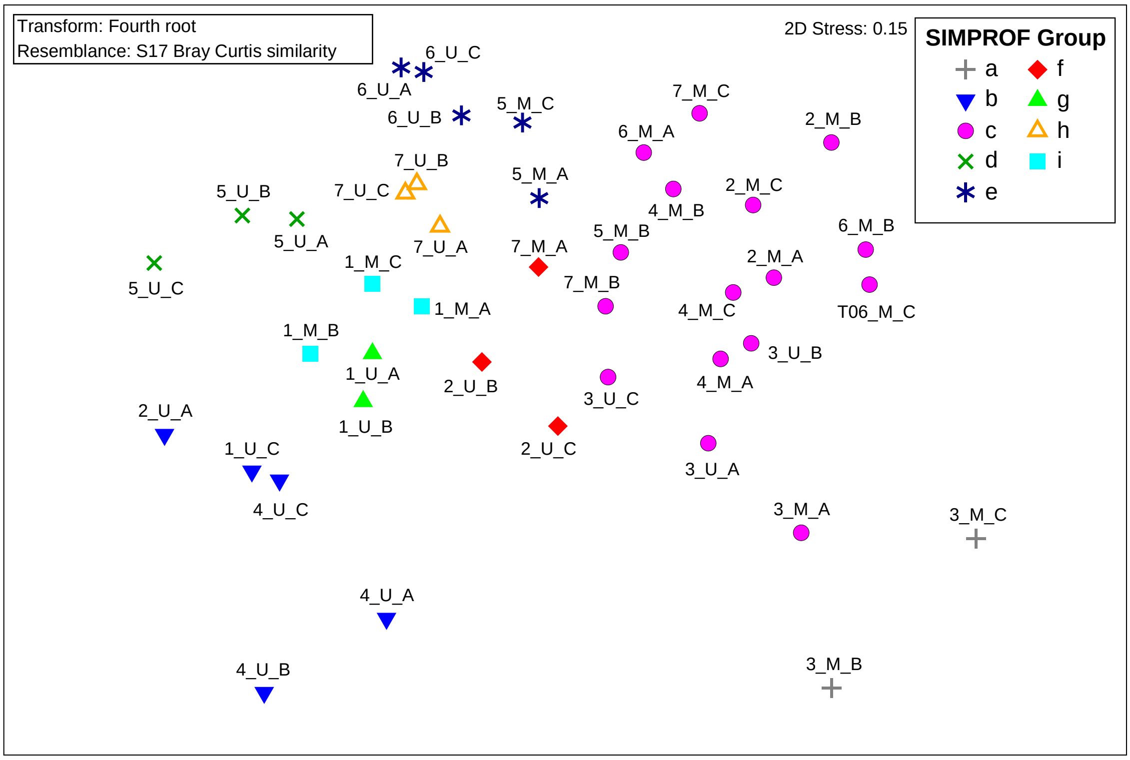

Figure 8: Multidimensional Scaling ordination plot for intertidal core invertebrate abundance.

Group a consisted of two samples (T03 Mid B and C), which separated from the other groups on the cluster dendrogram at just under 44% similarity and are placed towards the bottom right of the MDS plot away from the other samples. This group was characterised by the oligochaete *T. benedii,* the crustacean *C. volutator*, the Baltic clam *Limecola balthica* and the polychaete *Eteone longa* (aggregate), which together contributed 65.32% to within-group similarity.

Group b separated from groups c to i at 50% similarity and the samples from this group are distributed in the lower left corner of the MDS plot. This group was characterised by the oligochaetes *B. costatus* and *T. benedii*, the crustacean *C. volutator*, the polychaete *H. diversicolor* and nematodes, which the SIMPER results show had a combined contribution of 86.08% to within-group similarity.

Group c was the largest cluster group, consisting of 16 replicate samples spread along the survey area (T02 Mid A-C, T03 Upper A-C, T03 Mid A, T04 Mid A-C, T05 Mid B, T06 Mid A-C and T07 Mid B-C), which separated from groups d to i at 55% similarity on the cluster dendrogram. This group was characterised by *T. benedii, C. volutator*, *L. balthica, E. longa* (aggregate) and nematodes, which contributed to 66.91% of within-group similarity.

Group d, consisted of three samples (T05 Upper A-C), separated from groups e to i at 61% similarity. This group was characterised by *T. benedii* and Enchytraeidae, *C volutator*, *H. diversicolor* and nematodes, which had a cumulative contribution of 73.26% to average within-group similarity.

Group e contained five samples (T05 Mid A and C, T06 Upper A-C), separated from groups f to i at 65% similarity on the cluster dendrogram. This group was characterised by *C. volutator*, *T. benedii* and *B. costatus*, nematodes and the polychaetes *E. longa* (aggregate) and *Pygospio elegans*, which together contributed 68.48% of the average within-group similarity.

Group f contained three samples (T02 Upper B and C and T07 Mid A) and in the cluster analysis this group separated from groups g to i at 70% similarity. This group was characterised by *T. benedii* and *B. costatus, C. volutator*, nematodes and the polychaete *Streblospio* spp., which together contributed a cumulative 61% to average within-group similarity.

Group g contained two samples (T01 Upper A and B) and separated from groups h and i at 72% similarity on the cluster dendrogram. this group was characterised by *T. benedii* and *B. costatus, C. volutator*, nematodes and *H. diversicolor*, which had a combined contribution of 64.36% to average within-group similarity.

Group h consisted of three samples (T07 Upper A-C) and was separated from group i at 74% similarity on the cluster dendrogram. This group was characterised by *C. volutator*, *B. costatus* and *T. benedii*, nematodes and the polychaetes *Streblospio* spp. and *P. elegans*, which together contributed to 60.07% of average within-group similarity.

Group i consisted of three samples (T01 Mid A-C). This group was characterised by *B. costatus, T. benedii*, *Paranais litoralis* and Enchytraeidae, *C. volutator*, nematodes and *H. diversicolor*, which had a combined contribution of 71.08% to within-group similarity.

3.3.4.2 Subtidal survey

As with the intertidal samples, the SIMPROF test identified nine cluster groups that could be separated at the 5% significance level (Figures 9 & 10). SIMPER results indicating which taxa were principally responsible for similarity within the statistically distinct groups of stations, and percentage dissimilarity between groups are provided in Appendix 11.

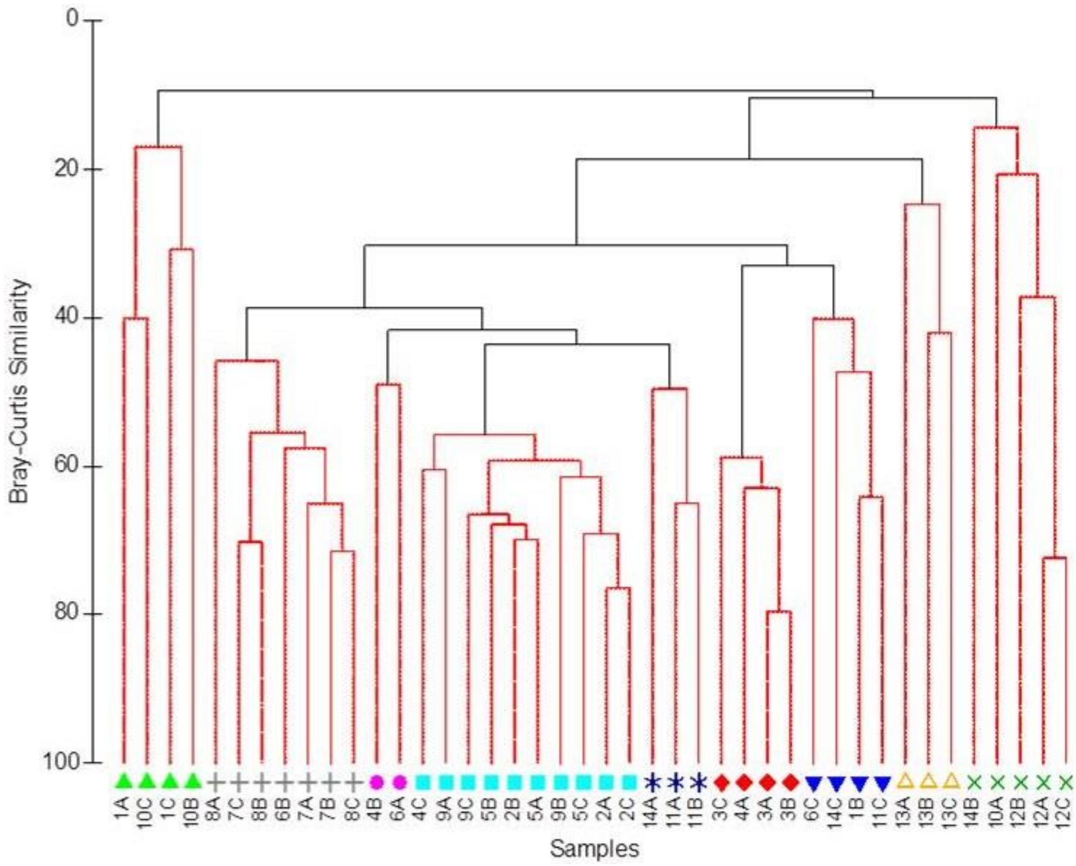

Figure 9: Cluster analysis dendrogram with SIMPROF for subtidal grab invertebrate abundance. Black lines show groupings at ≥5%. Black lines show groupings which are significant at 5% significance in SIMPER analysis.

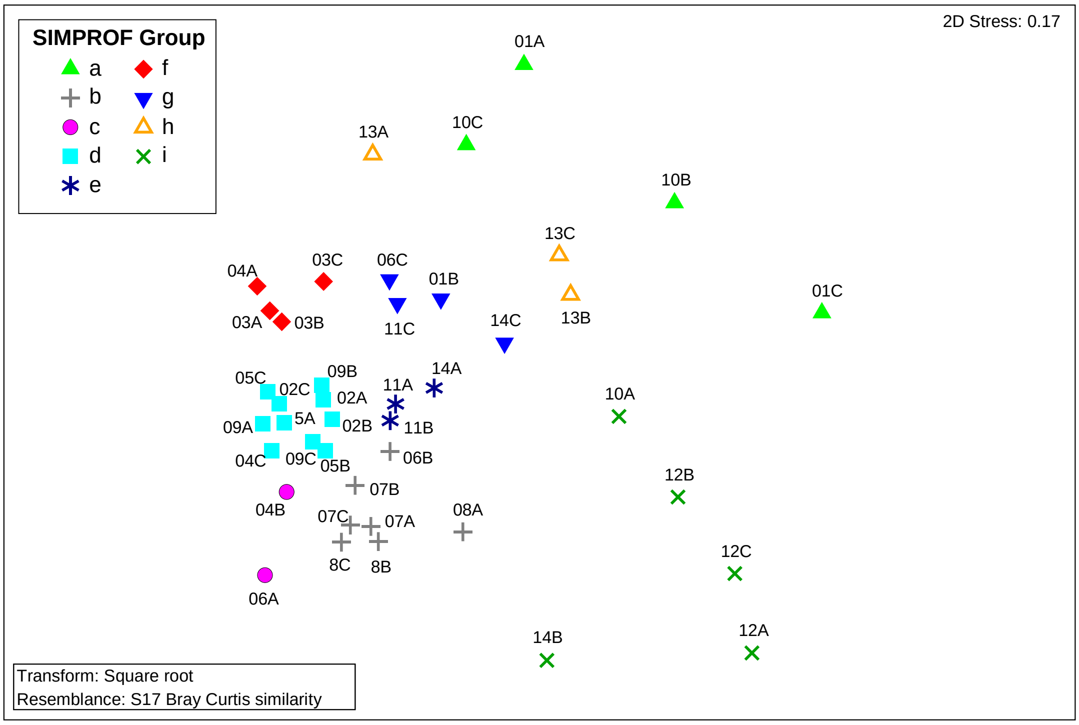

Figure 10: Multidimensional scaling plot for subtidal grab invertebrate abundance.

Group a differed the most from other samples, separating from all of the other samples at just under 10% similarity. The samples in this group were also positioned away from the other samples on the MDS plot and were more widely spread out, which corresponds to the low average within-group similarity (23.16%) in the SIMPER results. This group consisted of four samples (G01A, G01C, G10B and G10C) and SIMPER results indicated that samples in this group were characterised by the polychaete *Capitella* spp., the mysid shrimp *Schistomysis spiritus* and nematodes.

Group b was the second largest cluster group, consisting of seven samples (G06B, G07A-C and G08A-C). This group separated from groups c, d and e at 38% similarity. The SIMPER results showed an average within-group similarity of 55.37%. The group was characterised by the crustacean *C. volutator* and the polychaetes *P. cornuta*, *Streblospio* spp. and *P. elegans*, which together contributed to 77.21% of the within-group similarity.

Group c consisted of two samples (G04B and G06A). This group separated from groups d and e at just over 41% similarity. The SIMPER results showed an average within-group similarity of 48.99%. This group was characterised by the crustacean *C. volutator* and the polychaetes *H. diversicolor*, *Eteone longa* (aggregate), *P. cornuta* and *P. elegans*, which together contributed to just over 90% of the within-group similarity.

Group d was the largest cluster group and contained 10 samples (G02A-C, G04C, G05A-C, and G09A-C) with an average within-group similarity of 60.08%. This group separated from group e at 43% similarity and was characterised by the crustacean *C. volutator*, the oligochaete *T. benedii* and the polychaetes *P. cornuta*, *P. elegans* and *Tharyx* 'species A', which together contributed to just over 76% of the within-group similarity.

Group e contained three samples (G11A-B and G14A). This group was also characterised by the crustacean *Corophium volutator*, the oligochaete *Tubificoides benedii* and the polychaetes *Pygospio elegans* and *Tharyx* 'species A', although in lower abundances than group d.

The samples in groups b, c, d and e had overlapping species compositions, and were all grouped relatively close together in the lower left of the MDS plot (Figure 10).

Group f consisted of four samples (G03A-C and G04A) and was characterised by the polychaetes *Tharyx* 'species A' and *Streblospio* spp., the oligochaete *T. benedii* and the ostracod *E. zostericola*.

Group g consisted of four samples spread along the length of the survey area (G01B, G06C, G11C and G14C). This group separated from group f at just below 33% similarity and was characterised by the oligochaete *T. benedii* and the polychaetes *Tharyx* 'species A', *P. cornuta* and *Capitella* spp.

Group h separated from groups b to g on the cluster dendrogram at just below 19% similarity. This group consisted of the three replicate samples from Station G13. The SIMPER results show a within-group similarity of 30.5% and the taxa with the highest contributions were the polychaete *Nephtys cirrosa* and the oligochaete *T. benedii*, which contributed almost 70% to the within-group similarity.

Group i separated from cluster groups b to h at just above 10% similarity. This group consisted of five samples (G10A, G12A-C and G14B) and the SIMPER results again show a low average within-group similarity (26.62%). The group was characterised by the mysid shrimp *Mesopodopsis slabberi*, ribbon worms (Nemertea) and the gammarid shrimp *Gammarus salinus,* which together accounted for over 90% of the within-group similarity.

3.3.5 Biotope allocation

3.3.5.1 Intertidal survey

The intertidal habitat samples were more homogeneous than the subtidal samples and the nine discrete cluster groups were assigned to one biotope with some samples conforming to the standard description, and others assigned as a variant of that biotope. Most samples were assigned to the standard biotope LS.LMu.UEst.Hed.Cvol (*Hediste diversicolor* and *Corophium volutator* in littoral mud) whilst replicates T03 Mid B and T03 Mid C were assigned to the variant (termed *cf*. LS.LMu.UEst.Hed.Cvol herein) mostly due to the absence of *H. diversicolor* in these two samples and a generally lower diversity compared to that usually characteristic of this biotope (Table 6, Figure 11).

Table 6: Intertidal sample biotope allocations and cluster groups.

Cluster Group	Biotope	Description	EUNIS code	Replicates
A	*cf*. LS.LMu.UEst.Hed.Cvol	*Hediste diversicolor* and *Corophium volutator* in littoral mud, differing from the described biotope due to the lower diversity in the sample and the absence of *Hediste diversicolor*	A2.3222	T03 Mid B-C
B	LS.LMu.UEst.Hed.Cvol	*Hediste diversicolor* and *Corophium volutator* in littoral mud	A2.3222	T01 Upper C, T02 Upper A, T04 Upper A-C
C				T02 Mid A-C, T03 Upper A-C, T03 Mid A, T04 Mid A-C, T05 Mid B, T06 Mid A-C, T07 Mid B-C
D				T05 Upper A-C
E				T05 Mid A, T05 Mid C, T06 Upper A-C
F				T02 Upper B-C, T07 Mid A
G				T01 Upper A-B
H				T07 Upper A-C
I				T05 Upper A-C

3.3.5.2 Subtidal survey

The nine cluster groups identified through the multivariate analysis were assigned to five different biotopes (Table 7, Figure 12). Two of the cluster groups did not perfectly conform to any described biotope (Conner *et al*., 2004) and so have been ascribed to a variant of the biotope that is closest to them with differences from the described biotope noted in Table 7.

Polydora ciliata and *Corophium volutator* in variable salinity infralittoral firm mud or clay (SS.SMu.SMuVS.PolCvol) was the most common biotope characterising four cluster groups and 22 replicate samples (all replicates at the four stations in the vicinity of the current outfall were characterised by this biotope). The variant biotope that was similar to *Nephtys cirrosa* and *Macoma balthica* in variable salinity infralittoral mobile sand (termed *cf*. SS.SSa.SSaVS.NcirMac herein) had the fewest replicate samples assigned to it (the three replicate samples from G13). There were several instances where different replicate samples from a single station were allocated to different biotopes suggesting a patchy distribution of biotopes across the survey area. This was most apparent at Station G14 where each of the replicate samples was assigned to a different biotope. This station had relatively low abundance of most taxa and in each replicate a different taxon was the dominant species resulting in the clustering of these samples into different groups.

All replicates at the four sample stations in the vicinity of the proposed TEC outfall (which is in the same location as the Tilbury B power station outfall) were assigned the biotope 'SS.SMu.SMuVS.PolCvol' (G05, G07, G08, G09; Figure 12).

Table 7: Subtidal sample biotope allocations and cluster groups.

Cluster Group	Biotope	Description	EUNIS code	Replicates
A	SS.SMu.SMuVS.CapTubi	*Capitella capitata* and *Tubificoides* spp. in reduced salinity infralittoral muddy sediment	A5.325	G01A, G01C, G10B, G10C
B	SS.SMu.SMuVS.PolCvol	*Polydora ciliata* and *Corophium volutator* in variable salinity infralittoral firm mud or clay	A5.321	G06B, G07A, G07B, G07C, G08A, G08B, G08C
C				G04B, G06A
D				G02A, G02B, G02C, G04C, G05A, G05B, G05C, G09A, G09B, G09C
E				G11A, G11B, G14A
F	SS.SMu.SMuVS.AphTubi	*Aphelochaeta marioni* and *Tubificoides* spp. in variable salinity infralittoral mud	A5.322	G03A, G03B, G03C, G04A
G				G01B, G06C, G11C, G14C
H	*cf*. SS.SSa.SSaVS.NcirMac	*Nephtys cirrosa* and *Macoma balthica* in variable salinity infralittoral mobile sand), differing from the described biotope in the large numbers of oligochaetes and absence of the orbiniid worm *Scoloplos armiger*.	A5.212	G13A, G13B, G13C

Cluster Group	Biotope	Description	EUNIS code	Replicates
I	*cf*. SS.SMu.SMuVS.OlVS	Oligochaetes in variable or reduced salinity infralittoral muddy sediment, differing from the described biotope in its higher diversity, including many Crustacea and Nemertea.	A5.326	G10A, G12A, G12B, G12C, G14B

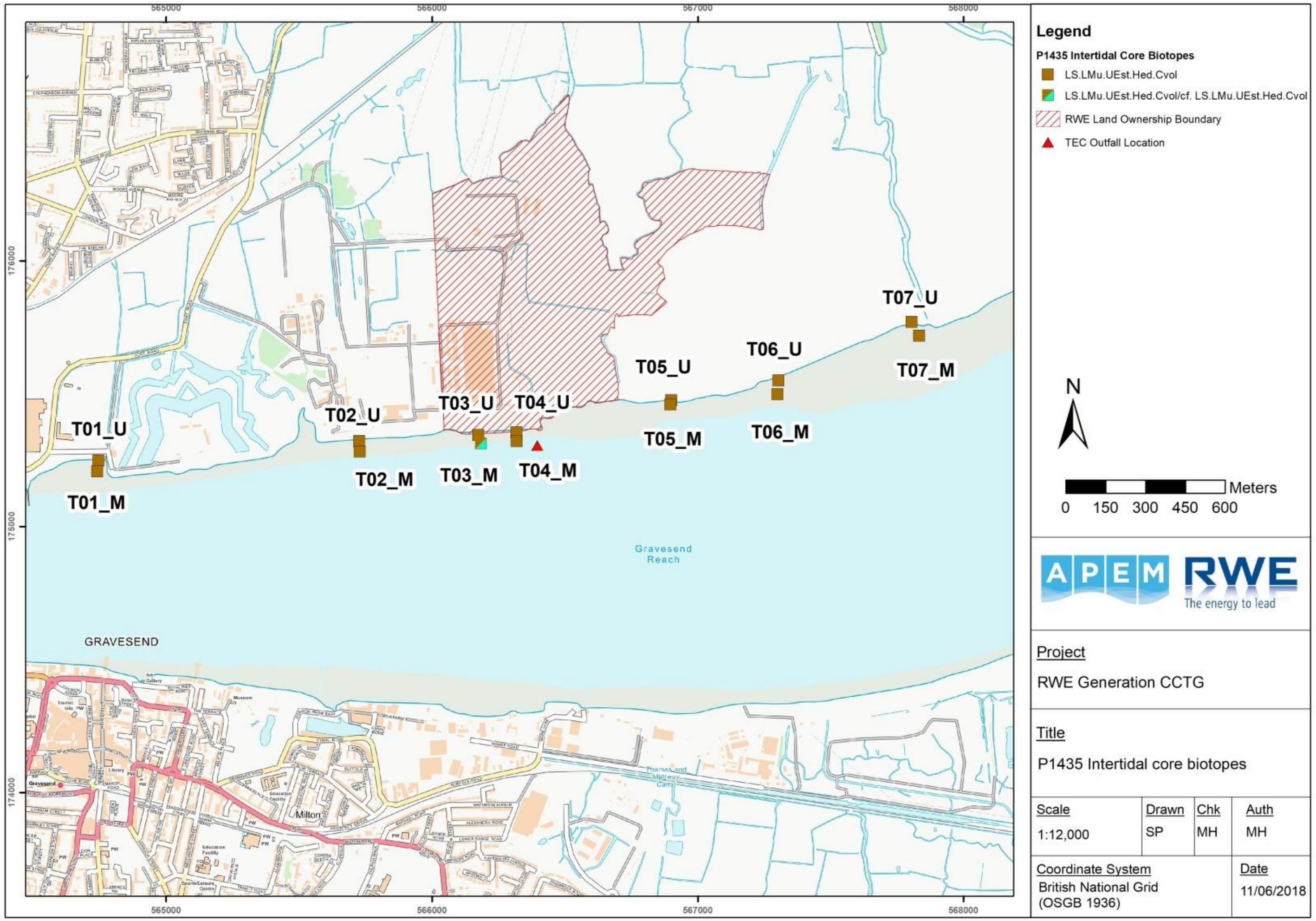

Figure 11: Biotopes allocated to intertidal survey stations.

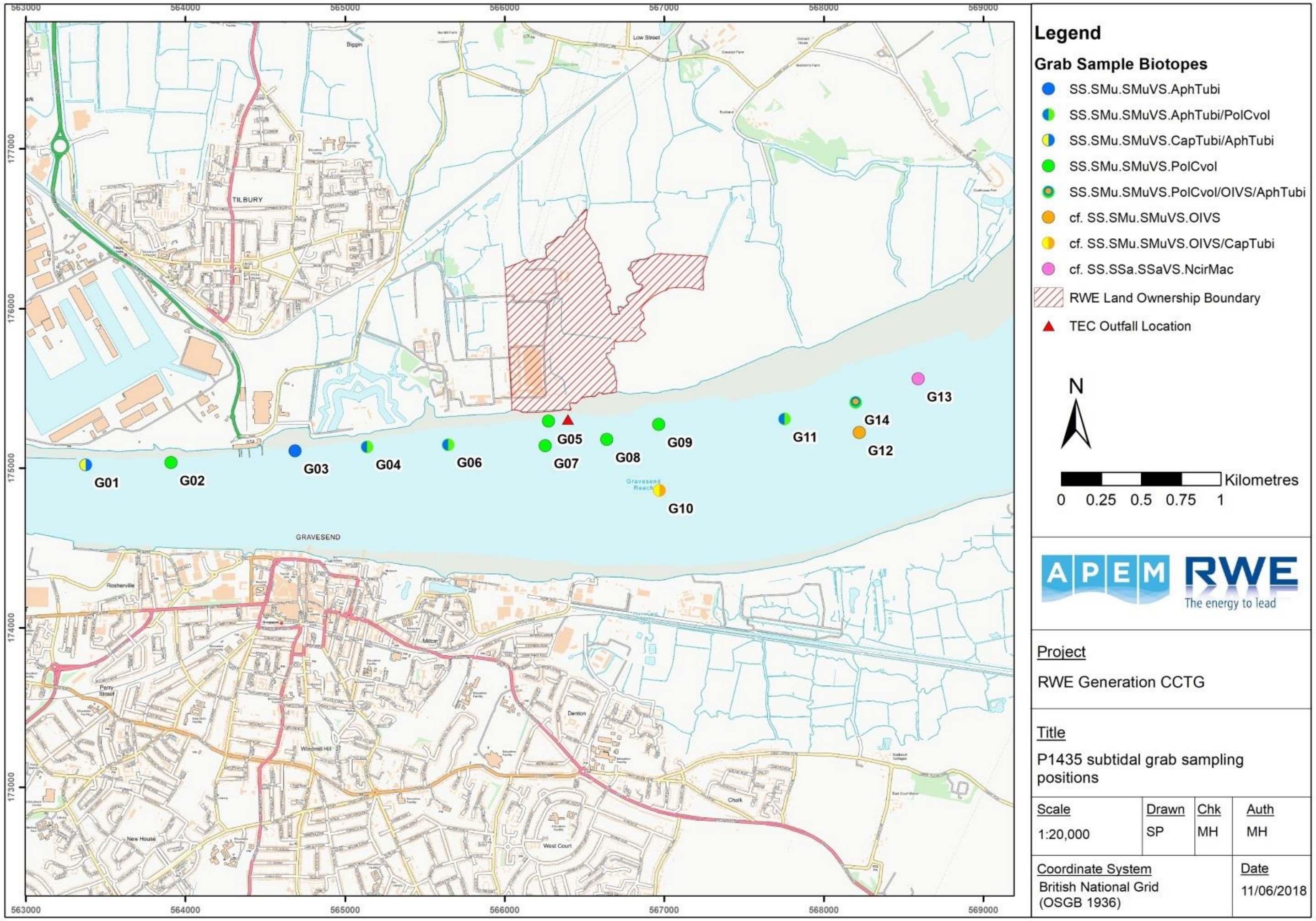

Figure 12: Biotopes allocated to subtidal survey stations.

3.4 Sediment chemistry

For the intertidal and subtidal stations at which samples were collected for chemical analyses a comparison of chemical concentrations against Chemical Action Levels (MMO 2015) and/or Canadian Sediment Quality Guidelines for the Protection of Aquatic Life (CCME 2002) is provided in Appendices 12 and 13, respectively. Not all chemicals have guidelines indicating thresholds for potential biological effects and the results for other selected chemical analyses are provided in Appendix 14.

3.4.1 Intertidal stations

The only exceedance of the cAL2 concentration was tPAH which was exceeded at Stations T06 Mid and T07 Upper. The greatest number of chemical exceedances was at Station T07 Upper (Appendix 12).

The heavy metals with most frequent exceedances were cadmium with cAL1 exceeded at all stations (although it was below the TEL at eight of the stations), chromium with cAL1 exceeded at all stations apart from Station 06 Mid (remaining below the TEL at three of the stations), and mercury with cAL1 exceeded at twelve of the fourteen stations (with PEL exceeded at three of the stations). The cAL1 for arsenic was only exceeded at Station T07 Upper.

The greatest number of exceedances for PAHs were at Stations T06 Mid and T07 Upper. For acenaphthene, fluorine and dibenzothiophene the only stations with exceedances of cAL1 were Station T06 Mid and T07 Upper. Acenaphthylene cAL1 was exceeded at eight stations, naphthalene at ten stations and anthracene at twelve. For all of the other PAHs cAL1 was exceeded at all stations.

For most PAHs, concentrations were generally below PEL, however, sample concentrations at all sites were above PEL for Benzo[b]fluoranthene, Benzo[k]fluoranthene, Benzo[e]pyrene, Benzo[a]pyrene, Indeno[123,cd]pyrene, Benzo[ghi]perylene and tPAH (Appendix 12).

For PCBs, sum of ICES 7 was below cAL1 at all stations, sum of 25 congeners just exceeded cAL1 at Station 04 Upper and 07 Upper while total PCBs only exceeded cAL1 at Station 07 Upper.

It was not possible to confirm concentrations of organocholorine pesticides due to the LODs of the analyses, however, all samples were below LOD for each pesticide.

3.4.2 Subtidal stations

In common with the intertidal stations the only exceedance of the cAL2 concentration was tPAH at Station G06. At station G12 there were no exceedances of cAL1 for any of the chemicals tested, likely due to the coarse gravel sediment present this station (see Table 3).

In general the greatest number of chemical exceedances were at Station G6, followed by Stations G7 and G8 (Appendix 13).

The only heavy metal with no exceedances of cAL1 at any of the stations was arsenic and the cAL1 for copper was only exceeded at two stations. In contrast, cadmium and chromium exceeded cAL1 concentrations at all stations except G12. Metal concentrations were highest at G06 followed by G10 and more heavy metals exceeded cAL1 at stations G06, G07, G08 and G10 (five to seven chemicals exceeding cAL1), than at G03 and G05 (two to four heavy metals exceeding cAL1).

All PAHs at Station G06 exceeded cAL1 and only one was below the PEL concentration. For acenaphthene and dibenzothiophene cAL1/PEL were only exceeded at Station G06. For naphthalene, acenaphthylene and fluorine cAL1/PEL were exceeded at Stations G06 to G08. For all of the other PAHs there were exceedances of cAL1/PEL at all stations except for G12.

For PCBs, sum of ICES 7, sum of 25 congeners and total PCBs only exceeded cAL1 at G06, G08 and G10.

In common with the intertidal samples, it was not possible to confirm concentrations of organocholorine pesticides due to the LODs of the analyses, however, all samples were below LOD for each pesticide.

4. Summary and discussion

An intertidal and a subtidal benthic ecology survey was conducted in May 2017 with samples collected for biotic analysis, PSA and chemical analysis (14 stations were sampled for both the subtidal and benthic ecology surveys).

The dominance of Sandy mud was noted for the intertidal stations, with just two stations classified as Slightly Gravelly Muddy Sand. This was consistent with the subtidal stations as sediment at eleven of the fourteen subtidal stations was classified as Sandy mud, with one of the stations classified as Gravel and the other two as Sand (the Gravel and Sand stations were at the eastern extent of the survey area). Sediment type can often be closely correlated to chemical concentrations with some chemicals tending to exhibit higher concentrations in muddier sediment fractions (due to adsorption preference). There was clear evidence for this within the TEC sediment samples as the subtidal Station G012 (Gravel substrate) did not exceed chemical threshold concentrations for any of the chemicals tested, whereas there were many exceedances at each of the other stations. The heavy metals which exceeded thresholds at most stations for both the intertidal and subtidal samples were cadmium and chromium, with mercury also exceeding thresholds at 12 of the 14 intertidal stations and five of the seven intertidal chemistry sample stations. The only exceedance of cAL2 was for tPAH (at two of the intertidal and one of the subtidal stations), and cAL1/PEL thresholds for numerous PAHs were exceeded at many of the sample stations. The presence of chemicals at the levels recorded is not unexpected for an industrial estuary such as the Thames Estuary.

A total of 52 taxa were recorded in the intertidal samples, with 79 recorded in the subtidal samples. Density of invertebrates at each station was highly variable ranging from 7,500 to 233,500 individuals m^{-2} for the intertidal samples and 167 to 4,420 individuals m^{-2} in the subtidal samples. The amphipod *C. volutator* was the most abundant taxon across the subtidal and intertidal samples, although polychaete and oligochaete worms were the most abundant taxon groups across both intertidal and subtidal samples. Biomass data for intertidal stations indicated that annelids dominated biomass within stations on Transects 1 to 4 in the western section of the survey area, with crustaceans having greater proportional biomass in the more eastern stations (Transects 5 to 7).

For the intertidal stations, biotic assemblages were relatively homogenous across the survey area with all stations apart from replicates at T03 Mid assigned to the biotope '*Hediste diversicolor* and *Corophium volutator* in littoral mud', while the replicates at T03 Mid were assigned to a variant of this biotope (due to lower diversity and absence of *H. diversicolor*). The subtidal grab samples were allocated to five biotopes indicating a range of community types despite similarity in substrate type across stations. Two of these biotopes were variants of more standard forms.

No benthic invertebrate species of conservation importance were recorded across all samples. Four non-native species were recorded during the intertidal survey (the American ostracod *E. zostericola*, the polychaete *H. lighti*, the barnacle *A. modestus* and the New Zealand mud snail *P. antipodarum*). *E. zostericola* and *H. lighti* were also recorded during the subtidal survey, along with the American piddock *P. pholadiformis* and the freshwater hydroid *C. caspia*).

None of the non-native species recorded from the intertidal and subtidal surveys are considered to be invasive (i.e. a non-native species that has the ability to spread causing damage to the environment, the economy and our health (GBNNSS 2018)). *E. zostericola* is known from a number of estuaries in south-eastern Britain including the Thames and it has previously been recorded in the vicinity of Tilbury Power Station (RWE nPower 2011 (unpublished data)). *E. zostericola* was believed to have been introduced into the UK with Pacific Oysters (Eno *et al*. 1997). *H. lighti* is native to California and the west coast of North America (the specimens from the current survey are the first known specimens from the Thames Estuary). The hydroid *C. caspia* was recorded in seven of the subtidal samples. This species has a preference for low salinity or freshwaters and is abundant in the Thames where it provides a valuable food resource for the sea slug *Tenellia adspersa* which is protected under the Wildlife and Countryside Act 1981 (as amended) but this slug was not recorded during the project surveys. The American piddock *P. pholadiformis* was introduced to the UK in the 19th Century and is abundant in the Thames.

Overall, both intertidal and subtidal assemblages were typical of those found throughout the length of the tidal Thames and are consistent with the assemblages recorded during other surveys in the area (e.g. RWE nPower 2011 (unpublished data), Port of Tilbury 2017).

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APPENDICES

Appendix 1 Intertidal and subtidal sampling positions

Table A1: Sample station coordinates. U=Upper shore; M = Mid shore.

Station	Sample Date	Sample Time (BST)	Sampling positions (decimal degrees, WGS84)		Sampling positions (NGR)	
			Latitude	Longitude	Easting	Northing
Intertidal						
T01 - U	31/05/2017	08:26	51.452257	0.369632	564745	175249
T01 - M	31/05/2017	08:50	51.451896	0.369560	564742	175209
T02 - U	31/05/2017	09:46	51.452636	0.383770	565726	175323
T02 - M	31/05/2017	09:58	51.452274	0.383785	565729	175283
T03 - U	31/05/2017	10:48	51.452705	0.390228	566175	175345
T03 - M	31/05/2017	11:04	51.452405	0.390339	566319	175322
T04 - U	30/05/2017	13:15	51.452455	0.392294	566901	175476
T04 - M	30/05/2017	12:52	51.452752	0.392299	566897	175460
T05 - U	30/05/2017	11:30	51.453668	0.400729	567304	175550
T05 - M	30/05/2017	11:52	51.453525	0.400672	567300	175498
T06 - U	30/05/2017	10:32	51.454214	0.406562	567805	175770
T06 - M	30/05/2017	10:42	51.453750	0.406483	567833	175719
T07 - U	30/05/2017	09:11	51.456042	0.413866	566184	175312
T07 - M	30/05/2017	09:31	51.455570	0.414250	566318	175355
Subtidal						
G01	09/05/2017	07:34	51.450597	0.349831	563376	175020
G02	09/05/2017	12:19	51.450576	0.357511	563909	175035
G03	09/05/2017	11:52	51.451004	0.368708	564686	175107
G04	09/05/2017	13:01	51.451102	0.375212	565137	175133
G05	09/05/2017	13:39	51.452215	0.391631	566274	175294
G06	09/05/2017	10:50	51.451066	0.382526	565646	175146
G07	09/05/2017	10:01	51.450846	0.391280	566255	175141
G08	09/05/2017	10:26	51.451078	0.396820	566639	175179
G09	09/05/2017	14:18	51.451828	0.401552	566965	175273
G10	08/05/2017	10:10	51.448106	0.401436	566970	174859
G11	09/05/2017	14:35	51.451897	0.412895	567752	175307
G12	08/05/2017	08:43	51.451002	0.419600	568222	175223
G13	08/05/2017	08:34	51.453913	0.425056	568590	175559
G14	09/05/2017	14:58	51.452709	0.419374	568200	175412

Appendix 2 Chemical analyses

Table A2: Water quality parameters measured from surface waters at each benthic grab station.

Test	Reporting Limits (in ppm unless otherwise stated)	Method
Trace Metals Arsenic (1), Cadmium (0.1), Chromium (0.5), Copper (2), Lead (2), Mercury (0.01), Nickel (0.5), Tin (0.5), Zinc (3)	Various, reporting limits in brackets	HF boric extraction followed by ICPMS
Organotins Tributyltin (2 µg/kg), Dibutylin (5 µg/kg)	Various, reporting limits in brackets	
Polychlorinated biphenyls (PCBs) Total of 25 congeners (including ICES 7), Individual concentrations of each congener	0.08 µg/kg	Solvent extraction and determination by GCECD
Polycyclic aromatic hydrocarbons (PAHs) Total hydrocarbon content, Acenapthene, Anthracene, Benz[a]anthracene, Benzo[a]pyrene, Benzo[b]fluoranthene, Benzo[e]pyrene, Benzo[g,h,i]perylene, Benzo[k]fluoranthene, C-1 to C-4 napthalenes, Chrysene, Fluoranthene, Fluorene, Indeno[123-c,d]pyrene, Naphthalene, Perylene, Phenanthrene, Pyrene, Dibenz[a,h]anthracene	0.001	DTI specification by GC-MS
Brominated flame retardants 2,2',4,4',6-pentabromodiphenyl ether, 2,2',3,4,4',5'-hexabromodiphenyl ether, 2,2',4,4',5,5'-hexabromodiphenyl ether, 2,2',4,4',5,6'-hexa-bromodiphenyl ether, 2,2´,4-tri-bromodiphenylether, 2,2',3,4,4',5',6-heptabromodiphenyl ether, 2,2',3,3',4,4',5,5',6,6'-decabrominated diphenyl ether, 2,4,4'-tribromodiphenyl ether, 2,2',4,4'-tetrabromodiphenyl ether, 2,3',4,4'-tetrabromodiphenyl ether, 2,2',3,4,4'-pentabromodiphenyl ether, 2,2',4,4',5-pentabromodiphenyl ether	0.001-0.1 µg/kg	
Organochlorine pesticides alpha-hexachlorocyclohexane (α-HCH), gamma-hexachlorocyclohexane (γ-HCH), Dieldrin, Hexachlorobenzene, 1,1-Dichloro-2,2-bis(p-chlorophenyl) ethylene (DDE), Dichlorodiphenyltrichloroethane (DDT), 1,1-dichloro-2,2-bis(p-chlorophenyl)ethane (TDE)	0.003 to 0.005	sonicated extraction followed by GCMS analysis
Organophosphorus pesticides Dichlorvos	0.001 to 0.01	sonicated extraction followed by GCMS analysis
Algicide/herbicide Diuron	0.1 mg/kg	

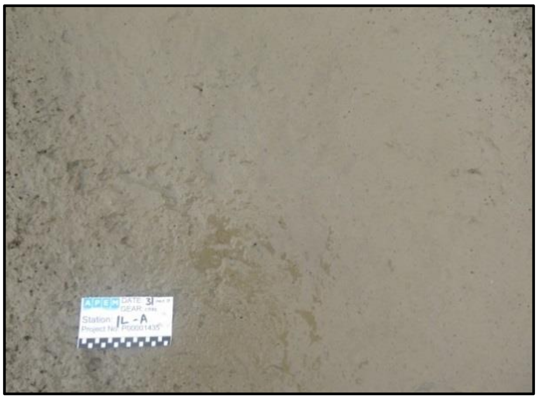
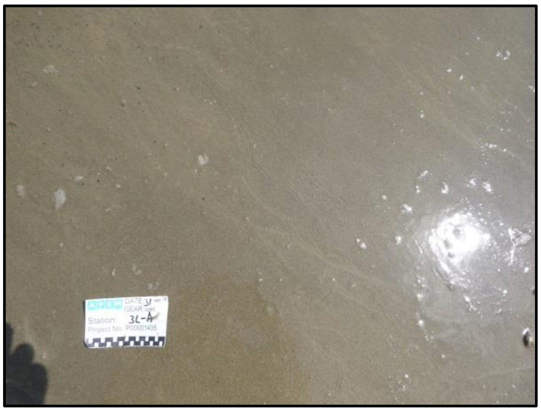
Appendix 3 Water quality data

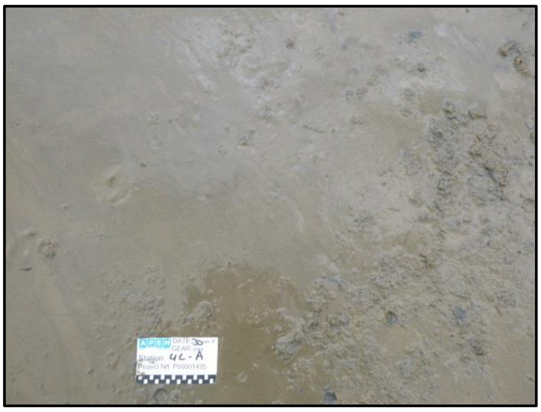
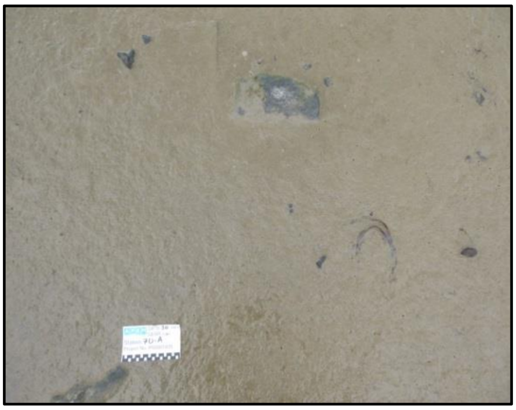
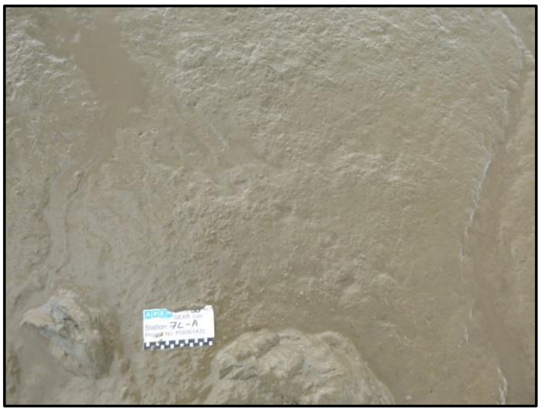
Table A3: Water quality parameters measured from surface waters at each benthic grab station.

Station	Temp. (°C)	DO saturation (%)	DO (mg/l)	Specific conductivity (µs/m)	Salinity (PSU)	pH	Time of sampling relative to high water*
G01	12.0	93.2	8.76	28615	17.63	6.27	-04:45
G02	11.9	75.7	7.02	38005	24.1	7.82	-00:00
G03	11.8	77.2	7.11	38943	24.75	7.79	-00:27
G04	12.1	87.7	7.81	39333	25.03	7.85	+00:42
G05	12.0	91.8	8.22	39886	25.42	7.88	+01:20
G06	11.9	77.1	7.2	36846	23.28	7.76	-01:29
G07	11.8	74.0	6.94	35478	22.34	7.74	-02:18
G08	11.9	101.8	8.81	36245	22.87	7.76	-01:53
G09	11.9	81.8	7.57	37891	24.02	7.83	+01:59
G10	11.7	76.3	7.1	38513	24.45	7.81	-01:29
G11	11.8	74.8	6.91	39225	24.95	7.85	+02:16
G12	11.5	69.7	6.54	37424	23.68	7.76	-02:56
G13	11.7	76.6	7.52	37296	23.6	7.68	-03:05
G14	11.8	79.7	7.37	39136	24.88	7.83	+02:39

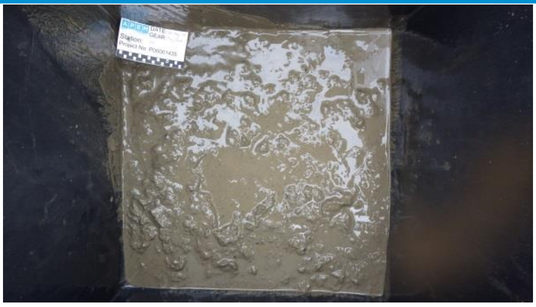
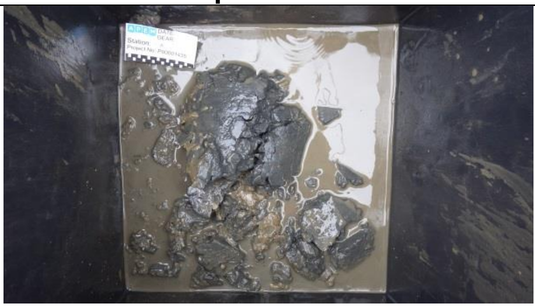
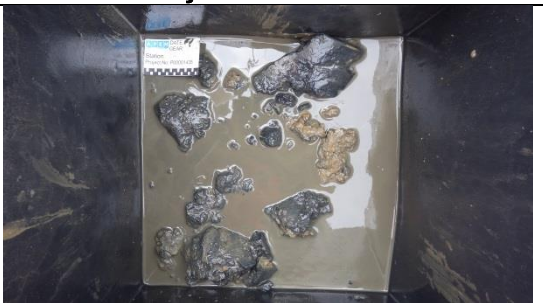
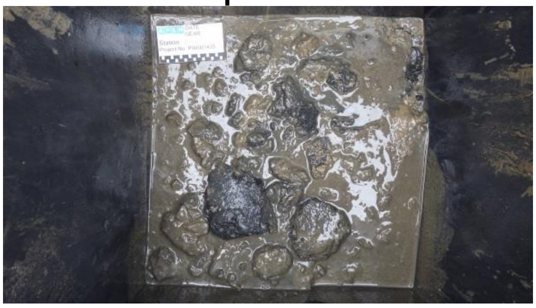
* - denotes before high water, + denotes after high water

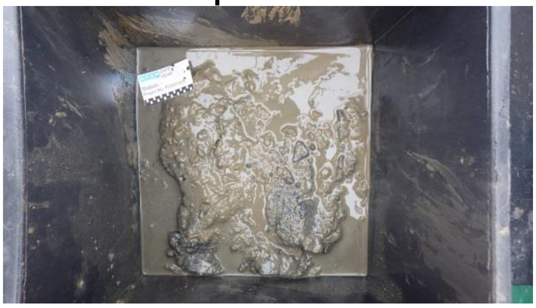
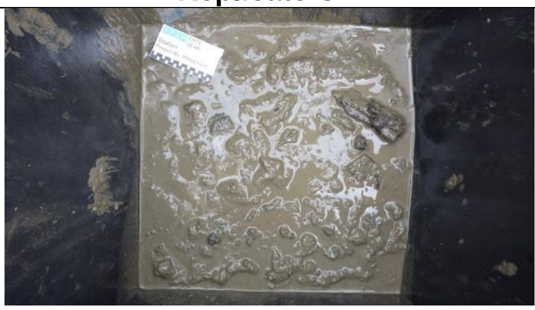
Appendix 4 Intertidal sampling station photographs

Station	Upper	Middle
T1		
T2		
T3		

Station	Upper	Middle
T4		
T5		
T6		
T7		

Appendix 5 Subtidal sample photographs

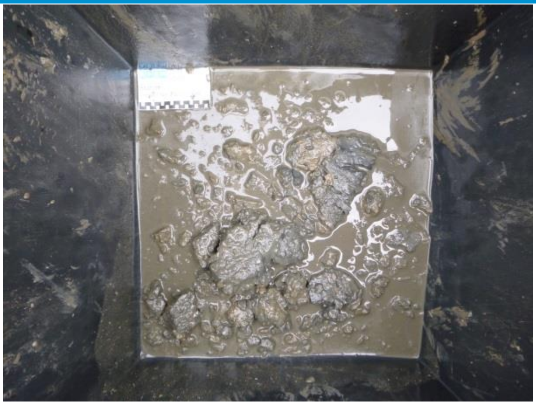
Station		
G01	 Replicate A	 Replicate B
	 Replicate C	 Physicochemical
G02	 Replicate A	 Replicate B
	 Replicate C	 Physicochemical

Station		
G03	 **Replicate A**	 **Replicate B**
	 **Replicate C**	 **Physicochemical**
G04	 **Replicate A**	 **Replicate B**
	 **Replicate C**	 **Physicochemical**

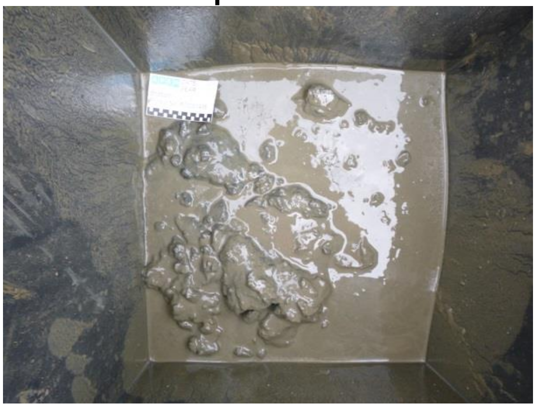
Station

G05

Replicate A



Replicate B

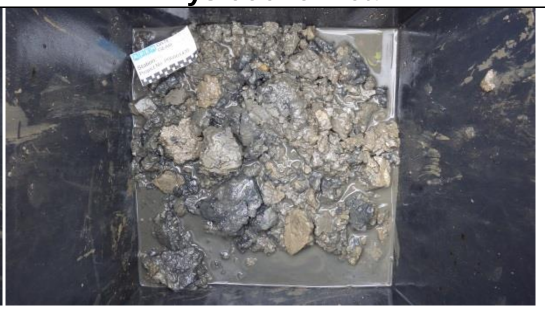


Replicate C

Physicochemical

G06

Replicate A



Replicate B

Replicate C

Physicochemical

Station

G07


Replicate A


Replicate B

No Photograph
Replicate C

No Photograph
Physicochemical

G08


Replicate A


Replicate B


Replicate C


Physicochemical

Station

G09

Replicate A

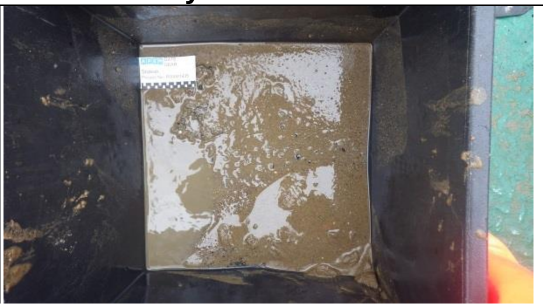
Replicate B

Replicate C

Physicochemical

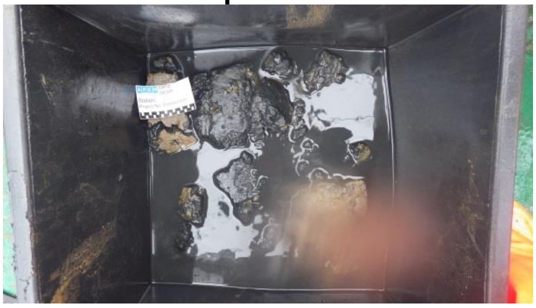
G10

Replicate A

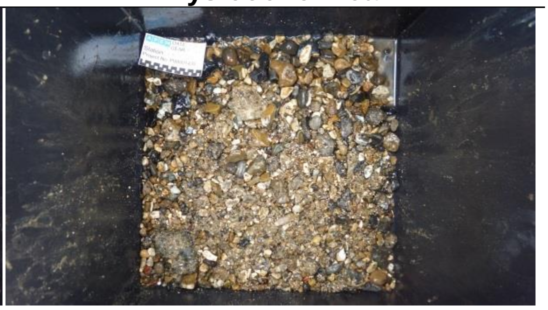


Replicate B

Replicate C



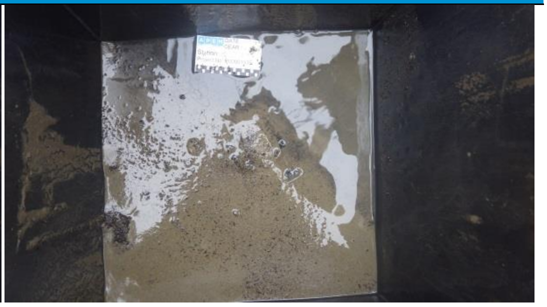
Physicochemical

Station		
G11	 Replicate A	 Replicate B
	No Photograph Replicate C	 Physicochemical
G12	 Replicate A	 Replicate B
	 Replicate C	 Physicochemical

Station

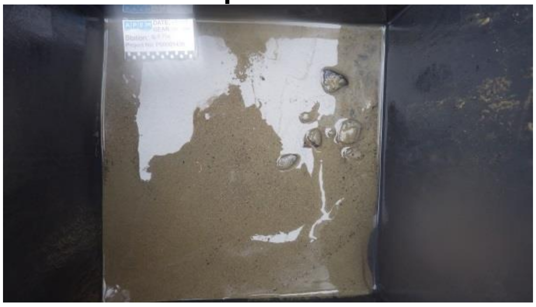
G13

Replicate A



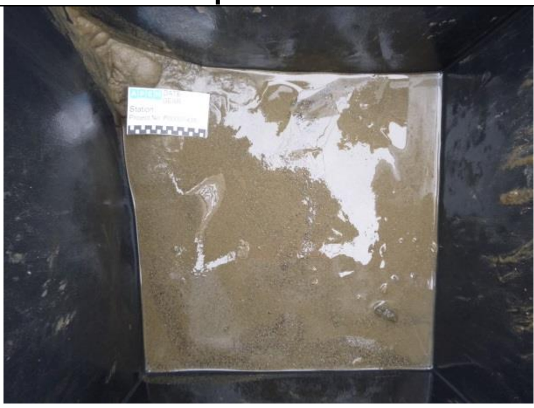
Replicate B

Replicate C



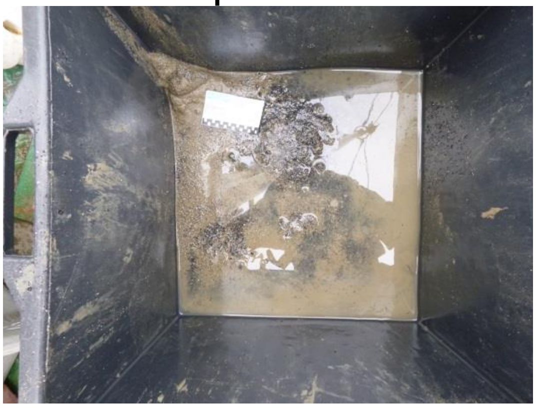
Physicochemical

G14



Replicate A

Replicate B



Replicate C

Physicochemical

Appendix 6 Particle size data for intertidal and subtidal stations

Intertidal stations

Station	Shore height	Date collected	Visual description of sediment	Folk (1954) classification	Mean (µm)	Mean (description)	Sorting (µm)	Sorting (description)	Skewness (µm)	Skewness (description)	Kurtosis (µm)	Kurtosis (description)
					Statistics calculated using Folk and Ward (1957) formulae							
T1	Upper	31/05/2017	Sandy Mud	Sandy Mud	13.8	Medium Silt	5.224	Very Poorly Sorted	-0.087	Symmetrical	1.111	Leptokurtic
T1	Lower	31/05/2017	Sandy Mud	Sandy Mud	12.3	Medium Silt	5.921	Very Poorly Sorted	-0.071	Symmetrical	1.005	Mesokurtic
T2	Upper	31/05/2017	Sandy Mud	Sandy Mud	13.4	Medium Silt	4.890	Very Poorly Sorted	-0.076	Symmetrical	1.095	Mesokurtic
T2	Lower	31/05/2017	Sandy Mud	Sandy Mud	19.9	Coarse Silt	4.921	Very Poorly Sorted	-0.117	Fine Skewed	0.899	Platykurtic
T3	Upper	31/05/2017	Sandy Mud	Sandy Mud	25.0	Coarse Silt	6.396	Very Poorly Sorted	-0.027	Symmetrical	0.965	Mesokurtic
T3	Lower	31/05/2017	Sandy Mud	Sandy Mud	19.8	Coarse Silt	5.530	Very Poorly Sorted	-0.147	Fine Skewed	0.897	Platykurtic
T4	Upper	30/05/2017	Sandy Mud	Sandy Mud	11.8	Medium Silt	5.434	Very Poorly Sorted	-0.079	Symmetrical	1.102	Mesokurtic
T4	Lower	30/05/2017	Sandy Mud	Sandy Mud	29.9	Coarse Silt	4.356	Very Poorly Sorted	-0.346	Very Fine Skewed	0.874	Platykurtic
T5	Upper	30/05/2017	Sandy Mud	Sandy Mud	8.8	Medium Silt	5.525	Very Poorly Sorted	-0.101	Fine Skewed	1.113	Leptokurtic
T5	Lower	30/05/2017	Sandy Mud	Sandy Mud	24.2	Coarse Silt	6.279	Very Poorly Sorted	-0.250	Fine Skewed	0.874	Platykurtic
T6	Upper	30/05/2017	Sandy Mud	Sandy Mud	35.4	Very Coarse Silt	7.390	Very Poorly Sorted	-0.230	Fine Skewed	0.977	Mesokurtic
T6	Lower	30/05/2017	Slightly Gravelly Sandy Mud	Slightly Gravelly Muddy Sand	46.9	Very Coarse Silt	6.095	Very Poorly Sorted	-0.383	Very Fine Skewed	0.935	Mesokurtic
T7	Upper	30/05/2017	Slightly Gravelly Sandy Mud	Slightly Gravelly Sandy Mud	26.7	Coarse Silt	9.921	Very Poorly Sorted	0.056	Symmetrical	0.931	Mesokurtic
T7	Lower	30/05/2017	Sandy Mud	Sandy Mud	13.0	Medium Silt	5.107	Very Poorly Sorted	-0.097	Symmetrical	1.083	Mesokurtic

Station	Shore height	Primary Mode (µm)	d10 (µm)	d50 (µm)	d90 (µm)	Gravel (>2 mm) (%)	Sand (63-2000 µm) (%)	Mud (<63 µm) (%)	V Coarse Gravel (32-64 mm) (%)	Coarse Gravel (16-32 mm) (%)	Medium Gravel (8-16 mm) (%)	Fine Gravel (4-8 mm) (%)	V Fine Gravel (2-4 mm) (%)	V Coarse Sand (1-2 mm) (%)	Coarse Sand (500-1000 µm) (%)
T1	Upper	13.3	1.4	14.1	98.4	0.0	17.1	82.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T1	Lower	9.4	1.0	12.1	102.6	0.0	19.1	80.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T2	Upper	13.3	1.5	13.3	90.0	0.0	16.1	83.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T2	Lower	106.7	2.1	20.0	118.4	0.0	29.2	70.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T3	Upper	106.7	2.2	23.9	248.5	0.0	35.2	64.8	0.0	0.0	0.0	0.0	0.0	0.0	3.1
T3	Lower	106.7	1.8	21.0	135.0	0.0	30.8	69.2	0.0	0.0	0.0	0.0	0.0	0.0	0.6
T4	Upper	13.3	1.1	12.0	91.1	0.0	15.4	84.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T4	Lower	106.7	3.4	40.2	137.0	0.0	41.2	58.8	0.0	0.0	0.0	0.0	0.0	0.0	1.0
T5	Upper	9.4	0.8	9.5	72.6	0.0	11.6	88.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T5	Lower	106.7	1.6	30.6	170.4	0.0	38.9	61.1	0.0	0.0	0.0	0.0	0.0	0.0	1.8
T6	Upper	106.7	2.0	45.7	378.6	0.0	44.6	55.4	0.0	0.0	0.0	0.0	0.0	0.0	4.9
T6	Lower	150.9	3.4	77.0	311.8	2.3	50.7	47.0	0.0	0.0	1.2	0.9	0.2	0.7	2.6
T7	Upper	13.3	1.3	21.9	476.0	3.3	31.6	65.1	0.0	0.6	1.3	0.8	0.6	1.2	4.8
T7	Lower	13.3	1.3	13.1	88.0	0.0	16.1	83.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Station	Shore height	Medium Sand (250-500 µm) (%)	Fine Sand (125-250 µm) (%)	V Fine Sand (63-125 µm) (%)	V Coarse Silt (31-63 µm) (%)	Coarse Silt (16-31 µm) (%)	Medium Silt (8-16 µm) (%)	Fine Silt (4-8 µm) (%)	V Fine Silt (2-4 µm) (%)	Clay (<2 µm) (%)	Percentages of the distribution in each 'half-phi' size interval, expressed in µm >63000	45000 to 63000	31500 to 45000	22400 to 31500	16000 to 22400	11200 to 16000	8000 to 11200	5600 to 8000	4000 to 5600	2800 to 4000
T1	Upper	0.9	5.8	10.4	13.7	16.4	18.1	14.3	7.9	12.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T1	Lower	1.5	4.7	12.9	11.5	13.3	16.7	14.9	9.1	15.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T2	Upper	0.3	4.8	10.9	12.5	16.7	19.4	15.0	8.5	11.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T2	Lower	0.1	8.1	21.0	12.2	14.7	16.2	12.1	6.4	9.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T3	Upper	6.8	9.7	15.6	10.4	12.7	14.9	11.5	6.0	9.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T3	Lower	2.0	8.8	19.3	12.2	12.9	14.5	12.1	6.9	10.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T4	Upper	0.6	5.5	9.4	12.3	15.4	18.0	15.5	9.0	14.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T4	Lower	1.2	9.9	29.1	13.1	12.0	13.2	9.5	4.8	6.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T5	Upper	0.4	3.9	7.3	10.6	14.7	18.2	16.5	10.4	18.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T5	Lower	2.5	14.9	19.7	10.8	10.4	11.7	10.5	6.5	11.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T6	Upper	10.4	9.8	19.4	11.2	9.4	10.4	9.1	5.5	9.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T6	Lower	6.7	24.5	16.2	7.5	9.4	11.0	8.2	4.3	6.6	0.0	0.0	0.0	0.0	0.0	0.3	0.9	0.6	0.3	0.1
T7	Upper	9.2	8.4	7.9	9.6	11.5	13.2	11.3	6.8	12.7	0.0	0.0	0.0	0.0	0.6	0.8	0.5	0.4	0.3	0.3
T7	Lower	0.3	4.7	11.1	13.7	15.4	18.7	15.0	8.0	13.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Station	Shore height	Percentages of the distribution in each 'half-phi' size interval, expressed in µm 2000 to 2800	1400 to 2000	1000 to 1400	710 to 1000	500 to 710	355 to 500	250 to 355	180 to 250	125 to 180	90 to 125	63 to 90	44.19 to 63	31.25 to 44.19	22.097 to 31.25	15.625 to 22.097	11.049 to 15.625	7.813 to 11.049	5.524 to 7.813	3.906 to 5.524	2.762 to 3.906	1.953 to 2.762	1.381 to 1.953
T1	Upper	0.0	0.0	0.0	0.0	0.0	0.0	0.9	2.9	2.9	4.7	5.7	6.1	7.5	7.7	8.7	9.3	8.8	7.9	6.4	4.7	3.3	2.5
T1	Lower	0.0	0.0	0.0	0.0	0.0	0.1	1.4	1.5	3.2	6.6	6.3	5.4	6.1	6.1	7.2	8.3	8.4	8.0	6.9	5.2	3.9	3.0
T2	Upper	0.0	0.0	0.0	0.0	0.0	0.0	0.3	2.3	2.6	5.1	5.8	5.6	6.9	7.6	9.1	10.0	9.4	8.2	6.8	5.0	3.5	2.6
T2	Lower	0.0	0.0	0.0	0.0	0.0	0.0	0.1	1.8	6.3	11.5	9.4	6.5	5.7	6.2	8.4	8.4	7.8	6.7	5.3	3.8	2.6	2.0
T3	Upper	0.0	0.0	0.0	0.6	2.6	3.1	3.7	4.4	5.3	8.3	7.3	5.1	5.3	5.8	7.0	7.5	7.4	6.5	5.1	3.5	2.5	2.0
T3	Lower	0.0	0.0	0.0	0.0	0.6	1.3	0.7	2.2	6.7	10.8	8.5	6.0	6.3	6.0	6.8	7.4	7.2	6.6	5.5	4.0	2.8	2.2
T4	Upper	0.0	0.0	0.0	0.0	0.0	0.0	0.6	2.6	2.9	4.4	5.0	5.4	7.0	7.2	8.2	9.0	9.0	8.4	7.1	5.3	3.8	2.8
T4	Lower	0.0	0.0	0.0	0.2	0.7	0.7	0.5	2.1	7.8	15.9	13.3	7.2	5.9	5.6	6.4	6.9	6.3	5.4	4.2	2.9	1.9	1.4
T5	Upper	0.0	0.0	0.0	0.0	0.0	0.0	0.4	1.9	2.1	3.5	3.8	4.4	6.1	6.7	8.0	9.0	9.2	8.8	7.7	6.0	4.4	3.4
T5	Lower	0.0	0.0	0.0	0.3	1.5	1.5	1.0	4.6	10.3	11.7	7.9	5.4	5.4	4.9	5.5	5.9	5.8	5.6	4.9	3.7	2.8	2.2
T6	Upper	0.0	0.0	0.0	1.3	3.6	6.3	4.1	3.4	6.4	10.3	9.1	6.0	5.2	4.5	4.9	5.2	5.1	4.9	4.3	3.2	2.3	1.9
T6	Lower	0.1	0.2	0.4	0.9	1.7	3.2	3.6	9.0	15.5	11.3	5.0	3.5	4.0	4.3	5.1	5.6	5.3	4.6	3.6	2.5	1.8	1.4
T7	Upper	0.3	0.4	0.9	1.1	3.7	4.6	4.6	4.6	3.9	3.9	4.0	4.3	5.2	5.4	6.1	6.7	6.6	6.1	5.2	3.9	2.9	2.3
T7	Lower	0.0	0.0	0.0	0.0	0.0	0.0	0.3	2.1	2.6	4.9	6.2	6.5	7.2	7.1	8.3	9.4	9.3	8.3	6.7	4.7	3.2	2.4

Station	Shore height	0.977 to 1.381	0.691 to 0.977	0.488 to 0.691	0.345 to 0.488	0.244 to 0.345	0.173 to 0.244	0.122 to 0.173	0.086 to 0.122	0.061 to 0.086	0.043 to 0.061	0.01 to 0.043
T1	Upper	2.0	1.7	1.6	1.5	1.3	0.9	0.6	0.3	0.1	0.0	0.0
T1	Lower	2.5	2.2	2.0	1.8	1.5	1.1	0.7	0.4	0.1	0.0	0.0
T2	Upper	2.0	1.6	1.5	1.4	1.2	0.8	0.5	0.3	0.1	0.0	0.0
T2	Lower	1.6	1.3	1.2	1.0	0.8	0.6	0.4	0.2	0.1	0.0	0.0
T3	Upper	1.6	1.3	1.2	1.0	0.9	0.6	0.4	0.2	0.1	0.0	0.0
T3	Lower	1.8	1.5	1.3	1.2	1.0	0.7	0.5	0.3	0.1	0.0	0.0
T4	Upper	2.3	2.0	1.9	1.7	1.4	1.0	0.7	0.4	0.1	0.0	0.0
T4	Lower	1.1	0.9	0.8	0.7	0.5	0.4	0.3	0.2	0.1	0.0	0.0
T5	Upper	2.8	2.5	2.3	2.1	1.8	1.3	0.9	0.5	0.2	0.0	0.0
T5	Lower	1.9	1.6	1.4	1.3	1.1	0.8	0.5	0.3	0.1	0.0	0.0
T6	Upper	1.6	1.4	1.2	1.1	1.0	0.7	0.5	0.3	0.1	0.0	0.0
T6	Lower	1.1	0.9	0.8	0.7	0.6	0.4	0.3	0.2	0.1	0.0	0.0
T7	Upper	2.0	1.8	1.7	1.5	1.3	0.9	0.6	0.4	0.1	0.0	0.0
T7	Lower	2.0	1.8	1.7	1.5	1.3	1.0	0.7	0.4	0.2	0.0	0.0

Subtidal stations

Station	Date collected	Visual description of sediment	Folk (1954) classification	Statistics calculated using Folk and Ward (1957) formulae							
				Mean		Sorting		Skewness		Kurtosis	
				(µm)	(description)	(µm)	(description)	(µm)	(description)	(µm)	(description)
1	09/05/2017	Sandy Mud	Sandy Mud	30.6	Coarse Silt	6.258	Very Poorly Sorted	-0.090	Symmetrical	0.761	Platykurtic
2	09/05/2017	Sandy Mud	Sandy Mud	40.1	Very Coarse Silt	5.623	Very Poorly Sorted	-0.321	Very Fine Skewed	0.914	Mesokurtic
3	09/05/2017	Sandy Mud	Sandy Mud	22.1	Coarse Silt	5.058	Very Poorly Sorted	-0.066	Symmetrical	0.816	Platykurtic
4	09/05/2017	Sandy Mud	Sandy Mud	18.1	Coarse Silt	7.172	Very Poorly Sorted	0.126	Coarse Skewed	0.886	Platykurtic
5	09/05/2017	Sandy Mud	Sandy Mud	31.8	Very Coarse Silt	5.451	Very Poorly Sorted	-0.504	Very Fine Skewed	0.819	Platykurtic
6	09/05/2017	Sandy Mud	Sandy Mud	13.4	Medium Silt	4.322	Very Poorly Sorted	-0.035	Symmetrical	1.080	Mesokurtic
7	09/05/2017	Sandy Mud	Sandy Mud	20.7	Coarse Silt	4.513	Very Poorly Sorted	-0.032	Symmetrical	0.922	Mesokurtic
8	09/05/2017	Sandy Mud	Sandy Mud	14.0	Medium Silt	3.928	Poorly Sorted	-0.040	Symmetrical	1.110	Mesokurtic
9	09/05/2017	Sandy Mud	Sandy Mud	16.5	Coarse Silt	4.931	Very Poorly Sorted	-0.030	Symmetrical	0.925	Mesokurtic
10	08/05/2017	Sandy Mud	Sandy Mud	28.6	Coarse Silt	7.453	Very Poorly Sorted	0.057	Symmetrical	0.789	Platykurtic
11	09/05/2017	Sandy Mud	Sandy Mud	12.7	Medium Silt	4.116	Very Poorly Sorted	-0.076	Symmetrical	1.120	Leptokurtic
12	08/05/2017	Gravel	Gravel	19066.3	Coarse Gravel	1.624	Moderately Well Sorted	-0.276	Fine Skewed	1.038	Mesokurtic
13	08/05/2017	Sand	Sand	162.6	Fine Sand	1.448	Moderately Well Sorted	-0.081	Symmetrical	1.255	Leptokurtic
14	09/05/2017	Sand	Sand	209.6	Fine Sand	1.583	Moderately Well Sorted	0.096	Symmetrical	1.460	Leptokurtic

Station	Primary Mode (µm)	d10 (µm)	d50 (µm)	d90 (µm)	Gravel (>2 mm) (%)	Sand (63-2000 µm) (%)	Mud (<63 µm) (%)	V Coarse Gravel (32-64 mm) (%)	Coarse Gravel (16-32 mm) (%)	Medium Gravel (8-16 mm) (%)	V Coarse Sand (1-2 mm) (%)	Coarse Sand (500-1000 µm) (%)
G1	215.0	2.6	31.2	248.3	0.0	43.2	56.8	0.0	0.0	0.0	0.3	1.7
G2	152.5	3.4	61.0	241.5	0.0	49.7	50.3	0.0	0.0	0.0	1.4	3.5
G3	107.5	2.4	21.2	149.6	0.0	33.0	67.0	0.0	0.0	0.0	0.0	0.5
G4	9.4	1.5	14.2	246.9	0.0	27.6	72.4	0.0	0.0	0.0	0.0	2.6
G5	107.5	2.2	57.1	164.8	0.0	48.7	51.3	0.0	0.0	0.0	0.0	0.7
G6	13.3	1.9	13.1	84.9	0.0	14.6	85.4	0.0	0.0	0.0	0.0	0.0
G7	13.3	2.8	19.8	126.4	0.0	25.7	74.3	0.0	0.0	0.0	0.0	0.6
G8	13.3	2.2	13.8	78.7	0.0	13.2	86.8	0.0	0.0	0.0	0.0	0.0
G9	13.3	1.9	15.5	113.0	0.0	23.0	77.0	0.0	0.0	0.0	0.0	0.0
G10	302.5	2.1	23.9	343.0	0.0	38.1	61.9	0.0	0.0	0.0	0.0	5.4
G11	13.3	1.9	13.1	74.3	0.0	12.2	87.8	0.0	0.0	0.0	0.0	0.0
G12	26950.0	9271.8	20565.0	31046.7	99.1	0.8	0.1	8.1	60.4	25.1	0.1	0.3
G13	152.5	99.8	162.3	241.2	0.0	95.9	4.1	0.0	0.0	0.0	0.0	0.7
G14	215.0	130.7	208.1	347.5	0.0	96.6	3.4	0.0	0.0	0.0	2.1	3.9

Station	Medium Sand (250-500 µm) (%)	Fine Sand (125-250 µm) (%)	V Fine Sand (63-125 µm) (%)	V Coarse Silt (31-63 µm) (%)	Coarse Silt (16-31 µm) (%)	Medium Silt (8-16 µm) (%)	Fine Silt (4-8 µm) (%)	V Fine Silt (2-4 µm) (%)
G1	7.8	24.2	9.2	6.8	9.9	14.2	11.7	6.4
G2	4.4	20.6	19.8	9.0	10.2	11.2	8.7	5.2
G3	1.2	13.3	17.9	10.1	13.5	16.3	12.3	6.6
G4	7.2	9.5	8.3	8.3	12.0	15.6	14.4	9.6
G5	2.1	17.5	28.4	9.2	8.1	9.2	9.2	6.5
G6	0.3	4.2	10.0	12.1	17.8	20.8	15.8	8.7
G7	1.7	7.9	15.5	13.7	16.6	17.8	12.7	6.5
G8	0.1	3.9	9.2	13.4	19.2	22.6	15.0	7.8
G9	0.2	7.4	15.3	11.9	14.9	17.8	14.3	8.0
G10	11.8	11.1	9.9	8.1	10.9	13.8	12.3	7.5
G11	0.1	3.7	8.4	12.6	19.7	21.2	15.3	8.7
G12	0.3	0.1	0.1	0.0	0.0	0.0	0.0	0.0
G13	5.9	75.0	14.3	0.9	0.6	0.6	0.5	0.4
G14	21.9	65.2	3.5	0.5	0.5	0.6	0.5	0.3

Station	Percentages of the distribution in each 'half-phi' size interval, expressed in µm													
	>63000	45000 to 63000	31500 to 45000	22400 to 31500	16000 to 22400	11200 to 16000	8000 to 11200	5600 to 8000	4000 to 5600	2800 to 4000	2000 to 2800	1400 to 2000	1000 to 1400	710 to 1000	500 to 710
G1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	1.4
G2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	1.9	1.6
G3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.5
G4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6
G5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7
G6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
G7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6
G8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
G9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
G10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	3.6
G11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
G12	0.0	0.0	8.5	35.2	24.9	16.7	8.4	3.3	1.4	0.6	0.2	0.1	0.0	0.1	0.2
G13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7
G14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	1.2	1.4	2.5

Station	Percentages of the distribution in each 'half-phi' size interval, expressed in µm														
	355 to 500	250 to 355	180 to 250	125 to 180	90 to 125	63 to 90	22.097 to 31.25	15.625 to 22.097	11.049 to 15.625	7.813 to 11.049	5.524 to 7.813	3.906 to 5.524	2.762 to 3.906	1.953 to 2.762	1.381 to 1.953	0.977 to 1.381
G1	2.4	5.5	11.6	12.6	5.8	3.3	4.2	5.7	7.0	7.2	6.5	5.2	3.8	2.6	1.9	1.5
G2	2.3	2.2	6.8	13.8	11.8	7.9	4.7	5.5	5.8	5.4	4.8	3.9	3.0	2.2	1.6	1.3
G3	0.6	0.6	3.1	10.2	11.0	6.8	6.1	7.4	8.3	8.0	6.9	5.4	3.9	2.7	2.0	1.6
G4	3.8	3.4	4.5	4.9	4.4	3.9	5.3	6.7	7.7	7.8	7.6	6.8	5.4	4.2	3.4	2.9
G5	1.2	0.9	3.9	13.6	17.2	11.1	3.9	4.2	4.6	4.7	4.7	4.4	3.6	2.8	2.3	2.0
G6	0.0	0.3	1.6	2.6	4.6	5.3	8.0	9.9	10.8	10.1	8.8	7.0	5.1	3.6	2.6	2.1
G7	1.0	0.7	2.2	5.7	7.9	7.4	7.7	8.8	9.3	8.5	7.2	5.5	3.9	2.6	1.9	1.5
G8	0.0	0.1	1.2	2.6	4.1	5.0	8.8	10.4	11.9	10.7	8.6	6.4	4.6	3.2	2.4	1.9
G9	0.0	0.2	1.9	5.5	7.7	7.5	6.9	8.0	9.0	8.9	7.9	6.4	4.7	3.3	2.5	2.1
G10	3.8	8.0	6.3	4.8	5.4	4.4	4.9	6.0	6.9	7.0	6.6	5.7	4.3	3.2	2.5	2.1
G11	0.0	0.1	1.3	2.4	3.8	4.5	8.9	10.7	11.1	10.1	8.5	6.8	5.0	3.6	2.8	2.2
G12	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
G13	1.5	4.4	30.8	44.2	12.3	2.0	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2
G14	2.9	19.0	39.6	25.6	2.8	0.6	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2

Station	Percentages of the distribution in each 'half-phi' size interval, expressed in µm									
	0.691	0.488	0.345	0.244	0.173	0.122	0.086	0.061	0.043	0.01
	to 0.977	to 0.691	to 0.488	to 0.345	to 0.244	to 0.173	to 0.122	to 0.086	to 0.061	to 0.043
G1	1.3	1.1	0.8	0.6	0.4	0.2	0.1	0.0	0.0	0.0
G2	1.0	0.8	0.6	0.4	0.2	0.1	0.0	0.0	0.0	0.0
G3	1.4	1.1	0.9	0.6	0.4	0.2	0.1	0.0	0.0	0.0
G4	2.4	1.8	1.2	0.6	0.2	0.0	0.0	0.0	0.0	0.0
G5	1.7	1.3	0.9	0.5	0.2	0.1	0.0	0.0	0.0	0.0
G6	1.7	1.4	1.0	0.7	0.4	0.2	0.1	0.0	0.0	0.0
G7	1.2	1.0	0.7	0.5	0.2	0.1	0.0	0.0	0.0	0.0
G8	1.6	1.2	0.8	0.5	0.2	0.1	0.0	0.0	0.0	0.0
G9	1.8	1.4	1.1	0.7	0.4	0.2	0.1	0.0	0.0	0.0
G10	1.7	1.3	0.9	0.5	0.2	0.0	0.0	0.0	0.0	0.0
G11	1.8	1.5	1.0	0.6	0.3	0.1	0.0	0.0	0.0	0.0
G12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
G13	0.2	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0
G14	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0

Appendix 7 Station feature record notes

Site Code	*Arenicola marina* casts (per m2)	Large siphon holes/burrows >5mm (per m2)	Small siphon holes/burrows <5mm (per m2)	Scrobicularia plana holes/burrows (per m2)	Lanice conchilega tubes (per m2)	Anoxic layer (code)	Surface relief (1-5; even to uneven)	Firmness (1-5; hard to soft)	Stability (1-5; stable to mobile)	Macroalgae present (% cover)	Sediment Underwater (%)	Anthropogenic pressures	Notes
T01 Upper	0	0	200-300	0	0	6 cm	2	5	5	5 (*Ulva* spp.)	30	Litter & debris	
T01 Mid	0	0	200-300	0	0	1 cm	2	5	5	0	30	Litter & debris	
T02 Upper	0	0	200-300	0	0	5 cm	4	5	5	20 (*Fucus vesiculosus)*	15	Sewage discharge Litter & debris	Diatom film present Near extensive Fucus vesiculosus canopy on rocks.
T02 Mid	0	0	200-300	0	0	1 cm	2	5	5	0	20	Sewage discharge Litter & debris	
T03 Upper	0	0	200-300	0	0	3 cm	3	5	5	15 (*Fucus vesiculosus*)	20	Litter & debris	Near extensive Fucus vesiculosus canopy on rocks.
T03Mid	0	0	200-300	0	0	1 cm	2	5	5	0	30	Litter & debris	
T04 Upper	0	0	200-300	0	0		4	4	4	85 (*Fucus vesiculosus*)	5	Litter & debris	Extensive Fucus vesiculosus canopy on rocks on upper/mid shore. Some Ulva spp.
T04 Mid	0	0	200-300	0	0	<1 cm	2	5	5	0	30	Litter & debris	
T05 Upper	0	0	200	0	0	1 cm	4	4	5	70 (*Fucus vesiculosus*)	15	Litter & debris	Surface layer fine mud. At 5 to 10 cm depth change to coarse sand and gravel. Patches of large rocks with Fucus vesiculosus + Ulva spp. Near area of very coarse sediment and small pebbles on upper shore.
T05 Mid	0	0	200-300	0	0	2 cm	3	5	5	0	20	Litter & debris	
T06 Upper	0	0	200	0	0	5 cm	4	4	5	20	15	Litter & debris	Occasional rocks with with isoalted patches of Fucus vesiculosus + Ulva spp. Near area of very coarse sediment and small pebbles on upper shore.
60T Mid	0	0	200	0	0	<1 cm	2	5	5	0	20	Litter & debris	
T07 Upper	0	0	200-300	0	0	No layer	3	4	5	30	10	Coastal defences - seawalls Litter & debris	Occasional rocks with with isolated patches of Fucus vesiculosus + Ulva spp. Near area of very coarse sediment and large pebbles /cobbles on upper shore.
T07 Mid	0	0	200	0	0	No layer	4	5	5	0	20	Sewage Discharge Litter & debris	

Appendix 8 Macrobenthic data for intertidal core samples. N/A = not applicable.

	Station		T1						T2						T3						T4						T5						T6						T7						
	Shore height		Upper			Mid			Upper			Mid			Upper			Mid			Upper			Mid			Upper			Mid			Upper			Mid			Upper			Mid			
Code	Replicate		a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	TOTAL
C0000	Animalia	eggs	0	0	P	0	0	0	0	0	0	0	0	0	0	0	0	P	0	0	P	0	0	0	0	0	0	0	0	0	0	P	0	P	0	0	0	0	0	0	0	0	0	0	0	N/A
D0433	Sertularia		0	0	0	0	0	P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	N/A
D0491	Campanulariidae		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	P	0	0	0	0	0	0	0	0	0	0	0	0	0	N/A
F0001	Platyhelminthes		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0	0	12
F0120	Dalyelliidae		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	2	0	0	0	0	0	0	0	0	0	1	0	6
G0001	Nemertea		0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	6
G0050	Lineus		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
HD0001	Nematoda		40	99	22	67	37	29	28	11	2	3	6	2	1	6	8	1	0	2	3	6	15	3	17	2	54	74	137	55	3	54	195	200	141	36	1	6	80	128	275	58	47	4	1958
P0118	*Eteone longa*	aggregate	0	0	0	1	0	1	0	0	3	2	2	4	2	1	6	5	2	2	1	0	0	6	5	3	4	2	1	19	7	19	75	49	76	17	4	9	10	12	7	11	8	16	392
P0123	*Hypereteone lighti*		0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	3
P0145	*Phyllodoce mucosa*		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	4
P0462	*Hediste diversicolor*		56	29	27	14	22	14	6	18	8	1	0	0	8	8	3	3	0	0	54	60	65	2	2	3	257	134	154	8	16	11	3	7	0	0	0	0	16	30	55	1	1	1	1097
P0494	*Nephtys* sp.	juvenile	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	9	5	2	0	0	0	0	0	0	21
P0499	*Nephtys hombergii*		0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	Frag.	0	2	0	0	0	0	0	0	4
P0753	*Polydora cornuta*		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
P0776	*Pygospio elegans*		1	0	0	1	0	1	0	3	0	4	3	5	0	4	1	7	1	1	1	0	1	3	9	5	43	32	24	6	2	10	24	49	22	2	4	2	17	36	30	1	1	0	356
P0798	*Streblospio* sp.		25	17	0	4	7	13	0	9	7	6	4	3	2	3	1	0	0	0	0	0	0	2	3	2	0	1	0	2	1	1	9	4	0	2	8	2	17	67	78	2	0	0	302
P0847	*Tharyx* species A		0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	2	0	2	0	0	0	2	2	5	0	0	0	0	1	1	0	4	0	77	52	18	0	0	0	0	0	0	169
P0917	*Heteromastus filiformis*		4	0	0	2	3	Frag.	0	0	2	0	0	0	3	1	3	0	0	0	0	1	0	Frag.	0	0	0	0	1	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	23
P1294	*Manayunkia aestuarina*		12	8	3	9	3	4	0	0	0	0	0	0	0	0	1	0	0	0	1	0	11	0	0	0	0	0	0	4	0	5	15	56	24	1	0	0	2	16	6	0	0	0	181
P1402	Oligochaeta	eggs	P	P	0	P	P	P	P	P	P	P	P	P	P	P	P	0	0	0	0	0	0	P	P	P	P	P	0	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	N/A
P1420	*Paranais litoralis*		0	4	0	13	42	10	0	4	4	0	0	4	0	0	1	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	8	8	18	1	0	0	125
P1425	Tubificidae		0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	24
P1479	*Baltidrilus costatus*		396	328	315	155	216	196	224	106	48	2	0	7	0	0	2	0	1	0	51	48	77	0	0	0	602	413	378	13	8	12	189	69	65	5	0	0	112	156	228	35	4	0	4461
P1490	*Tubificoides benedii*		39	84	224	11	13	12	44	204	347	184	136	160	198	408	266	48	10	11	6	9	12	104	167	93	10	15	18	357	341	371	607	292	190	236	161	145	45	44	42	280	56	208	6208
P1494	*Tubificoides diazi*	aggregate	60	7	0	0	0	1	0	0	6	0	0	1	0	0	1	0	0	0	7	0	14	0	0	0	0	0	0	0	0	1	15	0	0	0	0	0	0	0	0	1	0	0	114
P1501	Enchytraeidae		0	0	8	6	10	32	3	2	0	0	1	0	0	0	0	0	0	0	0	0	4	0	8	0	124	137	165	1	0	1	17	16	24	4	0	0	4	0	2	1	0	0	570
Q0052	Oribatei		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	4
Q0054	Acari		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	5
R0015	Sessilia		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
R0068	*Austrominius modestus*		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
R0142	Copepoda		0	0	0	0	0	0	2	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
R2432	*Eusarsiella zostericola*		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1	4	0	0	0	1	0	2	0	0	0	0	0	0	0	0	0	2	1	1	0	0	0	0	0	0	15
R2458	Podocopida		0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
S0464	Gammaridae	juvenile	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
S0616	*Corophium volutator*		317	145	51	97	60	41	76	55	10	4	2	3	35	10	39	74	23	8	57	44	123	113	162	153	395	211	198	529	423	2032	1403	1883	1199	135	50	58	337	743	757	278	72	510	12915
S0805	*Cyathura carinata*		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	3	1	0	0	0	0	0	2	0	0	0	0	9
S0884	*Jaera* sp.		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
S1594	*Carcinus maenas*	juvenile	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
T0002	Coleoptera		0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
T0002	Coleoptera	larva	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
T0003	Dolichopodidae	larva	0	1	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
T0005	Hemiptera		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	3
T0005	Aphididae		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
T0006	Formicidae		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
W0385	*Peringia ulvae*		4	1	1	0	0	0	0	1	1	0	0	0	0	0	0	1	3	1	2	0	1	2	0	0	0	0	0	0	2	0	0	0	0	4	1	2	0	1	0	1	0	0	29
W0393	*Potamopyrgus antipodarum*		4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
W1080	*Retusa truncatula*		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
W2029	*Limecola balthica*		3	1	0	2	3	3	0	2	1	7	2	4	1	1	2	2	1	3	0	0	0	6	9	6	7	0	Frag.	11	25	16	20	9	10	55	58	25	17	27	38	44	6	22	449
W2068	*Scrobicularia plana*		0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	1	0	0	5
W2068	*Scrobicularia plana*	juvenile	1	0	0	1	0	1	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	1	1	0	0	0	2	2	2	3	2	0	14	14	1	8	8	9	0	1	9	83
Y0096	*Anguinella palmata*		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	P	0	0	0	0	0	0	0	P	0	0	0	0	0	0	N/A
Y0176	*Einhornia crustulenta*		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	N/A
ZM	*Lemna* sp.		0	0	P	0	0	0	P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	N/A
ZN	Protozoa		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	P	0	0	0	0	0	0	P	0	0	0	0	0	N/A
ZR0087	*Elachista fucicola*		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	N/A
ZS0174	*Ulva* sp.		0	0	0	0	0	0	0	0	0	0	P	0	0	P	0	0	0	0	0	0	0	0	0	P	0	P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	N/A
	TOTAL		962	724	651	383	416	362	387	415	441	216	159	196	250	446	336	148	42	35	186	173	323	244	390	275	1497	1031	1079	1010	834	2550	2602	2646	1757	599	361	276	674	1282	1545	715	197	770	29585

Appendix 9 Macrobenthic data for subtidal grab samples. N/A = not applicable.

Code	Station		1			2			3			4			5			6			7			8			9			10			11			12			13			14			
Code	Replicate		a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	TOTAL
C0000	Animalia	eggs	0	0	0	0	0	P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	N/A
D0285	*Cordylophora caspia*		0	0	0	0	0	0	0	0	0	0	P	0	0	0	0	P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	P	0	0	0	0	N/A
D0424	*Hydrallmania falcata*		0	0	P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	N/A
D0433	*Sertularia* sp.		0	P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	N/A
D0491	Campanulariidae		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	P	0	0	0	0	0	0	0	0	0	0	0	0	P	0	0	0	0	N/A
E0006	*Pleurobrachia pileus*		0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
G0001	Nemertea		0	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	3	7	2	0	0	0	1	0	0	18
HD0001	Nematoda		0	0	1	5	1	0	9	3	4	0	0	13	0	0	1	80	1	0	0	0	0	1	7	0	2	0	0	0	1	0	0	2	0	0	2	4	0	0	0	0	0	16	153
K0045	*Pedicellina* sp.		0	P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	P	0	0	0	0	0	0	0	0	0	0
P0065	*Harmothoe impar*	aggregate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2
P0094	*Pholoe inornata* (sensu Petersen)		0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
P0118	*Eteone longa*	aggregate	0	0	0	0	4	0	3	4	1	4	7	4	0	0	7	32	1	0	0	2	0	0	0	1	10	2	4	0	0	0	0	2	2	0	0	0	0	0	0	3	1	2	96
P0123	*Hypereteone lighti*		0	0	0	0	0	0	0	0	0	10	0	8	0	0	0	0	0	0	0	1	0	0	0	0	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23
P0145	*Phyllodoce mucosa*		0	0	0	0	0	0	0	0	0	0	0	4	8	0	6	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	2	0	0	0	0	0	0	1	0	0	1	30
P0265	*Glycera tridactyla*		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
P0462	*Hediste diversicolor*		0	0	0	0	0	1	0	0	0	1	86	0	0	0	0	26	5	3	5	0	0	0	1	1	0	0	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	133
P0471	*Alitta succinea*		0	0	0	9	11	0	0	0	0	0	0	86	3	0	1	0	1	0	0	8	3	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	124
P0472	*Alitta virens*		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
P0494	*Nephtys*	juvenile	0	2	0	1	0	0	2	4	1	3	1	2	0	0	3	0	0	0	0	0	0	0	0	0	3	3	0	0	0	0	0	4	3	0	0	0	0	0	0	1	0	0	33
P0498	*Nephtys cirrosa*		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	5	4	0	0	1	12
P0499	*Nephtys hombergii*		0	0	0	0	0	0	5	2	3	1	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	0	0	0	1	0	0	0	0	1	18
P0672	*Scoloplos armiger*		0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
P0750	*Dipolydora coeca*	aggregate	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
P0753	*Polydora cornuta*		0	1	0	9	24	17	2	4	0	4	4	10	12	22	48	72	3	3	2	2	4	1	31	2	52	3	19	2	0	0	10	24	4	0	0	0	0	0	0	3	0	4	398
P0773	*Pseudopolydora* cf. *paucibranchiata*		0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
P0776	*Pygospio elegans*		0	0	0	8	6	34	12	8	1	0	2	4	17	1	13	32	8	0	2	7	3	0	3	11	37	2	8	0	0	0	2	9	0	0	0	0	0	1	0	0	0	0	231
P0791	*Spio martinensis*		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
P0798	*Streblospio* sp.		0	3	0	15	1	5	28	20	4	5	2	5	1	5	14	0	2	0	4	11	7	0	2	16	12	7	3	1	0	1	1	0	4	0	1	0	2	0	0	0	0	0	182
P0847	*Tharyx* species A		0	5	0	23	5	21	126	275	91	558	3	6	5	2	47	0	1	4	0	0	0	0	0	0	7	4	2	0	0	1	2	2	3	0	1	0	0	1	0	2	0	2	1199
P0906	*Capitella*		24	3	0	2	0	0	1	1	0	4	0	0	0	0	0	0	0	1	0	2	0	0	0	0	0	5	0	1	4	43	2	1	2	0	0	0	1	0	0	2	0	2	101
P0917	*Heteromastus filiformis*		0	0	0	6	2	4	12	4	8	4	0	0	0	0	6	0	0	2	2	4	3	0	1	0	11	8	4	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	83
P0928	Arenicolidae	juvenile	0	0	0	0	0	0	0	0	0	0	1	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
P1134	*Ampharete baltica*		0	0	0	0	0	0	1	0	0	0	3	2	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12
P1206	*Neoamphitrite figulus*		0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	3
P1206	*Neoamphitrite figulus*	juvenile	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3
P1402	Oligochaeta	eggs	0	P	0	0	P	0	P	0	0	0	0	0	0	0	P	0	P	0	0	0	0	0	0	0	P	0	0	0	0	0	0	0	P	0	0	0	0	P	0	0	0	P	0
P1420	*Paranais litoralis*		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
P1489	*Tubificoides amplivasatus*		0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
P1490	*Tubificoides benedii*		0	7	0	118	58	136	119	133	10	54	2	12	35	22	167	0	7	15	0	0	0	1	0	0	37	40	11	0	0	1	10	5	7	0	0	0	5	1	11	8	0	2	1034
P1494	*Tubificoides diazi*		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
P1494	*Tubificoides diazi*	aggregate	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	19	0	0	0	0	0	0	0	23

Code	Station		1			2			3			4			5			6			7			8			9			10			11			12			13			14			
Code	Replicate		a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	TOTAL
P1501	Enchytraeidae		0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
R0015	Sessilia	juvenile	4	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
R0078	*Amphibalanus improvisus*		0	0	0	0	0	0	0	0	0	0	1	0	0	2	0	4	9	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	19
R0142	Copepoda		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	2
R2432	*Eusarsiella zostericola*		4	0	0	3	1	8	16	8	5	11	2	10	12	0	9	0	0	0	0	0	0	0	0	0	6	12	2	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	111
S0025	Mysidacea	juvenile	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
S0074	*Mesopodopsis slabberi*		0	5	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	1	0	0	0	0	0	1	1	0	2	1	1	0	1	1	Frag.	2	1	21
S0086	*Schistomysis kervillei*		0	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	4
S0089	*Schistomysis spiritus*		0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	4
S0131	*Perioculodes longimanus*		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
S0133	*Pontocrates altamarinus*		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
S0452	*Bathyporeia elegans*		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	2
S0458	*Bathyporeia sarsi*		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	3
S0481	*Gammarus salinus*		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	4	0	7	0	0	0	0	0	0	12
S0550	*Microprotopus maculatus*		0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
S0616	*Corophium volutator*		0	0	0	71	145	107	0	1	0	1	97	258	187	178	92	80	26	0	17	22	54	24	41	16	607	66	162	0	0	0	35	38	0	0	0	0	0	0	1	9	2	0	2337
S0805	*Cyathura carinata*		0	0	0	0	0	0	0	0	0	0	2	5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	9
S1197	*Bodotria scorpioides*		0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
S1236	*Pseudocuma longicorne*		0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	4
S1385	*Crangon crangon*		0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	4
S1552	*Corystes cassivelaunus*		0	0	0	0	0	0	0	0	0	0	0	0	P	0	0	0	0	0	0	0	0	0	0	0	0	0	P	0	0	0	0	P	P	0	0	0	0	0	0	0	0	0	N/A
T0002	Coleoptera		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
W0385	*Peringia ulvae*		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2
W1696	*Mytilus edulis*	juvenile	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
W2029	*Limecola balthica*		0	1	0	1	1	1	9	5	3	0	0	1	0	0	4	0	0	1	1	0	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	34
W2068	*Scrobicularia plana*	juvenile	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
W2137	*Petricolaria pholadiformis*	juvenile	0	0	0	0	0	0	0	0	0	0	3	2	0	0	0	0	1	1	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11
W2174	Pholadidae	juvenile	0	0	0	0	0	0	0	0	0	Frag.	0	0	0	0	0	0	0	0	0	0	3	1	3	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	9
W2181	*Barnea candida*		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Y0096	*Anguinella palmata*		P	P	0	0	P	P	0	0	P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	P	P	0	0	0	0	P	P	0	0	0	0	0	P	P	0	0	0	N/A
Y0122	*Farrella repens*		0	P	0	0	P	0	0	P	0	P	0	0	P	P	P	0	P	0	P	P	P	0	0	P	0	0	0	0	P	0	0	0	P	0	0	0	0	P	0	0	0	P	N/A
Y0176	*Einhornia crustulenta*		P	0	0	0	P	P	0	0	P	P	0	0	P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	P	P	0	P	P	0	0	0	0	0	P	P	0	0	0	N/A
Y0178	*Electra pilosa*		0	0	0	0	0	0	0	0	0	0	0	0	0	0	P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	N/A
Y0222	*Amphiblestrum auritum*		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	P	0	0	0	0	0	P	0	0	0	0	0	N/A
ZG0029	Clupeidae		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
ZM	*Lemna* sp.		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	P	0	0	0	0	N/A
ZR0376	*Fucus* sp.	juvenile	0	0	0	0	P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	N/A
ZS0174	*Ulva* sp.		0	0	0	0	P	0	0	0	0	0	0	0	0	0	P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	N/A
ZS0189	*Chaetomorpha* sp.		0	0	0	0	0	0	0	0	0	P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	N/A
ZS0195	*Cladophora* sp.		0	0	0	0	0	0	0	0	0	P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	N/A
	TOTAL		32	27	3	274	260	335	347	478	131	664	219	443	285	233	428	328	66	31	34	59	79	32	92	47	804	157	227	12	9	50	67	92	30	9	31	14	18	12	20	33	6	34	6552

Appendix 10 Biomass data for intertidal core samples

Table A10: Biomass data for each 0.01 m² intertidal core. BWW = blotted wet weight; AFDW = ash free dry weight (converted using factors from Eleftheriou & Basford, 1989). All values in grams.

	T01 Upper - A		T01 Upper - B		T01 Upper - C		T01 Middle - A		T01 Middle - B		T01 Middle - C	
	BWW	AFDW	BWW	AFDW	BWW	AFDW	BWW	AFDW	BWW	AFDW	BWW	AFDW
Annelida	1.9981	0.309706	0.5737	0.088924	1.0957	0.169834	0.4356	0.067518	0.6251	0.096891	0.4739	0.073455
Crustacea	0.2791	0.062798	0.0792	0.017820	0.0853	0.019193	0.2320	0.052200	0.1004	0.022590	0.0686	0.015435
Mollusca	0.0489	0.004157	0.0101	0.000859	0.0001	0.000009	0.0248	0.002108	0.0171	0.001454	0.0340	0.002890
Echinodermata	-	-	-	-	-	-	-	-	-	-	-	-
Others	0.0012	0.000186	0.0137	0.002124	0.0004	0.000062	0.0003	0.000047	0.0015	0.000233	0.0019	0.000295

	T02 Upper - A		T02 Upper - B		T02 Upper - C		T02 Middle - A		T02 Middle - B		T02 Middle- C	
	BWW	AFDW	BWW	AFDW	BWW	AFDW	BWW	AFDW	BWW	AFDW	BWW	AFDW
Annelida	1.0174	0.157697	0.7735	0.119893	0.4401	0.068216	0.2248	0.034844	0.1304	0.020212	0.2768	0.042904
Crustacea	0.1642	0.036945	0.0836	0.018810	0.0199	0.004478	0.0051	0.001148	0.0014	0.000315	0.0104	0.002340
Mollusca	-	-	0.0813	0.006911	4.6787	0.397690	0.0024	0.000204	0.0009	0.000077	0.0015	0.000128
Echinodermata	-	-	-	-	-	-	-	-	-	-	-	-
Others	0.0222	0.003441	0.0001	0.000016	0.0001	0.000016	0.0001	0.000016	0.0001	0.000016	0.0001	0.000016

	T03 Upper - A		T03 Upper - B		T03 Upper - C		T03 Middle - A		T03 Middle - B		T03 Middle - C	
	BWW	AFDW	BWW	AFDW	BWW	AFDW	BWW	AFDW	BWW	AFDW	BWW	AFDW
Annelida	0.2943	0.045617	0.4950	0.076725	0.1589	0.024630	0.0190	0.002945	0.0128	0.001984	0.0090	0.001395
Crustacea	0.0747	0.016808	0.0083	0.001868	0.0675	0.015188	0.0750	0.016875	0.0571	0.012848	0.0202	0.004545
Mollusca	0.0002	0.000017	0.0490	0.004165	0.0006	0.000051	0.0012	0.000102	0.0033	0.000281	0.0036	0.000306
Echinodermata	-	-	-	-	-	-	-	-	-	-	-	-
Others	0.0001	0.000016	0.0072	0.001116	0.0014	0.000217	0.0001	0.000016	-	-	0.0001	0.000016

	T04 Upper - A		T04 Upper - B		T04 Upper - C		T04 Middle - A		T04 Middle - B		T04 Middle - C	
	BWW	AFDW	BWW	AFDW	BWW	AFDW	BWW	AFDW	BWW	AFDW	BWW	AFDW
Annelida	2.8426	0.440603	2.0661	0.320246	2.5881	0.401156	0.1316	0.020398	0.1328	0.020584	0.0914	0.014167
Crustacea	0.0555	0.012488	0.1281	0.028823	0.2364	0.053190	0.0744	0.016740	0.1334	0.030015	0.1489	0.033503
Mollusca	0.0010	0.000085	-	-	0.0041	0.000349	0.0089	0.000757	0.0304	0.002584	0.0142	0.001207
Echinodermata	-	-	-	-	-	-	-	-	-	-	-	-
Others	0.0337	0.005224	0.0386	0.005983	0.0002	0.000031	0.0001	0.000016	0.0050	0.000775	0.0001	0.000016

	T05 Upper - A		T05 Upper - B		T05 Upper - C		T05 Middle - A		T05 Middle - B		T05 Middle - C	
	BWW	AFDW	BWW	AFDW	BWW	AFDW	BWW	AFDW	BWW	AFDW	BWW	AFDW
Annelida	0.6877	0.106594	0.5489	0.085080	0.7530	0.116715	0.1944	0.030132	0.3699	0.057335	0.1857	0.028784
Crustacea	0.4314	0.097065	0.2073	0.046643	0.1479	0.033278	0.4269	0.096053	0.3335	0.075038	0.4562	0.102645
Mollusca	0.1889	0.016057	-	-	0.0002	0.000017	0.0633	0.005381	0.8043	0.068366	0.6564	0.055794
Echinodermata	-	-	-	-	-	-	-	-	-	-	-	-
Others	0.0056	0.000868	0.0058	0.000899	0.0066	0.001023	0.0015	0.000233	0.0045	0.000698	0.0012	0.000186

	T06 Upper - A		T06 Upper - B		T06 Upper - C		T06 Middle - A		T06 Middle - B		T06 Middle - C	
	BWW	AFDW	BWW	AFDW	BWW	AFDW	BWW	AFDW	BWW	AFDW	BWW	AFDW
Annelida	0.4795	0.074323	0.2540	0.039370	0.2728	0.042284	0.2358	0.036549	0.1911	0.029621	0.2234	0.034627
Crustacea	0.6849	0.154103	0.6266	0.140985	0.7383	0.166118	0.0573	0.012893	0.0192	0.004320	0.0253	0.005693
Mollusca	1.3121	0.111529	0.4042	0.034357	0.0260	0.002210	0.1381	0.011739	0.4443	0.037766	0.1572	0.013362
Echinodermata	-	-	-	-	-	-	-	-	-	-	-	-
Others	0.0350	0.005425	0.0009	0.000140	0.0005	0.000078	0.0011	0.000171	0.0001	0.000016	0.0003	0.000047

	T07 Upper - A		T07 Upper - B		T07 Upper - C		T07 Middle - A		T07 Middle - B		T07 Middle - C	
	BWW	AFDW	BWW	AFDW	BWW	AFDW	BWW	AFDW	BWW	AFDW	BWW	AFDW
Annelida	0.3428	0.053134	0.9246	0.143313	0.3770	0.058435	0.1826	0.028303	0.0344	0.005332	0.2209	0.034240
Crustacea	0.1681	0.037823	0.7011	0.157748	0.3586	0.080685	0.1361	0.030623	0.0424	0.009540	0.2054	0.046215
Mollusca	0.0904	0.007684	0.0939	0.007982	0.1689	0.014357	0.2067	0.017570	0.0012	0.000102	0.3318	0.028203
Echinodermata	-	-	-	-	-	-	-	-	-	-	-	-
Others	0.0037	0.000574	0.0092	0.001426	0.0071	0.001101	0.0021	0.000326	0.0017	0.000264	0.0001	0.000016

Appendix 11 SIMPER analysis results

Intertidal samples: Analysis results

SIMPER
Similarity Percentages - species contributions

One-Way Analysis
Data type: Abundance
Sample selection: All
Variable selection: All

Parameters
Resemblance: S17 Bray Curtis similarity
Cut off for low contributions: 90.00%

Factor Groups Sample	SIMPROF		Factor Groups Sample	SIMPROF
T03_Mid_B	a		T05_Upp_A	d
T03_Mid_C	a		T05_Upp_B	d
T01_Upp_C	b		T05_Upp_C	d
T02_Upp_A	b		T05_Mid_A	e
T04_Upp_A	b		T05_Mid_C	e
T04_Upp_B	b		T06_Upp_A	e
T04_Upp_C	b		T06_Upp_B	e
T02_Mid_A	c		T06_Upp_C	e
T02_Mid_B	c		T02_Upp_B	f
T02_Mid_C	c		T02_Upp_C	f
T03_Upp_A	c		T07_Mid_A	f
T03_Upp_B	c		T01_Upp_A	g
T03_Upp_C	c		T01_Upp_B	g
T03_Mid_A	c		T07_Upp_A	h
T04_Mid_A	c		T07_Upp_B	h
T04_Mid_B	c		T07_Upp_C	h
T04_Mid_C	c		T01_Mid_A	i
T05_Mid_B	c		T01_Mid_B	i
T06_Mid_A	c		T01_Mid_C	i
T06_Mid_B	c			
T06_Mid_C	c			
T07_Mid_B	c			
T07_Mid_C	c			

Group a
Average similarity: 71.26

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Tubificoides benedii	1.8	14.65	-	20.56	20.56
Corophium volutator	1.94	13.86	-	19.44	40
Eteone longa aggregate	1.19	9.8	-	13.75	53.75
Pygospio elegans	1	8.24	-	11.56	65.32
Eusarsiella zostericola	1.21	8.24	-	11.56	76.88
Peringia ulvae	1.16	8.24	-	11.56	88.44
Limecola balthica	1.16	8.24	-	11.56	100

Group b
Average similarity: 65.62

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Baltidrilus costatus	3.27	14.47	10.36	22.05	22.05
Corophium volutator	2.86	13.72	19.27	20.9	42.95
Hediste diversicolor	2.44	11.05	3.38	16.84	59.79
Tubificoides benedii	2.32	9.06	7.25	13.81	73.6
Nematoda	1.86	8.19	6.2	12.48	86.08
Enchytraeidae	0.88	1.93	0.62	2.93	89.01
Dolichopodidae larva	0.73	1.78	0.6	2.71	91.73

Group c
Average similarity: 66.08

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Tubificoides benedii	3.58	15.5	6.19	23.45	23.45
Corophium volutator	2.81	10.23	2.9	15.49	38.94
Limecola balthica	1.7	6.37	4.81	9.65	48.58
Eteone longa aggregate	1.49	6.24	6.18	9.44	58.03
Nematoda	1.51	5.87	4.89	8.88	66.91
Pygospio elegans	1.17	4.22	1.63	6.38	73.29
Oligochaeta eggs	0.94	4.11	2.44	6.23	79.52
Streblospio	1.03	3.47	1.29	5.26	84.77
Hediste diversicolor	0.92	2.62	0.89	3.96	88.73
Scrobicularia plana	0.86	2.14	0.89	3.24	91.98

Group d

Average similarity: 81.58

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Baltidrilus costatus	4.62	14.91	42.79	18.28	18.28
Corophium volutator	4.01	12.66	42.27	15.52	33.79
Hediste diversicolor	3.64	11.56	21.22	14.17	47.96
Enchytraeidae	3.45	11.29	44.66	13.84	61.81
Nematoda	3.02	9.34	26.01	11.45	73.26
Pygospio elegans	2.38	7.61	26.89	9.33	82.59
Tubificoides benedii	1.94	6.18	20.04	7.57	90.16

Group e

Average similarity: 76.27

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Corophium volutator	6.02	15.42	10.6	20.21	20.21
Tubificoides benedii	4.31	11.22	10.84	14.71	34.93
Nematoda	3.28	8.22	8.71	10.78	45.71
Eteone longa aggregate	2.54	6.34	7.74	8.31	54.02
Baltidrilus costatus	2.64	6.01	5.3	7.87	61.89
Pygospio elegans	2.07	5.02	8.44	6.58	68.48
Limecola balthica	1.89	4.99	10.88	6.54	75.02
Manayunkia aestuarina	1.97	4.52	5.99	5.92	80.94
Enchytraeidae	1.65	3.58	2.98	4.7	85.64
Oligochaeta eggs	1	2.79	11	3.66	89.29
Hediste diversicolor	1.29	2.42	1.12	3.17	92.46
Corophium volutator	3.84	11.79	-	14.83	33.02
Nematoda	2.83	8.55	-	10.75	43.76
Tubificoides benedii	2.76	8.49	-	10.68	54.44
Hediste diversicolor	2.53	7.89	-	9.92	64.36
Streblospio	2.13	6.9	-	8.68	73.04
Manayunkia aestuarina	1.77	5.72	-	7.19	80.23
Tubificoides diazi aggregate	2.2	5.53	-	6.95	87.18
Oligochaeta eggs	1	3.4	-	4.27	91.45

Group f
Average similarity: 76.39

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Tubificoides benedii	4.06	16.13	22.2	21.12	21.12
Baltidrilus costatus	2.76	10.41	9.96	13.62	34.74
Corophium volutator	2.86	8.67	4.18	11.35	46.09
Nematoda	1.92	5.8	4.18	7.59	53.68
Streblospio	1.52	5.59	4.06	7.32	61
Hediste diversicolor	1.58	5.16	2.64	6.76	67.75
Paranais litoralis	1.28	4.77	3.74	6.24	73.99
Limecola balthica	1.59	4.41	10.98	5.78	79.77
Oligochaeta eggs	1	4.16	18.83	5.44	85.22
Peringia ulvae	1	4.16	18.83	5.44	90.66

Group g
Average similarity: 79.52

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Baltidrilus costatus	4.36	14.46	-	18.19	18.19
Corophium volutator	3.84	11.79	-	14.83	33.02
Nematoda	2.83	8.55	-	10.75	43.76
Tubificoides benedii	2.76	8.49	-	10.68	54.44
Hediste diversicolor	2.53	7.89	-	9.92	64.36
Streblospio	2.13	6.9	-	8.68	73.04
Manayunkia aestuarina	1.77	5.72	-	7.19	80.23
Tubificoides diazi aggregate	2.2	5.53	-	6.95	87.18
Oligochaeta eggs	1	3.4	-	4.27	91.45

Group h
Average similarity: 86.73

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Corophium volutator	4.92	13.26	12.02	15.28	15.28
Baltidrilus costatus	3.56	9.67	60.17	11.14	26.43
Nematoda	3.48	8.99	27.83	10.37	36.8
Tubificoides benedii	2.57	7.39	27.78	8.52	45.32
Streblospio	2.62	6.64	5.81	7.66	52.97
Pygospio elegans	2.27	6.16	19.93	7.1	60.07
Limecola balthica	2.26	6.1	28.68	7.03	67.11
Hediste diversicolor	2.35	6.1	16.92	7.03	74.14
Paranais litoralis	1.81	4.86	29.8	5.61	79.74
Scrobicularia plana	1.7	4.86	29.8	5.61	85.35
Eteone longa aggregate	1.76	4.85	14.37	5.59	90.94

Group i
Average similarity: 84.70

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Baltidrilus costatus	3.7	13.7	18.71	16.18	16.18
Corophium volutator	2.82	9.97	10.3	11.77	27.95
Nematoda	2.55	9.03	12.98	10.66	38.6
Hediste diversicolor	2.01	7.36	23.12	8.69	47.3
Tubificoides benedii	1.86	6.98	22.57	8.24	55.54
Paranais litoralis	2.07	6.93	12.54	8.18	63.72
Enchytraeidae	1.91	6.23	11.85	7.35	71.08
Streblospio	1.65	5.65	11.01	6.67	77.75
Manayunkia aestuarina	1.49	5.13	43.69	6.06	83.81
Limecola balthica	1.27	4.69	14.02	5.53	89.34
Oligochaeta eggs	1	3.81	23.12	4.5	93.84

Intertidal samples: Average dissimilarity (%) between SIMPROF groups

Group	a	b	c	d	e	f	g	h
b	61.98							
c	47.26	56.43						
d	64.88	42.97	53.62					
e	64.40	51.29	42.63	41.29				
f	54.10	42.42	35.98	43.58	36.70			
g	63.94	37.65	48.05	40.86	39.95	29.95		
h	63.54	46.88	43.27	32.70	27.62	30.90	28.69	
i	62.06	39.58	46.11	34.28	37.24	29.09	27.15	25.65

Subtidal samples: Analysis results

SIMPER
Similarity Percentages - species contributions

One-Way Analysis
Data type: Abundance
Sample selection: All
Variable selection: All

Parameters
Resemblance: S17 Bray Curtis similarity
Cut off for low contributions: 90.00%

Factor Groups Sample	SIMPROF		Factor Groups Sample	SIMPROF
1A	a		3A	f
1C	a		3B	f
10B	a		3C	f
10C	a		4A	f
6B	b		1B	g
7A	b		6C	g
7B	b		11C	g
7C	b		14C	g
8A	b		13A	h
8B	b		13B	h
8C	b		13C	h
4B	c		10A	i
6A	c		12A	i
2A	d		12B	i
2B	d		12C	i
2C	d		14B	i
4C	d			
5A	d			
5B	d			
5C	d			
9A	d			
9B	d			
9C	d			
11A	e			
11B	e			
14A	e			

Group a
Average similarity: 23.16

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Capitella	3.36	12.98	0.8	56.05	56.05
Schistomysis spiritus	0.75	5.94	0.87	25.65	81.7
Nematoda	0.5	2.56	0.41	11.07	92.76

Group b
Average similarity: 55.37

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Corophium volutator	5.22	23.24	6.18	41.97	41.97
Polydora cornuta	2.08	6.88	7.15	12.42	54.4
Streblospio	2.11	6.41	1.23	11.58	65.98
Pygospio elegans	1.95	6.22	1.39	11.23	77.21
Petricolaria pholadiformis juvenile	0.71	2.43	0.9	4.4	81.61
Farrella repens	0.71	2.38	0.92	4.29	85.9
Heteromastus filiformis	0.88	1.75	0.59	3.15	89.06
Hediste diversicolor	0.92	1.69	0.57	3.05	92.1

Group c
Average similarity: 48.99

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Corophium volutator	9.4	19.82	-	40.46	40.46
Hediste diversicolor	7.19	11.3	-	23.07	63.53
Eteone longa aggregate	4.15	5.86	-	11.97	75.5
Polydora cornuta	5.24	4.43	-	9.05	84.55
Pygospio elegans	3.54	3.13	-	6.4	90.95

Group d
Average similarity: 60.08

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Corophium volutator	12.9	20.52	3.76	34.15	34.15
Tubificoides benedii	7.29	10.44	2.58	17.38	51.53
Polydora cornuta	4.36	6.6	2.95	10.99	62.52
Pygospio elegans	3.22	4.21	2.42	7.01	69.53
Tharyx species A	3.06	4.05	3.04	6.74	76.27
Streblospio	2.42	3.52	2.54	5.86	82.13
Eusarsiella zostericola	2.25	2.93	1.45	4.87	87
Heteromastus filiformis	1.65	1.75	0.88	2.91	89.91
Eteone longa aggregate	1.32	1.08	0.69	1.8	91.71

Group e
Average similarity: 54.69

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Corophium volutator	5.03	16.03	3.52	29.32	29.32
Tubificoides benedii	2.74	10.3	3.56	18.84	48.16
Polydora cornuta	3.26	8.96	4.23	16.37	64.53
Tharyx species A	1.41	5.92	6.92	10.82	75.35
Capitella	1.28	4.85	2.86	8.86	84.21
Eteone longa aggregate	1.05	1.97	0.58	3.61	87.82
Pygospio elegans	1.47	1.69	0.58	3.09	90.9

Group f
Average similarity: 63.65

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Tharyx species A	15.24	21.94	6.95	34.48	34.48
Tubificoides benedii	8.24	10.91	2.32	17.15	51.62
Eusarsiella zostericola	3.1	5.1	13.99	8.02	59.64
Streblospio	3.5	4.83	3.33	7.58	67.22
Heteromastus filiformis	2.57	4.3	3.54	6.76	73.97
Eteone longa aggregate	1.68	2.69	5.45	4.23	78.21
Nephtys hombergii	1.6	2.54	2.86	4	82.21
Nephtys juvenile	1.54	2.44	9.41	3.83	86.03
Limecola balthica	1.74	1.95	0.91	3.06	89.1
Nematoda	1.68	1.91	0.89	3	92.09

Group g
Average similarity: 46.54

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Tubificoides benedii	2.64	11.17	2.72	24	24
Tharyx species A	1.85	8.89	4.59	19.1	43.11
Polydora cornuta	1.68	7.7	3.02	16.55	59.66
Capitella	1.39	6.5	9.92	13.97	73.63
Oligochaeta eggs	0.75	2.5	0.91	5.38	79.01
Farrella repens	0.75	2.5	0.91	5.38	84.38
Streblospio	0.93	1.43	0.41	3.07	87.46
Nephtys juvenile	0.79	1.17	0.41	2.51	89.97
Eteone longa aggregate	0.71	1.15	0.41	2.47	92.44

Group h
Average similarity: 30.50

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Nephtys cirrosa	1.88	11.26	4.55	36.91	36.91
Tubificoides benedii	2.18	10.07	1.75	33.01	69.91
Anguinella palmata	0.67	2.34	0.58	7.66	77.57
Einhornia crustulenta	0.67	2.34	0.58	7.66	85.23
Mesopodopsis slabberi	0.67	2.33	0.58	7.65	92.88

Group i
Average similarity: 26.62

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Mesopodopsis slabberi	0.97	9.68	1.01	36.35	36.35
Nemertea	1.36	9.04	1.01	33.95	70.3
Gammarus salinus	1.13	5.51	0.52	20.72	91.02

Subtidal samples: Average dissimilarity (%) between SIMPROF groups

Group	a	b	c	d	e	f	g	h
b	93.02							
c	95.75	64.01						
d	92.04	61.76	56.55					
e	87.20	58.51	64.29	56.52				
f	88.79	77.73	80.07	58.01	70.34			
g	83.54	74.42	81.07	70.82	59.86	67.03		
h	89.72	85.70	93.05	82.46	73.20	81.93	70.73	
i	92.24	87.29	91.24	91.84	85.55	92.26	87.82	90.09

Appendix 12 Intertidal sediment – chemical concentrations against threshold levels

Table A11: Exceedance of thresholds for chemical in sediment. Cefas Contaminant Action Levels are chemical Action level 1 (cAL1) and Action level 2 (cAL2). If Cefas Guidelines are not available for a particular contaminant the OSPAR Guidelines have been used which are Effects Range Low (ERL) and Environmental Assessment Criteria (EAC). If neither guideline is available for a contaminant, the Canadian Guidelines have been used which are the interim sediment quality guidelines (ISQG) and probable effect level (PEL). NA = Not applicable; U = Upper shore; M = Mid shore.

Sediment Chemical Threshold exceedance	Colour Coding
Below cAL1	
Between cAL1 and TEL/ISQG	
Above cAL1 and TEL but below PEL	
Above cAL1 and PEL but below cAL2/above cAL1 if no other threshold	
Above cAL2	

Contaminant	Threshold						Station													
	cAL1	cAL2	TEL	PEL	ERL	LoD	1U	1M	2U	2M	3U	3M	4U	4M	5U	5M	6U	6M	7U	7M
Metals (mg/kg)																				
Arsenic	20	100	7.24	41.6		1	11.1	12.9	12.1	7.4	8.5	7.6	14.3	7.7	16.1	9.7	20	8.7	25.9	13.1
Cadmium	0.4	5	0.676	4.21	12	0.1	0.7	0.6	0.6	0.5	0.5	0.9	0.7	0.4	0.9	0.7	0.6	0.5	1.0	0.6
Chromium	40	400	52.3	160	810	0.5	88.4	79.3	77.7	41	52.7	51.2	86	44.5	125.7	54.2	54.2	39.8	109.1	71
Copper	40	400	18.7	108	340	2	78	31.4	33.6	18.7	29.3	35.8	32.9	21.3	85.5	34.5	116.8	23.5	212.4	36.1
Lead	50	500	30.2	112	470	2	125.5	62.5	63.5	35.9	95.3	47.2	76	42.3	240.4	87.6	276.5	48.8	493.2	125.8
Mercury	0.3	3	0.13	0.7	1.5	0.01	0.33	0.4	0.4	0.23	0.78	0.33	0.6	0.31	0.82	0.48	0.6	0.24	2.75	0.46
Nickel	20	200	15.9	42.8		0.5	34.6	29.8	29.5	15.1	21.6	18.9	32.9	17.1	39.2	22.3	35.2	16	51.4	27.1
Zinc	130	800	124	271	1500	3	253.7	150.7	155.3	86.9	138	110	167.1	91.7	352.9	141.2	392.3	89.5	598.2	152.4
TBT (µg/kg)																				
Tributyltin compounds	100	1000				5	10.6	9.8	6.9	6.07	12.5	5.1	8.7	4.6	9.5	7.4	4.2	3.3	7.1	8.1
DBT (µg/kg)																				
Dibutyltin	100	1,000			190	5	8.2	7.6	5.1	<5.0	<5.0	<5.0	8.1	<5.0	7.9	<5.0	<5.0	<5.0	5.8	7.6
PAH (µg/kg)																				
Naphthalene	100	NA	34.6	391	160	1	117.2	115.9	77.6	49.0	117	70.4	99.6	101	178.3	106.3	231.0	264.5	752.2	133.2
Acenaphthylene	100	NA	5.9	128		1	120.1	124.6	85.2	44.1	46.5	55.6	99.0	69.4	130.8	101.5	153.8	188.4	392.0	100.6
Acenaphthene	100	NA	6.7	88.9		1	56.7	56.8	30.9	27.8	42.3	48.5	37.9	43.0	62.6	62.8	37.9	162.3	161.8	48.2
Fluorene	100	NA	21.2	144		1	74.7	83.3	54.9	37.1	63.5	54.9	62.0	51.6	78.3	60.9	51.2	223.7	184.0	52.5
Phenanthrene	100	NA	86.7	544	240	1	375.0	409.2	227.4	224.9	333	298	327.9	263	499.0	321.6	502.1	1152	2298	472.8
Dibenzothiophene * (DBT)	100	NA				1	37.9	41.6	25.4	20.7	32.8	30.3	31.1	29.3	42.6	35.1	34.3	106.0	157.7	34.7
Anthracene	100	NA	46.9	245	85	1	137.8	160.0	93.1	77.3	112	111	122.4	103	161.6	140.8	190.4	507.7	657.9	151.1
Fluoranthene	100	NA	113.0	1494	600	1	837.2	894.0	521.5	460.8	473	585	679.0	655	1080.5	861.7	1178.3	2337	4319	916.4
Pyrene	100	NA	153.0	1398	665	1	765.0	817.0	495.2	409.4	428	502	618.1	591	999.8	786.7	1010.4	2001	3658	781.6
Benzo[a]anthracene	100	NA	74.8	693	261	1	449.0	503.6	272.0	236.3	243	307	354.7	346	599.4	482.8	724.3	1421	2494	486.5
Chrysene	100	NA	108.0	846	384	1	559.7	605.8	342.2	275.2	284	348	443.5	391	736.5	589.2	805.4	1528	2738	551.6
Benzo[b] fluoranthene	100	NA				1	697.3	713.7	519.1	361.8	346	396	526.3	527	943.2	707.3	881.6	1613	3120	645.6
Benzo[k]	100	NA				1	336.2	342.9	245.2	186.4	164	191	280.4	244	386.4	288.4	489.5	795.5	1279	313.3

Contaminant	Threshold						Station													
	cAL1	cAL2	TEL	PEL	ERL	LoD	1U	1M	2U	2M	3U	3M	4U	4M	5U	5M	6U	6M	7U	7M
fluoranthene																				
Benzo[e]pyrene	100	NA				1	648.5	697.8	447.0	300.8	296	340	518.4	418	786.6	630.8	745.7	1303	2391	554.8
Benzo[a]pyrene	100	NA	88.8	763	430	1	730.8	795.5	478.1	345.1	336	414	594.9	513.5	903.9	722.2	934.6	1681	3114	680.2
Perylene	NA	NA	NA	NA		1	282.4	318.7	237.8	148.3	129	173	262.7	218.8	337.4	250.8	295.6	567.9	919.8	239.9
Indeno[123,cd] pyrene	100	NA			240	1	702.0	774.8	497.9	316.3	308	383	595.3	467	853.5	707.6	847.8	1282	2808	619.1
Dibenzo[a,h] anthracene	10	NA	6.2	135		1	124.9	131.4	87.3	57.9	55.4	62.4	105.7	75.9	149.0	121.3	141.7	262.1	450.8	105.0
Benzo[ghi] perylene	100	NA			85	1	664.1	723.9	473.9	306.5	304	336	571.3	444	803.3	665.5	779.9	1197	2574	603.3
tPAH (EPA16)	3712	12760	This row uses suggested ALs in MMO 2015.				6748	7252	4502	3416	3656	4162	5518	4885	8566	6727	8960	16617	31001	6661
PAH Fractions (µg/kg)																				
C1 Naphthalenes *	100	NA			155	1	197.0	198.1	152.6	90.2	251	121	159.4	136.8	233.7	145.5	351.1	363	810.0	197
C2 Naphthalenes *	100	NA			150	1	235.6	212.1	149.0	87.0	251	129	187.0	127.1	215.0	142.2	266.7	363	581.4	160
Phenanthrene / Anthracene	100	NA				1	512.7	569.2	320.4	302.3	444	409	450.3	365.9	660.6	462.3	692.4	1660	2956	624
C1 178 *	100	NA			170	1	281	288	178	145	264	211	223	203	341	256	362	912	1151	280
C2 178 *	100	NA			200	1	263	274	163	135	246	174	201	190	283	238	315	908	891	242
C1 Dibenzothiophenes	100	NA			85	1	50	55	34	26	45	33	38	34	54	42	49	130	150	44
PCBs (µg/kg)																				
sum of ICES 7	10	None				0.08	8.3	8.7	7.3	4.8	6.9	6.8	9.1	5.7	8.9	6.0	5.6	4.6	9.2	8.7
Sum of 25 congeners	20	200				0.08	18.5	19.7	16.4	11.0	15.5	15.2	20.7	13.4	19.2	13.5	13.3	10.2	20.5	19.6
Total PCBs			21.5	189		0.08	20.2	21.4	17.9	11.0	16.8	16.4	21.2	14.5	20.9	14.4	14.4	11.0	22.4	21.5
Organochlorine pesticides (µg/kg)																				
γ-HCH			0.32	0.99	3	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
DDE			2.07	374	2.2	5	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Hexachlorobenzene					20	2	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Dieldrin	5		0.715	4.3	2	5	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
p,p’ DDT	1		1.19	4.77		5	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0

Appendix 13 Subtidal sediment - chemical concentrations against threshold levels

Table A7.1: Exceedance of thresholds for chemicals in sediment. Cefas Contaminant Action Levels are chemical Action level 1 (cAL1) and Action level 2 (cAL2). If Cefas Guidelines are not available for a particular contaminant the OSPAR Guidelines have been used which are Effects Range Low (ERL) and Environmental Assessment Criteria (EAC). If neither guideline is available for a contaminant, the Canadian Guidelines have been used which are the interim sediment quality guidelines (ISQG) and probable effect level (PEL).

Sediment Chemical Threshold exceedance	Colour Coding
Below cAL1	White
Between cAL1 and TEL/ISQG	Grey
Above cAL1 and TEL but below PEL	Yellow
Above cAL1 and PEL but below cAL2/above cAL1 if no other threshold	Green
Above cAL2	Red

	Threshold						Station						
Chemical	**cAL1**	**cAL2**	**TEL/ISQG**	**PEL**	**ERL**	**LoD**	G3	G5	G6	G7	G8	G10	G12
Metals (mg/kg)													
Arsenic	20	100	7.24	41.6		1	9	7.5	19.2	8.3	10.6	14.8	4
Cadmium	0.4	5	0.676	4.21	12	0.1	0.6	0.5	2	0.7	0.7	1.5	<0.1
Chromium	40	400	52.3	160	810	0.5	56.9	42.2	110.8	58	83.5	96	17.9
Copper	40	400	18.7	108	340	2	25	19.3	69.8	38.7	39.4	55.6	8
Lead	50	500	30.2	112	470	2	48.5	41.5	157	54.9	75.9	109.8	5.8
Mercury	0.3	3	0.13	0.7	1.5	0.01	0.3	0.2	1.5	0.4	0.5	1.4	0.04
Nickel	20	200	15.9	42.8		0.5	21.6	15.9	40.2	22.5	31.8	35.5	13.2
Zinc	130	800	124	271	1500	3	104	78.5	313.1	125.1	162.7	229.5	17.6
TBT (µg/kg)													
Tributyltin compounds	100	1000				5	5.1	4.8	11	<2.0	5.8	7.6	<2.0

	Threshold						Station						
Chemical	**cAL1**	**cAL2**	**TEL/ISQG**	**PEL**	**ERL**	**LoD**	G3	G5	G6	G7	G8	G10	G12
DBT (µg/kg)													
Dibutyltin	100	1,000			190	5	<5.0	<5.0	36.7	<5.0	7.5	5.2	<5.0
PAH (µg/kg)													
Naphthalene	100	NA	34.6	391	160	1	80.7	98.2	322.1	155.9	148.7	83.6	2.7
Acenaphthylene	100	NA	5.9	128		1	71.7	70.7	490.6	149.0	157.8	71.2	<1
Acenaphthene	100	NA	6.7	88.9		1	50.0	44.4	143.9	96.8	79.1	39.6	<1
Fluorene	100	NA	21.2	144		1	56.1	59.7	262.0	123.3	109.0	50.6	<1
Phenanthrene	100	NA	86.7	544	240	1	312.7	271.8	1096.3	573.2	489.2	250.1	2.2
Dibenzothiophene * (DBT)	100	NA				1	30.5	31.6	144.9	59.7	56.1	29.9	<1
Anthracene	100	NA	46.9	245	85	1	110.7	107.7	590.6	231.7	199.1	100.0	<1
Fluoranthene	100	NA	113.0	1494	600	1	656.7	567.0	3986.6	1425.9	1206.1	608.5	2.4
Pyrene	100	NA	153.0	1398	665	1	599.6	524.7	3186.3	1255.4	1105.8	590.0	2.2
Benzo[a]anthracene	100	NA	74.8	693	261	1	320.7	323.0	1909.8	752.7	622.5	328.4	1.2
Chrysene	100	NA	108.0	846	384	1	378.5	381.6	2251.0	896.6	738.1	380.1	1.6
Benzo[b]fluoranthene	100	NA				1	515.7	462.3	2539.3	1132.2	1134.9	613.5	1.9
Benzo[k]fluoranthene	100	NA				1	296.5	236.4	2387.4	549.7	521.5	272.8	<1
Benzo[e]pyrene	100	NA				1	447.1	426.6	2273.0	976.1	923.1	514.0	1.9
Benzo[a]pyrene	100	NA	88.8	763	430	1	507.8	490.5	2803.0	1106.0	1023.6	571.9	1.8
Perylene	NA	NA	NA	NA			222.2	197.1	954.1	459.3	471.8	261.2	1.3
Indeno[123,cd]pyrene	100	NA			240	1	513.6	473.7	2603.6	1104.1	1031.8	586.3	1.9
Dibenzo[a,h]anthracene	10	NA	6.2	135		1	80.8	76.8	418.5	174.0	165.3	100.3	<1
Benzo[ghi]perylene	100	NA			85	1	464.3	430.2	2469.7	969.2	975.4	527.7	1.8
tPAH (EPA16)	3712	12760	This row uses suggested ALs in MMO 2015.				5016.1	4618.7	27460.9	10695.8	9708.0	5174.5	19.5

	Threshold						Station						
Chemical	**cAL1**	**cAL2**	**TEL/ISQG**	**PEL**	**ERL**	**LoD**	G3	G5	G6	G7	G8	G10	G12
PAH Fractions (µg/kg)													
C1 Naphthalenes *	100	NA			155	1	150.3	178.5	468.5	297.1	269.9	149.9	6.3
C2 Naphthalenes *	100	NA			150	1	140.2	169.8	470.3	283.6	272.6	164.9	4.9
Phenanthrene / Anthracene	100	NA				1	423.3	379.5	1686.9	805.0	688.3	350.2	2.2
C1 178 *	100	NA			170	1	207	218	893	429	399	200	2
C2 178 *	100	NA			200	1	196	215	819	359	328	199	2
C1 Dibenzothiophenes *	100	NA			85	1	38	40	205	75	76	39	<1
PCBs (µg/kg)													
sum of ICES 7	10	None				0.08	6.2	6.5	34.0	8.3	11.5	49.0	1.0
Sum of 25 congeners	20	200				0.08	14.1	16.6	77.8	19.01	26.05	104.4	1.8
Total PCBs			21.5	189		0.08	15.1	17.6	83.8	20.4	28.1	116.0	1.8
Organochlorine pesticides (µg/kg)													
γ-HCH			0.32	0.99	3	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
DDE			2.07	374	2.2	5	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Hexachlorobenzene					20	2	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Dieldrin	5		0.715	4.3	2	5	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
p,p’ DDT	1		1.19	4.77		5	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0

Appendix 14 Additional Sediment Contaminant Analysis results

Analysis results additional to those provided in Appendix 11 and 12 are provided here.

Intertidal: Summary of selected additional sediment contaminant analysis results

Station	LoD	1U	1L	2U	2L	3U	3L	4U	4L	5U	5L	6U	6L	7U	7L
Other															
Total moisture @ 105°c (%)	0.1	59.4	55.7	54.2	36	43	41.9	58.7	39.4	55.7	43.8	43	36.1	57.5	49.4
Dry matter (%)	0.2	40.6	44.3	45.8	64	57	58.1	41.3	60.6	44.3	56.2	57	63.9	42.5	50.6
Dichlorvos (µg/kg)	2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2

Polybrominated Diphenyl Ethers (PBDEs), Dibutyltin (DBT), Tributyltin (TBT) and Diuron

					Customer Sample No	**S1764163**	**S1764164**	**S1764165**	**S1764166**	**S1764167**	**S1764168**	**S1764169**	**S1764170**	**S1764171**
					Customer Sample ID	Tilbury 1U	Tilbury 1L	Tilbury 2U	Tilbury 2L	Tilbury 3U	Tilbury 3L	Tilbury 4U	Tilbury 4L	Tilbury 5U
					RPS Sample No	333544	333545	333546	333547	333548	333549	333550	333551	333552
					Sample Type	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**
					Sample Depth (m)	0.20m	0.20m	0.20m	0.20m	0.20m	0.20m	0.20m	0.20m	0.20m
					Sampling Date	31/05/2017	31/05/2017	31/05/2017	31/05/2017	31/05/2017	31/05/2017	30/05/2017	30/05/2017	30/05/2017
Determinand	**CAS No**	**Codes**	**SOP**	**Units**	**RL**									
dry solids (at 105øC)		N	208	%		37.8	42.3	45.5	56.6	54.7	55.2	42.5	55.3	40.8
2,2',4,4',6-pentabromodiphenyl ether (BDE-100)	189084-64-8	N	in house	ug/kg DW	0.1	< 0.265	< 0.236	< 0.220	< 0.100	< 0.100	< 0.100	< 0.235	< 0.100	< 0.245
2,2',3,4,4',5'-hexabromodiphenyl ether (BDE-138)	182677-30-1	N	in house	ug/kg DW	0.1	< 0.26	< 0.24	< 0.22	< 0.10	< 0.10	< 0.10	< 0.24	< 0.10	< 0.25
2,2',4,4',5,5'-hexabromodiphenyl ether (BDE-153)	68631-49-2	N	in house	ug/kg DW	0.001	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100
2,2',4,4',5,6'-hexabromodiphenyl ether (BDE-154)	207122-15-4	N	in house	ug/kg DW	0.001	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100
2,2',4-tribromodiphenyl ether (BDE-17)	147217-75-2	N	in house	ug/kg DW	0.1	< 0.26	< 0.24	< 0.22	< 0.10	< 0.10	< 0.10	< 0.24	< 0.10	< 0.25
2,2',3,4,4',5',6-heptabromodiphenyl ether (BDE-183	207122-16-5	N	in house	ug/kg DW	0.001	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100
decabromodiphenylether (BDE-209)	1163-19-5	N	in house	ug/kg DW	0.001	52.38	44.88	47.20	23.84	24.48	39.89	55.27	33.07	55.67
2,4,4'-tribromodiphenyl ether (BDE-28)	41318-75-6	N	in house	ug/kg DW	0.001	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100
2,2',4,4'-tetrabromodiphenyl ether (BDE-47)	5436-43-1	N	in house	ug/kg DW	0.001	0.529	0.472	0.439	0.177	0.183	0.181	0.470	0.181	0.491
2,3',4,4'-tetrabromodiphenyl ether (BDE-66)	187084-61-5	N	in house	ug/kg DW	0.1	< 0.26	< 0.24	< 0.22	< 0.10	< 0.10	< 0.10	< 0.24	< 0.10	< 0.25
2,2',3,4,4'-pentabromodiphenyl ether (BDE-85)	182346-21-0	N	in house	ug/kg DW	0.1	< 0.26	< 0.24	< 0.22	< 0.10	< 0.10	< 0.10	< 0.24	< 0.10	< 0.25
2,2',4,4',5-pentabromodiphenyl ether (BDE-99)	60348-60-9	N	in house	ug/kg DW	0.001	0.529	0.472	0.439	0.177	0.183	0.181	0.706	0.181	0.491
dibutyltin (DBT)	1002-53-5	U	395	ug/kg as cation DW	5	8.25	7.61	5.12	< 5.00	< 5.00	< 5.00	8.11	< 5.00	7.92
diuron	330-54-1	N	in house	mg/kg DW	0.1	< 0.3	< 0.2	< 0.2	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2
tributyltin (TBT)	56573-85-4	U	395	ug/kg as cation DW	2	10.6	9.78	6.89	6.07	12.5	5.11	8.73	4.64	9.54

					Customer Sample No	**S1764172**	**S1764173**	**S1764174**	**S1764175**	**S1764176**
					Customer Sample ID	Tilbury 5L	Tilbury 6U	Tilbury 6L	Tilbury 7U	Tilbury 7L
					RPS Sample No	333553	333554	333555	333556	333557
					Sample Type	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**
					Sample Depth (m)	0.20m	0.20m	0.20m	0.20m	0.20m
					Sampling Date	30/05/2017	30/05/2017	30/05/2017	30/05/2017	30/05/2017
Determinand	**CAS No**	**Codes**	**SOP**	**Units**	**RL**					
dry solids (at 105øC)		N	208	%		53.0	55.8	66.1	43.3	40.2
2,2',4,4',6-pentabromodiphenyl ether (BDE-100)	189084-64-8	N	in house	ug/kg DW	0.1	< 0.100	< 0.100	< 0.100	< 0.231	< 0.249
2,2',3,4,4',5'-hexabromodiphenyl ether (BDE-138)	182677-30-1	N	in house	ug/kg DW	0.1	< 0.10	< 0.10	< 0.10	< 0.23	< 0.25
2,2',4,4',5,5'-hexabromodiphenyl ether (BDE-153)	68631-49-2	N	in house	ug/kg DW	0.001	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100
2,2',4,4',5,6'-hexabromodiphenyl ether (BDE-154)	207122-15-4	N	in house	ug/kg DW	0.001	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100
2,2',4-tribromodiphenyl ether (BDE-17)	147217-75-2	N	in house	ug/kg DW	0.1	< 0.10	< 0.10	< 0.10	< 0.23	< 0.25
2,2',3,4,4',5',6-heptabromodiphenyl ether (BDE-183	207122-16-5	N	in house	ug/kg DW	0.001	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100
decabromodiphenylether (BDE-209)	1163-19-5	N	in house	ug/kg DW	0.001	39.05	10.57	22.38	34.42	58.96
2,4,4'-tribromodiphenyl ether (BDE-28)	41318-75-6	N	in house	ug/kg DW	0.001	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100
2,2',4,4'-tetrabromodiphenyl ether (BDE-47)	5436-43-1	N	in house	ug/kg DW	0.001	0.189	< 0.100	0.151	0.462	0.498
2,3',4,4'-tetrabromodiphenyl ether (BDE-66)	187084-61-5	N	in house	ug/kg DW	0.1	< 0.10	< 0.10	< 0.10	< 0.23	< 0.25
2,2',3,4,4'-pentabromodiphenyl ether (BDE-85)	182346-21-0	N	in house	ug/kg DW	0.1	< 0.10	< 0.10	< 0.10	< 0.23	< 0.25
2,2',4,4',5-pentabromodiphenyl ether (BDE-99)	60348-60-9	N	in house	ug/kg DW	0.001	0.189	0.179	0.151	0.231	1.244
dibutyltin (DBT)	1002-53-5	U	395	ug/kg as cation DW	5	< 5.00	< 5.00	< 5.00	5.82	7.64
diuron	330-54-1	N	in house	mg/kg DW	0.1	< 0.1	< 0.1	< 0.1	< 0.2	< 0.2
tributyltin (TBT)	56573-85-4	U	395	ug/kg as cation DW	2	7.40	4.19	3.31	7.05	8.06

Subtidal: Summary of selected additional sediment contaminant analysis results

Station	**LoD**	Tilbury 3	Tilbury 5	Tilbury 6	Tilbury 7	Tilbury 8	Tilbury 10	Tilbury 12*
Other								
Total moisture @ 105°c (%)	0.1	43.4	34.9	57.2	49.7	56.5	47.8	6.5
Dry matter (%)	0.2	56.6	65.1	42.8	50.3	43.5	52.2	93.5
Dichlorvos (µg/kg)	2	<2	<2	<2	<2	<2	<2	<2

Polybrominated Diphenyl Ethers (PBDEs), Dibutyltin (DBT), Tributyltin (TBT) and Diuron

					Customer Sample No	**S1764177**	**S1764178**	**S1764179**	**S1764180**	**S1764181**	**S1764182**	**S1764183**
					Customer Sample ID	Tilbury 3	Tilbury 5	Tilbury 6	Tilbury 7	Tilbury 8	Tilbury 10	Tilbury 12
					RPS Sample No	333558	333559	333560	333561	333562	333563	333564
					Sample Type	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**
					Sampling Date	09/05/2017	09/05/2017	09/05/2017	09/05/2017	09/05/2017	09/05/2017	09/05/2017
Determinand	**CAS No**	**Codes**	**SOP**	**Units**	**RL**							
dry solids (at 105øC)		N	208	%		54.1	55.3	43.3	50.3	40.1	44.3	U/S
2,2',4,4',6-pentabromodiphenyl ether (BDE-100)	189084-64-8	N	in house	ug/kg DW	0.1	< 0.100	< 0.100	< 0.231	< 0.100	< 0.249	< 0.226	< 0.100
2,2',3,4,4',5'-hexabromodiphenyl ether (BDE-138)	182677-30-1	N	in house	ug/kg DW	0.1	< 0.10	< 0.10	< 0.23	< 0.10	< 0.25	< 0.23	< 0.10
2,2',4,4',5,5'-hexabromodiphenyl ether (BDE-153)	68631-49-2	N	in house	ug/kg DW	0.001	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100
2,2',4,4',5,6'-hexabromodiphenyl ether (BDE-154)	207122-15-4	N	in house	ug/kg DW	0.001	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100
2,2',4-tribromodiphenyl ether (BDE-17)	147217-75-2	N	in house	ug/kg DW	0.1	< 0.10	< 0.10	< 0.23	< 0.10	< 0.25	< 0.23	< 0.10
2,2',3,4,4',5',6-heptabromodiphenyl ether (BDE-183	207122-16-5	N	in house	ug/kg DW	0.001	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100
decabromodiphenylether (BDE-209)	1163-19-5	N	in house	ug/kg DW	0.001	43.47	49.01	0.577	61.44	127.0	99.89	< 0.500
2,4,4'-tribromodiphenyl ether (BDE-28)	41318-75-6	N	in house	ug/kg DW	0.001	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100
2,2',4,4'-tetrabromodiphenyl ether (BDE-47)	5436-43-1	N	in house	ug/kg DW	0.001	0.185	0.362	< 0.100	0.199	0.498	0.452	< 0.100
2,3',4,4'-tetrabromodiphenyl ether (BDE-66)	187084-61-5	N	in house	ug/kg DW	0.1	< 0.10	< 0.10	< 0.23	< 0.10	< 0.25	< 0.23	< 0.10
2,2',3,4,4'-pentabromodiphenyl ether (BDE-85)	182346-21-0	N	in house	ug/kg DW	0.1	< 0.10	< 0.10	< 0.23	< 0.10	< 0.25	< 0.23	< 0.10
2,2',4,4',5-pentabromodiphenyl ether (BDE-99)	60348-60-9	N	in house	ug/kg DW	0.001	0.185	0.362	< 0.100	0.199	0.498	0.452	< 0.100
dibutyltin (DBT)	1002-53-5	U	395	ug/kg as cation DW	5	< 5.00	< 5.00	36.7	< 5.00	7.45	5.18	< 5.00
diuron	330-54-1	N	in house	mg/kg DW	0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	< 0.2	< 0.1
tributyltin (TBT)	56573-85-4	U	395	ug/kg as cation DW	2	5.12	4.79	11.0	< 2.00	5.75	7.55	< 2.00