The Great Grid Upgrade

Sea Link

Sea Link

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Glossary

Abbreviation	Meaning
BAC	Background Assessment Concentration
BC	Background Concentration
cAL 1	CEFAS Action Level 1
CEFAS	Centre for Environment, Fisheries and Aquaculture Science
CEMP	Coordinated Environmental Monitoring Programme
DCM	Dichloromethane
DPR	Daily Progress Report
EIA	Environmental Impact Assessment
ERL	Effect Range Low
ERM	Effect Range Median
EUNIS	European Nature Information System
GC-MS	Gas Chromatography – Mass Spectrometry
H&S	Health and Safety
HOCI	Habitats of Conservation Importance
HVDC	High Voltage Direct Current
ICP-MS	Inductively Coupled Plasma- Mass Spectrometry
ICP-OES	Inductively Coupled Plasma Optical Emission Spectrometry
JNCC	Joint Nature Conservation Council
LoD	Limit of Detection
LOI	Loss on Ignition
KWT	Kent Wildlife Trust
MarLIN	Marine Life Information Network
MMO	Marine Management Organisation
MNCR	Marine Nature Conservation Review
MPA	Marine Protected Area
NDIR	Nondispersive Infrared
NGET	National Grid Electricity Transmission Plc
NMBAQC	North-east Atlantic Marine Biological Analytical Quality Control Scheme
NNS	Non-native Species
OSPAR	Oslo-Paris Commission
PAH	Polyaromatic Hydrocarbon
PEL	Probable Effects Level
PPE	Personal Protective Equipment
PRIMER	Plymouth Routines in Multivariate Ecological Research software

PSA	Particle Size Analysis
QC	Quality Control
RSPB	Royal Society for the Protection of Birds
SPA	Special Protection Area
SSSI	Site of Special Scientific Interest
TDP	Taxonomic Discrimination Protocol
TEL	Threshold Effects Level
THC	Total Hydrocarbon
TOC	Total Organic Carbon
TOM	Total Organic Matter
TPH	Total Petroleum Hydrocarbons
UKTAG	United Kingdom Technical Advisory Group
UV	Ultra Violet
UXO	Unexploded Ordinance
WFD	Water Framework Directive
WGS84	World Geodetic System 1984
WoRMS	World Register of Marine Species

Executive Summary

National Grid Electricity Transmission Plc (NGET) propose an electricity transmission link between Pegwell Bay, Kent and Aldeburgh, Suffolk. Ocean Infinity commissioned APEM to undertake surveys of intertidal habitats and biological communities in the vicinity of each of the two proposed landfall areas.

A site visit was made to Pegwell Bay on 22nd May 2023, ahead of the survey on 13th to 14th June 2023. At Aldeburgh, the site visit was on 26th July 2023 with the survey conducted between 11th and 12th September 2023. At both sites, intertidal biotopes were mapped and photographed. Upper, mid and lower shore sampling stations (with 3 replicate 0.01 m^2 sediment core samples for biota, 1 additional core sample for particle size analysis (PSA) and surface scrape samples for sediment chemistry) were planned along transects placed at intervals along each shore (3 transects at each). Additional samples were collected within a lagoon at Pegwell Bay: 3 cores; 2 qualitative sweep net samples; 1 PSA and 1 contaminants sample. Macrobiota samples were photographed and sieved at 0.5 mm at the laboratory. On the upper and mid shore stations at Aldeburgh, coarse pebbles and cobbles prevented coring and 0.25 m^2 quadrats were used to record conspicuous biota; additional cores were collected nearby on the mid shore. Supralittoral vegetation was recorded at Aldeburgh.

Most of the shore at Pegwell Bay was intertidal muddy sand. There were patches of saltmarsh and sandy mud on upper shore, together with a percolating lagoon that partially dried at low tide but included beds of tasselweed (*Ruppia maritima*). Mid and lower shore sediments were inhabited by polychaete worms, molluscs and crustaceans. The highest zone of the sandflats was often rippled and dominated by the amphipod *Bathyporeia pilosa* but also with abundant lugworms (*Arenicola marina*). The sediment was flatter lower down the mid shore with more cockles (*Cerastoderma edule*). The lower shore had extensive patches of sand mason worm (*Lanice conchilega*). Contaminant levels were below threshold and background levels on the sandflats but several metal concentrations were above threshold levels in the lagoon, possibly as a result of accumulation from the road in an enclosed environment.

At Aldeburgh, rich supralittoral shingle vegetation communities were recorded. The intertidal shingle below this was barren, as were the mixed sand and shingle sediments on the lower shore; the proportion of sand to gravel on the lower shore decreased dramatically between the site visit and main survey, suggesting that the distribution of coarse sediments varies with each tidal movement. Aldeburgh sediments had very low contaminant levels.

In both areas, there were occasional anthropogenic objects with green algae (*Ulva* spp.). No OSPAR threatened and/or declining species were recorded in the intertidal samples but protected plants (sea kale and sea pea) were found on supralittoral shingle at Aldeburgh. Invertebrate populations found in sandflats at Pegwell Bay would be expected to recover once disturbed sediments have settled, and the species found at Aldeburgh are adapted to

highly dynamic environments and regular disturbance. No non-native species (NNS) were observed during the survey or recorded from the samples. Sensitive habitats were recorded at both sites: Sea cliffs and shingle or stony beaches at Aldeburgh; Atlantic and continental salt marshes and salt meadows and a saline lagoon at Pegwell Bay. Care should be taken to avoid disturbance to vegetated shingle at Aldeburgh or to saltmarsh or the lagoon at Pegwell Bay, particularly impacts on the hydrology of channels adjacent to the lagoon.

1. Introduction

Ocean Infinity commissioned APEM to undertake surveys of intertidal habitats and biological communities in the vicinity of potential cable corridor landfall locations at Pegwell Bay (Kent) and Aldeburgh (Suffolk).

National Grid Electricity Transmission Plc (NGET) are developing a High Voltage Direct Current (HVDC) electricity transmission link on the east coast of England along a circa 130 km route from Kent to Suffolk with proposed landfalls at Pegwell Bay in Kent and Aldeburgh in Suffolk (Figure 1). As part of the planning process, marine surveys were required in the areas around the intertidal landfalls at Pegwell Bay and Aldeburgh. The results of these surveys will be used for the following purposes:

- Finalisation of route planning;
- Input and support to permits and any required environmental statement;
- A component of the cable installation ITT package;
- Provision of some of the data to be used in the Design and Installation process.

1.1 Survey Objectives

The objective of the intertidal surveys was to obtain data on existing conditions at the two proposed landfall locations to enable characterisation for EIA purposes. The following approaches were used:

- Macrobiota surveys (biotope maps, core samples, sweep nets and quadrats);
- Particle size analysis (PSA);
- Contaminants analysis.

This report presents the methodologies adopted by APEM for the collection, processing, and analysis of the survey samples and data, followed by a presentation of the data and summary of the findings from the surveys and analyses.

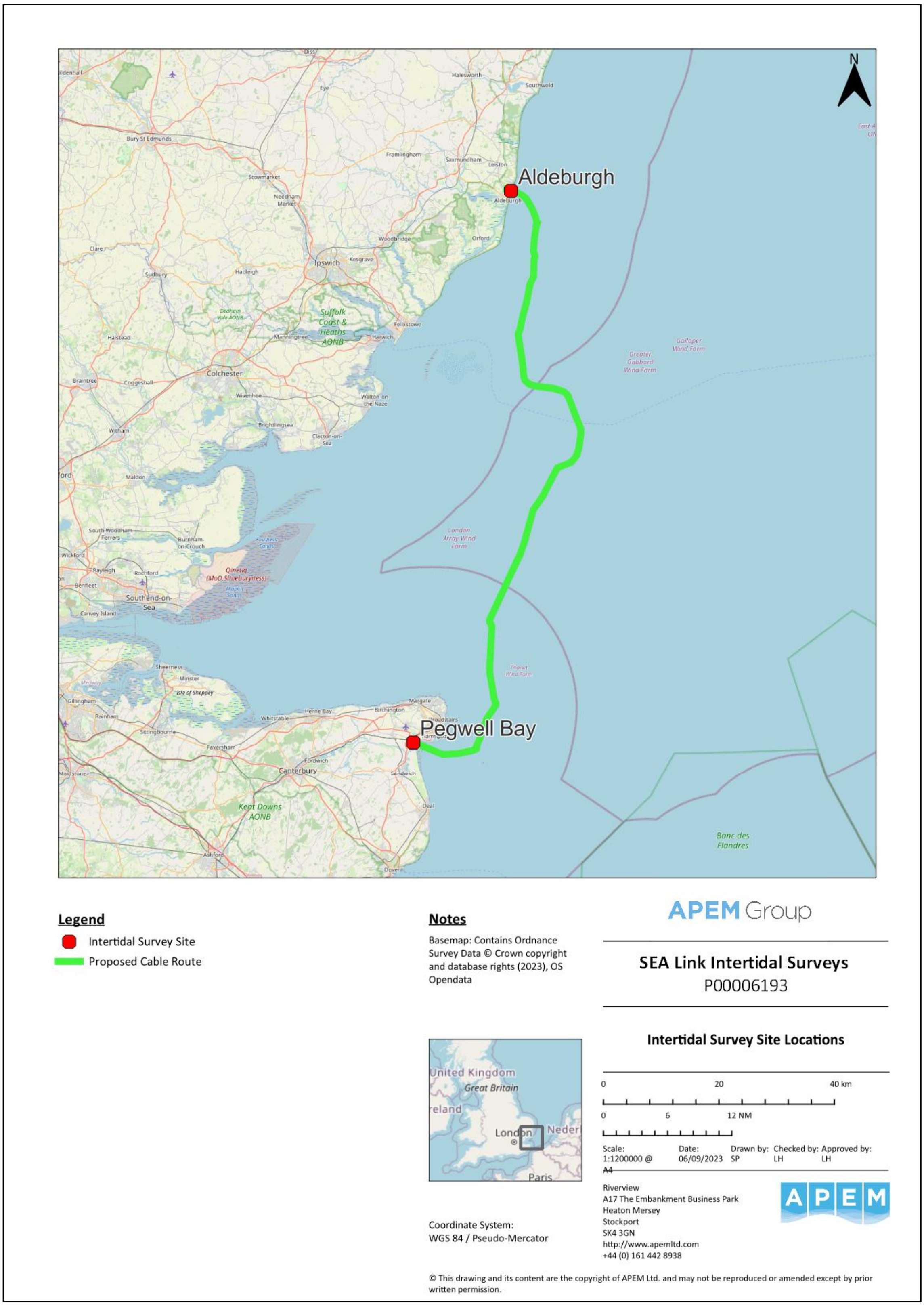

Figure 1. Map showing locations of the Pegwell Bay and Aldeburgh survey areas at either end of the proposed cable route

2. Methodology

2.1 Survey Permissions

Some consents or notifications were required prior to the survey at both sites.

The Pegwell Bay Site is within the Thanet Coast and Sandwich Bay Special Protection Area (SPA) and Ramsar site. The Site is also within the boundary of the Sandwich Bay to Hacklinge Marshes Site of Special Scientific Interest (SSSI). Designated sites in the vicinity of the Pegwell Bay survey area are shown in Figure 2.

The Aldeburgh site is within the Leiston – Aldeburgh SSSI and within the wider Outer Thames Estuary SPA. Designated sites in the vicinity of the Aldeburgh survey area are shown in Figure 3.

Therefore, in accordance with section 28H of the Wildlife and Countryside Act 1991 NGET had to give notice to the governing body, Natural England, of the planed work to be conducted at both Pegwell Bay and Aldeburgh, due to their SSSI designations (Natural England, 2022). The permission of work document and subsequent requirements stated by the legislation were always carried by the field team while on the shore. The standard 15 cm core depth, following Dalkin & Barnett (2001) and considering UKTAG Water Framework Directive (WFD) guidance (WFD-UKTAG, 2014), was revised to 20 cm by the Environment Agency.

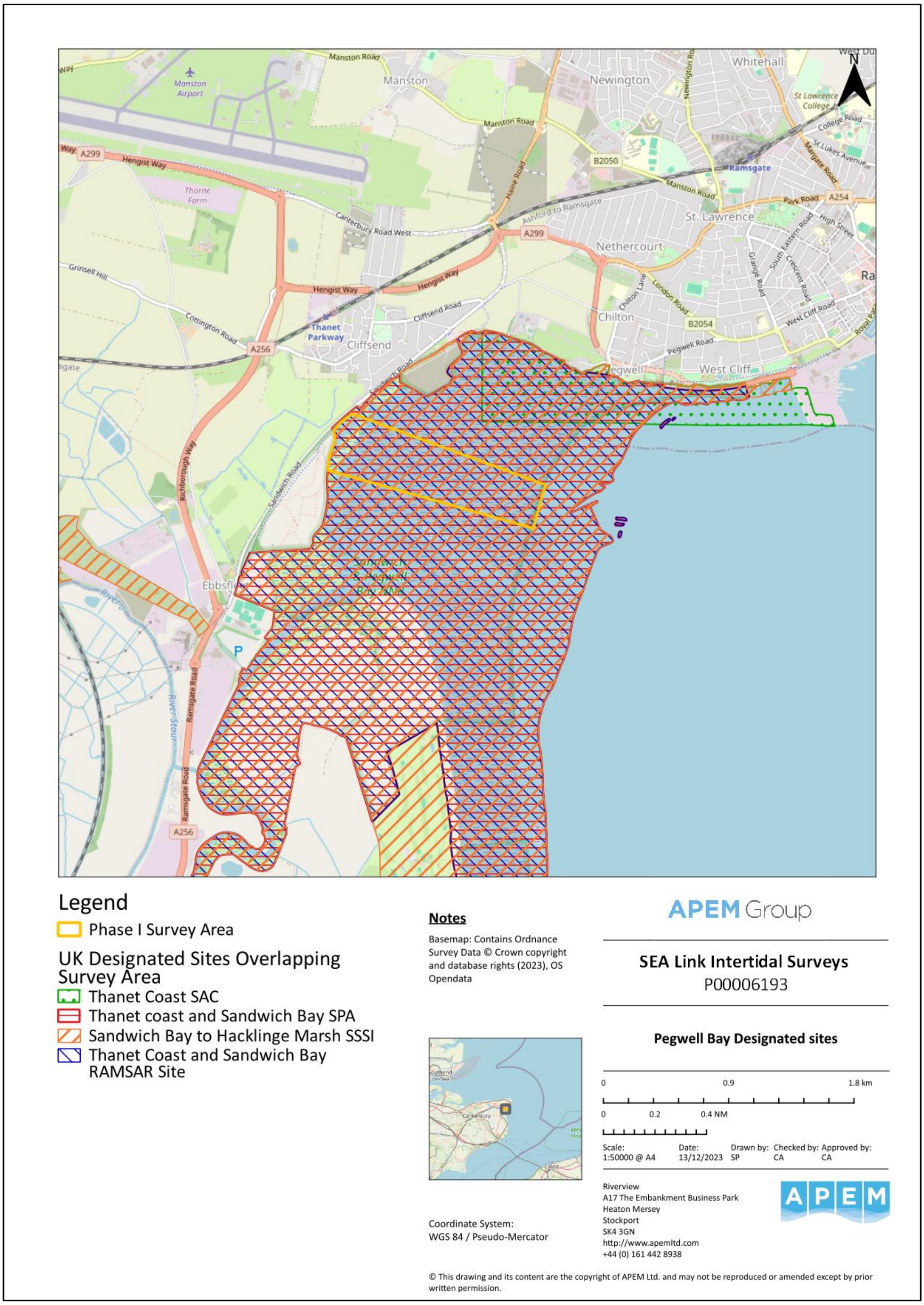

Figure 2. Map showing designated sites in the vicinity of the Pegwell Bay survey area. Note that the boundaries of the designated sites overlap.

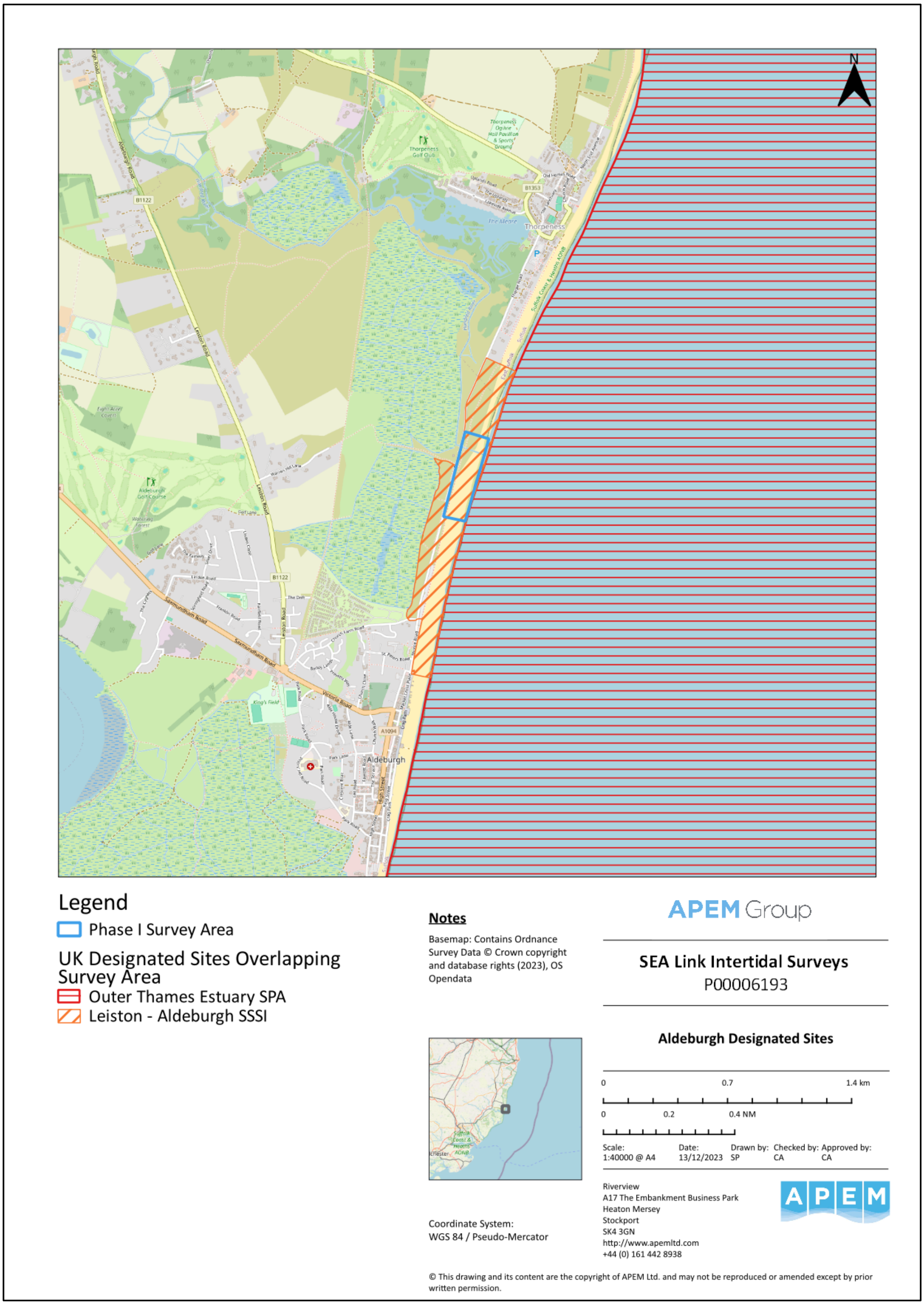

Figure 3. **Map showing designated sites in the vicinity of the Aldeburgh survey area.**

No prior permission or licencing was required for parking at Pegwell Bay as all parking points were public access. The Kent Wildlife Trust (KWT) provided written permission, to NGET for conducting ecological surveys on land managed by KWT at Sandwich and Pegwell Nature Reserve. The permit provided by KWT was carried at all times while the field team was working on site as instructed and all additional conditions highlighted in the permit were followed. Consultation was also made by NGET with the owners of the Nemo Link cable, which also makes landfall at Pegwell Bay, to inform them of the works and confirm that no intrusive sampling was to be undertaken within a 250 m buffer zone of that cable.

A Crown Estate Small Works Licence was obtained for the surveys at Aldeburgh and permission was provided by the RSPB to use one of their gated areas as a secure parking spot for the field team at Aldeburgh.

2.2 Survey Timings

In advance of each survey, a site visit was made to confirm access and egress points, refine sampling locations, assess any potential H&S considerations that may not have been evident from desk-based survey planning, and to determine any potential logistical constraints on the survey design.

An initial site visit was made to Pegwell Bay on 22nd May 2023; the main survey was completed between 13th and 14th June 2023. An initial site visit was made to Aldeburgh on 26th July 2023; the main survey was completed between 11th and 12th September 2023. Tide times and daylight hours for each survey date are given in Table 1, below.

Table 1. Tidal information for each landfall zone on the site visit and survey dates

	Site				
	Pegwell			Aldeburgh	
	Site Visit	Survey		Site Visit	Survey
Date	22/05/2023	13/06/2023	14/06/2023	26/07/2023	12/09/2023
Low tide (BST)	-	02:42	03:45	-	04:09
Height (m)	-	0.60	0.54	-	1.24
High tide (BST)	01:49	08:33	09:32	05:18	10:18
Height (m)	4.97	4.42	4.53	2.29	2.63
Low tide (BST)	08:41	15:09	16:10	10:43	16:31
Height (m)	0.84	1.05	0.92	1.2	0.66
High tide (BST)	14:11	20:45	21:44	17:17	23:15
Height (m)	4.87	4.55	4.70	2.58	2.63
Low tide (BST)	20:56	-	-	23:39	-
Height (m)	0.83	-	-	0.81	-
Sunrise (BST)	04:53	04:37	04:37	05:05	06:21
Sunset (BST)	20:48	21:11	21:01	20:54	19:17
Daylight Length (hours)	15:55	16:34	16:24	15:49	12:56

2.3 Health and Safety and public interaction

A Risk Assessment was carried out prior to the survey work. In addition, daily dynamic risk assessments were completed by the lead surveyor (Callum Nightingale) to address any site-specific issues. A NGET Client Representative attended the surveys at each location to oversee the works and provide a level of in-field quality assurance. They ensured that the work was being carried out according to the specifications, any licence conditions were being adhered to, risk assessments were being followed, and that H&S considerations were being observed. They also acted as a point of contact between the field team and both the client and the public.

Primary health and safety concerns were becoming trapped by incoming tides and exposure risks. In addition, there was a possibility of encountering unexploded ordinance (UXO) at Pegwell Bay. A UXO survey team from SEP Hydrographic surveyed the area before the biological survey; the APEM survey team also took a handheld magnetometer that was used at each station before sampling commenced as an additional precaution. All staff wore appropriate Personal Protective Equipment (PPE) for survey work, including life jackets and waterproofs, to minimise exposure risks; the team carried a field first aid kit and throw rope. All staff were provided with emergency contact numbers, the entry and exit points to the beach, tidal information for the survey areas and the times of sunrise and sunset for each day; these were carried at all times. Check-in and out calls were made to office-based staff at previously agreed times, coinciding with expected times on and off the shore. All team members working on shore had handheld radios set to the same frequency, providing a constant reliable means of contact.

A Daily Progress Report (DPR) was produced and sent to the client at the end of each working date, detailing work completed, and any H&S incidents or near misses.

2.4 Survey Design

Intertidal surveys, covering both hard and soft substrates, where both were present in the survey area, were completed at each of the proposed cable landfall sites. Any designated features of nearby Marine Protected Areas (MPAs) or other designated sites were noted. The surveys comprised Phase I habitat mapping, together with quantitative Phase II core, sweep net or quadrat sampling at representative habitats for macrobenthic communities, particle size analysis (PSA) and contaminants samples. Transects were surveyed covering upper, mid and lower shore zones at intervals of 250 m or less across each landfall zone. A lagoon noted at Pegwell Bay was also surveyed.

Pegwell Bay

At Pegwell Bay (Figure 4), three transects were plotted down the shore along a 400 m wide (along the shore, parallel to the water) stretch of shore. The survey area was reduced survey from 500 m wide due to concerns over proximity to the existing Nemo Link cable route to the north and by the River Stour to the south. Sampling points were also located based on data on unexploded ordinance from a magnetometer survey being conducted at the same time. The transects ran for a length of about 1 km between the tidal limits, below a saltmarsh zone that was not surveyed. Additional core and sweep net sampling stations were placed within a lagoon on the upper shore. All sites were photographed. Descriptions were made of the site and its characteristics.

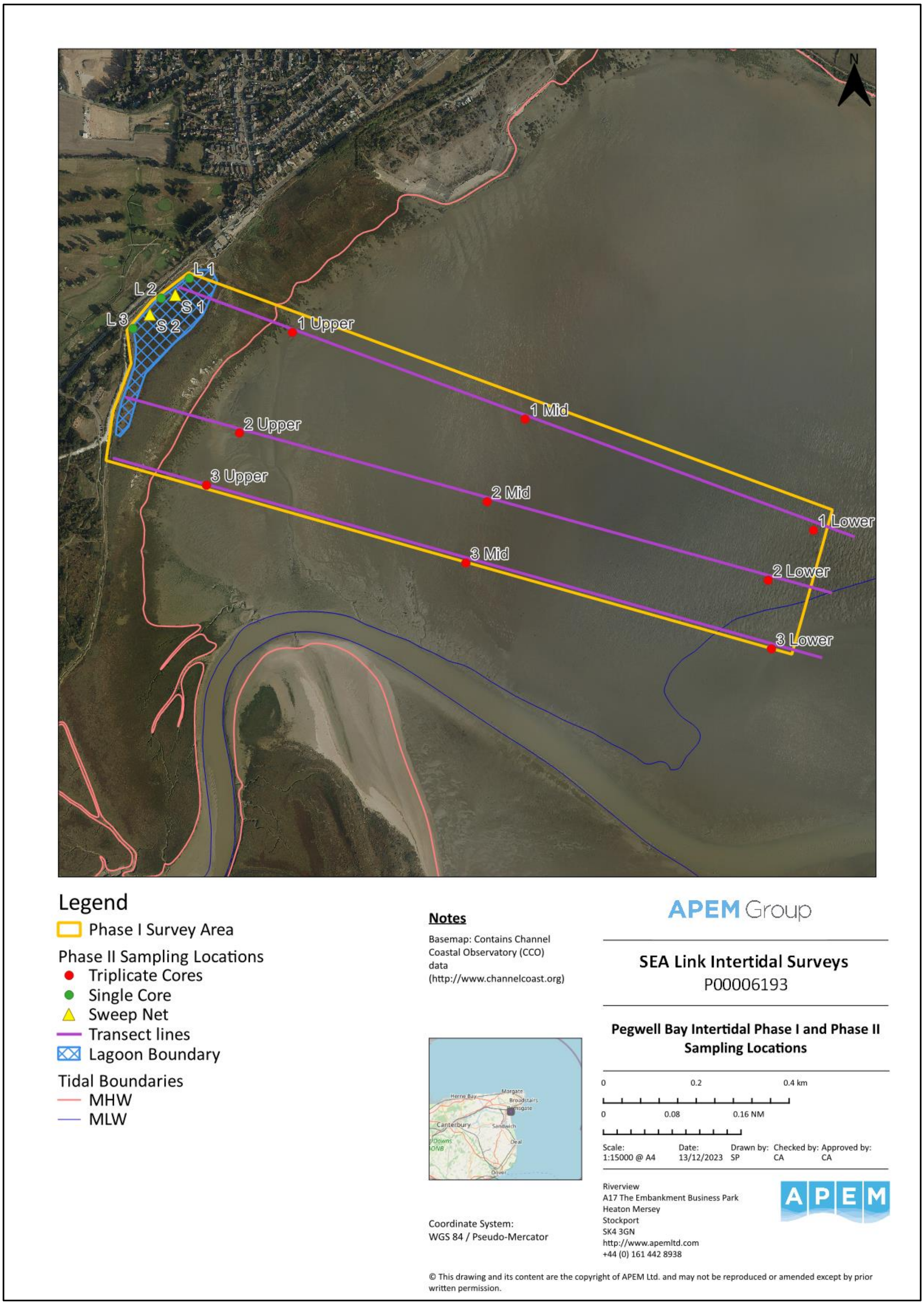

Figure 4. Map showing intertidal Phase I and II survey locations at Pegwell Bay

Aldeburgh

The area surveyed at Aldeburgh (Figure 5) was about 400 m wide (along the shore) and the beach about 100 m between the upper and lower tidal levels. Three transects were plotted from the upper to the lower shore. Shingle vegetation within the Phase I survey area, but above high-water level, was also surveyed. Due to the presence of cobbles at the proposed mid-shore stations, additional stations were established in the field to collect core samples as close as possible to the target locations, with quadrats being used at the target locations. The decision on these sampling methods and selection of alternative mid-shore sampling locations was made in thin field in consultation with NGET and the Client Representative.

Figure 5. **Map showing intertidal Phase I and II survey locations at Aldeburgh**

A summary of samples collected is presented in Table 2, below and details of sampling positions, dates and times are presented in Appendix 1 Stations were named T1 to T3, to represent transect numbers, followed by U, M or L, for upper, mid, or lower shore. Transects were prefixed with a "P" for Pegwell transects and an "A" for Aldeburgh transects to give the full station name, e.g., PT1U for Pegwell Transect 1 Upper. At the lagoon on the upper shore of Pegwell Bay, core samples were named L1 to L3 and sweep net samples were named S1 and S2.

Table 2. Sample types collected at each location.

		Pegwell Bay				Aldeburgh			
Transect	Shore Position	0.01 m^2 Biological Core	PSA	Contami-nant	Sweep	0.01 m^2 Biological Core	0.25 m^2 Quadrat	PSA	Contami-nant
T1	Upper	3	1	1	-	-	3	-	-
	Middle	3	1	1	-	-	3	-	-
	Lower-Mid	-	-	-	-	3	-	1	1
	Lower	3	1	1	-	3	-	1	1
T2	Upper	3	1	1	-	-	3	-	-
	Middle	3	1	1	-	-	3	-	-
	Lower-Mid	-	-	-	-	3	-	1	1
	Lower	3	1	1	-	3	-	1	1
T3	Upper	3	1	1	-	-	3	-	-
	Middle	3	1	1	-	-	3	-	-
	Lower-Mid	-	-	-	-	3	-	1	1
	Lower	3	1	1	-	3	-	1	1
L1	Lagoon	1	-	-	-	-	-	-	-
L2	Lagoon	1	1	1	-	-	-	-	-
L3	Lagoon	1	-	-	-	-	-	-	-
S1	Lagoon	-	-	-	1	-	-	-	-
S2	Lagoon	-	-	-	1	-	-	-	-

All samples were clearly labelled both internally and externally with the following information:

- Project number and title;
- Sample area and site code;
- Date and time of sampling.

2.4.1 Phase I surveys

Phase I surveys were conducted across the entire area of each of the potential landfall corridors to determine biotope composition, biotope distribution, extent of sub-features and notable biotopes, with the aim of achieving 100% coverage of each shore. This included any features of conservation importance, including Annex I habitats, and notable species, within the survey corridor. Standard methods (described below) were used for intertidal habitats at both shores and similar methods adapted for records from the supralittoral shingle vegetation at Aldeburgh.

All soft and hard substrata within the proposed landing sites were surveyed during the Phase I survey. Biotope data for each biotope in each sector were recorded on Marine Nature Conservation Review (MNCR) record forms.

A walkover survey was conducted in accordance with best practice guidance, including the JNCC Marine Monitoring Handbook Procedural Guideline (Davies *et al*., 2001) Wyn *et al*. (2006), JNCC (2010), Saunders *et al*. (2011), Nobel-James *et al*. (2018), and Natural Resources Wales (2019). A hand-held GPS system was carried throughout the survey to accurately plot waypoints of the features and delineate biotope boundaries to inform subsequent mapping. Intertidal biotopes were identified and characterised following the Marine Habitat Classification system for Ireland and Britain (Connor *et al*., 2004), with reference to Parry (2015) and updated to the EUNIS classification system (2012 and 2022 code systems included).

For each habitat/biotope surveyors recorded:

- Notes relating to the biotic assemblage including key taxa present;
- Substratum type;
- Wave exposure;
- Shore type;
- Presence of rockpools;
- Anthropogenic pressures; and
- Key features of interest.

Photographs were taken of each habitat or feature of interest, including conspicuous species. Any important survey findings, e.g., findings which could affect the routing or require development of specific mitigation measures, were reported to the project team informally as soon as possible following the survey.

2.4.2 Sediment Sampling: macrobiota, granulometry and contaminants

Intertidal core samples were collected at three stations (one upper shore, one mid shore and one lower shore) on each transect at each of the proposed landfall sites, where possible. At each location, three sediment core samples were collected for macrobiota analysis. At Pegwell Bay, three additional core samples were collected just below the water level along the northern edge of the lagoon. At Aldeburgh, upper and mid shore stations could not be cored, so quadrats were used but supplementary cores were collected from stations near the quadrats on the mid shore (named lower-mid). Samples were collected using a 0.01 m^2 hand-held core (Dalkin & Barnett, 2001; also considering UKTAG Water Framework Directive, WFD, guidance: WFD-UKTAG, 2014) pushed into the sediment to a depth of 20 cm, in accordance with instructions from the Environment Agency. Each sample was photographed, and the physical characteristics described (e.g., notable fauna or the depth of any anoxic layer). The biological samples were sieved over a standard 0.5 mm mesh, preserved in 4% formaldehyde solution, and stored in a suitable container.

At each station, an additional core sample was acquired for particle size analysis (PSA). PSA samples were stored in clearly labelled, rigid, watertight containers.

Samples for contaminants analysis were collected at each station, using a stainless-steel spoon, according to the Marine Management Organisation (MMO) guidelines (MMO, 2018 as referenced in Foden & Musgrave, 2019). Each sample was placed in a ¾ filled 1L amber glass jar that had been rinsed in acid and solvent. Solvent rinsed aluminium foil was placed onto the opening before the lid of the jar. Contaminants samples were frozen as soon after collection as practicable.

All samples were clearly labelled both internally and externally with a minimum of the following information:

- Contract and work order numbers;
- Reference of the sample area and site;
- Date and time of sampling.

In areas of hard substrata, core sampling was not possible and alternative sampling strategies were required.

2.4.3 Quadrat sampling

Quadrats were required at upper and mid shore sampling points at Aldeburgh due to pebbles and cobbles preventing sampling with core samplers. At these stations, a 0.25 m^2 quadrat was used to record biota. Three quadrats were placed at each of these stations. Conspicuous animals were counted; non-countable biota was recorded as percentage cover.

2.5 Sample analysis

All samples collected during the survey were transported to APEM's Letchworth laboratory, where biological samples were analysed. PSA samples were transported to Kenneth Pye Associates Ltd. for analysis, whilst contaminant samples were analysed by SOCOTEC Ltd.

2.5.1 Biological samples

Biological samples were sieved over a standard 0.5 mm mesh and all biota extracted, in accordance with NMBAQC standard methodologies (Worsfold & Hall, 2010). Sub-sampling was not required for any core sample. Sediment residues were retained following internal QC and stored in formaldehyde solution, pending client approval of the report.

Taxa were identified to the lowest practicable taxonomic level. Most were identified to species level but some taxonomic groups (e.g., insect larvae, nematodes, and certain oligochaetes) were identified to higher taxonomic levels according to widespread laboratory practices and the draft NMBAQC Scheme Taxonomic Discrimination Protocol (TDP), which will provide guidance on the most appropriate level to which different marine and brackish water taxa should be identified, as a routine. Appropriate taxonomic literature was used for identification, as listed in the NMBAQC Scheme's literature list (Worsfold et al., 2020), or sourced more recently. Where necessary, specimens were also compared with material maintained in APEM's laboratory reference collection.

Examples of each taxon recorded from the surveys were retained for inclusion in APEM's in-house reference collection, to act as a permanent record of the biota recorded from the project. These specimens can be revisited at later dates should new evidence (e.g., descriptions of a new, closely related species) call an original identification into question.

Taxonomic nomenclature follows the World Register of Marine Species (WoRMS Editorial Board, 2023), except where more recent revisions are known to supersede WoRMS. The species directory code (Howson & Picton, 1997) was added where appropriate. Notable taxa recorded from the survey, such as rare or protected species, non-native taxa or potentially un-described species, were highlighted.

2.5.2 Contaminants

Following collection, samples collected for contaminant analysis were stored and frozen at a temperature of -20°C. The following analyses were completed by SOCTOTEC, following the Marine Management Organisation (MMO) suite of analyses:

- Heavy and trace metals (As, Cd, Cr, Cu, Hg, Ni, Pb, V, Zn, Al, Ba, Be, Fe, Li, Sr),
- Total Organic carbon (TOC),
- Total Organic Matter (TOM) by LOI,
- Total Hydrocarbon Content (THC),
- PAHs (DTI 2-6 Ring Aromatics & EPA 16).

Summary methods and rationale for each analyses is provided in the following paragraphs. Internal QC was conducted on one in ten samples, including comparison against Certified Reference Material. Sediment contaminants were compared against standard reference limits detailed in Long *et al*. (1995), CCME (1999), UKOOA (2001), Spencer & MacLeod (2002), Buchman (2008), OSPAR (2014a), and MMO (2015).

Heavy and Trace Metals

Metals are generally not harmful to organisms at concentrations normally found in marine sediments and some are essential for normal metabolism but can become toxic above a critical threshold. In order to quantify potential effects on marine life, Long *et al*. (1995) defined "effect range low" (ERL) values as the lowest concentrations of a metal that produced adverse effects in 10% of the data reviewed, whilst "effect range median" (ERM) values designate the level at which half of the studies reported harmful effects. Consequently, metal concentrations recorded below the ERL are not expected to elicit adverse effects, while levels above the effect range median (ERM) are likely to be toxic to some marine life.

A portion of air-dried and ground sample was digested with Aqua Regia to extract heavy metals. Once cooled the extract was filtered and pre-diluted before being analysed. The metals were then analysed using either ICP-MS (As, Cd, Cr, Cu, Hg, Ni, Pb, Zn) or ICP-OES (Al, Ba, Be, Fe, Li, Sr) and quantified by comparing the results against a calibration curve for each of the target analytes.

Total Organic Carbon (TOC)

A portion of air-dried and ground sample was mixed with concentrated sulphurous acid. This was then warmed to 40°C for an extended period of time. The resultant mixture was then heated to dryness at 100°C. The dried residue was analysed for carbon content using an Eltra induction furnace fitted with a nondispersive infrared sensor (NDIR) cell. The total quantity of carbon liberated was calculated and reported as a percentage of the original mass of sample.

Total Organic Matter (TOM)

An aliquot of the dried and ground sample was weighed, heated in a furnace to the required temperature (450°C) which was maintained for 4 hours. Samples were weighed again when cooled. The organic matter content was estimated from the loss in mass. The total loss in mass was calculated and reported as a percentage of the original mass of sample.

Total Petroleum Hydrocarbons (TPH)

Total Petroleum Hydrocarbons are found in marine sediments as a result of offshore oil and gas rigs, and exploratory drilling. Contamination can also originate from domestic, industrial, natural, and mobile sources (land and sea based) and can be generally attributed to processes involving burning. The seabed can be a basin for the influx of sediments and petroleum related pollutants from rivers and estuaries. These pollutants are known carcinogens and therefore it is important that they are monitored in environmental situations.

Hydrocarbons are extracted from as received marine sediment by solvent extraction. Anhydrous Sodium Sulphate, Sodium Chloride and DCM were added to a portion of the 'As Received' sample and was vigorously agitated. The sample was placed in an ultrasonic bath and then centrifuged. The extract was then analysed by UV Fluorescence Screening and quantified by comparing the results against a Forties Oil calibration curve.

Polycyclic Aromatic Hydrocarbons

Polycyclic aromatic hydrocarbons (PAHs) are natural components of coal and oil and are also formed during the combustion of fossil fuels and organic material. They are one of the most widespread organic pollutants in the marine environment, entering the sea from offshore activities, operational and accidental oil spills from shipping, drilling activities, river discharges and the air (UKOOA, 2001).

PAHs include potentially carcinogenic, mutagenic and toxic compounds that concentrate in fatty tissues of organisms. They can adversely affect reproduction and may affect immune systems. Since they are bio-accumulative the higher levels of the food web, especially fish-eating birds and marine mammals can be particularly affected. Because of these properties, the OSPAR Commission identified PAHs as chemicals for priority action (OSPAR, 2009), focussing on a set of 6 PAH compounds as priority hazardous substances: anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(ghi)perylene, benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene; as well as naphthalene as a priority substance.

Methanol and DCM were added to a portion of the 'As Received' sample and mixed on a magnetic stirring plate. The solvent extract was then water partitioned and concentrated to a low volume. A double clean-up stage was employed to remove contaminants that may interfere with the analysis. The extract was analysed by GC-MS and quantified by comparing the results against a calibration curve for each of the target analytes.

2.5.3 Particle size analysis (PSA)

Particle size analysis (PSA) was conducted to provide data on the sediment composition of the shores. Sediment composition has an effect on the biological species composition and how species interact with the sediments (e.g., burrowing activities or growth on coarser particles). Sediment grain size also has a significant impact on the absorption of chemical pollutants, with finer particles tending to have a higher pollution load index than coarse particles. In addition, fine sediments may be more easily transported away from their sources, thus expanding the potential for pollution impacts. However, fine sediments are also usually found in more stable environments where pollutants may be sequestered until remobilised by a disturbance event.

PSA analysis was conducted following NMBAQC guidance (Mason, 2016), through a combination of sieve and laser analysis with wet separation at 2 mm. The <2 mm fraction was analysed through laser diffraction, whilst the >2 mm fraction was analysed through dry sieving. Summary statistics were calculated using GRADISTAT v8 (Blott & Pye, 2001); they were reported at half-phi intervals providing the full particle size distribution, mean particle size, sorting coefficient, skewness, kurtosis and modal size. Sediment classifications were determined following Folk (1954), BGS (1982 in BGS (1982-1991)) and Blott & Pye (2012).

2.6 Data analysis and Reporting

2.6.1 Statistical analyses

Following data collection and sample analysis, data matrices were produced to show abundances of each recorded taxon per sample. For the quantitative core samples, basic data truncation was applied, to combine data for different life stages of the same taxon. Univariate statistical analyses were undertaken using the PRIMER software package (Clarke & Warwick 2001; Clarke & Gorley, 2006; Clarke et al., 2014). Multivariate techniques were not considered appropriate to the size of the data set.

Univariate Statistics

- Number of taxa (S);
- Abundance (number of individuals) per sample (N);
- Abundance (number of individuals) per m^2;
- Margalef's Species Richness (D): a measure of the number of species present for a given number of individuals;
- Pielou's Evenness (J'): represents the uniformity in distribution of individuals spread between species in a sample; high values indicate more evenness or more uniform distribution of individuals; the output range is from zero to one;
- Shannon Wiener Diversity 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 & Gorley, 2006);
- Simpson Diversity (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 zero to one with higher values representing a more diverse community without dominant taxa;
- Total Biomass: total wet weight biomass of all mobile animals (biomass of individual recorded taxa per sample also provided).

Non-countable taxa, such as colonial bryozoans and hydroids, were included when calculating total numbers of taxa, but excluded from calculations of total numbers of individuals, biomass and other diversity indices. Abundances and biomass were also standardised to numbers per m^2 and averaged for each taxon for each quantitative sample type.

2.6.2 Notable taxa

Notable taxa, such as rare or protected species (Bratton, 1991; Sanderson, 1996; Betts, 2001; Chadd & Extence, 2004), non-native species (Eno et al., 1997; Reise et al., 1999; Goulletquer et al., 2002; Wolff, 2005; Gollasch & Nehring, 2006; Minchin, 2007; Minchin et al., 2013), or potentially un-described species were highlighted, and their significance discussed. Results were also reviewed for the presence of any Annex I habitats.

3. Results

3.1 Health and Safety Incidence and public interaction

There were no incidents, near misses or other health and safety issues to report under APEM's Health and Safety procedures.

Field team members encountered several concerned and curious members of the public. The presence of a client representative gave an opportunity for the field team to redirect any questions, mitigating the chance of any incidents or wasted time.

3.2 General descriptions of areas

The surveys covered short stretches of shore at each of the two potential cable landfall sites: Pegwell Bay and Aldeburgh. At Pegwell Bay, the survey area extended about 400 m along the upper shore (including a shallow lagoon) to the south of Cliffsend (near Ramsgate) and east south east towards the lower shore, for about 1 km. At Aldeburgh, the survey area extended about 300 m along the upper shore to the north of the town and east south east towards the lower shore, for about 100 m.

3.2.1 Pegwell Bay

Pegwell Bay was a semi-enclosed, horseshoe-shaped bay, extending about 1 km northeast to southwest between the Pegwell suburb of Ramsgate and the estuary of the Kentish River Stour. Its intertidal area extended over 1 km out to the southeast, comprising almost the entire bay. The survey area comprised a box within the southern half of the bay about 400 m along the upper shore, to the south of Cliffsend and out east southeast towards the lower shore, for about 1 km (Figure 6).

Figure 6. View NW from the mid shore towards the upper shore of the Pegwell Bay survey area and Cliffsend; 14 June 2023

There was a footpath above high-water level extending along the whole length of the survey area, with a narrow strip of coastal vegetation on a steep slope between the path and a shallow lagoon. The lagoon extended about 400 m along the landward side of the survey area; it was about 100 m wide for about two thirds of its length, to the northeast, and about 10 m wide along a narrow extension to the southwest. The 100 m wide expanse of saltmarsh and coastal vegetation between the lagoon and the sandflats to their seaward was not included in the survey.

Figure 7. View NE from the footpath near the narrow western extremity of the lagoon at Pegwell Bay; path, coastal vegetation strip, lagoon, saltmarsh and sandflats (left to right); 22 May 2023

Most of the survey area comprised extensive flats of muddy sand. The upper shore flats, adjacent to the seaward extent of saltmarsh, included more muddy sediments. The mid shore was sandier, with ripples and lugworm casts. The lower shore was flat, with more sand mason worm tubes.

3.2.2 Aldeburgh

The shore adjacent to South Marsh, north of the town of Aldeburgh, was part of an exposed shingle beach that extends for over 30 km from Orford Ness to Lowestoft. The survey area comprised a steep shingle bank about 100 m wide extending about 400 m north to south. There was a bank of shingle vegetation above the high-water level, barren shingle across most of the shore and sandy gravel or gravelly sand patches on the lower shore. During the initial site visit, there was more sand on the lower shore (Figure 8); this had mostly been covered by shingle by the date of the main survey (Figure 9).

Figure 8. View N towards Thorpeness along lower shore coarse sand; 26th July 2023

Figure 9. View N towards Thorpeness along lower shore shingle with occasional sand patches; 12th September 2023

Figure 10. View S towards Aldeburgh along shingle beach and vegetated bank

3.3 Substratum characteristics from particle size analysis (PSA)

3.3.1 Pegwell Bay

At Pegwell Bay, the lagoon had mud or sandy mud around its edges and within, colonised by seagrass. The upper shore flats, adjacent to the seaward extent of saltmarsh, included both muddy sand and muddy sediments. The mid shore was sandier, with ripples and lugworm casts. The lower shore was flat, with more sand mason worm tubes. There were some large pieces of litter and collapsed concrete structures scattered across the mid shore.

Photographs of each core sample from Pegwell are shown in Appendix 4. Raw PSA data are presented in Appendix 3. Summaries are provided below in Table 3 and mapped in Figure 13. Upper shore stations were classified (Folk, 1954) as Slightly gravelly muddy sand (PT1U and PT2U) and Gravelly muddy sand (PT3U). Mid shore stations were classified as Slightly gravelly sand. Lower shore stations were classified as Slightly gravelly sand (PT1L and PT3L) and Slightly gravelly muddy sand (PT2L). The single lagoon station was classified as Slightly gravelly sandy mud.

The lagoon station was mesokurtic (Figure 11) signifying it is more like a normal distribution and very poorly sorted indicating there were a wide range of grain sizes present. All other stations were either Extremely Leptokurtic, Very Leptokurtic or Leptokurtic (Figure 12), indicating the data is more heavily concentrated around the mean particle size than the normal distribution. All the upper stations and PT2L were poorly sorted indicating a wide range of grain sizes present. The mid and lower stations were moderately sorted or moderately well sorted indicating less variation in grain size.

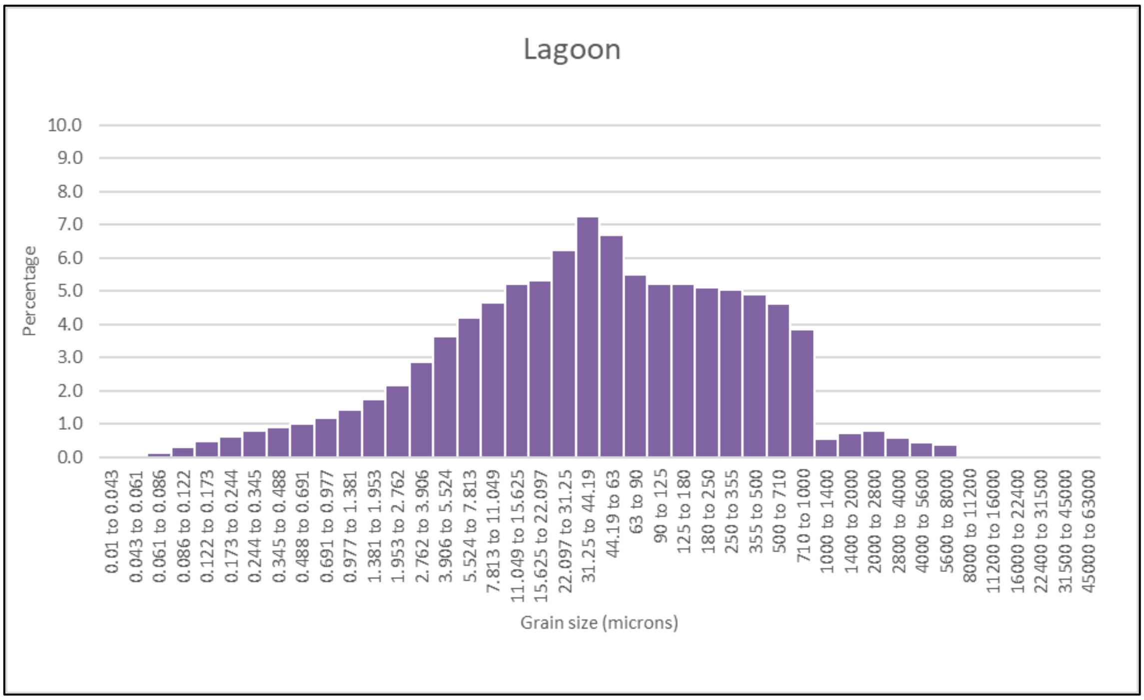

Figure 11. Particle size plots for Pegwell lagoon station.

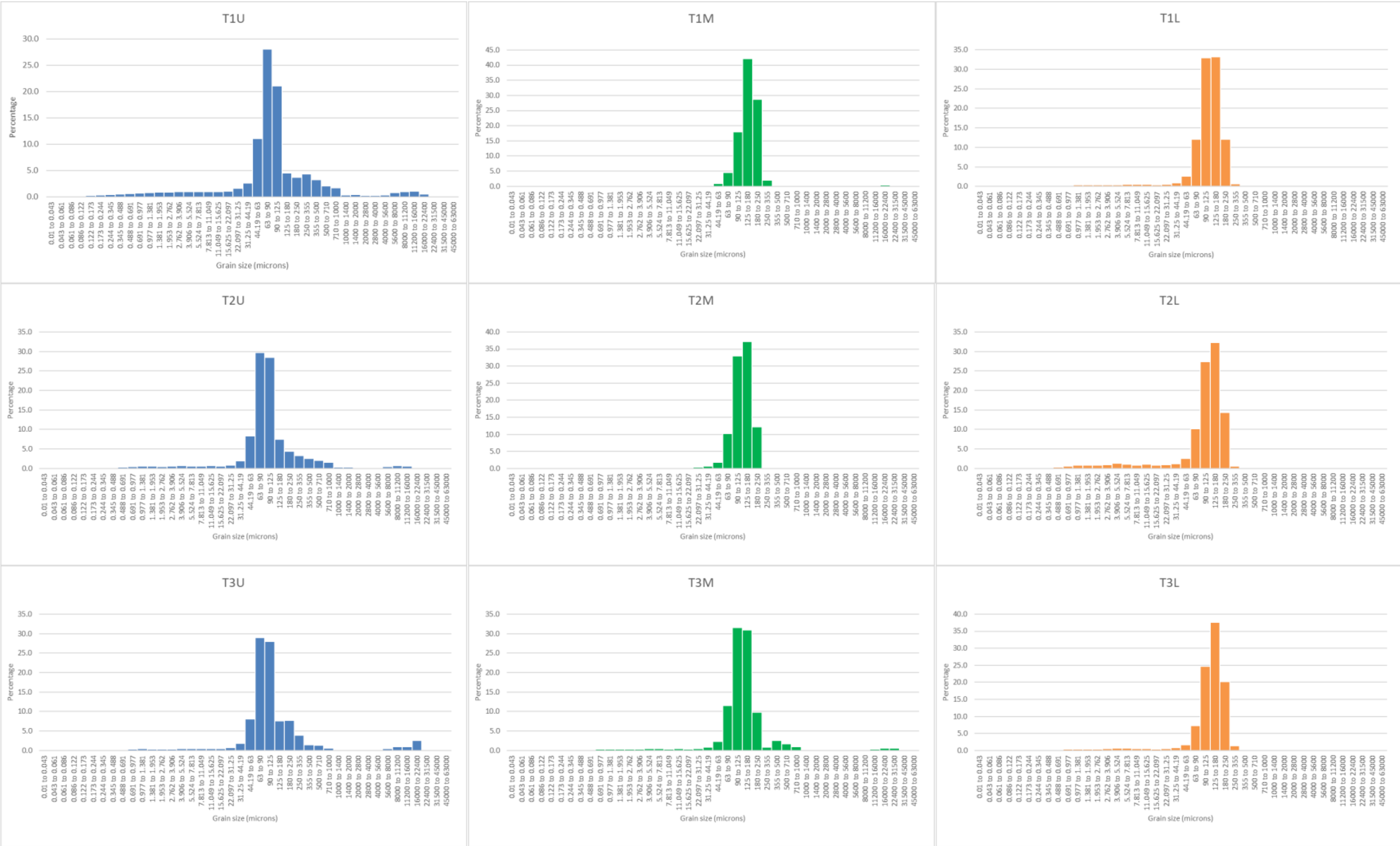

Figure 12. Particle size plots for Pegwell Bay sampling stations.

Table 3. Summary of Particle Size Analysis at Pegwell Bay

Station	Mean (µm)	Gravel (%)	Sand (%)	Mud (%)	Folk (1954)	Blott & Pye (2012)	Sorting	Skewness	Kurtosis
PT1U	97.2	3.97	69.22	26.81	Slightly Gravelly Muddy Sand	Very slightly gravelly muddy sand	Poorly Sorted	Symmetrical	Extremely Leptokurtic
PT1M	149.0	0.73	95.47	3.81	Slightly Gravelly Sand	Very slightly muddy sand	Moderately Well Sorted	Fine Skewed	Leptokurtic
PT1L	116.6	0.39	90.87	8.74	Slightly Gravelly Sand	Slightly muddy sand	Moderately Sorted	Fine Skewed	Very Leptokurtic
PT2U	100.0	2.32	80.12	17.56	Slightly Gravelly Muddy Sand	Very slightly gravelly slightly muddy sand	Poorly Sorted	Symmetrical	Very Leptokurtic
PT2M	124.1	1.17	92.87	5.96	Slightly Gravelly Sand	Very slightly gravelly slightly muddy sand	Moderately Well Sorted	Fine Skewed	Leptokurtic
PT2L	112.4	0.73	84.87	14.40	Slightly Gravelly Muddy Sand	Slightly muddy sand	Poorly Sorted	Very Fine Skewed	Very Leptokurtic
PT3U	108.6	5.19	79.54	15.27	Gravelly Muddy Sand	Slightly gravelly slightly muddy sand	Poorly Sorted	Very Coarse Skewed	Very Leptokurtic
PT3M	123.2	2.22	89.77	8.00	Slightly Gravelly Sand	Very slightly gravelly slightly muddy sand	Moderately Sorted	Symmetrical	Very Leptokurtic
PT3L	133.2	0.23	91.22	8.55	Slightly Gravelly Sand	Slightly muddy sand	Moderately Sorted	Very Fine Skewed	Very Leptokurtic
Lagoon	43.1	2.22	40.79	56.99	Slightly Gravelly Sandy Mud	Very slightly gravelly sandy mud	Very Poorly Sorted	Symmetrical	Mesokurtic

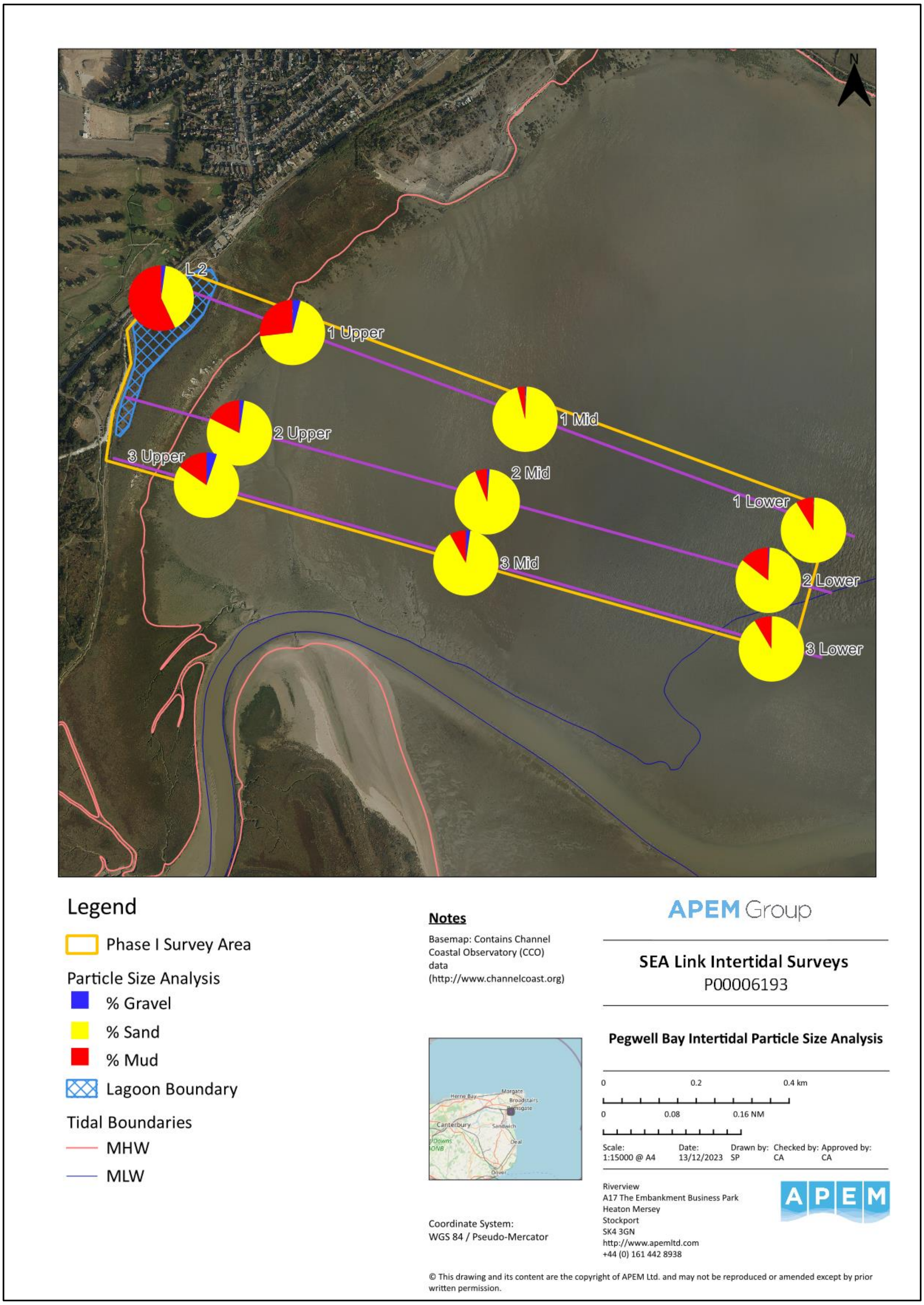

Figure 13. Summary of Particle Size Analysis at Pegwell Bay

3.3.2 *Aldeburgh*

Photographs of each Aldeburgh core sample are shown in Appendix 5. Raw PSA data are presented in Appendix 3. Summaries are provided below in Table 4 and mapped in Figure 15. All Aldeburgh stations were classified as Sandy gravel (Folk, 1954). All stations were very poorly sorted, indicating a wide range of grain sizes were present, and demonstrated a bi-modal distribution (Figure 14). AT2L and AT3L were both leptokurtic, whilst the other stations were very platykurtic.

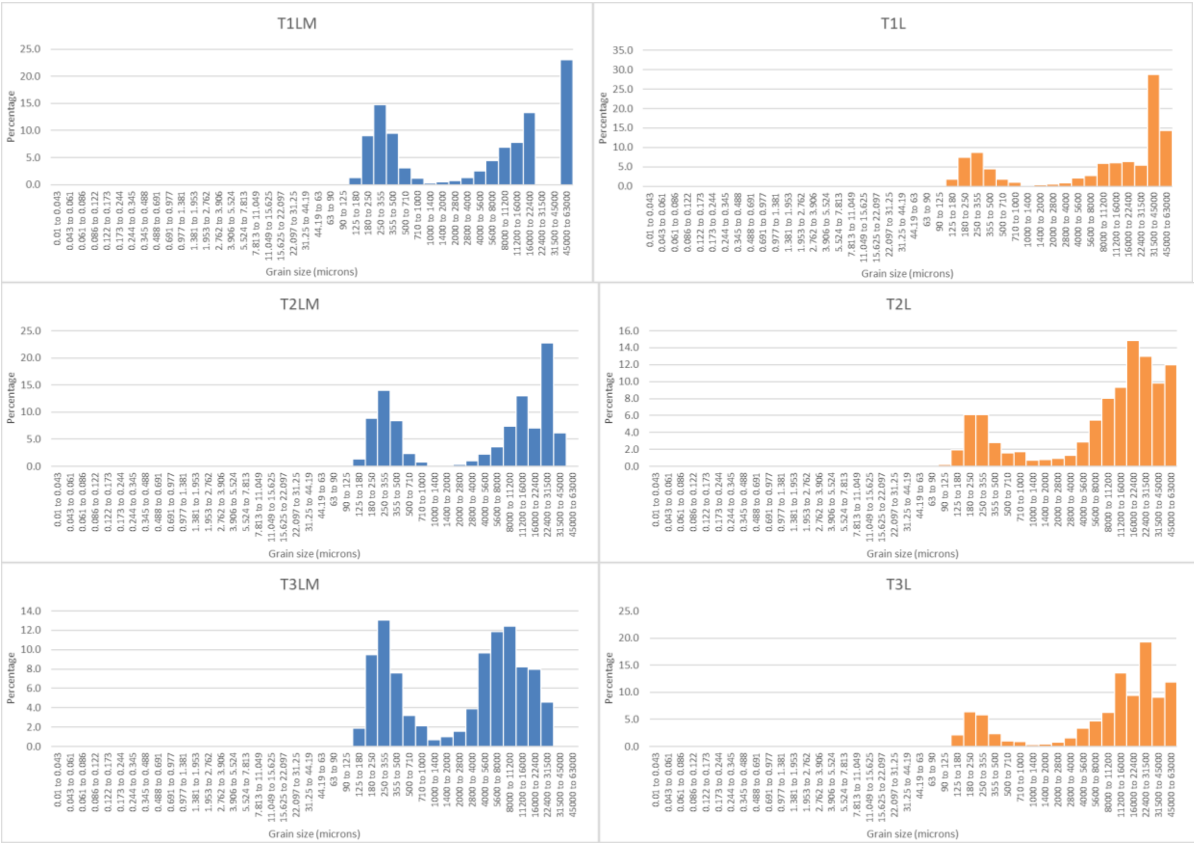

Figure 14. Particle size plots for the Aldeburgh sampling stations.

Table 4. Summary of Particle Size Analysis at Aldeburgh

Station	Mean (µm)	Gravel (%)	Sand (%)	Mud (%)	Folk (1954)	Blott & Pye (2012)	Sorting	Skewness	Kurtosis
AT1LM	4,928.7	60.12	39.88	0.00	Sandy Gravel	Sandy gravel	Very Poorly Sorted	Very Fine Skewed	Very Platykurtic
AT1L	6,626.3	73.26	26.41	0.32	Sandy Gravel	Sandy gravel	Very Poorly Sorted	Very Fine Skewed	Very Platykurtic
AT2LM	4,369.3	63.59	36.41	0.00	Sandy Gravel	Sandy gravel	Very Poorly Sorted	Very Fine Skewed	Very Platykurtic
AT2L	6,329.6	77.59	22.11	0.30	Sandy Gravel	Sandy gravel	Very Poorly Sorted	Very Fine Skewed	Leptokurtic
AT3LM	2,620.4	60.19	39.28	0.53	Sandy Gravel	Sandy gravel	Very Poorly Sorted	Very Fine Skewed	Very Platykurtic
AT3L	6,273.6	79.87	19.84	0.29	Sandy Gravel	Slightly sandy gravel	Very Poorly Sorted	Very Fine Skewed	Leptokurtic

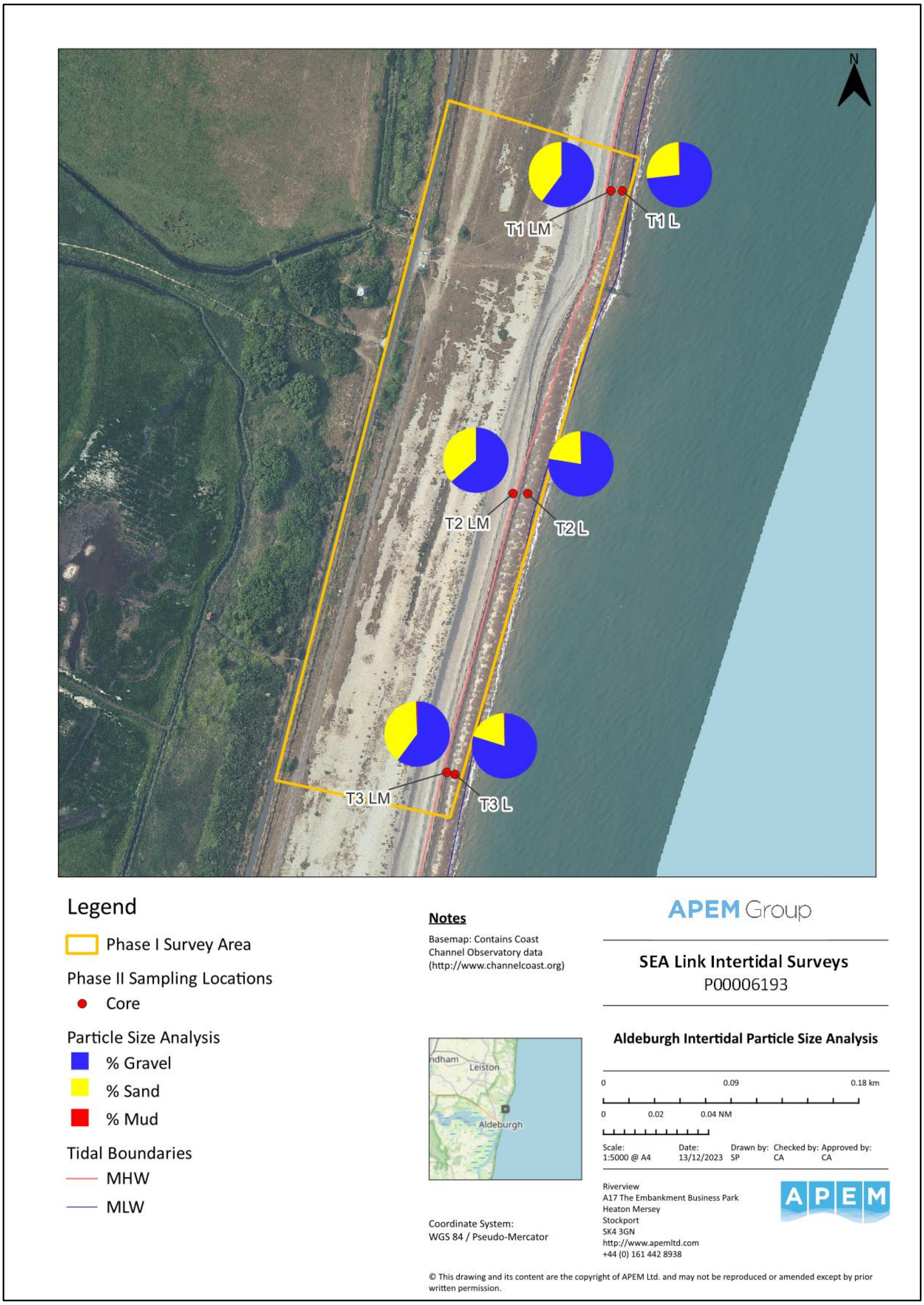

Figure 15. Summary of Particle Size Analysis at Aldeburgh

3.4 Contaminants Data

The current environmental focus of the Coordinated Environmental Monitoring Programme (CEMP) around heavy metals is on Cadmium, Mercury, and Lead (OSPAR, 2014b). Cadmium and Lead occur within the natural environment but can be toxic whilst Mercury is extremely toxic to humans and biota (OSPAR, 2014a). Some other heavy metals, for example Arsenic, can be harmful to organisms at concentrations lower than are naturally found in marine sediments.

Hydrocarbons, and particularly PAHs, include potentially carcinogenic, mutagenic and toxic compounds that concentrate in fatty tissues of organisms. They can adversely affect reproduction and may affect immune systems. Since they are bio-accumulative the higher levels of the food web, especially fish-eating birds and marine mammals can be particularly affected.

Data were compared against:

- TEL = Threshold Effects Level: Maximum concentration at which no effects are observed (Source: CCME, 1999)
- PEL = Probable Effects Level: Lower limit of the range of concentrations at which adverse effects are always observed (Source: CCME, 1999)
- ERL = Effects Range Low: 10th percentile values in effects (Sources: Long et al., 1995; Buchman, 2008; OSPAR, 2014a) [consistent with Spencer & MacLeod, 2002])
- BC = Background Concentration: the concentration that it should naturally occur in undisturbed environment (Source: OSPAR, 2014a)
- BAC = Background Assessment Concentration: an assessment threshold for testing whether contaminant concentrations are 'near background'(Source: OSPAR, 2014a)
- Cefas Action Levels (CAL 1; Source: MMO, 2015)

3.4.1 Pegwell Bay

Contaminants data for Pegwell Bay are presented in Appendix 3, with summaries in Table 5, for metals and Table 6, for hydrocarbons, total organic carbon and total organic matter. Heavy metal concentrations at each sampling station are plotted in Figure 16, whilst THC values are plotted in Figure 17.

In the sandflat samples, heavy and trace metals were found in concentrations below the BC and, other than for Arsenic, also below the TEL. Normalised arsenic concentrations were higher than the TEL for several samples but still fell below BC, as arsenic can have effects on organisms at lower concentrations than are naturally found in sediments.

In the lagoon sample, higher concentrations of heavy and trace metals were observed, compared with other stations, for all but Strontium. They were above the TEL and the ERL for Copper, Mercury, Nickel, Lead and Zinc and above the BC for Cadmium.

Total organic Carbon and Total Organic Matter were highest in the lagoon sample, as were concentrations of some organic contaminants. However, all were well below BAC and both OSPAR ERL and CEFAS Action Level (cAL 1).

High concentrations of hydrocarbons were detected at PT2U, PT3U and in the lagoon. No threshold values exist for THC but for individual alkanes, all values were blow the respective threshold values (Table 6).

Table 5. Summary of metal concentrations at each sampling station in Pegwell Bay

Analyte	Arsenic	Cadmium	Chromium	Copper	Mercury	Nickel	Lead	Vanadium	Zinc	Aluminium	Barium	Beryllium	Iron	Lithium	Strontium
Method	**Aqua-Regia Extraction & ICPMS**									**Aqua-Regia Extraction & ICPOES**					
LOD (mg/kg)	**0.5**	**0.04**	**0.5**	**0.5**	**0.01**	**0.5**	**0.5**	**0.5**	**2**	**10**	**0.5**	**0.1**	**36**	**2**	**0.5**
PT1U	4.6	0.05	10.6	3.1	0.05	6.4	8.5	19.0	22.3	2180	101.0	0.23	9690	6.0	99.2
PT1M	8.3	<0.04	7.3	0.8	0.02	3.5	5.6	18.8	19.9	1400	8.8	0.22	9720	2.7	64.8
PT1L	7.3	<0.04	9.7	1.5	0.02	4.6	7.0	20.8	19.9	1850	58.0	0.25	11500	3.5	72.7
PT2U	4.3	<0.04	9.9	2.6	0.05	5.3	9.8	20.0	24.7	2050	81.7	0.21	9080	5.2	154.0
PT2M	8.2	<0.04	9.7	1.8	<0.01	4.5	7.4	19.6	22.1	1820	27.1	0.25	10400	3.5	67.6
PT2L	9.2	<0.04	8.7	1.8	<0.01	4.5	6.7	18.2	19.2	1740	42.6	0.21	10200	3.8	85.1
PT3U	7.6	0.06	9.3	2.8	<0.01	6.1	8.0	18.5	23.8	1870	72.7	0.17	8570	4.8	129.0
PT3M	9.0	<0.04	10.5	1.9	<0.01	5.0	8.4	21.7	23.1	1920	42.8	0.33	11200	3.9	91.2
PT3L	12.2	<0.04	10.3	2.1	<0.01	4.7	7.6	22.4	20.2	1850	30.6	0.22	12100	3.4	64.8
LAGOON	14.0	0.28	34.4	565.0	0.32	21.0	178.0	45.5	603.0	10200	319.0	0.60	21000	32.3	93.3
Min	4.3	0.05	7.3	0.8	0.0	3.5	5.6	18.2	19.2	1400	8.8	0.2	8570	2.7	64.8
Max	14.0	0.28	34.4	565.0	0.32	21.0	178.0	45.5	603.0	10200	319.0	0.6	21000	32.3	154.0
Mean	8.5	0.13	12.0	58.3	0.1	6.6	24.7	22.5	79.8	2688	78.4	0.3	11346	6.9	92.2
Median	8.3	0.06	9.8	2.0	0.1	4.9	7.8	19.8	22.2	1860	50.4	0.2	10300	3.9	88.2
%RSD	35.2	-	65.8	305.1	139.5	78.4	218.1	36.6	230.3	98	113.4	45.9	31	129.9	31.9
TEL	7.24	0.7	52.3	18.7	0.13	15.9	30.2	-	124	-	-	-	-	-	-
PEL	41.6	41.6	160	108	0.7	42.8	112	-	271	-	-	-	-	-	-
OSPAR ERL	-	1.2	-	-	0.15	-	47	-	-	-	-	-	-	-	-
NOAA ERL	8.2	1.2	81	34	-	20.9	46.7	-	150	-	-	-	-	-	-
BC	15	0.2	60	20	-	30	25	-	90	-	-	-	-	-	-
BAC	25	0.31	81	27	0.07	36	38	-	122	-	-	-	-	-	-

Colour coding is applied in sequence from greatest to smallest value. Therefore, exceedance of the highest threshold also implies exceedance of lower thresholds (eg. ERL>BAC>BC).

Table 6. Summary of Organic Carbon, Organic Matter, PAH, and Total Hydrocarbon data for Pegwell Bay

Analyte	Total Organic Carbon	Total Organic Matter	Naphtha-lene	Anthra-cene	Benzo [b] fluor-anthene	Benzo [k] fluor-anthene	Benzo [a] pyrene	Indeno [123,cd] pyrene	Benzo [ghi] perylene	THC
Units	%	%	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
LOD	0.02	0.2	0.001	0.001	0.001	0.001	0.001	0.001	0.001	1
PT1U	0.30	1.3	0.005	0.005	0.026	0.025	0.028	0.022	0.019	6.29
PT1M	0.23	0.6	<0.001	<0.001	0.005	0.006	0.007	0.006	0.005	<1.00
PT1L	0.22	0.7	<0.001	<0.001	0.003	0.003	0.003	0.003	0.003	<1.00
PT2U	0.49	1.2	0.022	0.063	0.200	0.195	0.255	0.163	0.143	71.90
PT2M	0.23	1.0	<0.001	<0.001	0.004	0.004	0.004	0.004	0.003	2.12
PT2L	0.28	1.4	<0.001	<0.001	0.004	0.005	0.005	0.004	0.004	3.08
PT3U	0.45	1.5	0.02	0.011	0.038	0.034	0.042	0.027	0.027	30.60
PT3M	0.24	1.1	0.003	0.002	0.012	0.011	0.013	0.009	0.009	2.49
PT3L	0.22	1.1	<0.001	<0.001	0.005	0.005	0.005	0.004	0.004	<1.00
LAGOON	3.36	13.6	0.014	0.035	0.240	0.211	0.240	0.205	0.192	42.00
Min	0.22	0.6	<0.001	<0.001	0.003	0.003	0.003	0.003	0.003	<1.00
Max	3.36	13.6	0.022	0.063	0.200	0.195	0.255	0.163	0.143	71.90
Mean	0.60	2.35	-	-	0.054	0.05	0.06	0.045	0.041	-
Median	0.26	1.15	-	-	0.009	0.009	0.01	0.008	0.007	-
%RSD	161.78	168.64	-	-	165.5	163	164.9	167	167	-
OSPAR Effect Range Low (ERL)			160	-	-	-	430	240	85	-
Cefas Action Level (cAL 1)			-	-	100	100	100	-	100	-
BC			5	3	-	-	15	50	45	-
BAC			8	5	-	-	30	103	80	-

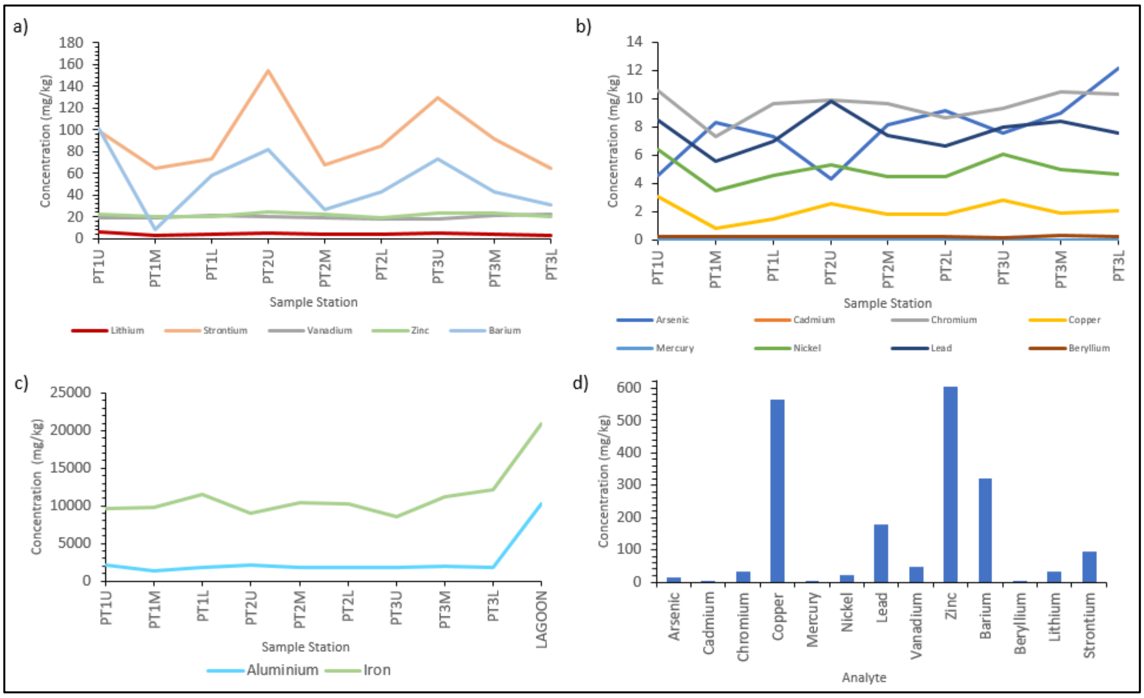

Figure 16. Concentrations of metals at each sampling station in Pegwell Bay. a) Li, Sr, V, Zn, Ba. b) As, Cd, Cr, Cu, Hg, Ni, Pb, Be. c) Al, Fe. d) Lagoon contaminants, except Al and Fe. Where concentrations measured were lower than the LoD, the LoD has been used for graphical purposes.

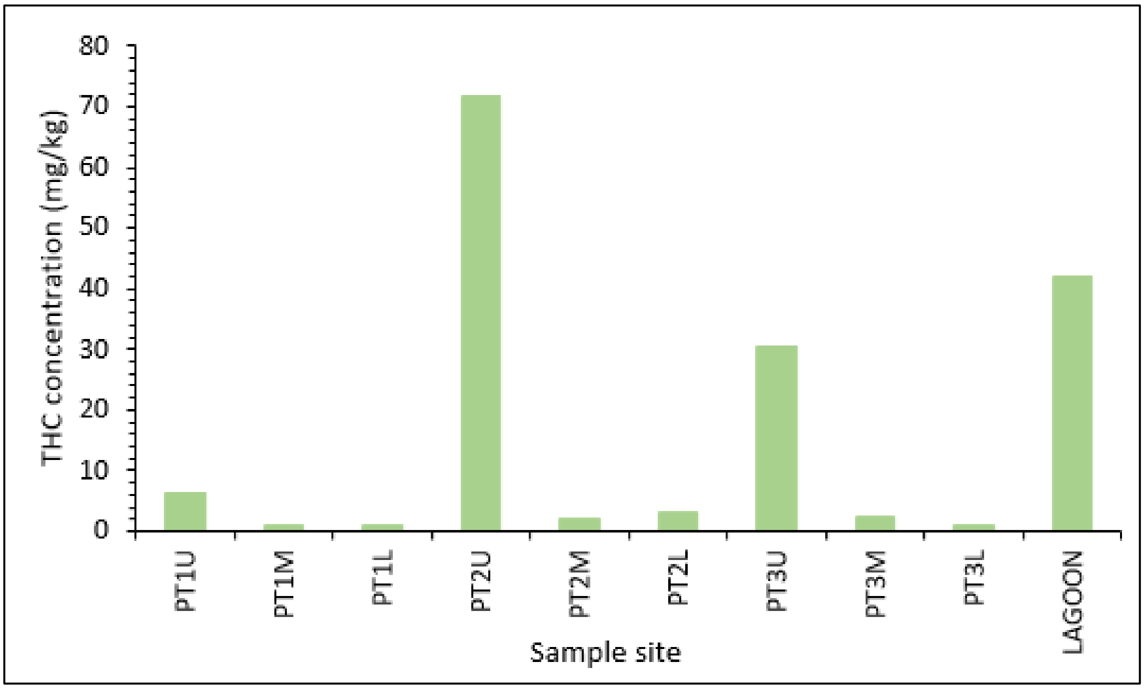

Figure 17. THC concentration at each Pegwell Bay sampling station

3.4.2 Aldeburgh

Contaminants data for Aldeburgh are presented in Appendix 3, with summaries in Table 7, for metals and Table 8, for hydrocarbons, total organic carbon and total organic matter. Concentrations of metals are plotted in Figure 18.

Heavy and trace metals were found in concentrations well below the BC, TEL and ERL levels for all metals analysed. No consistent trends in concentrations were noted, but elevated concentrations for Barium were noted at AT2LM and AT3L, for Zinc at AT1LM and AT2LM, and for Iron at AT3LM.

In all Aldeburgh samples, total organic Carbon and total organic matter (loss on ignition) were low (below 1%) and concentrations of all measured organic contaminants were below the Limit of Detection (LoD).

Table 7. Summary of metal concentrations at each sampling station in Aldeburgh

Analyte	Arsenic	Cadmium	Chromium	Copper	Mercury	Nickel	Lead	Vanadium	Zinc	Aluminium	Barium	Beryllium	Iron	Lithium	Strontium
Method	Aqua-Regia Extraction & ICPMS									Aqua-Regia Extraction & ICPOES					
LOD (mg/kg)	0.5	0.04	0.5	0.5	0.01	0.5	0.5	0.5	2	10	0.5	0.1	36	2	0.5
AT1LM	3.6	<0.04	2.2	2.5	0.01	1.8	2.5	5.0	9.6	289	4.0	<0.10	2860	<2.0	31.7
AT1L	3.1	<0.04	1.8	1.2	<0.01	2.6	1.3	3.8	6.1	258	3.8	<0.10	2670	<2.0	30.4
AT2LM	3.4	<0.04	1.8	1.2	<0.01	2.2	2.4	3.7	7.9	226	7.8	<0.10	2890	<2.0	39.8
AT2L	3.2	<0.04	1.5	0.9	0.01	1.7	1.3	3.9	4.5	299	3.7	<0.10	2670	<2.0	37.8
AT3LM	3.9	<0.04	1.6	0.9	<0.01	1.4	1.1	4.4	4.6	268	3.5	<0.10	4420	<2.0	31.8
AT3L	3.4	<0.04	1.7	1.1	<0.01	2.4	1.7	4.0	6.3	258	8.4	<0.10	3460	<2.0	37.5
Min	3.1	-	1.5	0.9	-	1.4	1.1	3.7	4.5	226	3.5	-	2670	-	30.4
Max	3.9	-	2.2	2.5	-	2.6	2.5	5.0	9.6	299	8.4	-	4420	-	39.8
Mean	3.4	-	1.8	1.3	-	2.0	1.7	4.1	6.5	266	5.2	-	3162	-	34.8
Median	3.4	-	1.8	1.2	-	2.0	1.5	4.0	6.2	263	3.9	-	2875	-	34.7
%RSD	8.4	-	13.7	46.4	-	22.7	35.0	11.8	30.3	10	43.6	-	22	-	11.4
TEL	7.24	0.7	52.3	18.7	0.13	15.9	30.2	-	124	-	-	-	-	-	-
PEL	41.6	41.6	160	108	0.7	42.8	112	-	271	-	-	-	-	-	-
OSPAR ERL	-	1.2	-	-	0.15	-	47	-	-	-	-	-	-	-	-
NOAA ERL	8.2	1.2	81	34	-	20.9	46.7	-	150	-	-	-	-	-	-
BC	15	0.2	60	20	-	30	25	-	90	-	-	-	-	-	-
BAC	25	0.31	81	27	0.07	36	38	-	122	-	-	-	-	-	-

Table 8. Summary of Organic Carbon, Organic Matter, PAH, and Total Hydrocarbon data for Aldeburgh

Analyte	Total Organic Carbon	Total Organic Matter	Naphtha-lene	Anthra-cene	Benzo [b] fluor-anthene	Benzo [k] fluor-anthene	Benzo [a] pyrene	Indeno [123,cd] pyrene	Benzo [ghi] perylene	THC
Units	%	%	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
LOD	0.02	0.2	0.001	0.001	0.001	0.001	0.001	0.001	0.001	1
AT1LM	0.16	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<1
AT1L	0.17	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<1
AT2LM	0.17	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<1
AT2L	0.17	0.6	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<1
AT3LM	0.17	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<1
AT3L	0.17	0.6	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<1
Min	0.16	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<1
Max	0.17	0.6	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<1
Mean	0.17	0.53	-	-	-	-	-	-	-	-
Median	0.17	0.5	-	-	-	-	-	-	-	-
%RSD	2.43	9.68	-	-	-	-	-	-	-	-
OSPAR Effect Range Low (ERL)			160	-	-	-	430	240	85	-
Cefas Action Level (cAL 1)			-	-	100	100	100	-	100	-
BC			5	3	-	-	15	50	45	-
BAC			8	5	-	-	30	103	80	-

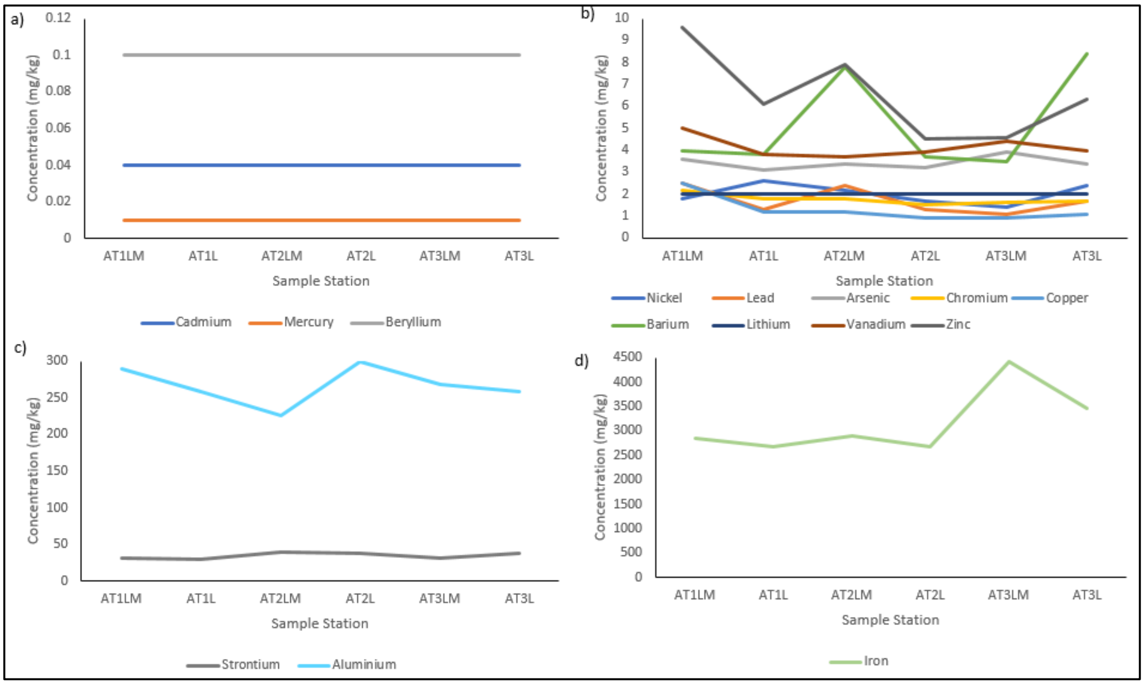

Figure 18. Concentrations of metals at each sampling station at Aldeburgh. a) Be, Cd, Hg. b) As, Ba, Cr, Cu, Li, Ni, Pb, V, Zn. c) Al, Sr. d) Fe. Where concentrations measured were lower than the LoD, the LoD has been used for graphical purposes.

3.5 Macrobenthos

3.5.1 Pegwell Bay

Raw biological data are presented in Appendix 3 for core samples. Appendix 4 shows photographs of *in situ* core samples. Mean abundance data for each sampling point, standardised to numbers per m^2, and univariate statistics are presented for core samples in Table 9, below. Total numbers of taxa and numbers per m^2 are mapped in Figure 19 and Figure 20, respectively.

Table 9. Pooled abundance data per m^2 in core samples from Pegwell Bay

Taxon Name	Qualifier	Lagoon	PT1 U	PT2 U	PT3 U	PT1 M	PT2 M	PT3 M	PT1 L	PT2 L	PT3 L	Mean
Animalia	eggs					P						-
Hydrallmania falcata											P	-
Nemertea		33.3		33.3								33.3
Nematoda		133.3	266.7	600.0	2166.7						33.3	640.0
Malmgrenia arenicolae											33.3	33.3
Eteone longa	aggregate		133.3					33.3				83.3
Phyllodoce mucosa									66.7	33.3		50.0
Eumida sanguinea	aggregate								166.7	66.7	100.0	111.1
Hediste diversicolor		1,566.7	333.3	33.3	133.3					33.3		420.0
Nephtys cirrosa							66.7					66.7
Nephtys hombergii								66.7	66.7			66.7
Scoloplos armiger			66.7			66.7	66.7	100.0	33.3	166.7	266.7	109.5
Malacoceros	juvenile		266.7									266.7
Polydora cornuta		166.7										166.7
Pygospio elegans		66.7	566.7	66.7	66.7	400.0	833.3	833.3	600.0	333.3	133.3	390.0
Pygospio elegans	eggs					P	P		P			-
Pygospio elegans	larva						P	P	P			-
Spiophanes bombyx									33.3			33.3
Streblospio			66.7									66.7
Tharyx species A			233.3									233.3
Capitella					66.7				33.3	66.7		55.6
Arenicolidae				33.3								33.3
Lanice conchilega									866.7	900.0	1,300.0	1,022.2
Monopylephorus irroratus		100.0										100.0
Baltidrilus costatus		2,666.7										2,666.7
Tubificoides benedii					33.3					33.3		33.3
Tubificoides diazi	aggregate										33.3	33.3
Enchytraeidae					33.3							33.3

Taxon Name	Qualifier	Lagoon	PT1 U	PT2 U	PT3 U	PT1 M	PT2 M	PT3 M	PT1 L	PT2 L	PT3 L	Mean
Achelia echinata	aggregate									133.3		133.3
Acari							33.3					33.3
Copepoda							33.3					33.3
Podocopida		277,866.7										277,866.7
Urothoe poseidonis				33.3		33.3			166.7	33.3	100.0	73.3
Bathyporeia pilosa			33.3	833.3	7,233.3		66.7					2,041.7
Bathyporeia sarsi				866.7	300.0	6,033.3	1,533.3	366.7	266.7		33.3	1,342.9
Gammarus locusta												
Corophium arenarium			33.3		66.7							50.0
Cyathura carinata				66.7	66.7							66.7
Tanaissus lilljeborgi						133.3	100.0	200.0			66.7	125.0
Cumopsis goodsir								66.7				66.7
Crangon crangon			Frag.	Frag.		33.3	33.3			33.3	33.3	33.3
Carcinus maenas	juvenile									66.7	33.3	50.0
Coleoptera		33.3										33.3
Chironomidae	larva	66.7										66.7
Psocoptera		33.3										33.3
Thysanoptera				33.3						33.3		33.3
Peringia ulvae		5,400.0	400.0					33.3			33.3	1,466.7
Ecrobia ventrosa												
Mytilus edulis	juvenile				66.7				33.3		33.3	44.4
Kurtiella bidentata			100.0	66.7						33.3	33.3	58.3
Cerastoderma edule			133.3	33.3	33.3	100.0	33.3	33.3	33.3	100.0	200.0	77.8
Cerastoderma edule	juvenile						33.3			33.3		33.3
Spisula	juvenile										33.3	33.3
Macoma balthica			133.3	66.7	33.3				33.3	100.0	66.7	72.2
Abra tenuis			33.3									33.3
Penetrantiidae		P										-
Amathia							P					-
Electra pilosa											P	-

Taxon Name	Qualifier	Lagoon	PT1 U	PT2 U	PT3 U	PT1 M	PT2 M	PT3 M	PT1 L	PT2 L	PT3 L	Mean
Phoronis			Frag.									-
Amphiuridae	juvenile								33.3			33.3
Pomatoschistus microps												-
Ceramium							P					-
Polysiphonia							P					-
Ulva		P	P		P		P	P		P		-
Lemna		P	P	P	P	P	P	P	P	P		-
Ruppia		P										
Total No. Taxa		16.0	17.0	14.0	15.0	9.0	15.0	11.0	15.0	18.0	20.0	
Total No. Individuals per m²		288,133.3	2,800.0	2,766.7	10,300.0	6,800.0	2,833.3	1,733.3	2,433.3	2,200.0	2,566.7	
Margalef's Species Richness (D)		1.2	3.2	2.7	2.1	1.1	2.0	2.0	3.0	3.6	3.9	
Pielou's Evenness (J')		0.1	0.9	0.7	0.4	0.3	0.6	0.7	0.7	0.8	0.7	
Shannon Wiener Diversity (H') loge		0.2	2.4	1.7	1.0	0.5	1.3	1.6	1.9	2.1	1.9	
Simpson Diversity (1-λ')		0.1	0.9	0.8	0.5	0.2	0.6	0.7	0.8	0.8	0.7	
Dominance		96.4	20.2	31.3	70.2	88.7	54.1	48.1	35.6	40.9	50.6	
Co-Dominance		98.3	34.5	61.4	91.3	94.6	83.5	69.2	60.3	56.1	61.0	

Sixty-one taxa were recorded from the sweep net and sediment core samples at Pegwell Bay. These excluded separations of adults and juveniles but included eggs, fragments, and organisms that may not have been part of the living biota of the samples, such as duckweed (*Lemna*) that may have been washed down from less saline habitats or insects (bark lice: Psocoptera; thrips: Thysanoptera) that may have fallen onto the sample. Fifty-six taxa were recorded, after rationalisation. The upper shore samples had many polychaete worms (*Hediste diversicolor, Pygospio elegans*) at PT1 but PT2 and PT3 were dominated by burrowing amphipod Crustacea (*Bathyporeia pilosa, B. sarsi*). The dominant mid-shore core species were the sedentary polychaete *Pygospio elegans* and the amphipod *Bathyporeia sarsi*. Many lugworm (*Arenicola marina*) casts were seen in the field but they were too scattered to appear in the samples. In the lower shore samples, sand mason worms (*Lanice conchilega*) were abundant and their tubes were also conspicuous in the field. Cockles (*Cerastoderma edule*) were scattered across the whole shore. The highest abundances on the sandflats were for *Bathyporeia* amphipods, with the greatest density at a station for *B. pilosa* (7,233 per m^2 at PT3U).

The lagoon was colonised by tasselweed (*Ruppia maritima*), growing in sandy mud. Cores from the sediment contained many ragworms (*Hediste diversicolor*), oligochaete worms (*Baltidrilus costatus*), ostracod crustaceans (Podocopida) and mud snails (*Peringia ulvae*). The nekton and epibiota of the seagrass, characterised by qualitative sweep nets, included taxa not found in the cores, such as the lagoon specialist snail *Ecrobia ventrosa* and a common goby (*Pomatoschistus microps*).

Hard substrata were present only as scattered anthropogenic items, such as large pieces of litter and collapsed concrete structures. They were colonised by green algae (*Ulva* sp/p.).

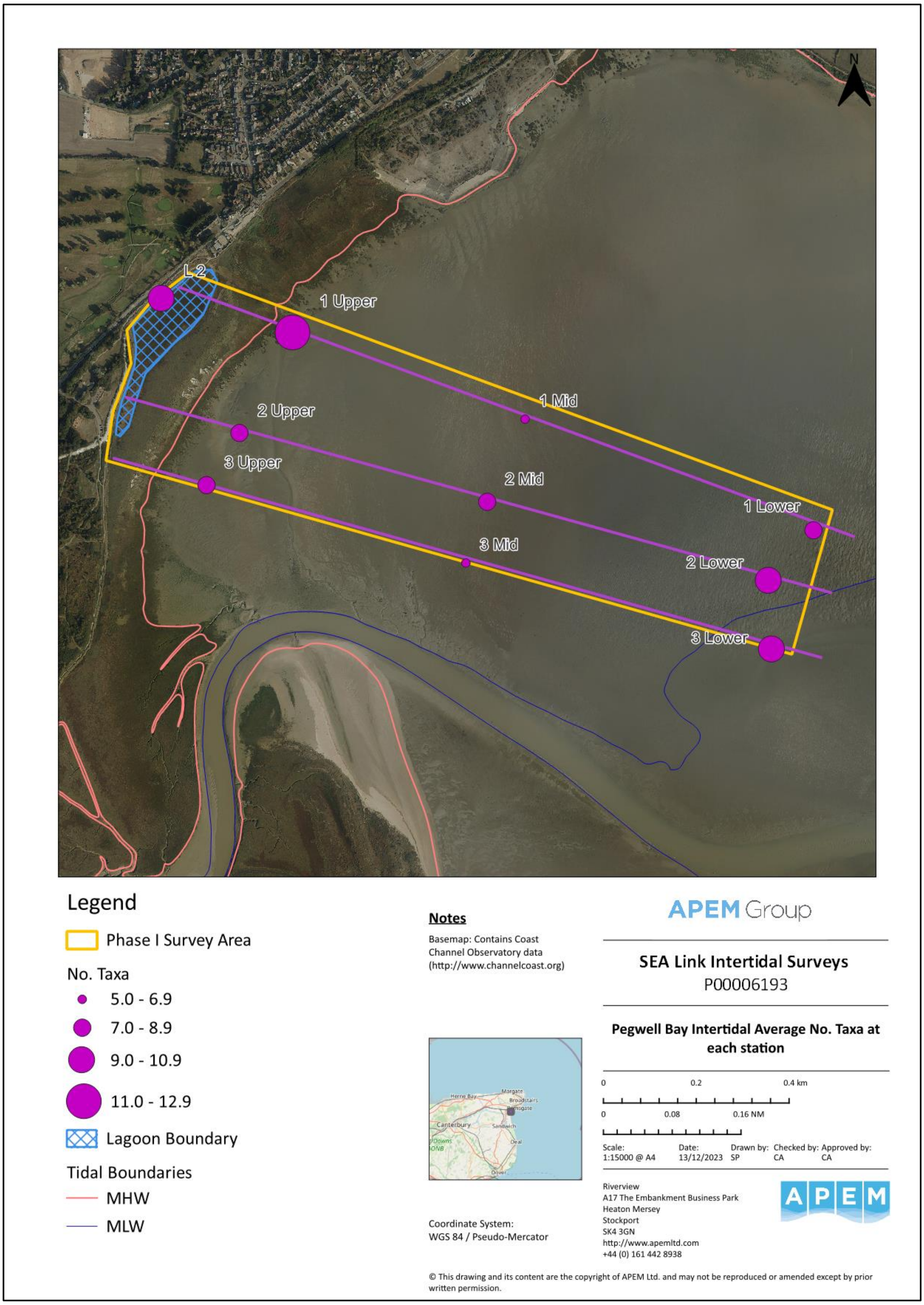

Figure 19. Mean numbers of taxa per station at Pegwell Bay

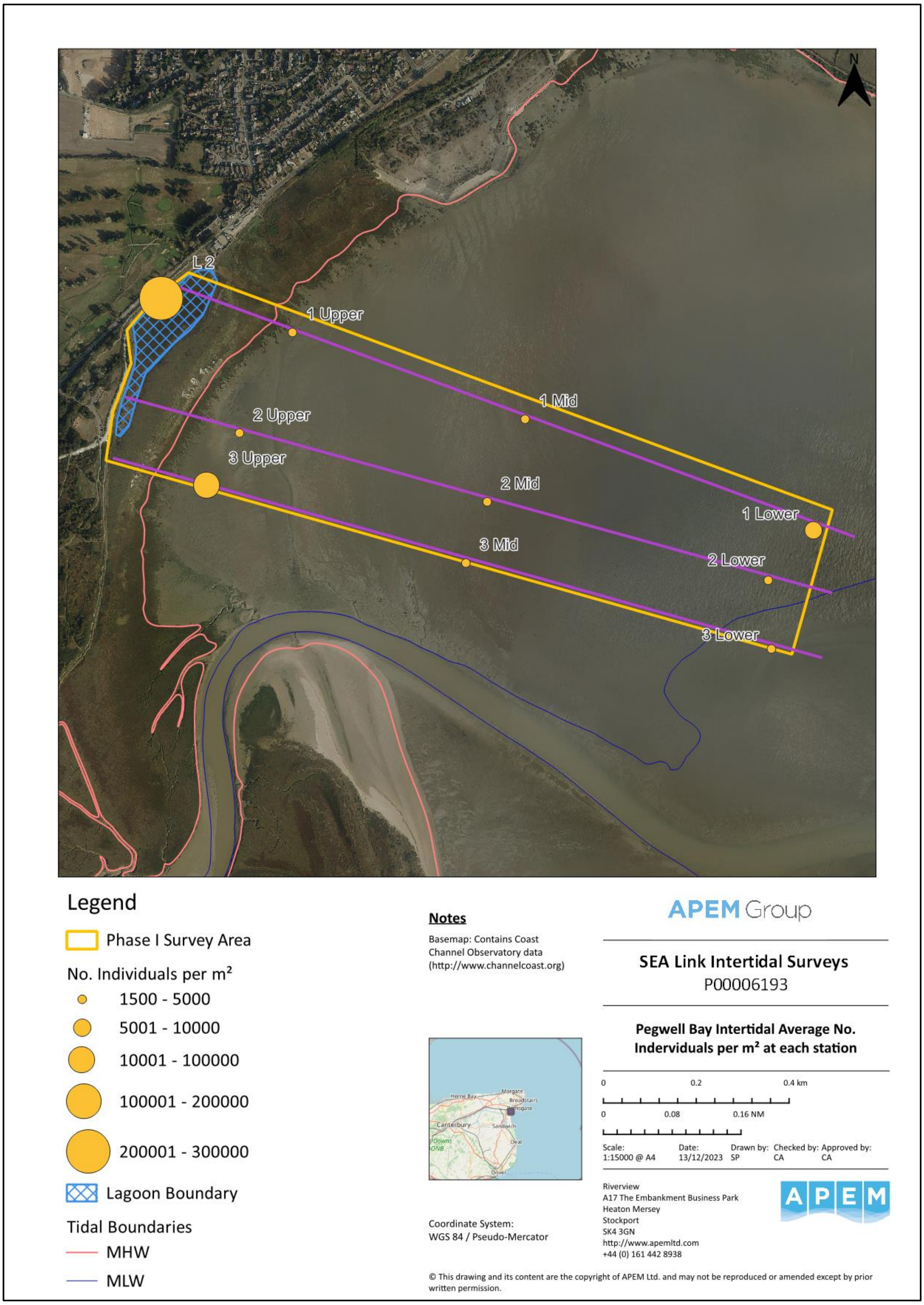

Figure 20. Mean numbers of individuals per m² per station at Pegwell Bay

3.5.2 *Aldeburgh*

Raw biological data are presented in Appendix 3 for core samples. Appendix 5 shows photographs of *in situ* core samples. Appendix 6 shows photographs of *in situ* quadrat samples. Mean abundance data for each sampling point, standardised to numbers per m^2, are presented for core samples in Table 10, below.

Table 10. Average abundance data per m^2 in core samples from Aldeburgh

Taxon Name	Qualifier	AT1 M	AT2 M	AT3 M	AT1 L	AT2 L	AT3 L	Mean
Animalia	eggs	-	P	-	-	-	-	-
Nematoda		-	-	-	33.33	-	33.33	33.33
Spionidae	larva	-	-	-	-	-	66.67	66.67
Eurydice inermis		-	-	-	-	-	33.33	33.33
Total no. taxa		0	1	0	1	0	2	-

Most Aldeburgh core samples were without biota. Four taxa were recorded across all samples, including non-countable eggs; all were found only as single occurrences per sample, with the exception of two nematodes in AT3C.

Raw data for the quadrats are presented in Table 11 and photographs of quadrats are shown in Appendix 6.

Table 11. Average abundance data per m^2 in Aldeburgh quadrat samples

Taxon name	Station																	
	Upper Shore									Mid Shore								
	AT1A	AT1B	AT1C	AT2A	AT2B	AT2C	AT3A	AT3B	AT3C	AT1A	AT1B	AT1C	AT2A	AT2B	AT2C	AT3A	AT3B	AT3C
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Bare Cobbles	99	100	95	97	100	55	100	100	100	100	100	100	100	100	100	100	100	100
Lathyrus japonicus	1		5			45												
Crambe maritima				3														
Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Upper shore quadrats included occasional shingle vegetation, also noted for the wider area. Mid and lower shore quadrats were without conspicuous biota and no invertebrates or algae were found in any quadrat.

3.6 Supralittoral vegetation

Saltmarsh vegetation was noted along and above high-water level at Pegwell Bay but not surveyed.

At Aldeburgh, shingle vegetation was recorded above a steeply sloping barren shingle zone above high-water level. Above the barren zone, there was a shingle ridge colonised by sea kale (*Crambe maritima*; Appendix 7) and sea pea (*Lathyrus japonicus*; Appendix 7). *Crambe maritima* made up most of the vegetation cover of the shingle ridge, just above the barren zone. *Lathyrus japonicus* sporadically occurred along the ridge, as single plants, or small clusters of individuals. In vegetated areas, there was organic material (soil) between the pebbles. There was a channel behind the ridge with more barren shingle. Behind this channel, the higher ground included mainly terrestrial vegetation but also on shingle. On the North side of the boundary, the vegetation was mostly small herbaceous flowering plants and carpeting vegetation such as grasses and mosses. Among the most common vegetation within the Northern boundary were: Buck's-horn Plantain (*Plantago coronopus*, Appendix 7), Narrow-leaved Plantain (*Plantago lanceolata*, Appendix 7), Cat's-ear (*Hypochaeris radicata*, Appendix 7), Sheep's sorrel (*Rumex acetosella*, Appendix 7), Common sorrel (*Rumex acetosa*, Appendix 7), Curled dock (*Rumex crispus*, Appendix 7and Common yarrow (*Achillea millefolium*, Appendix 7). Shrubs such as, Wormwood (*Artemisia absinthium*, Appendix 7) and Sea wormwood (*Artemisia maritima*, Appendix 7) were also present on the northern side of the boundary. The southern part of the boundary had sparser vegetation cover, including the plants listed above, however, it hosted a greater number of shrubs and bushes. The shrubs and bushes located on the southern edge of the boundary were identified as Holm Oak (*Quercus ilex*, Appendix 7) and Holly (Ilex a*quifolium*, Appendix 7). The main road and the beach were separated by a thick line of vegetation and a ditch. The vegetation separating the road and beach comprised Bramble (*Rubus fruticosus* agg., Appendix 7), Roses (*Rosa* sp./p., Appendix 7) Other species found are included in the appendix (Appendix 7).

3.7 Calculated indices

The core samples collected from the two areas showed different characteristics and are discussed separately, below.

3.7.1 Pegwell Bay

Univariate statistics are presented in Table 9. Shannon Wiener diversity $\log_e$ values for the core samples ranged from 0.08 in the lagoon (Lag 3) to 2.40 at an upper shore station (PT1UB). Simpson diversity values ranged from 0.18 at PT1MA to 0.91 at PT1UB and PT3LC. Margalef's species richness (D) ranged from 0.77 at PT1MC to 3.50 at PT1UB. Pielou's Evenness (J') values ranged from 0.28 at PT1MA to 0.96 at PT3MB. An average from each set of upper, mid and lower core samples indicated that the highest diversity was on the lower shore, with the lowest on the mid shore. The average biomass per m^2 ranged from 464.17g at PT3L to 0.003g in the lagoon.

3.7.2 Aldeburgh

For most stations at Aldeburgh, values were unattainable for diversity indices due to the absence or scarcity of biota.

3.8 Notable taxa

3.8.1 Pegwell Bay

None of species recorded from the Pegwell Bay core samples were confirmed as non-native (NNS). However, the polychaete *Polydora cornuta* is considered cryptogenic (possibly non-native), and the same may be true for *Tharyx* 'Species A', which is probably *T. robustus*. Also, some of the taxa recorded at higher taxonomic levels could include NNS: *Streblospio*, Chironomidae and *Amathia*.

No British Red Data Book (Bratton, 1991) or protected species (Betts, 2001) were recorded. The snail *Ecrobia ventrosa* is a lagoonal specialist, listed as Nationally Scarce (Sanderson, 1996). Brown shrimp (*Crangon crangon*), mussels (*Mytilus edulis*) and cockles (*Cerastoderma edule*) are edible species of potential commercial importance.

3.8.2 Aldeburgh

None of species recorded from the Aldeburgh core samples were confirmed as NNS and no British Red Data Book (Bratton, 1991) or protected species (Betts, 2001) were recorded.

Of the species recorded from the shingle vegetation, Sea Pea (*Lathyrus japonicus*) is in decline and listed as Nationally Scarce in the UK by JNCC. Both sea pea and sea kale (*Crambe maritima*) are protected under the Wildlife & Countryside Act (1981) and must not be picked without permission from the landowner.

3.9 Biotope assignments: Pegwell Bay

Recorded biotopes for Pegwell Bay are included in Table 12, below. They are mapped in

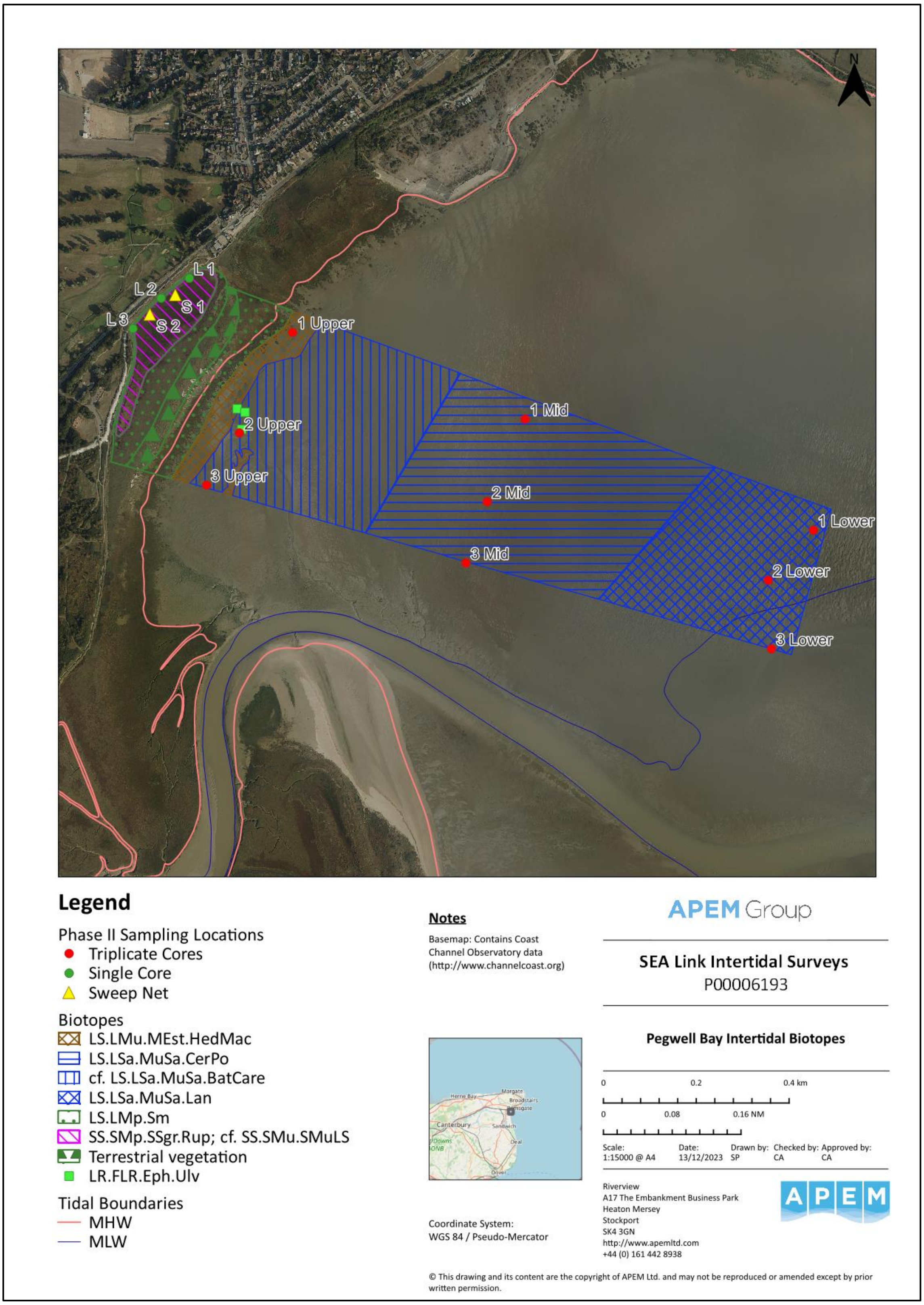

Figure 21, below.

Table 12. Biotope descriptions and codes for Pegwell Bay

JNCC Code	Description	EUNIS Code (2022)	EUNIS code (2012)
LR.FLR.Eph.Ent	*Enteromorpha* spp. on freshwater-influenced and/or unstable upper eulittoral rock	MA123G	A1.451
LS.LMp.Sm	Saltmarsh	MA22	A2.5
LS.LMu.MEst.HedMac	*Hediste diversicolor* and *Macoma balthica* in littoral sandy mud	MA6224	A2.312
LS.LSa.MuSa.BatCare	*Bathyporeia pilosa* and *Corophium arenarium* in littoral muddy sand	MA5254	A2.244
LS.LSa.MuSa.MacAre	*Macoma balthica* and *Arenicola marina* in littoral muddy sand	MA5251	A2.241
LS.LSa.MuSa.CerPo	*Cerastoderma edule* and polychaetes in littoral muddy sand	MA5252	A2.242
LS.LSa.MuSa.Lan	*Lanice conchilega* in littoral sand	MA5255	A2.245
SS.SMp.SSgr.Rup	*Ruppia maritima* in reduced salinity *Atlantic infralittoral* muddy sand	MB5224	A5.5343
cf. SS.SMu.SMuLS	Sublittoral mud in low or reduced salinity (lagoons)	MB626	A5.31

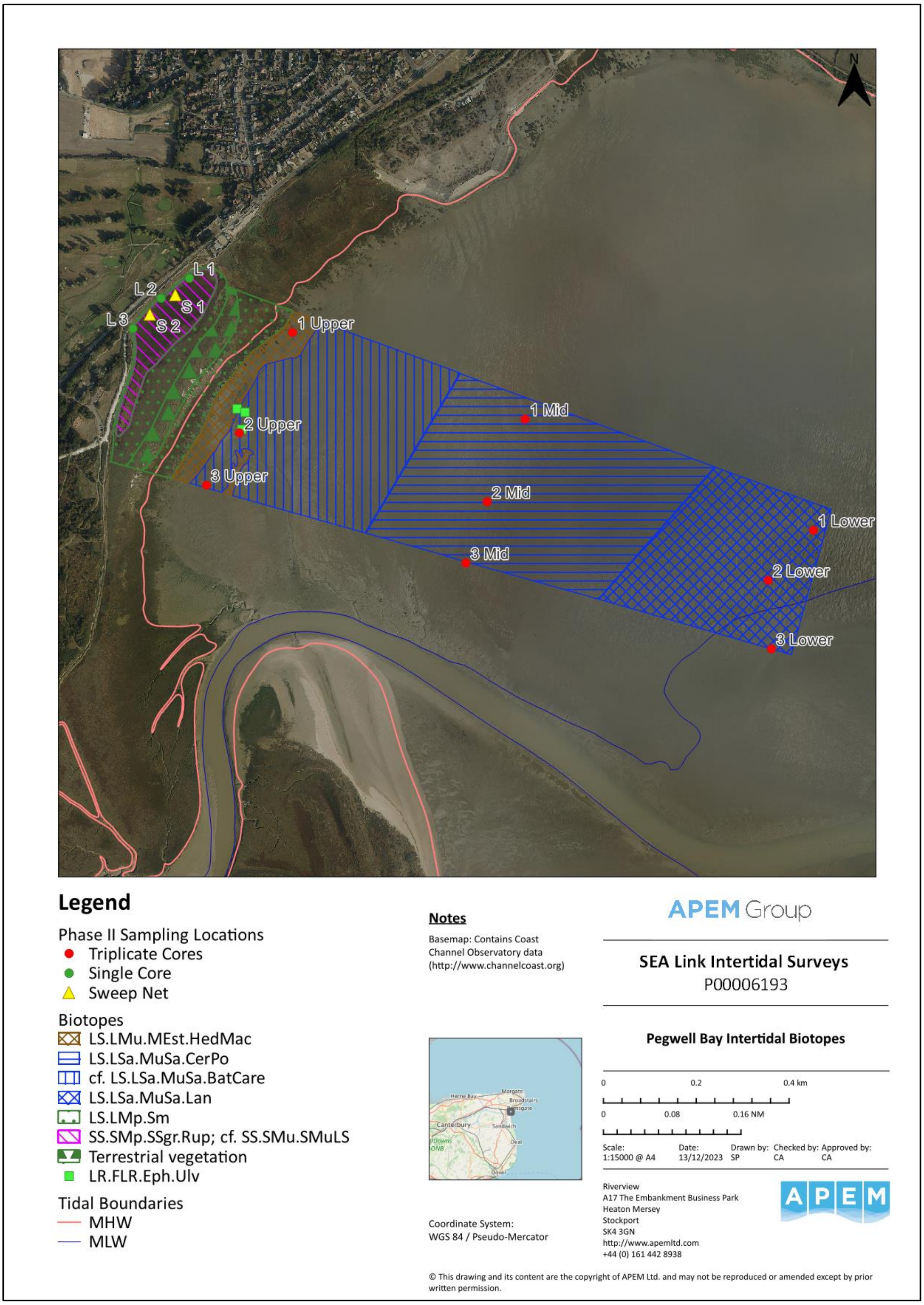

Figure 21. Biotope map for Pegwell Bay

3.9.1 Littoral rock (LR; MA1) biotopes at Pegwell Bay

Some scattered items of litter and collapsed concrete structures on the upper to mid shore at Pegwell Bay were colonised by *Ulva* sp/p. (Figure 22) and could be classified as LR.FLR.Eph.Ent (*Enteromorpha* spp. on freshwater-influenced and/or unstable upper eulittoral rock; MA123G; A1.451).

Figure 22. Concrete structure with *Ulva* (LR.FLR.Eph.Ent) on the mid shore at Pegwell Bay; Cliffsend in background; 13th June 2023

3.9.2 Saltmarsh (LS.LMp.Sm; MA22) biotopes at Pegwell Bay

Saltmarsh and other supralittoral vegetation was noted across most of the high-water level and above and along both landward and seaward edges of the lagoon (Figure 23). It was not surveyed in detail and is left assigned to the complex LS.LMp.Sm, which is contained within the wider biogenic habitat classification (Atlantic littoral biogenic habitat; MA22; A2.5) in the EUNIS system.

Figure 23. Saltmarsh (LS.LMp.Sm) on either side of narrow section of lagoon, 13th June 2023

3.9.3 Littoral sand (LS; MA5) biotopes at Pegwell Bay

LS.LMu.MEst.HedMac (*Hediste diversicolor* and *Macoma balthica* in littoral sandy mud; MA6224; A2.312) was recorded from patches of upper shore mudflats, where the sediment was noticeably muddier and from the fauna in cores from the upper shore of Transect 1.

The other upper shore sediments (Figure 24) were provisionally assigned to LS.LSa.MuSa.BatCare (*Bathyporeia pilosa* and *Corophium arenarium* in littoral muddy sand; MA5254; A2.244) on the basis of sample data. However, there were few *Corophium arenarium* and many lugworm casts (Figure 25) were noticed in the field, so that they also showed characteristics of LS.LSa.MuSa.MacAre (*Macoma balthica* and *Arenicola marina* in littoral muddy sand; MA5251; A2.241).

Figure 24. Upper shore rippled sand (cf. LS.LSa.MuSa.BatCare); Cliffsend in background to NE, 13th June 2023

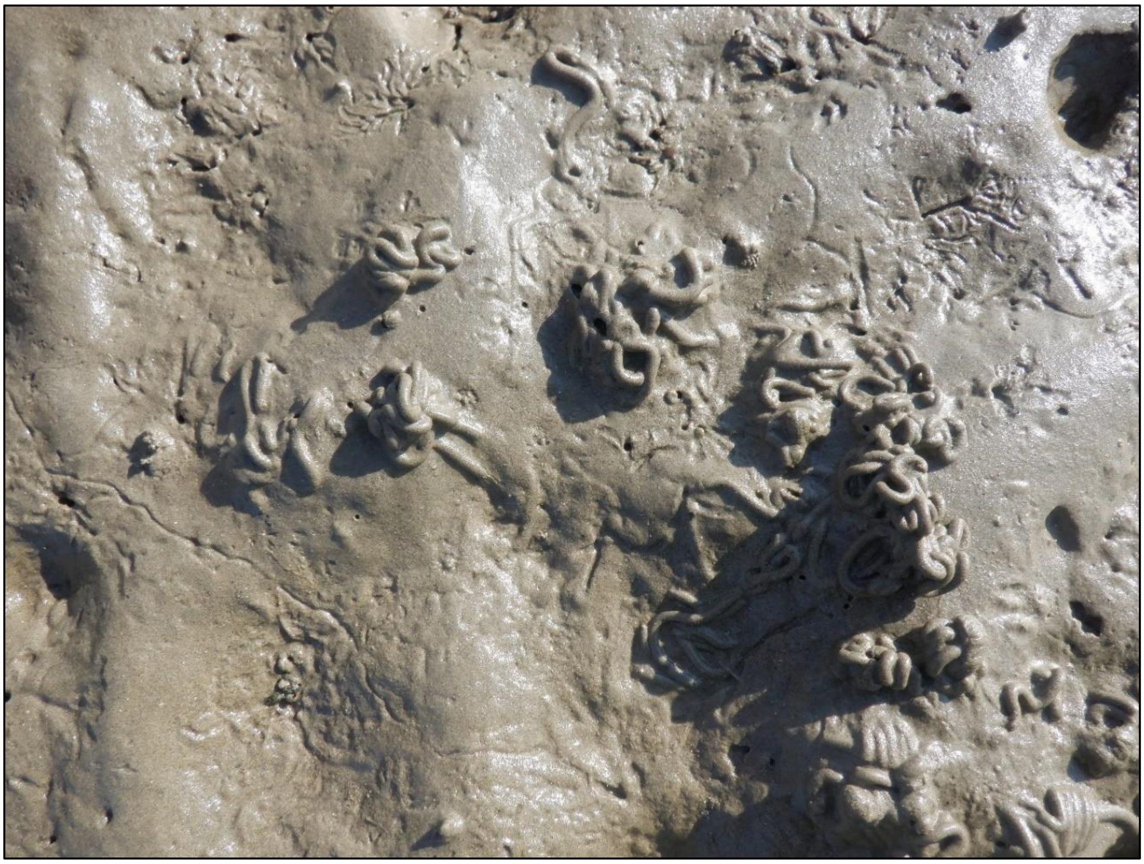

Figure 25. *Arenicola marina* casts and other burrows (LS.LSa.MuSa.MacAre), PT1, 13th June 2023

The mid shore sandflats (Figure 26) were less rippled and included more polychaete worms (such as *Pygospio elegans* and *Scoloplos armiger*) and cockles (*Cerastoderma edule*). The core samples were assigned to LS.LSa.MuSa.CerPo (*Cerastoderma edule* and polychaetes in littoral muddy sand; MA5252; A2.242).

Figure 26. Mid shore sandflat (LS.LSa.MuSa.CerPo), near PT3, 14th June 2023

The lower shore sandflats (Figure 27) included extensive beds of sand mason worms (*Lanice conchilega*); their tubes could be noted and mapped in the field. Both field observations and cores fitted the biotope LS.LSa.MuSa.Lan (*Lanice conchilega* in littoral sand; MA5255; A2.245).

Figure 27. Lower shore sand mason worm patches (LS.LSa.MuSa.Lan), Ramsgate cliffs in background to NE, 14th June 2023

The muddy sand within the lagoon (Figure 28) could be characterised as SS.SMp.SSgr.Rup (*Ruppia maritima* in reduced salinity Atlantic infralittoral muddy sand; MB5224; A5.5343). It could also be considered to fit within cf. SS.SMu.SMuLS (Sublittoral mud in low or reduced salinity (lagoons); MB626; A5.31).

Figure 28. ***Ruppia maritima*** **in lagoon (SS.SMp.SSgr.Rup), Ramsgate cliffs in background to east, 13th June 2023**

3.10 Biotope assignments: Aldeburgh

Recorded biotopes for Aldeburgh are included in Table 13, below. They are mapped in Figure 29, below.

Table 13. Biotope descriptions and codes for Aldeburgh

JNCC Code	Description	EUNIS Code (2022)	EUNIS code (2012)
LR.FLR.Eph.Ent	*Ulva intestinalis* on freshwater-influenced and/or unstable upper eulittoral rock	MA123G	A1.451
LS.LCS.Sh.BarSh	Barren littoral shingle	MA3211	A2.111
(none)	Unvegetated mobile shingle beaches above the driftline	N21#1	B2.2
(none)	Channel *Crambe maritima* communities	N215	B2.32
(none)	Upper shingle with terrestrial vegetation	N21#2	B2.3

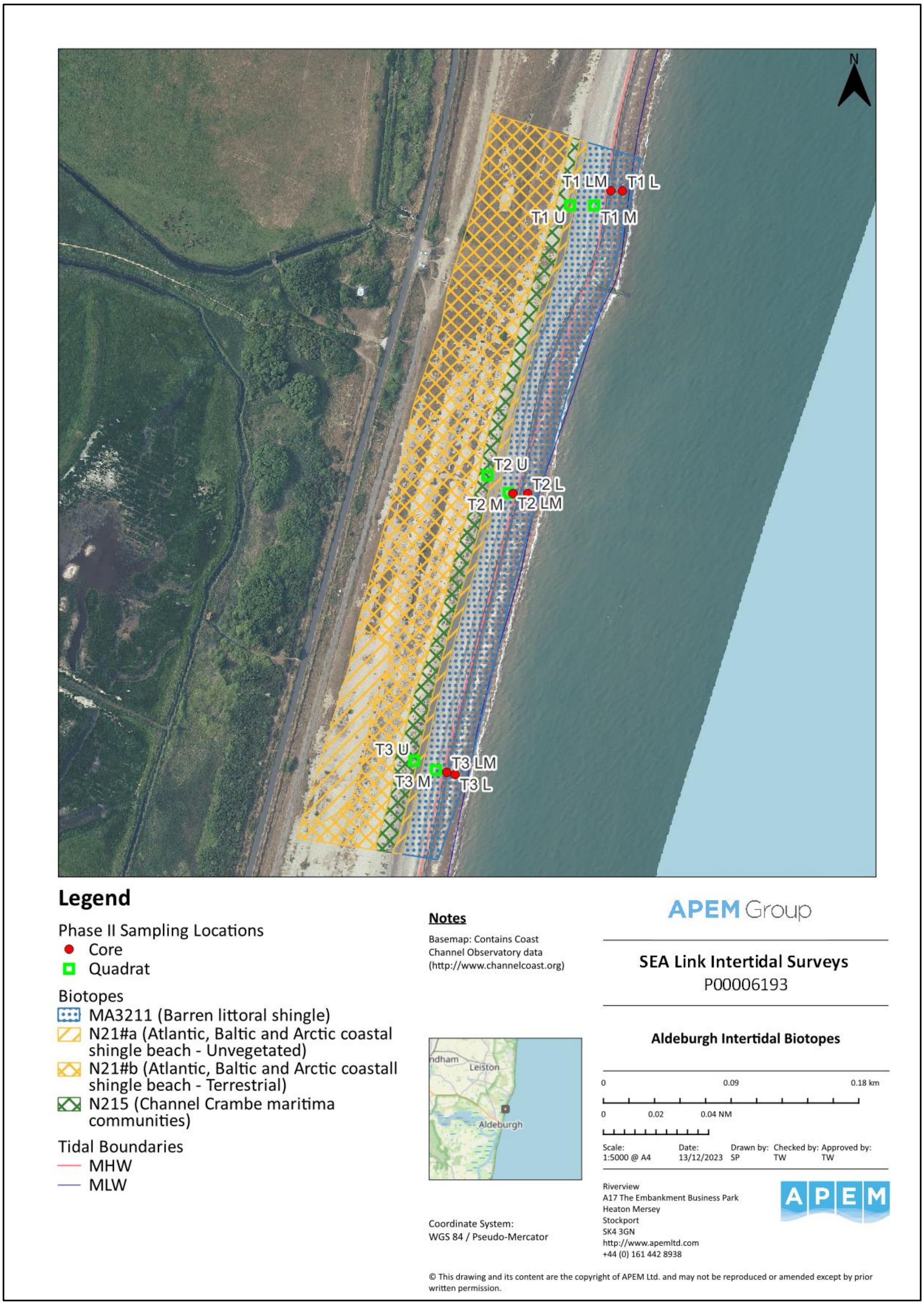

Figure 29. Biotope map for Aldeburgh

3.10.1 Littoral rock (LR; MA1) biotopes

Concrete structures on the upper to mid shore were colonised by *Ulva* sp/p. (Figure 30). and could be classified as LR.FLR.Eph.Ent (*Enteromorpha* spp. on freshwater-influenced and/or unstable upper eulittoral rock; MA123G; A1.451).

Figure 30. *Ulva* (LR.FLR.Eph.Ent) on concrete block at Aldeburgh, 12 September 2023

3.10.2 Littoral sand (LS; MA5) biotopes at Aldeburgh

The upper shore and most of the mid shore at Aldeburgh was covered in barren shingle (Figure 31 and Figure 32). Most of the area clearly fitted LS.LCS.Sh.BarSh (Barren littoral shingle; MA3211; A2.111).

Figure 31. Extensive steep bank of upper to mid shore barren shingle (LS.LCS.Sh.BarSh), view S towards Aldeburgh, 12th September 2023

Figure 32. Upper shore barren shingle (LS.LCS.Sh.BarSh), Aldeburgh, 12th September 2023

The lower shore at Aldeburgh was coarse sand mixed with pebbles (Figure 33); on the mid shore, the sand merged into the barren shingle. As with the upper shore, these areas are mapped as LS.LCS.Sh.BarSh, due to the large gravel component even in sandy areas. However, the sandier patches were intermediate with LS.LSa.MoSa.BarSa (Barren littoral coarse sand; MA5231; A2.221).

Figure 33. Lower shore Coarse sand (LS.LCS.Sh.BarSh) mixed with shingle (LS.LCS.Sh.BarSh), Aldeburgh, Thorpeness in background, 12th September 2023

3.10.3 Coastal shingle (N2) biotopes at Aldeburgh

The supralittoral shingle at Aldeburgh (Figure 34) fitted the 2021 EUNIS habitat N21 (Atlantic, Baltic and Arctic coastal shingle beach; B2 of 2004), not covered by the JNCC (Connor et al., 2004) classification. The zone of barren shingle above high-water level could be classified as unvegetated mobile shingle beaches above the driftline (B2.2 of 2004); as this biotope appears not to be included in the most recent classification, it has been listed as N21#A on the map (Figure 29). The vegetated shingle with sea kale (*Crambe maritima*) and sea pea (Lathyrus japonicus) fitted N215 (channel *Crambe maritima* communities; B232 of 2012). The shingle above this zone included mainly terrestrial vegetation that could not be easily fitted to EUNIS and has been listed as N21#B.

Figure 34. Vegetated shingle with sea kale (*Crambe maritima*) (N215) above the shore at Aldeburgh, 12th September 2023

4. Discussion

The two proposed landfall sites were very different from each other in terms of the characteristics of the shore, and habitats and species present.

4.1 Pegwell Bay

Pegwell Bay comprised a wide expanse of sandflats, with saltmarsh vegetation and a shallow percolating lagoon on the upper shore. The upper shore sand was muddier and included areas with many ragworms (*Hediste diversicolor*) that were assigned to LS.LMu.MEst.HedMac (*Hediste diversicolor* and *Macoma balthica* in littoral sandy mud; MA6224; A2.312). Other upper shore sand was more rippled, with scattered lugworm (*Arenicola marina*) casts and many burrowing amphipods, *Bathyporeia pilosa*; these fitted LS.LSa.MuSa.BatCare (*Bathyporeia pilosa* and *Corophium arenarium* in littoral muddy sand; MA5254; A2.244). On the mid shore, the sand was less rippled, included more polychaete worms and cockles (*Cerastoderma edule*) and fitted LS.LSa.MuSa.CerPo (*Cerastoderma edule* and polychaetes in littoral muddy sand; MA5252; A2.242) The lower shore included beds of sand mason worms (*Lanice conchilega*) and was assigned to LS.LSa.MuSa.Lan (*Lanice* *conchilega* in littoral sand; MA5255; A2.245). There were also scattered concrete structures and items of litter colonised by green algae (*Ulva* sp/p.) that could be assigned to LR.FLR.Eph.Ent (*Enteromorpha* spp. on freshwater-influenced and/or unstable upper eulittoral rock; MA123G; A1.451). Within the lagoon, beds of tasselweed (*Ruppia maritima*) suggested the biotope SS.SMp.SSgr.Rup (*Ruppia maritima* in reduced salinity Atlantic infralittoral muddy sand; MB5224; A5.5343). Areas of saltmarsh surrounding the lagoon and other parts of the extreme upper shore were not surveyed in detail.

Saltmarsh and mudflats are listed in the List of priority habitats and species in England ('Section 41 habitats and species'), as are saline lagoons. The *Ruppia*-dominated habitat within the lagoon could be considered to belong to one of the Habitats of Conservation importance (HOCI) listed by MarLIN (Tyler-Walters & d'Avack, 2015): *Ruppia maritima* in reduced salinity infralittoral muddy sand. This biotope is listed by MarLIN as having low resistance to water flow changes and to 'disturbance of the substratum subsurface'. The fauna of the sandflats would be expected to recover once disturbed sediment has returned to its original state. Any disturbance to the saltmarsh or lagoon should be avoided, particularly where there may be a danger of affecting hydrology (i.e. patterns of water entering or leaving the lagoon), such as changes to the nature of drainage channels around the lagoon.

The metals and hydrocarbons analysed for the Pegwell Bay sandflats were below background and threshold levels, with the exception of Arsenic, which was higher than the threshold for several samples but still below background levels; arsenic can have effects on organisms at lower concentrations than may naturally be found in sediments. Both metal and hydrocarbon concentrations within the lagoon were much higher and above threshold levels for Copper, Mercury, Nickel, Lead and Zinc and above the background level for Cadmium. It is likely that the enclosed nature of the lagoon allowed for gradual accumulation of contaminants from the nearby road. Hydrocarbons were also elevated at two of the upper shore stations. The reason for this is not immediately obvious, but it may be that hydrocarbons in the lagoon, which were also elevated, have percolated through the sediment to the upper shore as the water from the lagoon drains between tides.

4.2 Aldeburgh

At Aldeburgh, the shore was dominated by shingle, often steeply sloping, with some sandy areas on the lower shore and vegetation above the upper shore. As at Pegwell Bay, there were also some isolated concrete structures colonised by green algae (*Ulva* sp/p.) that could be assigned to LR.FLR.Eph.Ent (*Enteromorpha* spp. on freshwater-influenced and/or unstable upper eulittoral rock; MA123G; A1.451). The intertidal shingle was almost barren and assigned to LS.LCS.Sh.BarSh (Barren littoral shingle; MA3211; A2.111). Supralittoral shingle communities are not covered by the JNCC classification. Barren shingle above high-water level falls within the EUNIS (2022) habitat N21 (Atlantic, Baltic and Arctic coastal shingle beach) and is given the suffix #A to represent the more precise habitat that it had been given under the previous (2012) classification: B2.2 (unvegetated mobile shingle beaches above the driftline). Vegetated shingle above the barren zone was colonised by sea kale (*Crambe maritima*) and sea pea (*Lathyrus japonicus*) and fitted N215 (B2.32; channel *Crambe maritima* communities). Denser vegetation higher up the shingle bank included brambles (*Rubus fruticosus* agg.) and other fully terrestrial species and is listed as N21#B.

The vegetated shingle, included in the List of priority habitats and species in England (‘Section 41 habitats and species’) as ‘Coastal vegetated shingle’ are considered sensitive to disturbance. The area adjacent to the proposed Aldeburgh landfall is listed by Sneddon & Randall (1994), as part of the Thorpeness site in their list of shingle sites in England. Murdock et al. (2010) describe deterioration in the quality of the Thorpeness site due to sediment change and human disturbance. It will be important to ensure that any further damage cannot be attributed to the landfall by avoiding any disturbance to supralittoral vegetated shingle.

None of the marine species recorded in either area were non-native or considered to be of conservation importance. However, two of the shingle plants, sea kale (*Crambe maritima*) and sea pea (*Lathyrus japonicus*), are considered important and protected under the Wildlife & Countryside Act (1981), with *L. japonicus* considered to be declining. The few species to be found in the mobile gravel habitats comprising most of the intertidal at Aldeburgh have opportunistic life history strategies, with short lifespans, rapid maturation and extended reproductive periods and can withstand sediment mobilisation through a combination of robustness, mobility and ability to re-position themselves within the substratum. As such, they are tolerant of disturbed environments and can recover quickly.

The metals and hydrocarbons analysed for Aldeburgh were all below background and threshold levels, with most below detectable limits.

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Appendix 1 Core and Sweep Sample Locations at Pegwell Bay

Original label	Label used on survey	Sample Type	Date	Time	Lat (WGS84)	Long (WGS84)
T1 upper	PT1U A	Core	13/06/2023	17:28	51.323430	1.367407
T1 upper	PT1U B	Core	13/06/2023	17:28	51.323430	1.367407
T1 upper	PT1U C	Core	13/06/2023	17:28	51.323430	1.367407
T2 upper	PT2U A	Core	13/06/2023	16:45	51.321483	1.365768
T2 upper	PT2U B	Core	13/06/2023	16:45	51.321483	1.365768
T2 upper	PT2U C	Core	13/06/2023	16:45	51.321483	1.365768
T3 Upper	PT3U A	Core	13/06/2023	16:21	51.320475	1.3647502
T3 upper	PT3U B	Core	13/06/2023	16:21	51.320475	1.3647502
T3 upper	PT3U C	Core	13/06/2023	16:21	51.320475	1.3647502
Lagoon 1	PLag 1	Core	13/06/2023	18:30	51.324473	1.364219
Lagoon 2	PLag 2	Core	13/06/2023	18:37	51.324087	1.363347
Lagoon 3	PLag 3	Core	13/06/2023	18:48	51.323500	1.362477
T1 middle	PT1M A	Core	13/06/2023	14:05	51.321750	1.374598
T1 middle	PT1M B	Core	14/06/2023	14:05	51.321750	1.374598
T1 middle	PT1M C	Core	14/06/2023	14:05	51.321750	1.374598
T2 middle	PT2M A	Core	14/06/2023	13:33	51.320153	1.373427
T2 middle	PT2M B	Core	14/06/2023	13:33	51.320153	1.373427
T2 middle	PT2M C	Core	14/06/2023	13:33	51.320153	1.373427
T3 middle	PT3M A	Core	14/06/2023	13:14	51.318970	1.372767
T3 middle	PT3M B	Core	14/06/2023	13:14	51.318970	1.372767
T3 middle	PT3M C	Core	14/06/2023	13:14	51.318970	1.372767
T1 lower	PT1L A	Core	14/06/2023	14:48	51.319603	1.383512
T1 lower	PT1L B	Core	14/06/2023	14:48	51.319603	1.383512
T1 lower	PT1L C	Core	14/06/2023	14:48	51.319603	1.383512
T2 lower	PT2L A	Core	14/06/2023	15:08	51.318636	1.382114
T2 lower	PT2L B	Core	14/06/2023	15:08	51.318636	1.382114
T2 lower	PT2L C	Core	14/06/2023	15:08	51.318636	1.382114
T3 lower	PT3L A	Core	14/06/2023	15:24	51.317310	1.382213
T3 lower	PT3L B	Core	14/06/2023	15:24	51.317310	1.382213
T3 lower	PT3L C	Core	14/06/2023	15:24	51.317310	1.382213
Sweep 1	PS1 U	Sweep	14/06/2023	11:57	51.324152	1.363784
Sweep 1	PS1 L	Sweep	14/06/2023	11:57	51.324152	1.363784
Sweep 2	PS2 U	Sweep	14/06/2023	11:45	51.323774	1.362997
Sweep 2	PS1 L	Sweep	14/06/2023	11:45	51.323774	1.362997

Appendix 2 Core and Quadrats Sample Locations at Aldeburgh

Original label	Label used on survey	Sample Type	Date	Time	Lat (WGS84)	Long (WGS84)
T1 upper	AT1U A	Quadrat	12/09/2023	13:32	52.168322	1.609359
T1 upper	AT1U B	Quadrat	12/09/2023	13:32	52.168322	1.609359
T1 upper	AT1U C	Quadrat	12/09/2023	13:32	52.168322	1.609359
T2 upper	AT2U A	Quadrat	12/09/2023	14:08	52.166616	1.608508
T2 upper	AT2U B	Quadrat	12/09/2023	14:08	52.166616	1.608508
T2 upper	AT2U C	Quadrat	12/09/2023	14:08	52.166616	1.608508
T3 Upper	AT3U A	Quadrat	12/09/2023	12:01	52.164812	1.607753
T3 upper	AT3U B	Quadrat	12/09/2023	12:01	52.164812	1.607753
T3 upper	AT3U C	Quadrat	12/09/2023	12:01	52.164812	1.607753
T1 middle	AT1M A	Quadrat	12/09/2023	13:45	52.168322	1.609608
T1 middle	AT1M B	Quadrat	12/09/2023	13:45	52.168322	1.609608
T1 middle	AT1M C	Quadrat	12/09/2023	13:45	52.168322	1.609608
T2 middle	AT2M A	Quadrat	12/09/2023	14:24	52.166504	1.608726
T2 middle	AT2M B	Quadrat	12/09/2023	14:24	52.166504	1.608726
T2 middle	AT2M C	Quadrat	12/09/2023	14:24	52.166504	1.608726
T3 middle	AT3M A	Quadrat	12/09/2023	12:40	52.164753	1.607976
T3 middle	AT3M B	Quadrat	12/09/2023	12:40	52.164753	1.607976
T3 middle	AT3M C	Quadrat	12/09/2023	12:40	52.164753	1.607976
T1 lower-middle	AT1LM A	Core	12/09/2023	16:50	52.168415	1.609780
T1 lower-middle	AT1LM B	Core	12/09/2023	16:50	52.168415	1.609780
T1 lower-middle	AT1LM C	Core	12/09/2023	16:50	52.168415	1.609780
T2 lower-middle	AT2LM A	Core	12/09/2023	14:46	52.166501	1.608771
T2 lower-middle	AT2LM B	Core	12/09/2023	14:46	52.166501	1.608771
T2 lower-middle	AT2LM C	Core	12/09/2023	14:46	52.166501	1.608771
T3 lower-middle	AT3LM A	Core	12/09/2023	15:53	52.164738	1.608089
T3 lower-middle	AT3LM B	Core	12/09/2023	15:53	52.164738	1.608089
T3 lower-middle	AT3LM C	Core	12/09/2023	15:53	52.164738	1.608089
T1 lower	AT1L A	Core	12/09/2023	17:06	52.168414	1.609898
T1 lower	AT1L B	Core	12/09/2023	17:06	52.168414	1.609898
T1 lower	AT1L C	Core	12/09/2023	17:06	52.168414	1.609898
T2 lower	AT2L A	Core	12/09/2023	16:10	52.166500	1.608923
T2 lower	AT2L B	Core	12/09/2023	16:10	52.166500	1.608923
T2 lower	AT2L C	Core	12/09/2023	16:10	52.166500	1.608923
T3 lower	AT3L A	Core	12/09/2023	15:26	52.164725	1.608174
T3 lower	AT3L B	Core	12/09/2023	15:26	52.164725	1.608174
T3 lower	AT3L C	Core	12/09/2023	15:26	52.164725	1.608174

Appendix 3 Raw data for biological, particle size and contaminant samples for Pegwell Bay and Aldeburgh

Please see file attached within this PDF.

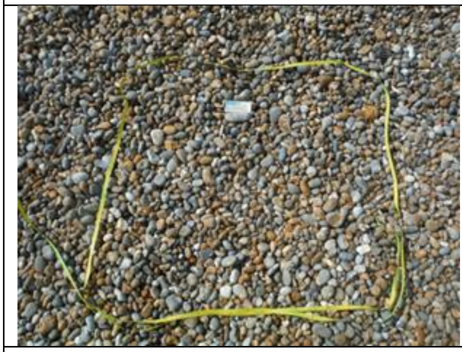
Appendix 4 Photographs of each core sample: Pegwell Bay

		
PT1U	**PT1M**	**PT1L**
		
PT2U	**PT2M**	**PT2L**
		
PT3U	**PT3M**	**PT3L**
		
PL1	**PL2**	**PL3**

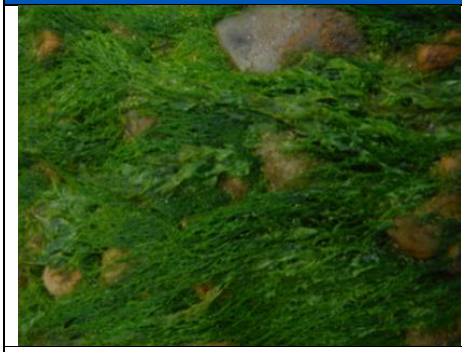
Appendix 5 Photographs of each core sample: Aldeburgh

		
AT1M	**AT2M**	**AT3M**
		
AT1L	**AT2L**	**AT3L**

Appendix 6 Photographs of each quadrat sample: Aldeburgh

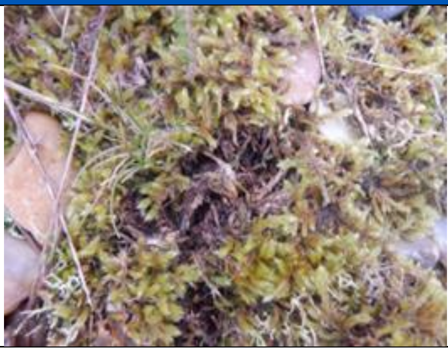
		
AT1U	**AT2U**	**AT3U**
		
AT1M	**AT2M**	**AT3M**

Appendix 7 Photographs of species found during the surveys.

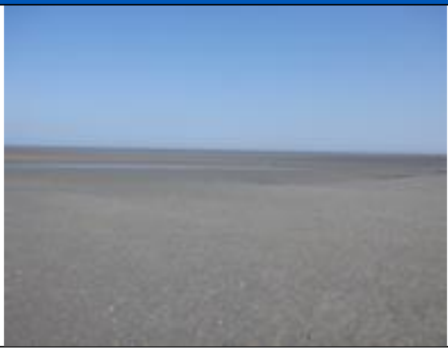
		
***Ulva intestinalis* at Aldeburgh** **(Lat: 52.167694, Long: 1.609592)**	***Ruppia maritima* at Pegwell Bay** **(Lat: 51.324152, Long: 1.363784)**	**Lichens (*Ramalina*) at Aldeburgh** **(Lat: 52.164969, Long: 1.607238)**
		
Yellow horned poppy (*Glaucium flavum*) at Aldeburgh **(Lat: 52.164617, Long: 1.607127)**	**Rest harrow (*Ononis repens*) at Aldeburgh** **Track: Veg patch path**	**Bird's-foot Trefoil (*Lotus corniculatus*) at Aldeburgh** **Track: Pebble North bound**
		
Sea Pea (*Lathyrus japonicus*) at Aldeburgh **(Lat: 52.168322, Long: 1.609359)**	**Bramble (*Rubus fruticosus* agg.) at Aldeburgh** **(Lat: 52.168176, Long: 1.608255)**	**Roses (*Rosa* sp.) at Aldeburgh** **(Lat: 52.166132, Long: 1.607129)**

		
Holm Oak (*Quercus ilex*) at Aldeburgh (Lat: 52.165407, Long: 1.607451)	**Redstem stork's-bill (*Erodium cicutarium*) at Aldeburgh Track: North bound veg**	**Sea Kale (*Crambe maritima*) at Aldeburgh (Lat: 52.168494, Long: 1.609028)**
		
Sheep's sorrel (*Rumex acetosella*) at Aldeburgh (Track: Pebble North bound)	**Common sorrel (*Rumex acetosa*) at Aldeburgh (Lat: 52.164468, Long: 1.606928)**	**Sea campion (*Silene uniflora*) at Aldeburgh (Lat: 52.167412, Long: 1.608316)**
		
Curled dock (*Rumex crispus*) at Aldeburgh (Track: Pebble North bound)	**Lady's bedstraw (*Galium verum*) at Aldeburgh (Track: North bound veg)**	**Buck's-horn Plantain (*Plantago coronopus*) at Aldeburgh (Track: Grass path)**

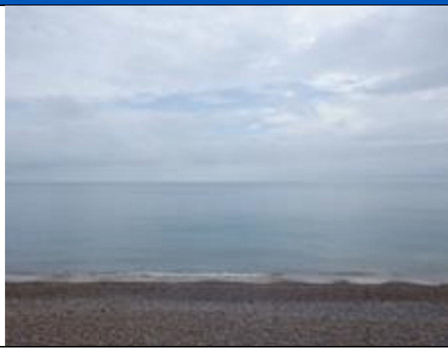
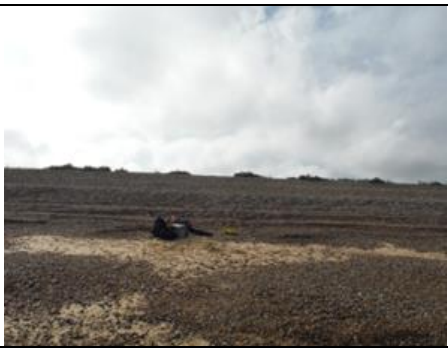
		
Common Toadflax (*Linaria vulgaris*) at Aldeburgh (Lat: 52.166832, Long: 1.607468)	**Narrow-leaved Plantain (*Plantago lanceolata*) at Aldeburgh (Track: North bound veg)**	**Holly (Ilex a*quifolium*) at Aldeburgh (Lat: 52.165163, Long: 1.607086)**
		
Cat's-ear (*Hypochaeris radicata*) at Aldeburgh (Lat: 52.16741, Long: 1.608301)	**Yellow Asteraceae (Track: Veg patch path)**	**Musk thistle (*Carduus nutans*) at Aldeburgh (Track: Veg patch path)**
		
***Wormwood (Artemisia absinthium)* at Aldeburgh (Track: Veg patch path)**	**Sea wormwood (*Artemisia maritima*) at Aldeburgh (Track: Veg patch path)**	**Common yarrow (*Achillea millefolium*) at Aldeburgh (Track: Veg patch path)**

		
Flower of sow thistle (*Sonchus*) at Aldeburgh (Lat: 52.168176, Long: 1.608255)	**Moss (Bryopsida) at Aldeburgh (Lat: 52.16741, Long: 1.608301)**	**Sand mason worm tubes (*Lanice conchilega*) at Pegwell Bay (Lat: 51.31731, Long: 1.382213)**
		
Common Carder bumble bee (*Bombus pascuorum*) at Aldeburgh (Track: Veg patch path)	**Caterpillars (Lepidoptera) at Aldeburgh (Lat:52.168176, Long: 1.608255)**	**Spider (Araneae) at Aldeburgh (Lat:52.168176, Long: 1.608255)**
		
Common garden snail (*Helix aspersa*) at Aldeburgh (Lat:52.168176, Long: 1.608255)	**Seven-spotted ladybird (*Coccinella septempunctata*) at Aldeburgh (Track: Veg patch path)**	

Appendix 8 Photographs of transects at Pegwell Bay.

		
View down shore from PT1U	**View down shore from PT2U**	**View down shore from PT3U**
		
View up shore from PT1L	**View up shore from PT2L**	**View up shore from PT3L**

Appendix 9 Photographs of transects at Aldeburgh.

		
View down shore from AT1U	**View down shore from AT2U**	**View down shore from AT3U**
		
View up shore from AT1L	**View up shore from AT2L**	**View up shore from AT3L**

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