# Preliminary Environmental Information Report Volume 2

## Appendix 19.1 Benthic Survey Report

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NEXTGEO

DOCUMENT

# Results Report - Benthic and Environmental Survey

PROJECT

## Lion Link Marine Cable Route Survey

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**Table of Abbreviations**

| **Abbreviations** | | | |
|---|---|---|---|
| AMBI | AZTIs Marine Biotic Index | NMCAQC | National Marine Chemical Analytical Quality Control Scheme |
| BAC | Background Assessment. Concentrations | nMDS | Non-Metric Multidimensional-Scaling |
| BC | Background Concentration | NMEAQC | National Marine ecotoxicological Analytical Quality Control Scheme |
| BCI | Biotic Coefficient Index | NMMP | UK National Marine Monitoring Programme |
| BDC | Biodiversity Committee | NOOA | National Oceanic and Atmospheric Administration |
| BSL | Benthic Solutions Limited | NPD | Nitrogen-Phosphorus Detector |
| CBD | Convention on Biological Diversity | OSPAR | Oslo-Paris Commission |
| CCME | Canadian Council of Ministers of the Environment | PAH | Polycyclic Aromatic Hydrocarbons |
| CEFAS | Centre for Environment, Fisheries and Aquaculture Science | PC | Physico-chemistry |
| CEMP | Coordinated Environmental Monitoring Programme | PCA | Principal Component Analysis |
| CPI | Carbon Preference Index | Ph | Phytane |
| DDV | Dual Van Veen | PMF | Priority Marine Features |
| EBS | Environmental Baseline Survey | Pr | Pristane |
| EC | European Council | PRIMER | Plymouth Routines in Multivariate Ecological Research |
| EEC | European Economic Community | PSA | Particle Size Analysis |
| EMODnet | European Marine Observation and Data Network | QGIS | Quantum Geographic Information System |
| EOL | End of Line | ROV | Remotely Operated Vehicle |
| ETRS89 | European Terrestrial Reference System 1989 | SAB_ADD | Sabellaria Additional (transect) |
| ERL | Effect Low Range | SAC | Special Areas of Conservation |
| EU | European Union | SACFOR | Superabundant, Abundant, Common, Frequent, Occasional and Rare |
| EUBS | European Union Biodiversity Strategy | SBL | Scottish Biodiversity List |
| EUNIS | European Nature Information System | SBP | Sub-bottom Profiler |
| FOCI | Feature of Conservation Interest | SD | Standard Definition |
| GPS | Global Positioning System | SD | Standard Deviation |
| GC-MS | Gas Chromatography-Mass spectrometry | SIMPROF | Similarity Profiling |

| **Abbreviations** | | | |
|---|---|---|---|
| HAS | Habitat Assessment Survey | SOL | Start of Line |
| HD | High Definition | Sp. | Species |
| HDAC | High Voltage Alternating Current | SPA | Special Protection Areas |
| HDVC | High Voltage Direct Current | SSS | Side Scan Sonar |
| HM | Heavy Metals | THC | Total Hydrocarbon Content |
| HSG | Herring Spawning Ground | TOC | Total Organic Carbon |
| IQI | Infaunal Quality Index | UK | United Kingdom |
| IUCN | International Union for Conservation of Nature | UKOOA | UK Offshore operators Association |
| JNCC | Joint Nature Conservation Committee | UK BAP | UK Biodiversity Action Plan |
| kHz | Kilohertz | UKCS | United Kingdom Continental Shelf |
| KP | Kilometre Points | UTM | Universal Transverse Mercator |
| LAT | Lowest Astronomical Tide | WAS | Wilson-auto Siever |
| LOI | Loss on Ignition | VORF | Vertical Offshore Reference Frame |
| MAG | Magnetometer | | |
| MBES | Multi Beam Echosounder | | |
| N/A | Not Applicable | | |
| NMBAQC | National Marine Biology Analytical Quality Control Scheme | | |

## Executive Summary

National Grid Ventures (NGV), in partnership with TennetT, commissioned Next GeoSolutions (NEXT), supported by Benthic Solutions Limited (BSL), to carry out a geophysical, environmental baseline and habitat assessment survey along the proposed Lion Link cable corridor. Environmental operations were carried out by Benthic Solutions Limited (BSL) aboard the *Ievoli Grey* between the 3rd and 21st of September 2024, and the remaining nearshore scope completed aboard the *Isle of Jura* between the 31st January and the 4th of February 2025.

Environmental sampling included the collection of 84 grab samples for particle size analysis, 36 samples for physico-chemical analysis (nine processed as MMO-accredited sand-sweeping stations), and 41 faunal replicates. The BSL dual Van Veen (DVV) grab was deployed at 84 stations, successfully retrieving samples at 78 locations. At six stations (LL_01_EBS, LL_02_TR, LL_03_TR, LL_64_EBS, LL_49_EBS, and LL_51_SG), the DVV grab was unable to retain samples due to coarser sediments, prompting the use of the Mini Hamon grab instead. Additionally, underwater video footage and still photographs were captured using a BSL MOD4 camera across 99 camera transects.

The seabed along the Lion Link cable route varied in gradients and composition. In the nearshore section (0.8m to 21m below LAT), sediments were mostly sandy mud, transitioning to gravelly mud and muddy gravel. Offshore (19.8m to 54.2m below LAT), the seabed was predominantly sand and gravelly sand, gradually shifting to coarser sediments.

The particle size analysis revealed variable seabed sediments along the cable route. Nearshore sediments were characterised by a higher proportion of fines (mean: 52.7%±26.0SD), with smaller amounts of sand and variable gravel. Offshore sediments were predominantly sand (45% to 100%), with variable fines and gravel, reflecting features like sandwaves and ripples. Gravel content was highly variable, with notable peaks associated with gravelly sands and pebbles. Total organic matter (TOM) and total organic carbon (TOC) were highest within the nearshore area and lower at offshore stations, corresponding to the higher sand proportions in the offshore sediments and higher fines content in the nearshore sediments.

Total hydrocarbon content (THC) and total n-alkane concentrations varied along the cable route, with the highest values in the nearshore area and lower at offshore stations. Gas chromatography (GC) traces showed hydrocarbon signatures typical of background sediments, with nearshore stations displaying a higher contribution from North Sea runoff and terrigenous material. Total PAH levels were highest nearshore, where all but one station exceeded the UKOOA 95th percentile ($0.336mg.kg^{-1}$), and one station marginally surpassed the NOAA ERL of $4.02mg.kg^{-1}$.

Organotin compounds (tributyltin and dibutyltin), organochlorine pesticides (OCPs) and polychlorinated biphenyls (PCBs) were all below their respective limits of detections at all nine stations they were analysed at. Extractable organic halogens (EOX) were below LOD at all but one station, attributed to its proximity to the shore.

In the nearshore area, concentrations of several metals (Ba, Cd, Cr, Cu, Pb, Ni, and Zn) exceeded the UKOOA SNS 50th percentile reference values, with Pb, Hg, and Zn surpassing the 95th percentile. In contrast, offshore

metal concentrations were generally lower, with no metals exceeding the UKOOA 95$^{th}$ percentile thresholds. Arsenic concentrations exceeded the NOAA ERL reference value (8.2mg.kg$^{-1}$) at most nearshore stations and surpassed Cefas cAL 1 (20mg.kg$^{-1}$) and 2 (50mg.kg$^{-1}$) levels at multiple offshore locations. Elevated arsenic levels are attributed to natural geological sources and anthropogenic activities, including historical industrial processes, and agricultural runoff from major rivers in the southern North Sea. Despite higher arsenic levels, likely due to the local geology, most other metals were below Cefas cALs and OSPAR ERL levels, indicating minimal environmental risk. Almost all chemical parameters showed a positive correlation with fines and a negative correlation with water depth, indicating higher concentrations of organics, hydrocarbons, and heavy metals at nearshore stations with finer sediments, compared to sandier offshore stations.

Macrofaunal analysis identified 4,259 individuals, with Annelida contributing the most to the total abundance. Species richness and abundance were more variable offshore, with generally lower values in the central region, which had sandy sediments and low fines content. Multivariate analysis revealed five distinct macrofaunal groupings at a 12% Bray-Curtis similarity level, correlated to sediment composition, organic matter, hydrocarbons, and metals. Sediment type was identified as the primary driver of benthic distribution, with variations in the abundance of specific species, such as the mud-dwelling polychaetes (*Lagis koreni*), and sand-dwelling bristleworm (*Nephtys cirrosa* and *Spiophanes bombyx*), differentiating the main groupings. Remaining clusters were differentiated due to low abundances of species and individuals.

The survey identified four level-four JNCC/EUNIS habitats along the cable route, predominantly classified as ‘Offshore circalittoral sands’ (SS.SSa.Osa/MD521), with patches of ‘Offshore circalittoral mixed sediment’ (SS.SMx.OMx/MD421), ‘Offshore circalittoral coarse sediment’ (SS.SCS.OCS/MD321), and occasional ‘Circalittoral muddy sand’ (SS.SSa.CMuSa/MD521) in the northernmost stations and southern coastal areas. Biogenic level-five communities included *Abra alba* and *Nucula nitidosa* in circalittoral muddy sand (SS.SSa.CMuSa.AalbNuc/MC5214), *Lagis koreni* and *Phaxas pellucidus* in circalittoral sandy mud (SS.SMu.CSaMu.LkorPpel/MC6215), and a Polychaete-rich deep *Venus* community in offshore circalittoral mixed sediment (SS.SMx.OMx.PoVen/MD4211).

The survey route showed scattered *Sabellaria spinulosa* aggregations, mainly in Blocks 10, 11, and 12, within ‘Offshore Circalittoral Mixed Sediment’ and ‘Offshore Circalittoral Coarse Sediment’ habitats. From the 59 assessed camera transects, there were 8 instances of ‘Low resemblance Reef’, 46 instances of ‘No Reef’ and 141 instances of ‘Not a Reef’, all of which were corroborated with geophysical survey data.

The survey route shows potential for sandeel nursery or spawning grounds, especially along the northern extent within the 'Offshore circalittoral sand' habitat. Observations of sandeels during video and grab sampling further suggest the route's potential for sandeel habitats. In contrast, the survey route has limited potential for herring spawning, with most stations deemed 'Unsuitable' due to low gravel and high mud content. However, four stations were classified as ‘Prime/Preferred’ or 'Sub-Prime/Preferred' and show increased potential for spawning due to higher gravel content.

The video assessment recorded small *M. edulis* across two transects in the 'Offshore Circalittoral Sand' habitat. Their small size, sparse distribution, and ephemeral growth likely caused their absence in the side scan sonar data. The low-density aggregations did not meet the 20% cover threshold over 25m$^2$, so they did not qualify as significant Annex I mussel beds.

Both the 'Offshore Circalittoral Sand' (SS.SSa.OSa) and 'Offshore Circalittoral Coarse Sediment' (SS.SCS.CCS) biotopes were present along the survey route and can be considered representative examples of the subtidal sands and gravels habitat of principal importance.

Several UK protected species were observed along the route, including the dog whelk (*Nucella lapillus*), thumbnail crab (*Thia scutellata*), European plaice (*Pleuronectes platessa*), sand goby (*Pomatoschistus minutus*), thornback ray (*Raja clavata*), and the IUCN Least Concern small spotted catshark (*Scyliorhinus canicula*). However, no ocean quahog (*Arctica islandica*) was found in video reviews or grab samples.

# 1 Introduction

## 1.1 Project Information

| | |
|---|---|
| **Client:** | National Grid Ventures (NGV) |
| **Client Reference:** | LLK1-NGS-REP-REP-000002 |
| **Project:** | Lion Link Next Geo NGV |
| **Main Contractor:** | Next GeoSolutions Europe S.p.A. (NEXT) |
| **Main Contractor Reference:** | P2066-010-REP-002 |
| **Subcontractor:** | Benthic Solutions Limited |
| **Survey Areas:** | UK section of international cable route between Suffolk and the Netherlands, with landfalls in Walberswick and Southwold, UK. |
| **Survey Type:** | Environmental Baseline Survey (EBS) and Habitat Assessment (HAS) |
| **Survey Period:** | Offshore: 03/09/2024 - 21/09/2024 |
| | Nearshore: 31/01/2025 – 04/02/2025 |
| **Survey Equipment:** | BSL Double Van Veen (DVV), BSL Mini Hamon Grab (HG), MOD4 Camera Systems, and Freshwater Lens attachment (FWL), *Wilson* Auto-Siever (WAS). |
| **Main Contractor Project Manager:** | Lucy Cotton (l.cotton@nextgeosolutions.com) |
| **Subcontractor Project Manager:** | Cinda Houldsworth (cinda.houldsworth@benthicsolutions.com) |

## 1.2 Project Overview

The Lion Link power project involves the installation of a high voltage direct current (HVDC) link, approximately 187km in length, which will connect the electricity transmission networks of the United Kingdom and Netherlands', incorporating a link to a wind farm located in Dutch waters. This link originates from Southwold and Walberswick, in Suffolk, UK crossing the Southern North Sea (SNS) to connect with the offshore grid infrastructure on the Dutch continental shelf (Figure 2 1). The water depth along the cable route ranged from 2m to 50m below LAT.

National Grid Ventures (NGV), in partnership with TennetT, commissioned Next GeoSolutions (NEXT), supported by Benthic Solutions Limited (BSL), to carry out geophysical and environmental operations along the cable route. The geophysical survey was conducted aboard the *Shore Presence* in water depths <20m and aboard the *Ievoli Amber* and *Ievoli Cobalt* for the remaining route. Environmental operations were conducted aboard the *Ievoli Grey* between the 3rd and the 21st of September 2024. The outstanding three nearshore stations within Block 4, at the Walberswick landfall, which were inaccessible to the *Ievoli Grey* due to their shallow location, were completed on the *Isle of Jura* on the 3rd of February, 2025.

The geophysical spread involved the acquisition of bathymetry via a vessel-mounted multibeam echosounder (MBES), towed side scan sonar (SSS), sub-bottom profiler (SBP) and magnetometry (MAG).

Environmental seabed sampling and video assessment was carried out along the Lion Link route to gather information on the physico-chemical, biological environment, as well as the habitats present. This included identifying any Annex I habitats under the EC Habitats Directive habitats, in preparation for cable installation. Seabed sediment samples were acquired using either a Dual Van Veen (DVV) grab sampler in sandy sediments or a mini-Hamon grab sampler in mixed sediment types. Seabed video footage was acquired using a BSL MOD4 camera system.

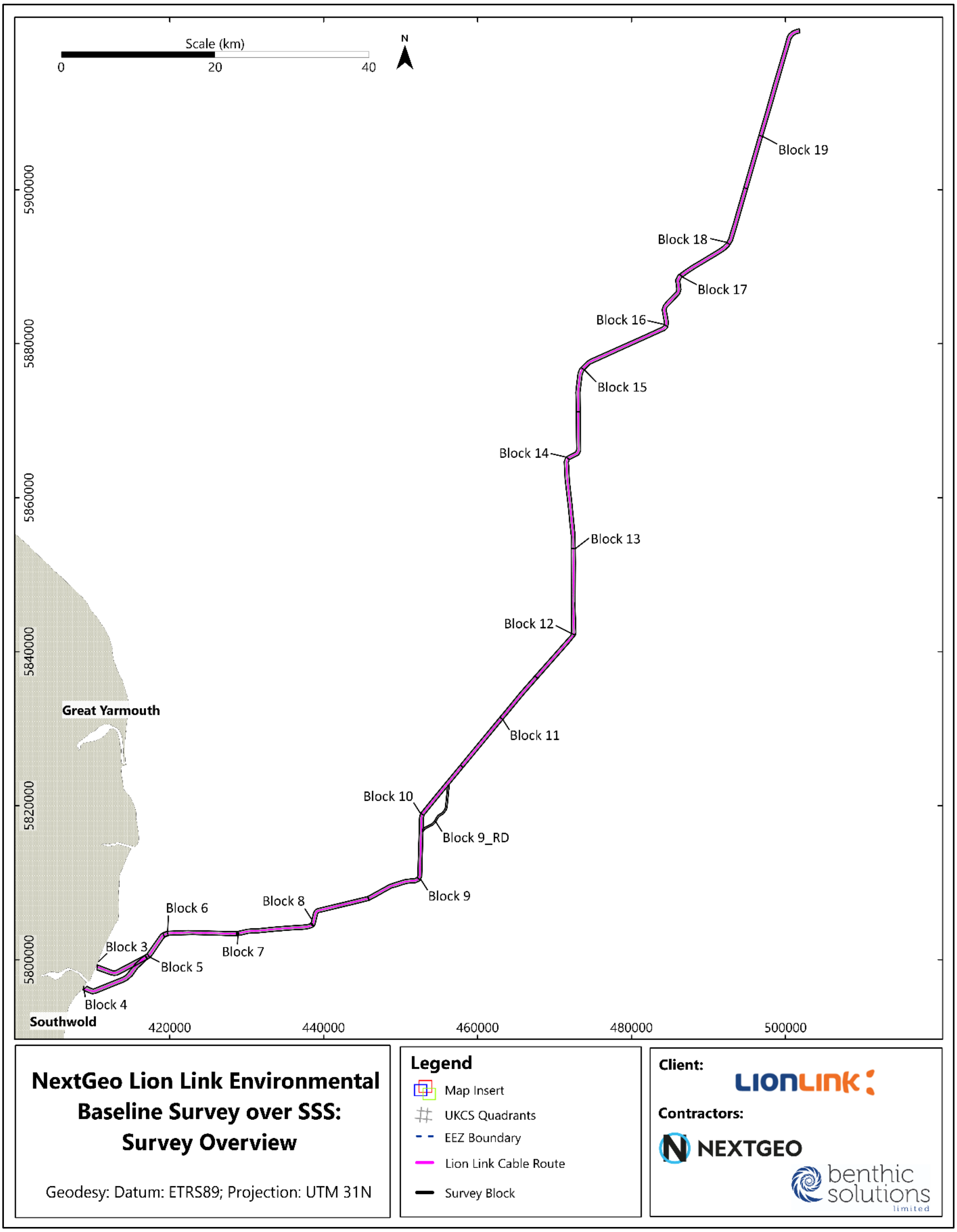



**Figure 1-1 Lion Link Route Overview**

## 1.3 Scope of Work

The aim of the environmental survey was to characterise the benthic habitats and investigate the sediment physio-chemistry (PC) and sediment benthic macrofauna community to provide an understanding of baseline conditions along the cable route.

The specific objectives of the benthic survey are:

- Undertake a review of the acquired geophysical data within the survey area to preliminarily identify all habitats for further investigation and characterisation;
- Follow a benthic sampling plan and methodology agreed with the Client; to support consenting and environmental impact assessment (EIA) requirements;
- Acquire baseline data of PC and sediment biological characteristics across the survey area;
- Characterise the benthic environment across the sites to assign habitat types to biological level according to JNCC/EUNIS habitat classification systems;
- Identify habitats and species of potential conservation interest, defined as those listed in Annex I of the EC Habitats Directive, the OSPAR List of Threatened and/or Declining Species and Habitats, the UK Biodiversity Framework (UKBF) (formerly the UK Biodiversity Action Plan Priority Habitat and UK Post-2010 Biodiversity Framework descriptions).

## 1.4 Reporting Structure

The following reports will be provided by BSL, relating to the benthic and environmental survey conducted along the Lion Link marine cable route:

- P2066-010-REP-014: Offshore Benthic and Environmental Survey Operations Report
- P2066-010-REP-013: Nearshore Benthic and Environmental Survey Operations Report
- **P2066-010-REP-002: Results Report - Benthic and Environmental Survey** (This Report)

## 1.5 Background and Existing Information

### 1.5.1 Background Information on the Lion Link Survey Area

National Grid Ventures (NGV) holds a licence under section 35 of the Planning Act 2008 to create a HDVC transmission cable between the UK and Netherlands. The cables will cross between the countries whilst also connecting to offshore wind farm/s. Each cable end would then connect to an onshore converter station to transform HDVC into High Voltage Alternating Current (HDAC) to feed the energy into each country's transmission network. For the purposes of the survey and subsequent reporting, the cable route is split into 19 blocks, shown in Figure 1-1.

The proposed cable route located within the UK section between Suffolk and the Netherlands crosses four UKCS Quadrants (49, 50, 52 and 53), with the whole route located in the Southern North Sea.

### 1.5.2 Reference Sources

A variety of reference values, including regional background levels and threshold effect levels, have been used in this report to aid in the interpretation of the survey results. These are summarised in Table 1-1 and detailed further in the subsequent sections.

**Table 1-1 Seabed Chemistry Reference Values**

| Reference/ Parameters | Total Organic Matter | Total Hydrocarbon Content | Polycyclic Aromatic Hydrocarbons | Heavy and Trace Metals |
|---|---|---|---|---|
| OSPAR BC | | | X | X |
| OSPAR BAC | | | X | X |
| OSPAR ERL | | | X | X |
| OSPAR ERM | | | X | X |
| CEFAS Action Level 1 | | | X | X |
| CEFAS Action Level 2 | | | | X |
| UKOOA 50$^{th}$ %ile | X | X | | X |
| UKOOA 95$^{th}$ %ile | X | X | | X |
| NOAA ERM | | | X | |
| *Note: There are no reference values for PSA or macrofauna data, therefore these parameters have not been included in this table.* | | | | |

#### 1.5.2.1 UKOAA 50$^{th}$ and 95$^{th}$ Percentiles for Background North Sea Sediments

In 2001, the United Kingdom Offshore Operators Association (referred to as UKOOA) issued sediment quality reference values for the UK North Sea (UKOOA, 2001). These values, based on data collected between 1975 to 1995, establish 'background' levels for various parameters (e.g., organic carbon, hydrocarbon, and metals content) in sediments more than 5km from existing oil and gas platform. The UKOOA (2001) reports provides 50$^{th}$ and 95$^{th}$ percentile levels for background sediments which are presented for specific North Sea sectors. The Lion Link cable route is situated solely in the Southern North Sea (SNS) and these have been applied in this report.

#### 1.5.2.2 OSPAR Background Concentrations and Background Assessment Concentrations

To monitor progress towards 'background conditions' in the marine environment, OSPAR developed a range of background concentrations (BCs) and background assessment concentrations (BACs) for use as reference levels throughout the OSPAR marine area. BCs are concentrations of contaminants derived from analysis of core samples to reflect pre-industrial, pristine, background levels for the OSPAR area (OSPAR,, 2009). BACs have been statistically derived from BCs and represent the level above which concentrations can be considered to be significantly higher than the relevant BC, with concentrations said to be near background if they are below their corresponding BAC (OSPAR, 2008). In the current report, reference to BCs and BACs has been made after normalisation of metals and PAHs using the method described in detail in the corresponding results sections and Appendix B – Data Presentation, Laboratory and Statistical Analyses.

#### 1.5.2.3 OSPAR Effect Range-Low and Effect-Range Median Levels

In order to assign a level of context for toxicity, an approach used by Long *et al.*, (1995) to characterise contamination in sediments will be used in this report. 'Effect range low' (ERL) levels were defined as concentration of metals at which adverse effects were reported in 10% of the data reviewed, whilst 'effect range median' (ERM) levels were defined as the concentrations at which 50% of studies reported harmful effects. The ERLs and ERMs have been used to evaluate the ecological significance of heavy and trace metal concentrations within the survey area.

#### 1.5.2.4 Cefas Chemical Action Levels 1 and 2

Action levels for the disposal of dredged material are not statutory concentrations for dredged material but are used as part of a weight of evidence approach to decision making on the disposal of dredged material to sea (MMO, 2015). While the action levels are strictly intended for consideration of dredging applications, they are often used to evaluate sediment physico-chemistry for non-dredging projects.

- Contaminant levels in dredged material below chemical action level (cAL) 1 are of no concern and are unlikely to influence the licencing decision.
- Dredged material with contaminant levels between cAL1 and cAL2 requires further consideration and testing before a decision can be made.
- Contaminant levels in dredged material above cAL2 are generally considered unsuitable for sea disposal.

The cAL1, due to the relatively low values, is the most effective of the European approaches at filtering out potentially toxic samples. i.e. potentially most protective of the environment. Whereas cAL2 values are among the least conservative of the OSPAR countries, and so have the potential to fail to prevent disposal at sea for sub-lethally or acutely toxic sediments.

#### 1.5.2.5 NOAA Effect Range Low and Effect Range Median Levels

In order to assign a level of context for toxicity, an approach used by Long *et al.* (1995), to characterise contamination in sediments will be used in this report. 'Effect range low' (ERL) levels were defined as concentration of metals at which adverse effects were reported in 10% of the data reviewed, whilst 'effect range median' (ERM) levels were defined as the concentrations at which 50% of studies reported harmful effects. The ERLs and ERMs have been used to evaluate the ecological significance of heavy and trace metal concentrations within the survey area.

#### 1.5.2.6 EMODnet Predicted Habitat Distributions

To further aid interpretation, comparison has been made with the predicted seabed habitat distribution data produced by the European marine observation and data network (EMODnet). EMODnet is a long-term marine data initiative developed through a stepwise approach to collect data and build on existing databases to provide access to European marine data across seven discipline-based themes: bathymetry, geology, seabed habitats, chemistry, biology, physics, and human activities (EMODnet, 2021). The broad-scale seabed habitat map is a predictive delineation of habitats within all European seas to the EUNIS classification system (EMODnet, 2022). Formulated through international (OSPAR) and national monitoring programmes in collaboration with European projects such as MESH or Mesh Atlantic the predicted seabed habitat map can be a useful resource in confidently assigning biotopes within a given survey area.

### 1.5.3 Legislative Background

#### 1.5.3.1 UK Biodiversity Framework

The UK Biodiversity Framework (UKBF), published in May 2024, supersedes both the previous UK Post-2010 Biodiversity Framework and the UK Biodiversity Action Plan (UKBAP). Developed in response to the Kunming-Montreal Global Biodiversity Framework agreed upon at the 15$^{th}$ Conference of the Parties (COP15) of the Convention on Biological Diversity in December 2022, the UKBF outlines the UK's strategic approach to biodiversity conservation (JNCC, 2024).

The UKBF emphasises collaborative efforts among the UK's four nations to meet international biodiversity commitments. It identifies key activities that can be more effectively achieved through joint action, enhancing the efficiency and impact of conservation initiatives across the UK.

In England, the Natural Environment and Rural Communities (NERC) Act 2006, Section 41 (S41), provides a key legislative mechanism to implement these priorities at a national level (DEFRA, 2006). S41 legally enforces biodiversity conservation by establishing a list of Species of Principal Importance (SPI) and Habitats of Principal Importance. (HPI) A total of 56 HPI have been identified and include: maerl beds, subtidal sands and gravels, seagrass beds, *Sabellaria* reefs and fragile sponge and anthozoan communities on subtidal rocky habitats.

#### 1.5.3.2 OSPAR Commission

At its Biodiversity Committee (BDC) meeting in 2003, OSPAR agreed to proceed with a programme to collate existing data on the distribution of 14 key habitats, as part of a wider programme to develop measures for their protection and conservation. The UK agreed to compile the relevant data for its own marine waters and submit these for collation into composite maps on the distribution of each habitat type across the whole OSPAR area. The work is being coordinated by the Joint Nature Conservation Committee (JNCC). Key OSPAR habitats that may occur in an open water marine environment include: '*Sabellaria spinulosa* Reefs', '*Modiolus modiolus* Beds', '*Arctica islandica*', 'Seapens & Burrowing Megafauna Communities'.

#### 1.5.3.3 European Habitats Directive

The United Kingdom (including Scotland), a signatory of the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention, 1979), adopted the European Community Habitats Directive in 1992 to fulfil its obligations under the convention. This Directive mandates member states to undertake various measures including, protecting species listed in Annexes, monitoring habitats and species, and submitting reports every six years on Directive Implementation.

The Directive lists 189 habitats in Annex I and 788 species in Annex II, which Member States must protect through a network of sites. Each Member State must propose a national list of sites for evaluation, leading to the establishment of a European network of Sites of Community Importance (SCIs). Eventually, these sites will be designated as Special Areas of Conservation (SACs) and, together with Special Protection Areas (SPAs) under the EC Birds Directive (2009), form the Natura 2000 protected area network. The Directive underwent amendments in 1997 and 2003.

Implementation of the Habitats Directive in offshore waters began in 2000, identifying potential habitats for SAC selection in UK offshore waters. Relevant habitats for this region include Sub-tidal reefs and Submarine structures formed by leaking gases. The Directive applies the precautionary principle to protect sensitive areas, allowing projects only if they do not adversely affect site integrity.

Following the UK's exit from the European Union (EU), new regulations have transposed the land and marine aspects of the Habitats Directive and Wild Birds Directive. The Conservation of Habitats and Species (EU exit) Regulations 2019, effective from January 1, 2021, amended the 2017 regulations to ensure their continued functionality post-EU exit. These amendments primarily transferred functions from the European Commission to authorities in England, Wales and Scotland, while retaining existing processes and terms (GOV.UK, 2022).

#### 1.5.3.4 The UK Marine Monitoring Programme

The UK National Marine Monitoring Programme (NMMP) was established in response to the 1986 House of Lords select committee on marine science and technology, who recommended that a common approach to marine monitoring should be established to comply with the international and national commitments (OSPAR Convention and EC Directives). The NMMP focuses on stable depositional sites and records data on sediment chemistry, biological communities, the bioaccumulation of heavy metals (cadmium, mercury, and lead) and their ecological effects (Bordin *et al.,* 1992; McLeese *et al.,* 1987).

A National Marine Biology Analytical Quality Control Scheme (NMBAQC) was established in 1992 to establish quality assurance standards for the biological aspects of the NMMP. Similar schemes exist for chemical monitoring (NMCAQC) and ecotoxicological monitoring (NMEAQC) (Davies *et al.,* 2001).

### 1.5.4 Habitat Investigation

#### 1.5.4.1 Habitat Classification

A marine biotope classification system for British waters, developed by Connor *et al.* (2004) and revised by Parry (2015), provides an improved classification of deep-sea habitats. The combined JNCC (2014) classification system is analogous with the European Nature Information Service Habitat Classification (EUNIS, 2022), both based on the same hierarchical analysis. Abiotic habitats are defined at four levels, with biological communities linked at two lower levels to create a biotope classification (Connor *et al.,* 2004; EUNIS, 2022).

Habitat descriptions have been interpreted from the side scan sonar (SSS), bathymetric data, seabed photography and grab sampling acquired during the current survey. As illustrated in Figure 1-2, the predicted EUNIS habitats in close proximity to the Lion Link survey area include: ‘Atlantic Offshore Circalittoral Sand’ (A5.27/MD52), ‘Atlantic Offshore Circalittoral Coarse Sediment’ (A5.15/MD32), ‘Atlantic Circalittoral Sand’ (A5.25/MC52) and ‘Atlantic Offshore Circalittoral Mixed Sediment’ (A5.45/MD42).

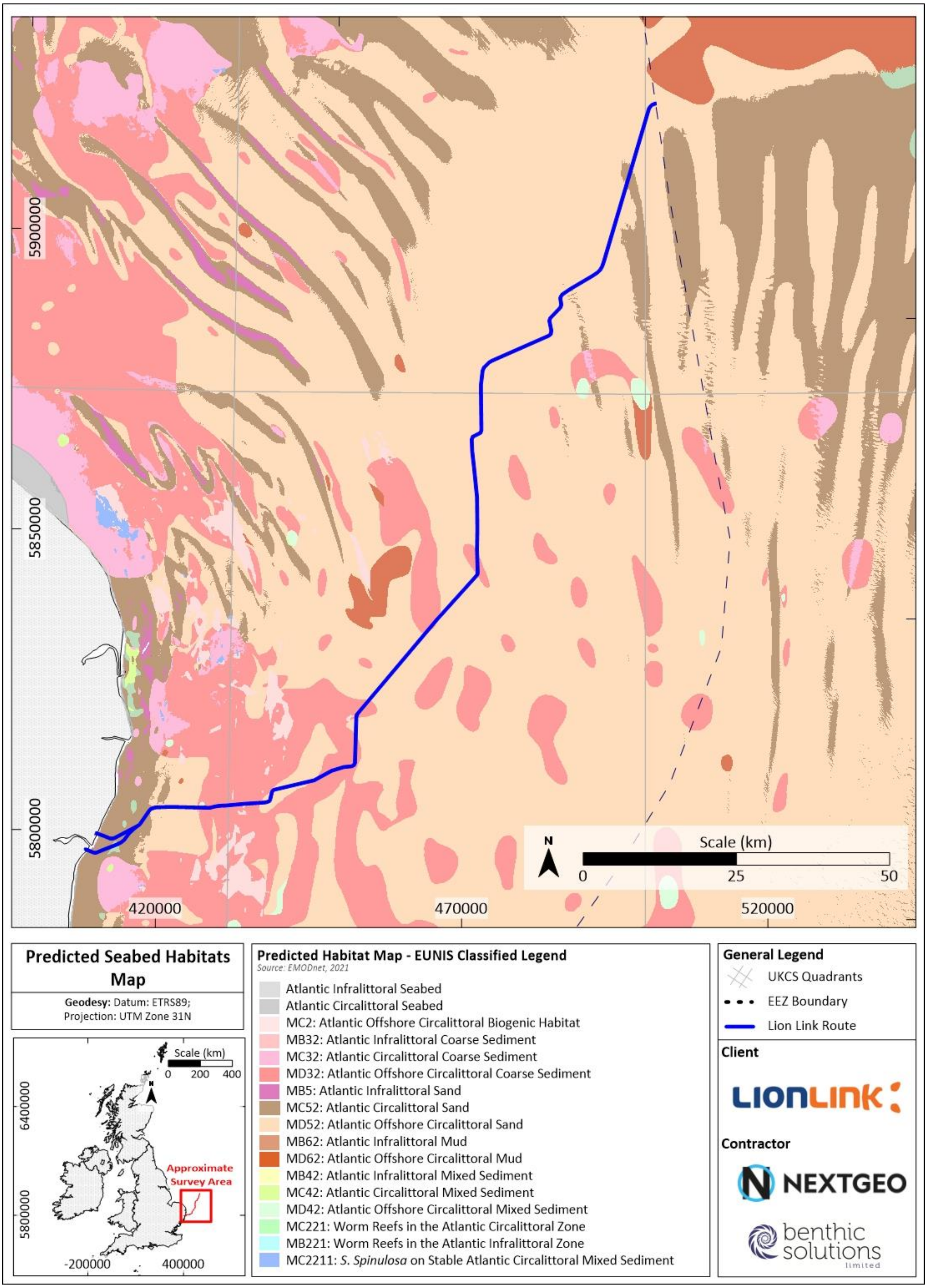



**Figure 1-2 EMODnet predicted seabed habitats map in relation to survey area**

#### 1.5.4.2 Expected Habitat Sensitivities

The Lion Link survey area is situated within the Southern North Sea Special Area of Conservation (SAC), which stretches from the central North Sea (north of Dogger Bank) to the Straits of Dover in the south (Figure 1-3). This SAC is specifically designated for the protection of harbour porpoises. While other SACs and Marine Conservation Zones (MCZs) in the Southern North Sea are designated for Annex I benthic habitats, such as sandbanks and gravel beds, the Lion Link survey area does not overlap with any of these sites. The project's route was carefully planned to avoid such areas, as outlined in Table 1-2, which summarises the nearby MCZs, SACs, and SPAs along with their primary designation features.

**Table 1-2 Key Aspects of Nearby Protected Areas**

| Protected Area Type | Designated Site | Site Area | Closest Distance to Survey Site | Key Aspects |
|---|---|---|---|---|
| MCZ | Orford Inshore | 72km$^2$ | 11.9km South West of nearshore route section | The site protects the subtidal mixed sediments habitats, which is important nursery and spawning grounds for many fish species, including Dover sole (*Solea solea*), lemon sole (*Microstomus kitt*) and sandeels. Important shark species are also found within the site, including the small-spotted catshark (*Scyliorhinus canicula*). |
| SAC | Southern North Sea | 36,951km$^2$ | Situated within | Important area for Annex II harbour porpoise (*Phocoena phocoena*). |
| | North Norfolk Sandbanks & Saturn Reef | 3,603km$^2$ | 13.9km East | Offshore linear ridge and tidal sandbanks with extensive sand waves and areas of *Sabellaria spinulosa* biogenic reefs |
| | Haisborough, Hammond & Winterton | 1,468km$^2$ | 10.6km East | Sandbanks formed via headland associated geological processes and occasional areas of *Sabellaria spinulosa*. |
| SPA | Outer Thames Estuary | 3, 924km$^2$ made up of three inshore and offshore areas | Part of Route Situated within | Protects the wintering red-throated diver, breeding little terns and breeding common terns. The area also contains sandbanks (Annex I) |
| | Greater Wash | 3,536 km$^2$ | 42.1km East | Protects a range of sea birds, such as red-throated diver (*Gavia stellata*), common scoter (*Melanitta nigra*), and little gull (*Hydrocoloeus minutus*); in a range of marine habitats, including intertidal mudflats and sandflats, subtidal sandbanks and biogenic reef, including *Sabellaria* reefs and mussel beds. Borders a number of SACs and MCZs. |

#### 1.5.4.3 Protected Habitat Assessment

Based on the features that were granted protection in the above areas, the habitats and species of particular relevance to this region of UK waters are:

- Geogenic Reefs (EC Habitats Directive Annex I, Habitat of Principle Importance);
- Subtidal Sands and Gravels (Habitat of Principle Importance);
- Ross worm (*Sabellaria spinulosa*) Biogenic Reef (EC Habitats Directive Annex I, OSPAR Threatened and/or Declining Habitat, Habitat of Principle Importance);
- Blue mussel (*Mytilus edulis*) Beds (EC Habitats Directive Annex I, Habitat of Principle Importance);
- Sensitive and Priority Species, including:
    - Raitt's sandeels - *Ammodytes marinus* (Species of Principal Importance);
    - Atlantic herring – *Clupea harengus* (Species of Principal Importance);
    - Ocean quahog – *Arctica islandica* (OSPAR Threatened and/or Declining Species, Species of Conservation Interest).

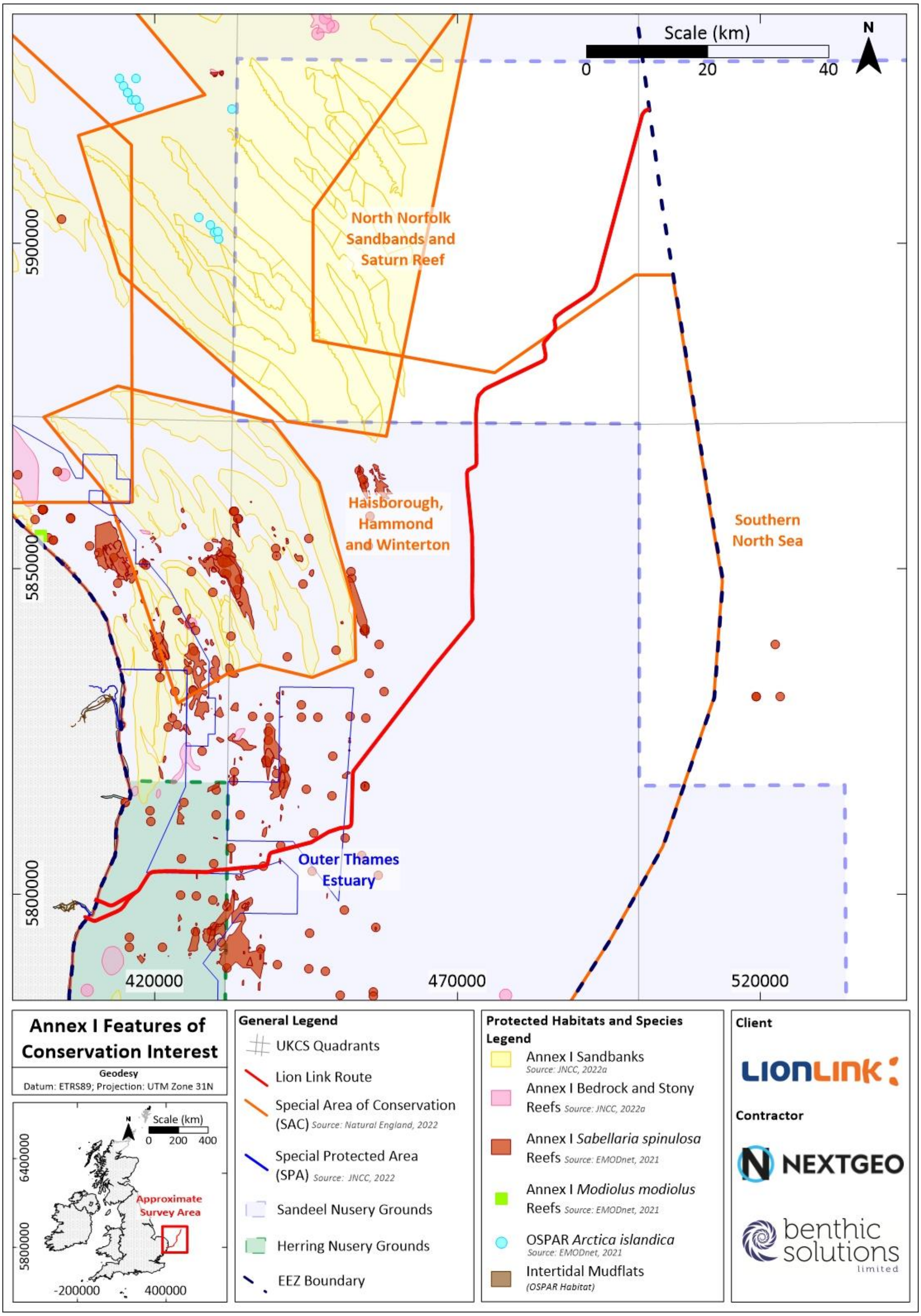



**Figure 1-3 Location of Features of Conservation Interest in Relation to the Survey Area**

# 2 Field Survey and Analytical Methods

## 2.1 Geodetic Parameters

The horizontal datum was referenced to the ETRS89 Datum, UTM 31N projection. The geodetic parameters used are provided below in Table 2-1.

**Table 2-1 Geodetic Parameters**

| **Required Datum** | |
|---|---|
| GPS Datum | ETRS1989 |
| **Projection Parameters** | |
| Projection | UTM 31N |
| Central Meridian | 03° 00’ 00.0” E |
| Latitude of Natural Origin | 00° 00’ 00.0” E |
| False Easting | 500 000 m |
| False Northing | 0 m |
| Scale Factor at Origin | 0.9996 at CM |

### 2.1.1 Vertical Datum

All depth measurements were reduced to the Lowest Astronomical Tide (LAT). Real-time reduction from the United Kingdom Hydrographic Office (UKHO) was performed using the Vertical Offshore Reference Frame (VORF).

## 2.2 Geophysical Data

Analogue geophysical data, comprised of multibeam echosounder (MBES), side scan sonar (SSS) data magnetometer (MAG) and sub-bottom profiler (SBP) seismic. All sensors operated simultaneously during the survey operations with all data being processed offline by NEXT. Nearshore data was acquired by the *Shore Presence* vessel and offshore data was acquired by the *Ievoli Amber* (geophysical) and *Ievoli Cobalt* (geophysical and ROV utility crossing survey). The following datasets were available for review during the preparation of this report:

- Bathymetric data was acquired using an R2Sonic Sonic2024 multibeam echosounder. For the nearshore Blocks (1 to 5), the multibeam was set to 450kHz and operated in Ultra High Density (UHD) mode. Noise was manually removed in a "line-by-line" fashion. The MBES for the offshore section (Blocks 6 to 19), was set to 400kHz, with a maximum coverage of 6m in water depth. Data acquisition allowed major bathymetric features and minor bathymetric changes to be identified and highlighted. This included the identification of sand megaripples and sand waves as well as boulders and bedrock outcrops. The MBES data gridding was performed using a grid parameter of 0.5m by 0.5m.
- SSS data was acquired using an Edgetech 4205 dual frequency at 300kHz/600kHz. The dataset was interpreted within MOGA SeaView and QGIS, focusing on seabed features, obstructions, and seabed sediment variations. The high frequency of 600kHz provided good resolution, allowing for the detection of SSS contacts greater than 0.5m.

- The SBP data was acquired using an Innomar SES-2000 system, which has an operating range of 2 to 16kHz. The dataset was interpreted in DUG software and focused on identifying the different sedimentary layers from the seabed and 5m to 10m below the surface. The data was generally of good quality. Some noise was present in the data and was addressed through denoising. The required penetration of 5m was achieved along the surveyed areas, and no diffractions were observed in the SBP data.
- The MAG data was acquired using the G-882 Magnetometer Sensor, which was "piggy-backed" onto other towed sensors and logged with Geometrics' MagLog software. The average altitude above the seafloor was 3.1m across the survey site. In the nearshore areas of Block 3 and 4, the altitude ranged between 0.4 and 2m above the seabed.

## 2.3 Environmental Ground-Truthing and Sampling

The environmental sampling survey strategy was outlined in the Scope of Works and Technical Specification (Doc Ref: C2 – Scope of Works). The survey strategy for Lion Link was broadly split into three main categories: environmental baseline (EBS), sandeel & herring spawning ground (SG) and sand sweeping (SS) stations. Station selection was aided by using geophysical data to ensure sufficient coverage of all habitat types present across the Lion Link cable route. Camera transects were also co-located with the aforementioned grab stations, with additional camera transects proposed to ground truth features of interest not covered by grab sampling. It should be noted that not all SG stations were co-located with camera transects due to the suspected featureless homogeneous sediment which was de-risked via geophysical review prior to grab deployment. All amendments to the environmental data acquisition were agreed prior to sampling.

### 2.3.1 Sediment Sampling

A total of 84 grab stations were completed during the survey. One grab sample (LL_20_SG) was excluded from particle size analysis due to the presence of small blue mussel (*Mytilus edulis,* 10mm – 30mm) aggregations, as outlined in Appendix P – Management of Change Reports. To address this, the grab sample location was relocated to a de-risked area identified from geophysical data, following observations of mussel aggregations in video footage at the original site. Despite this relocation, small blue mussels were still present at the new sampling site. This suggests that the mussel aggregations were either too sparse or too low-lying to produce a detectable signature in the side scan sonar data. Furthermore, their ephemeral nature during early growth stages may have contributed to their absence in the earlier sonar survey. During early growth stages, mussels are not yet firmly attached to hard substrates and can be easily dislodged by strong currents, as observed in the survey site, allowing them to resettle and mature elsewhere (Seed & Suchanek, 1992).

An additional grab sample was collected at station LL_16_SG_ADD to compensate for poor video footage acquisition, ensuring sufficient ground-truthing where video footage was unavailable (Appendix P – Management of Change Reports). At five stations, seabed turbidity restricted visibility on camera transects. To supplement habitat classification where video data could not be obtained, grab samples comprising faunal and PSA samples were collected, these samples were named as per the camera transect name, with the addition of 'G' (Appendix P – Management of Change Reports).

The BSL dual Van Veen grab (2 × 0.1 m$^2$) was deployed at all 82 stations, successfully retrieving samples at 79 stations. At three locations (LL_64_EBS, LL_49_EBS, and LL_51_SG), the Van Veen grab failed to retain samples in coarser sediments, requiring the use of the Mini Hamon grab (1 × 0.1 m$^2$) instead.

A comprehensive suite of physico-chemical and fauna samples was collected which included:

- 84 samples for particle size analysis, which were processed as per MMO-accreditation standard;
- 36 samples for physico-chemical analysis (9 of which were processed as MMO-accredited as per the pre-sweeping sampling plan), the remaining 26 of which were processed as per standard NMBAQC to UKAS accreditation and;
- 41 faunal replicate samples.

A summary of the grab samples acquired are tabulated in Table 2-2. The subtidal field operations are detailed in Appendix A – Field Operations, with sample logs in Appendix L –Subtidal Sampling Log Sheets.

**Table 2-2 Summary of the Acquired Grab Sampling Stations**

| Geodetics; ETRS89, UTM 31N | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Station** | **Easting (m)** | **Northing (m)** | **PSA** | **HC** | **EOX** | **ED** | **HM** | **OCP** | **Fauna** |
| LL_01_EBS | 409 175 | 5 796 281 | X | X | X | - | X | - | X |
| LL_02_TR | 409 325 | 5 795 989 | X | - | - | - | - | - | X |
| LL_03_TR | 409 525 | 5 796 156 | X | - | - | - | - | - | X |
| LL_04_TR_G | 410 323 | 5 795 952 | X | - | - | - | - | - | X |
| LL_05_SG | 411 197 | 5 796 280 | X | - | - | - | - | - | - |
| LL_06_TR_G | 411 929 | 5 796 572 | X | - | - | - | - | - | X |
| LL_07_TR_G | 412 693 | 5 796 825 | X | - | - | - | - | - | X |
| LL_08_EBS | 413 439 | 5 797 225 | X | X | X | - | X | - | X |
| LL_09_TR_G | 413 963 | 5 797 450 | X | - | - | - | - | - | X |
| LL_11_EBS | 415 559 | 5 798 731 | X | X | X | - | X | - | X |
| LL_13_EBS | 411 794 | 5 798 525 | X | X | X | - | X | - | X |
| LL_14_TR_G | 412 579 | 5 798 278 | X | - | - | - | - | - | X |
| LL_15_SG | 413 626 | 5 798 561 | X* | - | - | - | - | - | - |
| LL_16_SG_ADD | 414 269 | 5 798 802 | X | - | - | - | - | - | - |
| LL_17_EBS | 414 919 | 5 799 259 | X | X | X | - | X | - | X |
| LL_20_SG | 417 478 | 5 800 801 | N/S* | - | - | - | - | - | - |
| LL_21_EBS | 418 732 | 5 802 622 | X | X | X | - | X | - | X |
| LL_23_SS_SG | 420 544 | 5 803 446 | X** | X** | - | X** | X** | X** | - |
| LL_27_EBS | 423 240 | 5 803 552 | X | X | X | - | X | - | X |
| LL_30_SG | 425 885 | 5 803 408 | X | - | - | - | - | - | - |
| LL_32_EBS | 429 023 | 5 803 408 | X | X | X | - | X | - | X |
| LL_34_SG | 430 900 | 5 803 772 | X | - | - | - | - | - | - |
| LL_38_EBS | 433 343 | 5 803 901 | X | X | X | - | X | - | X |
| LL_42_SG | 435 839 | 5 804 136 | X | - | - | - | - | - | - |

| Geodetics; ETRS89, UTM 31N | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Station** | **Easting (m)** | **Northing (m)** | **PSA** | **HC** | **EOX** | **ED** | **HM** | **OCP** | **Fauna** |
| LL_44_EBS | 438 315 | 5 804 413 | X | X | X | - | X | - | X |
| LL_45_SG_SS | 438 850 | 5 805 964 | X | X** | - | X** | X** | X** | - |
| LL_49_EBS | 441 904 | 5 807 027 | X | X | X | - | X | - | X |
| LL_51_SG | 444 327 | 5 807 599 | X | - | - | - | - | - | - |
| LL_55_EBS_SS | 447 121 | 5 808 655 | X | X** | X** | X** | X** | X** | X |
| LL_57_SG | 448 867 | 5 809 604 | X | - | - | - | - | - | - |
| LL_60_EBS | 451 279 | 5 810 223 | X | X | X | - | X | - | X |
| LL_62_SG | 452 580 | 5 811 902 | X | - | - | - | - | - | - |
| LL_64_EBS | 452 590 | 5 814 351 | X | X | X | - | X | - | X |
| LL_67_SG | 452 669 | 5 816 992 | X | - | - | - | - | - | - |
| LL_72_EBS_SS | 454 940 | 5 818 680 | X | X** | X** | X** | X** | X** | X |
| LL_73_EBS_SS | 453 248 | 5 819 357 | X | X** | X** | X** | X** | X** | X |
| LL_78_EBS_SS | 455 988 | 5 819 843 | X | X** | X** | X** | X** | X** | X |
| LL_82_SG | 454 606 | 5 821 235 | X | - | - | - | - | - | - |
| LL_85_EBS_SS | 456 315 | 5 823 202 | X | X** | X** | X** | X** | X** | X |
| LL_86_SG | 457 859 | 5 825 026 | X | - | - | - | - | - | - |
| LL_87_EBS | 459 453 | 5 826 950 | X | X | X | - | X | - | X |
| LL_88_SG | 461 048 | 5 828 879 | X | - | - | - | - | - | - |
| LL_89_EBS | 462 638 | 5 830 805 | X | X | X | - | X | - | X |
| LL_91_SG | 464 237 | 5 832 731 | X | - | - | - | - | - | - |
| LL_94_EBS | 465 980 | 5 834 774 | X | X | X | - | X | - | X |
| LL_95_SG | 467 103 | 5 836 266 | X | - | - | - | - | - | - |
| LL_97_EBS | 469 145 | 5 838 400 | X | X | X | - | X | - | X |
| LL_98_SG | 470 800 | 5 840 270 | X | - | - | - | - | - | - |
| LL_99_EBS | 472 429 | 5 842 168 | X | X | X | - | X | - | X |
| LL_100_SG | 472 319 | 5 844 948 | X | - | - | - | - | - | - |

| Geodetics; ETRS89, UTM 31N | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Station** | **Easting (m)** | **Northing (m)** | **PSA** | **HC** | **EOX** | **ED** | **HM** | **OCP** | **Fauna** |
| LL_102_EBS | 472 348 | 5 847 409 | X | X | X | - | X | - | X |
| LL_103_SG | 472 465 | 5 849 649 | X | - | - | - | - | - | - |
| LL_104_EBS | 472 442 | 5 852 150 | X | X | X | - | X | - | X |
| LL_105_SG | 472 420 | 5 854 654 | X | - | - | - | - | - | - |
| LL_106_EBS_SS | 472 025 | 5 857 313 | X | X** | X** | X** | X** | X** | X |
| LL_107_SG | 471 965 | 5 859 622 | X | - | - | - | - | - | - |
| LL_108_EBS | 471 692 | 5 862 107 | X | X | X | - | X | - | X |
| LL_109_SG | 471 551 | 5 864 607 | X | - | - | - | - | - | - |
| LL_110_SG | 473 134 | 5 866 288 | X | - | - | - | - | - | - |
| LL_111_SG | 473 105 | 5 868 791 | X | - | - | - | - | - | - |
| LL_112_EBS_SS | 473 058 | 5 871 419 | X | X** | X** | X** | X** | X** | X |
| LL_113_SG | 473 062 | 5 873 790 | X | - | - | - | - | - | - |
| LL_114_SG | 473 392 | 5 876 261 | X | - | - | - | - | - | - |
| LL_115_SG | 475 174 | 5 877 912 | X | - | - | - | - | - | - |
| LL_116_EBS | 477 456 | 5 878 937 | X | X | X | - | X | - | X |
| LL_117_SG | 479 736 | 5 879 958 | X | - | - | - | - | - | - |
| LL_118_SG | 482 018 | 5 880 982 | X | - | - | - | - | - | - |
| LL_119_SG | 484 270 | 5 882 083 | X | - | - | - | - | - | - |
| LL_120_EBS | 484 229 | 5 884 430 | X | X | X | - | X | - | X |
| LL_121_SG | 485 761 | 5 886 345 | X | - | - | - | - | - | - |
| LL_122_SG | 486 238 | 5 888 660 | X | - | - | - | - | - | - |
| LL_124_SG | 488 265 | 5 890 082 | X | - | - | - | - | - | - |
| LL_125_EBS | 490 418 | 5 891 374 | X | X | X | - | X | - | X |
| LL_126_SG | 492 439 | 5 892 806 | X | - | - | - | - | - | - |
| LL_127_SG | 493 369 | 5 895 117 | X | - | - | - | - | - | - |
| LL_128_SG | 494 061 | 5 897 507 | X | - | - | - | - | - | - |

| Geodetics; ETRS89, UTM 31N | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Station** | **Easting (m)** | **Northing (m)** | **PSA** | **HC** | **EOX** | **ED** | **HM** | **OCP** | **Fauna** |
| LL_129_EBS | 494 758 | 5 899 921 | X | X | X | - | X | - | X |
| LL_130_SG | 495 451 | 5 902 310 | X | - | - | - | - | - | - |
| LL_131_SG | 496 149 | 5 904 724 | X | - | - | - | - | - | - |
| LL_132_SG | 496 816 | 5 907 115 | X | - | - | - | - | - | - |
| LL_133_EBS | 497 537 | 5 909 529 | X | X | X | - | X | - | X |
| LL_134_SG | 498 265 | 5 911 951 | X | - | - | - | - | - | - |
| LL_135_SG | 498 927 | 5 914 329 | X | - | - | - | - | - | - |
| LL_137_SG | 499 619 | 5 916 719 | X | - | - | - | - | - | - |
| LL_138_EBS | 500 317 | 5 919 133 | X | X | X | - | X | - | X |

***Notes:***

*- = Analysis not required as per scope of work*

*N/S* = no sample retained due to grab comprised solely of blue mussels (Mytilus edulis)*

*X = sample analysis undertaken as per standard NMBAQC to UKAS accreditation*

*X*= small PSA sample retained (<40%)*

*X** = sample analysis undertaken as per MMO accreditation*

*_ADD = additional grab*

*_G = PSA, PC and F1 ground-truthing where camera not possible*

*PSA = particle size analysis; HC = hydrocarbons (including organic matter and carbon, total hydrocarbon content and polycyclic aromatic hydrocarbons); EOX = extractable organic halogens; ED = endocrine disrupters (including organotin, polychlorinated biphenyls (PCB), organochlorine pesticides (OCP)); HM = heavy and trave metals; Fauna = macro-invertebrate replicate sample processed over a 1mm aperture sieve in the field*

### 2.3.2 Seabed Photography and Video

A total of 102 camera transects were carried out along the cable route using a BSL MOD4 camera system. Due to high turbidity from strong currents and suspended sediment, 25 transects had poor visibility but were deemed complete following field and Client review, as documented Appendix P – Management of Change Reports. Three nearshore stations had no visibility due to high turbidity and following Client review were considered inconclusive for use, as documented Appendix Q – Environmental Concession Reports.

To ensure sufficient potential sensitive features were investigated along the route, areas of mottled reflectivity reviewed on analogue data were targeted with additional transects. Nine transects were included in the survey to investigate the potential presence of the ross worm, *Sabellaria spinulosa* (LL_40_ADD, LL_19_ADD, LL_19_ADD1, LL_19_TR_D, LL_19_TR_E, LL_68_ADD, LL_90_ADD, and LL_92_ADD), and the blue mussel, *Mytilus edulis* (LL_20_ADD), as detailed in Appendix P – Management of Change Reports. One transect (LL_37_TR) was repositioned southeast of its original location due to fishing gear interference, targeting the geophysical features per Client approval in Appendix P – Management of Change Reports.

Four transects were not completed as per discussion with the Client due to the shallow water depths in these areas (LL_01_TR, LL_02_TR, LL_03_TR and LL_12_TR).

Where video struggled to maintain visibility against bottom currents in the nearshore area, it was decided that transects would not be undertaken for seven stations (LL_04_TR, LL_05_SG, LL_06_TR, LL_07_TR, LL_08_EBS, LL_09_TR and LL_14_TR). Instead, drop-down video was attempted prior to the acquisition of grab samples for ground-truthing data as approved by the Client in the Environmental Concession Form (ECF; Appendix Q – Environmental Concession Reports). Two transects were also abandoned due to multiple failed transect attempts in the nearshore area (LL_10_TR and LL_15_TR) outlined within the MOC Appendix P – Management of Change Reports).

A summary of the surveyed transects are provided in Table 2-3 and illustrated in Figure 2-1 and Figure 2-2.

**Table 2-3 Summary of Camera Transect Acquisition**

| Geodetics; ETRS89, UTM 31N | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Transect | | Date | Time (UTC) | Easting (m) | Northing (m) | Video footage (mm: ss) | HD Video Quality | SD Video Quality |
| LL_01_EBS | SOL | 03/02/2025 | 12:03 | 409 177 | 5 796 280 | 08:00 | X | X |
| | EOL | | 12:11 | 409 191 | 5 796 205 | | | |
| LL_02_TR | SOL | 03/02/2025 | 15:59 | 409 247 | 5 796 034 | 25:00 | X | X |
| | EOL | | 16:24 | 409 500 | 5 795 889 | | | |
| LL_03_TR | SOL | 03/02/2025 | 10:38 | 409 439 | 5 796 016 | 34:00 | X | X |
| | EOL | | 11:12 | 409 652 | 5 796 227 | | | |
| LL_04_DD | SOL | 13/09/2024 | 14:02 | 410 323 | 5 795 952 | 02:15 | X | X |
| | EOL | | 14:04 | | | | | |
| LL_05_DD | SOL | 13/09/2024 | 12:26 | 411 197 | 5 796 280 | 02:36 | X | X |
| | EOL | | 12:28 | | | | | |
| LL_06_DD | SOL | 13/09/2024 | 10:44 | 411 929 | 5 796 572 | 03:25 | X | X |
| | EOL | | 10:47 | | | | | |
| LL_07_DD | SOL | 13/09/2024 | 09:34 | 412 693 | 5 796 825 | 02:08 | X | X |
| | EOL | | 09:36 | | | | | |
| LL_08_DD | SOL | 13/09/2024 | 07:22 | 413 439 | 5 797 225 | 02:43 | X | X |
| | EOL | | 07:25 | | | | | |
| LL_09_DD | SOL | 13/09/2024 | 16:37 | 413 963 | 5 797 450 | 02:10 | X | X |
| | EOL | | 16:39 | | | | | |
| LL_10_TR[3] | SOL | - | - | - | - | - | - | - |
| | EOL | | | | | | | |
| LL_11_TR | SOL | 12/09/2024 | 08:18 | 415 436 | 5 798 789 | 27:00 | ✓* | ✓* |
| | EOL | | 08:46 | 415 639 | 5 798 689 | | | |
| LL_12_TR[2] | SOL | - | - | - | - | - | - | - |
| | EOL | | | | | | | |
| LL_13_TR[4] | SOL | - | - | - | - | - | - | - |
| | EOL | | | | | | | |
| LL_14_DD | SOL | 13/09/2024 | 15:23 | 412 579 | 5 798 278 | 02:08 | X | X |
| | EOL | | 15:25 | | | | | |
| LL_15_TR[3] | SOL | - | - | - | - | - | - | - |
| | EOL | | | | | | | |
| LL_16_TR[5] | SOL | - | - | - | - | - | - | - |
| | EOL | | | | | | | |
| LL_17_TR | SOL | 12/09/2024 | 04:31 | 414 946 | 5 799 251 | 44:10 | ✓* | ✓* |
| | EOL | | 04:51 | 414 793 | 5 799 291 | | | |
| LL_18_TR | SOL | 10/09/2024 | 13:13 | 415 762 | 5 799 770 | 44:20 | ✓* | ✓* |
| | EOL | | 13:57 | 416 109 | 5 799 677 | | | |
| LL_19_TR | SOL | 10/09/2024 | 12:03 | 416 468 | 5 800 140 | 32:54 | ✓* | ✓* |
| | EOL | | 12:36 | 416 687 | 5 800 056 | | | |
| LL_19_TR_Add_a | SOL | 10/09/2024 | 20:03 | 416 565 | 5 800 355 | 42:00 | ✓ | ✓ |
| | EOL | | 20:45 | 416 664 | 5 799 903 | | | |
| LL_19_TR_Add1 | SOL | 10/09/2024 | 21:28 | 416 371 | 5 800 138 | 38:00 | ✓* | ✓* |
| | EOL | | 22:06 | 416 351 | 5 799 796 | | | |
| LL_19_TR_D_a | SOL | 13/09/2024 | 00:24 | 416 417 | 5 800 693 | 08:10 | ✓ | ✓ |
| | EOL | | 00:33 | 416 469 | 5 800 693 | | | |
| LL_19_TR_E | SOL | 13/09/2024 | 01:12 | 416 380 | 5 799 300 | 13:54 | ✓* | ✓* |
| | EOL | | 01:26 | 416 480 | 5 799 300 | | | |

| Geodetics; ETRS89, UTM 31N | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Transect | | Date | Time (UTC) | Easting (m) | Northing (m) | Video footage (mm: ss) | HD Video Quality | SD Video Quality |
| LL_20_TR | SOL | 10/09/2024 | 09:27 | 417 392 | 5 800 844 | 16:14 | ✓* | ✓* |
| | EOL | | 09:44 | 417 328 | 5 800 895 | | | |
| LL_20_TR_Add | SOL | 10/09/2024 | 10:29 | 417 356 | 5 801 044 | 16:35 | ✓ | ✓ |
| | EOL | | 10:46 | 417 342 | 5 800 929 | | | |
| LL_21_TR | SOL | 10/09/2024 | 07:26 | 418 732 | 5 802 645 | 11:40 | ✓* | ✓* |
| | EOL | | 07:38 | 418 732 | 5 802 595 | | | |
| LL_22_TR | SOL | 09/09/2024 | 22:13 | 419 366 | 5 803 339 | 52:00 | ✓* | ✓* |
| | EOL | | 23:06 | 419 488 | 5 803 271 | | | |
| LL_23_TR | SOL | 09/09/2024 | 21:06 | 420 524 | 5 803 431 | 55:53 | ✓* | ✓* |
| | EOL | | 21:29 | 420 565 | 5 803 461 | | | |
| LL_24_TR[6] | SOL | - | - | - | - | - | - | - |
| | EOL | | | | | | | |
| LL_25_TR | SOL | 09/09/2024 | 19:47 | 422 480 | 5 803 347 | 21:42 | ✓ | ✓ |
| | EOL | | 20:09 | 422 323 | 5 803 365 | | | |
| LL_26_TR | SOL | 10/09/2024 | 03:48 | 423 100 | 5 803 521 | 21:55 | ✓* | ✓* |
| | EOL | | 04:10 | 422 933 | 5 803 526 | | | |
| LL_27_TR | SOL | 10/09/2024 | 02:43 | 423 348 | 5 803 576 | 13:38 | ✓ | ✓ |
| | EOL | | 02:56 | 423 232 | 5 803 549 | | | |
| LL_28_TR[6] | SOL | - | - | - | - | - | - | - |
| | EOL | | | | | | | |
| LL_29_TR | SOL | 10/09/2024 | 01:38 | 424 814 | 5 803 696 | 11:32 | ✓ | ✓ |
| | EOL | | 01:55 | 424 758 | 5 803 605 | | | |
| LL_31_TR | SOL | 06/09/2024 | 19:51 | 427 460 | 5 803 528 | 14:02 | ✓ | ✓ |
| | EOL | | 20:06 | 427 339 | 5 803 506 | | | |
| LL_32_TR | SOL | 07/09/2024 | 00:44 | 429 013 | 5 803 406 | 17:43 | ✓* | ✓* |
| | EOL | | 01:03 | 429 152 | 5 803 442 | | | |
| LL_33_TR[6] | SOL | - | - | - | - | - | - | - |
| | EOL | | | | | | | |
| LL_35_TR | SOL | 13/09/2024 | 23:27 | 431 320 | 5 803 629 | 21:01 | ✓ | ✓ |
| | EOL | | 23:48 | 431 503 | 5 803 723 | | | |
| LL_36_TR | SOL | 07/09/2024 | 06:23 | 431 936 | 5 803 709 | 16:01 | ✓* | ✓* |
| | EOL | | 06:39 | 432 033 | 5 803 641 | | | |
| LL_37_TR | SOL | 14/09/2024 | 14:44 | 432 949 | 5 803 703 | 19:40 | ✓ | ✓ |
| | EOL | | 15:04 | 433 096 | 5 803 710 | | | |
| LL_38_TR_a | SOL | 07/09/2024 | 08:09 | 433 328 | 5 803 902 | 09:12 | ✓* | ✓* |
| | EOL | | 08:18 | 433 418 | 5 803 902 | | | |
| LL_39_TR_a | SOL | 07/09/2024 | 13:19 | 434 402 | 5 804 060 | 22:13 | ✓* | ✓* |
| | EOL | | 13:42 | 434 535 | 5 803 935 | | | |
| LL_40_TR_a | SOL | 07/09/2024 | 14:44 | 435 159 | 5 804 180 | 12:07 | ✓* | ✓* |
| | EOL | | 14:56 | 435 169 | 5 804 089 | | | |
| LL_40_TR_Add | SOL | 13/09/2024 | 21:35 | 435 205 | 5 804 151 | 12:08 | ✓* | ✓* |
| | EOL | | 21:46 | 435 106 | 5 804 141 | | | |
| LL_41_TR | SOL | 07/09/2024 | 15:23 | 435 365 | 5 804 150 | 18:18 | ✓* | ✓* |
| | EOL | | 15:42 | 435 232 | 5 804 055 | | | |
| LL_42_SG[8] | SOL | - | - | - | - | - | - | - |
| | EOL | | | | | | | |
| LL_43_TR | SOL | 07/09/2024 | 18:59 | 437 429 | 5 804 072 | 09:51 | ✓* | ✓* |
| | EOL | | 19:11 | 437 497 | 5 804 106 | | | |

| Geodetics; ETRS89, UTM 31N | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Transect | | Date | Time (UTC) | Easting (m) | Northing (m) | Video footage (mm: ss) | HD Video Quality | SD Video Quality |
| LL_44_TR | SOL | 07/09/2024 | 19:47 | 438 318 | 5 804 436 | 06:26 | ✓ | ✓ |
| | EOL | | 19:55 | 438 314 | 5 804 393 | | | |
| LL_45_TR | SOL | 07/09/2024 | 21:25 | 438 888 | 5 806 013 | 10:58 | ✓ | ✓ |
| | EOL | | 21:38 | 438 823 | 5 805 927 | | | |
| LL_46_TR[5] | SOL | - | - | - | - | - | - | - |
| | EOL | | | | | | | |
| LL_47_TR | SOL | 08/09/2024 | 02:30 | 440 982 | 5 806 807 | 13:20 | ✓ | ✓ |
| | EOL | | 02:43 | 440 927 | 5 806 719 | | | |
| LL_48_TR | SOL | 08/09/2024 | 01:26 | 441 348 | 5 806 898 | 22:44 | ✓ | ✓ |
| | EOL | | 01:49 | 441 535 | 5 806 834 | | | |
| LL_49_TR | SOL | 08/09/2024 | 03:23 | 441 927 | 5 807 026 | 13:48 | ✓ | ✓ |
| | EOL | | 03:37 | 441 797 | 5 807 023 | | | |
| LL_50_TR | SOL | 08/09/2024 | 13:21 | 442 907 | 5 807 158 | 14:33 | ✓* | ✓* |
| | EOL | | 13:35 | 442 963 | 5 807 038 | | | |
| LL_52_TR | SOL | 08/09/2024 | 09:21 | 444 798 | 5 807 461 | 06:21 | ✓ | ✓ |
| | EOL | | 09:27 | 444 839 | 5 807 491 | | | |
| LL_53_TR | SOL | 08/09/2024 | 09:57 | 445 056 | 5 807 617 | 12:15 | ✓ | ✓ |
| | EOL | | 10:08 | 444 960 | 5 807 626 | | | |
| LL_54_TR | SOL | 08/09/2024 | 12:09 | 445 727 | 5 808 164 | 10:08 | ✓ | ✓ |
| | EOL | | 12:19 | 445 695 | 5 808 102 | | | |
| LL_55_TR | SOL | 14/09/2024 | 02:30 | 447 122 | 5 808 682 | 06:18 | ✓ | ✓ |
| | EOL | | 02:36 | 447 122 | 5 808 632 | | | |
| LL_56_TR | SOL | 14/09/2024 | 04:09 | 448 194 | 5 809 313 | 12:10 | ✓ | ✓ |
| | EOL | | 04:21 | 448 294 | 5 809 308 | | | |
| LL_58_TR | SOL | 14/09/2024 | 05:15 | 449 494 | 5 809 787 | 09:34 | ✓ | ✓ |
| | EOL | | 05:24 | 449 565 | 5 809 776 | | | |
| LL_59_TR | SOL | 14/09/2024 | 06:13 | 450 872 | 5 810 442 | 22:23 | ✓ | ✓ |
| | EOL | | 06:35 | 451 024 | 5 810 431 | | | |
| LL_60_TR | SOL | 14/09/2024 | 08:56 | 451 110 | 5 810 229 | 21:56 | ✓ | ✓ |
| | EOL | | 09:18 | 451 302 | 5 810 219 | | | |
| LL_61_TR | SOL | 14/09/2024 | 11:10 | 452 424 | 5 810 963 | 20:00 | ✓ | ✓ |
| | EOL | | 11:30 | 452 264 | 5 810 927 | | | |
| LL_62_TR | SOL | 14/09/2024 | 19:51 | 452 429 | 5 811 987 | 19:30 | ✓ | ✓ |
| | EOL | | 20:10 | 452 582 | 5 811 903 | | | |
| LL_63_TR | SOL | 14/09/2024 | 21:16 | 452 536 | 5 813 661 | 25:33 | ✓ | ✓ |
| | EOL | | 21:42 | 452 732 | 5 813 620 | | | |
| LL_64_TR | SOL | 14/09/2024 | 22:35 | 452 590 | 5 814 375 | 06:13 | ✓ | ✓ |
| | EOL | | 22:41 | 452 590 | 5 814 326 | | | |
| LL_65_TR_a | SOL | 15/09/2024 | 03:23 | 452 751 | 5 815 161 | 15:35 | ✓ | ✓ |
| | EOL | | 03:39 | 452 722 | 5 815 028 | | | |
| LL_66_TR | SOL | 15/09/2024 | 06:46 | 452 393 | 5 815 301 | 20:01 | ✓ | ✓ |
| | EOL | | 07:06 | 452 468 | 5 815 473 | | | |
| LL_68_TR | SOL | 15/09/2024 | 08:01 | 453 013 | 5 816 989 | 09:10 | ✓ | ✓ |
| | EOL | | 08:10 | 453 079 | 5 816 990 | | | |
| LL_68_TR_Add | SOL | 15/09/2024 | 10:07 | 453 027 | 5 817 170 | 06:23 | ✓ | ✓ |
| | EOL | | 10:13 | 452 977 | 5 817 161 | | | |
| LL_69_TR | SOL | 15/09/2024 | 08:47 | 452 909 | 5 817 231 | 17:48 | ✓ | ✓ |
| | EOL | | 09:05 | 452 833 | 5 817 386 | | | |

| Geodetics; ETRS89, UTM 31N | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Transect** | | **Date** | **Time (UTC)** | **Easting (m)** | **Northing (m)** | **Video footage (mm: ss)** | **HD Video Quality** | **SD Video Quality** |
| LL_70_TR | SOL | 15/09/2024 | 10:47 | 452 747 | 5 817 712 | 12:26 | ✓* | ✓* |
| | EOL | | 10:59 | 452 837 | 5 817 684 | | | |
| LL_71_TR | SOL | 15/09/2024 | 14:11 | 453 140 | 5 819 225 | 18:53 | ✓ | ✓ |
| | EOL | | 14:30 | 453 218 | 5 819 097 | | | |
| LL_72_TR | SOL | 15/09/2024 | 15:22 | 454 940 | 5 818 681 | 06:12 | ✓ | ✓ |
| | EOL | | 15:29 | 454 923 | 5 818 646 | | | |
| LL_73_TR | SOL | 15/09/2024 | 20:32 | 453 243 | 5 819 357 | 30:40 | ✓ | ✓ |
| | EOL | | 21:02 | 453 489 | 5 819 444 | | | |
| LL_74_TR | SOL | 15/09/2024 | 22:37 | 455 235 | 5 818 833 | 09:17 | ✓ | ✓ |
| | EOL | | 22:48 | 455 306 | 5 818 836 | | | |
| LL_75_TR | SOL | 16/09/2024 | 02:36 | 453 731 | 5 820 227 | 21:57 | ✓* | ✓* |
| | EOL | | 02:58 | 453 726 | 5 820 006 | | | |
| LL_76_TR | SOL | 16/09/2024 | 03:47 | 453 637 | 5 820 144 | 23:38 | ✓ | ✓ |
| | EOL | | 04:10 | 453 873 | 5 820 163 | | | |
| LL_77_TR | SOL | 16/09/2024 | 04:53 | 453 949 | 5 820 029 | 21:20 | ✓ | ✓ |
| | EOL | | 05:14 | 454 079 | 5 820 162 | | | |
| LL_78_TR | SOL | 16/09/2024 | 08:25 | 455 991 | 5 819 837 | 20:20 | ✓ | ✓ |
| | EOL | | 08:45 | 455 941 | 5 820 005 | | | |
| LL_79_TR | SOL | 16/09/2024 | 10:22 | 454 039 | 5 820 300 | 23:02 | ✓ | ✓ |
| | EOL | | 10:45 | 454 192 | 5 820 430 | | | |
| LL_80_TR | SOL | 16/09/2024 | 15:33 | 454 484 | 5 820 584 | 26:07 | ✓ | ✓ |
| | EOL | | 15:59 | 454 438 | 5 820 808 | | | |
| LL_81_TR | SOL | 16/09/2024 | 16:27 | 454 432 | 5 820 900 | 26:07 | ✓ | ✓ |
| | EOL | | 16:43 | 454 508 | 5 820 796 | | | |
| LL_82_TR | SOL | 16/09/2024 | 17:16 | 454 518 | 5 821 174 | 14:47 | ✓ | ✓ |
| | EOL | | 17:31 | 454 613 | 5 821 241 | | | |
| LL_83_TR[6] | SOL | - | - | - | - | - | - | - |
| | EOL | | | | | | | |
| LL_84_TR | SOL | 16/09/2024 | 21:40 | 454 974 | 5 821 900 | 17:06 | ✓ | ✓ |
| | EOL | | 21:58 | 455 141 | 5 821 949 | | | |
| LL_85_TR | SOL | 16/09/2024 | 23:02 | 456 298 | 5 823 161 | 10:07 | ✓ | ✓ |
| | EOL | | 23:12 | 456 329 | 5 823 249 | | | |
| LL_87_TR | SOL | 17/09/2024 | 03:56 | 459 454 | 5 826 977 | 06:05 | ✓ | ✓ |
| | EOL | | 04:02 | 459 454 | 5 826 927 | | | |
| LL_89_TR | SOL | 09/09/2024 | 04:13 | 462 642 | 5 830 829 | 07:19 | ✓ | ✓ |
| | EOL | | 04:20 | 462 642 | 5 830 779 | | | |
| LL_90_TR | SOL | 09/09/2024 | 06:31 | 464 059 | 5 832 507 | 14:38 | ✓ | ✓ |
| | EOL | | 06:45 | 463 930 | 5 832 500 | | | |
| LL_90_TR_Add | SOL | 17/09/2024 | 09:39 | 464 072 | 5 832 549 | 10:31 | ✓ | ✓ |
| | EOL | | 09:50 | 464 024 | 5 832 486 | | | |
| LL_91_TR | SOL | 09/09/2024 | 07:22 | 464 211 | 5 832 755 | 07:48 | ✓ | ✓ |
| | EOL | | 07:29 | 464 247 | 5 832 719 | | | |
| LL_92_TR_a | SOL | 09/09/2024 | 09:17 | 464 577 | 5 833 158 | 18:46 | ✓ | ✓ |
| | EOL | | 09:35 | 464 483 | 5 833 055 | | | |
| LL_92_TR_Add | SOL | 09/09/2024 | 10:51 | 464 663 | 5 833 088 | 19:14 | ✓ | ✓ |
| | EOL | | 11:11 | 464 518 | 5 833 128 | | | |
| LL_93_TR | SOL | 09/09/2024 | 12:03 | 465 094 | 5 833 831 | 17:57 | ✓ | ✓ |
| | EOL | | 12:21 | 465 199 | 5 833 809 | | | |

| Geodetics; ETRS89, UTM 31N | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Transect** | | **Date** | **Time (UTC)** | **Easting (m)** | **Northing (m)** | **Video footage (mm: ss)** | **HD Video Quality** | **SD Video Quality** |
| LL_94_TR | SOL | 17/09/2024 | 10:40 | 465 983 | 5 834 779 | 12:00 | ✓ | ✓ |
| | EOL | | 10:52 | 465 951 | 5 834 678 | | | |
| LL_95_TR | SOL | 19/09/2024 | 18:50 | 467 098 | 5 836 249 | 12:52 | ✓ | ✓ |
| | EOL | | 19:03 | 467 122 | 5 836 330 | | | |
| LL_96_TR | SOL | 19/09/2024 | 19:42 | 468 281 | 5 837 519 | 18:25 | ✓ | ✓ |
| | EOL | | 20:01 | 468 425 | 5 837 539 | | | |
| LL_97_TR | SOL | 20/09/2024 | 06:14 | 469 142 | 5 838 429 | 07:47 | ✓ | ✓ |
| | EOL | | 06:21 | 469 143 | 5 838 369 | | | |
| LL_99_TR | SOL | 20/09/2024 | 07:43 | 472 428 | 5 842 192 | 07:01 | ✓ | ✓ |
| | EOL | | 07:50 | 472 428 | 5 842 142 | | | |
| LL_100_TR | SOL | 20/09/2024 | 11:36 | 472 275 | 5 844 945 | 14:13 | ✓ | ✓ |
| | EOL | | 11:50 | 472 390 | 5 844 956 | | | |
| LL_101_TR | SOL | 20/09/2024 | 12:30 | 472 391 | 5 846 658 | 21:06 | ✓ | ✓ |
| | EOL | | 12:51 | 472 474 | 5 846 702 | | | |
| LL_102_TR | SOL | 19/09/2024 | 13:40 | 472 238 | 5 847 399 | 23:57 | ✓ | ✓ |
| | EOL | | 14:04 | 472 370 | 5 847 407 | | | |
| LL_104_TR | SOL | 19/09/2024 | 12:07 | 472 443 | 5 852 174 | 05:50 | ✓ | ✓ |
| | EOL | | 12:13 | 472 443 | 5 852 124 | | | |
| LL_106_TR | SOL | 19/09/2024 | 10:39 | 472 013 | 5 857 339 | 07:13 | ✓* | ✓* |
| | EOL | | 10:47 | 472 033 | 5 857 293 | | | |
| LL_108_TR | SOL | 20/09/2024 | 17:53 | 471 681 | 5 862 134 | 09:53 | ✓* | ✓* |
| | EOL | | 18:03 | 471 701 | 5 862 088 | | | |
| LL_112_TR | SOL | 19/09/2024 | 05:26 | 473 049 | 5 871 439 | 07:59 | ✓ | ✓ |
| | EOL | | 05:34 | 473 069 | 5 871 393 | | | |
| LL_116_EBS[7] | SOL | - | - | - | - | - | - | - |
| | EOL | | | | | | | |
| LL_120_TR | SOL | 05/09/2024 | 04:48 | 484 219 | 5 884 451 | 06:01 | ✓ | ✓ |
| | EOL | | 04:54 | 484 241 | 5 884 400 | | | |
| LL_123_TR[5] | SOL | - | - | - | - | - | - | - |
| | EOL | | | | | | | |
| LL_125_TR | SOL | 05/09/2024 | 00:07 | 490 418 | 5 891 351 | 06:02 | ✓ | ✓ |
| | EOL | | 00:14 | 490 418 | 5 891 402 | | | |
| LL_129_TR | SOL | 04/09/2024 | 19:15 | 494 748 | 5 899 944 | 10:19 | ✓ | ✓ |
| | EOL | | 19:24 | 494 768 | 5 899 898 | | | |
| LL_133_TR | SOL | 04/09/2024 | 14:44 | 497 528 | 5 909 550 | 09:15 | ✓ | ✓ |
| | EOL | | 14:54 | 497 548 | 5 909 503 | | | |
| LL_134_TR | SOL | 04/09/2024 | 12:33 | 498 306 | 5 911 938 | 09:41 | ✓ | ✓ |
| | EOL | | 12:43 | 498 254 | 5 911 954 | | | |
| LL_136_TR[6] | SOL | - | - | - | - | - | - | - |
| | EOL | | | | | | | |
| LL_138_TR | SOL | 04/09/2024 | 07:59 | 500 307 | 5 919 156 | 06:54 | ✓ | ✓ |
| | EOL | | 08:08 | 500 327 | 5 919 110 | | | |

***Notes:***
**Some stills/HD poor quality due to sediment plumes caused by currents but data deemed acceptable by Client for habitat assessment.*
*[2]Transects removed as per discussion with the Client due to shallow water depths.*
*[3]Transects abandoned due to multiple failed transect attempts as approved by Client.*
*[4]Transects abandoned due to poor visibility as approved by the Client.*

| **Geodetics; ETRS89, UTM 31N** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Transect** | **Date** | **Time (UTC)** | **Easting (m)** | **Northing (m)** | **Video footage (mm: ss)** | **HD Video Quality** | **SD Video Quality** |

*[5]Transects removed from scope before acquisition began as approved by the Client.*
*[6]Transects removed from scope as no Sabellaria spinulosa observed nearby as approved by the Client.*
*[7]Transects removed from scope due to time constraints as approved by the Client.*
*[8]Transects removed from scope due to similar geophysical signature investigated nearby as approved by the client.*
*_DD = Acquired drop-down video footage*
*X = No usable stills/HD footage acquired due to strong currents preventing visibility at seabed.*

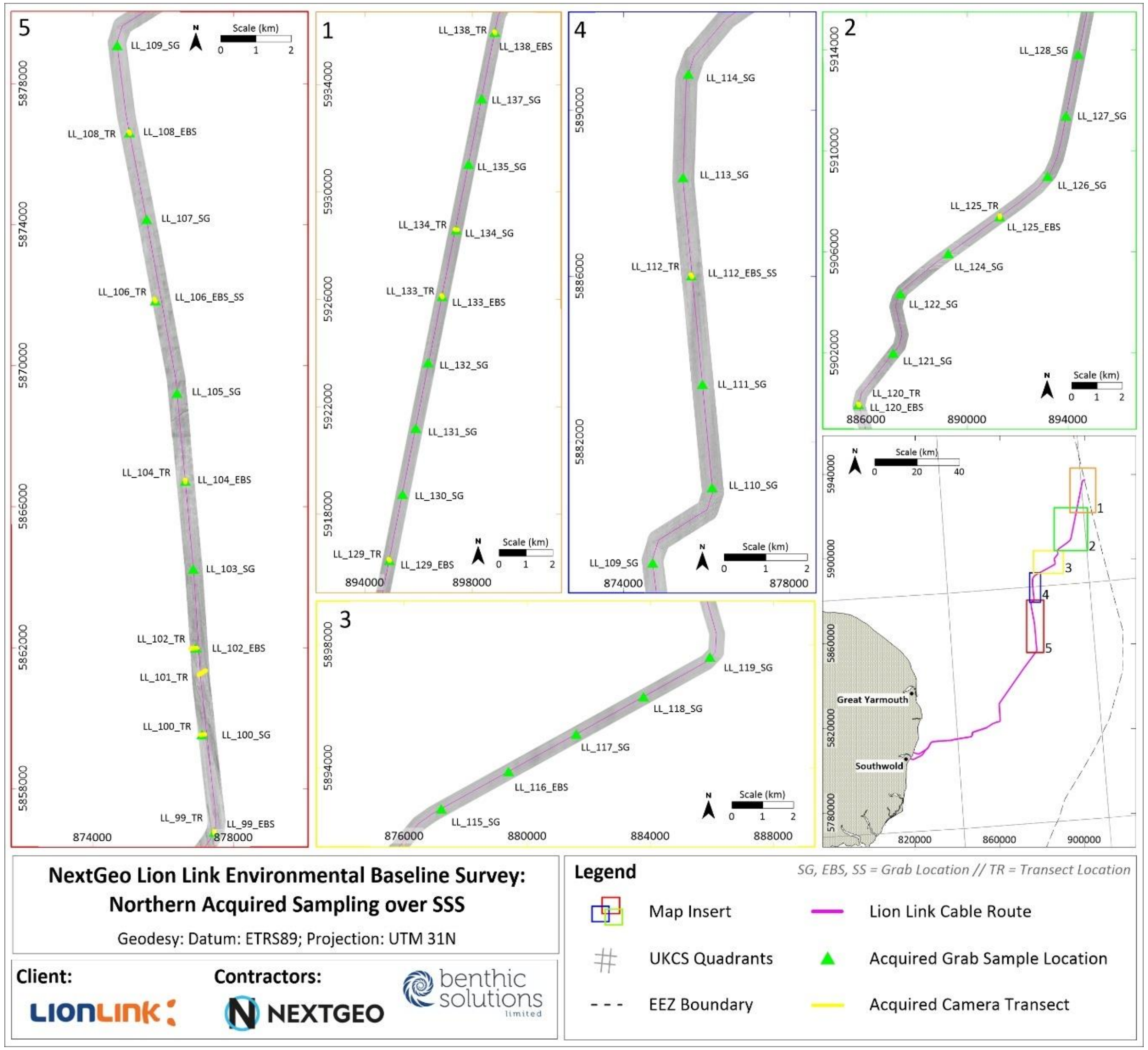



**Figure 2-1 Field Sampling Acquisition (Northern Part of Route)**

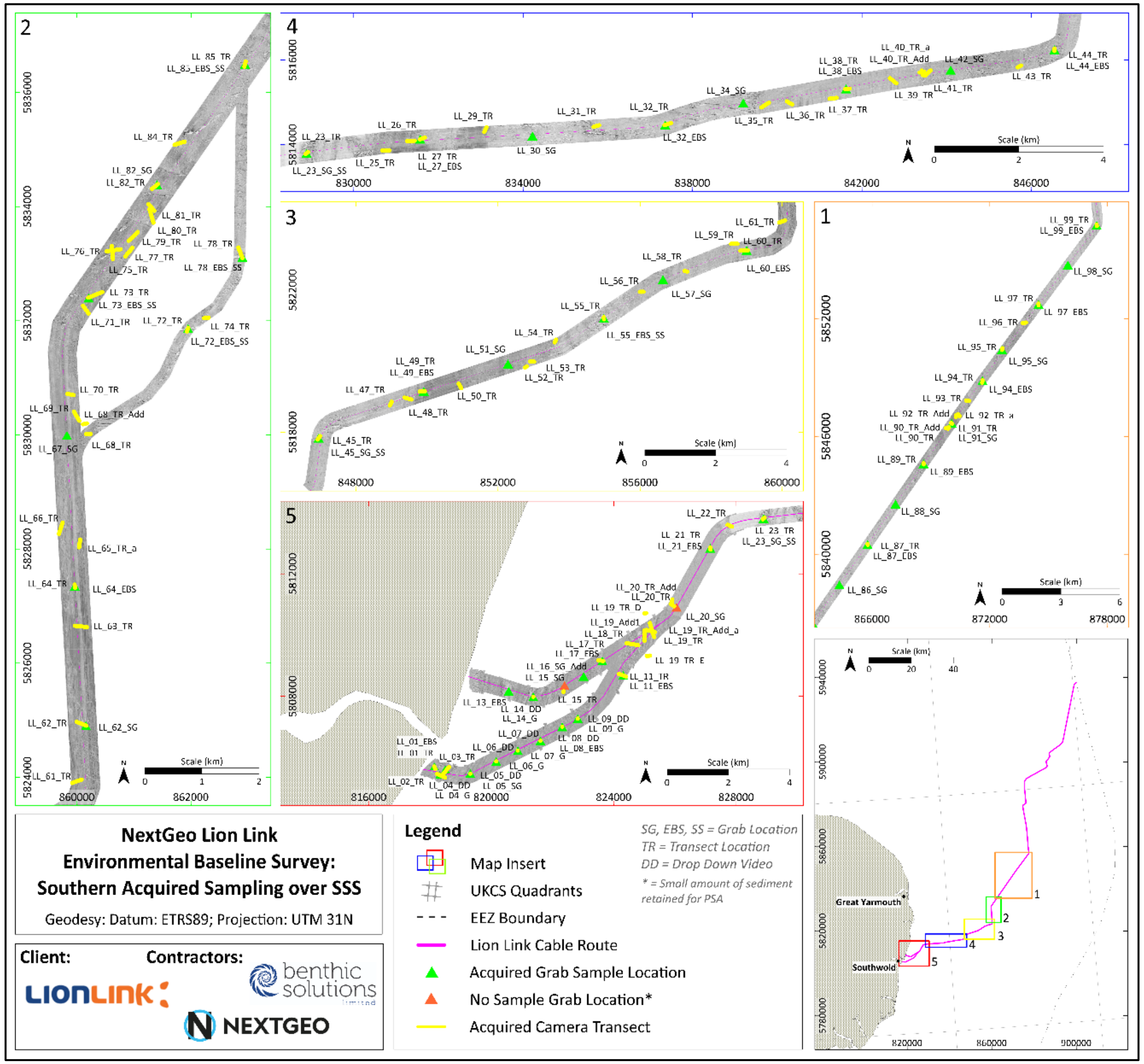



**Figure 2-2 Field Sampling Acquisition (Southern Part of Route)**

## 2.4 Sediment Sample Analyses

The recovered benthic samples were appropriately stored prior to demobilisation and transportation of the material to the following analytical laboratories:

- BSL: Macro-invertebrate Analysis
- BSL: Particle Size Analysis
- Socotec: Sediment Chemistry

The analytical methods used for the current survey are summarised below in Table 2-4 with further detail provided in Appendix B – Data Presentation, Laboratory and Statistical Analyses.

**Table 2-4 Analytical Methods and Limit of Detection**

| Determinant | | Detection Limits | Accreditation | Laboratory Technique |
|---|---|---|---|---|
| Particle Size Distribution | | N/S | NMBAQC & MMO | Sieving and laser diffraction (Malvern Mastersizer) to whole and half phi intervals, respectively |
| Moisture Content | | 0.20% | UKAS | Documented in-house method, oven drying at 105°C, No TMSS |
| Total Organic Carbon | | 0.02% | ISO 17025 & UKAS/MMO | Documented in-house method with carbonate removal and sulphurous acid/combustion at 1600°C/NDIR, WSLM59 |
| Total Organic Matter (TOM) | | 0.01% | ISO 17025 & UKAS | Loss on Ignition (LOI) at 440°C |
| Total THC (>C8-C40) | | $10mg.kg^{-1}$ | - | Documented in-house method involving solvent extraction and clean up followed by GC-FID |
| Heavy Metals | Al | $10mg.kg^{-1}$ | ISO 17025, UKAS/MMO | Aqua Regia (half strength) acid extraction followed by ICPMS or ICPOES. |
| | As | $0.5mg.kg^{-1}$ | | |
| | Ba | $0.5mg.kg^{-1}$ | | |
| | Cd | $0.04mg.kg^{-1}$ | | |
| | Cr | $0.5mg.kg^{-1}$ | | |
| | Cu | $0.5mg.kg^{-1}$ | | |
| | Pb | $0.5mg.kg^{-1}$ | | |
| | Li | $0.5mg.kg^{-1}$ | | |
| | Hg | $0.01mg.kg^{-1}$ | | |
| | Ni | $0.5mg.kg^{-1}$ | | |
| | Sn | $0.5mg.kg^{-1}$ | | |
| | Zn | $2mg.kg^{-1}$ | | |
| Sediment Endocrine Disruptors (Organotins, PCBs and OCPs) | | Various | UKAS/MMO | Solvent extraction and derivatisation followed by GC-MS analysis. |
| EPA list of 16 potentially hazardous compounds and DTI parent and alkylated PAH list | | $1μg.kg^{-1}$ | ISO 17025 & | Documented in-house method using DTI specification involving solvent extraction and clean up followed by GC-MS. |
| Extractable Organic Halogens (EOX) | | $20mg.kg^{-1}$ | - | MSSL Method 3023 based upon BS EN ISO 9562:2004 using a Behr Coulometric analyser |

| **Determinant** | **Detection Limits** | **Accreditation** | **Laboratory Technique** |
|---|---|---|---|
| Benthic Macrofauna | n/a | NMBAQC | Biological identification of >500µm fractions with univariate and multivariate analyses. 2 of 3 replicates processed. |
| *Note:*<br>*-Detection limit is the lowest quantity of a substance that can be distinguished from the absence of that of a blank value with a stated confidence level*<br>*-NMBAQC is not strictly an accreditation but provides external quality assurance for particle size and macrofaunal analysis* | | | |

# 3 Results and Interpretation

## 3.1 Bathymetry and Seabed Features

The following text was adapted from the geophysical report for the Lion Link route area (Doc Ref: P2066-010-REP-001) to describe the bathymetry and seabed features across the survey area.

The seabed within the survey area had a variable gradient with a deviation of more than 10 degrees occurring along the corridor. In the nearshore area, maximum slopes ranged from 4.5° in the intertidal areas of Blocks 3 to 5° in Block 4. The subtidal zones of Blocks 3 and 4 exhibited steeper slopes, with maximum gradients of 20° and 14°, respectively. In the offshore section (Block 5 to Block 19), the maximum slope varied from 4° in Block 19 to 37° in Block 9_RD. Water depths ranged from 0.08m below LAT to 21m LAT in the nearshore section and from 19.8m LAT in Block 5 to 54.2m LAT in Block 10 offshore.

Seabed composition varied slightly along the survey route. The intertidal areas of Blocks 3 and 4 were predominantly sandy-mud, transitioning to gravelly mud and muddy gravel in the subtidal sections of Blocks 3 and 4. Offshore, Blocks 5 to 8 also consisted mainly of sand and gravelly sand. In Blocks 9 to 13, the seabed transitioned into mixed material, interpreted as sand, mud and gravels and rock outcrops. Blocks 14 to 16 were dominated by sand without coarse material, while Blocks 17 to 19 featured predominantly sand and mud, with coarse sediments observed within Block 19 before the seabed returned to sand and mud towards the end of the route.

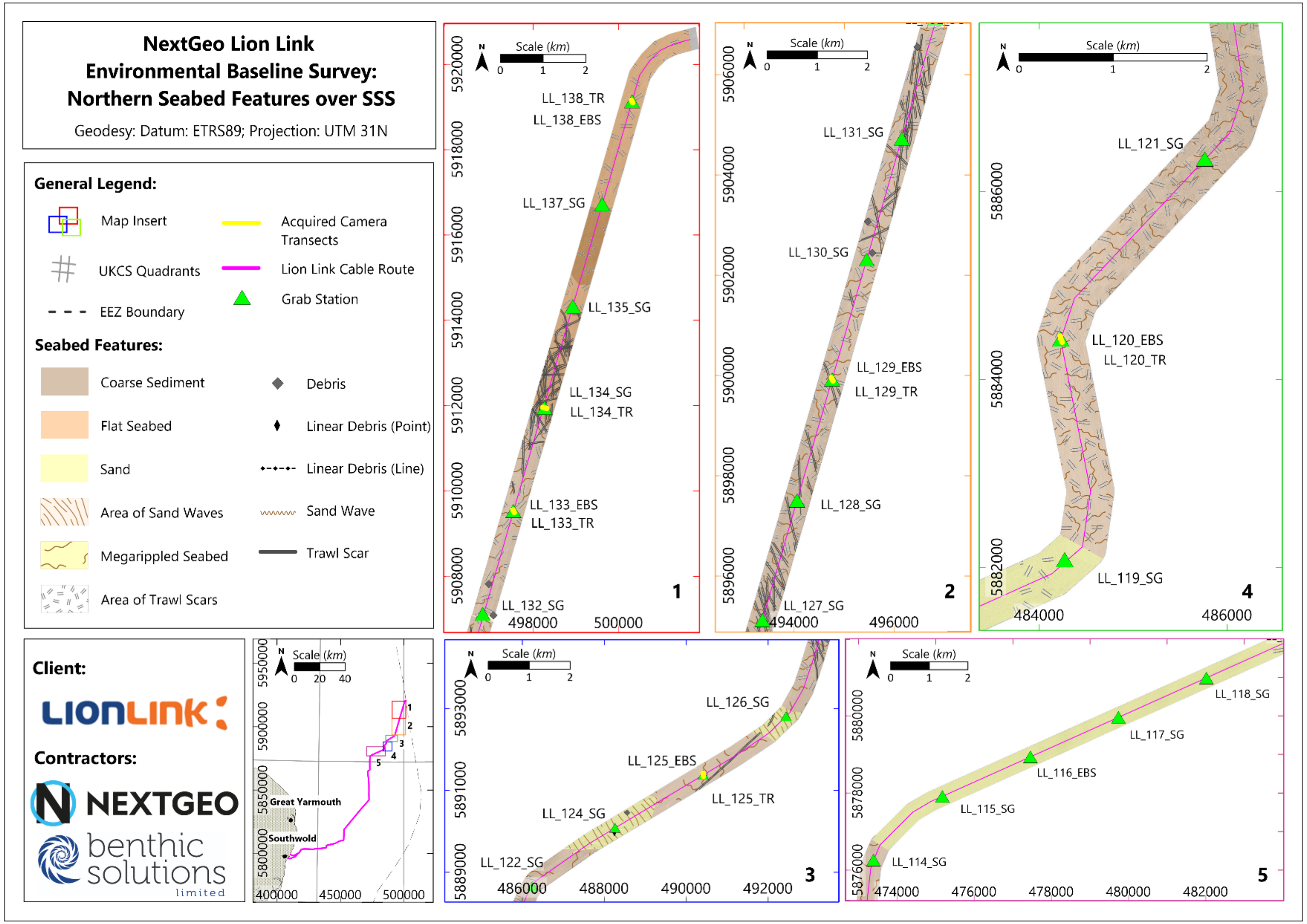



**Figure 3-1 Northern Seabed Features over SSS (Figure 1 of 2)**

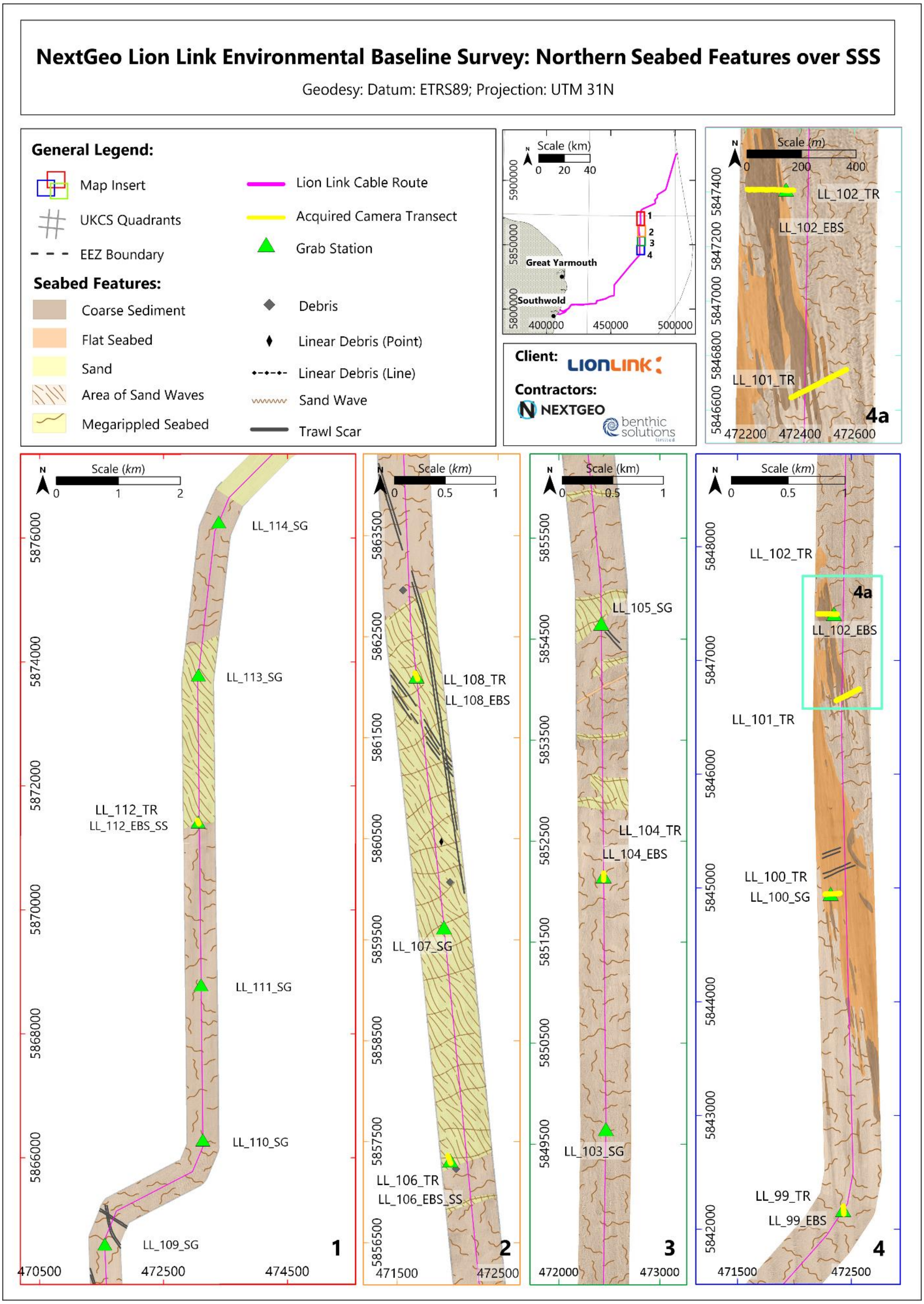



**Figure 3-2 Northern Seabed Features over SSS (Figure 2 of 2)**

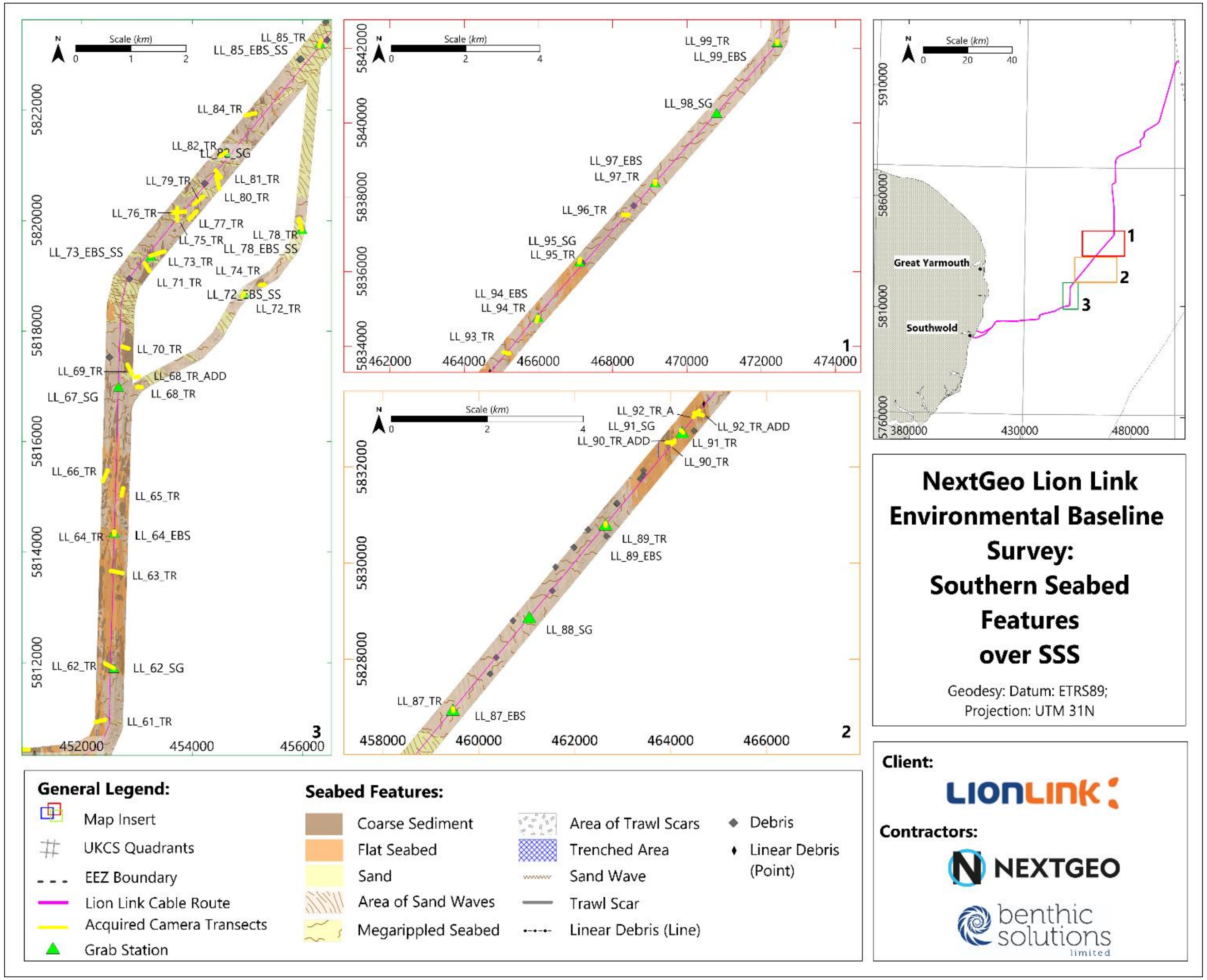



**Figure 3-3 Southern Seabed Features over SSS (Figure 1 of 3)**

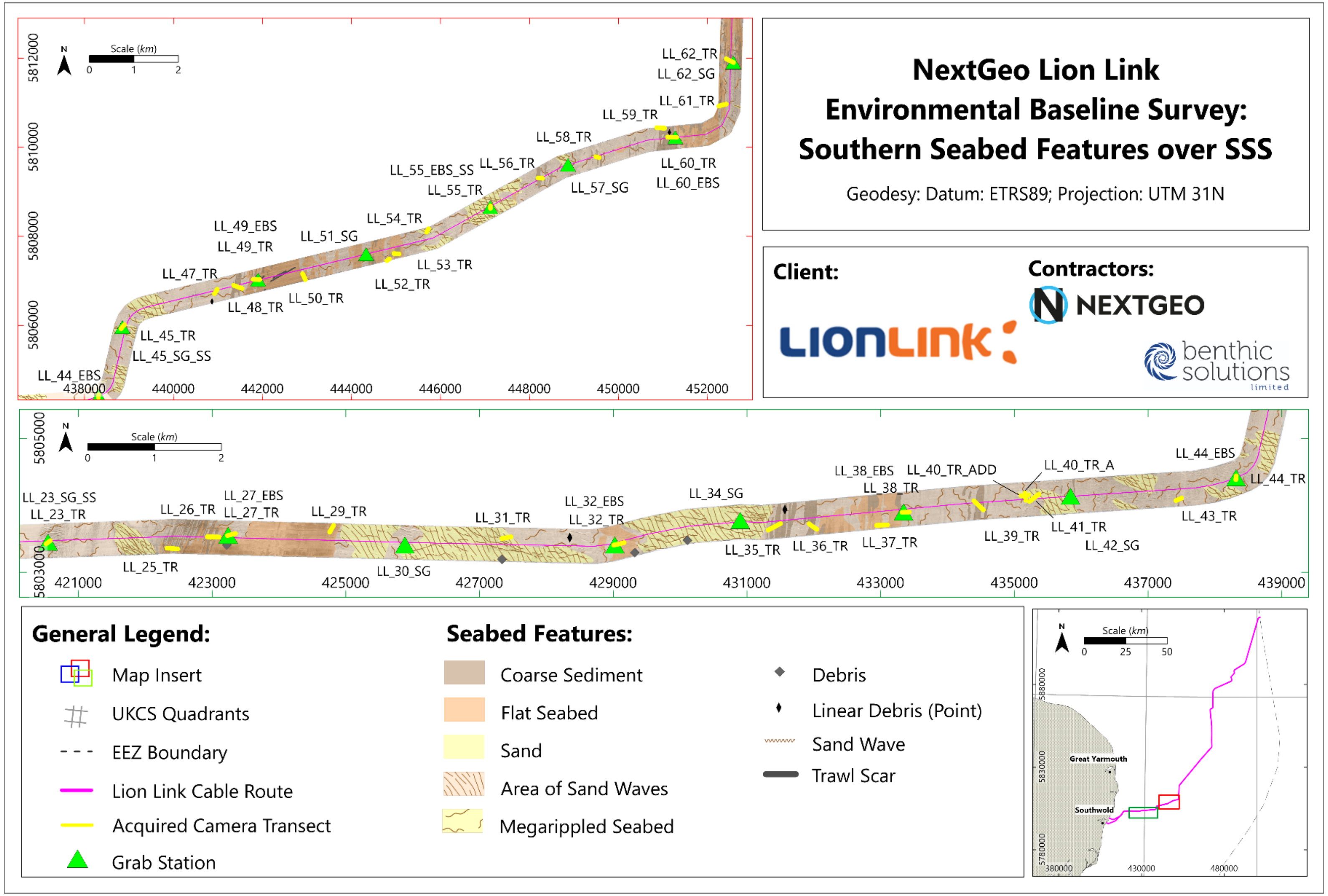



**Figure 3-4 Southern Seabed Features over SSS (Figure 2 of 3)**

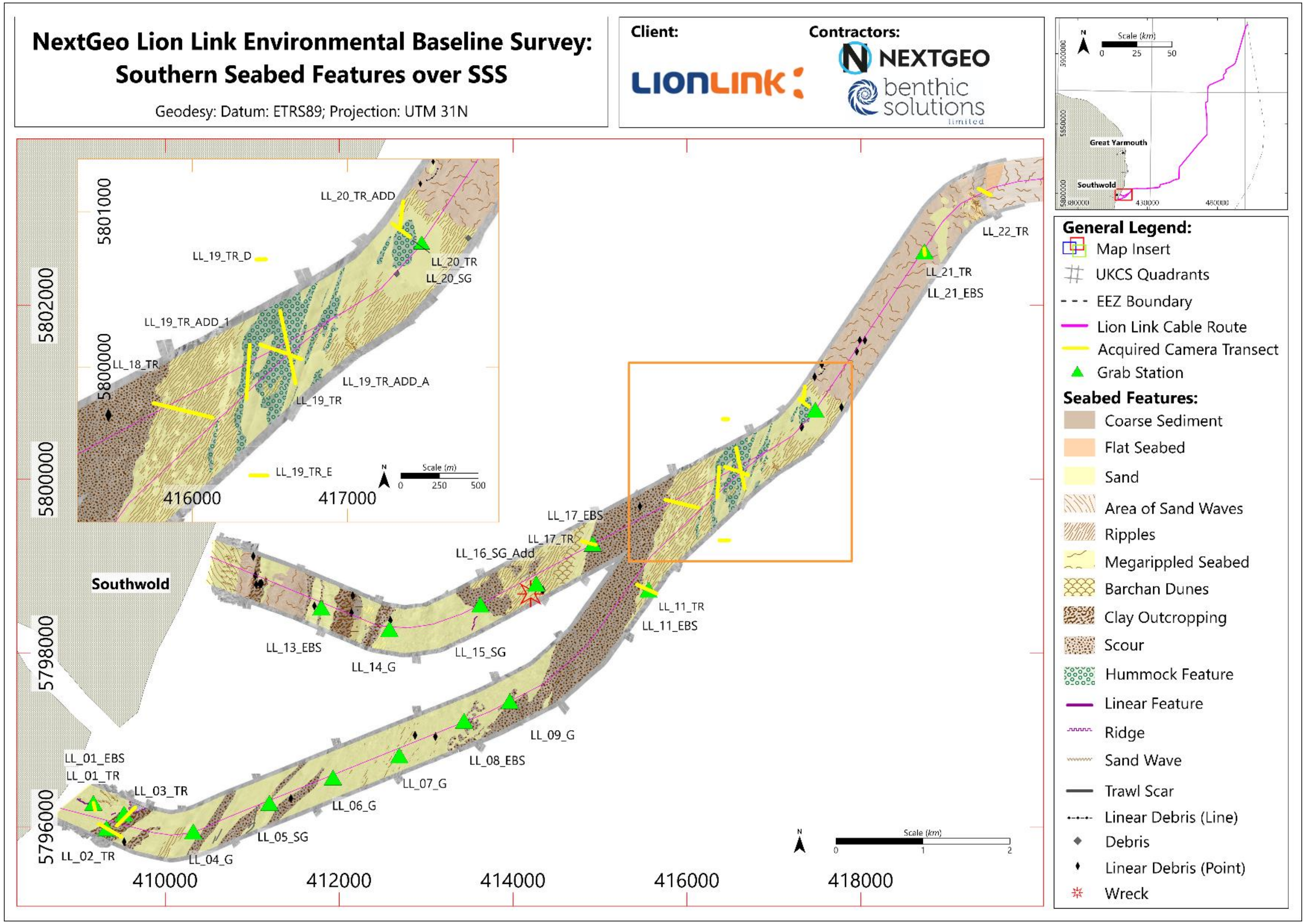



**Figure 3-5 Southern Seabed Features over SSS (Figure 3 of 3)**

## 3.2 Particle Size Distribution

The particle size interpretation of sediments from the environmental baseline survey along the Lion Link cable route was based on observations made from the acoustic data, seabed photography, and from the analytical results acquired from the surface sediments at 84 stations. Material for particle size analysis was recovered from the surface 5cm of the grab samples and was analysed by BSL upon return of the samples to Norfolk, UK. Please refer to Appendix B – Data Presentation, Laboratory and Statistical Analyses for the laboratory methods employed.

The sediment characteristics for each station are listed in Table 3-1. Individual particle size distribution plots are presented in Appendix C – Particle Size Distribution.

### 3.2.1 General Description

The results of the particle size analysis indicated variable seabed sediments along the cable route with the nearshore region (stations LL_01_EBS to LL_17_EBS) comprised mainly of fines (mean: 52.7%±26.0SD), with smaller proportions of sands (mean 33.3%±15.8SD) and low proportions of gravel (mean 14.2%±23.6SD, Table 3-1). Whereas the offshore sediments (stations LL_21_EBS to LL_138_EBS) were sands dominant (mean: 86.5%±15.3SD), with small but variable fines (mean: 7.79%±10.5SD) and gravel contents (mean: 5.69%±10.1SD, Table 3-1).

Proportions of fines were predominantly higher in the nearshore section, ranging from 21.5% at LL_15_SG to 77.8% at LL_13_EBS (Figure 3-6), whereas stations LL_01_EBS and LL_03_TR had minimal fines proportions (0.0% to 1.8% respectively). This pattern suggests that Blocks 3 and 4 contain outcropping areas of cohesive fine material, supported by grab sample images and deck log observations noting the presence of 'anoxic clay'. The slightly lower fines content at LL_15_SG compared to other nearshore stations can be explained by the smaller sample volume obtained (Table 2-2), whilst stations LL_01_EBS and LL_03_TR were sampled in a mixed gravelly area. The proportion of fines in the offshore area was more variable as evidenced by a high coefficient of variance of 135%. The highest fines content of 43.7% in the offshore area was recorded at station LL_30_SG in Block 06 in an area of sandwaves.

Sand proportions were higher in the offshore section, ranging from 45% at LL_27_EBS to 100% at LL_34_G. In contrast, the nearshore area exhibited consistently lower sand content, with all but one station recording <46% (Figure 3-7). The exception, LL_01_EBS, recorded 83.8% sand due to its grab location within an area of megarippling sands. The higher offshore sand content aligns with the EMODnet predicted sediment classification of 'Atlantic Offshore Circalittoral Sand' (A5.27/MD52) and corresponds to seabed features identified in the geophysical survey, including sandwaves, megaripples and sand ripples.

Gravel content varied along the entire cable route, with high coefficients of variance recorded both nearshore (166.7%) and offshore (177.0%). The highest gravel contents were observed at stations LL_15_SG (60.6%), LL_02_TR (46.7%), LL_49_EBS (41.8%), and LL_51_SG (41.1%), located in areas characterised by 'Gravelly Sands' or 'Muddy Gravel' as interpreted from geophysical seabed features, including pebbles and shells (Figure 3-8). The heterogeneity of the seabed at these locations necessitated the use of the mini-Hamon grab sampler to obtain successful samples, after multiple failed attempts with the double Van Veen sampler.

The Folk (1954) and Wentworth (1922) classifications for each station are listed in Table 3-1 The Wentworth classification assigns a single sediment class based on the mean particle size and is appropriate for well sorted modal sediments, dominated by a narrow range of sediment particle sizes. The Folk classification provides a more representative description for poorly sorted sediments, encompassing a range of particle sizes as it considers the relative proportions of fines (<63µm), sand (63µm-2mm) and gravel (>2mm) fractions. For the purposes of this study, we have used the modified Folk classification produced by the British Geological Survey (Long, 2006).

The nearshore stations represented four different Folk classifications of 'Sandy Mud', 'Slightly Gravelly Sandy Mud', 'Gravelly Mud' and 'Muddy Gravel'. The offshore stations were more varied and represented eight different Folk classifications with the most common (32% of stations) being 'Sand'. (Table 3-1).

**Table 3-1 Summary of Surface Particle Characteristics**

| Station | Depth (m) | Mean Sediment Size (mm) | Mean Sediment Size (Phi) | Wentworth Classification | Sorting Coefficient | Sorting Classification | Fines (%) | Sands (%) | Gravel (%) | Modified Folk Scale |
|---|---|---|---|---|---|---|---|---|---|---|
| **Nearshore** | | | | | | | | | | |
| LL_01_EBS | 5 | 0.52 | 0.94 | Coarse Sand | 1.9 | Poorly Sorted | 0.0 | 83.8 | 17.2 | Gravelly Sand |
| LL_02_TR | 8 | 0.48 | 1.06 | Medium Sand | 4.5 | Extremely Poorly Sorted | 33.1 | 20.2 | 46.7 | Muddy Gravel |
| LL_03_TR | 6 | 2.97 | -1.57 | Granule | 2.3 | Very Poorly Sorted | 1.8 | 32.2 | 67.4 | Sandy Gravel |
| LL_04_TR_G | 10 | 0.02 | 5.61 | Medium Silt | 2.4 | Very Poorly Sorted | 72.5 | 27.4 | 0.1 | Sandy Mud |
| LL_05_SG | 14 | 0.03 | 5.15 | Coarse Silt | 2.5 | Very Poorly Sorted | 64.1 | 31.0 | 5.0 | Slightly Gravelly Sandy Mud |
| LL_06_TR_G | 12 | 0.04 | 4.81 | Coarse Silt | 2.51 | Very Poorly Sorted | 53.9 | 45.2 | 0.9 | Sandy Mud |
| LL_07_TR_G | 12 | 0.03 | 5.14 | Medium Silt | 2.4 | Very Poorly Sorted | 63.8 | 36.1 | 0.1 | Sandy Mud |
| LL_08_EBS | 14 | 0.03 | 4.9 | Coarse Silt | 3.18 | Very Poorly Sorted | 68.1 | 25.8 | 6.1 | Gravelly Mud |
| LL_09_TR_G | 18 | 0.02 | 5.69 | Medium Silt | 2.41 | Very Poorly Sorted | 71.4 | 28.3 | 0.3 | Sandy Mud |
| LL_11_EBS | 20 | 0.02 | 5.41 | Medium Silt | 2.35 | Very Poorly Sorted | 72.2 | 27.5 | 0.4 | Sandy Mud |
| LL_13_EBS | 12 | 0.02 | 5.6 | Medium Silt | 2.02 | Very Poorly Sorted | 77.8 | 22.2 | 0.1 | Sandy Mud |
| LL_14_TR_G | 14 | 0.04 | 4.72 | Coarse Silt | 3.09 | Very Poorly Sorted | 59.1 | 34.6 | 6.3 | Gravelly Mud |
| LL_15_SG | 16 | 1.75 | 5.15 | Medium Silt | 4.63 | Extremely Poorly Sorted | 21.5 | 17.9 | 60.6 | Muddy Gravel |
| LL_16_SG_ADD | 16 | 0.04 | 4.58 | Coarse Silt | 2.41 | Very Poorly Sorted | 57.3 | 41.6 | 1.1 | Slightly Gravelly Sandy Mud |
| LL_17_EBS | 16 | 0.02 | 5.53 | Medium Silt | 2.03 | Very Poorly Sorted | 74.0 | 26.0 | 0.0 | Sandy Mud |
| **Mean** | | **0.40** | **4.18** | **-** | **2.71** | **-** | **52.71** | **33.3** | **14.2** | **-** |
| **Standard Deviation** | | **0.84** | **2.19** | **-** | **0.83** | **-** | **26.0** | **15.8** | **23.6** | **-** |
| **Variance (%)** | | **209.9** | **52.39** | **-** | **30.7** | **-** | **49.4** | **47.5** | **166.7** | **-** |
| **Minimum** | | **0.02** | **-1.57** | **-** | **1.9** | **-** | **0.0** | **17.9** | **0.0** | **-** |
| **Maximum** | | **2.97** | **5.69** | **-** | **4.63** | **-** | **77.8** | **83.8** | **67.4** | **-** |
| **Offshore** | | | | | | | | | | |
| LL_21_EBS | 20 | 0.19 | 2.4 | Fine Sand | 0.5 | Moderately Well Sorted | 2.0 | 98.0 | 0.0 | Sand |
| LL_23_SG_SS | 35 | 0.3 | 1.75 | Medium Sand | 2.01 | Very Poorly Sorted | 14.7 | 83.1 | 2.3 | Slightly Gravelly Muddy Sand |

| Station | Depth (m) | Mean Sediment Size (mm) | Mean Sediment Size (Phi) | Wentworth Classification | Sorting Coefficient | Sorting Classification | Fines (%) | Sands (%) | Gravel (%) | Modified Folk Scale |
|---|---|---|---|---|---|---|---|---|---|---|
| LL_27_EBS | 32 | 0.38 | 1.4 | Medium Sand | 3.87 | Very Poorly Sorted | 22.5 | 45.0 | 32.5 | Muddy Sandy Gravel |
| LL_30_SG | 35 | 0.07 | 3.85 | Very Fine Sands | 2.48 | Very Poorly Sorted | 43.7 | 56.2 | 0.1 | Muddy Sand |
| LL_32_EBS | 34 | 0.23 | 2.14 | Fine Sand | 4.02 | Extremely Poorly Sorted | 30.9 | 47.4 | 21.7 | Gravelly Muddy Sand |
| LL_34_SG | 24 | 0.37 | 1.45 | Medium Sand | 0.44 | Well Sorted | 0.0 | 100.0 | 0.0 | Sand |
| LL_38_EBS | 35 | 0.25 | 1.98 | Medium Sand | 1.28 | Poorly Sorted | 13.7 | 86.3 | 0.0 | Muddy Sand |
| LL_42_SG | 37 | 1.15 | -0.2 | Very Coarse Sand | 2.27 | Very Poorly Sorted | 4.0 | 57.4 | 38.6 | Sandy Gravel |
| LL_44_EBS | 40 | 0.41 | 1.3 | Medium Sand | 0.61 | Moderately Well Sorted | 0.0 | 99.9 | 0.1 | Sand |
| LL_45_SG_SS | 40 | 1.05 | -0.06 | Very Coarse Sand | 1.85 | Poorly Sorted | 0.8 | 71.4 | 27.8 | Gravelly Sand |
| LL_49_EBS | 44 | 1.25 | -0.32 | Very Coarse Sand | 2.65 | Very Poorly Sorted | 9.1 | 49.1 | 41.8 | Muddy Sandy Gravel |
| LL_51_SG | 38 | 1.42 | -0.5 | Very Coarse Sand | 2.69 | Very Poorly Sorted | 6.1 | 52.8 | 41.1 | Muddy Sandy Gravel |
| LL_55_EBS_SS | 39 | 0.49 | 1.02 | Medium Sand | 0.66 | Moderately Well Sorted | 0.0 | 96.2 | 3.8 | Slightly Gravelly Sand |
| LL_57_SG | 39 | 0.5 | 1 | Coarse Sand | 0.69 | Moderately Well Sorted | 0.0 | 95.5 | 4.5 | Slightly Gravelly Sand |
| LL_60_EBS | 41 | 0.41 | 1.28 | Medium Sand | 0.79 | Moderately Sorted | 1.3 | 92.8 | 5.9 | Gravelly Sand |
| LL_62_SG | 44 | 1.36 | -0.44 | Very Coarse Sand | 2.12 | Very Poorly Sorted | 0.7 | 71.8 | 27.9 | Gravelly Sand |
| LL_64_EBS | 46 | 0.47 | 1.08 | Medium Sand | 1.61 | Poorly Sorted | 7.5 | 82.0 | 10.5 | Gravelly Sand |
| LL_67_SG | 44 | 0.6 | 0.75 | Coarse Sand | 0.59 | Moderately Well Sorted | 0.0 | 97.0 | 3.1 | Slightly Gravelly Sand |
| LL_72_EBS_SS | 44 | 0.42 | 1.24 | Medium Sand | 0.8 | Moderately Sorted | 0.0 | 93.9 | 6.1 | Gravelly Sand |
| LL_73_EBS_SS | 46 | 0.62 | 0.69 | Coarse Sand | 0.69 | Moderately Well Sorted | 2.5 | 94.8 | 2.9 | Slightly Gravelly Sand |
| LL_78_EBS_SS | 42 | 0.51 | 0.97 | Coarse Sand | 0.75 | Moderately Sorted | 0.0 | 93.3 | 6.7 | Gravelly Sand |
| LL_82_SG | 48 | 0.26 | 1.93 | Medium Sand | 2.27 | Very Poorly Sorted | 15.1 | 74.2 | 10.7 | Gravelly Muddy Sand |
| LL_85_EBS_SS | 46 | 0.47 | 1.07 | Medium Sand | 0.5 | Moderately Well Sorted | 0.0 | 97.4 | 2.6 | Slightly Gravelly Sand |
| LL_86_SG | 48 | 0.35 | 1.5 | Medium Sand | 0.5 | Well Sorted | 0.9 | 98.1 | 1.1 | Slightly Gravelly Sand |
| LL_87_EBS | 50 | 0.19 | 2.43 | Fine Sand | 1.63 | Poorly Sorted | 17.4 | 82.5 | 0.1 | Muddy Sand |
| LL_88_SG | 51 | 0.33 | 1.6 | Medium Sand | 0.99 | Moderately Sorted | 7.3 | 90.1 | 2.6 | Slightly Gravelly Sand |
| LL_89_EBS | 51 | 0.44 | 1.2 | Medium Sand | 0.75 | Moderately Sorted | 0.1 | 96.9 | 2.9 | Slightly Gravelly Sand |
| LL_91_SG | 46 | 0.24 | 2.06 | Fine Sand | 3.07 | Very Poorly Sorted | 19.9 | 66.6 | 13.4 | Gravelly Muddy Sand |

| Station | Depth (m) | Mean Sediment Size | | Wentworth Classification | Sorting Coefficient | Sorting Classification | Fines (%) | Sands (%) | Gravel (%) | Modified Folk Scale |
|---|---|---|---|---|---|---|---|---|---|---|
| | | (mm) | (Phi) | | | | | | | |
| LL_94_EBS | 48 | 0.37 | 1.45 | Medium Sand | 0.8 | Moderately Sorted | 3.1 | 94.1 | 2.8 | Slightly Gravelly Sand |
| LL_95_SG | 47 | 0.2 | 2.29 | Fine Sand | 3.24 | Very Poorly Sorted | 26.0 | 62.2 | 12.0 | Gravelly Muddy Sand |
| LL_97_EBS | 44 | 0.36 | 1.47 | Medium Sand | 0.44 | Well Sorted | 0.0 | 98.7 | 1.3 | Slightly Gravelly Sand |
| LL_98_SG | 43 | 0.31 | 1.67 | Medium Sand | 0.45 | Well Sorted | 0.0 | 99.8 | 0.2 | Sand |
| LL_99_EBS | 44 | 0.34 | 1.56 | Medium Sand | 0.4 | Well Sorted | 0.0 | 99.4 | 0.6 | Sand |
| LL_100_SG | 43 | 0.08 | 3.72 | Very Fine Sands | 2.81 | Very Poorly Sorted | 42.8 | 54.1 | 3.1 | Slightly Gravelly Muddy Sand |
| LL_102_EBS | 39 | 0.31 | 1.69 | Medium Sand | 1.95 | Poorly Sorted | 15.1 | 76.6 | 8.2 | Gravelly Muddy Sand |
| LL_103_SG | 37 | 0.39 | 1.37 | Medium Sand | 0.81 | Moderately Sorted | 0.0 | 93.8 | 6.2 | Gravelly Sand |
| LL_104_EBS | 36 | 0.36 | 1.46 | Medium Sand | 0.98 | Moderately Sorted | 2.8 | 90.3 | 6.9 | Gravelly Sand |
| LL_105_SG | 36 | 0.36 | 1.48 | Medium Sand | 0.46 | Well Sorted | 0.0 | 97.7 | 2.3 | Slightly Gravelly Sand |
| LL_106_EBS_SS | 36 | 0.36 | 1.46 | Medium Sand | 0.48 | Well Sorted | 0.0 | 98.0 | 2.0 | Slightly Gravelly Sand |
| LL_107_SG | 37 | 0.4 | 1.32 | Medium Sand | 0.51 | Moderately Well Sorted | 0.0 | 98.9 | 1.1 | Slightly Gravelly Sand |
| LL_108_EBS | 37 | 0.36 | 1.48 | Medium Sand | 0.46 | Well Sorted | 0.0 | 98.2 | 1.8 | Slightly Gravelly Sand |
| LL_109_SG | 28 | 0.34 | 1.57 | Medium Sand | 0.49 | Well Sorted | 4.5 | 94.7 | 0.8 | Sand |
| LL_110_SG | 27 | 0.16 | 2.69 | Fine Sand | 2 | Very Poorly Sorted | 24.0 | 75.1 | 0.9 | Muddy Sand |
| LL_111_SG | 35 | 0.38 | 1.4 | Medium Sand | 0.47 | Well Sorted | 0.0 | 99.1 | 0.9 | Sand |
| LL_112_EBS_SS | 34 | 0.33 | 1.58 | Medium Sand | 0.42 | Well Sorted | 1.9 | 97.2 | 0.9 | Sand |
| LL_113_SG | 35 | 0.34 | 1.56 | Medium Sand | 0.39 | Well Sorted | 0.0 | 99.8 | 0.2 | Sand |
| LL_114_SG | 39 | 0.32 | 1.64 | Medium Sand | 0.45 | Well Sorted | 0.4 | 98.8 | 0.8 | Sand |
| LL_115_SG | 34 | 0.31 | 1.71 | Medium Sand | 0.47 | Well Sorted | 3.2 | 96.3 | 0.5 | Sand |
| LL_116_EBS | 35 | 0.26 | 1.97 | Medium Sand | 1.19 | Poorly Sorted | 13.1 | 86.6 | 0.3 | Muddy Sand |
| LL_117_SG | 25 | 0.25 | 2 | Medium Sand | 1.34 | Poorly Sorted | 14.6 | 85.3 | 0.0 | Muddy Sand |
| LL_118_SG | 33 | 0.34 | 1.54 | Medium Sand | 0.43 | Well Sorted | 0.0 | 99.7 | 0.3 | Sand |
| LL_119_SG | 23 | 0.3 | 1.74 | Medium Sand | 0.45 | Well Sorted | 0.0 | 99.6 | 0.4 | Sand |
| LL_120_EBS | 34 | 0.22 | 2.16 | Fine Sand | 3.02 | Very Poorly Sorted | 19.4 | 67.7 | 12.8 | Gravelly Muddy Sand |
| LL_121_SG | 32 | 0.31 | 1.71 | Medium Sand | 1.47 | Poorly Sorted | 10.2 | 87.4 | 2.4 | Slightly Gravelly Muddy Sand |

| Station | Depth (m) | Mean Sediment Size | | Wentworth Classification | Sorting Coefficient | Sorting Classification | Fines (%) | Sands (%) | Gravel (%) | Modified Folk Scale |
|---|---|---|---|---|---|---|---|---|---|---|
| | | (mm) | (Phi) | | | | | | | |
| LL_122_SG | 21 | 0.34 | 1.57 | Medium Sand | 0.54 | Moderately Well Sorted | 1.2 | 98.7 | 0.1 | Sand |
| LL_124_SG | 30 | 0.29 | 1.77 | Medium Sand | 0.45 | Well Sorted | 0.0 | 99.9 | 0.1 | Sand |
| LL_125_EBS | 31 | 0.27 | 1.91 | Medium Sand | 0.47 | Well Sorted | 1.7 | 97.4 | 0.9 | Sand |
| LL_126_SG | 30 | 0.27 | 1.88 | Medium Sand | 0.51 | Moderately Well Sorted | 2.7 | 97.1 | 0.2 | Sand |
| LL_127_SG | 22 | 0.26 | 1.96 | Medium Sand | 0.47 | Well Sorted | 2.3 | 97.4 | 0.3 | Sand |
| LL_128_SG | 30 | 0.24 | 2.05 | Fine Sand | 1.83 | Poorly Sorted | 14.8 | 77.9 | 7.2 | Gravelly Muddy Sand |
| LL_129_EBS | 31 | 0.25 | 2.03 | Fine Sand | 0.91 | Moderately Sorted | 6.5 | 92.5 | 1.0 | Slightly Gravelly Sand |
| LL_130_SG | 38 | 0.24 | 2.04 | Fine Sand | 0.45 | Well Sorted | 2.0 | 98.0 | 0.0 | Sand |
| LL_131_SG | 29 | 0.14 | 2.82 | Fine Sand | 1.55 | Poorly Sorted | 16.2 | 83.3 | 0.5 | Muddy Sand |
| LL_132_SG | 27 | 0.23 | 2.12 | Fine Sand | 0.55 | Moderately Well Sorted | 4.6 | 94.6 | 0.8 | Sand |
| LL_133_EBS | 27 | 0.24 | 2.07 | Fine Sand | 0.46 | Well Sorted | 3.9 | 96.0 | 0.1 | Sand |
| LL_134_SG | 30 | 0.2 | 2.29 | Fine Sand | 1 | Moderately Sorted | 8.7 | 91.1 | 0.2 | Sand |
| LL_135_SG | 29 | 0.11 | 3.22 | Very Fine Sands | 1.73 | Poorly Sorted | 18.3 | 81.4 | 0.3 | Muddy Sand |
| LL_137_SG | 30 | 0.07 | 3.85 | Very Fine Sands | 2.02 | Very Poorly Sorted | 32.2 | 67.6 | 0.2 | Muddy Sand |
| LL_138_EBS | 29 | 0.08 | 3.61 | Very Fine Sands | 1.84 | Poorly Sorted | 20.5 | 79.3 | 0.2 | Muddy Sand |
| **Mean** | | **0.38** | **1.67** | - | **1.22** | - | **7.79** | **86.5** | **5.69** | - |
| **Standard Deviation** | | **0.27** | **0.87** | - | **0.94** | - | **10.5** | **15.3** | **10.1** | - |
| **Variance (%)** | | **72.1** | **51.8** | - | **76.7** | - | **135** | **17.7** | **177** | - |
| **Minimum** | | **0.07** | **-0.5** | - | **0.39** | - | **0** | **45** | **0** | - |
| **Maximum** | | **1.42** | **3.85** | - | **4.02** | - | **43.7** | **100** | **41.8** | - |

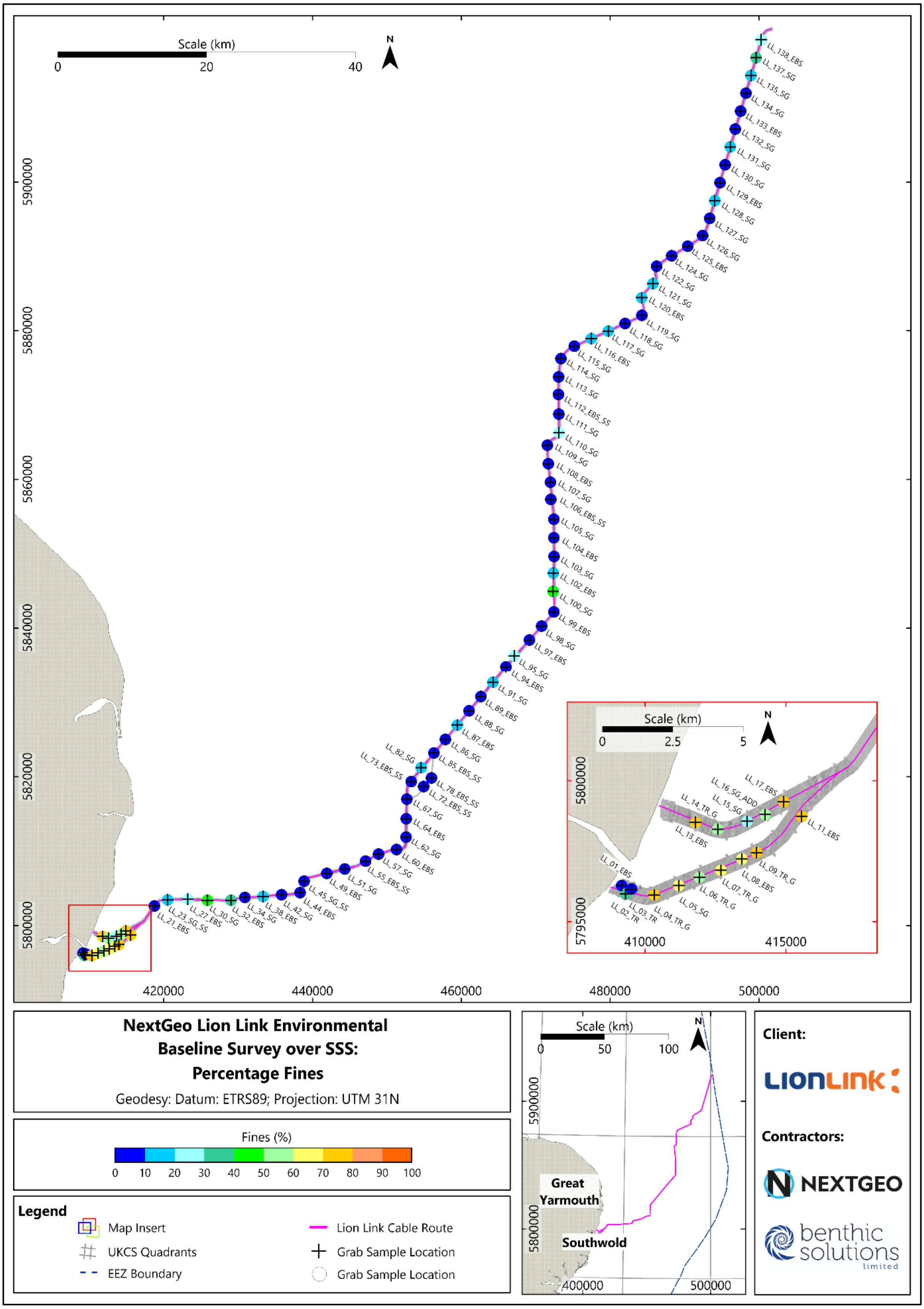



**Figure 3-6 Percentage Fines**

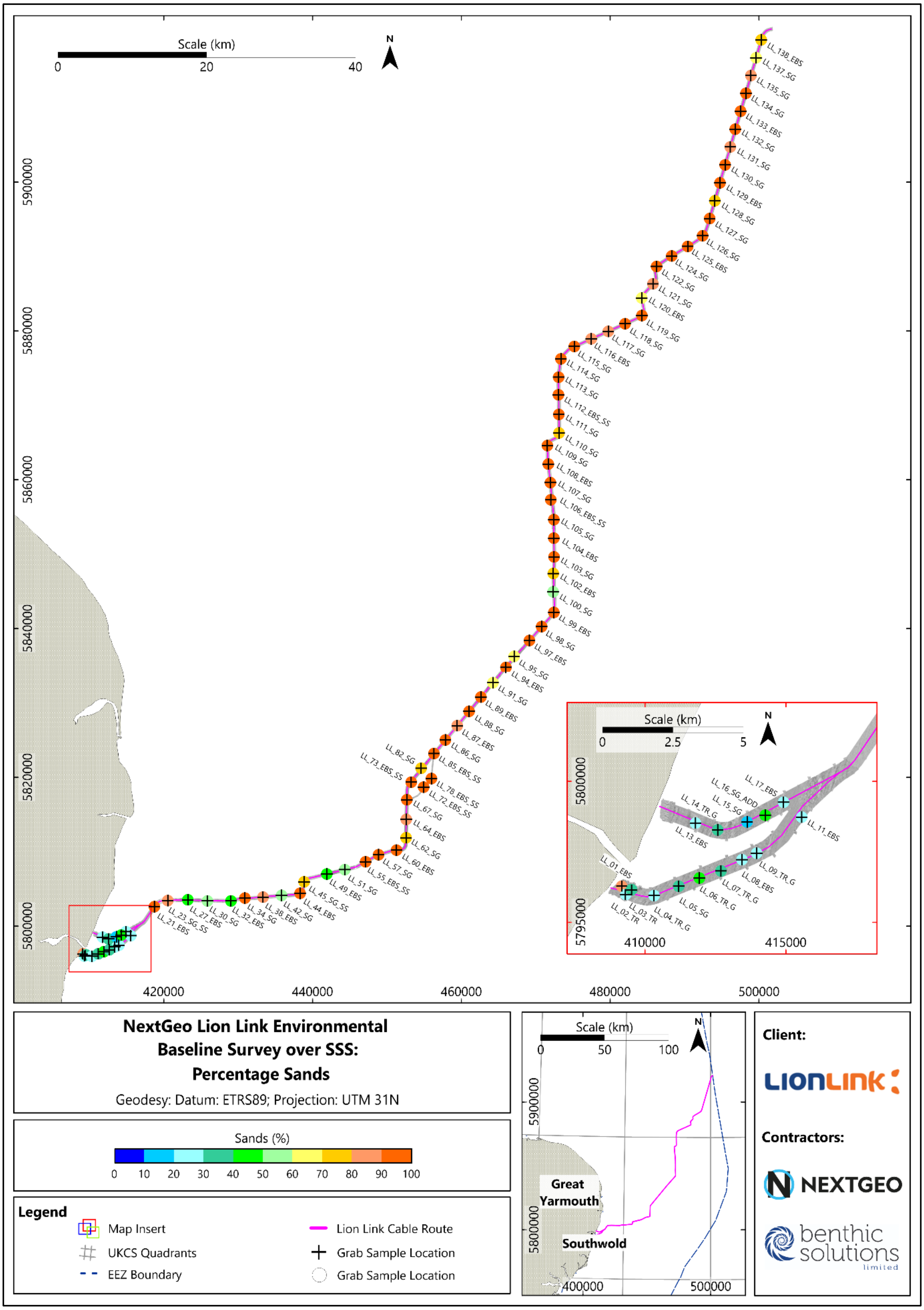



**Figure 3-7 Percentage Sands**

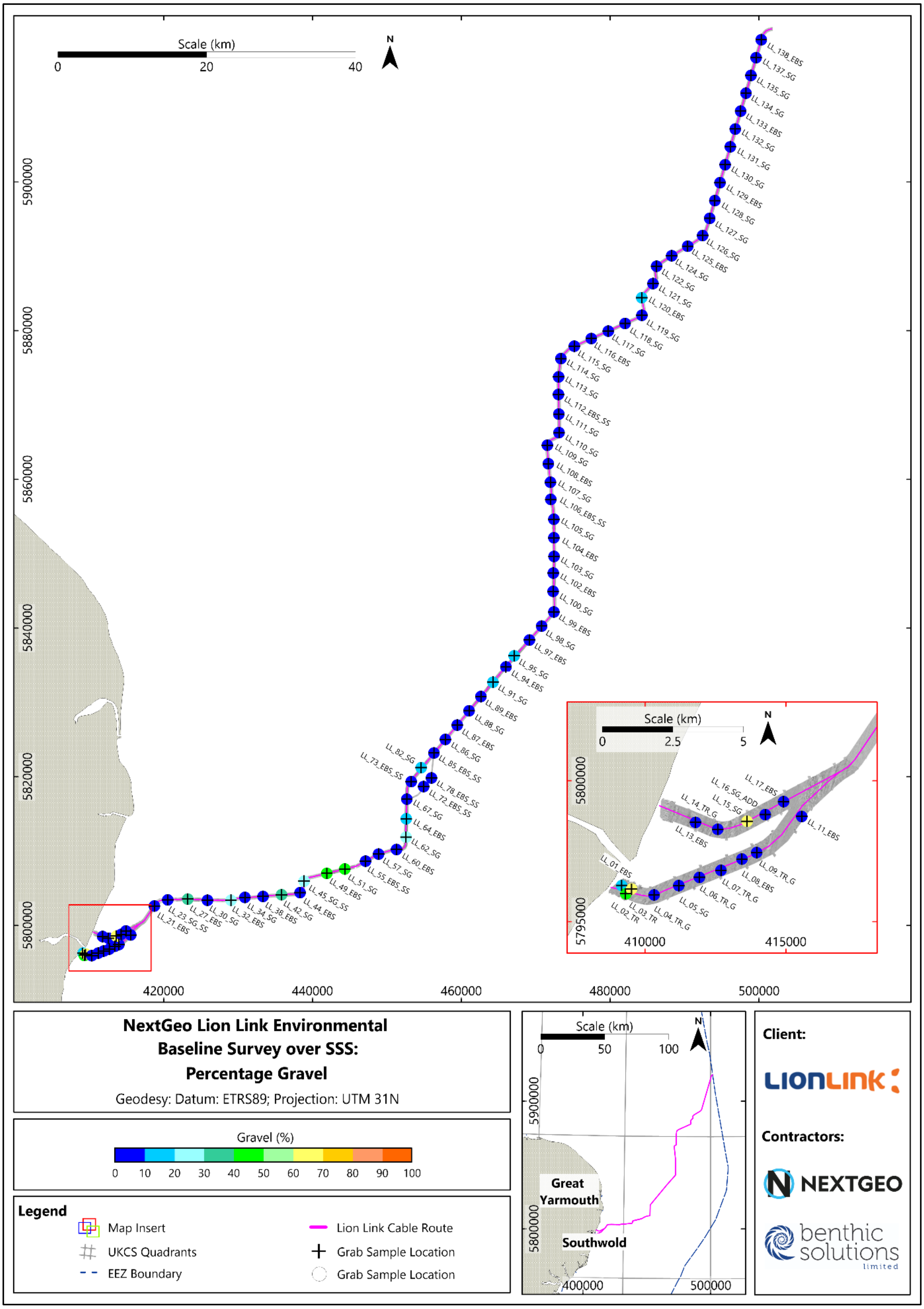



**Figure 3-8 Percentage Gravels**

### 3.2.2 Multivariate Analysis

The particle size distribution of sediments across the survey area were subjected to further detailed investigation by multivariate analysis using the Plymouth Routines in Multivariate Ecological Research software (PRIMER 7.0.17; Clarke *et al.,* 2014) to elucidate any spatial trends within the data.

A similarity dendrogram was generated by hierarchical agglomerative clustering (CLUSTER) using particle size data (phi) to illustrate similarities/differences between stations using the Euclidean distance dissimilarity measure. The dendrogram produced by cluster analysis is shown in Figure 3-9, with red lines denoting statistically similar stations and black lines revealing significant differences. Whilst the similarity profiling analysis (SIMPROF) originally indicated the presence of 24 significantly different ($p$<0.05) clusters, a slice was placed at a Euclidean distance of 40 due to the similarity of stations across the survey area. The six remaining clusters were as follows:

- Cluster 'a': The first cluster contained the majority of the stations across the offshore survey area with a high proportion of sands (75% to 100%), a generally low but variable gravel content (0.0% to 24.0%) and a minimal proportion of fines (0.0% to 8.2%).
- Cluster 'b': The second cluster consisted of the most northern stations of the route, with an exception of LL_01_EBS and LL_21_EBS. This cluster was sand dominant (>67%) but had a greater proportion of fines (1.73% to 32%) and minimal gravel content (0% to 7.2%) compared to cluster 'a'.
- Cluster 'c': The third cluster included all but three nearshore stations, these stations clustered out due to the poorly sorted sediment comprising of predominantly fines (average 67.2%±12.2SD) and sands (average 31.4%±22.8SD). Gravels were generally low with an average of 1.9%±138.9SD, with folk classifications of mostly 'Sandy Mud' across stations within the cluster.
- Cluster 'd': The fourth cluster comprised a number of stations along the southern extent of the cable route and occasional stations along the central area of the route, ranging from 'Poorly Sorted' to 'Extremely Poorly Sorted'. Sands typically dominated stations within this cluster (average 45.7%±44SD) with a slightly lower fraction of fines (average 39.4%±71SD) and lower gravel contents (average 15%±177SD).
- Cluster 'e': The fifth cluster consisted of three nearshore stations (LL_02_TR, LL_03_TR and LL_15_SG), which had the highest gravel content along the survey area (46.7% to 67.4%), with lower proportions of fines (1.8% to 33.1%) and sands (17.9% to 32.2%).
- Cluster 'f': The final cluster consisted of two stations (LL_67_SG and LL_73_EBS_SS) that both had high proportions of sand (97% and 94.8%, respectively) and minimal proportions of fines (0% to 2.5%) and gravel (2.9% to 3.1%).

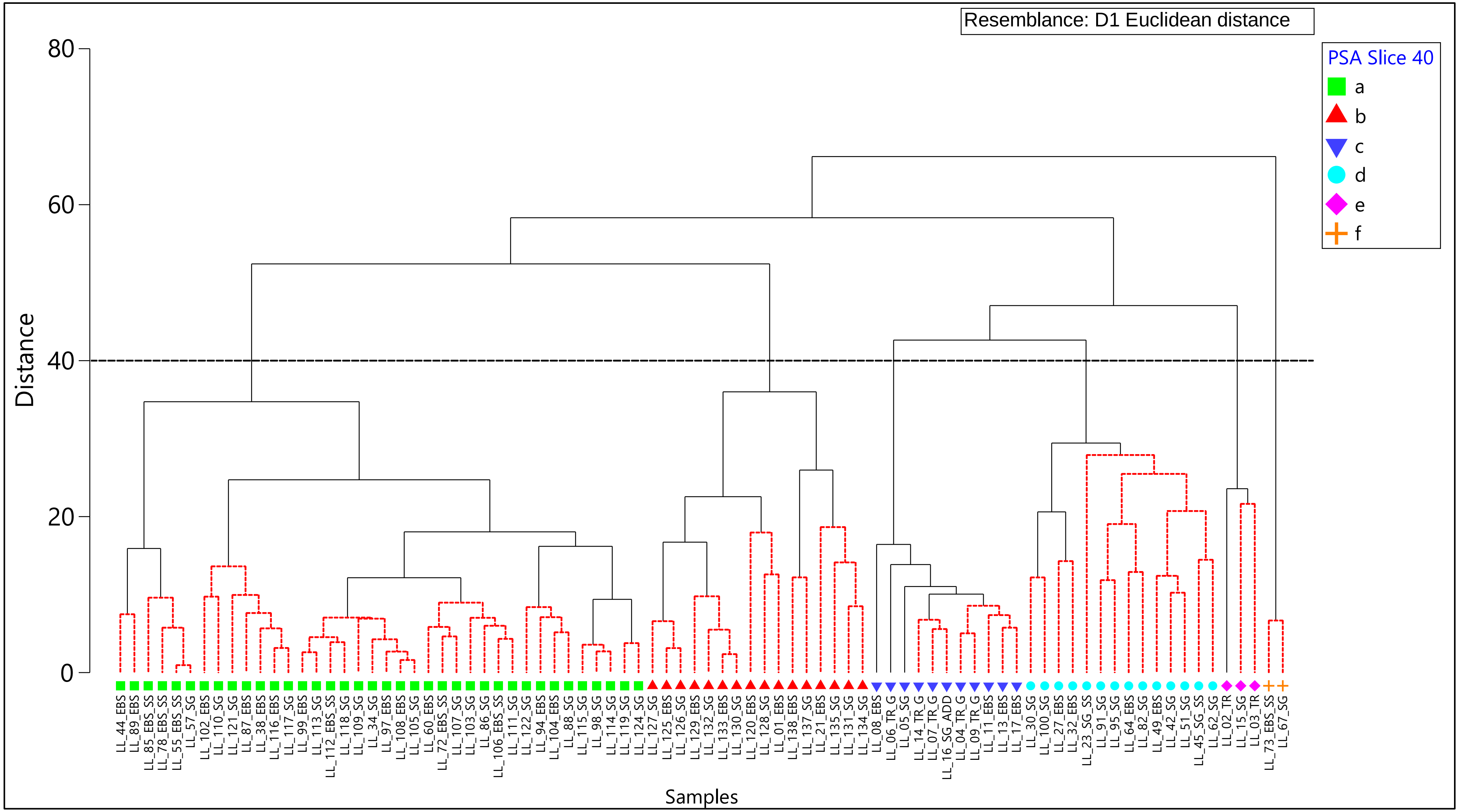



**Figure 3-9 Particle Size Analysis Dendrogram**

A PCA was carried out on the proportional whole phi sieve fraction data for all stations to further explore the variation in particle size distributions along the Lion Link cable route. The resultant PCA plot (Figure 3-10) illustrated the overriding importance of coarse sand (phi 1), medium sand (phi 2) and fine sand (phi 3)) in driving the variability in sediments, as evidenced by the length of the eigenvectors. Cluster ‘a’ was separated from other clusters due to the high medium to coarse sand content (phi 2 to 1, respectively) and lower levels of fines and gravel, whereas cluster ‘b’ was separated from other clusters due the higher proportions of fine sand (phi 3) and lower content of coarse sand (phi 1). Cluster ‘c’ was ordinated to the right of the plot due to the poorly sorted composition consisting of fines and sands from fine sand (phi 3) to clay (phi 9) evidencing a variable fine sediment type. Cluster ‘d’ ordinated right but relatively central to the plot suggesting a poor sorting coefficient of sedimentary proportions between coarse to medium sands (phi 1 and 2) and lower proportions of medium to fine silts (phi 6 to 8). The separation of cluster ‘e’ was influenced by its high proportion of gravel (phi 3). Although categorised separately, this station was ordinated near the other nearshore stations in cluster ‘c’, indicating notable similarities to nearby locations. The similarities these stations share are likely the higher proportions of silts and lower proportions of medium sand. Cluster ‘f’ was separated from all other clusters due to the highest proportions of ‘Coarse sand’ (phi 1) recorded in the survey area.

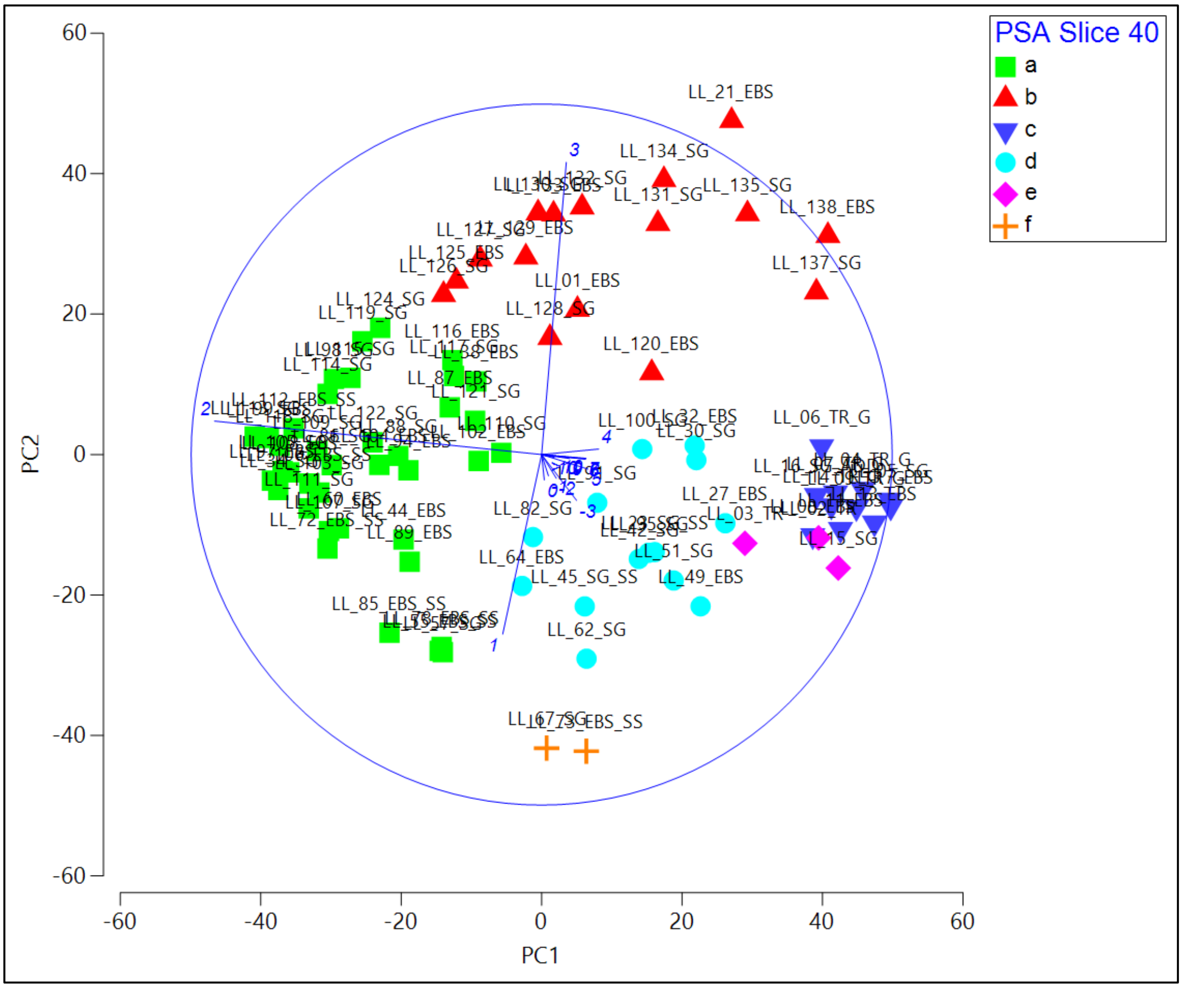
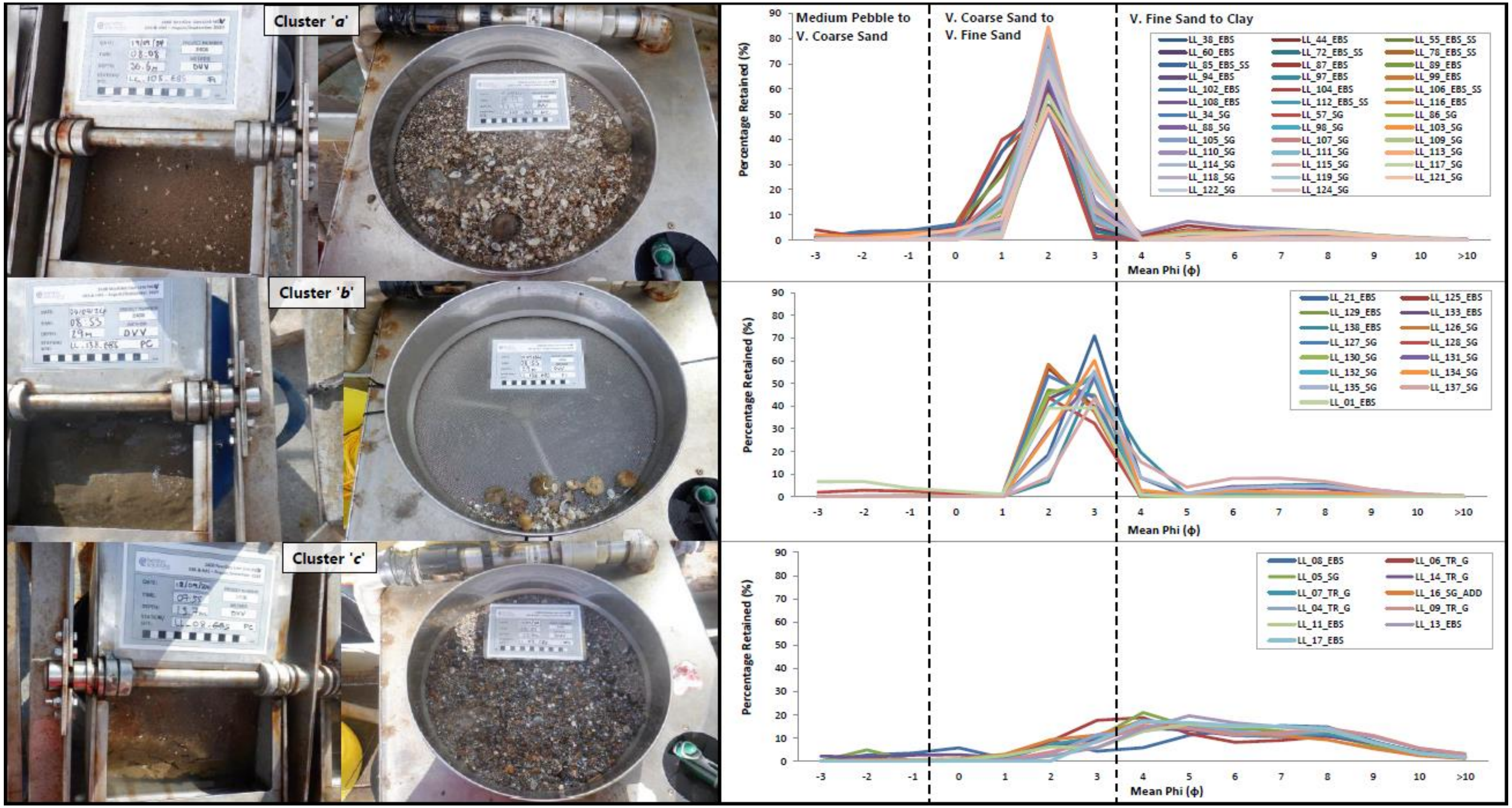



**Figure 3-10 Particle Size Analysis PCA Ordination**

A comparison of the full particle size distribution data using the Wentworth (1922) size categories, and split into the six clusters described above, is shown in Figure 3-11 along with example seabed and grab sample photographs. The plot illustrates clusters 'a', 'b', 'd' and 'f', sharing a common sediment fraction of 'coarse sand' to 'very fine sand' fractions between phi 1 and phi 4. Between these clusters they all showed variable proportions of the different sand fractions which distinguished one from another. Cluster 'a' peaked in the medium sand fraction (phi 2). Two peaks appeared in cluster 'b', the highest peak appeared in the fine sand fraction (phi 3) and the second highest in the medium sand fraction (phi 2), with all stations showing a relatively high proportion of both phi fractions. Cluster 'c' had dominant low-lying proportions of fine sand to clay (phi 3 to 9) suggesting a poor sorting coefficient across stations within this cluster. Cluster 'd' had a multimodal distribution evidencing a mixed sediment type with peaks at medium sand (phi 2), gravel (phi-1 to -3) and fines (phi 4 to > 10). Cluster 'e' showed the most variation from the other clusters and observed maximum peaks at phi -3, showing a high proportion of pebble. Cluster 'f' showed the highest peak at the coarse sand fraction (phi 1), with minimal gravel and fines contribution. The geographical distribution of the clusters is displayed in Figure 3-12.


Cluster 'a'
Cluster 'b'
Cluster 'c'
Medium Pebble to V. Coarse Sand
V. Coarse Sand to V. Fine Sand
V. Fine Sand to Clay
Percentage Retained (%)
Mean Phi (ϕ)
LL_38_EBS
LL_44_EBS
LL_55_EBS_SS
LL_60_EBS
LL_72_EBS_SS
LL_78_EBS_SS
LL_85_EBS_SS
LL_87_EBS
LL_89_EBS
LL_94_EBS
LL_97_EBS
LL_99_EBS
LL_102_EBS
LL_104_EBS
LL_106_EBS_SS
LL_108_EBS
LL_112_EBS_SS
LL_116_EBS
LL_34_SG
LL_57_SG
LL_86_SG
LL_88_SG
LL_98_SG
LL_103_SG
LL_105_SG
LL_107_SG
LL_109_SG
LL_110_SG
LL_111_SG
LL_113_SG
LL_114_SG
LL_115_SG
LL_117_SG
LL_118_SG
LL_119_SG
LL_121_SG
LL_122_SG
LL_124_SG
LL_21_EBS
LL_125_EBS
LL_129_EBS
LL_133_EBS
LL_138_EBS
LL_126_SG
LL_127_SG
LL_128_SG
LL_130_SG
LL_131_SG
LL_132_SG
LL_134_SG
LL_135_SG
LL_137_SG
LL_01_EBS
LL_08_EBS
LL_06_TR_G
LL_05_SG
LL_14_TR_G
LL_07_TR_G
LL_16_SG_ADD
LL_04_TR_G
LL_09_TR_G
LL_11_EBS
LL_13_EBS
LL_17_EBS

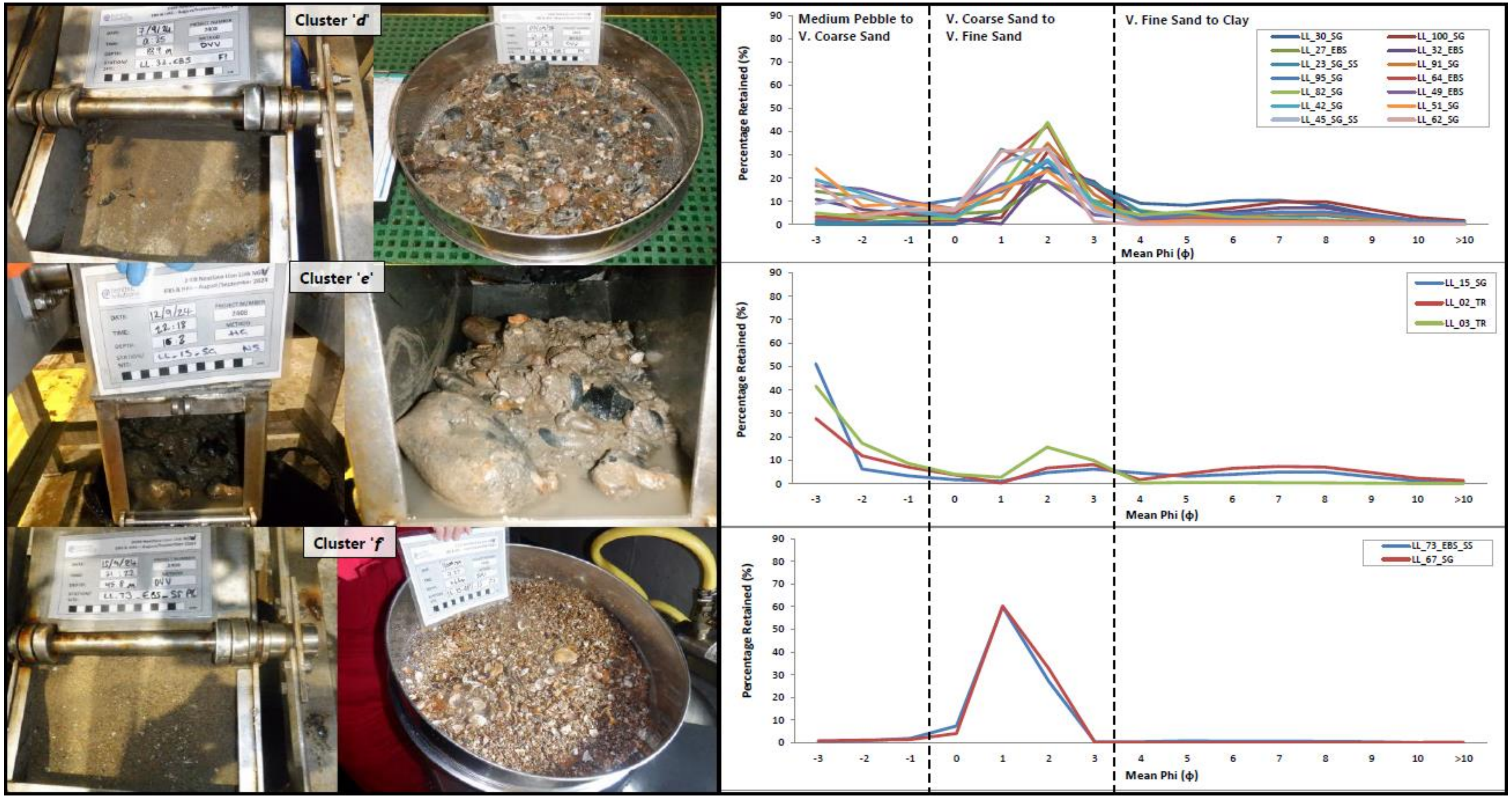



**Figure 3-11 Particle Size Distribution for the Different Clusters**

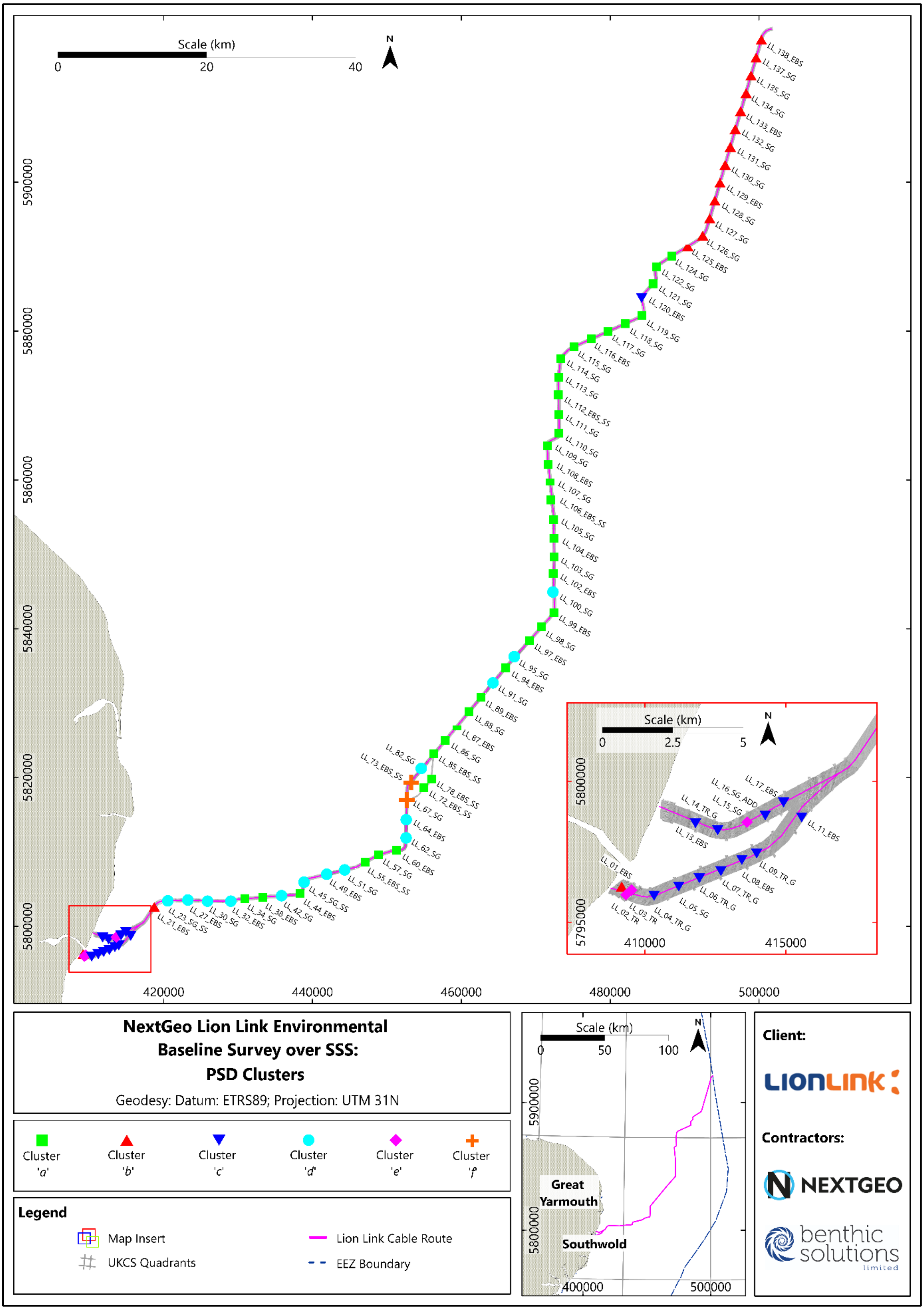



**Figure 3-12 Particle Size Analysis SIMPROF Groupings**

## 3.3 Total Organic Matter, Carbon and Moisture Content

The sediment samples were analysed for total organic matter (TOM), total organic carbon (TOC) and moisture content; the results of which are presented in Table 3-2. TOC represents the proportion of biological material and organic detritus within substrates. The method is less susceptible to the interference sometimes recorded using crude simple combustion techniques, such as analysing TOM by loss on ignition (LOI).

Across the Lion Link corridor route the TOM content was highest in the nearshore area (mean 4.90%±2.6SD) compared to the offshore stations (mean 1.1%±0.5SD; Table 3-2). At four nearshore stations (LL_08_EBS, LL_11_EBS, LL_13_EBS and LL_17_EBS), TOM content exceeded the UKOOA (2001) 95$^{th}$ percentile for the SNS of 2.3 %, whilst LL_01_EBS was low at 0.8%. The higher TOM values at these stations can be attributed to the greater fines content of the sediment (>65%). Siltier sediments have a higher adsorption capacity, resulting in higher TOM levels compared to the sandier sediments found offshore, which are associated with lower TOM values.

TOC in surface sediments is an important source of food for benthic fauna (Snelgrove & Butman, 1994), however, TOC in excess may lead to reduced species richness and abundance due to oxygen depletion. The TOC values along the survey area were variable, following a similar pattern to the TOM values. The lowest TOC concentrations (0%) were recorded at stations LL_23_SG_SS and LL_45_SG_SS, while the highest concentrations (0.68% to 1.95%) were observed at four nearshore stations (LL_08_EBS, LL_11_EBS, LL_13_EBS and LL_17_EBS; Figure 3-13). Increases in TOC reflect natural increases in both physical factors (i.e., fines) and common co-varying environmental factors through greater absorption on increased sediment surface areas (Thompson and Lowe, 2004). All stations with higher TOC values noted higher proportions of fines.

Terrestrially derived carbon from runoff and fluvial systems, combined with primary production from sources such as phytoplankton blooms, contribute to the TOC levels recorded in sediments. Allochthonous and autochthonous sources are likely to be present throughout the survey area.

Moisture content varied across the survey area, with higher content in the nearshore stations (mean 38.9%±9.5SD) compared to the offshore stations (mean 14.9%±10.1SD). This variation reflects the transition from muddier sediments in the nearshore region to coarser, sandier sediments at the offshore stations.

**Table 3-2 Total Organic Matter, Carbon and Moisture Content**

| Station | Depth (m) | Total Organic Matter (%w/w) | Total Organic Carbon (%M/M) | Moisture Content (% w/w) |
|---|---|---|---|---|
| **Nearshore** | | | | |
| LL_01_EBS | 5 | 0.8 | 0.1 | 23.5 |
| LL_08_EBS | 14 | 4.5 | 1.95 | 44.1 |
| LL_11_EBS | 20 | 6.4 | 0.91 | 42.8 |
| LL_13_EBS | 12 | 7.7 | 1.05 | 47.5 |
| LL_17_EBS | 16 | 5.1 | 0.68 | 36.7 |
| **Nearshore Mean** | | **4.9** | **0.94** | **38.9** |
| **Standard Deviation** | | **2.6** | **0.7** | **9.5** |
| **Variance (%)** | | **53.1** | **71.6** | **24.3** |
| **Minimum** | | **0.8** | **0.1** | **23.5** |
| **Maximum** | | **7.7** | **1.95** | **47.5** |
| **Offshore** | | | | |
| LL_21_EBS | 20 | 0.8 | 0.09 | 23.0 |
| LL_23_SG_SS | 35 | 0.0 | 0.00 | 0.20 |
| LL_27_EBS | 32 | 2.0 | 0.16 | 23.6 |
| LL_32_EBS | 34 | 1.6 | 0.14 | 28.5 |
| LL_38_EBS | 35 | 1.3 | 0.10 | 15.6 |
| LL_44_EBS | 40 | 0.8 | 0.07 | 16.2 |
| LL_45_SG_SS | 40 | 0.0 | 0.00 | 0.15 |
| LL_49_EBS | 44 | 1.7 | 0.14 | 20.2 |
| LL_55_EBS_SS | 39 | 0.8 | 0.07 | 0.10 |
| LL_60_EBS | 41 | 1.0 | 0.10 | 19.2 |
| LL_64_EBS | 46 | 1.7 | 0.19 | 21.2 |
| LL_72_EBS_SS | 44 | 0.7 | 0.06 | 0.10 |
| LL_73_EBS_SS | 46 | 0.6 | 0.06 | 0.10 |
| LL_78_EBS_SS | 42 | 0.5 | 0.08 | 0.22 |
| LL_85_EBS_SS | 46 | 0.7 | 0.08 | 0.21 |
| LL_87_EBS | 50 | 1.3 | 0.13 | 19.1 |
| LL_89_EBS | 51 | 1.2 | 0.07 | 15.7 |
| LL_94_EBS | 48 | 0.9 | 0.10 | 16.6 |
| LL_97_EBS | 44 | 0.6 | 0.05 | 17.5 |
| LL_99_EBS | 44 | 0.8 | 0.06 | 19.0 |
| LL_102_EBS | 39 | 1.8 | 0.29 | 22.0 |
| LL_104_EBS | 36 | 1.0 | 0.09 | 22.2 |
| LL_106_EBS_SS | 36 | 0.8 | 0.06 | 0.21 |
| LL_108_EBS | 37 | 1.1 | 0.11 | 18.5 |
| LL_112_EBS_SS | 34 | 0.8 | 0.04 | 0.19 |
| LL_116_EBS | 35 | 1.3 | 0.14 | 23.0 |
| LL_120_EBS | 34 | 1.5 | 0.15 | 25.5 |
| LL_125_EBS | 31 | 1.0 | 0.10 | 25.2 |
| LL_129_EBS | 31 | 1.2 | 0.11 | 25.6 |
| LL_133_EBS | 27 | 1.2 | 0.10 | 17.8 |
| LL_138_EBS | 29 | 2.0 | 0.23 | 24.9 |
| **Offshore Mean** | | **1.1** | **0.10** | **14.9** |
| **Standard Deviation** | | **0.5** | **0.1** | **10.1** |
| **Variance (%)** | | **48** | **59** | **68** |
| **Minimum** | | **0.0** | **0.00** | **0.10** |
| **Maximum** | | **2.0** | **0.29** | **28.5** |
| **Reference Values** | | | | |
| **UKOOA (2001) SNS 50th %ile** | | **1.1** | **-** | **-** |
| **UKOOA (2001) SNS 95th %ile** | | **2.3** | **-** | **-** |

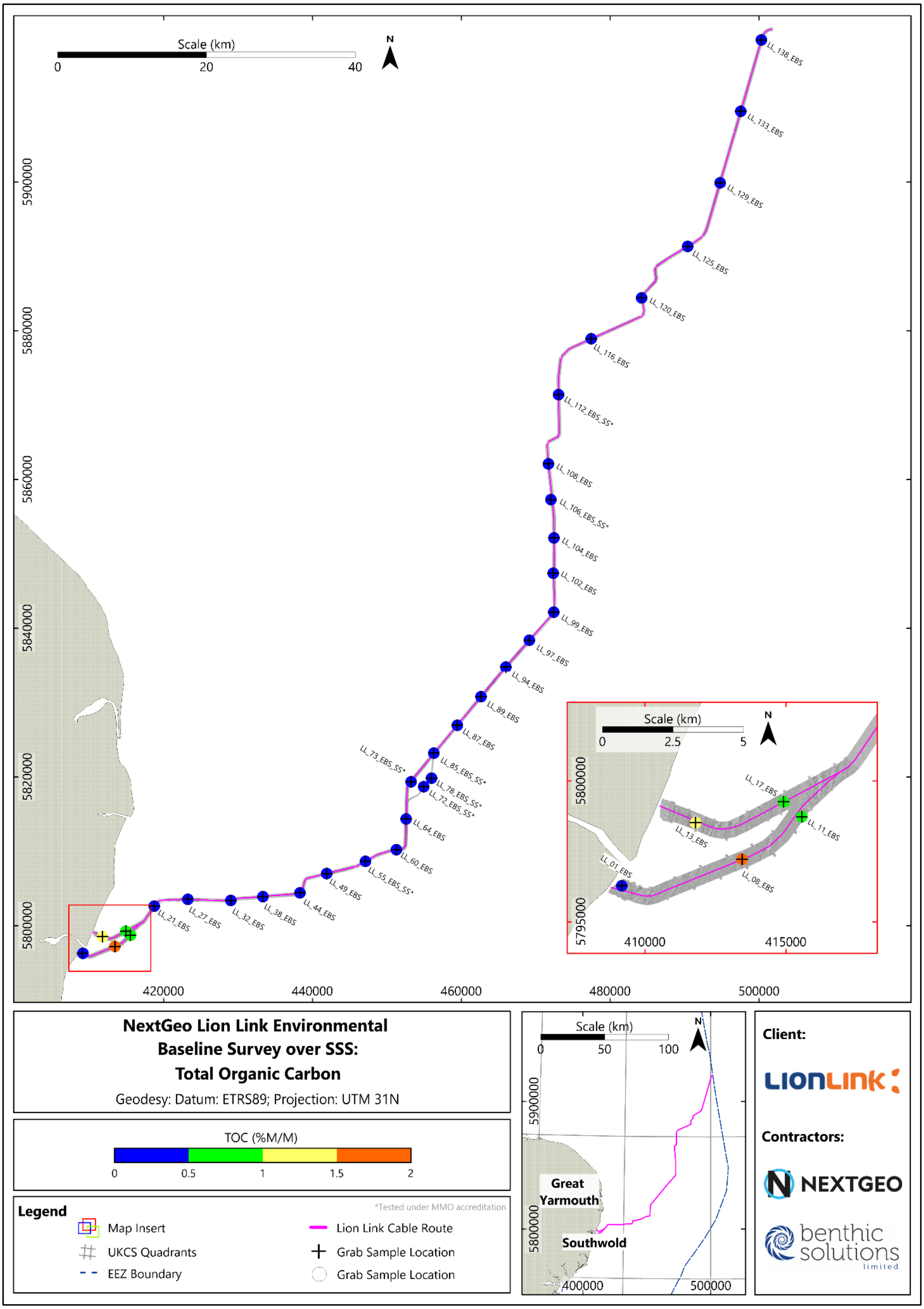



**Figure 3-13 Total Organic Carbon**

## 3.4 Sediment Hydrocarbons

Results for hydrocarbon analyses are summarised and tabulated as total hydrocarbon concentrations (THC) and total n-alkane and homologue ratios in Table 3-3 with individual alkanes ($nC_{10}$-$nC_{37}$) listed in Appendix D – Total Aliphatic Concentrations by Station (µg.kg$^{-1}$). Examples of the gas chromatograms are presented in Figure 3-14 and Figure 3-15, showing the aliphatic hydrocarbon traces for stations LL_13_EBS and LL_97_EBS with the remainder presented in Appendix E – GC FID Traces (Saturates). Chromatograms are labelled with every second n-alkane, the isoprenoid hydrocarbon, pristane, along with the internal standards hepta-methylnonane (A), 1 chlorooctadecane (B) and Squalene (C).

### 3.4.1 Total Hydrocarbon Content

The total hydrocarbon content (THC) of sediments, measured by integration of all non-polarised components within the GC trace, varied across the Lion Link cable route. THC values ranged from 0.18mg.kg$^{-1}$ (LL_78_EBS_SS) to 60.1mg.kg$^{-1}$ (LL_11_EBS). The highest THC concentrations were observed across nearshore stations (mean 32.02mg.kg$^{-1}$±21.3SD), where four of the five nearshore stations exceeded the UKOOA (2001) 95$^{th}$ percentile threshold for the SNS (11.4mg.kg$^{-1}$). The higher THC was primarily attributed to the higher fines content (>65%) in these sediments (Figure 3-16). In contrast, THC was lower in the offshore area (mean 2.71mg.kg$^{-1}$±2.6SD), where sediments were predominantly sandy, similarly to the nearshore station LL_01_EBS (0.69mg.kg$^{-1}$). Among the offshore stations, 11 recorded THC levels slightly above the UKOOA (2001) 50$^{th}$ percentile threshold for the SNS (3.20mg.kg$^{-1}$), but all remained below the UKOOA (2001) 95th percentile.

### 3.4.2 Saturate/Aliphatic Hydrocarbons

A selection of sampling stations were analysed for n-alkanes using gas chromatography with flame ionisation detection (GC-FID). The results are summarised Table 3-3 are individually listed in Appendix D – Total Aliphatic Concentrations by Station (µg.kg$^{-1}$), which gives a breakdown of consecutive n-alkane content from $nC_{10}$ through to $nC_{37}$, together with the isoprenoid hydrocarbons Pristane (Pr) and Phytane (Ph). The total saturate alkane concentrations are illustrated in Figure 3-19 with examples of gas chromatograms given in Figure 3-14 and Figure 3-15.

Total n-alkane concentrations were low throughout the majority of the survey area, ranging from 0mg.kg$^{-1}$ at nine stations, to 2.59mg.kg$^{-1}$ at LL_11_EBS (Table 3-3). Similar to THC concentrations, four of the five nearshore stations (LL_08_EBS, LL_11_EBS, LL_13_EBS and LL_17_EBS) exceeded the UKOOA 95$^{th}$ percentile reference value for the SNS (0.78mg.kg$^{-1}$; Table 3-3). However, only three offshore stations (LL_27_EBS, LL_120_EBS and LL_138_EBS) exceeded the UKOOA (2001) 50$^{th}$ percentile threshold for the SNS (0.19mg.kg$^{-1}$).

Inspection of the individual gas chromatograms for the analysed stations showed hydrocarbon signatures indicative of those typically seen for background sediments on the United Kingdom continental shelf (UKCS) (Figure 3-14, Figure 3-15; Appendix E – GC FID Traces (Saturates)). Traces of an unresolved complex mixture (UCM) spanning the majority of the trace ($nC_{10}$ to $nC_{37}$) but peaking in the range $nC_{24}$ to $nC_{37}$, superimposed by a series of odd-carbon dominated n-alkanes in the same range. UCM is composed of a complex mixture of hydrocarbons that remain after substantial weathering and biodegradation (McDougall, 2000). Hydrocarbons in the weight range $nC_{24}$ to $nC_{37}$ commonly originate from terrestrial plant sources (Harborne, 1999), or they may represent the residue of highly weathered and biodegraded petrogenic material including natural seeps, shipping discharges, or oil and gas exploration and extraction (McDougall, 2000; Bouloubassi *et al.*, 2001). All stations showed some variation of the typical background sediments, however four of five stations located nearer-shore indicated increased contribution from typical north sea run-off and terrigenous material (LL_08_EBS, LL_11_EBS, LL_13_EBS, LL_17_EBS, LL_120_EBS, LL_129_EBS and LL_138_EBS) as well as increased TOC and THC, attributed to their fine sedimentary content.

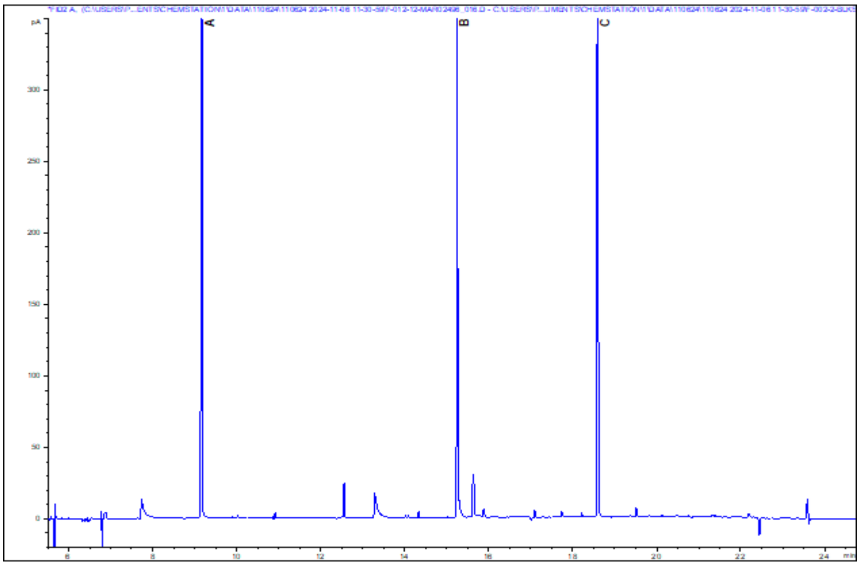



**Figure 3-14 Example Gas Chromatogram Saturate Hydrocarbons (LL_97_EBS)**

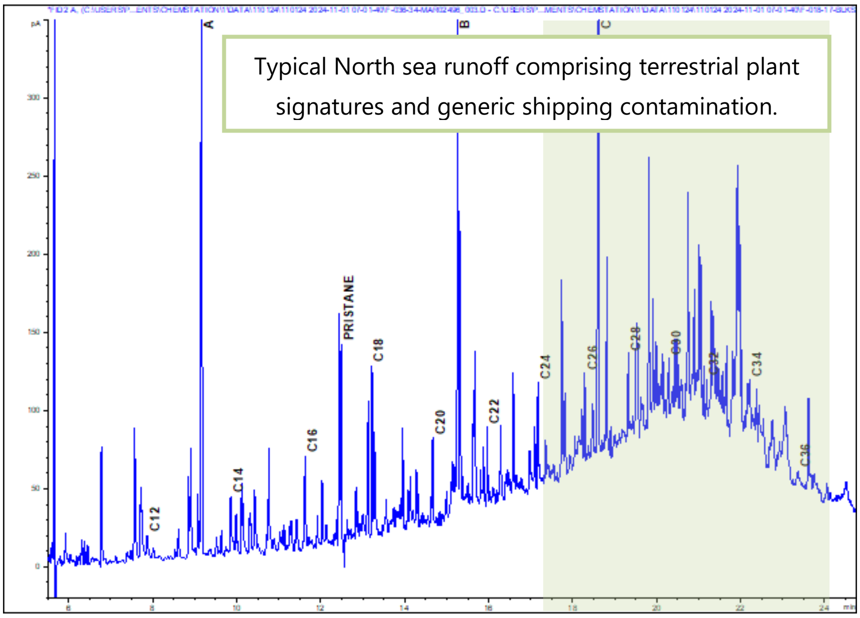



**Figure 3-15 Example Gas Chromatogram Saturate Hydrocarbons (LL_13_EBS)**

**Table 3-3 Summary of Hydrocarbon Concentrations**

| Station | Depth (m) | THC (mg.kg$^{-1}$) | Total n-alkanes (mg.kg$^{-1}$) | Carbon Preference Index | Petrogenic/ Biogenic Ratio | Pristane/ Phytane Ratio | Proportion of Alkanes (%) | Total PAHs (mg.kg$^{-1}$) | NPD (mg.kg$^{-1}$) | NPD (%) | EOX (mg.kg$^{-1}$) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Nearshore** | | | | | | | | | | | |
| LL_01_EBS | 5.0 | 0.69 | 0 | NC | NC | NC | NC | 0 | 0 | NC | 70.0 |
| LL_08_EBS | 13.7 | 36.8 | 1.93 | 2.15 | 0.52 | 1.25 | 5.24 | 1.73 | 0.74 | 42.6 | <20.0 |
| LL_11_EBS | 19.6 | 60.1 | 2.59 | 2.22 | 0.36 | 3.42 | 4.31 | 4.39 | 1.13 | 25.7 | <20.0 |
| LL_13_EBS | 11.8 | 34.5 | 1.76 | 1.86 | 0.74 | 2.61 | 5.1 | 2.06 | 0.81 | 39.5 | <20.0 |
| LL_17_EBS | 15.5 | 28.0 | 1.37 | 1.93 | 0.69 | 2.58 | 4.89 | 1.47 | 0.64 | 43.5 | <20.0 |
| **Nearshore Mean** | | **32.02** | **1.53** | **1.63** | **0.58** | **2.47** | **4.89** | **1.93** | **0.66** | **37.83** | **<20.0** |
| **Standard Deviation** | | **21.3** | **1.0** | **0.9** | **0.2** | **0.9** | **0.4** | **1.6** | **0.4** | **8.3** | **0.0** |
| **Variance (%)** | | **66.5** | **62.9** | **56.6** | **29.9** | **36.5** | **8.4** | **82.1** | **62.4** | **21.8** | **0.0** |
| **Minimum** | | **0.69** | **0.00** | **0.00** | **0.36** | **1.25** | **4.31** | **0.00** | **0.00** | **25.70** | **<20.0** |
| **Maximum** | | **60.10** | **2.59** | **2.22** | **0.74** | **3.42** | **5.24** | **4.39** | **1.13** | **43.50** | **<20.0** |
| **Offshore** | | | | | | | | | | | |
| LL_21_EBS | 20.3 | 7.44 | 0.17 | 1.86 | 0.41 | 3.04 | 2.26 | 0.21 | 0.08 | 37.6 | <20.0 |
| LL_23_SG_SS | 35.1 | NC | 0 | 0 | NC | NC | NC | 0 | 0 | NC | -* |
| LL_27_EBS | 32 | 7.68 | 0.22 | 1.37 | 0.36 | 0.84 | 2.8 | 0.16 | 0.07 | 44.8 | <20.0 |
| LL_32_EBS | 33.9 | 4.52 | 0.08 | 1.37 | 0.37 | 1.49 | 1.83 | 0.08 | 0.04 | 44 | <20.0 |
| LL_38_EBS | 34.5 | 4.33 | 0.16 | 2.53 | 0.32 | 1.52 | 3.73 | 0.21 | 0.08 | 39.4 | <20.0 |
| LL_44_EBS | 40.3 | 0.43 | 0 | NC | 0.61 | 1 | 0.47 | 0 | 0 | NC | <20.0 |
| LL_45_SG_SS | 40.2 | NC | 0 | 0 | NC | NC | NC | 0 | 0 | NC | -* |
| LL_49_EBS | 44.2 | 2.48 | 0.08 | 2.43 | 0.32 | 6.37 | 3.34 | 0.06 | 0.03 | 53.9 | <20.0 |
| LL_55_EBS_SS | 38.6 | 0.88 | 0.01 | 5.87 | 0.43 | 3.94 | 1.69 | 0 | 0 | NC | <20.0 |
| LL_60_EBS | 41.4 | 0.72 | 0.01 | NC | 0.53 | 1 | 1.06 | 0 | 0 | NC | <20.0 |
| LL_64_EBS | 46.4 | 3.31 | 0.07 | 4.09 | 0.25 | 7.7 | 2.23 | 0.03 | 0.02 | 67 | <20.0 |
| LL_72_EBS_SS | 43.9 | 0.3 | 0 | NC | 0.65 | 1 | 0 | 0 | 0 | NC | <20.0 |
| LL_73_EBS_SS | 45.8 | 0.87 | 0.09 | 1.4 | 0.19 | 17.19 | 11 | 0.02 | 0.01 | 51.5 | <20.0 |
| LL_78_EBS_SS | 41.6 | 0.18 | 0 | NC | 0.65 | 1 | 0 | 0 | 0 | NC | <20.0 |
| LL_85_EBS_SS | 45.6 | 0.46 | 0 | NC | 0.64 | 1 | 0.27 | 0 | 0 | NC | <20.0 |

| Station | Depth (m) | THC (mg.kg$^{-1}$) | Total n-alkanes (mg.kg$^{-1}$) | Carbon Preference Index | Petrogenic/ Biogenic Ratio | Pristane/ Phytane Ratio | Proportion of Alkanes (%) | Total PAHs (mg.kg$^{-1}$) | NPD (mg.kg$^{-1}$) | NPD (%) | EOX (mg.kg$^{-1}$) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| LL_87_EBS | 50.4 | 1.98 | 0.05 | 2.09 | 0.31 | 5.14 | 2.57 | 0.01 | 0.01 | 100 | <20.0 |
| LL_89_EBS | 51.1 | 1.04 | 0.03 | 3.89 | 0.32 | 1 | 2.49 | 0 | 0 | NC | <20.0 |
| LL_94_EBS | 47.7 | 0.87 | 0.01 | NC | 0.45 | 1 | 1.32 | 0 | 0 | NC | <20.0 |
| LL_97_EBS | 43.6 | 0.39 | 0 | NC | 0.64 | 1 | 0.32 | 0 | 0 | NC | <20.0 |
| LL_99_EBS | 44 | 0.86 | 0 | NC | 0.63 | 1 | 0.17 | 0 | 0 | NC | <20.0 |
| LL_102_EBS | 39.2 | 4.34 | 0.15 | 2.68 | 0.27 | 4.56 | 3.52 | 0.1 | 0.04 | 45.4 | <20.0 |
| LL_104_EBS | 36.1 | 1.06 | 0.03 | 6.98 | 0.33 | 3.34 | 2.95 | 0 | 0 | 100 | <20.0 |
| LL_106_EBS_SS | 35.9 | 0.39 | 0.01 | 5.18 | 0.53 | 1 | 1.95 | 0 | 0 | NC | <20.0 |
| LL_108_EBS | 36.6 | 0.7 | 0.01 | 4.61 | 0.52 | 1 | 1.03 | 0 | 0 | NC | <20.0 |
| LL_112_EBS_SS | 34.3 | 1.86 | 0.03 | 5.38 | 0.5 | 4.5 | 1.63 | 0.02 | 0.01 | 52.8 | <20.0 |
| LL_116_EBS | 35.2 | 2.59 | 0.04 | 2.18 | 0.38 | 3.43 | 1.41 | 0.01 | 0.01 | 100 | <20.0 |
| LL_120_EBS | 34 | 6.89 | 0.2 | 1.68 | 0.5 | 3.93 | 2.86 | 0.13 | 0.07 | 50.4 | <20.0 |
| LL_125_EBS | 31.4 | 3.75 | 0.05 | 2.95 | 0.28 | 2.75 | 1.24 | 0 | 0 | 100 | <20.0 |
| LL_129_EBS | 31 | 5.93 | 0.19 | 1.92 | 0.67 | 1.84 | 3.16 | 0.14 | 0.07 | 50.3 | <20.0 |
| LL_133_EBS | 27.3 | 3.53 | 0.07 | 3.8 | 0.36 | 3.93 | 1.97 | 0.04 | 0.02 | 56.5 | <20.0 |
| LL_138_EBS | 29 | 8.89 | 0.28 | 2.52 | 0.71 | 1.74 | 3.15 | 0.21 | 0.11 | 52 | <20.0 |
| **Offshore Mean** | | **2.71** | **0.07** | **2.90** | **0.45** | **3.04** | **2.15** | **0.05** | **0.02** | **61.5** | **<20.0** |
| **Standard Deviation** | | **2.60** | **0.10** | **1.80** | **0.2** | **3.3** | **2** | **0.07** | **0.03** | **23** | **0.0** |
| **Variance (%)** | | **95** | **119** | **62.2** | **33.2** | **108** | **94.4** | **154** | **146** | **37.4** | **0.0** |
| **Minimum** | | **0.18** | **0** | **0** | **0.19** | **0.84** | **0** | **0** | **0** | **37.6** | **<20.0** |
| **Maximum** | | **8.89** | **0.28** | **6.98** | **0.71** | **17.19** | **11.0** | **0.21** | **0.11** | **100** | **<20.0** |
| **Reference Values** | | | | | | | | | | | |
| **UKOOA (2001) SNS 50th %ile** | | **3.2** | **0.19** | **1.32** | **-** | **-** | **5.94** | **0.006** | **-** | **-** | **-** |
| **UKOOA (2001) SNS 95th %ile** | | **11.4** | **0.78** | **2.12** | **-** | **-** | **6.84** | **0.366** | **-** | **-** | **-** |
| **Cefas (2015) cAL1** | | **-** | **-** | **-** | **-** | **-** | **-** | **0.1** | **-** | **-** | **-** |
| **NOAA (2008) ERL** | | **-** | **-** | **-** | **-** | **-** | **-** | **4.022** | **-** | **-** | **-** |
| **NOAA (2008) ERM** | | **-** | **-** | **-** | **-** | **-** | **-** | **16.77** | **-** | **-** | **-** |

***Notes:***
*NC = Not calculated: measured concentration of contaminant in sample <LOD // '-*' = Not analysed as per scope of work*

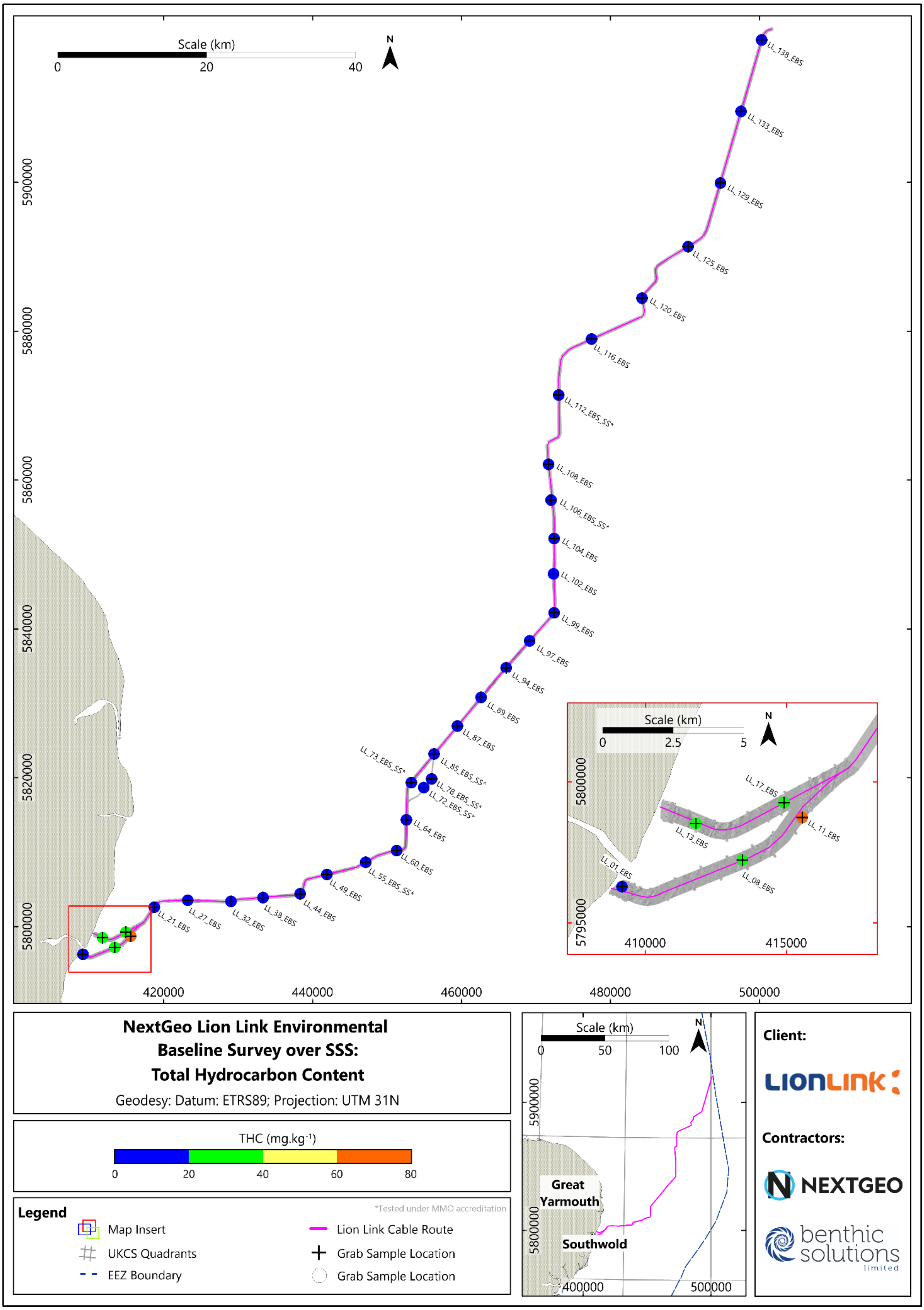



**Figure 3-16 Total Hydrocarbon Content**

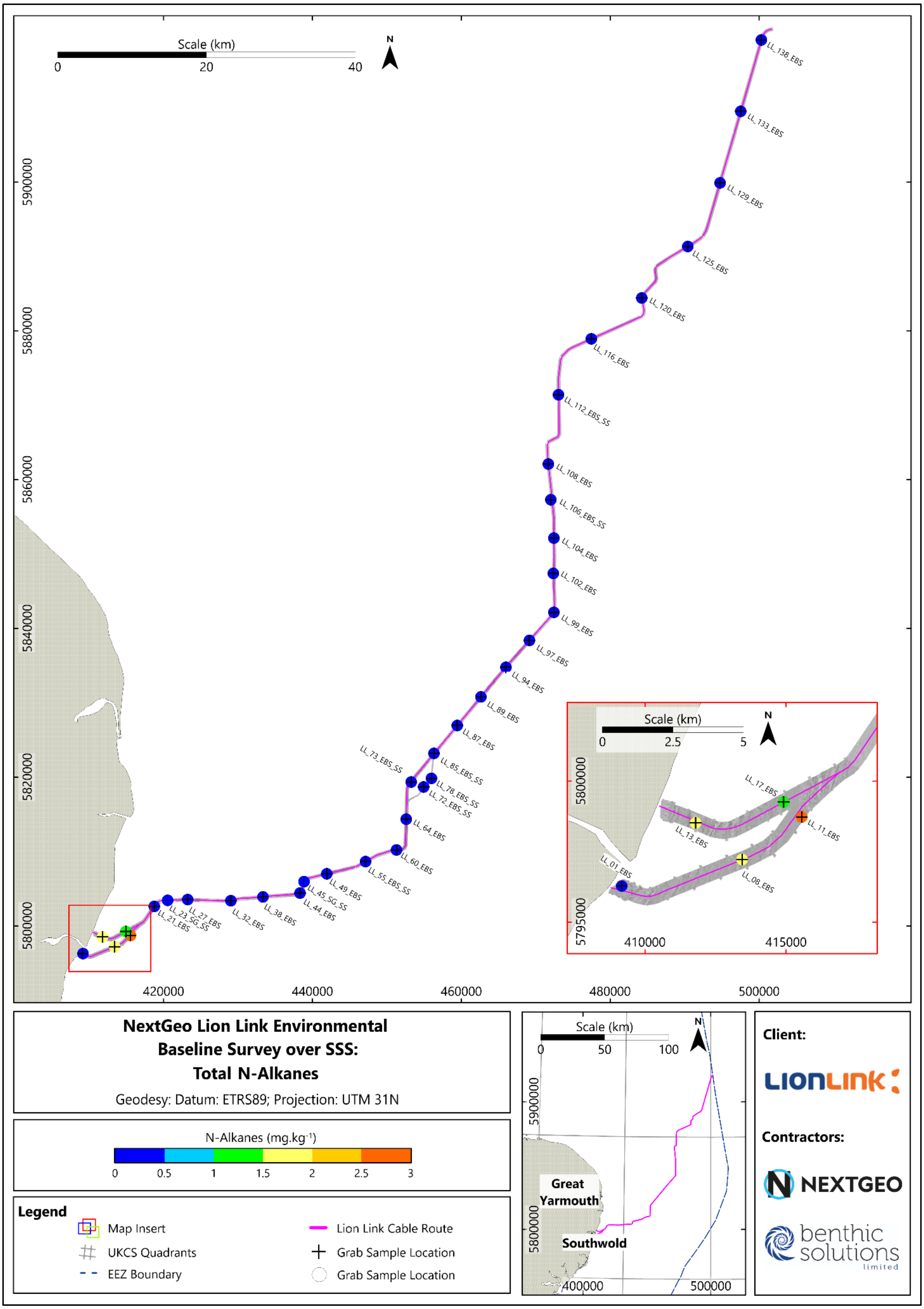



**Figure 3-17 Total N-alkanes Concentration**

### 3.4.3 Carbon Preference Index

The carbon preference index (CPI) is associated with the preference for biogenic n-alkanes (i.e., that of a preference for off carbon numbered homologues, particularly around $nC_{27}$-$nC_{33}$ (Sleeter *et al.,* 1980)), derived from fatty acids, alcohols, ester and land plant waxes. The CPI for the full saturate range ($nC_{10}$ to $nC_{37}$; Table 3-3) was low to moderate along the Lion Link cable route, ranging from 0 (LL_23_SG_SS and LL_45_SG_SS) to 6.98 (LL_104_EBS), with nine stations being incalculable. The CPI was generally higher along the middle to northern end of the survey route. Overall, the results indicate a dominance of biogenic, odd-carbon numbered alkanes across the survey area with the majority of stations recording a CPI>2, corroborated by the presence of a variable terrigenous signature.

### 3.4.4 Petrogenic/Biogenic (P/B) Ratio

The P/B ratio compares the lighter, more petrogenic aliphatics ($nC_{10-20}$) with the heavier, more biogenic aliphatics ($nC_{21-37}$). Ratios varied from 0.19 to 0.74 (LL_73_EBS_SS and LL_13_EBS respectively) across the cable route. All stations were therefore influenced by biogenic aliphatic compounds (P/B ratio of <1; Table 3-3).

### 3.4.5 Pristane/Phytane (Pr/Ph) Ratio

Pristane and phytane are isoprenoid alkanes commonly found as constituents within crude oils (Berthou and Friocourt, 1981). However, in biogenic environments, only pristane is commonly found in the marine environment as it is naturally biosynthesised and a product of phytol moiety of chlorophyll. Phytane is generally absent or only present at low levels in uncontaminated natural systems (Blumer and Snyder, 1965). This ratio can be taken as an indication of a depositional environment (Peters *et al.,* 2005). The presence of both isoprenoids at similar levels is typically taken as an indication of petroleum contamination.

Pr/Ph ratios were incalculable at three stations (LL_01_EBS, LL_23_SG_SS and LL_45_SG_SS) as phytane was below the detection limit (<1µg.kg$^{-1}$). The Pr/Ph ratio along the remaining cable route varied from 0.84 at LL_27_EBS to 17.2 at LL_45_SG_SS, indicating oxic conditions (Peters *et al.,* 2005).

It should be stated that pristane/phytane ratios can often be difficult to interpret due to their erratic nature and should be used mainly to substantiate other interpretations. The use of the ratio in interpretative discourse is open to criticism, mainly owing to the natural occurrence of phytane in some older sediments and the confusing variation of sedimentary pristane, induced by the variability of phytoplankton numbers (Blumer and Snyder, 1965).

### 3.4.6 Polycyclic Aromatic Hydrocarbons

#### 3.4.6.1 Non-normalised Polycyclic Aromatic Hydrocarbons

Polycyclic aromatic hydrocarbons (PAH) were analysed at each station using gas chromatography-mass spectrometry (GC-MS). Results of the single ion current (SIC) analyses are summarised in Table 3-3 and detailed in Appendix F – Polycyclic Aromatic Hydrocarbon Concentrations (μg.kg$^{-1}$), Appendix G – Polycyclic Aromatic Hydrocarbon Concentrations: EPA 19 (μg.kg$^{-1}$) and Appendix H – Polycyclic Aromatic Hydrocarbon: Parents Compounds and Alkyl Derivatives, showing concentrations for both parent compounds and their alkyl derivatives.

PAHs and their alkyl derivatives have been recorded in a wide range of marine sediments (Laflamme and Hites, 1978) with many compounds produced from what is thought to be pyrolytic sources. These include the combustion of organic material such as forest fires (Youngblood and Blumer, 1975), the burning of fossil fuels and, in the case of offshore oil fields, flare stacks. The resulting PAHs, rich in the heavier weight 4-6 ring aromatics, are normally transported to the sediments via atmospheric fallout or river runoff (Neff, 1979). Another PAH source is petroleum hydrocarbon, often associated with localised drilling activities. These are rich in the lighter, more volatile 2 and 3 ring PAHs (NPD; naphthalene (128), phenanthrene, anthracene (178) and dibenzothiophene (DBT)) with their alkyl derivatives.

Total PAH levels were varied across the Lion Link cable route. Total PAH values ranged from 0.00mg.kg$^{-1}$ at 17 stations to 4.39mg.kg$^{-1}$ at LL_11_EBS (Figure 3-19). The highest PAH concentrations were observed in the nearshore stations (mean 1.93mg.kg$^{-1}$±1.6SD), where four of five stations exceeded UKOOA (2001) 95$^{th}$ percentile threshold for the SNS (0.336mg.kg$^{-1}$), and one (LL_11_EBS) also exceeded the NOAA ERL of 4.022mg.kg$^{-1}$. In contrast, total PAH was lower in the offshore area (mean 0.05mg.kg$^{-1}$±0.07SD), where all stations were below the UKOAA 95$^{th}$ percentile threshold but six stations were marginally above the Cefas cAL1 threshold of 0.1mg.kg$^{-1}$. The same four of five nearshore stations were also above the Cefas cAL1 threshold of 0.1mg.kg$^{-1}$. The NPD fraction of the PAH demonstrated a similar pattern to the total PAH levels with the highest value of 1.13 mg.kg$^{-1}$ recorded at station LL_11_EBS.

Further information on the source(s) of PAH in the surface sediments may be obtained from a study of their alkyl homologue distributions (i.e., the degree of methyl, ethyl, and substitution of the parent compounds). Pyrolytically derived PAHs are predominantly unalkylated, whereas PAHs derived from petrogenic sources are formed at relatively low temperatures (<150 °C) and contain mainly alkylated species. The proportion of 2-6 ring PAH comprising unalkylated parent compounds also reflects whether the source is petrogenic or pyrolytic. This trend is represented graphically in Figure 3-18 which shows three-dimensional plots of the parent compound distribution and the alkyl homologue distribution of the aromatic material in each of the sediments analysed. Note that station values which recorded below the LOD are not included in Figure 3-18, as they would not accurately represent their true compound distribution. As illustrated, where calculable, most stations along the route were identified as mixed, with a majority being identified as having a greater presence of petrogenic hydrocarbons. One station (LL_64_EBS) was identified as slightly petrogenic Figure 3-18.

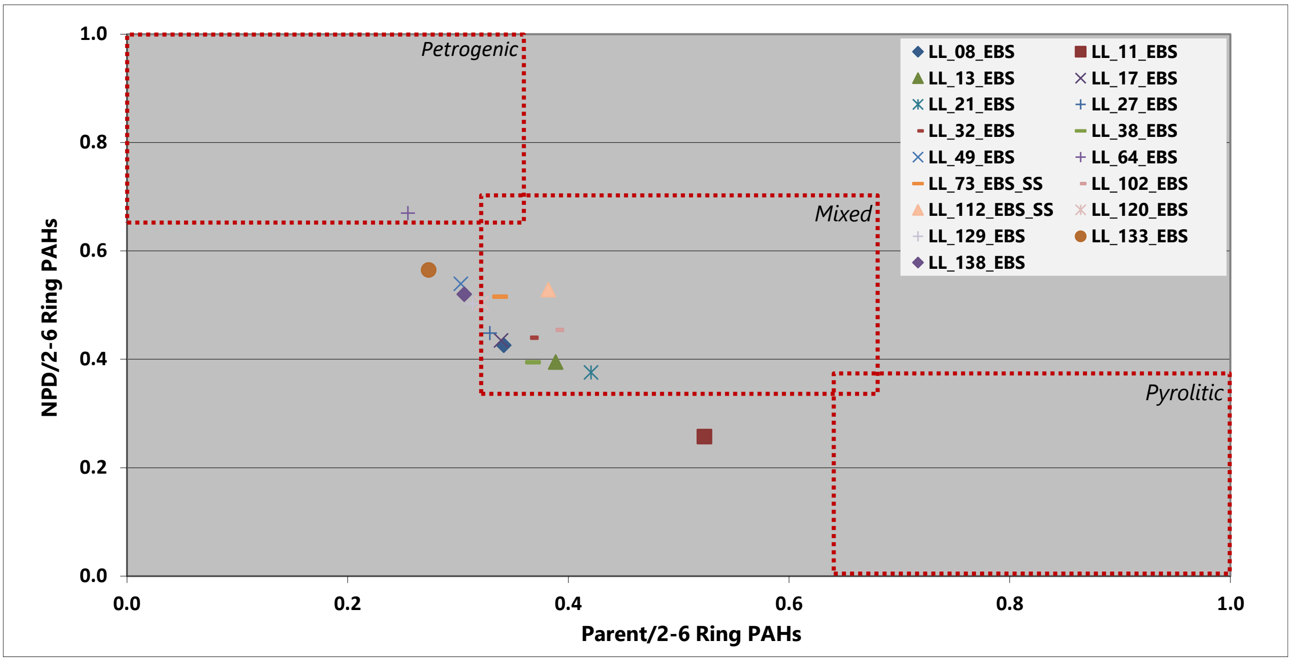



**Figure 3-18 PAH Source Assignment**

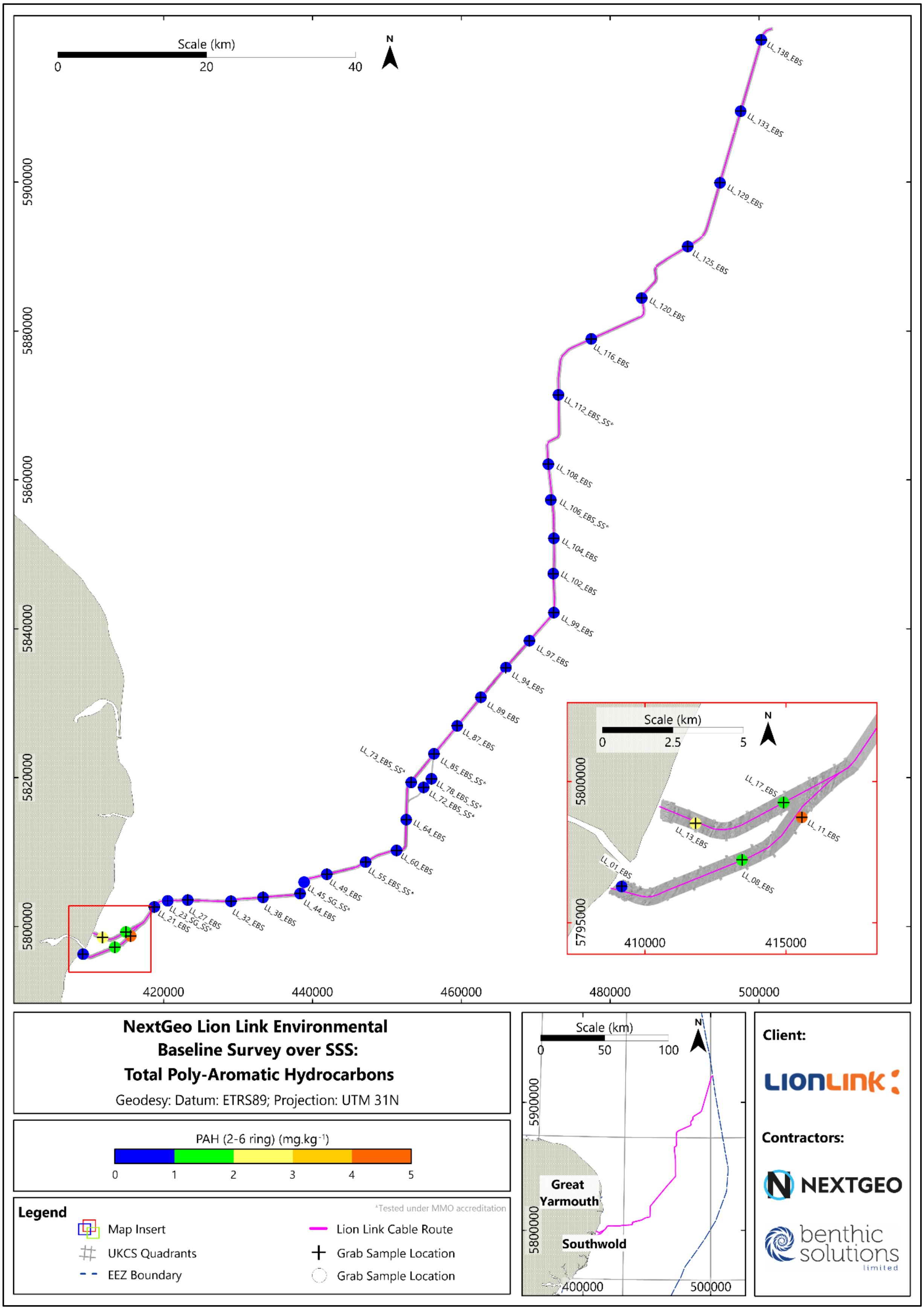



**Figure 3-19 Total Polycyclic Aromatic Hydrocarbons**

### 3.4.6.2 Normalised Polycyclic Aromatic Hydrocarbons

Normalised total PAH concentrations were calculated to provide estimates of the proportion of bioavailable contaminants and to enable standardised comparisons between samples, minimising the influence of organic matter and sediment composition. Contaminants tend to show a much higher affinity to fine particulate matter due to the increased adsorption capacity of organic matter and clay minerals (OSPAR, 2009). All total PAH concentrations (based on the 19 PAH components outlined in OSPAR, 2014) were normalised to the 2.5% total organic carbon content of the sediment at each station, with the results displayed in Table 3-4, along with the OSPAR background concentrations (BCs) and background assessment concentrations (BACs). BCs are concentrations of contaminants derived from analysis of samples to reflect pre-industrial background levels for the OSPAR area. BACs have been statistically derived from BCs and represent the level above which concentrations can be considered to be significantly higher than the relevant BC (OSPAR, 2008).

Normalised PAHs were incalculable at most stations due to concentrations below the detection limit (<1μg.kg$^{-1}$). Nine stations were not calculable for the majority of or all PAHs, however, of those which were calculable, 10 PAHs (naphthalene, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benzo[a]anthracene, chrysene and benzo[a]pyrene) the majority of stations above their OSPAR BACs (Table 3-4) with anthracene and benzo[a]anthracene reporting all calculable stations to have values above the OSPAR BAC). Given that the site is undeveloped the normalised levels of PAH likely reflect natural variation in hydrocarbons across the survey area, and slightly elevated values at a majority of nearshore stations can be attributed to past terrigenous runoff, combined with the fine-dominated sediment, which has a higher capacity for retaining inorganic material.

**Table 3-4 Normalised Total Polycyclic Aromatic Hydrocarbons (µg.kg$^{-1}$)**

| Station | Water Depth (m) | Naphthalene | Acenaphthylene | Acenaphthene | Fluorene | Phenanthrene | Dibenzothiophene | Anthracene | Fluoranthene | Pyrene | Benzo[a]anthracene | Chrysene | Benzo[b]fluoranthene | Benzo[k]fluoranthene* | Benzo[e]pyrene | Benzo[a]pyrene | Perylene | Indeno[123,cd]pyrene | Dibenzo[a,h]anthracene | Benzo[ghi]perylene |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Nearshore** | | | | | | | | | | | | | | | | | | | | |
| LL_01_EBS | 5.0 | NC | NC | NC | NC | NC | 0.00 | NC | NC | NC | NC | NC | NC | NC | 0.00 | NC | NC | NC | NC | NC |
| LL_08_EBS | 13.7 | 50.6 | 5.12 | 5.93 | 12.2 | 84.9 | 7.55 | 11.6 | 81.9 | 74.8 | 40.4 | 58.7 | 61.2 | 60.2 | 54.2 | 52.2 | 22.4 | 45.4 | 10.2 | 65.3 |
| LL_11_EBS | 19.6 | 140 | 70.0 | 26.3 | 52.3 | 389 | 31.7 | 88.3 | 684 | 748 | 383 | 436 | 650 | 577 | 467 | 570 | 150 | 505 | 94.0 | 552 |
| LL_13_EBS | 11.8 | 98.2 | 15.6 | 12.6 | 30.9 | 196 | 15.7 | 41.2 | 241 | 211 | 115 | 145 | 160 | 131 | 125 | 145 | 59.7 | 111 | 25.0 | 148 |
| LL_17_EBS | 15.5 | 107 | 12.5 | 15.5 | 31.8 | 204 | 18.5 | 25.2 | 221 | 204 | 99.4 | 136 | 157 | 120 | 124 | 128 | 59.3 | 113 | 25.8 | 149 |
| **Offshore** | | | | | | | | | | | | | | | | | | | | |
| LL_21_EBS | 20.3 | 102 | 27.8 | 27.8 | 42.4 | 324 | 27.8 | 47.0 | 341 | 292 | 135 | 182 | 184 | 182 | 145 | 168 | 70.5 | 162 | 27.8 | 177 |
| LL_23_SG_ | 35.1 | NC | NC | NC | NC | NC | NC | NC | NC | NC | NC | NC | NC | NC | NC | NC | NC | NC | NC | NC |
| LL_27_EBS | 32 | 58.8 | 15.6 | 15.6 | 15.6 | 90.4 | 15.6 | 15.6 | 97.8 | 88.3 | 42.2 | 66.2 | 79.3 | 52.7 | 59.1 | 52.9 | 29.0 | 52.9 | 15.6 | 74.1 |
| LL_32_EBS | 33.9 | 36.1 | 17.9 | 17.9 | 17.9 | 54.3 | 17.9 | 17.9 | 50.5 | 44.5 | 25.8 | 39.6 | 50.7 | 41.0 | 40.3 | 36.3 | 17.9 | 36.5 | 17.9 | 51.8 |
| LL_38_EBS | 34.5 | 121 | 25.0 | 25.0 | 29.7 | 206 | 25.0 | 25.0 | 214 | 202 | 104 | 149 | 156 | 149 | 143 | 146 | 56.5 | 137 | 30.3 | 176 |
| LL_44_EBS | 40.3 | 35.7 | 35.7 | 35.7 | 35.7 | 35.7 | 35.7 | 35.7 | 35.7 | 35.7 | 35.7 | 35.7 | 35.7 | 35.7 | 35.7 | 35.7 | 35.7 | 35.7 | 35.7 | 35.7 |
| LL_45_SG_ | 40.2 | NC | NC | NC | NC | NC | NC | NC | NC | NC | NC | NC | NC | NC | NC | NC | NC | NC | NC | NC |
| LL_49_EBS | 44.2 | 36.8 | 17.9 | 17.9 | 17.9 | 47.6 | 17.9 | 17.9 | 39.8 | 38.3 | 17.9 | 25.1 | 23.5 | 27.4 | 23.1 | 17.9 | 17.9 | 17.9 | 17.9 | 25.9 |
| LL_55_EBS | 38.6 | NC | NC | NC | NC | NC | 0.00 | NC | NC | NC | NC | NC | NC | NC | 0.00 | NC | NC | NC | NC | NC |
| LL_60_EBS | 41.4 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 |
| LL_64_EBS | 46.4 | 20.5 | 13.2 | 13.2 | 13.2 | 22.9 | 13.2 | 13.2 | 19.6 | 18.1 | 13.2 | 13.2 | 13.2 | 13.2 | 13.2 | 13.2 | 13.2 | 13.2 | 13.2 | 13.2 |
| LL_72_EBS | 43.9 | NC | NC | NC | NC | NC | 0.00 | NC | NC | NC | NC | NC | NC | NC | 0.00 | NC | NC | NC | NC | NC |
| LL_73_EBS | 45.8 | NC | NC | NC | NC | 406 | 0.00 | NC | 99.6 | 126 | 60.4 | 163 | 51.7 | NC | 0.00 | NC | NC | NC | NC | 54.6 |
| LL_78_EBS | 41.6 | NC | NC | NC | NC | NC | 0.00 | NC | NC | NC | NC | NC | NC | NC | 0.00 | NC | NC | NC | NC | NC |

| Station | Water Depth (m) | Naphthalene | Acenaphthylene | Acenaphthene | Fluorene | Phenanthrene | Dibenzothiophene | Anthracene | Fluoranthene | Pyrene | Benzo[a]anthracene | Chrysene | Benzo[b]fluoranthene | Benzo[k]fluoranthene* | Benzo[e]pyrene | Benzo[a]pyrene | Perylene | Indeno[123,cd]pyrene | Dibenzo[a,h]anthracene | Benzo[ghi]perylene |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LL_85_EBS | 45.6 | NC | NC | NC | NC | NC | 0.00 | NC | NC | NC | NC | NC | NC | NC | 0.00 | NC | NC | NC | NC | NC |
| LL_87_EBS | 50.4 | 19.2 | 19.2 | 19.2 | 19.2 | 19.2 | 19.2 | 19.2 | 19.2 | 19.2 | 19.2 | 19.2 | 19.2 | 19.2 | 19.2 | 19.2 | 19.2 | 19.2 | 19.2 | 19.2 |
| LL_89_EBS | 51.1 | 35.7 | 35.7 | 35.7 | 35.7 | 35.7 | 35.7 | 35.7 | 35.7 | 35.7 | 35.7 | 35.7 | 35.7 | 35.7 | 35.7 | 35.7 | 35.7 | 35.7 | 35.7 | 35.7 |
| LL_94_EBS | 47.7 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 |
| LL_97_EBS | 43.6 | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 |
| LL_99_EBS | 44 | 41.7 | 41.7 | 41.7 | 41.7 | 41.7 | 41.7 | 41.7 | 41.7 | 41.7 | 41.7 | 41.7 | 41.7 | 41.7 | 41.7 | 41.7 | 41.7 | 41.7 | 41.7 | 41.7 |
| LL_102_EB | 39.2 | 19.7 | 8.62 | 8.62 | 8.62 | 37.0 | 8.62 | 8.62 | 47.5 | 41.2 | 14.4 | 24.1 | 25.8 | 23.3 | 20.3 | 19.1 | 22.8 | 20.3 | 8.62 | 21.8 |
| LL_104_EB | 36.1 | 27.8 | 27.8 | 27.8 | 27.8 | 27.8 | 27.8 | 27.8 | 27.8 | 27.8 | 27.8 | 27.8 | 27.8 | 27.8 | 27.8 | 27.8 | 27.8 | 27.8 | 27.8 | 27.8 |
| LL_106_EB | 35.9 | NC | NC | NC | NC | NC | 0.00 | NC | NC | NC | NC | NC | NC | NC | 0.00 | NC | NC | NC | NC | NC |
| LL_108_EB | 36.6 | 22.7 | 22.7 | 22.7 | 22.7 | 22.7 | 22.7 | 22.7 | 22.7 | 22.7 | 22.7 | 22.7 | 22.7 | 22.7 | 22.7 | 22.7 | 22.7 | 22.7 | 22.7 | 22.7 |
| LL_112_EB | 34.3 | NC | NC | NC | NC | NC | 0.00 | NC | NC | NC | NC | NC | NC | NC | 0.00 | NC | NC | NC | NC | NC |
| LL_116_EB | 35.2 | 17.9 | 17.9 | 17.9 | 17.9 | 17.9 | 17.9 | 17.9 | 17.9 | 17.9 | 17.9 | 17.9 | 17.9 | 17.9 | 17.9 | 17.9 | 17.9 | 17.9 | 17.9 | 17.9 |
| LL_120_EB | 34 | 73.2 | 16.7 | 16.7 | 16.7 | 87.2 | 16.7 | 16.7 | 77.6 | 68.5 | 30.7 | 53.6 | 59.3 | 60.9 | 44.0 | 35.7 | 27.8 | 37.1 | 16.7 | 56.0 |
| LL_125_EB | 31.4 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 |
| LL_129_EB | 31 | 118 | 22.7 | 22.7 | 22.7 | 126 | 22.7 | 22.7 | 112 | 96.6 | 45.6 | 78.8 | 67.6 | 90.0 | 68.3 | 63.5 | 22.7 | 57.1 | 22.7 | 81.8 |
| LL_133_EB | 27.3 | 34.6 | 25.0 | 25.0 | 25.0 | 48.1 | 25.0 | 25.0 | 42.5 | 36.5 | 25.0 | 25.0 | 33.1 | 31.7 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 31.6 |
| LL_138_EB | 29 | 58.5 | 10.9 | 10.9 | 14.7 | 96.0 | 10.9 | 10.9 | 78.3 | 69.0 | 30.2 | 56.3 | 60.5 | 55.3 | 45.5 | 38.2 | 17.7 | 40.2 | 10.9 | 54.2 |
| **Reference Value** | | | | | | | | | | | | | | | | | | | | |
| **OSPAR (2014) BC** | | **5** | **-** | **-** | **-** | **17** | **0.6** | **3** | **20** | **13** | **9** | **11** | **-** | **-** | **-** | **15** | **-** | **50** | **-** | **45** |
| **OSPAR (2014) BAC** | | **8** | **-** | **-** | **-** | **32** | **-** | **5** | **39** | **24** | **16** | **20** | **-** | **-** | **-** | **30** | **-** | **103** | **-** | **80** |

***Notes:***
*Yellow cell* = *above* OSPAR (2014) BC *Orange cell* = *above* OSPAR (2014) BAC *NC = Not calculated: measured concentration of contaminant in sample <LOD*

### 3.4.7 Extractable Organic Halogens (EOX)

Halogen organic compounds are formed in the environment by both natural and anthropogenic processes. Natural processes include the formation of these compounds during combustion, fires and volcanic eruptions but also from synthesis carried out by fungi, algae, sponges and lichens, while anthropogenic sources include chemical oxidation, disinfection, and coagulation with chlorine-containing compounds (Wlodarczyk-Makula and Wiśniowska, 2019). Extractable organic halogens (EOX) have been reported to be higher near industrial areas and large urban agglomerations and shown to correlate well with TOC (Niemirycz *et al.*, 2005). EOX concentrations were below the limit of detection (20mg.kg$^{-1}$) at all but one nearshore station (LL_01_EBS) which had a value of 70mg.kg$^{-1}$ (Table 3-3). This higher value is likely due to its close proximity to the shore and the mouth of the River Blyth, Southwold, where eutrophication from anthropogenic sources has likely led to this stations increased concentration.

### 3.4.8 Sediment Endocrine Disrupters

#### 3.4.8.1 Organotin

Organotin compounds, principally tributyltin (TBT), have historically been used in marine antifouling products, but their use is now prohibited due to the disruption of the reproductive capabilities of a number of gastropod species (Iguchi *et al.,* 2007). No formal environmental assessment criteria (EAC) thresholds for TBT in sediment have been set through CEMP (OSPAR, 2008a), however, limits have been proposed via various OSPAR programmes and meetings, with 0.01µg.kg$^{-1}$ suggested as a provisional EAC for TBT (OSPAR, 2009). No organotin compounds (Dibutyltin (DBT) and TBT) were recorded above their respective LoD of <1ug.kg$^{-1}$ (Table 3-5).

**Table 3-5 Summary of Sediment Organotin Analysis (µg.kg$^{-1}$)**

| Station | Depth (m) | Dibutyltin (DBT) | Tributyltin (TBT) |
|---|---|---|---|
| LL_23_SG_SS | 35.1 | <1 | <1 |
| LL_45_SG_SS | 40.2 | <1 | <1 |
| LL_55_EBS_SS | 38.6 | <1 | <1 |
| LL_72_EBS_SS | 43.9 | <1 | <1 |
| LL_73_EBS_SS | 45.8 | <1 | <1 |
| LL_78_EBS_SS | 41.6 | <1 | <1 |
| LL_85_EBS_SS | 45.6 | <1 | <1 |
| LL_106_EBS_SS | 35.9 | <1 | <1 |
| LL_112_EBS_SS | 36.6 | <1 | <1 |
| *Notes:*<br>*NC = Not calculated: measured concentration of contaminant in sample <LOD* | | | |

#### 3.4.8.2 Polychlorinated Biphenyls

Polychlorinated biphenyls (PCBs) are compounds which are considered a major environmental concern due to their high lipophilicity and resistance to metabolic degradation and are used on oil and gas platforms in electrical plants and transformer oils. PCBs are non-ionic (hydrophobic) organic chemicals that have low solubility and as such concentrations in water and sediments are generally low (Cefas, 2001). PCB concentrations were below the limit of detection at all nine stations they were analysed at (LoD of <0.08µg.kg$^{-1}$; Table 3-6).

**Table 3-6 Summary of Sediment Polychlorinated Biphenyls Analysis (µg.kg$^{-1}$)**

| Station | LL_23_SG_SS | LL_45_SG_SS | LL_55_EBS_SS | LL_72_EBS_SS | LL_73_EBS_SS | LL_78_EBS_SS | LL_85_EBS_SS | LL_106_EBS_SS | LL_112_EBS_SS |
|---|---|---|---|---|---|---|---|---|---|
| **PCB 18** | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 |
| **PCB 28** | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 |
| **PCB 31** | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 |
| **PCB 44** | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 |
| **PCB 47** | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 |
| **PCB 49** | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 |
| **PCB 52** | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 |
| **PCB 66** | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 |
| **PCB 101** | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 |
| **PCB 105** | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 |
| **PCB 110** | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 |
| **PCB 118** | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 |
| **PCB 128** | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 |
| **PCB 138** | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 |
| **PCB 141** | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 |
| **PCB 149** | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 |
| **PCB 151** | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 |
| **PCB 153** | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 |
| **PCB 156** | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 |
| **PCB 158** | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 |
| **PCB 170** | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 |
| **PCB 180** | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 |
| **PCB 183** | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 |
| **PCB 187** | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 |
| **PCB 194** | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 |
| **Total ICES 7 PCB** | **NC** | **NC** | **NC** | **NC** | **NC** | **NC** | **NC** | **NC** | **NC** |
| **Total of 25 Congeners** | **NC** | **NC** | **NC** | **NC** | **NC** | **NC** | **NC** | **NC** | **NC** |

***Notes:***
*NC = Not calculated: measured concentration of contaminant in sample <LOD*

#### 3.4.8.3 Organochlorine Pesticides

Organochlorine pesticides (OCPs) are synthetic pesticides used globally for the control of biological vectors. OCPs are considered persistent organic pollutants due to their high toxicity, degradation resistance, fat solubility and bioaccumulation. Many OCPs are semi-volatile and can be transported over long distances via atmospheric currents in a gaseous state before wet or dry deposition occurs in the oceans. These compounds are transported from the surface waters to the bottom sediments as OCPs are denser than water and can adsorb onto fine particles. Humans and biota can be affected by the toxic effects caused by OCPs, which involve reproductivity damage, endocrine disruption and immune suppression (Girones *et al.*, 2020). Eight OCPs were analysed during the current survey and all were below their respective LoD of <0.1ug.kg$^{-1}$ (Table 3-7).

**Table 3-7 Summary of Sediment Organochlorine Analysis (µg.kg$^{-1}$)**

| Station | Depth (m) | AHCH | BHCH | GHCH | Dieldrin | HCB | PPTDE | PPDDE | PPDDT |
|---|---|---|---|---|---|---|---|---|---|
| LL_23_SG_SS | 35.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| LL_45_SG_SS | 40.2 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| LL_55_EBS_SS | 38.6 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| LL_72_EBS_SS | 43.9 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| LL_73_EBS_SS | 45.8 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| LL_78_EBS_SS | 41.6 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| LL_85_EBS_SS | 45.6 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| LL_106_EBS_SS | 35.9 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| LL_112_EBS_SS | 36.6 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |

***Notes*:**
*NC = Not calculated: measured concentration of contaminant in sample <LOD*
*AHCH = alpha-Hexachlorocyclohexane; BHCH = beta-Hexachlorocyclohexane; GHCH = gamma-Hexachlorocyclohexane; HCB = Hexachlorobenzene; PPTDE = p,p'-Dichlorodiphenyltrichloroethane; PPDE = p,p'-Dichlorodiphenyldichloroethylene; PPDDT = p,p'-Dichlorodiphenyltrichloroethane*

## 3.5 Heavy and Trace Metals

### 3.5.1 Non-normalised Heavy Metals

The sediments at all grab stations acquired underwent heavy and trace metals analysis. All of the heavy metals analysed (aluminium (Al), arsenic (As), barium (Ba), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), lithium (Li), mercury (Hg), nickel (Ni) Tin (Sn) and Zinc (Zn)) underwent an aqua regia digest followed by ICP analysis and extraction for total sediment metals.

The question of bioavailability of metals to marine organisms is a complex one, as sediment granulometry and the interface between water and sediment all affect the bioavailability and subsequent toxicity. Therefore, even if a metal is found in higher concentrations it does not necessarily follow that this will have a detrimental effect on the environment if present in an insoluble state. Historically, several extraction techniques have been applied to metal analysis, with the most common applying to an hydrofluoric/perchloric extraction for total metals, and a weaker nitric or aqua regia extraction. The latter techniques have shown close correlation to metal burdens in the tissues of benthic organisms (Luoma and Davies, 1983; Bryan and Langston, 1992). However, the way bioavailability is reflected by the extent to which a particular metal digests is not well understood, and research is ongoing.

Metals occur naturally in the marine environment and are widely distributed in both dissolved and sedimentary forms. Some are essential to marine life while others may be toxic to numerous organisms (Paez Osuna and Ruiz-Fernandez, 1995). Rivers, coastal discharges, and the atmosphere are the principal modes of entry for most metals into the marine environment (Schaule and Patterson, 1983), with anthropogenic inputs occurring primarily as components of industrial and municipal wastes.

Trace metal contaminants in the marine environment tend to form associations with the non-residual phases of mineral matter, such as Fe and manganese oxides and hydroxides, metal sulphides, organics, and carbonates. Metals associated with these non-residual phases are prone to various environmental interactions and transformations (physical, chemical and biological), potentially increasing their biological availability (Tessier *et al*., 1979). Residual trace metals are defined as those which are part of the silicate matrix of the sediment and that are located mainly in the lattice structures of the component minerals. Non-residual trace metals are not part of the silicate matrix and have been incorporated into the sediment from aqueous solution by processes such as adsorption and organic complexes and may include trace metals originating from sources of pollution. Therefore, in monitoring trace metal contamination of the marine environment, it is important to distinguish these more mobile metals from the residual metals held tightly in the sediment lattice (Chester and Voutsinou, 1981), which are of comparatively little environmental significance.

Metals are generally not harmful to organisms at concentrations normally found in marine sediments and some, like zinc, may be essential for normal metabolism although can become toxic above a critical threshold. In order to assign a level of context for toxicity, an approach used by Long, *et al*. (1995) to characterise contamination in sediments will be used here. Metal concentrations recorded below the ERL value are not expected to elicit adverse effects, while levels above the ERM value are likely to be toxic to some marine life.

Within the nearshore area, the concentration of seven metals (Ba, Cd, Cr, Cu, Pb, Ni and Zn) were above their respective UKOOA SNS 50$^{th}$ percentile reference values at one or more stations (Table 3-8). Additionally, three metals (Pb, Hg and Zn) recorded values exceeding the 95$^{th}$ percentile (Table 3-8). The geographical distribution of As, Cr, Cu, Pb, Ni and Zn are shown in Figure 3-20 to Figure 3-25.

In the offshore region, most stations reported lower metal concentrations compared to the nearshore area, with no metals exceeding the UKOOA 95$^{th}$ percentile thresholds. This difference is attributed to variations in sediment type. A majority of the nearshore sediments contain a higher proportion of fine particles (>65%), which have greater adsorption capacity and tend to retain more heavy metals. In contrast, the offshore sediments are sandier, resulting in lower metal concentrations due to reduced adsorption potential.

Arsenic exceeded its NOAA ERL reference value (8.2mg.kg$^{-1}$) for all except three stations (LL_01_EBS, LL_21_EBS and LL_87_EBS). In addition to exceeding the OSPAR ERL value, arsenic concentrations also exceeded the Cefas cAL 1 (20mg.kg$^{-1}$) at 15 stations and the Cefas cAL 2 (50mg.kg$^{-1}$) at one station (LL_89_EBS) (Table 3-8 and Figure 3-20). In general, Arsenic concentrations were found to be higher at the sampling stations located further offshore. Elevated arsenic levels in marine sediments of the SNS are attributed to a combination of natural geological inputs and historical anthropogenic activities. The region's underlying geological formation, particularly the London Clay Formation, is known to contain naturally elevated arsenic concentrations (Lee *et al.,* 2015). Additionally, coastal erosion along East Anglia, which exposes this geological formation, further contributes to arsenic levels in the sediment. Moreover, historical industrial processes, agricultural runoff, and inputs from major rivers—including the Rhine, Meuse, Humber Estuary, and Scheldt—are significant sources of arsenic pollution in this region (Emeis *et al.,* 2020; NOAA, 2020). Although these rivers are not in the immediate vicinity of the survey area, the SNS functions as a sediment sink, where fine-grained particles transported from various sources, including river outflows further north, accumulate. This process facilitates the deposition and concentration of contaminants such as arsenic (Logemann *et al.,* 2022).

The concentrations of almost all metals, with the exception of arsenic, are below Cefas cALs and OSPAR ERL levels for most stations, indicating there is minimal risk to marine life and no significant environmental impact at these locations.

**Table 3-8 Total Heavy and Trace Metal Concentrations (mg.kg-1)**

| Station | Depth (m) | Aluminium (Al) | Arsenic (As) | Barium (Ba) | Cadmium (Cd) | Chromium (Cr) | Copper (Cu) | Lead (Pb) | Lithium (Li) | Mercury (Hg) | Nickel (Ni) | Tin (Sn) | Zinc (Zn) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Nearshore** | | | | | | | | | | | | | |
| LL_01_EBS | 5 | 545 | 6.6 | 14.4 | <0.04 | 4.0 | 5.0 | 3.7 | <2.0 | 0.0 | 3.2 | 0.5 | 14.1 |
| LL_08_EBS | 14 | 6,760 | 18.2 | 32 | 0.05 | 14.6 | 6.6 | 13.6 | 18.9 | 0.03 | 11.8 | 0.5 | 34.2 |
| LL_11_EBS | 19.6 | 11,400 | 16.5 | 60.3 | 0.12 | 24.5 | 13.1 | 31.0 | 33.0 | 0.16 | 18.4 | 2.4 | 64.8 |
| LL_13_EBS | 11.8 | 14,000 | 12.2 | 68.2 | 0.12 | 27.7 | 14.6 | 20.2 | 39.4 | 0.06 | 20.6 | 1.2 | 56.9 |
| LL_17_EBS | 15.5 | 8,730 | 10.8 | 74.9 | 0.08 | 19.8 | 9.5 | 16.2 | 24.1 | 0.04 | 15.0 | 0.9 | 41.3 |
| **Mean** | | **8,287** | **12.9** | **50.0** | **0.09** | **18.1** | **9.8** | **16.9** | **28.9** | **0.07** | **13.8** | **1.1** | **42.3** |
| **Standard Deviation** | | **5,118** | **4.6** | **25.7** | **0.03** | **9.3** | **4.1** | **9.9** | **9.13** | **0.05** | **6.8** | **0.8** | **19.9** |
| **Variance (%)** | | **61.8** | **36.0** | **51.5** | **36.8** | **51.4** | **42.0** | **58.7** | **31.6** | **81.3** | **49.3** | **71.3** | **47.0** |
| **Minimum** | | **545** | **6.6** | **14.4** | **0.05** | **4.0** | **5.0** | **3.7** | **18.9** | **0.03** | **3.2** | **0.5** | **14.1** |
| **Maximum** | | **14,000** | **18.2** | **74.9** | **0.12** | **27.7** | **14.6** | **31.0** | **39.4** | **0.16** | **20.6** | **2.4** | **64.8** |
| **Offshore** | | | | | | | | | | | | | |
| LL_21_EBS | 20 | 1,340 | 5.3 | 17.4 | 0.04 | 5.3 | 2.0 | 3.3 | 2.4 | 0.01 | 4.5 | 0.5 | 10.7 |
| LL_23_SG_SS | 35.1 | 0 | 36 | 0.0 | <0.04 | 6.0 | 2.6 | 8.9 | 0.0 | <0.01 | 5.6 | 0.0 | 28.4 |
| LL_27_EBS | 32 | 2,010 | 28.9 | 28.3 | 0.04 | 7.5 | 4.8 | 6.7 | 5.0 | 0.01 | 8.0 | 0.5 | 18.5 |
| LL_32_EBS | 33.9 | 1,710 | 20 | 14.4 | 0.04 | 7.7 | 3.1 | 6.2 | 3.8 | 0.01 | 6.3 | 0.5 | 17.3 |
| LL_38_EBS | 34.5 | 1,550 | 20 | 18.9 | 0.04 | 6.9 | 3.5 | 6.4 | 2.9 | 0.01 | 7.3 | 0.5 | 14.6 |
| LL_44_EBS | 40.3 | 1,120 | 16.4 | 8.3 | 0.04 | 6.7 | 1.6 | 4.9 | 2.2 | 0.01 | 4.0 | 0.5 | 16.8 |
| LL_45_SG_SS | 40.2 | 0 | 46.3 | 0.0 | <0.04 | 4.7 | 3.1 | 6.2 | 0.0 | <0.01 | 8.5 | 0.0 | 23.5 |
| LL_49_EBS | 44.2 | 1,680 | 29 | 24.7 | 0.04 | 7.7 | 3.0 | 6.6 | 4.1 | 0.01 | 7.2 | 0.5 | 17.0 |
| LL_55_EBS_SS | 38.6 | 1,000 | 41.4 | 5.7 | <0.04 | 4.1 | 1.4 | 7.3 | 2.1 | 0.01 | 5.2 | 0.5 | 21.8 |
| LL_60_EBS | 41.4 | 937 | 17.9 | 7.6 | 0.04 | 4.8 | 2.8 | 4.2 | 2.3 | 0.01 | 5.4 | 0.5 | 10.8 |
| LL_64_EBS | 46.4 | 2,350 | 30.1 | 24.5 | 0.04 | 6.8 | 3.5 | 5.4 | 5.6 | 0.01 | 7.8 | 0.5 | 17.0 |
| LL_72_EBS_SS | 43.9 | 757 | 36.8 | 5.4 | <0.04 | 2.8 | 1.9 | 3.4 | 2.2 | <0.01 | 4.6 | 0.5 | 12.8 |
| LL_73_EBS_SS | 45.8 | 560 | 23.6 | 5.2 | <0.04 | 3.3 | 1.3 | 3.5 | 2.0 | <0.01 | 4.3 | 0.5 | 12.0 |
| LL_78_EBS_SS | 41.6 | 424 | 14.1 | 3.0 | <0.04 | 2.8 | 2.0 | 2.4 | 2.0 | 0.01 | 3.6 | 0.5 | 19.8 |
| LL_85_EBS_SS | 45.6 | 600 | 19.6 | 5.4 | <0.04 | 3.4 | 2.5 | 3.7 | 2.0 | <0.01 | 4.2 | 0.5 | 18.9 |
| LL_87_EBS | 50.4 | 2,320 | 8.0 | 13.8 | 0.04 | 7.0 | 2.0 | 4.9 | 5.3 | 0.01 | 4.9 | 0.5 | 14.4 |
| LL_89_EBS | 51.1 | 1,430 | 54.1 | 8.7 | 0.04 | 6.5 | 1.6 | 7.6 | 3.8 | 0.01 | 4.8 | 0.5 | 17.8 |
| LL_94_EBS | 47.7 | 1,340 | 24.8 | 7.5 | 0.04 | 5.7 | 1.2 | 5.6 | 3.9 | 0.01 | 4.0 | 0.5 | 14.9 |
| LL_97_EBS | 43.6 | 821 | 13.2 | 6.2 | 0.04 | 4.9 | 0.9 | 3.1 | 2.3 | 0.01 | 2.9 | 0.5 | 9.5 |

| Station | Depth (m) | Aluminium (Al) | Arsenic (As) | Barium (Ba) | Cadmium (Cd) | Chromium (Cr) | Copper (Cu) | Lead (Pb) | Lithium (Li) | Mercury (Hg) | Nickel (Ni) | Tin (Sn) | Zinc (Zn) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LL_99_EBS | 44 | 1,250 | 12.8 | 11.3 | 0.04 | 6.0 | 1.6 | 3.8 | 3.2 | 0.01 | 4.1 | 0.5 | 11.3 |
| LL_102_EBS | 39.2 | 2,570 | 19.3 | 11.5 | 0.04 | 7.9 | 2.2 | 6.5 | 6.9 | 0.01 | 5.4 | 0.5 | 17.2 |
| LL_104_EBS | 36.1 | 1,300 | 14.4 | 12.0 | 0.04 | 5.2 | 1.2 | 3.7 | 3.6 | 0.01 | 3.4 | 0.5 | 11.2 |
| LL_106_EBS_SS | 35.9 | 986 | 23.6 | 8.0 | <0.04 | 5.4 | 2.2 | 6.9 | 2.7 | <0.01 | 4.2 | 0.5 | 22.4 |
| LL_108_EBS | 36.6 | 1,330 | 40.9 | 8.1 | 0.04 | 7.0 | 1.5 | 7.6 | 3.7 | 0.01 | 4.6 | 0.5 | 18.9 |
| LL_112_EBS_SS | 34.3 | 1,560 | 30.4 | 8.5 | <0.04 | 5.9 | 1.9 | 8.0 | 4.6 | <0.01 | 4.5 | 0.5 | 29.8 |
| LL_116_EBS | 35.2 | 1,950 | 19.1 | 12.9 | 0.04 | 9.4 | 3.3 | 7.7 | 5.0 | 0.01 | 9.0 | 0.5 | 24.5 |
| LL_120_EBS | 34 | 2,430 | 25 | 12.4 | 0.04 | 10.5 | 3.2 | 8.8 | 6.6 | 0.01 | 9.4 | 0.5 | 25.3 |
| LL_125_EBS | 31.4 | 1,650 | 17.4 | 7.2 | 0.04 | 8.8 | 2.1 | 6.6 | 4.6 | 0.01 | 6.9 | 0.5 | 23.2 |
| LL_129_EBS | 31 | 2,070 | 30.5 | 9.2 | 0.04 | 12.0 | 2.6 | 10.7 | 5.6 | 0.01 | 8.7 | 0.5 | 31.1 |
| LL_133_EBS | 27.3 | 2,180 | 39.9 | 7.0 | 0.04 | 13.0 | 1.8 | 13.7 | 5.9 | 0.01 | 9.0 | 0.5 | 34.4 |
| LL_138_EBS | 29 | 3,630 | 5.9 | 24.1 | 0.04 | 13.3 | 3.8 | 7.7 | 10.2 | 0.01 | 11.3 | 0.5 | 32.1 |
| **Mean** | | **1,447** | **24.7** | **10.9** | **0.04** | **6.7** | **2.3** | **6.2** | **3.8** | **0.01** | **5.9** | **0.5** | **19.3** |
| **Standard Deviation** | | **790** | **12.0** | **7.1** | **0.00** | **2.7** | **0.91** | **2.4** | **2.1** | **0.00** | **2.1** | **0.1** | **6.8** |
| **Variance (%)** | | **54.6** | **48.6** | **65.4** | **0.0** | **40.2** | **38.9** | **39.4** | **55.7** | **0.00** | **36.2** | **26.7** | **35.4** |
| **Minimum** | | **0.00** | **5.30** | **0.00** | **0.04** | **2.8** | **0.9** | **2.4** | **0.0** | **0.01** | **2.9** | **0.0** | **9.50** |
| **Maximum** | | **3,630** | **54.1** | **28.3** | **0.04** | **13.3** | **4.8** | **13.7** | **10.2** | **0.01** | **11.3** | **0.5** | **34.4** |
| **Reference Values** | | | | | | | | | | | | | |
| **UKOOA (2001) SNS 50th %ile** | | - | - | **26** | **0.03** | **6.51** | **2.04** | **6** | **-** | **0.02** | **3.97** | **-** | **12.2** |
| **UKOOA (2001) SNS 95th %ile** | | - | - | **272** | **0.72** | **44.8** | **13.9** | **21.0** | **-** | **0.05** | **21.5** | **-** | **36** |
| **NOAA ERL (Buchman, 2008)** | | - | **8.2** | - | **1.2** | **81** | **34** | **46.7** | - | **0.15** | **20.9** | - | **150** |
| **Cefas cAL1 (MMO, 2015)** | | - | **20** | - | **0.4** | **40** | **40** | **50** | - | **0.3** | **20** | - | **130** |
| **Cefas cAL2 (MMO, 2015)** | | - | **50** | - | **2.0** | **400** | **400** | **50** | - | **3** | **200** | - | **800** |
| **NOAA ERM (Buchman, 2008)** | | - | **70** | - | **9.6** | **370** | **270** | **218** | - | **0.71** | **51.6** | - | **410** |

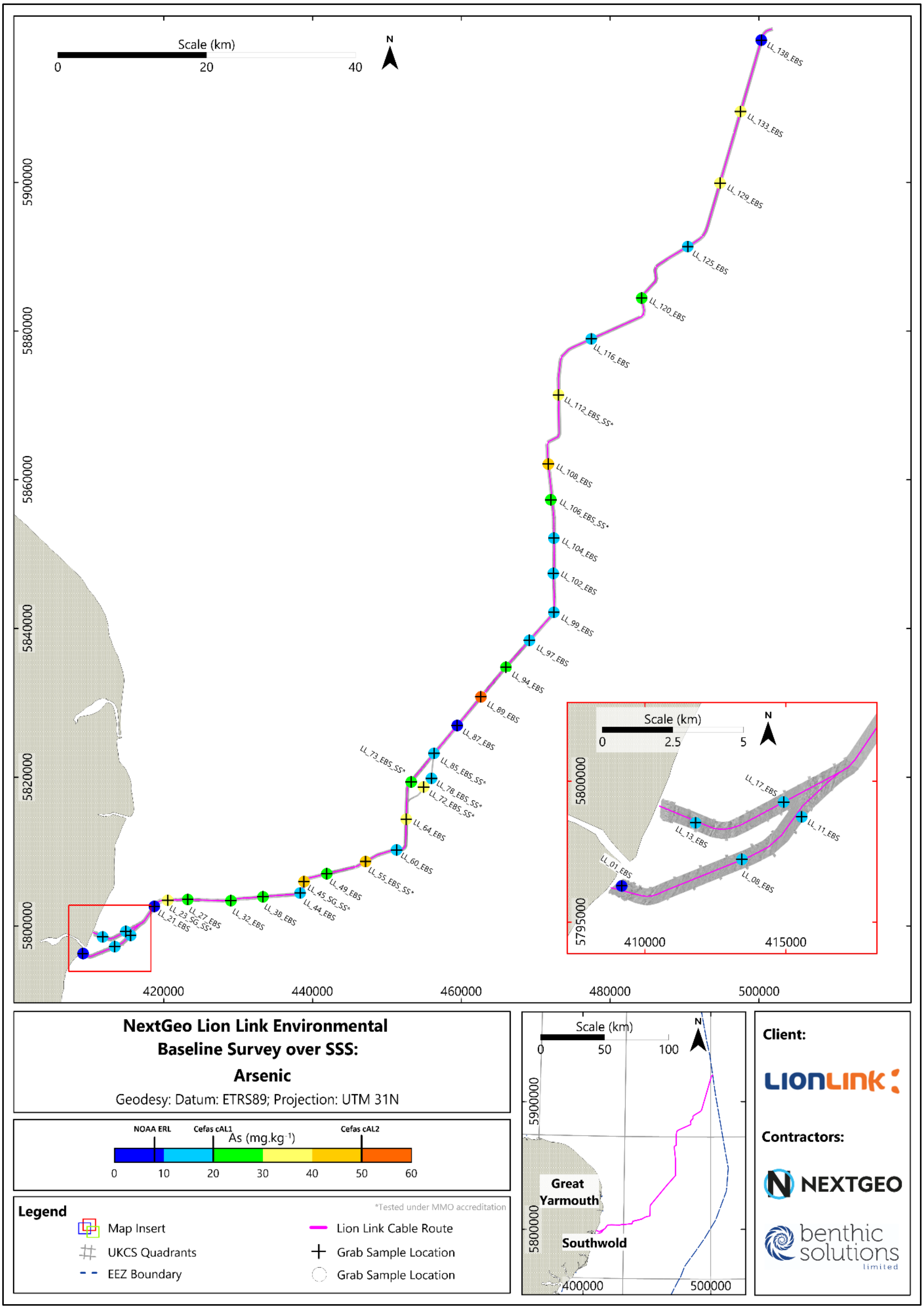



**Figure 3-20 Concentration of Arsenic**

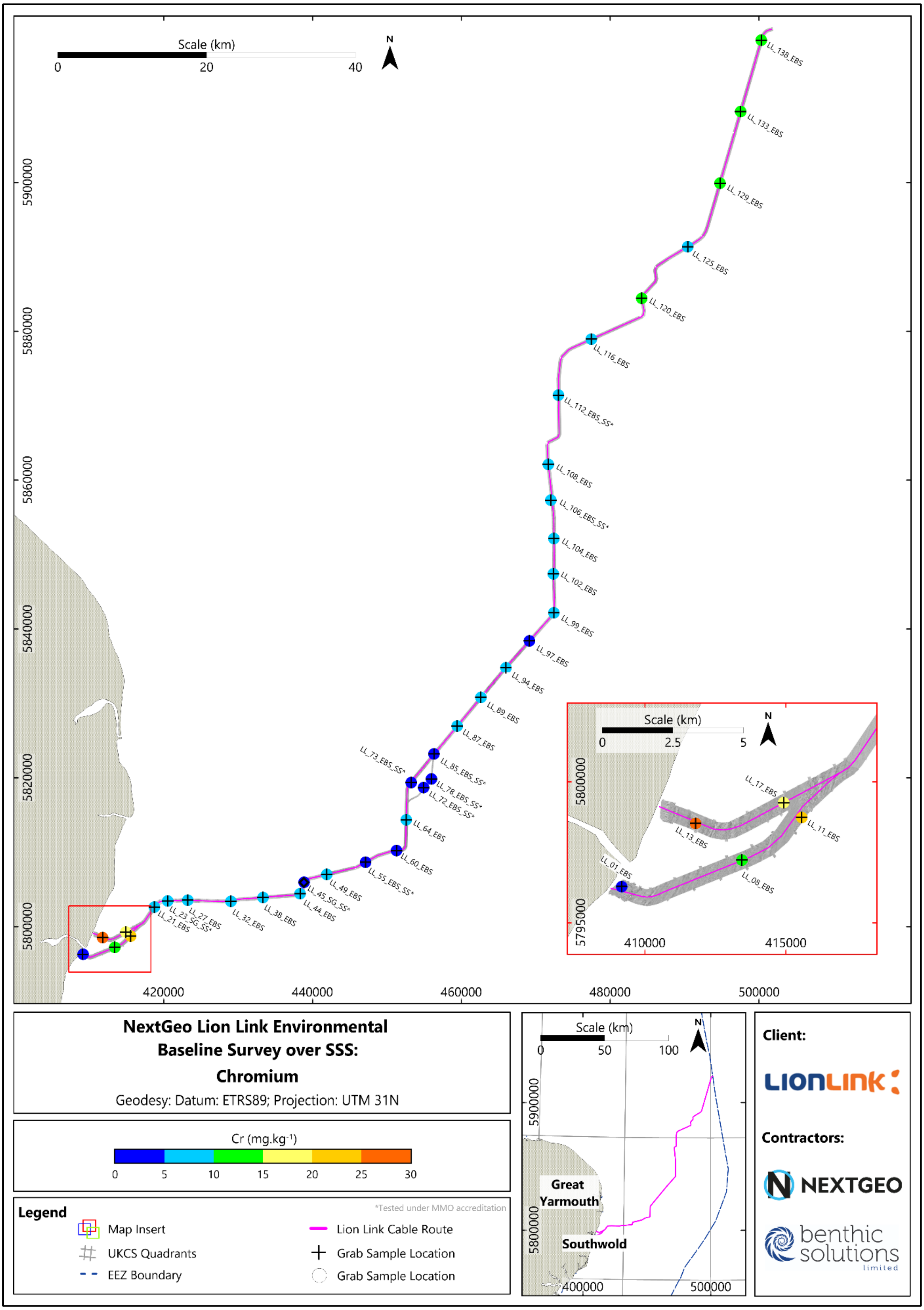



**Figure 3-21 Concentration of Chromium**

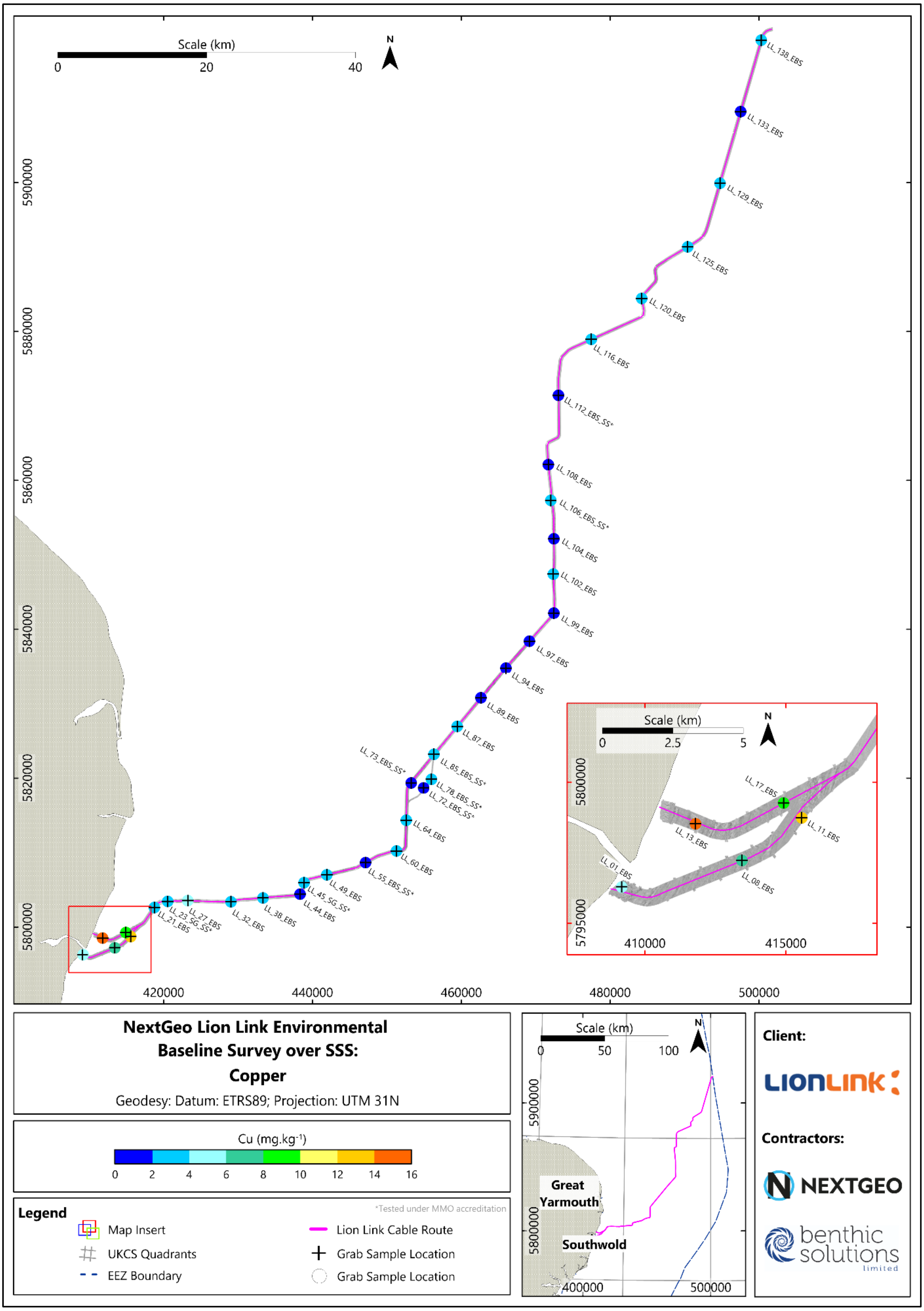



**Figure 3-22 Concentration of Copper**

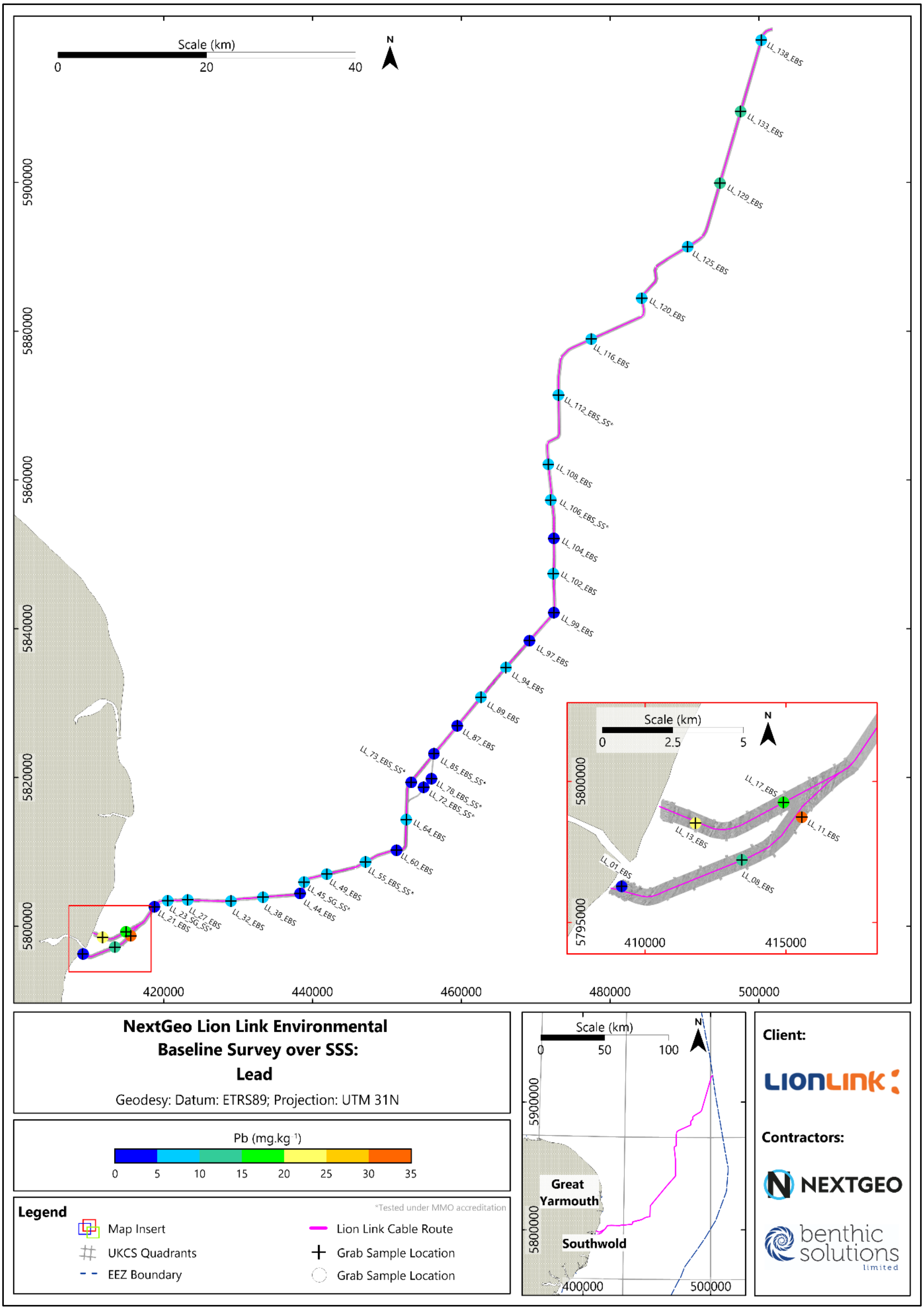



**Figure 3-23 Concentration of Lead**

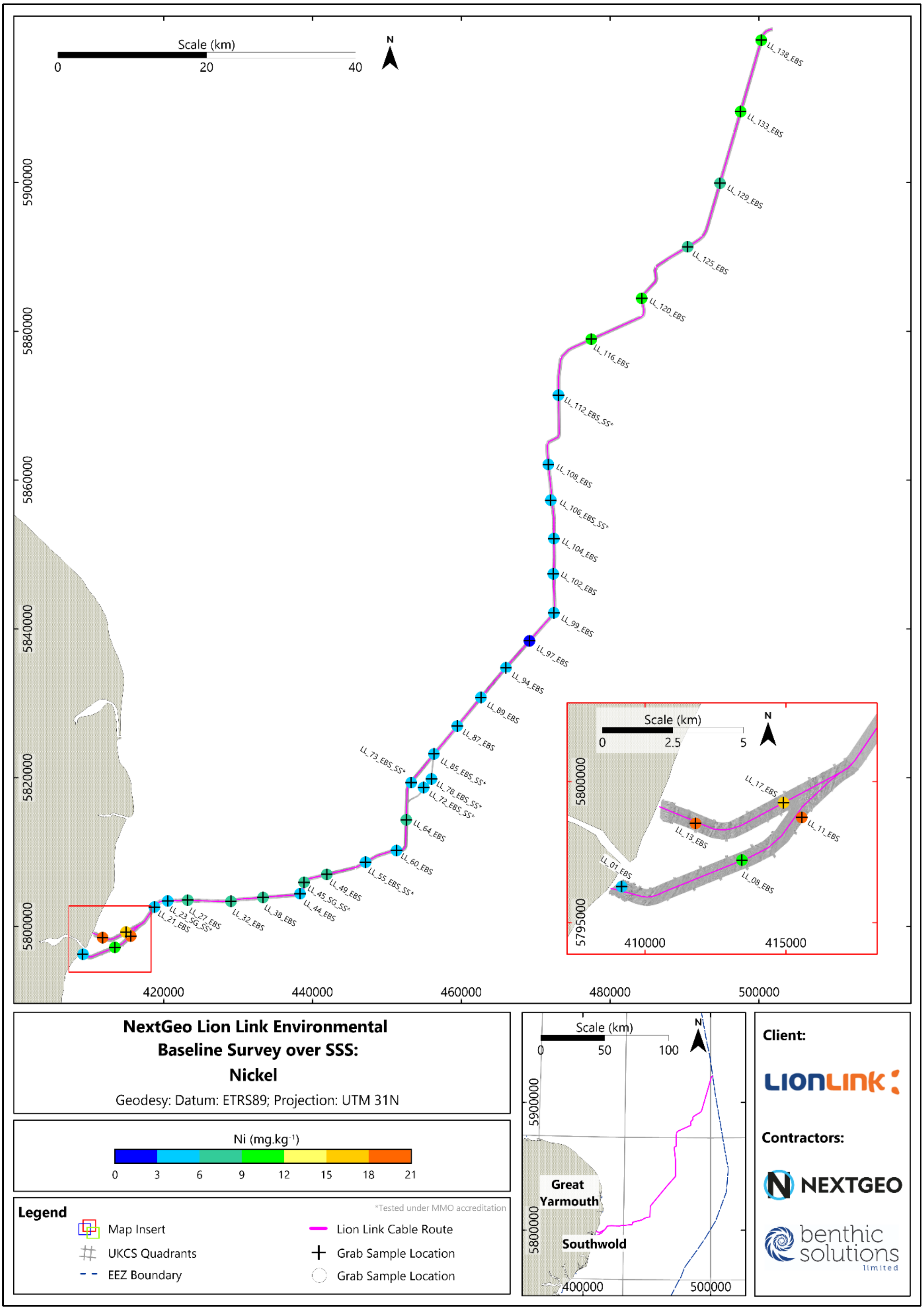



**Figure 3-24 Concentration of Nickel**

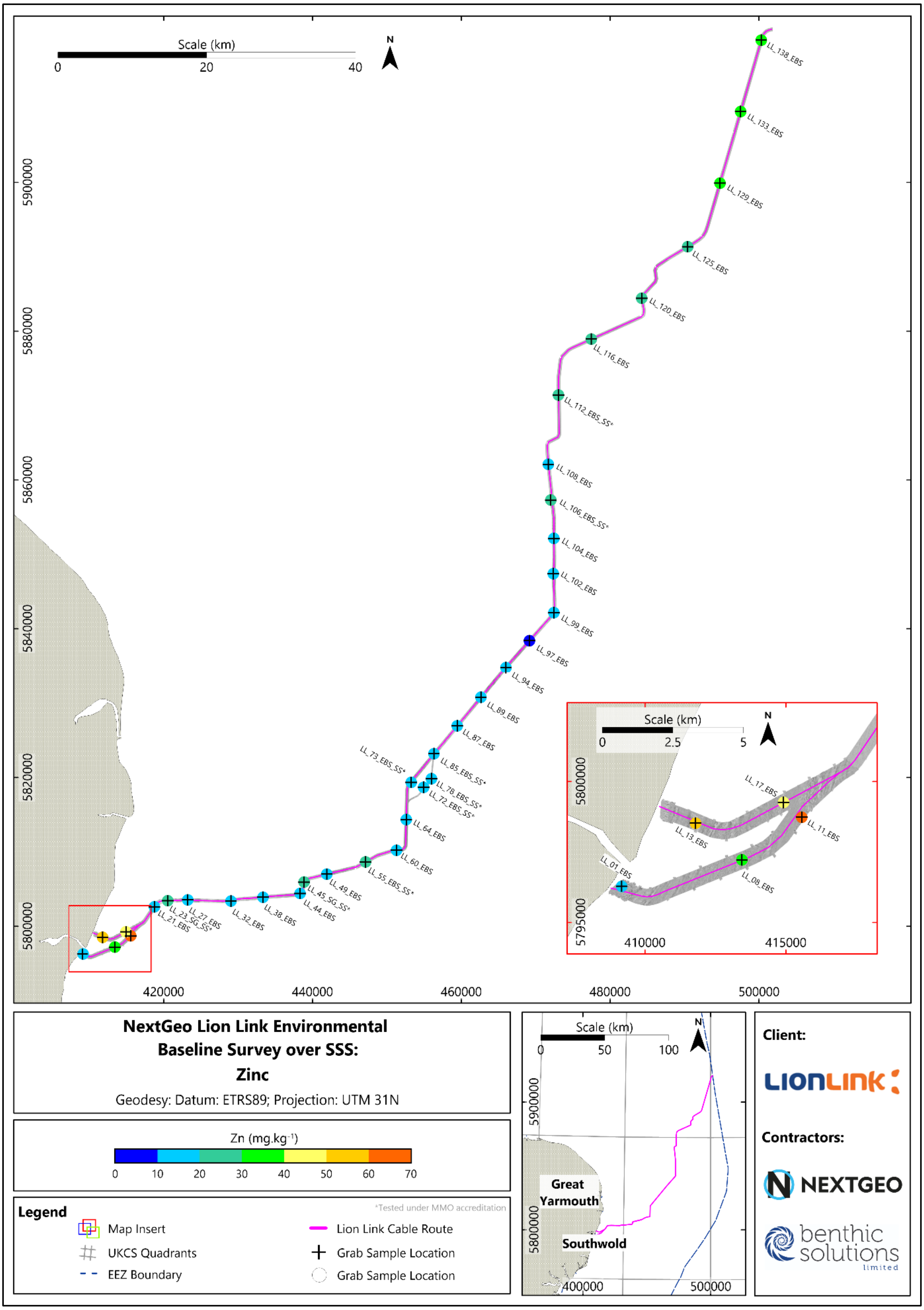



**Figure 3-25 Concentration of Zinc**

### 3.5.2 Normalised Heavy Metals

Normalised heavy and trace metal values were calculated to provide estimates of the proportion of bioavailable contaminants and to enable standardised comparisons between samples, minimising the influence of organic matter and sediment composition. The normalisation of metals used the current Coordinated Environmental Monitoring Programme (CEMP) normalisation procedure using pivot values (OSPAR, 2009a). In accordance with the CEMP normalisation procedure, heavy metals were normalised against lithium and are displayed in Table 3-9, along with OSPAR BC and BACs.

Some metals were environmentally inadmissible as the concentration of the normaliser contaminant was less than the normaliser pivot values and as such have been represented by '-' in Table 3-9. Barium and tin were unable to be normalised due to a lack of normaliser pivot values and have therefore been removed from the table of results. Where station values were below their limit of detection no normalised concentrations could be calculated, and therefore presented as 'NC' in Table 3-9. In addition, any normalised results returning a negative or any values higher than the possible maximum concentrations (three times non normalised concentration) were regarded as environmentally inadmissible by OSPAR CEMP guidance and as such have been excluded.

Heavy and trace metals at all offshore stations were either below the OSPAR BC or assessed as environmentally admissible based on the OSPAR CEMP guidance. In contrast, arsenic and lead concentrations exceeded their respective OSPAR BACs at nearshore stations LL_08_EBS and LL_11_EBS. Mercury concentrations exceeded the BAC at three of the five nearshore stations.

**Table 3-9 Normalised Total Heavy and Trace Metal Concentrations (mg.kg$^{-1}$)**

| Station | Depth (m) | Arsenic (As) | Cadmium (Cd) | Chromium (Cr) | Copper (Cu) | Lead (Pb) | Mercury (Hg) | Nickel (Ni) | Zinc (Zn) |
|---|---|---|---|---|---|---|---|---|---|
| **Nearshore** | | | | | | | | | |
| LL_01_EBS | 5.0 | - | NC | - | - | - | - | - | - |
| LL_08_EBS | 13.7 | 52.0 | 0.09 | 18.2 | 19.0 | 39.4 | - | 32.5 | 92.4 |
| LL_11_EBS | 19.6 | 25.3 | 0.18 | 32.0 | 21.0 | 50.0 | 0.26 | 28.8 | 102 |
| LL_13_EBS | 11.8 | 15.5 | 0.15 | 32.9 | 19.4 | 26.7 | 0.08 | 27.0 | 74.3 |
| LL_17_EBS | 15.5 | 21.6 | 0.15 | - | 21.3 | 35.9 | 0.10 | 32.4 | 87.5 |
| **Offshore** | | | | | | | | | |
| LL_21_EBS | 20.3 | - | - | - | - | - | - | - | - |
| LL_23_SG_SS | 35.1 | - | NC | - | - | - | NC | - | - |
| LL_27_EBS | 32.0 | - | - | - | - | - | - | - | - |
| LL_32_EBS | 33.9 | - | - | - | - | - | - | - | - |
| LL_38_EBS | 34.5 | - | - | - | - | - | - | - | - |
| LL_44_EBS | 40.3 | - | - | - | - | - | - | - | - |
| LL_45_SG_SS | 40.2 | - | NC | - | - | - | NC | - | - |
| LL_49_EBS | 44.2 | - | - | - | - | - | - | - | - |
| LL_55_EBS_SS | 38.6 | - | NC | - | - | - | - | - | - |
| LL_60_EBS | 41.4 | - | - | - | - | - | - | - | - |
| LL_64_EBS | 46.4 | - | - | - | - | - | - | 161.5 | - |

| Station | Depth (m) | Arsenic (As) | Cadmium (Cd) | Chromium (Cr) | Copper (Cu) | Lead (Pb) | Mercury (Hg) | Nickel (Ni) | Zinc (Zn) |
|---|---|---|---|---|---|---|---|---|---|
| LL_72_EBS_SS | 43.9 | - | NC | - | - | - | NC | - | - |
| LL_73_EBS_SS | 45.8 | - | NC | - | - | - | NC | - | - |
| LL_78_EBS_SS | 41.6 | - | NC | - | - | - | - | - | - |
| LL_85_EBS_SS | 45.6 | - | NC | - | - | - | NC | - | - |
| LL_87_EBS | 50.4 | - | - | - | - | - | - | - | - |
| LL_89_EBS | 51.1 | - | - | - | - | - | - | - | - |
| LL_94_EBS | 47.7 | - | - | - | - | - | - | - | - |
| LL_97_EBS | 43.6 | - | - | - | 3.82 | - | - | - | - |
| LL_99_EBS | 44.0 | - | - | - | - | - | - | - | - |
| LL_102_EBS | 39.2 | - | - | - | 20.9 | - | - | - | - |
| LL_104_EBS | 36.1 | - | - | - | - | - | - | - | - |
| LL_106_EBS_SS | 35.9 | - | NC | - | - | - | NC | - | - |
| LL_108_EBS | 36.6 | - | - | - | - | - | - | - | - |
| LL_112_EBS_SS | 34.3 | - | NC | - | - | - | NC | - | - |
| LL_116_EBS | 35.2 | - | - | - | - | - | - | - | - |
| LL_120_EBS | 34.0 | - | - | - | - | - | - | - | - |
| LL_125_EBS | 31.4 | - | - | - | - | - | - | - | - |
| LL_129_EBS | 31.0 | - | - | - | - | - | - | - | - |
| LL_133_EBS | 27.3 | - | - | 13.0 | - | - | - | - | - |
| LL_138_EBS | 29.0 | - | - | 15.3 | - | - | 0.08 | - | - |
| **Reference Value** | | | | | | | | | |
| **OSPAR (2014) BC** | | **15** | **0.20** | **60** | **20** | **25** | **0.05** | **30** | **90** |
| **OSPAR (2014) BAC** | | **25** | **0.31** | **81** | **27** | **38** | **0.07** | **36** | **122** |

*Notes:*
*NC = Not calculated: measured concentration of contaminant in sample <LOD*
*'-' = Environmentally inadmissible results as per OSPAR CEMP (2008)*

## 3.6 Macrofaunal Analysis

Macrofaunal analysis was conducted at 41 stations in the survey area, with 12 nearshore and 29 offshore stations. The nearshore area was predominantly muddy sediments, with classifications of Sandy Mud and Gravelly Mud. In the offshore area, the seabed varied throughout the route with a mix of Sand, Slightly Gravelly Muddy Sand, Muddy Sandy Gravel, Gravelly Muddy Sand, Muddy Sand, Gravelly Sand and Slightly Gravelly Sand. Samples across all stations were acquired using a 0.1m$^2$ grab sampler and sieved over a 1mm sieve in the field.

For this assessment epifaunal species are separated into two categories: solitary epifauna and colonial epifauna. Solitary epifauna includes taxa which are epifaunal in nature but form distinct and countable units which can be attached to hard substrate. Colonial epifauna are inclusive of encrusting epifauna, which are counted on a presence and absence basis. Within these analyses, solitary epifauna have been included within infaunal species, however colonial epifauna have been omitted and this component of the macrobenthos is discussed separately in Section 3.6.1.

Subsequent macrofaunal taxonomy of all recovered fauna identified a total of 4,259 individuals (infauna and solitary epifauna) from the 41 samples analysed. Faunal data for each sample are listed in Appendix I – Macrofaunal Species Lists, whilst univariate analyses are summarised in Table 3-10. Of the 147 taxa recorded, 10 were colonial epifauna, 2 were solitary epifauna and 135 were infauna, with 69 species of annelid accounting for 45.6% of the total individuals. Crustaceans were represented by 34 species (4.7% of total individuals), and molluscs by 19 species (41.4% of total individuals) and the echinoderms by seven species (accounting for 5.8% of the total individuals). All other groups (Nemertea and Nematoda etc.) were represented by six species, accounting for 1.2% of the total individuals.

The as sampled species accumulation curve (Figure 3-26) shows a gradual increase in fauna with each new grab, which was reflective of the relatively consistent largely sand dominant sediment across the survey area. This analysis estimated the maximum species accumulation (Chao expected curve) for the survey area to be 172 species, compared to the actual 137 infaunal species recorded during the survey. The number of species recorded exceeded the representative proportion of the population (i.e. 67% or 115 species) meaning no additional replicates would be required to adequately sample the macrofaunal community.

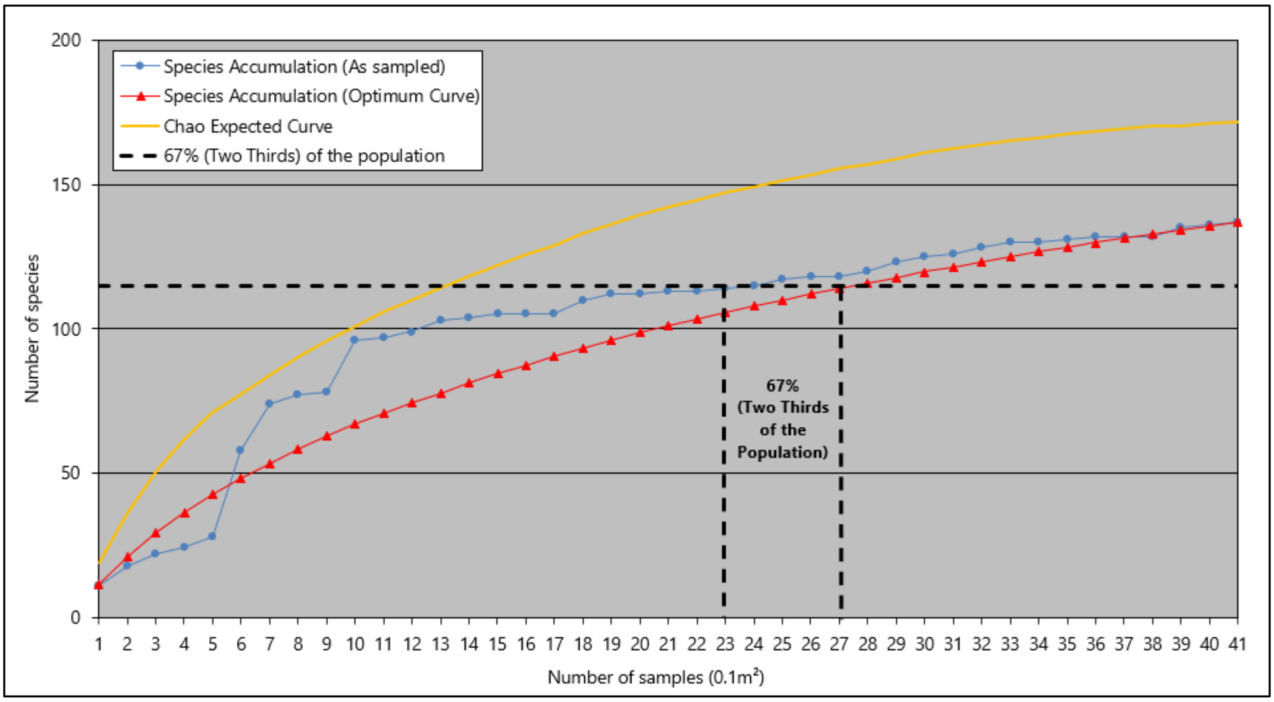



**Figure 3-26 Species Accumulation Curve of the Survey Area**

### 3.6.1 Primary and Univariate Parameters

The primary and univariate parameters for all stations are listed in Table 3-10 and represented by Figure 3-27 to Figure 3-29.

The number of individuals per 0.1m$^2$ was variable, within nearshore region ranging from 9 for sample LL_14_TR_G to 187 for stations LL_08_EBS (mean: 46±57SD; Figure 3-28). Whilst the offshore stations indicated greater variability, ranging from three individuals (station LL_55_EBS_SS) to 1,395 individuals (station LL_27_EBS). The high number of individuals at LL_27_EBS can be attributed to the trumpet worm (*Lagis koreni)* and the two-toothed Montagu shell (*Kurtiella bidentata*) which contributed 47.1% and 32.5%, respectively, to the total number of individuals at this station. The number of species per 0.1m$^2$ was less varied for both nearshore and offshore, with the nearshore ranging from 4 at LL_07_TR_G to 11 at three different stations (mean 8.0±2.4D; Figure 3-27). Offshore stations had a greater variability in the number of species present, ranging from 3 at LL_55_EBS_SS to 45 species at S2P_27_EBS (mean 13±11.0SD; Figure 3-27).

Margalef's Index, a measure of species richness, indicated a relatively diverse community across the survey route, ranging from 0.84 at station LL_07_TR_G to 6.47 at station LL_32_EBS. The offshore and nearshore region showed relatively consistent community diversities (mean: 2.94±1.4SD and 2.18±0.7SD, respectively; Table 3-10). Pielou's equitability was lowest at station LL_138_EBS (0.230) and highest at LL_102_EBS (1.000). Diversity values represented by Shannon's H(log2) ranged from poor (0.96 at LL_138_EBS) to good (3.41 at LL_87_EBS) diversity following the threshold values outlined in Dauvin *et al* (2012) whereby values >4.00 indicate high diversity; values between 3.00 and 4.00 indicate good diversity, values between 2.00 and 3.00 indicate moderate diversity and values between 1.00 and 2.00 indicate bad diversity, whilst values <1.00 indicate poor diversity (Table 3-10). Simpsons diversity indices varied from 0.234 at station LL_138_EBS to 1.000 at station LL_55_EBS_SS and LL_104_EBS (Table 3-10; Figure 3-29). However, this interpretation should be approached with caution, as a value of 1 typically indicates infinite diversity. In this case however, it reflects the presence of only one individual from each species at the stations, rather than true infinite diversity.

The Infaunal Quality Index (IQI) is a multi-metric index composed of three individual components, the AZTI Marine Biotic Index (AMBI), the Simpson's Dominance (1- λ) and the number of taxa (S), which together describe the ecological health of the biological quality element of the macrofauna. Each individual metric is normalised to a reference value, which is the expected value for that metric in the habitat type that is being assessed when there is minimal or no disturbance due to human activities. All stations were considered to have either "Good/Moderate" (0.64-0.74) ecological status with the exception of one nearshore station; LL_07_TR_G which ranked as "Moderate/Poor". Overall, the following results show a moderate to high diversity community across all stations, with slight variations in spatial patterns relating to natural variation.

**Table 3-10 Univariate Faunal Parameters (Per 0.1m²)**

| Station | Number of Species (S) | Number of Individuals (N) | Richness (Margalef) | Evenness (Pielou's ) | Shannon Wiener Diversity H'(log2) | Simpson's Diversity (1-Lambda') | IQI | Ecological Status (v4) |
|---|---|---|---|---|---|---|---|---|
| **Nearshore** | | | | | | | | |
| LL_01_EBS | 10 | 19 | 3.1 | 0.860 | 2.86 | 0.854 | 0.57 | MODERATE |
| LL_02_TR | 5 | 10 | 1.7 | 0.881 | 2.05 | 0.800 | 0.57 | MODERATE |
| LL_03_TR | 9 | 17 | 2.8 | 0.807 | 2.56 | 0.787 | 0.51 | MODERATE |
| LL_04_TR | 6 | 16 | 1.8 | 0.696 | 1.80 | 0.617 | 0.47 | MODERATE |
| LL_06_TR | 9 | 36 | 2.2 | 0.809 | 2.56 | 0.789 | 0.61 | MODERATE |
| LL_07_TR | 4 | 36 | 0.8 | 0.575 | 1.15 | 0.422 | 0.42 | POOR |
| LL_08_EBS | 11 | 187 | 1.9 | 0.593 | 2.05 | 0.673 | 0.53 | MODERATE |
| LL_09_TR | 11 | 142 | 2.0 | 0.626 | 2.17 | 0.696 | 0.53 | MODERATE |
| LL_11_EBS | 11 | 20 | 3.3 | 0.881 | 3.05 | 0.884 | 0.54 | MODERATE |
| LL_13_EBS | 8 | 33 | 2.0 | 0.779 | 2.34 | 0.760 | 0.56 | MODERATE |
| LL_14_TR | 6 | 9 | 2.3 | 0.936 | 2.42 | 0.889 | 0.61 | MODERATE |
| LL_17_EBS | 8 | 28 | 2.1 | 0.811 | 2.43 | 0.796 | 0.67 | GOOD |
| **Mean** | **8** | **46** | **2.18** | **0.771** | **2.29** | **0.747** | **0.55** | - |
| **Standard Deviation** | **2.4** | **56.9** | **0.66** | **0.12** | **0.50** | **0.13** | **0.06** | - |
| **Variance (%)** | **29.9** | **123.4** | **30.4** | **15.7** | **21.9** | **17.6** | **11.8** | - |
| **Minimum** | **4** | **9** | **0.8** | **0.575** | **1.1** | **0.422** | **0** | - |
| **Maximum** | **11** | **187** | **3.3** | **0.936** | **3.0** | **0.889** | **1** | - |
| **Offshore** | | | | | | | | |
| LL_21_EBS | 7 | 9 | 2.7 | 0.971 | 2.73 | 0.944 | 0.71 | GOOD |
| LL_27_EBS | 45 | 1395 | 6.1 | 0.431 | 2.37 | 0.669 | 0.63 | MODERATE |
| LL_32_EBS | 37 | 261 | 6.5 | 0.651 | 3.39 | 0.822 | 0.69 | GOOD |
| LL_38_EBS | 16 | 51 | 3.8 | 0.846 | 3.38 | 0.889 | 0.66 | GOOD |
| LL_44_EBS | 6 | 8 | 2.4 | 0.967 | 2.50 | 0.929 | 0.68 | GOOD |
| LL_49_EBS | 39 | 425 | 6.3 | 0.611 | 3.23 | 0.805 | 0.69 | GOOD |
| LL_55_EBS_SS | 3 | 3 | 1.8 | 1.000 | 1.59 | 1.000 | 0.62 | MODERATE |

| Station | Number of Species (S) | Number of Individuals (N) | Richness (Margalef) | Evenness (Pielou's ) | Shannon Wiener Diversity H'(log2) | Simpson's Diversity (1-Lambda') | IQI | Ecological Status (v4) |
|---|---|---|---|---|---|---|---|---|
| LL_60_EBS | 12 | 32 | 3.2 | 0.943 | 3.38 | 0.919 | 0.67 | GOOD |
| LL_64_EBS | 18 | 83 | 3.8 | 0.762 | 3.18 | 0.844 | 0.78 | HIGH |
| LL_72_EBS_SS | 6 | 8 | 2.4 | 0.967 | 2.50 | 0.929 | 0.63 | MODERATE |
| LL_73_EBS_SS | 6 | 10 | 2.2 | 0.976 | 2.52 | 0.911 | 0.50 | MODERATE |
| LL_78_EBS_SS | 3 | 4 | 1.4 | 0.946 | 1.50 | 0.833 | 0.64 | MODERATE |
| LL_85_EBS_SS | 3 | 5 | 1.2 | 0.865 | 1.37 | 0.700 | 0.51 | MODERATE |
| LL_87_EBS | 13 | 26 | 3.7 | 0.922 | 3.41 | 0.920 | 0.61 | MODERATE |
| LL_89_EBS | 13 | 32 | 3.5 | 0.817 | 3.02 | 0.847 | 0.63 | MODERATE |
| LL_94_EBS | 9 | 21 | 2.6 | 0.850 | 2.70 | 0.843 | 0.71 | GOOD |
| LL_97_EBS | 6 | 12 | 2.0 | 0.859 | 2.22 | 0.803 | 0.57 | MODERATE |
| LL_99_EBS | 4 | 22 | 1.0 | 0.690 | 1.38 | 0.571 | 0.64 | GOOD |
| LL_102_EBS | 4 | 4 | 2.2 | 1.000 | 2.00 | 1.000 | 0.66 | GOOD |
| LL_104_EBS | 4 | 9 | 1.4 | 0.988 | 1.98 | 0.833 | 0.70 | GOOD |
| LL_106_EBS_SS | 5 | 6 | 2.2 | 0.970 | 2.25 | 0.933 | 0.60 | MODERATE |
| LL_108_EBS | 8 | 14 | 2.7 | 0.852 | 2.56 | 0.824 | 0.67 | GOOD |
| LL_112_EBS_SS | 4 | 9 | 1.4 | 0.988 | 1.98 | 0.833 | 0.63 | MODERATE |
| LL_116_EBS | 15 | 119 | 2.9 | 0.678 | 2.65 | 0.770 | 0.67 | GOOD |
| LL_120_EBS | 15 | 135 | 2.9 | 0.635 | 2.48 | 0.764 | 0.62 | MODERATE |
| LL_125_EBS | 9 | 19 | 2.7 | 0.929 | 2.95 | 0.901 | 0.67 | GOOD |
| LL_129_EBS | 18 | 74 | 4.0 | 0.792 | 3.30 | 0.862 | 0.69 | GOOD |
| LL_133_EBS | 20 | 124 | 3.9 | 0.535 | 2.31 | 0.578 | 0.65 | GOOD |
| LL_138_EBS | 19 | 786 | 2.7 | 0.230 | 0.98 | 0.236 | 0.54 | MODERATE |
| **Mean** | **13** | **128** | **2.95** | **0.816** | **2.48** | **0.818** | **0.64** | - |
| **Standard Deviation** | **11** | **293** | **1.42** | **0.19** | **0.68** | **0.15** | **0.06** | - |
| **Variance (%)** | **87.1** | **229.4** | **48.2** | **23.4** | **27.6** | **18.8** | **9.2** | - |
| **Minimum** | **3** | **3** | **1.0** | **0.230** | **1.0** | **0.236** | **0.50** | - |
| **Maximum** | **45** | **1395** | **6.5** | **1.000** | **3.4** | **1.000** | **0.78** | - |

**IQI Score:**
**≥0.75 = High / Good; 0.64 - 0.74 = Good / Moderate; 0.45 - 0.63 = Moderate / Poor; ≤ 0.44= Poor / Bad**

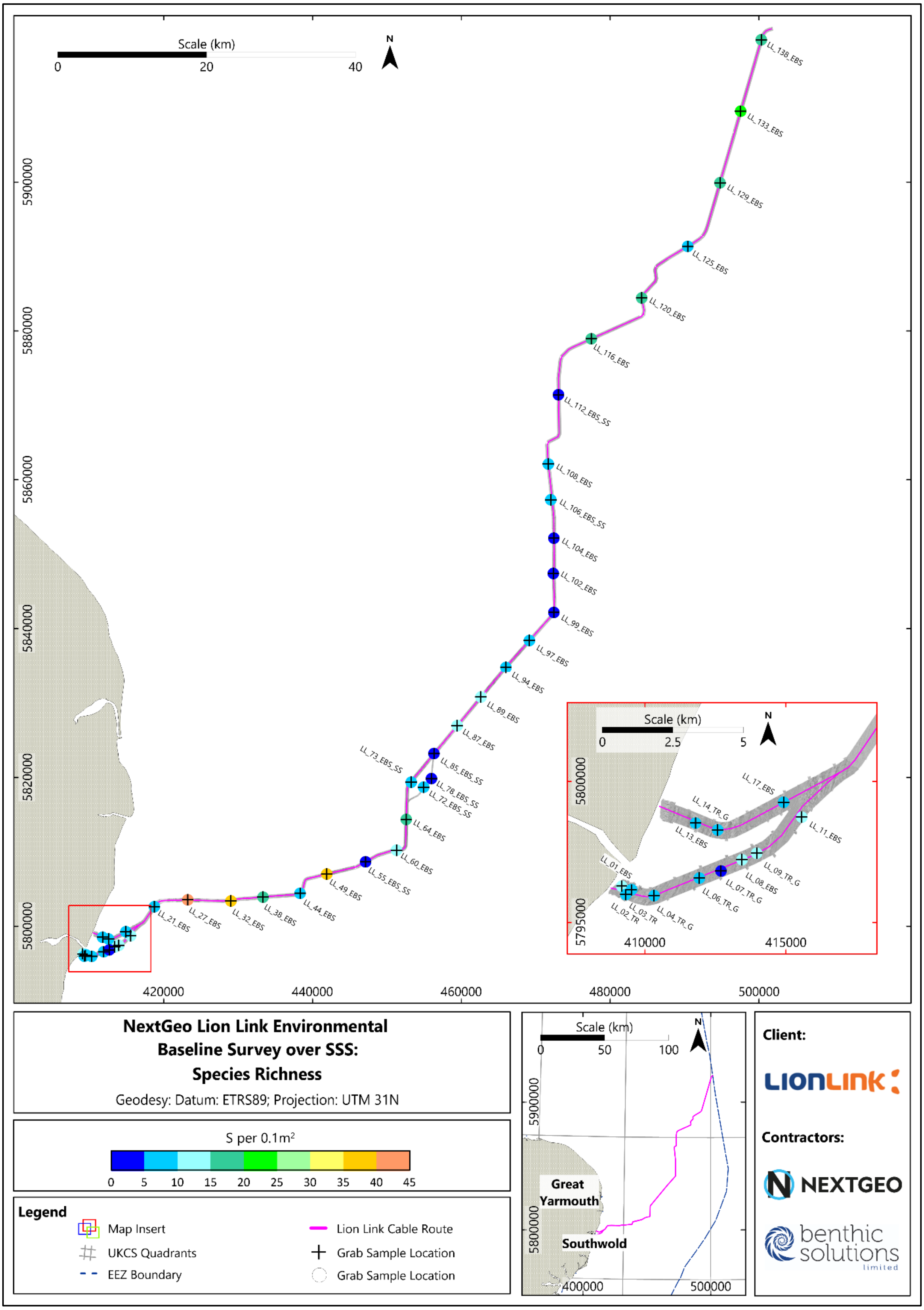



**Figure 3-27 Macrofauna Species Richness**

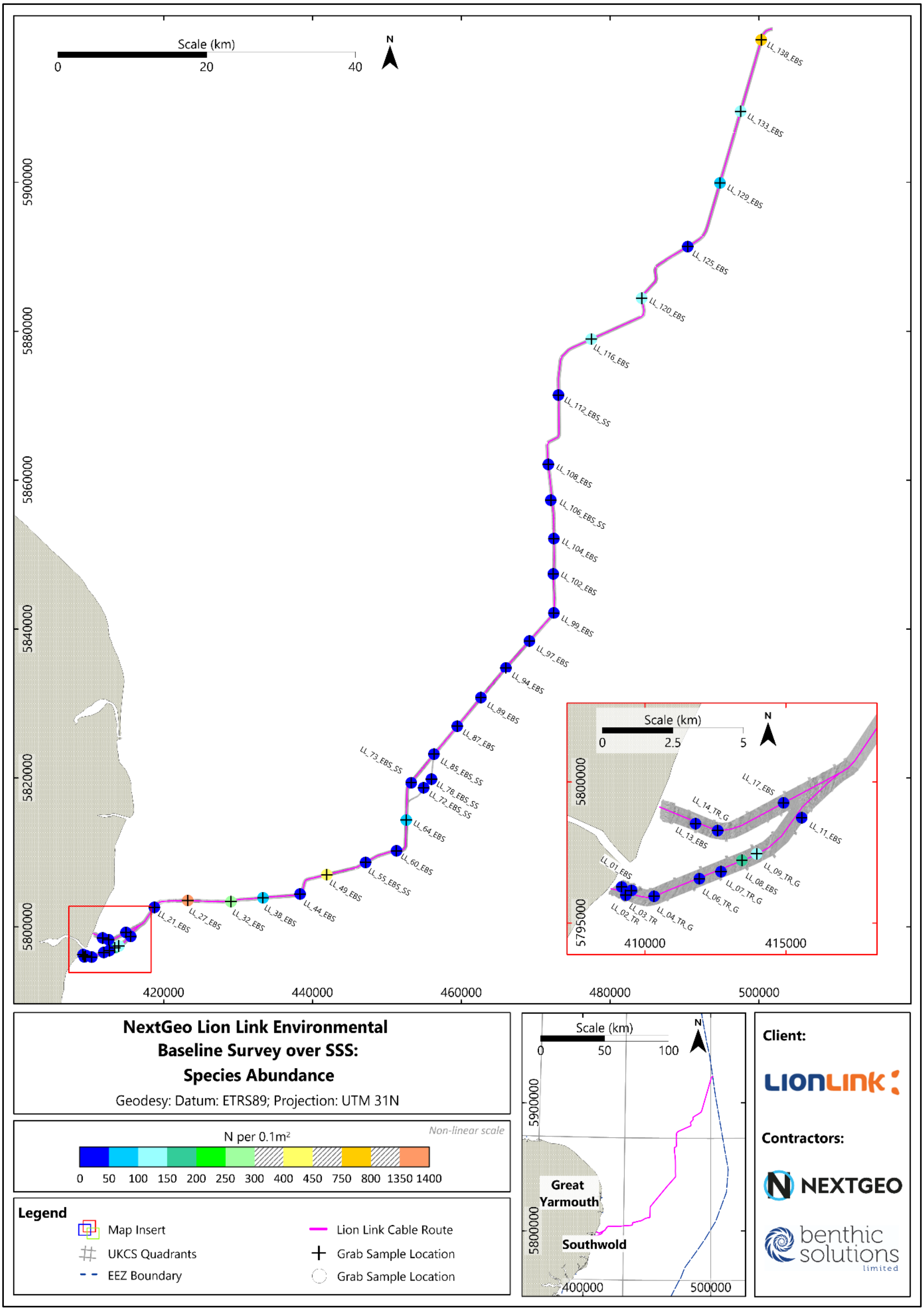



**Figure 3-28 Macrofauna Species Abundance**

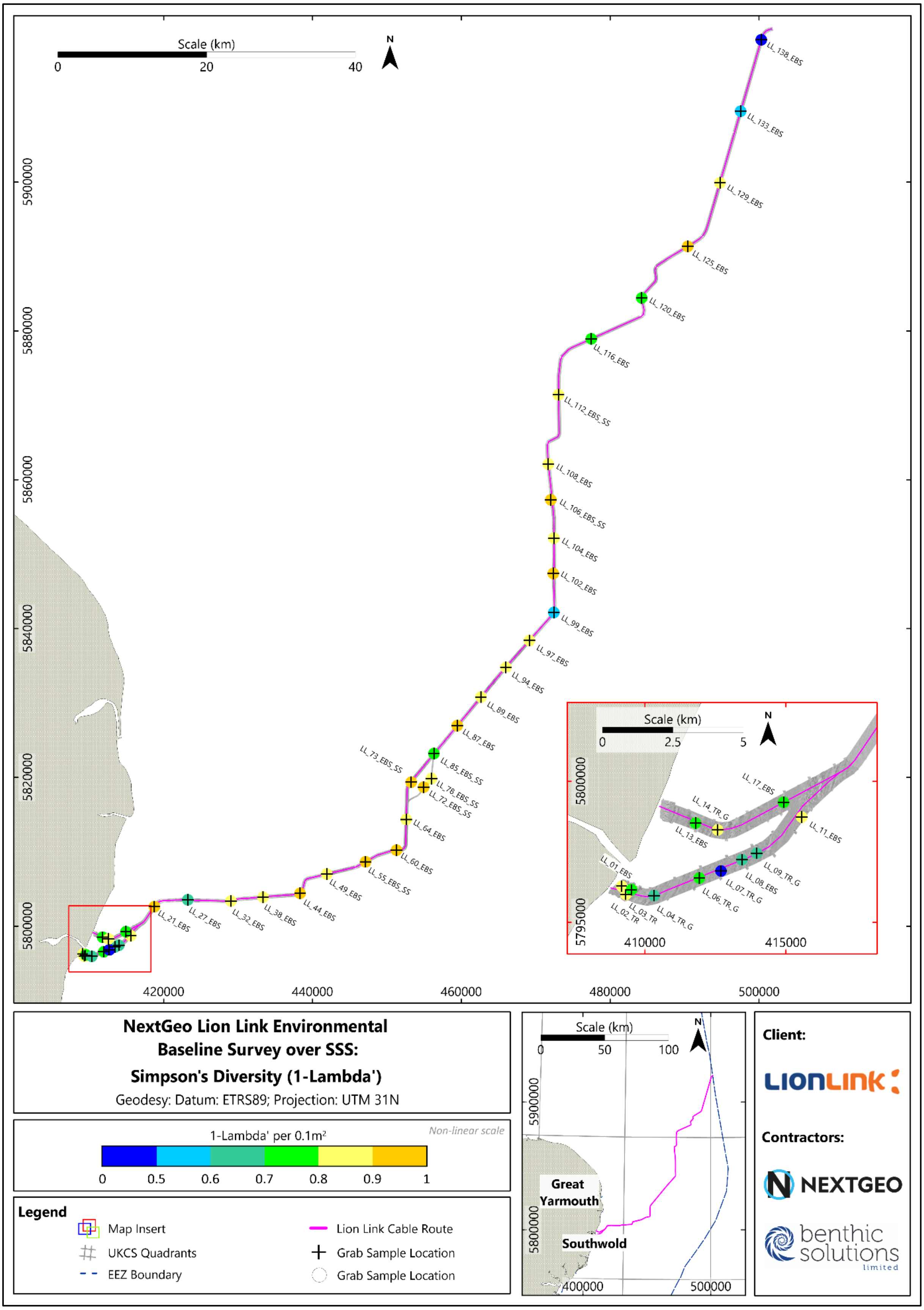



**Figure 3-29 Macrofauna Simpson's Diversity**

### 3.6.2 Multivariate Analysis

To provide a more thorough examination of the macrofaunal community, multivariate analysis was performed upon the sample data using Plymouth Routines in Multivariate Ecological Research software (PRIMER 7.0.17; Clarke *et al*., 2014) to illustrate data trends. Unlike univariate or derived diversity indices, multivariate analyses preserve the identity of the different species by assigning a similarity or dissimilarity between the samples based on differences in the abundances of constituent species. All station data was fourth-root transformed prior to analysis to down-weight the influence of any dominant species between sample similarities/dissimilarities.

#### 3.6.2.1 Hierarchical Agglomerative Clustering – Group Average Method

A similarity dendrogram was created using single linkage hierarchical agglomerative clustering (CLUSTER) and is presented for all stations in Figure *3-30*.

. SIMPROF analysis highlighted the presence of 11 significantly different ($p$<0.05) clusters which were differentiated by black branches on the dendrogram whilst red dashed branches showed similarity. Stations displayed inter-sample Bray Curtis similarities of between 5% and 35%, however this was thought to have over-differentiated the dataset. A slice at 12% Bray-Curtis similarity was overlain which reduced the number of clusters to five, which are described in below in Table 3-11.

**Table 3-11 SIMPROF Station Groupings**

| SIMPROF Group | Similarity (%) | Stations | Interpretation |
|---|---|---|---|
| a | 23.09 | LL_21_EBS, LL_44_EBS, LL_55_EBS_SS, LL_72_EBS_SS, LL_78_EBS_SS, LL_85_EBS_SS, LL_94_EBS, LL_97_EBS, LL_99_EBS, LL_104_EBS, LL_108_EBS, LL_112_EBS_SS, LL_14_TR, LL_01_EBS | This cluster consists of both nearshore and offshore stations, ranging in sediment classifications from Sand, Slightly Gravelly Sand, Gravelly Sand and Gravelly Mud, all of which depend on the dominance of sand and minimal elements of fines and gravels. This cluster has a low species richness (3 to 10) and abundance (3 to 22), comprising of predominantly Annelida and Nemertea which both typically inhabit finer sediment such as sands and muds. |
| b | 22.32 | LL_08_EBS, LL_11_EBS, LL_13_EBS, LL_17_EBS, LL_27_EBS, LL_32_EBS, LL_38_EBS, LL_49_EBS, LL_60_EBS, LL_64_EBS, LL_73_EBS_SS, LL_87_EBS, LL_89_EBS, LL_116_EBS, LL_120_EBS, LL_125_EBS, LL_129_EBS, LL_133_EBS, LL_138_EBS, LL_04_TR, LL_06_TR, LL_09_TR | This cluster consisted of nearshore and offshore stations with variable sediment classifications, dependent on the dominant particle size (sand or fines). Classifications range from Sand, Sandy Mud, Muddy Sand, Gravelly Mud, Muddy Sandy Gravel, Gravelly Muddy Sand, Slightly Gravelly Sand, Slightly Gravelly Sandy Mud, indicating dominance of fines and sands with minor coarse material proportions. Species such as *Spiophanes bombyx, Diastylis bradyi* and *Nephtys cirrosa* were shared across two other clusters with similar fine and sand contents, however presenting different contributions of individuals. |
| c | 33.87 | LL_07_TR, LL_02_TR, LL_03_TR | This cluster consists of three nearshore stations, all of which had sediment variations of 'Muddy Gravel', 'Sandy Gravel' and 'Sandy Mud' on the BGS Modified Folk Classification and being Very to Extremely Poorly Sorted. This cluster presented with low species richness (4 to 9) and abundance (10 to 36) which consisted of only 5 species attributed to Annelida, Arthropoda and Cnidaria. All identified species are known to have a positive association with soft sediment environments. |
| d | <2 samples | LL_106_EBS_SS | This cluster consists of one station in the central section of the cable route. This cluster had low species richness (5) and abundance (6) only consisting of annelids and Nemertea likely attributed to its sediment type being predominantly 98.0% sands and 2.0% gravel, assigned to the BGS Modified Folk Classification of 'Slightly Gravelly Sand'. The identified species within this cluster are known to inhabit relatively coarse-grained, unstable sediment which can limit the diversity and density of macrofauna. |
| e | <2 samples | LL_102_EBS | This cluster comprised one station in the central section of the survey route assigned 'Gravelly Muddy Sand' on the BGS Modified Folk Classification. Again, it noted low species richness (4) and abundance (4). This cluster comprised only of annelids and crustaceans in very low abundances (1 individual for each taxa), it was also the only cluster with the amphipod *Unciola crenatipalma* present. |

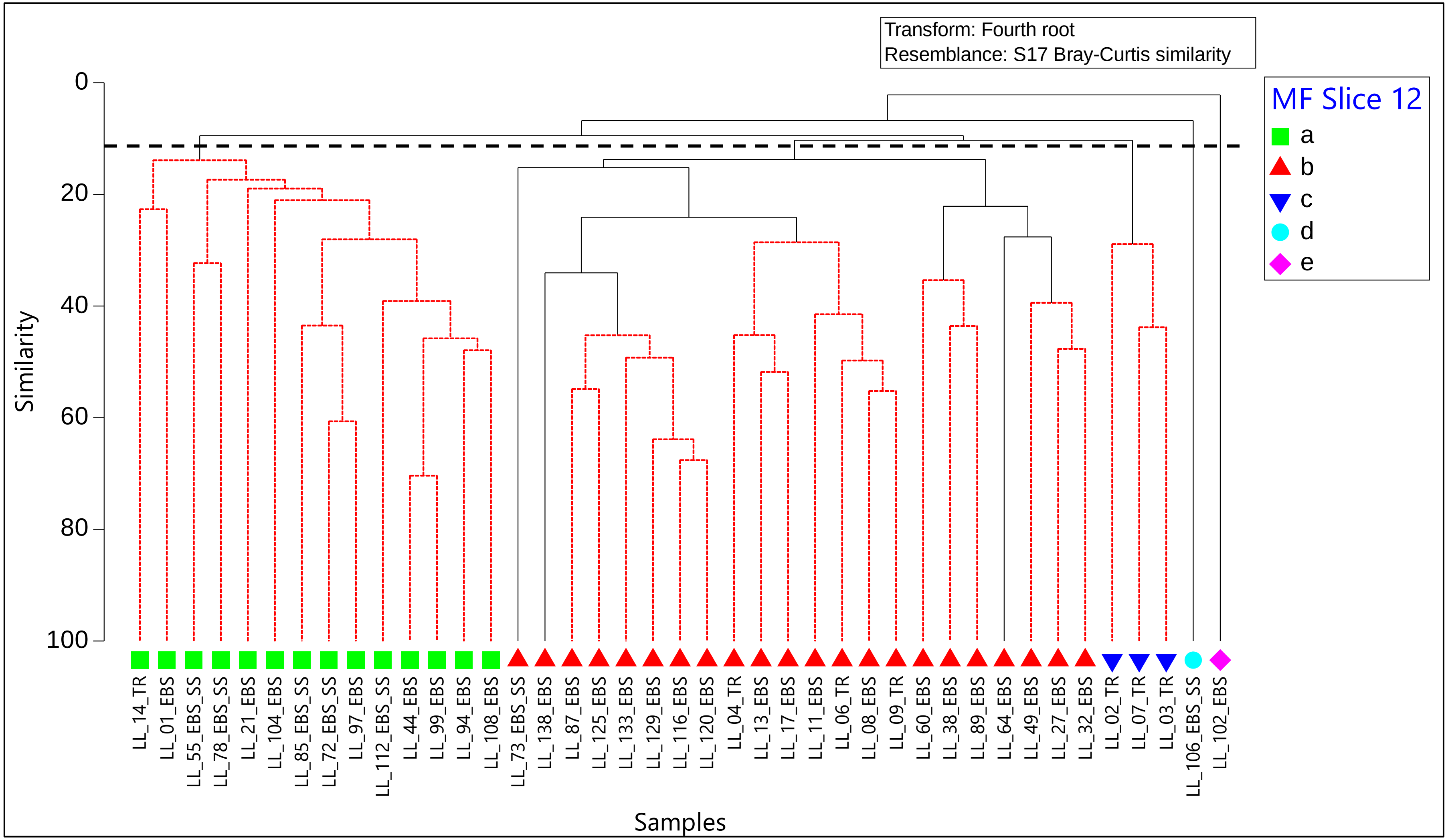



**Figure 3-30 Dendrogram of Macrofaunal Stations (Per 0.1m$^2$)**

### 3.6.2.2 Non-Metric Multi-Dimensional (nMDS) Ordination

Similarities in the macrofaunal communities recorded across the subtidal survey area are presented in Figure 3-31 as a 2-dimensional non-metric multi-dimensional scaling (nMDS) ordination. The nMDS plot presents the 38 stations along the cable route, revealing a moderate ordination of the data with a stress level of 0.19.

These plotted stations were consistent with the clusters identified in the dendrogram (Figure 3-30), with clusters 'a' and 'b' representing the two overarching macrofaunal communities that were differentiated due to variations in gravels and fines content resulting in varied contributions of different taxa. Both clusters display intra-cluster variability with some stations ordinating closer together and some spread across the distance matrix, indicating a less similar species composition between some stations. In cluster 'c', one station (LL_02_TR) is ordinated at a much further distance from all other stations within the cluster. This is likely due to this station having the lowest species abundance across the stations within the cluster, but displaying similar macrofaunal composition. Cluster 'd' comprised one station (LL_106_EBS_SS) and ordinated slightly right of the majority of stations, showing greater dissimilarity to the majority of clusters and overarching macrofaunal compositions. However, two stations, one from cluster 'a' and one from cluster 'b', ordinated loosely with this station indicating some similarities in their macrofaunal compositions. Finally, cluster 'e' (station LL_102_EBS) ordinated at the bottom right of the plot, located furthest from all other clusters showing the highest dissimilarity to other clusters due to the low species richness and abundance.

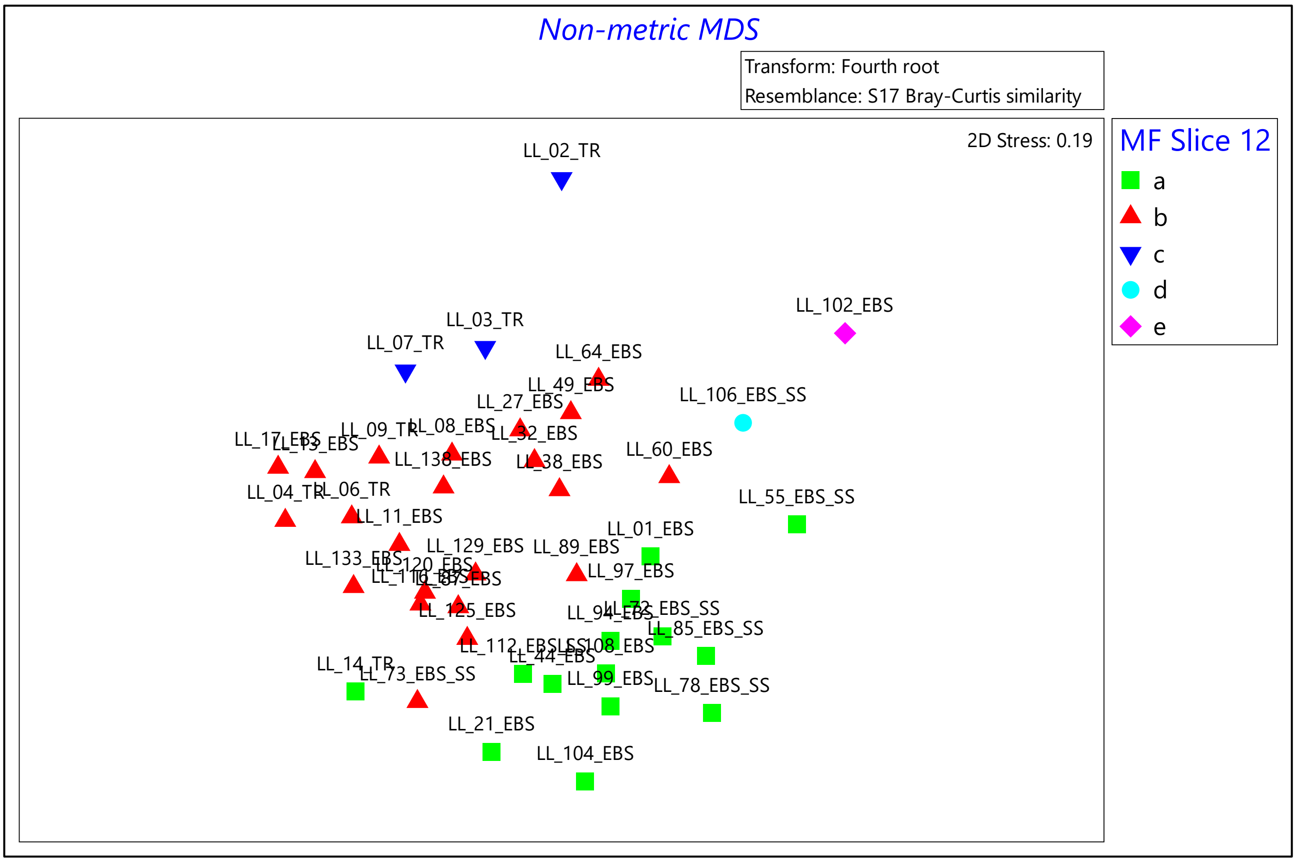



**Figure 3-31 nMDS Ordination**

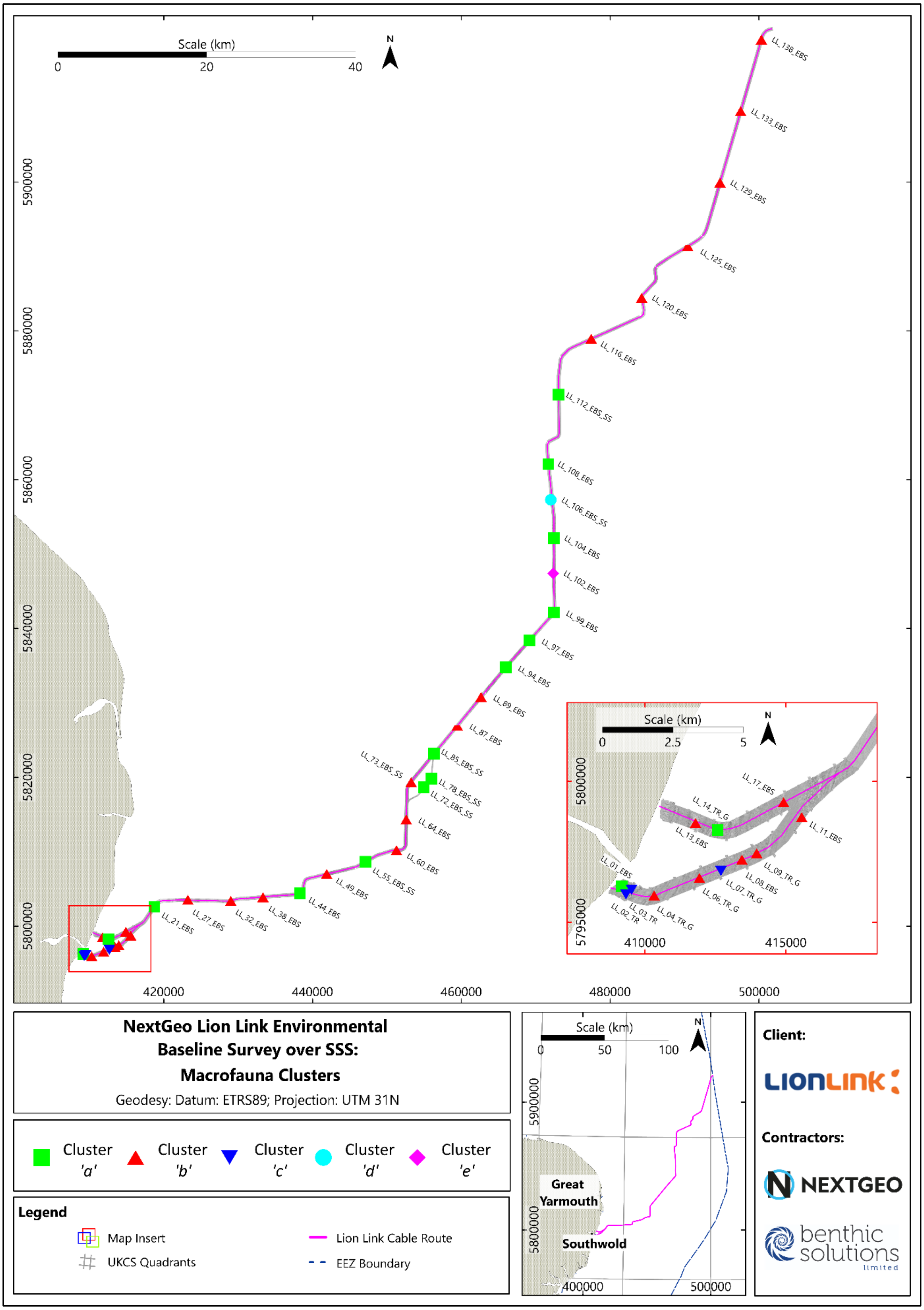



**Figure 3-32 Macrofaunal Cluster Groups**

#### 3.6.2.3 Correlation with Environmental Variables

To assess whether the observed differences in community composition were related to the sediment composition of the site a RELATE test (correlation test) was performed. The result revealed there to be a significant correlation between the two parameters ($\varrho=0.398$, $p<0.001$). To visualise this relationship, a PCA was carried out on the PSA phi data overlain with the clusters identified from the macrofaunal dataset (Figure 3-33). The plot shows that macrofaunal communities within cluster 'a' was primarily characterised by coarse to medium sand (phi 2 to 3), but few stations were also influenced by proportions of fine sand, silts and clay (phi 3, 4 and 5 respectively), showing varied intra-cluster variation. Cluster 'b' was primarily characterised by gravel (phi -3 to -1) but showed great intra-cluster variation spanning from coarse sand (phi 1) to pebble (phi -3). Cluster 'c' plotted closely to a majority of stations within cluster 'b' with minimal intra-cluster variation, suggesting a similar macrofaunal community driven by poorly sorted materials from silts and clays (phi 5 to 10) and coarse contents (phi 0 to -3). Cluster 'd' plotted with the majority of stations in cluster 'a', influenced by the presence of both medium to fine sands (phi 1 and 2), suggesting similar sediment components in differing proportions which drives the different macrofaunal communities. Finally, cluster 'e' plotted towards the centre of the plot however specifically shows greater proportions of coarse to medium sands (phi 1) than any other phi grades. It is important to note that whilst macrofauna data from the five 'TR_G' stations was included in this analysis, there were no corresponding chemistry data, and therefore this could have affected the clustering of stations and the RELATE tests.

Further RELATE tests were carried out between the macrofaunal dataset and organics (TOC), hydrocarbons, and heavy metals to investigate any potential relationship between the benthic macrofauna and physico-chemical characteristics. These also found significant relationships between the macrofauna community data and organics ($\varrho=0.313$ $p=0.001$), the selected hydrocarbon concentrations ($\varrho=0.154$ $p=0.034$) and with metals data ($\varrho=0.172$ $p=0.019$). However, a higher sample statistic for PSD coupled with the fact all other physico-chemical results showed only small variation along the survey route, suggests that the sediment composition along the route is the main driver of macrofauna community variation rather than any point source contamination.

To summarise, sediment composition is the main driver of macrofaunal community variation, with clusters linked to specific sediment types. Organics, hydrocarbons, and metals also showed significant correlations with macrofauna, although their influence was weaker. Given the minimal variation in these factors along the survey route, sediment composition, rather than contamination, is the key influence on macrofaunal distribution.

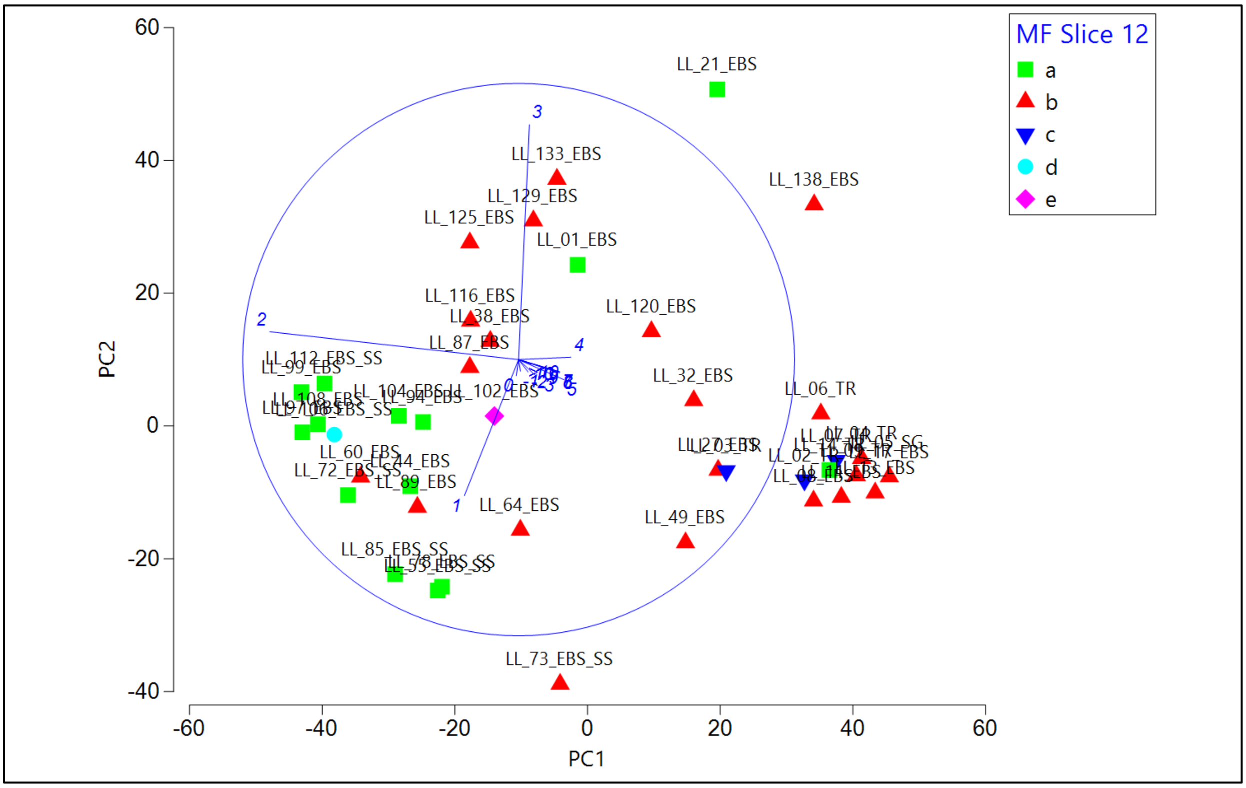



**Figure 3-33 Macrofaunal Clusters Plotted Over PSA PCA Plot**

#### 3.6.2.4 Inter-Cluster Variation in Community Composition

To investigate the differing macrofaunal communities described by the identified multivariate clusters, the ranges of primary and derived univariate diversity indices for stations grouped within each cluster were calculated and are summarised in Table 3-12.

**Table 3-12 Overview of the Univariate Parameters per SIMPROF Clusters**

| SIMPROF Cluster | Number of Species (S) | | Number of Individuals (N) | | Richness (Margalef) | | Evenness (Pielou's) | | Shannon Wiener Diversity | | Simpson's Diversity (1-Lambda') | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max |
| a | 3 | 10 | 3 | 22 | 0.97 | 3.06 | 0.690 | 1.000 | 1.37 | 2.86 | 0.571 | 1.000 |
| b | 6 | 45 | 10 | 1395 | 1.80 | 6.47 | 0.230 | 0.976 | 0.98 | 3.41 | 0.236 | 0.920 |
| c | 4 | 9 | 10 | 36 | 0.84 | 2.82 | 0.575 | 0.881 | 1.15 | 2.56 | 0.422 | 0.800 |
| d* | - | 5 | - | 6 | - | 2.23 | - | 0.970 | - | 2.25 | - | 0.933 |
| e* | - | 4 | - | 4 | - | 2.16 | - | 1.000 | - | 2.00 | - | 1.000 |

*Cluster has less than two samples in group*

Differences in the relative phyletic composition of macrofaunal communities were explored by plotting the average percentage contribution of major phyla to the overall number of individuals and number of species within each cluster (Figure 3-34 and Figure 3-35).

The results indicated that cluster 'a' was predominantly characterised by Annelida, which made up 50.0% of the total individuals. This was largely driven by *Nephtys cirrosa*, which alone accounted for 58.3% of all individuals within the cluster. Cluster 'b' was similarly dominated by Annelida, comprising 44.8% of the total individuals, primarily driven by *Lagis koreni*, which accounted for 23.1%. Mollusca were also well-represented, making up 43.4% of the cluster, largely due to the presence of the white furrow shell (*Abra alba*). Cluster 'c' presented with an individual dominance of Annelida (82.5%) which is attributed to a bristle worm, *Glycera tridactyla* (41.6% of all individuals within the cluster). Cluster 'd' had phylum contributions from five species of Annelida (83.3% of individuals in the cluster) and one species of 'Other' (16.7% of all individuals in the cluster). While Cluster 'e' had an equal abundance of Crustacea and Annelida (50%), this included two individuals of different taxa from each phyla.

There was a variable presence of molluscs across the site, ranging from 0.0% in clusters 'c', 'd' and 'e' to 8.6% and 43.4% in cluster 'a' and 'b' respectively. Echinoderms were also absent from clusters 'c', 'd' and 'e' and were relatively consistent across clusters 'a' (3.9%) and 'b' (6.0%). Other species (Nematoda, Nemertea, Platyhelminthes, Phoronida etc) showed varied contributions between 0.0% at cluster 'e' to 16.7% at cluster 'd'. Abundance of solitary epifauna was low across the clusters but were most prevalent in cluster 'c' (9.5%), associated with a higher abundances of sea anemones (Actiniaria), likely due to the increased gravelly substrate sampled across stations within this cluster.

In terms of contribution of phyla to the number of species, whilst the clusters were similar there were slight differences in dominating phyla. In contrast to the overall number of individuals, Annelida was the most dominant across clusters 'a' (44.2%), 'b' (52.0%), 'c' (58.3%) and 'd' (80.0%), where cluster 'e' showed a contribution of 50%, equal to Crustacea. Crustacea were absent at cluster 'd' and variable between other clusters, with the lowest noted in cluster 'c' (16.7%) and the highest at cluster 'e' (50%). Molluscs were also varied, again absent at clusters 'c', 'd' and 'e' with relatively consistent proportions across other clusters ranging from 14.4% at cluster 'b' to 16.3% at cluster 'a'. Echinoderms were only present in clusters 'a' and 'b', making up only a small portion of each cluster (7.0% and 5.6% respectively). Other fauna showed some variability across clusters, absent from cluster 'e' but ranging from 4.0% at cluster 'b' to 20% at cluster 'd'. Solitary epifauna showed a difference in dominant phyla, where the highest species contribution appeared at cluster 'c' (8.3%).

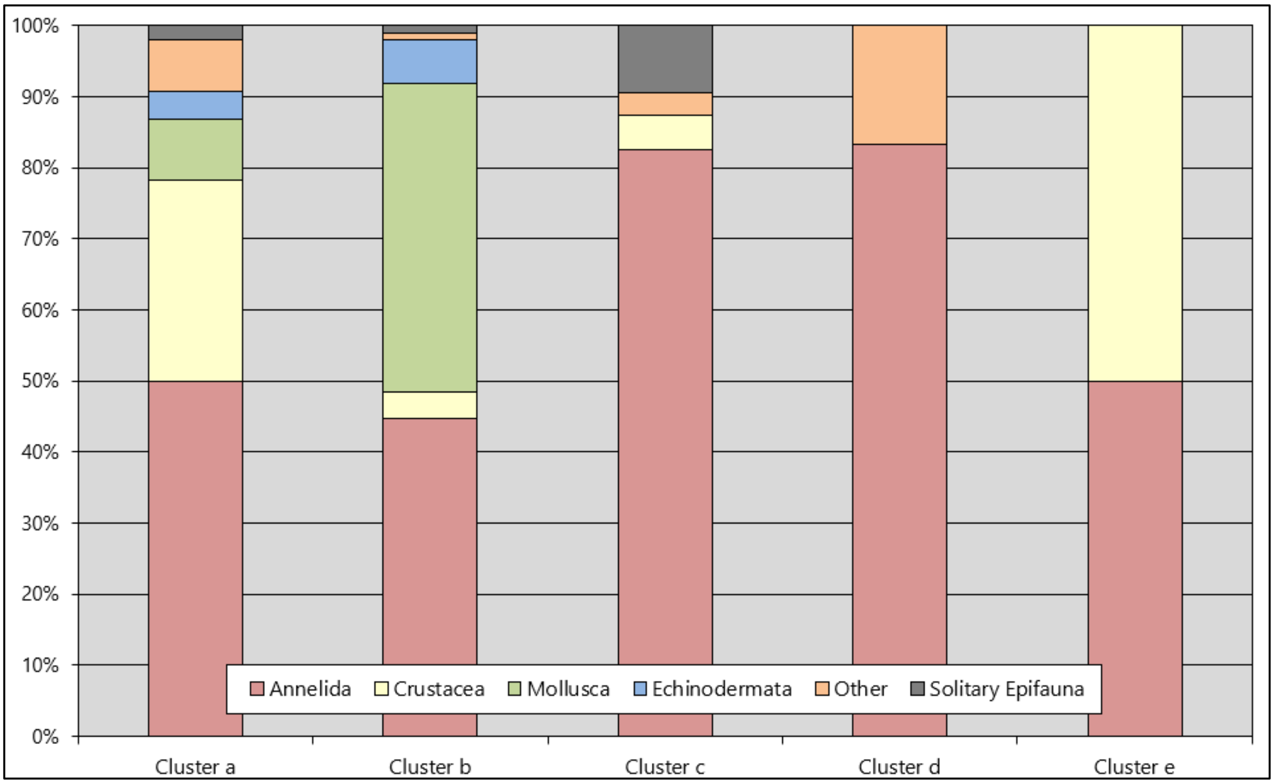



**Figure 3-34: Average Contribution of Each Phylum to Total Faunal Abundance for Each Cluster**

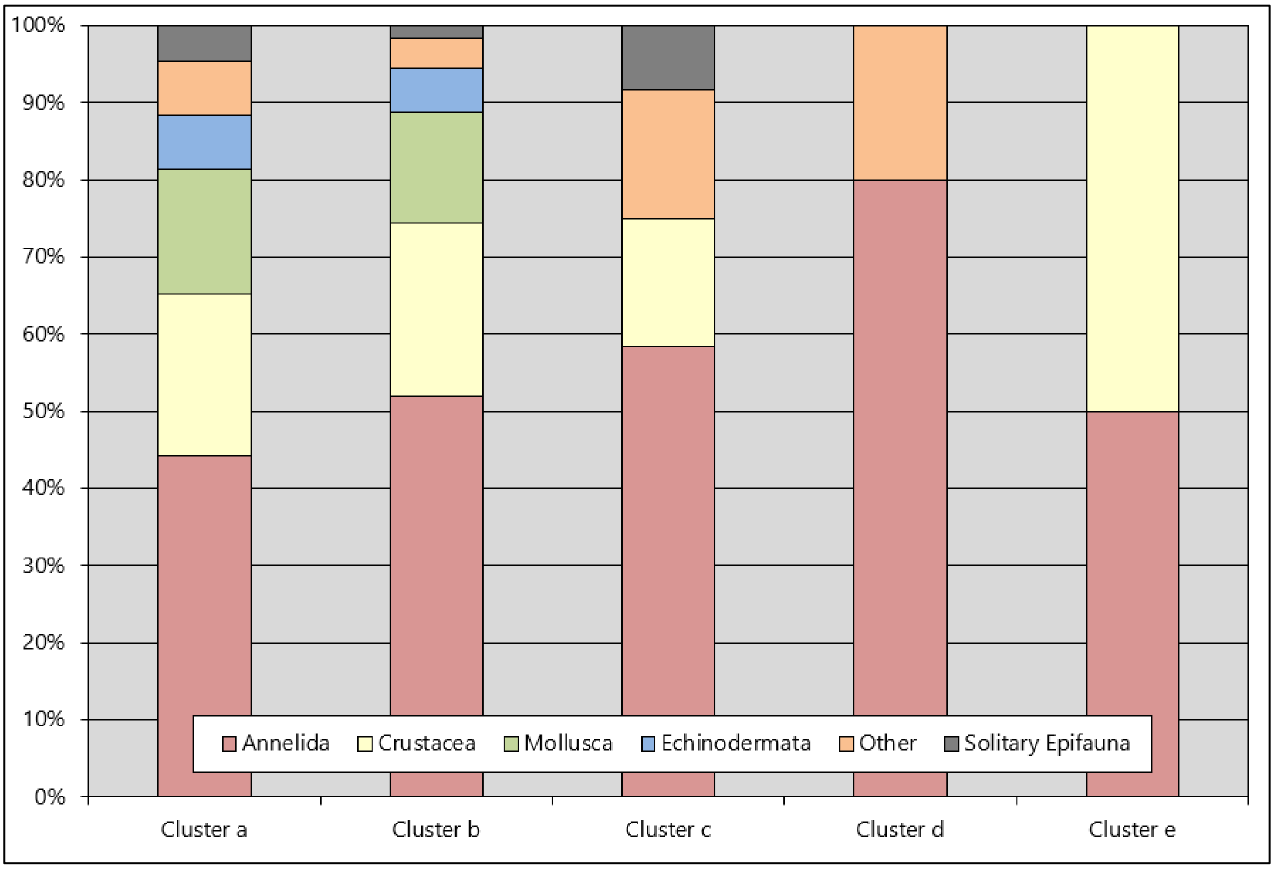



**Figure 3-35: Average Contribution of Each Phylum to Total Number of Species for Each Cluster**

Table 3-12 provides further information on the ecological parameters driving separation of macrofaunal clusters across the survey area. The contribution of different ecological groups (EG) was calculated using AMBI developed by Borja *et al.,* 2000. In the AMBI index, species are classified into five EGs based on their tolerance to organic pollution. Group I species are highly sensitive and thrive in clean, well-oxygenated environments, while Group II species tolerate slight pollution but prefer relatively unimpacted habitats. Group III species can adapt to a range of conditions, including moderate organic enrichment, whereas Group IV and Group V species are increasingly tolerant of pollution, with Group V thriving in heavily degraded, hypoxic environments. The relative abundance of these groups provides insight into the ecological health of an area, with a dominance of Groups I and II indicating good environmental quality and higher proportions of Groups IV and V suggesting pollution impacts. This information is displayed for each of the identified clusters in Figure 3-36.

This revealed that clusters 'b' and 'c' were dominated by disturbance tolerant species (EG III), largely attributed to the bristleworm (*Scalibregma inflatum*). EG III species were also joint dominant with the EG I species *Ophelia borealis* in cluster 'd' (33.3%) with other EG I species present in all remaining clusters. Disturbance indifferent taxa (EG II) were present in every cluster and were found most dominant in cluster 'a' (47.7%) attributed to the presence of *Nephtys cirrosa*. Disturbance sensitive species (EG I) were present in every cluster with the highest proportion in cluster 'e' (50%), however this only accounts for the presence of 2 individuals. The contribution of second order opportunistic species (EG IV) was variable across the survey area (2.1% in cluster 'a' to 16.9% in cluster 'b') and present in clusters 'a' to 'd', first (EG V) order opportunistic species showed the lowest contributions across clusters (<1%) and were only present in cluster 'b'.

Furthermore, the AMBI Biotic Coefficient Index (BCI) was developed to determine the impacts and the quality status in soft-bottom marine benthic communities but is now broadly used along European coastlines to aid in determining the level of pollution within an environment (WFD-UKTAG, 2014). The system operates between 0 and 7, with lower numbers corresponding to higher or good ecological status (WFD-UKTAG, 2014). All clusters scored <3.5 indicative of "Moderate", "Good" and "High" ecological status. A "Moderate" ecological status indicates some taxa indicative of pollution are present, a "High" ecological status indicates all the disturbance-sensitive taxa associated with undisturbed conditions are present whilst "Good" ecological status indicates that most of the sensitive taxa of the type-specific communities are present (WFD-UKTAG, 2014).

**Table 3-13: Overview of AMBI Ecological Groups Per SIMPOF Cluster**

| SIMPROF Cluster | EG I (%) | | EG II (%) | | EG III (%) | | EG IV (%) | | EG V (%) | | AMBI BCI | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max |
| **a** | 0.0 | 77.8 | 22.2 | 80.0 | 0.0 | 37.5 | 0.0 | 22.2 | 0.0 | 0.0 | 0.3 | 2.0 |
| **b** | 0.0 | 60.2 | 0.0 | 40.0 | 18.2 | 91.9 | 0.0 | 51.2 | 0.0 | 10.0 | 1.0 | 3.5 |
| **c** | - | 0.0 | - | 3.2 | - | 87.1 | - | 9.7 | - | 0.0 | - | 3.1 |
| **d** | - | 33.3 | - | 16.7 | - | 33.3 | - | 16.7 | - | 0.0 | - | 2.0 |
| **e** | - | 50.0 | - | 25.0 | - | 25.0 | - | 0.0 | - | 0.0 | - | 1.1 |

| AMBI Group | Feeding Method | | *AMBI BCI:* |
|---|---|---|---|
| Group I | Disturbance sensitive species | | *0.0 ≤ 1.2 = High status* |
| Group II | Disturbance indifferent species | | *1.2 ≤ 3.3 = Good status* |
| Group III | Disturbance tolerant species | | *3.3 ≤ 4.3 = Moderate status* |
| Group IV | Second order opportunistic species | | *4.3 ≤ 5.5 = Poor status* |
| Group V | First order opportunistic taxa | | *5.5 ≤ 7.0 = Bad status* |

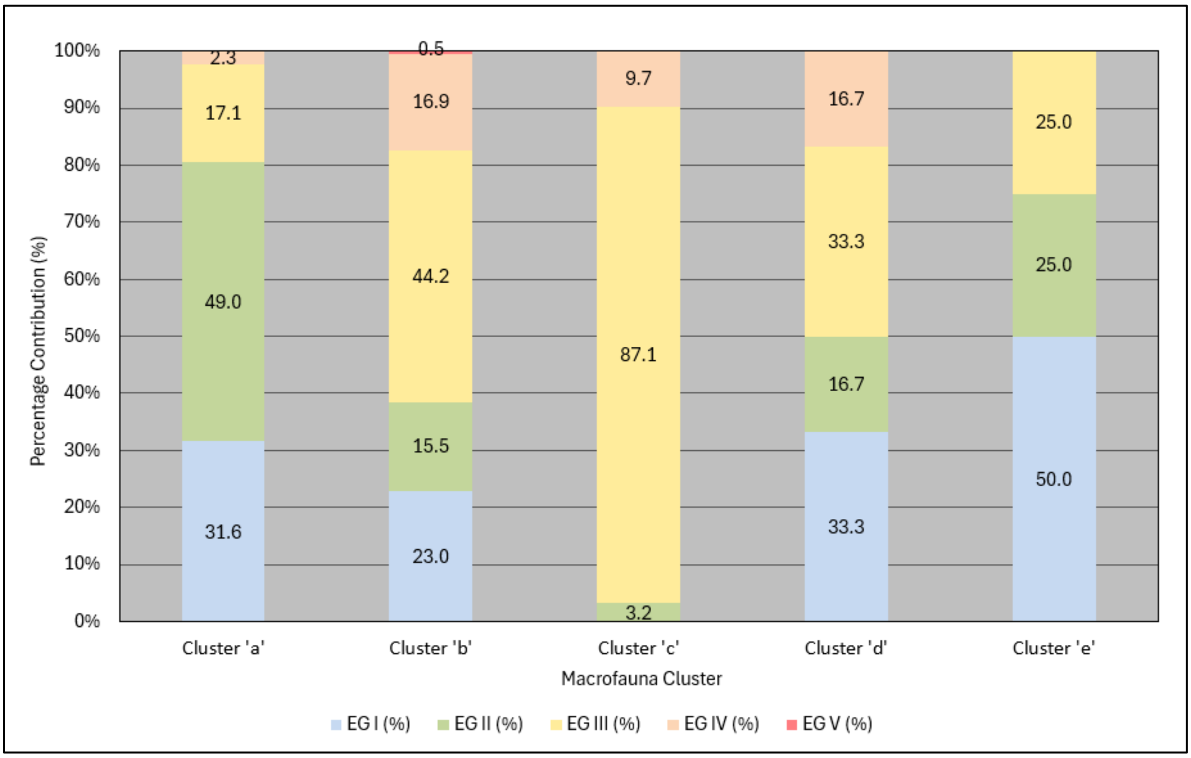



**Figure 3-36: AMBI Ecological Groups I-V Percentage Contribution per SIMPROF Clusters**

To determine the species driving the differences between the five clusters identified, Table 3-14 presents the characterising taxa in each cluster together with their percentage contribution to the overall similarity within the cluster. Table 3-15 shows the top five species responsible for differences between clusters.

All clusters but cluster 'e' shared at least one top characterising species with another cluster group, however two clusters 'c' and 'd' had only one shared taxa (Nemertea and *Lagis koreni*, respectively). The remaining three species; *Nephtys cirrosa*, *Spiophanes bombyx* and *Diastylis bradyi* were shared between clusters 'a' and 'b', likely linked to the general fines/sand dominance across both clusters.

Cluster 'c' had a top contributor of common bloodworms (*Glycera tridactyla*) likely due to the fines and silts contributions, whilst the polychaete *Paucibranchia* sp. and *A. paucibranchiata* typically found in coarse sediments, appeared as a top contributor for cluster 'e' with a combined contribution of 50%. This cluster showed gravelly sediments likely explaining the presence of this species within this cluster.

*Nephtys cirrosa* showed the highest contribution of all species across the clusters with a contribution of 58.3% in cluster 'a' (Figure 3-37), due to the generally higher proportions of sand within this cluster. This species appeared within cluster 'b' but with a much lower contribution. A similar pattern was observed for two other species shared between clusters 'a' and 'b', this distinction likely contributed to the separation of clusters 'a' and 'b,' despite their similar species richness. Cluster 'd' and 'e' had the most unique species in their top ten characterising species, having four taxa not found in the other cluster's list.

A review of the taxa most responsible for differentiating the five clusters (Table 3-15) revealed the tube-building polychaete (*L. koreni*), bristleworm (*N. cirrosa*) and (*O. borealis*), glycerine worm (*G. tridactyla*), and white furrow shell (*A. alba*) to be the main taxa for causing dissimilarity, associated with their fine/muddy sand (*L. koreni, G. tridactyla* and *A. alba*), sand (*N. cirrosa*) and gravelly sands (*O. borealis*) preferences (Figure 3-37).

The top differentiating species between clusters (*Lagis koreni, Nephtys cirrosa, Ophelia borealis*, *Glycera tridactyla,* and *Abra alba*) were present across multiple stations in cluster 'a', suggesting a diverse macrofaunal community driven by species abundance. Cluster 'b' also contained four of these species, though in varying proportions, further indicating that differences in abundance contribute to cluster separation. *L. koreni* was most abundant in cluster 'b' (1,080 individuals), while *N. cirrosa* and *O. borealis* were more frequent in cluster 'a'. The white furrow shell (*A. alba*) and the Montagu shell (*Kurtiella bidentata*) were notably higher in cluster 'b', reinforcing that species richness was similar between clusters, but abundance differences drove their distinction. Dissimilarity values ranged from 89.69% to 100%, with some clusters showing completely distinct macrofaunal communities.

Remaining clusters dissimilarities is driven by varied abundances of key species attributed to sediment proportions. Examples of key species causing dissimilarity between the cluster groups is graphically represented in Figure 3-32.

**Table 3-14 Top Species Abundance For SIMPROF Clusters**

| Top 10 Species | Cluster a | | | Cluster b | | | Cluster c | | | Cluster d | | | Cluster e | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Average similarity: 23.09% | | | Average similarity: 22.32% | | | Average similarity: 33.87% | | | Less than 2 samples in group | | | Less than 2 samples in group | | |
| | Species | Av. Abundance | Contribution (%) | Species | Av. Abundance | Contribution (%) | Species | Av. Abundance | Contribution (%) | Species | Av. Abundance | Contribution (%) | Species | Av. Abundance | Contribution (%) |
| 1 | *Nephtys cirrosa* | 1.1 | 58.3 | *Lagis koreni* | 1.7 | 23.1 | *Glycera tridactyla* | 1.1 | 41.6 | *Ophelia borealis* | 2.0 | 33.3 | *Paucibranchia* | 1.0 | 25.0 |
| 2 | *Spiophanes bombyx* | 0.6 | 17.8 | *Abra alba* | 1.4 | 15.7 | *Notomastus* | 1.1 | 18.4 | Nemertea | 1.0 | 16.7 | *Aonides paucibranchiata* | 1.0 | 25.0 |
| 3 | *Urothoe brevicornis* | 0.5 | 8.4 | *Scalibregma inflatum* | 1.0 | 7.7 | Actiniaria | 0.9 | 15.0 | *Lumbrineris cingulata* | 1.0 | 16.7 | *Unciola crenatipalma* | 1.0 | 25.0 |
| 4 | *Gastrosaccus spinifer* | 0.3 | 5.7 | *Spiophanes bombyx* | 0.8 | 6.5 | *Nototropis guttatus* | 0.7 | 12.6 | *Spio goniocephala* | 1.0 | 16.7 | *Pisidia longicornis* | 1.0 | 25.0 |
| 5 | Nemertea | 0.2 | 2.7 | *Diastylis bradyi* | 0.5 | 6.1 | *Lagis koreni* | 0.8 | 12.3 | *Chaetozone christiei* | 1.0 | 16.7 | | | |
| 6 | *Glycera oxycephala* | 0.2 | 2.6 | *Nucula nitidosa* | 0.6 | 4.4 | | | | | | | | | |
| 7 | *Nephtys longosetosa* | 0.1 | 0.8 | *Kurtiella bidentata* | 0.9 | 3.9 | | | | | | | | | |
| 8 | *Echinocyamus pusillus* | 0.1 | 0.7 | *Nephtys hombergii* | 0.3 | 2.5 | | | | | | | | | |
| 9 | *Bathyporeia elegans* | 0.1 | 0.7 | *Nephtys cirrosa* | 0.4 | 2.5 | | | | | | | | | |
| 10 | *Diastylis bradyi* | 0.1 | 0.7 | *Ophiura ophiura* | 0.3 | 2.5 | | | | | | | | | |

Legend:
Red = Shared Across 2 Clusters / Grey = No species

**Table 3-15 Dissimilarity Percentages For SIMPROF Clusters**

| | **Cluster b** | | **Cluster c** | | **Cluster d** | | **Cluster e** | |
|---|---|---|---|---|---|---|---|---|
| **Cluster a** | **Average dissimilarity = 89.81%** | | **Average dissimilarity = 95.67%** | | **Average dissimilarity = 90.80%** | | **Average dissimilarity = 98.05%** | |
| | *Lagis koreni* | 5.84 | *Glycera tridactyla* | 8.28 | *Ophelia borealis* | 9.83 | *Nephtys cirrosa* | 10.74 |
| | *Abra alba* | 5.13 | *Nephtys cirrosa* | 8.24 | *Nephtys cirrosa* | 9.57 | *Paucibranchia* | 10.22 |
| | *Nephtys cirrosa* | 3.81 | *Notomastus* | 7.7 | *Lumbrineris cingulata* | 8.63 | *Unciola crenatipalma* | 10.22 |
| | *Scalibregma inflatum* | 3.47 | *Scalibregma inflatum* | 6.47 | *Spio goniocephala* | 8.55 | *Pisidia longicornis* | 10.22 |
| | *Spiophanes bombyx* | 3.01 | Actiniaria | 6.42 | *Chaetozone christiei* | 8.55 | *Aonides paucibranchiata* | 9.24 |
| | | **Cluster b** | **Average dissimilarity = 89.69%** | | **Average dissimilarity = 94.45%** | | **Average dissimilarity = 97.26%** | |
| | | | *Abra alba* | 5.01 | *Lagis koreni* | 6.33 | *Lagis koreni* | 6.71 |
| | | | *Glycera tridactyla* | 4.66 | *Abra alba* | 5.45 | *Abra alba* | 5.78 |
| | | | *Scalibregma inflatum* | 4.49 | *Ophelia borealis* | 4.94 | *Unciola crenatipalma* | 4.91 |
| | | | *Notomastus* | 4.03 | *Spio goniocephala* | 4.6 | *Pisidia longicornis* | 4.78 |
| | | | *Lagis koreni* | 3.87 | *Chaetozone christiei* | 4.33 | *Paucibranchia* | 4.64 |
| | | | | **Cluster c** | **Average dissimilarity = 95.57%** | | **Average dissimilarity = 100.00%** | |
| | | | | | *Ophelia borealis* | 9.78 | *Glycera tridactyla* | 10.21 |
| | | | | | *Glycera tridactyla* | 9.19 | *Paucibranchia* | 9.13 |
| | | | | | *Lumbrineris cingulata* | 8.22 | *Aonides paucibranchiata* | 9.13 |
| | | | | | *Spio goniocephala* | 8.22 | *Unciola crenatipalma* | 9.13 |
| | | | | | *Chaetozone christiei* | 8.22 | *Pisidia longicornis* | 9.13 |
| | | | | | | **Cluster d** | **Average dissimilarity = 100.00%** | |
| | | | | | | | *Ophelia borealis* | 12.94 |
| | | | | | | | Nemertea | 10.88 |
| | | | | | | | *Paucibranchia* | 10.88 |
| | | | | | | | *Lumbrineris cingulata* | 10.88 |
| | | | | | | | *Aonides paucibranchiata* | 10.88 |

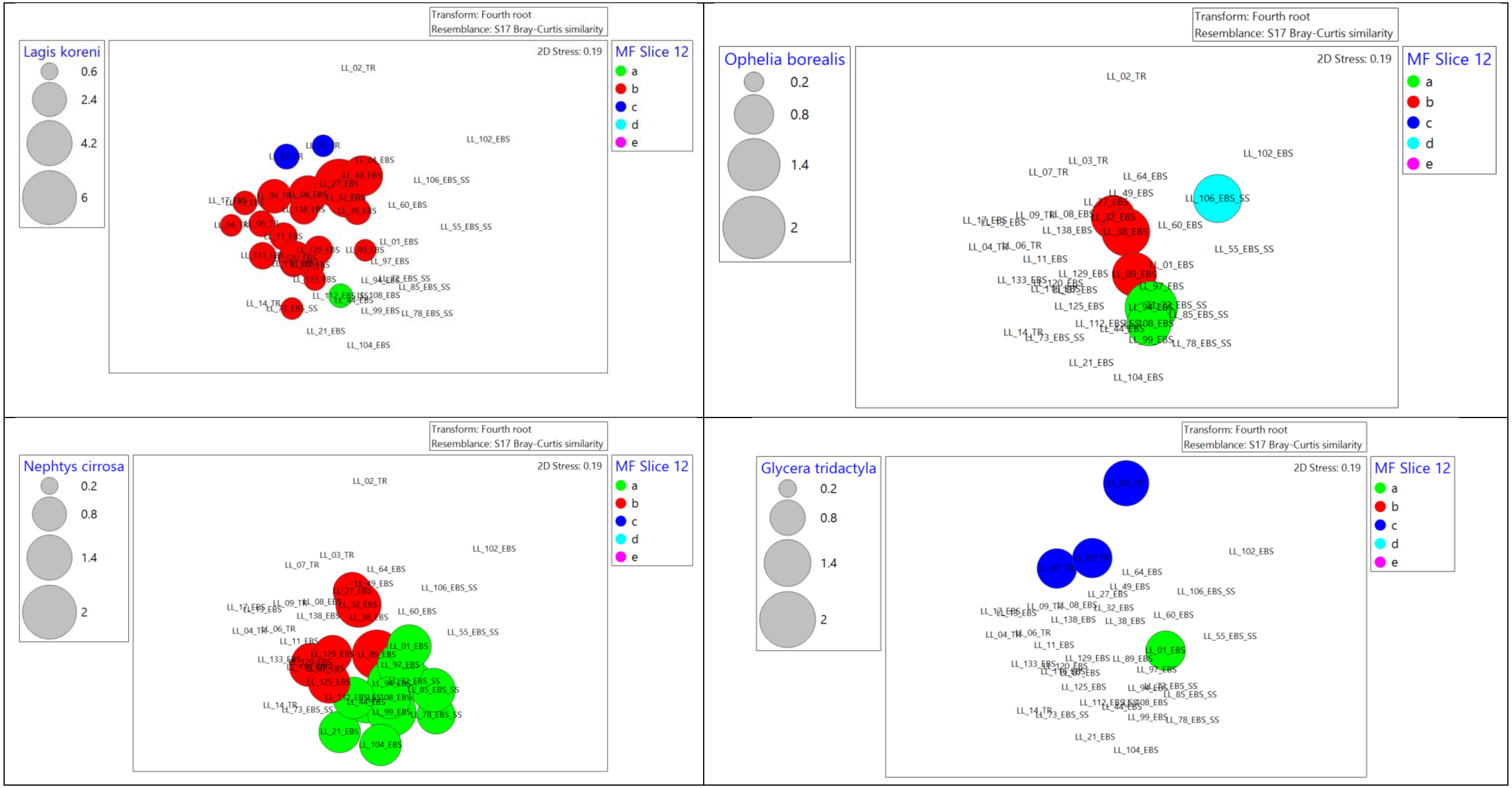



**Figure 3-37 Bubble Plot for Key Species**

### 3.6.3 Epifaunal and Other Biological Groups

Along the Lion Link survey route at 14 stations the presence of colonial epifauna was recorded, these were not statistically assessed within the infauna data analysis, as they were tabulated on a presence/absence basis. Due to the presence/absence scale to which epifaunal species were identified, for the purpose of this chart and to highlight the epifaunal richness; where epifaunal species were recorded as present this was given the numerical value of "1" to represent the colony. The distribution of epifaunal assemblages across the survey area between stations is represented in Figure 3-38. The analysis indicated that infauna was dominant across the survey area, with colonial making up a small part of the community. Infaunal and epifaunal species are listed separately Appendix I – Macrofaunal Species Lists.

There were several epifaunal taxa present belonging to the phyla Cnidaria and Bryozoa. Cluster '*b*' showed the highest richness of colonial epifaunal with 10 species, likely due to the higher gravel content across stations within the cluster. Colonial epifaunal taxa were also present at clusters '*a*' and '*c*' , with 7 and 1 species, respectively. Solitary epifauna remained low with clusters 'a' and 'b' with 2 species and cluster 'c' with 1. With the route mostly consisting of sand or mud dominated sediments, the higher numbers of infauna with limited epifauna species presence would be expected as epifauna lack the hard substrate to attach to. Grab sampling often fails to recover coarse material, especially larger pebbles, cobbles, and boulders colonised by epifauna; therefore, it is important to not only assess epifauna through physical samples, but also to analyse video footage.

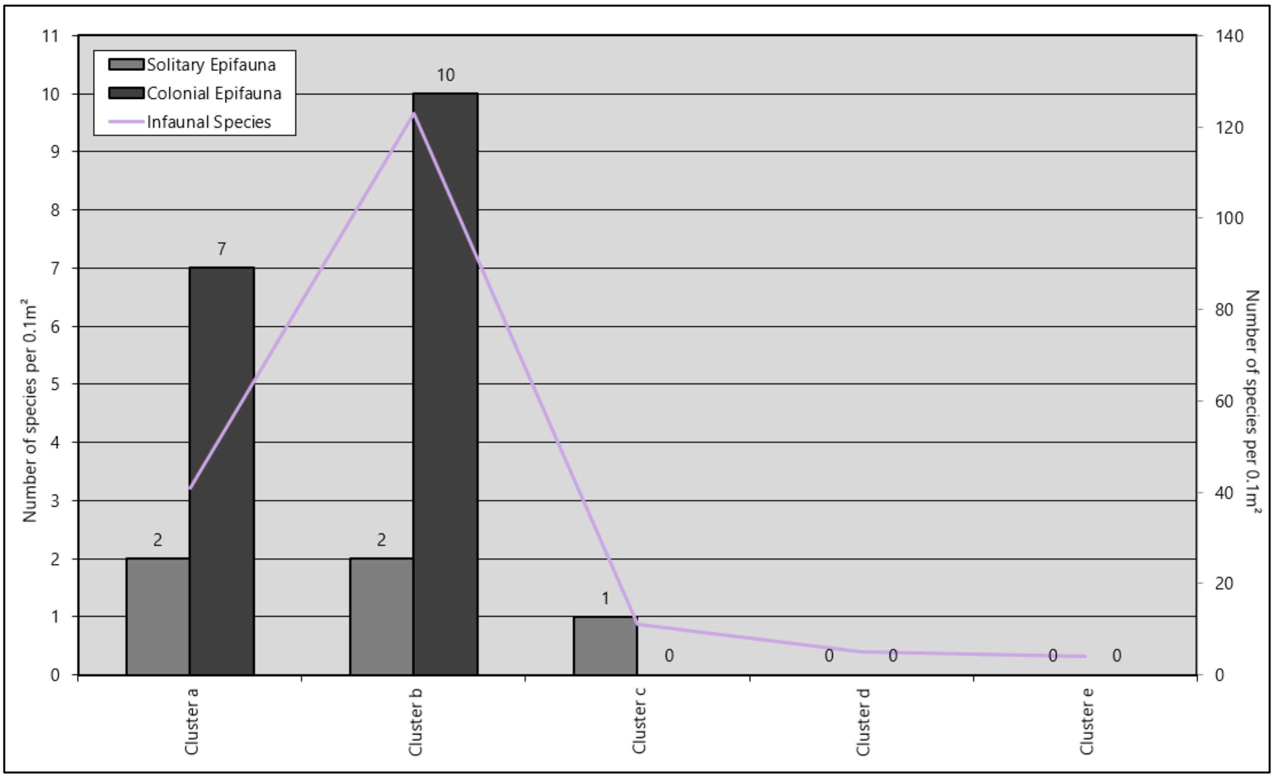



**Figure 3-38: Epifaunal versus Infaunal Clusters**

## 3.7 Environmental Habitat Assessment

Sides scan sonar imagery, multibeam bathymetry, delineated geophysical seabed features by NEXT, as well as video and still photographic ground truthing from 99 transects across the Lion Link cable route was utilised in the assignment of benthic habitats. It is important to note that habitat classifications may differ slightly from the seabed features identified from the geophysical aspect of the survey, as they are required for different purposes and use different sediment classification nomenclature.

Based on the datasets obtained, the furthermost offshore area in the north (e.g. LL_TR_138 to LL_TR_101; 38m below LAT) was characterised predominantly by the EUNIS/JNCC level four habitat classification of either 'Circalittoral muddy sand' (SS.SSa.CMuSa/ MC621) or 'Offshore circalittoral sand' (SS.SSa.OSa/ MD521). The centre portion of the cable route (e.g. LL_100_TR to LL_58_TR) was variable with rippled sand waves alternating patches of 'Offshore circalittoral sand' (SS.SSa.OSa/ MD521), 'Offshore circalittoral mixed sediment' (SS.SMx.OMx/ MD421) and 'Offshore circalittoral coarse sediment' (SS.SCS.OCS/ MD321), which collected in the troughs of the sand waves.

The southern portion of the cable route (e.g. LL_52_TR to LL_11_TR) which is located closer to shore, was similar to that of the central area of the route but showed a higher frequency of 'Circalittoral muddy sand' (SS.SSa.CMuSa / MC621). The majority of the cable route had large areas of rippled and mottled seabed, with several associated biotopes meaning areas of transition may include overlapped or impoverished versions of said biotopes, particularly towards the southern high-energy nearshore area where the seabed becomes more variable and water depth shallower.

A total of five Level 4, and three Level 5 JNCC/EUNIS habitats were recorded along the route., which are tabulated in Table 3-16 and their extents illustrated in Figure 3-43 to Figure 3-46. It is to be noted that stations with minimal macrofaunal identification have not been assigned a further Level 5 biotope due to lack of characterising species needed to classify the biotope, similarly stations without faunal sampling have not been assigned to a Level 5 biotope.

**Table 3-16 Summarised Marine Habitats**

| BGS Modified Folk Classification of Particle Size Analysis | Level 4 JNCC Classification | Level 4 EUNIS Classification | Associated Level 5 JNCC Classification | Associated Level 5 EUNIS Classification |
|---|---|---|---|---|
| Muddy Sand, Sandy Mud, Slightly Gravelly Muddy Sand, Slightly Gravelly Sandy Mud, Gravelly Mud, Muddy Gravel. | SS.SSa.CMuSa Circalittoral muddy sand | MC621 Faunal communities of Atlantic circalittoral mud | SS.SSa.CMuSa.AalbNuc *Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment<br><br>SS.SMu.CSaMu.LkorPpel *Lagis koreni* and *Phaxas pellucidus* in circalittoral sandy mud | MC5214 *Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment<br><br>MC6215 *Lagis koreni* and *Phaxas pellucidus* in circalittoral sandy mud |
| Sand, Slightly Gravelly Sand, Gravely Muddy sand, | SS.SSa.Osa Offshore circalittoral sand | MD521 Faunal communities in Atlantic offshore circalittoral sand | SS.SSa.CMuSa.AalbNuc *Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment<br><br>SS.SMu.CSaMu.LkorPpel *Lagis koreni* and *Phaxas pellucidus* in circalittoral sandy mud | MC5214 Abra alba and Nucula nitidosa in circalittoral muddy sand or slightly mixed sediment<br><br>MC6215 *Lagis koreni* and *Phaxas pellucidu*s in circalittoral sandy mud |
| Gravelly Mud, Gravelly Muddy sand, Muddy Gravel. Sandy Mud, Gravel | SS.SMx.OMx Offshore circalittoral mixed sediment | MD421 Faunal communities in Atlantic offshore circalittoral mixed sediment | SS.SMx.OMx.PoVen Polychaete-rich deep *Venus* community in offshore mixed sediments | MD4211 Polychaete-rich deep *Venus* community in offshore mixed sediments |
| Muddy Sandy Gravel, Gravelly Muddy Sand, Gravelly Sand, Sandy Gravel, Muddy Gravel | SS.SCS.OCS Offshore circalittoral coarse sediment | MD321 Faunal communities in Atlantic offshore circalittoral coarse sediment | - | - |

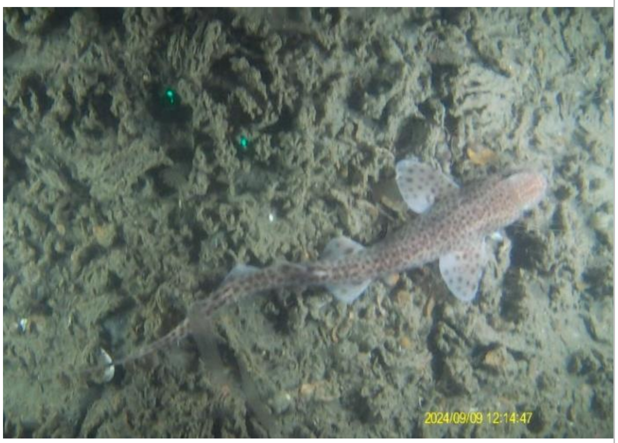
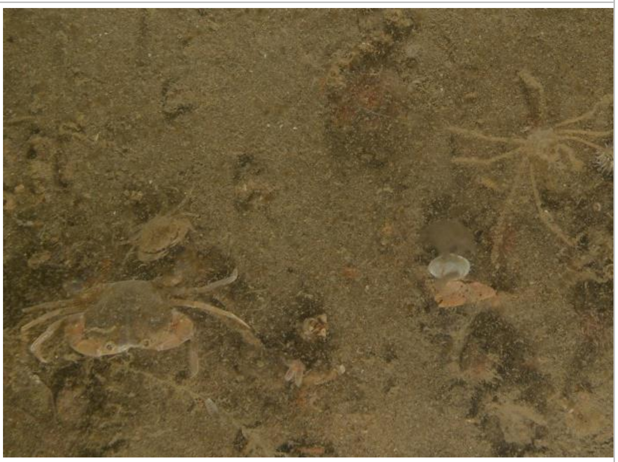
Conspicuous fauna within the survey area revealed a high level of diversity, abundance, and density with a wide range of species observed throughout the cable route, particularly concentrated in areas of ross worm (*Sabellaria spinulosa*) aggregations. Echinoderms were the second most commonly observed, with increased occurrences of brittlestars (Ophiuroidea) and common starfish (*Asterias rubens*). Crustaceans observed throughout the route included shrimp (Caridea and *Callianassa* sp.) and a range of crabs.

Bivalve molluscs observed along the route included the common whelk (*Buccinum undatum*), blue mussel (*Mytilus edulis*) and moon snail (*Eurspira nitida*); with cephalopod molluscs including the common squid (*Loligo vulgaris*). Additionally, there was a wide variety of ray finned fish observed along the cable route with the small-spotted catshark (*Scyliorhinus canicula*), lesser sandeel (*Ammodytes tobianus*) and various flatfish (Plueronectiformes) among the most commonly observed. Species from several other phyla were present including Ascidians, Bryozoans and Porifera, alongside the ross worm (*S. spinulosa*), sand mason worm (*Lanice conchilega*) and (*Sabella pavonia*) .

Example images of conspicuous fauna are presented in Table 3-17, while example seabed images for each transect are provided in Appendix O – Sample and Seabed Photographs.

**Table 3-17 Examples of Epifaunal and Mobile Fauna Recorded within the Survey Area**

| **Examples of Conspicuous Fauna** | |
|---|---|
| <br>Brittlestar<br>(Ophiuridae) | <br>Green Urchin<br>(*Psammechinus miliaris*) |
| <br>Ross worm and common starfish<br>(*Sabellaria spinulosa* and *Asterias rubens*) | <br>Dahlia anemone<br>*(Urticina felina)* |
| <br>Common squid<br>*(Loligo vulgaris)* | <br>Blue mussel<br>(*Mytulis edulis*) |

| **Examples of Conspicuous Fauna** | |
|---|---|
| <br>Common whelk<br>(Buccinidae) | <br>Dover sole<br>(*Solea solea*) |
| <br>Pogge<br>(*Agonus cataphractus*) | <br><br>Small spotted catshark<br>(*Scyliorhinus canicula*) |
| <br>Prideaux's Hermit Crab with Cloak Anemone<br>(*Pagurus prideax* & *Adamsia palliata*) | <br>Swimming Crab and Spider crab<br>(*Polybius depurator* & *Inachus* sp.) |

#### 3.7.1.1 Circalittoral Muddy Sand (SS.SSa.CMuSa / MD521)

This biotope is described by JNCC/ EUNIS as "*Circalittoral non-cohesive muddy sands with the silt content of the substratum typically ranging from 5% to 20%. This habitat is generally found in water depths of over 15-20m*". This biotope was observed to contain burrows as well as a more noticeable fines content at the seabed surface. This habitat was associated with locations at the northern end of the cable route in an area of flat seabed delineated as 'Muddy Sand'. This biotope also occurs at several other locations interspersed with coarse and mixed sediments along the southern portion of the cable route towards the nearshore area, which was classified as either 'sand', 'mixed sediment' or 'coarse sediment' due to its proximity to the shoreline (<5km). This habitat occurred in water depths ranging from 29m to 38m below LAT.

This habitat supported a variety of fauna including echinoderms such as brittlestars (Ophiuroidea) and common starfish (*Asterias rubens*). A number of fish species were present such as the European flounder (*Pleuronectes platessa*), ling (Lotidae sp)., thornback ray (*Raja clavata*) and small-spotted catshark (*Scyliorhinus canicula*). Hermit crabs (Paguridae) were common, with other Crustacea species present including Caridean shrimp and swimming crabs *Polybius depurator* and *Necora puber*. The gastropod dog whelk (*Nucella lapillus*), as well as annelids including the sand mason worm (*Lanice conchilega*), peacock worm (*Sabella pavonia*), tube worm (*Spirobranchus triqueter*) and ross worm (*Sabellaria spinulosa*) were also present within this habitat.

Due to presence of the ross worm (*Sabellaria spinulosa*) observed in the video footage at transects LL_20_TR, and LL_31_TR, these areas have the potential to conform to the level 5 biogenic habitat '*Sabellaria spinulosa* on stable circalittoral mixed sediment' (SS.SBR.PoR.SspiMx/ MC221), which is further discussed in Section 0. Patches of *Mytilus edulis* were also observed during the aforementioned transects which possibly conform to '*Mytilus* [i]*edulis* beds on sublittoral sediment' (SS.SBR.SMus.MytSS/ A5.625) and is discussed in Section 3.8.2.5.

Two level 5 EUNIS/JNCC habitats are associated with this biotope, and utilising macrofaunal data from grab samples '*Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment' (SS.SSa.CMuSa.AalbNuc/ MC5214) showed the strongest conformance to the regions further offshore (LL_138_TR), which consisted of BGS Modified Folk Classification 'Muddy Sand'. This is due to a number of key species associated with this habitat observed across transects, in addition to *A. albra*, and sometimes *N. nitidosa,* occurring in larger numbers within grab samples. '*Lagis koreni* and *Phaxas pellucidus* in circalittoral sandy mud' (SS.SMu.CSaMu.LkorPpel/ MC6215) showed the greatest conformance to the regions closer to shore (LL_32_TR) which consisted of BGS Modified Folk Classification 'Gravelly Muddy Sand'.

Example images are provided in Figure 3-39, and the spatial extent of the Level 4 JNCC sediment habitat SS.SSa.CMuSa / MD521 is mapped in Figure 3-43 to Figure 3-46. The occurrence along video transects of the Level 5 JNCC biogenic habitats SS.SSa.CMuSa.AalbNuc/ MC5214 and 'SS.SMu.CSaMu.LkorPpel/ MC6215 are also illustrated in Figure 3-43 to Figure 3-46.

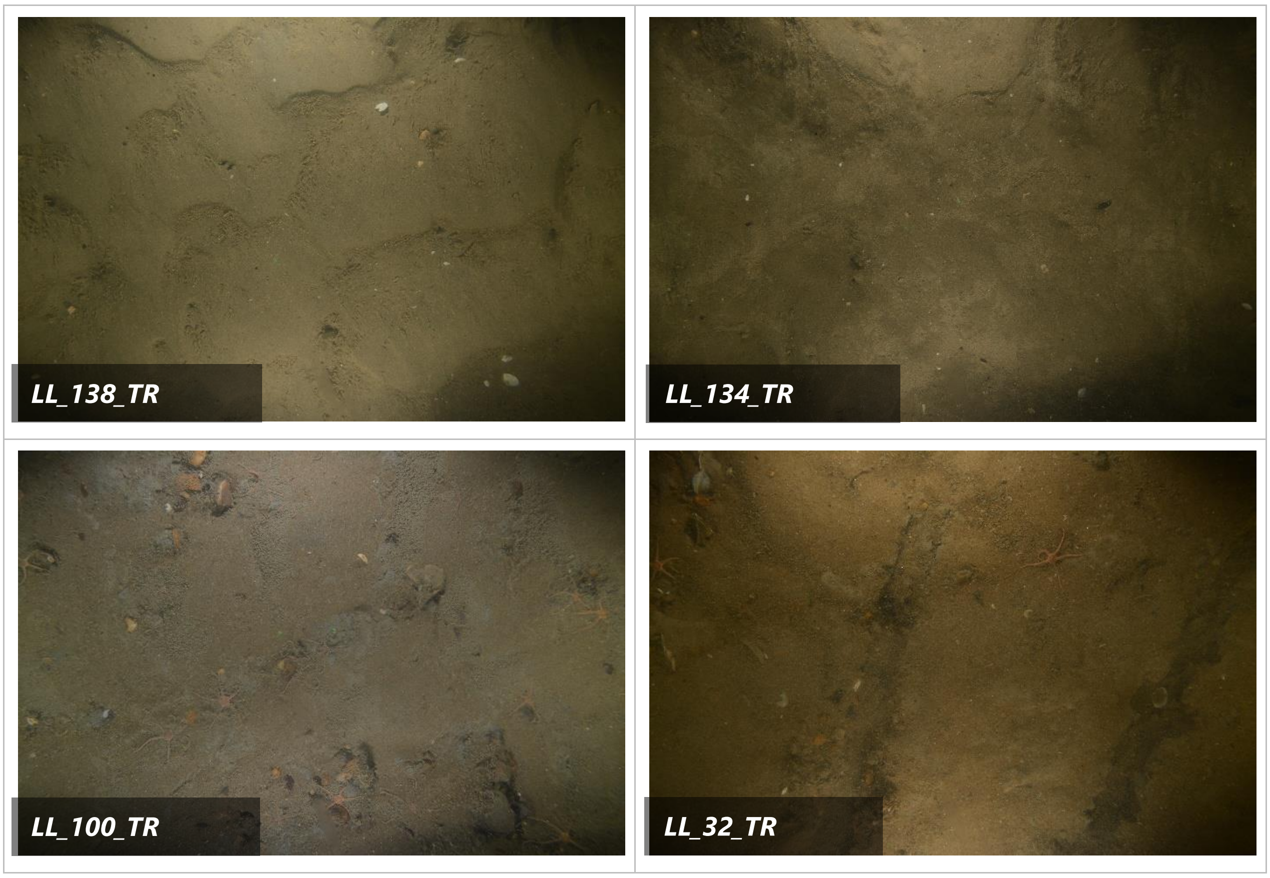



**Figure 3-39 Example images of 'Circalittoral Muddy Sand' Habitats**

#### 3.7.1.2 Offshore Circalittoral Sand (SS.SSa.OSa / MD521)

This biotope is described by JNCC/ EUNIS as "*Clean fine sands with less than 5% silt/clay in deeper water, either on the open coast or in tide-swept channels of marine inlets in depths of over 15-20 m*". This biotope was associated with the seabed feature 'Silt' and 'Megaripples'. This habitat occurred in water depths between 15m to 49m below LAT.

A consistent variety of fauna were observed on the HD video, including echinoderms such as the common starfish (*A. rubens*) and brittlestars (Ophiuroidea). Various flatfish species (Pleuronectiformes) were present, in addition to other fish species including the Raitt's sandeel (*Ammodytes marinus*), sand goby (*Pomatoschistus minutus*) and small-spotted catshark (*S. canicula*). Molluscs such as common whelks (*Buccinum undatum*) were present alongside Crustaceans including hermit crabs (Paguridae) and shrimp (Caridea & *Callianassa* sp). Annelids including the sand mason worm (*L. conchilega*), peacock worm (*S. pavonia*) and ross worm (*S. spinulosa*) were also distributed throughout this habitat.

Due to presence of the ross worm (*S. spinulosa*) observed in the video footage at transects LL_48_TR, LL_49_TR, LL_92_TR_A and LL_92_TR_ADD, these areas have the potential to conform to the level 5 biogenic habitat '*Sabellaria spinulosa* on stable circalittoral mixed sediment' (SS.SBR.PoR.SspiMx/ MC221), which is further discussed in Section 0.

Two level 5 EUNIS/JNCC habitats are associated with this biotope, and utilising macrofaunal data from grab samples '*Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment' (SS.SSa.CMuSa.AalbNuc/ MC5214) showed the greatest conformance to the regions further offshore (LL_87_TR and LL_120_TR to LL_133_TR) which consisted of BGS Modified Folk Classification 'Sand', 'Slightly Gravelly Sand' and 'Gravelly Muddy Sand'. This is due to a number of key species associated with this habitat observed across transects, in addition to *A. albra*, and sometimes *N. nitidosa,* occurring in larger numbers within grab samples. '*Lagis koreni* and *Phaxas pellucidus* in circalittoral sandy mud' (SS.SMu.CSaMu.LkorPpel/ MC6215) showed the greatest conformance to the regions closer to shore (LL_27_TR and LL_49_TR) which consisted of 'Muddy Sandy Gravel'. These level 5 habitats also appear in the level 4 habitat 'Circalittoral muddy sand' (SS.SSa.CMuSa/ MD521). The highly mobile sediments present along the survey route are likely the reason for the overlap between habitats. The areas delineated as 'Muddy Sand' generally showed higher fines content than the areas delineated as 'Sand'. However, some of the sandier habitats may still show a notable proportion of fines due to the resuspension of nearby sediments.

Example images are provided in Figure 3-40, and the spatial extent of the Level 4 JNCC sediment habitat SS.SSa.OSa/ MD521 is mapped in Figure 3-43 to Figure 3-46. The occurrence along video transects of the Level 5 JNCC biogenic habitats SS.SSa.CMuSa.AalbNuc/ MC5214 and SS.SMu.CSaMu.LkorPpel/ MC6215 are also illustrated in Figure 3-43 to Figure 3-46.

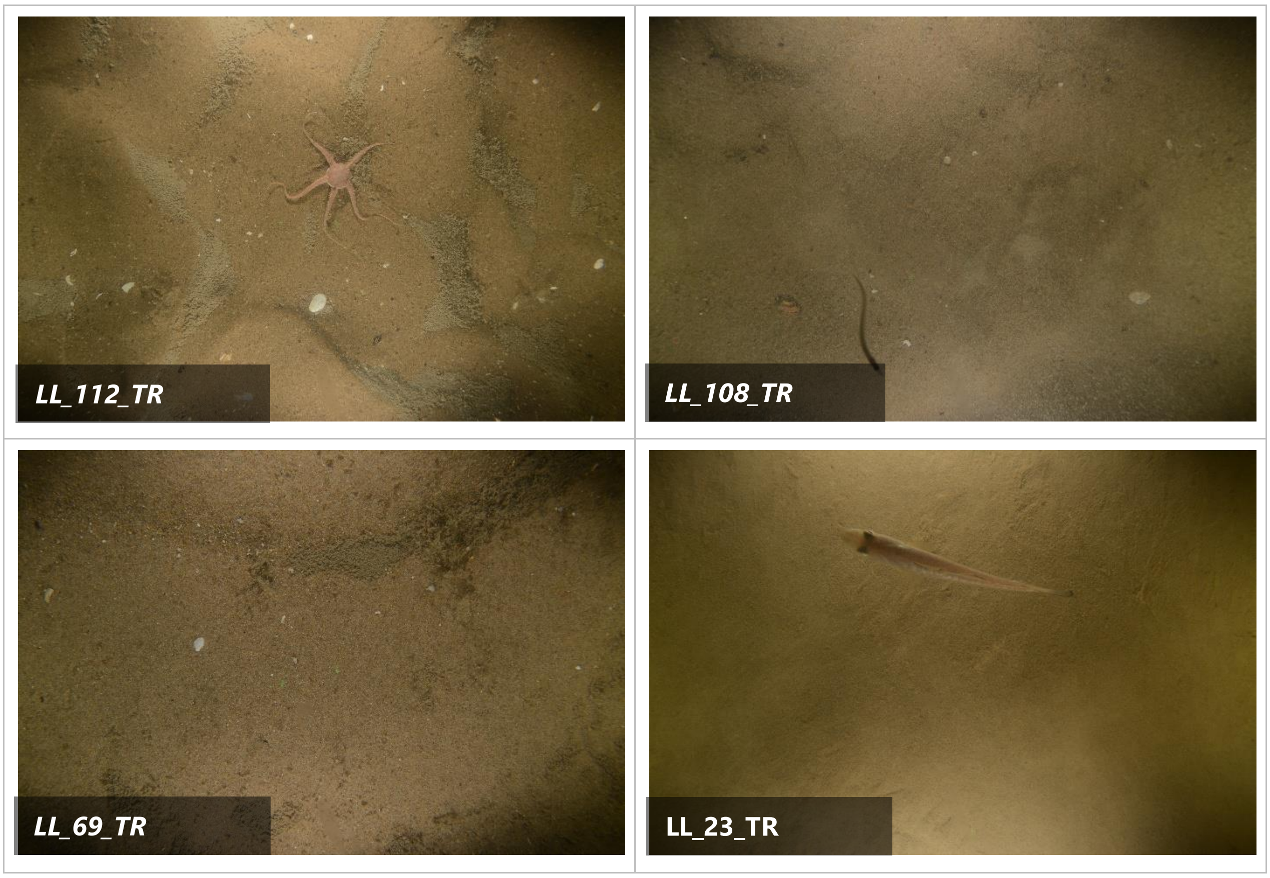



**Figure 3-40 Example Images of 'Offshore Circalittoral Sand' Habitat**

### 3.7.1.3 Offshore Circalittoral Mixed Sediment (SS.SMx.OMx / MD421)

Occurring most often throughout the southern area of the route within areas delineated as 'Flat seabed', this habitat is described by EUNIS as "*Mixed (heterogeneous) sediment habitats in the circalittoral zone (generally below 15-20 m) including well mixed muddy gravelly sands or very poorly sorted mosaics of shell, cobbles and pebbles embedded in or lying upon mud, sand or gravel*". This habitat occurred in water depths of 42 to 29m below LAT.

This habitat supported a range of Cnidarians including Actiniaria anemones, elegant anemones (*Cylista* sp.) and multiple species of Hydrozoans (e.g. *Sertularia* sp. and *Nemertesia antennia*). Ascidians were also common throughout this habitat including the tunicate *Polycarpa pomeria.* Echinoderms such as the green sea urchin (*Psammechinus miliaris*), common starfish (*A. rubens*) and brittlestars (Ophiuroidea) also appeared frequently. Flatfish such as the dover sole (*Solea solea*) and other fish species including the small-spotted catshark (*S. canicula*), sand goby (*Pomatoschistus minutus*) and bib (*Trisopterus luscus*) also appeared throughout the habitat. Molluscs such as common whelks (*B. undatum*) were common and the blue mussel (*Mytilus edulis*) was present. Crustaceans such as hermit crabs (Paguridae) and spider crabs (Majidae) were also common, along with annelid species including the ross worm (*S. spinulosa*), peacock worm (*S. pavonia*) and tube worm (*Spirobranchus triqueter*).

Due to presence of the ross worm (*S. spinulosa*) observed in the video footage at transects LL_20_TR, LL_20_TR_ADD, LL_48_TR, LL_52_TR, LL_53_TR, LL_69_TR, LL_92_TR_A, LL_92_TR_ADD and LL_93_TR, these areas have the potential to conform to the level 5 biogenic habitat '*Sabellaria spinulosa* on stable circalittoral mixed sediment' (SS.SBR.PoR.SspiMx/ MC221), which is further discussed in Section 0.

One level 5 EUNIS/JNCC habitat is associated with this biotope, and utilising macrofaunal data from grab samples 'Polychaete-rich deep *Venus* community in offshore circalittoral mixed sediment' (SS.SMx.OMx.PoVen/ MD4211) showed the greatest conformance to the regions central of the route in areas of 'Gravelly Sand' (LL_60_TR and LL_64_TR).

Example images are provided in Figure 3-41, and the spatial extent of the Level 4 JNCC sediment habitat SS.SMx.OMx / MD421 is mapped in Figure 3-43 to Figure 3-46. The occurrence along video transects of the Level 5 JNCC biogenic habitat 'SS.SMx.OMx.PoVen / MD4211 is also illustrated in Figure 3-43 to Figure 3-46.

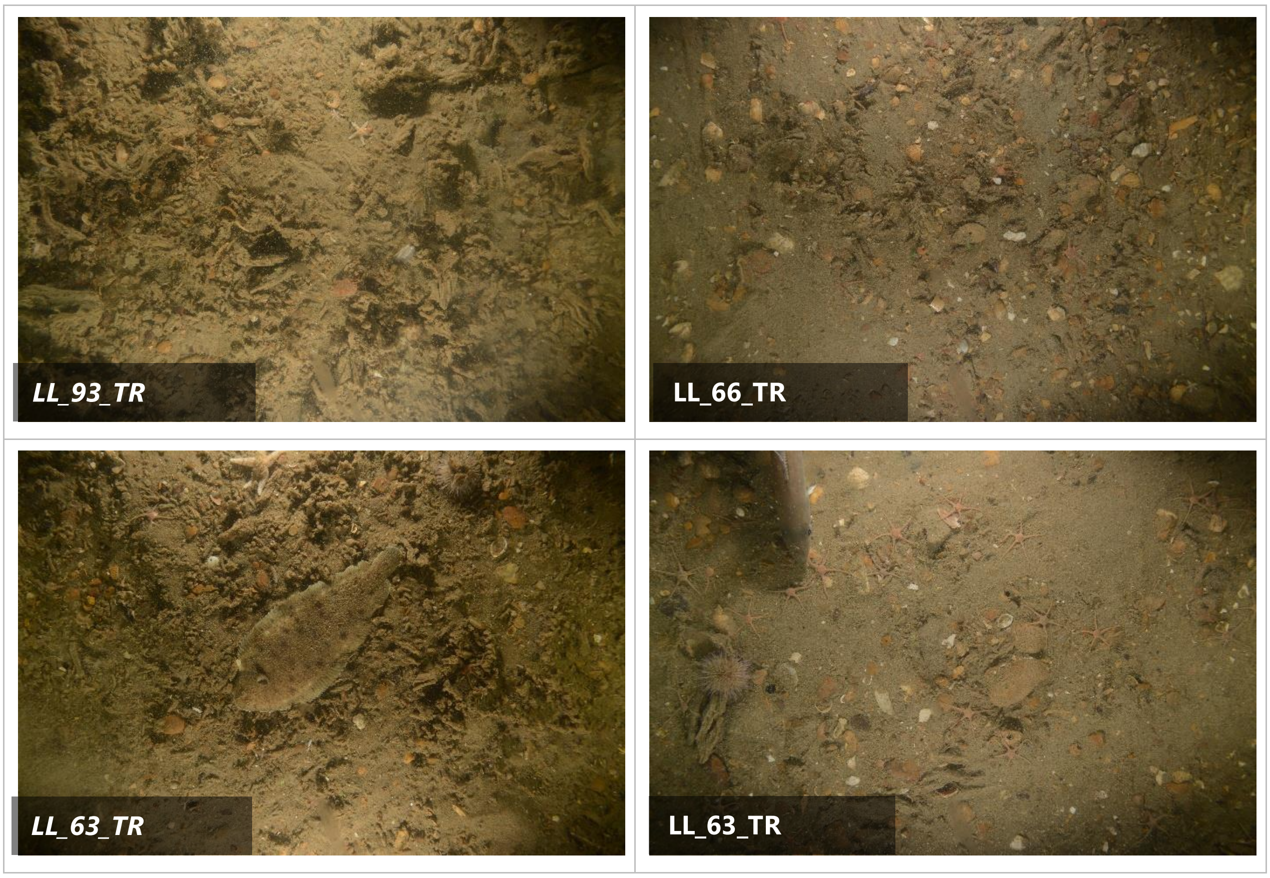



**Figure 3-41 Example Images of 'Offshore Circalittoral Mixed Sediment' Habitat**

#### 3.7.1.4 Offshore Circalittoral Coarse Sediment (SS.SCS.OCS / MD321)

This biotope is described by the JNCC as consisting of "*Offshore (deep) circalittoral habitats with coarse sands and gravel or shell*". This biotope occurred frequently throughout the southern areas of the cable route interspersed in the troughs between mega-rippled sand waves and was associated with areas of 'Gravelly Muddy Sand', 'Gravelly Sand' and 'Muddy Sandy Gravel'. This habitat occurred in water depths of 42m to 29m below LAT.

This habitat supported a variety of fauna observed on the HD video with increased presence of epifaunal taxa including cnidarians such as elegant anemones (*Cylista* sp.) and Hydrozoa species *Sertularia* sp. and *N. antennia*. Echinoderms were present including the common starfish (*A. rubens*), brittlestars (Ophiuroidea) and green sea urchin (*P. miliaris*) were common throughout this habitat. Ascidians were also common epifaunal taxa alongside Molluscs such as common whelks (*B. undatum*) and crustaceans including hermit crabs (Paguridae). Fish species such as the dover sole (*S. solea*) and other fish including the Raitt's sandeel (*A. marinus*), small-spotted catshark (*S. canicula*) and bib (*T. luscus*) were present throughout the habitat. Annelids were also present including the ross worm (*S. spinulosa*) and sand mason worm (*L. conchilega*).

Due to presence of the ross worm (*S. spinulosa*) observed in the video footage at transects LL_48_TR, LL_49_TR, LL_50_TR, LL_90_TR, LL_92_TR_A and LL_92_TR_ADD, these areas have the potential to conform to the level 5 biogenic habitat '*Sabellaria spinulosa* on stable circalittoral mixed sediment' (SS.SBR.PoR.SspiMx/ MC221), which is further discussed in Section 0.

Within areas of 'Offshore circalittoral coarse sediment' (SS.SCS.OCS/ MD321), there was not a sufficient amount of key species recorded to appropriately assign any particular level 5 JNCC habitats associated with this biotope.

Example images are provided in Figure 3-42, and the spatial extent of the Level 4 JNCC sediment habitat SS.SCS.OCS / MD321 is mapped in Figure 3-43 to Figure 3-46.

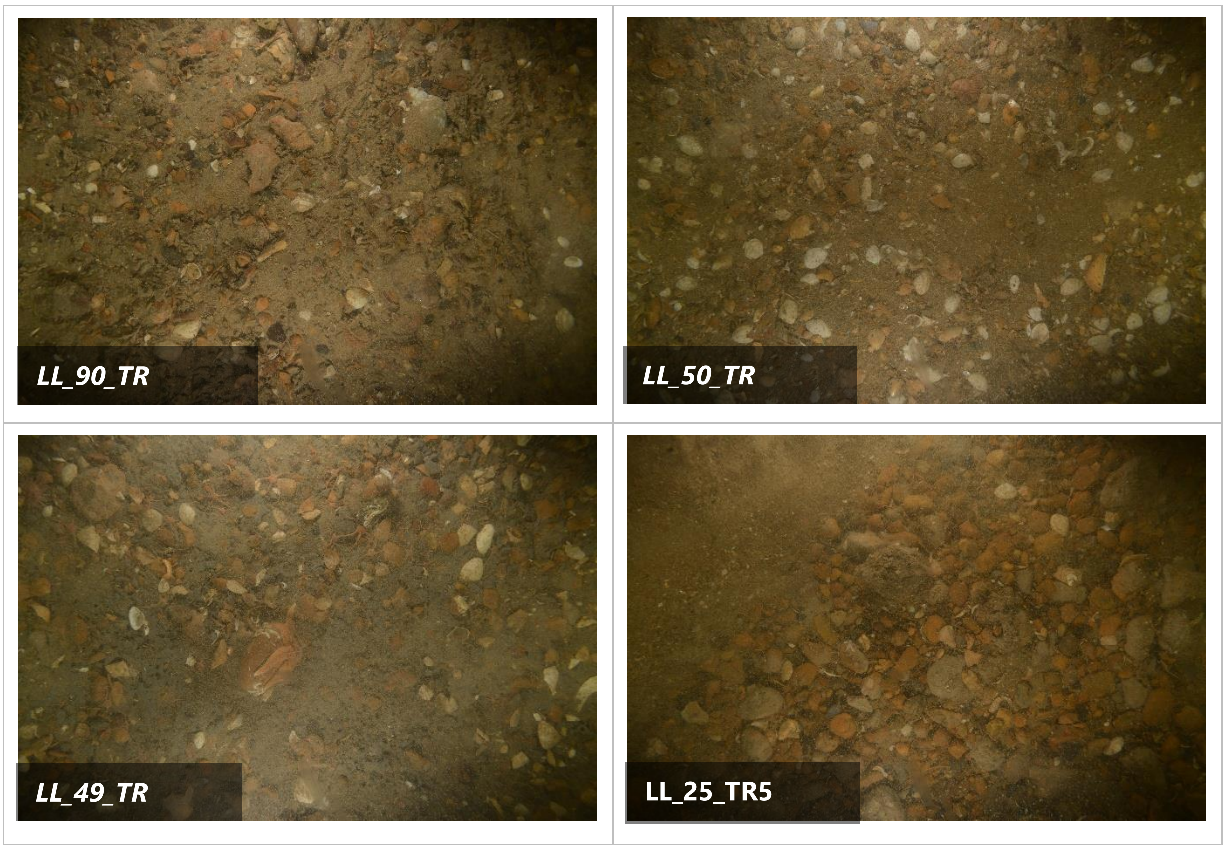



**Figure 3-42 Example images of 'Offshore Circalittoral Coarse Sediment' Habitat**

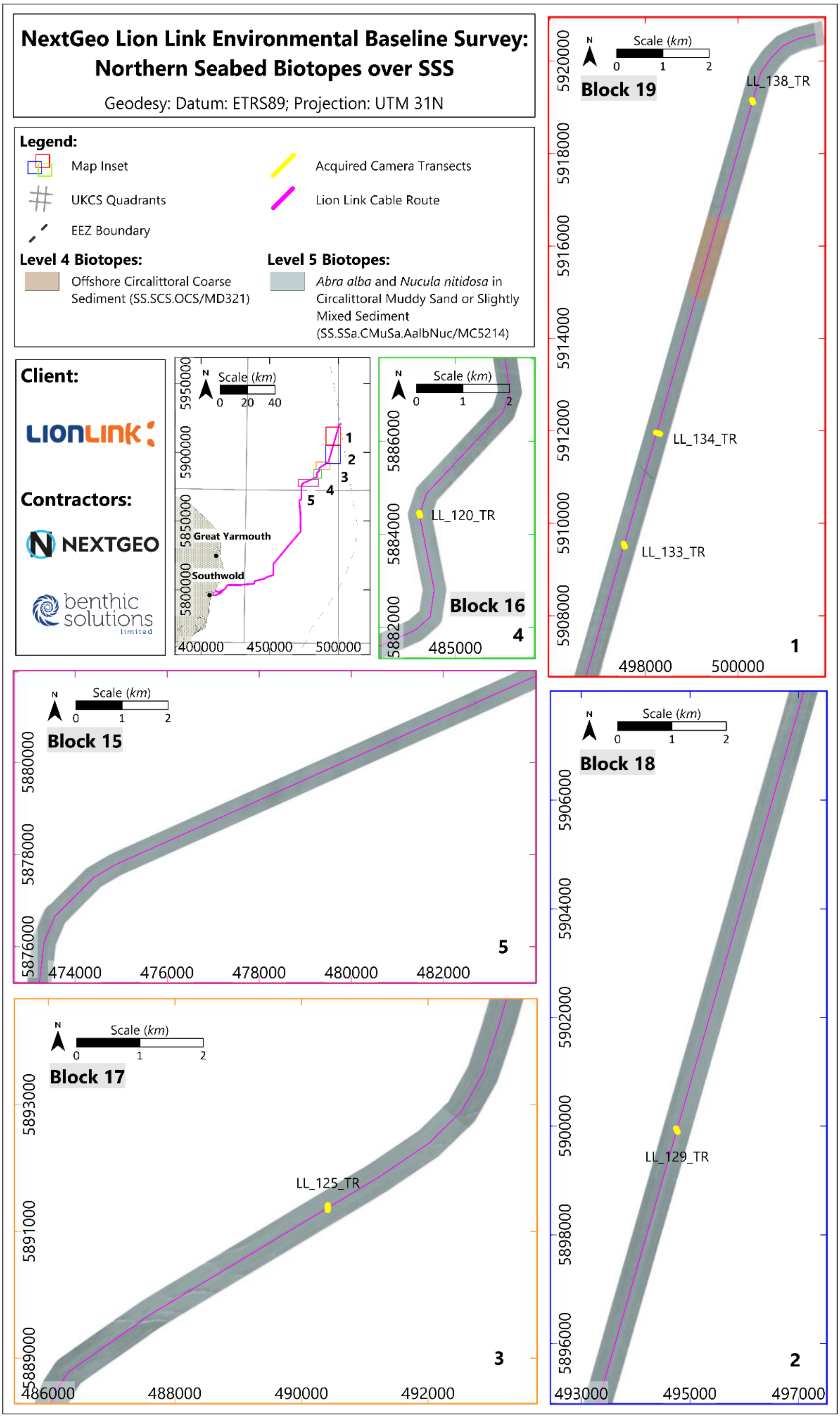



**Figure 3-43 Environmental Habitats within Block 19 to Block 15**

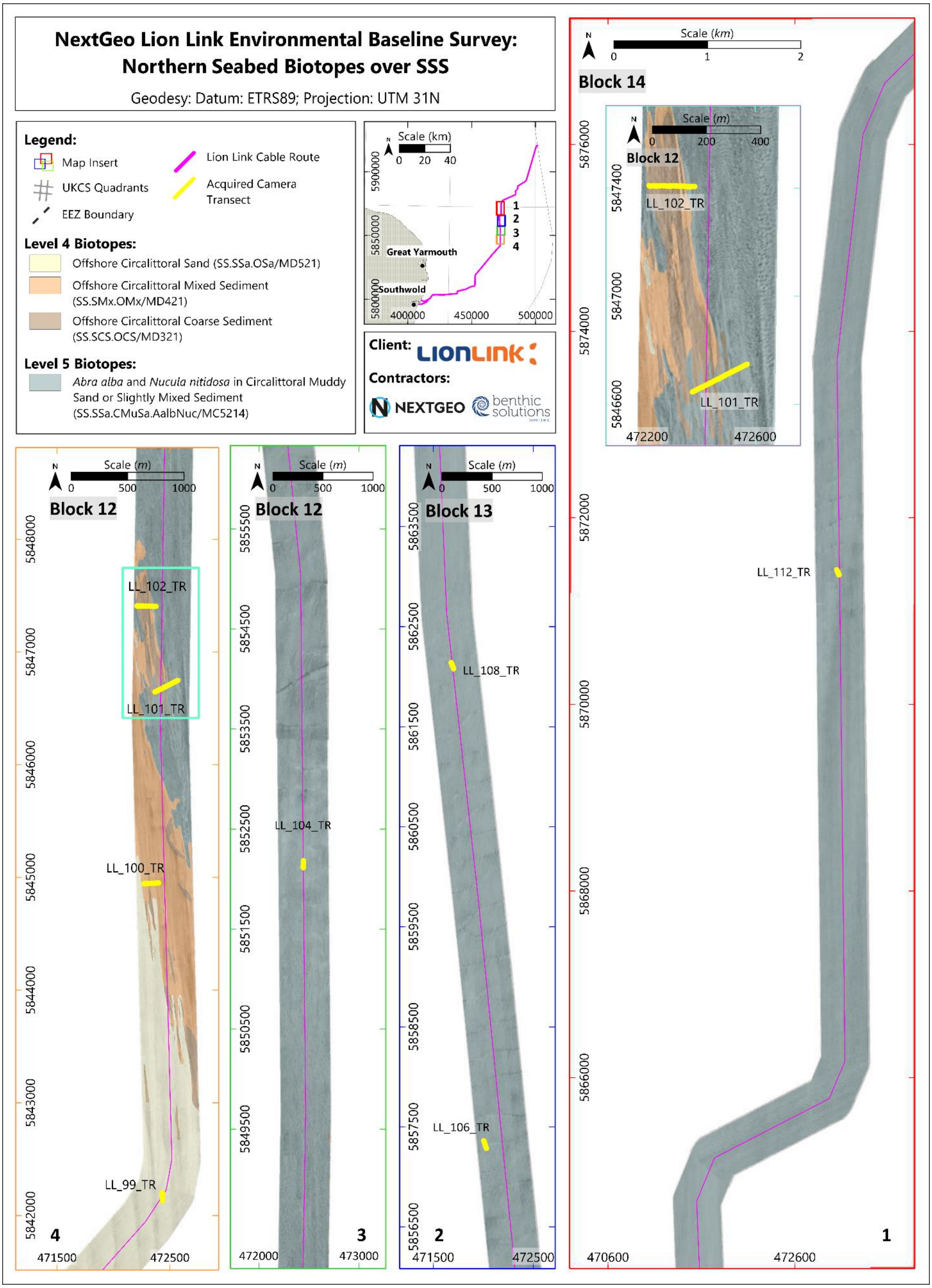



**Figure 3-44 Environmental Habitats within Block 14 to Block 12**

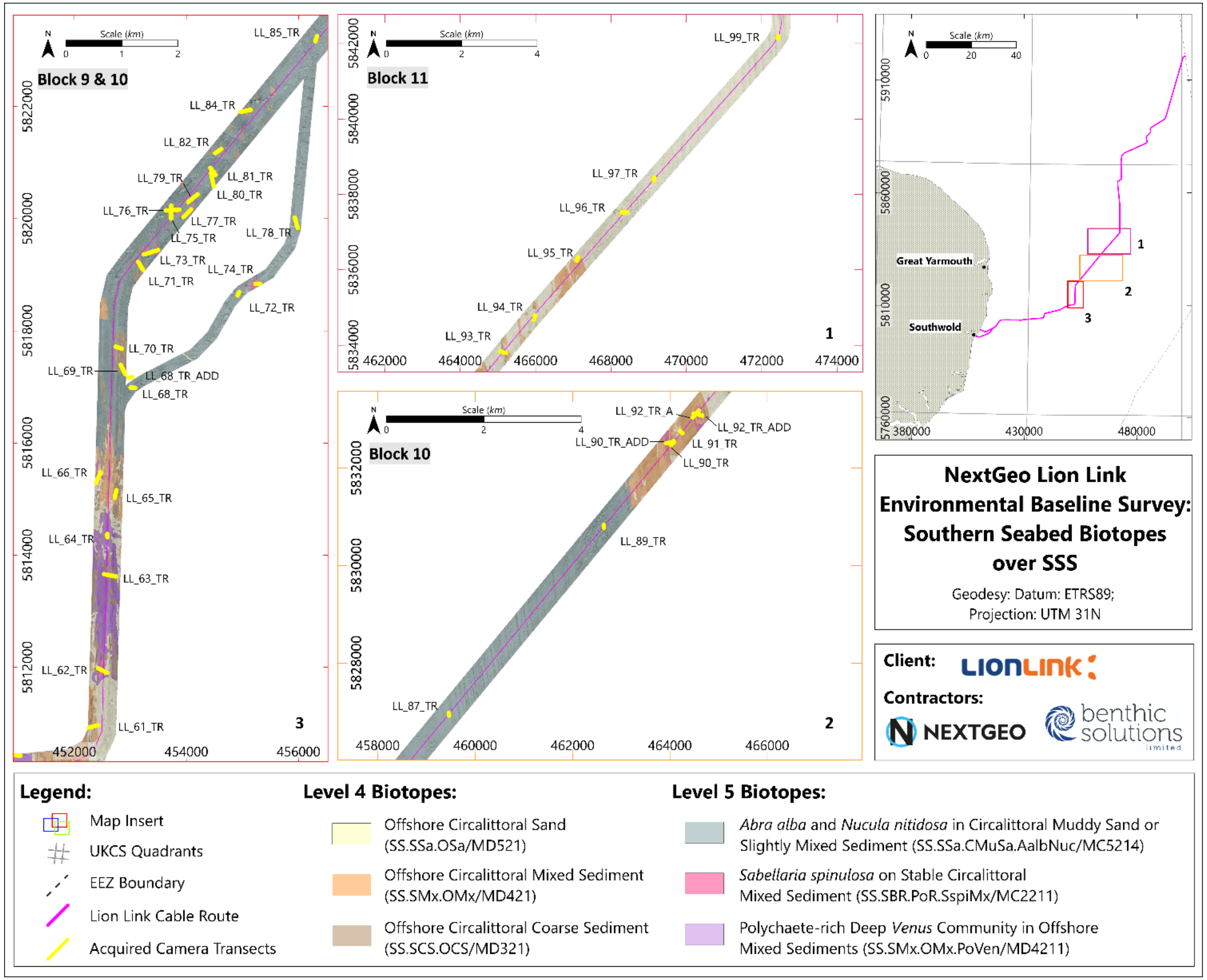



**Figure 3-45 Environmental Habitats within Block 11 to Block 9**

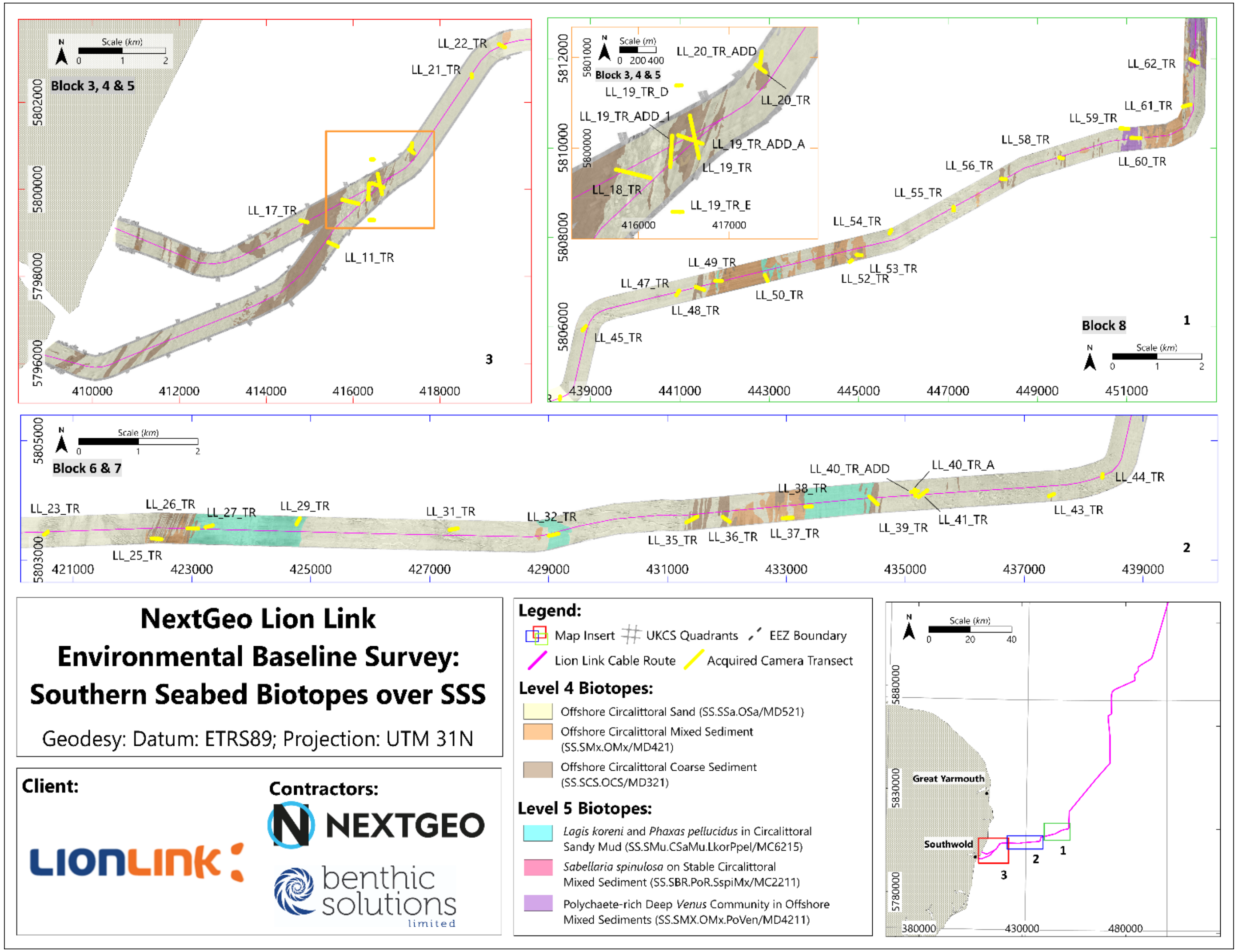



**Figure 3-46 Environmental Habitats within Block 8 to Block 3**

## 3.8 Potential Sensitive Habitats and Species

### 3.8.1 Legislative Species Protection

To assess if any species afforded legislative protection in the UK were present within the survey area, macrofaunal data from grab samples and subtidal underwater video assessment were run through a listed species database developed by BSL staff.

Species which have designated legislative protection and the transects they were identified on are presented below in Table 3-18.

**Table 3-18 Legislative Species Protection Results**

| Sensitive Species | Video Transect Species Observed | Associated Grab Sample Species Present |
|---|---|---|
| Dogwhelk (*Nucella lapillus*)<br><br>(OSPAR Threatened and/or Declining Species) | LL_94_TR, LL_133_TR, LL_134_TR, LL_138_TR | - |
| Thumbnail crab (*Thia scutellata*)<br><br>(Great Britain Rarity Status (Nationally Scarce) | - | LL_89_EBS |
| Raitt's sandeel (*Ammodytes marinus*)<br><br>(Species of Principal Importance) | LL_19_TR_D, LL_19_TR_ADD1, LL_19_TR_ADD_A, LL_35_TR, LL_47_TR, LL_48_TR, LL_65_TR_A, LL_71_TR, LL_72_TR, LL_73_TR, LL_74_TR, LL_75_TR, LL_76_TR, LL_77_TR, LL_82_TR, LL_84_TR, LL_96_TR, LL_97_TR, LL_104_TR, LL_106_TR, LL_108_TR, LL_112_TR, LL_125_TR | LL_108_EBS |
| Atlantic Herring (*Clupea harengus*)<br><br>(Species of Principal Importance) | LL_23_TR | - |
| European plaice (*Pleuronectes platessa*)<br><br>(Species of Principal Importance, IUCN Least concern) | LL_36_TR, LL_66_TR, LL_68_TR_ADD, LL_76_TR, LL_77_TR, LL_80_TR, LL_84_TR, LL_87_TR, LL_100_TR | - |
| Sand Goby (*Pomatoschistus minutus*)<br><br>(IUCN Least concern) | LL_19_TR_ADD_A, LL_22_TR, LL_35_TR, LL_47_TR, LL_56_TR, LL_61_TR, LL_63_TR, LL_65_TR_A, LL_68_TR, LL_75_TR, LL_76_TR, LL_77_TR, LL_78_TR, LL_79_TR, LL_84_TR, LL_87_TR, LL_93_TR, LL_96_TR, LL_100_TR, LL_102_TR, LL_133_TR | - |
| Dover sole (*Solea solea*)<br><br>(Species of Principal Importance) | LL_19_TR_ADD_A, LL_62_TR, LL_63_TR | - |
| Thornback ray (*Raja clavata*)<br><br>(OSPAR Threatened and/or Declining Species, IUCN Near Threatened) | LL_31_TR | - |
| Small-spotted catshark (*Scyliorhinus canicula*)<br><br>(IUCN Least concern) | LL_26_TR, LL_35_TR, LL_39_TR_A, LL_40_TR_ADD, LL_41_TR, LL_47_TR, LL_48_TR, LL_56_TR, LL_62_TR, LL_69_TR, LL_75_TR, LL_76_TR, LL_78_TR, LL_81_TR, LL_82_TR, LL_85_TR, LL_90_TR_ADD, LL_92_TR_ADD, LL_93_TR | - |

#### 3.8.1.1 Ocean quahog (*Arctica islandica*)

Field assessment of *Arctica islandica* can be challenging for specimens with shell sizes below 5cm due to their morphological similarities to other species such as *Dosinia*. To ensure accurate identification during field processing, *A. islandica* specimens with a shell diameter above 5cm—approximately half the typical adult size of 10-13 cm (Begum *et al.*, 2009)—are classified as adults. These specimens are measured, logged, and returned to the sea. Specimens with a shell diameter below 5cm are retained within the grab sample for further taxonomic review. During this review, individuals with a shell size above 1cm are logged as adults, while those below 1cm are categorised as juveniles, following the NMBAQC guidance (August 2023).

The results showed that no juvenile (shell diameter <5cm) or adult quahogs (shell diameter >5cm) were recovered during the grab sampling or during taxonomical analysis, as well as no other sighting of their distinctive siphons during review of acquired video footage and photographic stills.

### 3.8.2 Habitats

As previously discussed, there are several potentially sensitive habitats which are known to occur in this region of the UK including:

- Biogenic Reefs formed by the ross worm (*S. spinulosa*) Biogenic Reefs (UKBF, Bern Convention, EC Habitats Directive Annex I, OSPAR Threatened and/or Declining Habitat, Habitat of Principle Importance)
    - Observed habitat of '*Sabellaria spinulosa* on stable circalittoral mixed sediment' (SS.SBR.PoR.SspiMx/ MC221) (UKBF, Bern Convention, OSPAR Threatened and/or Declining Habitat, EC Habitats Directive Annex I)
- Stony Reefs (EC Habitats Directive Annex I, Habitat of Principle Importance)
- Biogenic Reefs formed by Blue mussels (*Mytilus edulis*) on sediment (EC Habitats Directive Annex I, Habitat of Principle Importance)
- Raitt's Sandeels (*Ammodytes marinus*) Spawning and Nursery Grounds (Species of Principal Importance)
- Subtidal Sands and Gravels (Habitat of Principle Importance)
- Atlantic Herring (*Clupea harengus)* Spawning and Nursery Grounds (Species of Principal Importance).

These habitats are listed by one or more International Conventions, European Directives or UK Legislation (including devolved UK administrations). Note: while European Directives are no longer directly relevant following the UK's exit from the European Union, UK legislation implementing these Directives is still applicable and there has not yet been any policy change (GOV.UK, 2022).

#### 3.8.2.1 Annex I Biogenic reefs formed by ***Sabellaria Spinulosa***

*Sabellaria spinulosa* is a tube-building polychaete worm and can occur as isolated individuals, small aggregations, thin crust-like veneers, or when in large numbers can form hard reef-like structures which can act to stabilise the surrounding seabed (Gibb *et al.,* 2014). As their tubes are built of sand, a high suspended sediment content is essential for growth of reef like structures and the mobile sandy seabed within the survey area may provide this. However, these structures are transient in nature and can degrade and reform over time (OSPAR, 2010).

The presence of *S. spinulosa* was observed across 59 out of 114 camera transects and included the eight additional transects specifically chosen to ground-truth potential *S. spinulosa* features identified from the geophysical data. It should be noted that, excluding the 59 with a notable *S. spinulosa* presence, 24 of the 111 camera transects had instances of high sediment resuspension and turbidity, whilst utilising the BSL adapted fresh water lens, which obscured the visibility of the seabed and hence identification of *S. spinulosa* along these transects. The presence of *S. spinulosa* along the route was corroborated by the taxonomic dataset as *S. spinulosa* individuals were recorded at 7 of the 38 macrofauna stations (Appendix K –Sabellaria spinulosa Reef Assessment).

An assessment of 'reefiness' as described by Gubbay (2007) and presented in Table 3-19 was performed on the aforementioned 59 camera transects to describe the habitat, focusing on transects where *S. spinulosa* was recorded during review of video footage and stills photographs. Changes in coverage and density of the *S. spinulosa* tubes were noted during the videos in order to accurately estimate the area covered by *S. spinulosa.* The characterisation of *S. spinulosa* to determine the presence and absence of biogenic reef is important, as the *S. spinulosa* reef structures provide additional structural habitat complexity, capable of supporting an enriched and biodiverse faunal community (Holt *et al.,* 1998, Pearce *et al*., 2011, OSPAR, 2013).

**Table 3-19: *Sabellaria* Reefiness Criteria as Outlined by Gubbay (2007)**

| Measure of 'Reefiness' | Not a Reef | Low | Medium | High |
|---|---|---|---|---|
| Elevation (average tube height, cm) | <2 | 2-5 | 5-10 | >10 |
| Area ($m^2$) | <25 | 25-10,000 | 10,000–1,000,000 | >1,000,000 |
| Composition (%Cover) | <10 | 10-20 | 20-30 | >30 |

To apply the Gubbay (2007) protocol to the acquired data, it was further separated into reef 'structure' and overall 'reefiness' (Table 3-20 and Table 3-21). The advantage of this method is that the reef structure value, derived from the composition (i.e. percent coverage) and tube elevation reefiness, can be assessed against the extent to produce a measure of overall reefiness, (Appendix K –Sabellaria spinulosa Reef Assessment) This method was initially devised by BSL staff and later approved by the JNCC in 2010 (see Jenkins et al. (2015) for an example of application by JNCC and Cefas).

Following the assessment of composition, the height of Sabellaria tubes, referred to as "topographic distinctiveness" by Gubbay (2007), is measured relative to the underlying hard substratum (shells and pebbles etc.). Given natural variation in tube height within *Sabellaria* aggregations, an average height must be determined and categorised within predefined brackets. To ensure precision, the laser scale must be referenced (50mm) during the still imagery review, where high-definition video is also observed to clarify any obscured measurements.

When possible, laser measurements of horizontal (older) tubes are used as an additional indicator of height above the seafloor. Height approximations are be rounded to 0 decimal places (0dp) to align with category boundaries, as the classification is based on bracketed ranges rather than precise percentage differences which is tabulated below in Table 3-20.

*S. spinulosa* was present in the sediment types of 'Offshore Circalittoral Sand', 'Offshore Circalittoral Coarse' and 'Offshore Circalittoral Mixed' along the route corridor. It should be noted that characterising the tube elevation of *S. spinulosa* encrusting coarse sediment (i.e., cobbles and boulders) can be challenging as the height of the underlying substrate is obscured by the growth of *S. spinulosa,* so tube elevation levels were estimated by the reviewer focussing on differentiating between tube elevation size classes of relevance to 'reefiness' assessment.

To avoid potential bias of manual still photographs towards areas of greater environmental interest and to more accurately quantify the reefiness of heterogeneous patches of *S. spinulosa*, screengrabs were taken approximately every 5 seconds along the aforementioned 59 camera transects. Each still was assessed for *S. spinulosa* composition and tube elevation, which were then combined to assess reef structure Table 3-20 and Table 3-21).

**Table 3-20 *Sabellaria spinulosa* Reef Assessment Composition vs Elevation (after Gubbay, 2007)**

| Reef Structure Matrix | | | Elevation (cm) | | | |
|---|---|---|---|---|---|---|
| | | | <2 | 2 to 5 | 5 to 10 | >10 |
| | | | Not a Reef | Low | Medium | High |
| Composition | <10% | Not a Reef | Not a Reef | Not a Reef | Not a Reef | Not a Reef |
| | 10-20% | Low | Not a Reef | Low | Low | Low |
| | 20-30% | Medium | Not a Reef | Low | Medium | Medium |
| | >30% | High | Not a Reef | Low | Medium | High |

**Table 3-21 *Sabellaria spinulosa* Reef Assessment Structure vs Extent (after Gubbay, 2007)**

| Reef Structure vs Area | | Area (m$^2$) | | | |
|---|---|---|---|---|---|
| | | <25 | 25-10,000 | 10,000-1,000,000 | >1,000,000 |
| | | Not a Reef | Low | Medium | High |
| Reef Structure (incl. Composition and Elevation) | Not a Reef | Not a Reef | Not a Reef | Not a Reef | Not a Reef |
| | Low | Not a Reef | Low | Low | Low |
| | Medium | Not a Reef | Low | Medium | Medium |
| | High | Not a Reef | Medium | High | High |

The 5 second still images indicated a relatively variable, but low density of *S. spinulosa* across the survey area with transects mainly comprised of low elevation elements of *S. spinulosa* on top of mixed sediment and coarse sand. Of the 5,729 total images assessed, 340 (5.9%) were assessed as unclear for analysis due to high turbidity, with 3,417 (59.6%) classified as 'No Reef' (an absence of *Sabellaria*). In terms of percentage cover 1,278 stills (22.3%) were considered 'Not a Reef', 375 stills (6.5%) were considered resembling a 'Low Reef', 161 (2.8%) were considered resembling a 'Medium Reef' and 158 stills (2.8%) were considered resembling a 'High Reef'. In terms of elevation, 1,281 stills (22.4%) were classified as 'Not a Reef', 677 stills (11.8%) were considered resembling a 'Low Reef' and 10 stills (0.2%) were considered as resembling a 'Medium Reef' with no stills considered as resembling a 'High Reef' (Table 3-22). When both composition and elevation were taken into account to assess the overall reef structure, 1,560 images (27.2%) were considered 'Not a Reef', 407 stills (7.1%) were considered as resembling 'Low Reef', 5 stills (0.1%) were considered as resembling 'Medium Reef' and none were classed as resembling 'High Reef'. The distribution of the stills and their reef structure is illustrated in Figure 3-47 to Figure 3-50.

It is to be noted that *Sabellaria spinulosa* is widely distributed in the southern North Sea, typically occurring as isolated individuals or in low-density aggregations. It is only designated as a protected Annex I habitat under the EU Habitats Directive when it forms distinct reef structures, which are of significant ecological importance. Outside of these reef formations, the species does not receive the same level of protection, despite being commonly found across various sediment types in the region (OSPAR, 2009b).

**Table 3-22 *Sabellaria spinulosa* Reef Assessment (Composition vs Elevation)**

| 'Reefiness' of Video Screengrabs | Unclear UW Still | | No *Sabellaria* | | Not a Reef | | Low | | Medium | | High | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **No.** | **%** | **No.** | **%** | **No.** | **%** | **No.** | **%** | **No.** | **%** | **No.** | **%** |
| Composition (% cover) | 340 | 5.9 | 3,417 | 59.6 | 1,278 | 22.3 | 375 | 6.5 | 161 | 2.8 | 158 | 2.8 |
| Elevation (Tube height) | | | | | 1,281 | 22.4 | 677 | 11.8 | 10 | 0.2 | 0 | 0 |
| Reef Structure (incl. Composition and Elevation) | | | | | 1,560 | 27.2 | 407 | 7.1 | 5 | 0.1 | 0 | 0 |

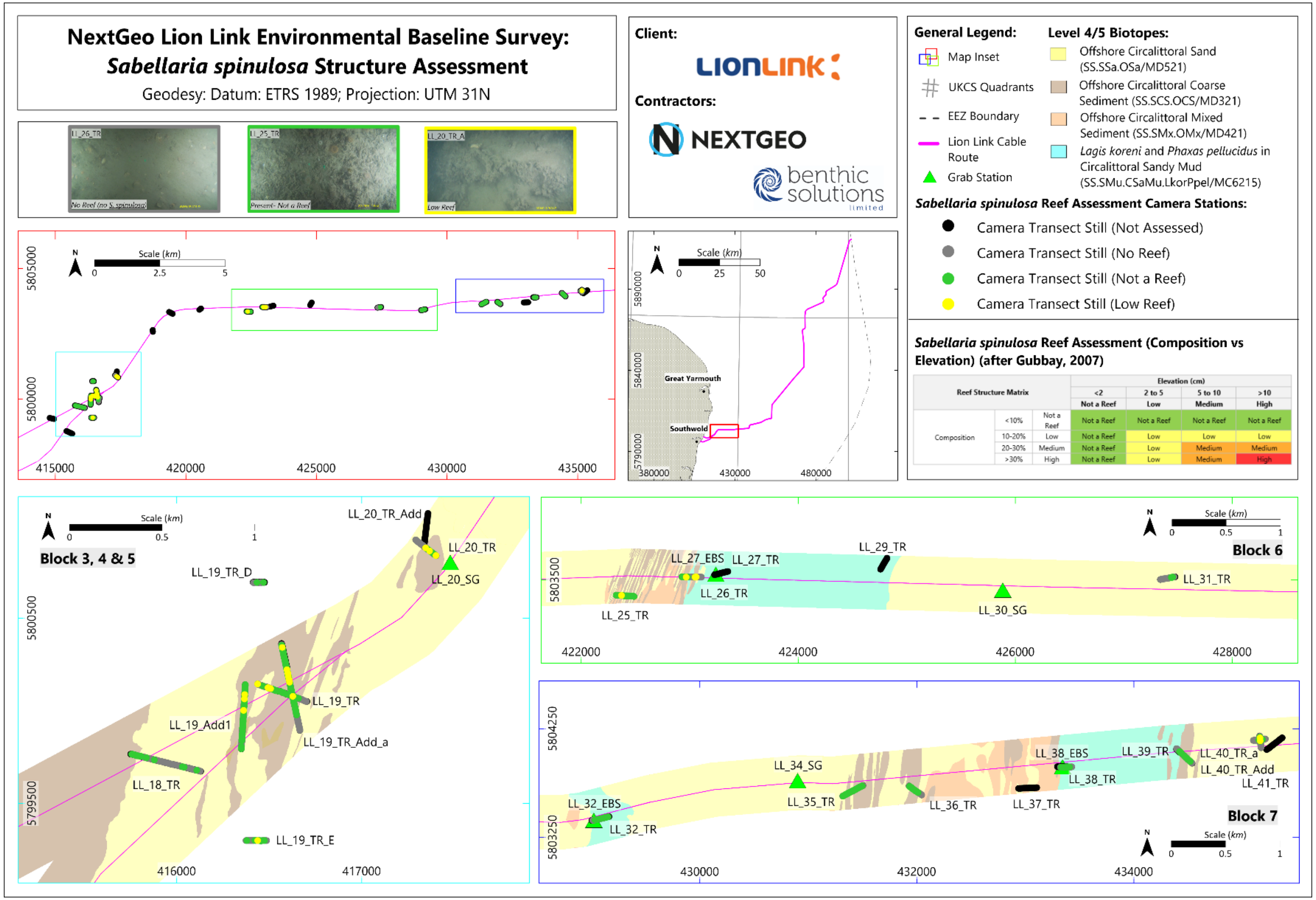



**Figure 3-47 *Sabellaria* Reef Assessment (Composition vs Elevation) within Block 3 to Block 7**

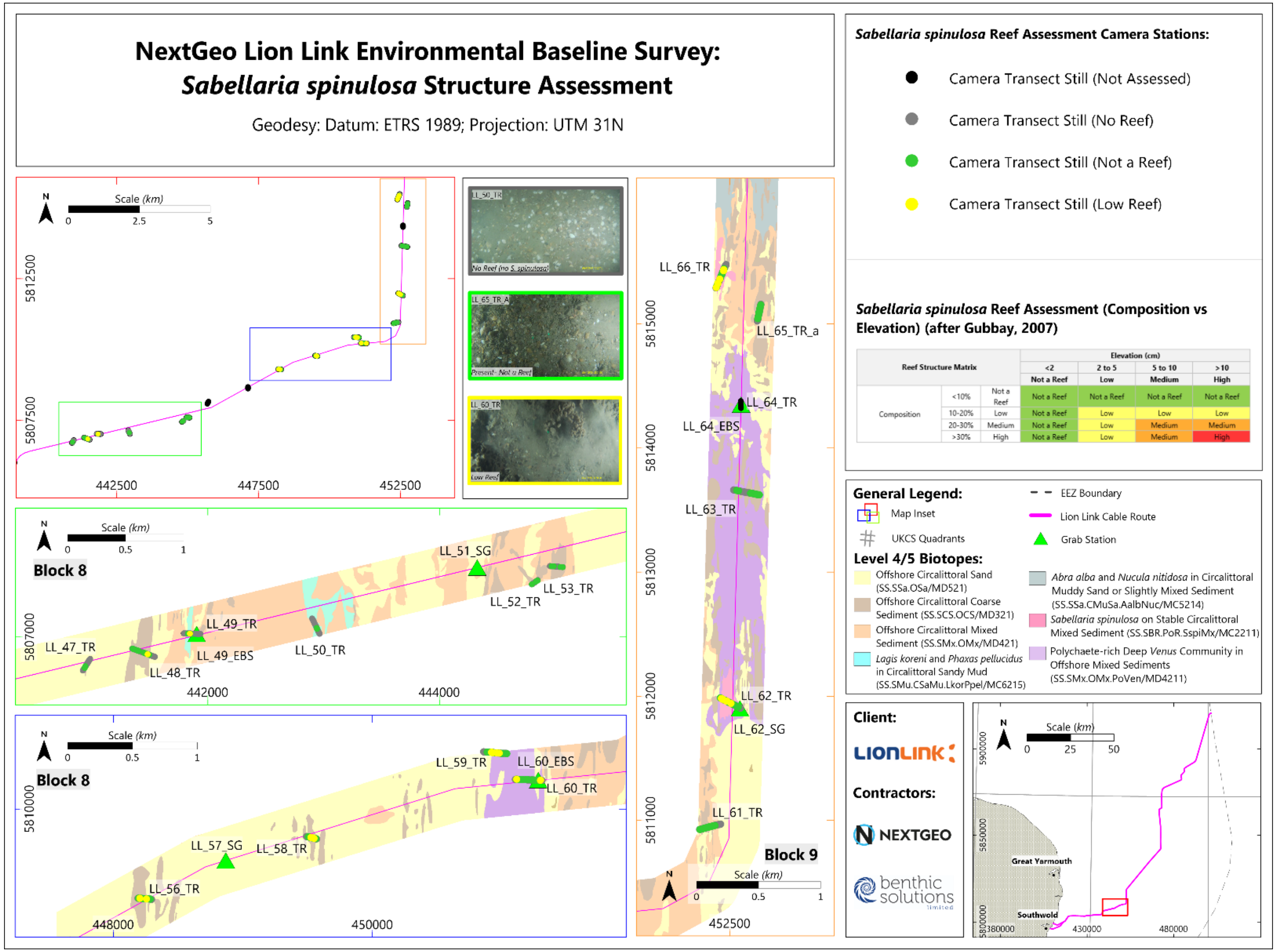



**Figure 3-48 *Sabellaria* Reef Assessment (Composition vs Elevation) within Block 8 to Block 9**

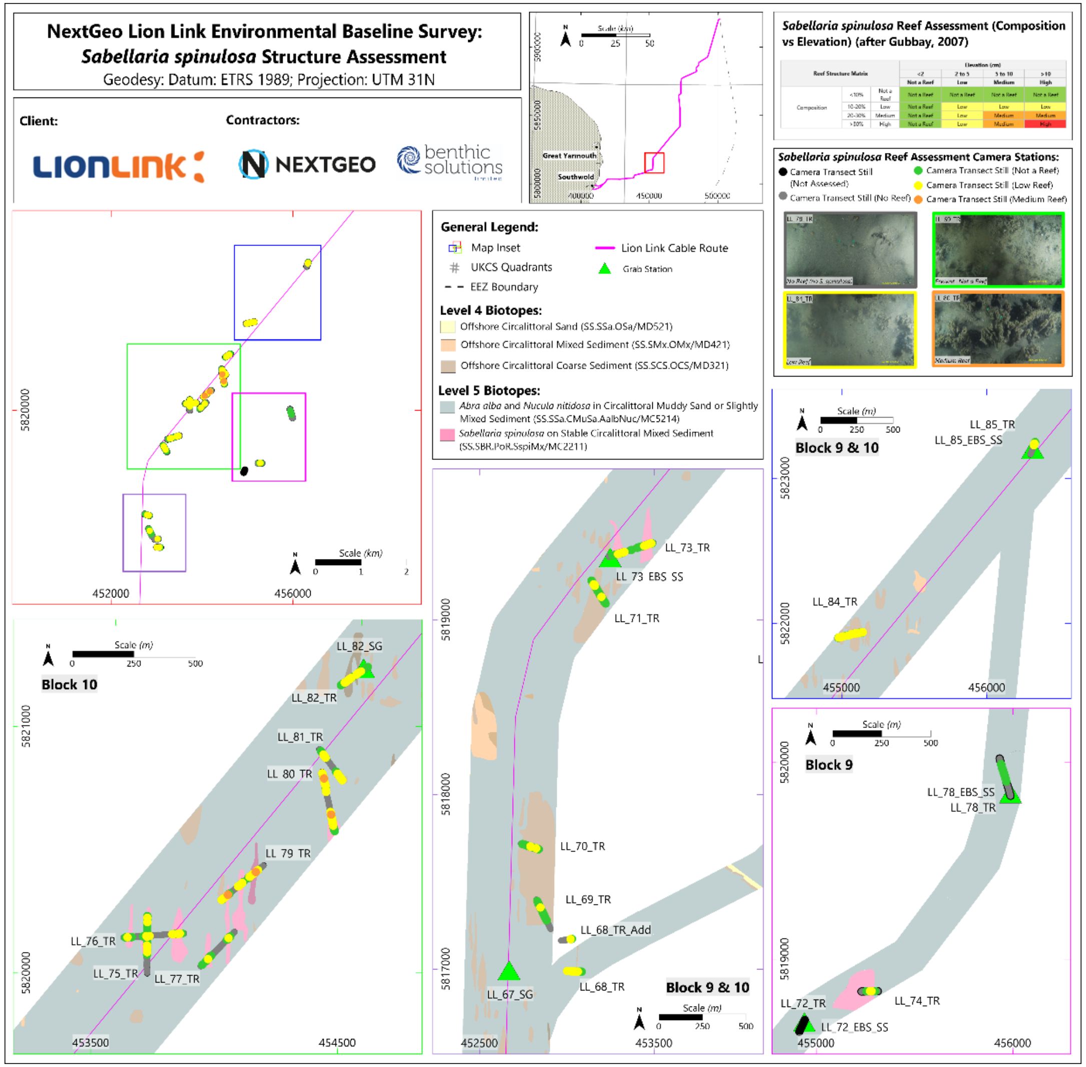



**Figure 3-49 *Sabellaria* Reef Assessment (Composition vs Elevation) within Block 9 to Block 10**

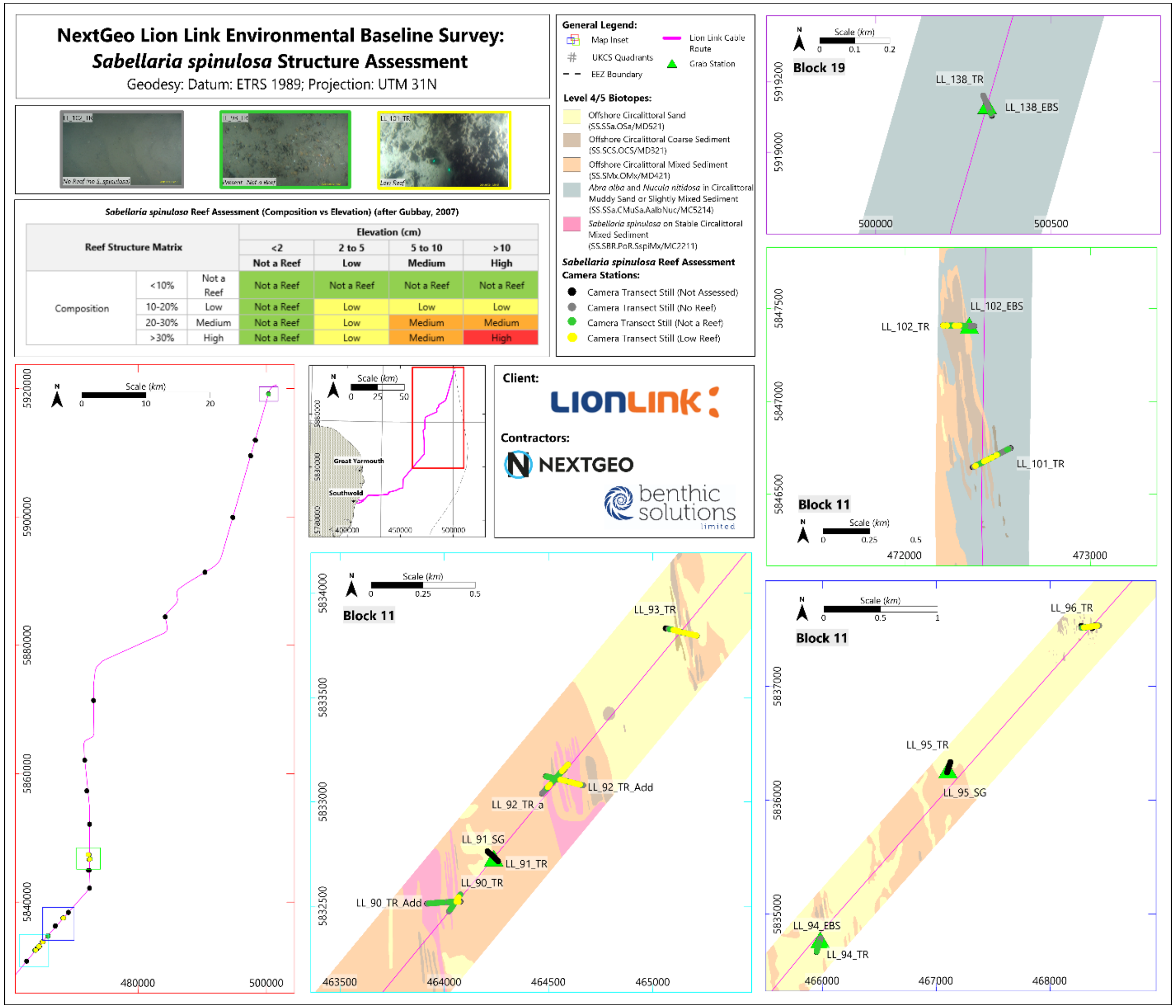



**Figure 3-50 *Sabellaria* Reef Assessment (Composition vs Elevation) within Block 11 to Block 19**

Across the route, the SSS signatures associated with *S. spinulosa* aggregations were highly variable, allowing a visual correlation to be observed between reef formations and the types of SSS reflectivity, as well as the geophysical seabed features classified by NEXT. To statistically validate these correlations, a chi-square frequency test was performed, showing a strong association between areas of 'mixed sediment', 'coarse sediment' and 'sand' and reef areas. In these regions, the underwater still images were grouped based on SSS reflectivity to estimate the extent of the reef. Each distinct patch was assigned a unique patch ID, consisting of a numerical value and a letter indicating whether the polygon had been directly ground-truthed. The average reef structure was then calculated, and the polygon area was used to estimate the reef extent, as outlined in Table 3-22 (Appendix K –Sabellaria spinulosa Reef Assessment). The results identified a further 9 patches of "Low" resemblance reef along the route, which occurred in Blocks 10 and 11 (Patch IDs: 2, 5, 8, 9, 12, 13, 14, 17, 42) (Figure 3-51 to Figure 3-54). No areas of "Medium" or "High" resembling reef were identified (Appendix K –Sabellaria spinulosa Reef Assessment).

Seabed areas closely associated with these ground-truthed patches were also assigned a reefiness value, based on their similarity in SSS signature to the nearby ground-truthed areas. However, the mapping of these patches does not confirm the presence of *S. spinulosa* or the reef structure of any aggregations. As a result, the boundaries of these patches should be considered indicative only. The mapped polygons outside the camera ground-truthing areas highlight sections of the route with a higher likelihood of encountering *S. spinulosa* reefs with a 'Low' reef resemblance.

Alternatively, in areas where there were no distinct acoustic facies, such as featureless areas of the seabed, where small and scattered aggregation of Sabellaria was visible in underwater still images, it was difficult to delineate the extent of the *Sabellaria* habitat using pre-existing seabed feature polygons or BSL interpreted areas of mottled reflectivity. In these cases a precautionary approach was taken to estimate the extent of the reef formation. This approach assumed that the reefs occupied circular areas of the seabed, with the straight-line distance between known reef still locations representing the diameter of a circle. The area was then calculated using the formula $\pi r^2$ and the result used to estimate the reef extent, as outlined in Table *3-22*. This method identified five occurrences of 'Low' resembling reef of Sabellaria along four camera transects which were located in broader sand or muddy sand polygons that lacked distinct SSS textures in Blocks 10, 11 and 12 (Table *3-23*, Figure 3-51 to Figure 3-54). No areas of "Medium" or "High" resembling reef were identified (Appendix K –Sabellaria spinulosa Reef Assessment).

The occurrence of *S. spinulosa* was most commonly found in areas designated as 'Offshore Circalittoral Mixed Sediment' (SS.SMx.OMx/ MD421) and 'Offshore Circalittoral Coarse Sediment' (SS.SCS.OCS/ MD321), particularly along the southern part of the route corridor. Despite variations in sediment preference, both the mixed and coarse sediment types supported *S. spinulosa* reef structures, with the species forming crusts on available hard substrates (e.g., occasional low lying pebbles). In the southern half of the survey area, the mixed variant of *S. spinulosa* was classified as '*Sabellaria spinulosa* on stable circalittoral mixed sediment' (SS.SBR.PoR.SspiMx/ MC22).

While the morphology of *S. spinulosa* was similar in both sediment types, variability in sediment composition affected whether a patch was classified as 'Not a Reef' or 'Low' resembling reef. For example, in transects LL_19_ADD1, LL_19_TR, and LL_19_ADD_A (within polygon ID 24; Figure 3-51), a heterogeneous distribution of *S. spinulosa* was observed, with percentage composition ranging from 1% to 50%. Despite this variability, the reef structure was classified as 'Not a Reef' due to the consistent low tube elevation of <2mm. Thus, polygons with similar signatures were also classified as 'Not a Reef'. In contrast, the classification of 'Low' resembling reef in transects LL_79_TR and LL_93_TR (*Sabellaria* polygon ID 2, 4, 12, 13, 14, and 17; Table 3-24, Figure 3-53 and Figure 3-54) was based primarily on tube elevation, rather than percentage composition.

*S. spinulosa* in 'Offshore Circalittoral Sand' (SS.SSa.Osa/ MD521) had lower percentage composition and elevation compared to those in mixed and coarse sediments. Patches identified as 'Not a Reef' within this habitat due to the lack of stable substrate and strong currents were also visually 'smothered' by mobile sand. Similarly, two occurrences of *S. spinulosa* were found in 'Offshore Circalittoral Muddy Sand' (SS.SSa.CMuSa/MD521), such as transect LL_138_TR, but the reef structure was again classified as 'Not a Reef' due to smothering by fines and increased turbidity. These 'smothered' crusts were more commonly observed in the northern part of the route corridor, where mobile sediments were more prevalent.

Overall, the *Sabellaria* assessment results indicate a heterogeneous presence along the route, predominantly observed in scattered aggregations within Blocks 10, 11, and 12. However, these aggregations did not form strong justification for Annex I protection.

**Table 3-23 Summary of Transects with Average Structure Resemblance Using the πr² Method**

| Geodetics: ERTS 1989; Projection UTM 31N | | | | *Sabellaria* Reefiness (After Gubbay 2007) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Transect** | **Easting (m)** | **Northing (m)** | **SSS Reflectivity** | **Mean Sabellaria cover for areas of similar cover** | **Mean height (cm) cover for areas of similar cover** | **Mean Reefiness (Structure)** | **Linear Extent (m)** | **Area ($m^2$)** | **Possible Incidences of Low Reef (Y/N)** | **Possible Incidences of Medium Reef (Y/N)** |
| LL_138_TR | 500 330<br>500 307 | 5 919 107<br>5 919 161 | Mottled low reflectivity | 0.0 | 0.0 | Not a Reef | 58.9 | 2722 | N | N |
| LL_102_TR | 472 207<br>472 318 | 5 847 409<br>5 847 407 | See Patch 001 | | | | | | | |
| | 472 319<br>472 375 | 5 847 407<br>5 847 406 | Mottled low reflectivity | 0.1 | 0 | Not a Reef | 55.9 | 2457 | N | N |
| LL_101_TR | 472 566<br>472 504 | 5 846 747<br>5 846 716 | Mottled low reflectivity | 0.1 | 0.1 | Not a Reef | 72.1 | 4085 | N | N |
| | 472 502<br>472 493 | 5 846 715<br>5 846 710 | Mottled medium reflectivity | 10.7 | 2 | Low Reef | 16.2 | 206 | Y | N |
| | 472 489<br>472 476 | 5 846 708<br>5 846 701 | Mottled low reflectivity | 0.2 | 0.1 | Not a Reef | 21.9 | 377 | N | N |
| | 472 474<br>472 465 | 5 846 700<br>5 846 695 | Mottled low reflectivity | 9.4 | 1.5 | Not a Reef | 13.9 | 152 | Y | N |
| | 472 463<br>472 452 | 5 846 694<br>5 846 689 | Mottled low reflectivity | 0.5 | 0.7 | Not a Reef | 15.9 | 199 | N | N |
| | 472 451<br>472 439 | 5 846 689<br>5 846 682 | See Patch 001 | | | | | | | |
| | 472 437<br>472 431 | 5 846 681<br>5 846 678 | Mottled low reflectivity | 0.2 | 0.2 | Not a Reef | 11.8 | 109 | N | N |
| | 472 429<br>472 406 | 5 846 677<br>5 846 666 | See Patch 001 | | | | | | | |
| | 472 405<br>472 391 | 5 846 665<br>5 846 659 | Mottled low reflectivity | 0 | 0 | No Reef | 18.4 | 267 | N | N |
| | 472 390<br>472 377 | 5 846 658<br>5 846 651 | See Patch 001 | | | | | | | |
| | 472 375<br>472 371 | 5 846 650<br>5 846 648 | Mottled low reflectivity | 0 | 0 | No Reef | 6.5 | 33 | N | N |
| LL_96_TR | 468 430<br>468 406 | 5 837 533<br>5 837 531 | Mottled low reflectivity | 0 | 0 | No Reef | 14.8 | 172 | Y | N |
| | 468 404<br>468 395 | 5 837 531<br>5 837 530 | Mottled medium reflectivity | 13.3 | 2.1 | Low Reef | 13.0 | 132 | Y | N |
| | 468 393<br>468 373 | 5 837 530<br>5 837 528 | Mottled low reflectivity | 0.1 | 0.1 | Not a Reef | 14.0 | 155 | N | N |
| | 468 372<br>468 352 | 5 837 528<br>5 837 524 | Mottled low reflectivity | 8.8 | 1.5 | Not a Reef | 14.2 | 159 | Y | N |
| | 468 350<br>468 340 | 5 837 524<br>5 837 523 | Mottled low reflectivity | 0 | 0 | No Reef | 12.7 | 126 | N | N |
| | 468 338<br>468 326 | 5 837 522<br>5 837 521 | Mottled low reflectivity | 9.9 | 1.2 | Not a Reef | 14.0 | 154 | Y | N |
| | 468 326<br>468 302 | 5 837 521<br>5 837 519 | Mottled low reflectivity | 1.1 | 0.5 | Not a Reef | 25.6 | 513 | N | N |
| | 468 301<br>468 284 | 5 837 519<br>5 837 516 | Mottled low reflectivity | 3.9 | 0.6 | Not a Reef | 19.5 | 299 | Y | N |
| | 468 282<br>468 277 | 5 837 516<br>5 837 515 | Mottled low reflectivity | 0 | 0 | No Reef | 5.7 | 25 | N | N |
| LL_94_TR | 465 950<br>465 984 | 5 834 671<br>5 834 788 | Mottled low reflectivity | 0.2 | 0.18 | Not a Reef | 121.7 | 17770 | N | N |
| LL_93_TR | 465 210<br>465 188 | 5 833 798<br>5 833 803 | See Patch 002 | | | | | | | |
| | 465 186<br>465 170 | 5 833 803<br>5 833 807 | Mottled medium reflectivity | 20.7 | 1.7 | Not a Reef | 20.1 | 318 | Y | N |
| | 465 168<br>465 148 | 5 833 807<br>5 833 812 | Mottled low reflectivity | 2.8 | 0.7 | Not a Reef | 24.8 | 481 | Y | N |
| | 465 146<br>465 133 | 5 833 812<br>5 833 814 | Mottled low reflectivity | 0 | 0 | No Reef | 16.9 | 225 | N | N |
| | 465 131<br>465 102 | 5 833 815<br>5 833 824 | Mottled high reflectivity | 39.6 | 2.3 | Low Reef | 33.2 | 863 | Y | N |
| | 465 101<br>465 076 | 5 833 824<br>5 833 829 | Mottled low reflectivity | 6.2 | 1 | Not a Reef | 26.4 | 546 | Y | N |
| LL_92_TR_ADD | 464 665<br>464 655 | 5 833 080<br>5 833 082 | Mottled low reflectivity | 0 | 0 | No Reef | 10.2 | 81 | N | N |
| | 464 653<br>464 596 | 5 833 082<br>5 833 097 | See Patch 003 | | | | | | | |
| | 464 595<br>464 585 | 5 833 098<br>5 833 100 | Mottled low reflectivity | 6.1 | 0.4 | Not a Reef | 10.2 | 82 | N | N |
| | 464 583<br>464 544 | 5 833 101<br>5 833 109 | See Patch 004 | | | | | | | |
| | 464 542<br>464 534 | 5 833 110<br>5 833 112 | Mottled low reflectivity | 0 | 0 | No Reef | 8.8 | 61 | N | N |
| | 464 533<br>464 518 | 5 833 112<br>5 833 115 | Mottled low reflectivity | 0.2 | 0.2 | Not a Reef | 17.9 | 253 | N | N |
| | 464 516<br>464 490 | 5 833 116<br>5 833 122 | Mottled medium reflectivity | 4 | 1.1 | Not a Reef | 28.5 | 639 | N | N |
| LL_92_TR_A | 464 594<br>464 588 | 5 833 180<br>5 833 174 | See Patch 003 | | | | | | | |
| | 464 586<br>464 576 | 5 833 172<br>5 833 161 | Mottled low reflectivity | 3.9 | 0.3 | Not a Reef | 18.4 | 265 | Y | N |
| | 464 576<br>464 545 | 5 833 160<br>5 833 126 | See Patch 004 | | | | | | | |
| | 464 543<br>464 514 | 5 833 124<br>5 833 090 | Mottled low reflectivity | 0.8 | 0.3 | Not a Reef | 49.5 | 1923 | N | N |
| | 464 512 | 5 833 089 | Mottled medium reflectivity | 9.1 | 1.3 | Not a Reef | 50.5 | 2004 | Y | N |

| **Geodetics: ERTS 1989; Projection UTM 31N** | | | | ***Sabellaria* Reefiness (After Gubbay 2007)** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Transect** | **Easting (m)** | **Northing (m)** | **SSS Reflectivity** | **Mean Sabellaria cover for areas of similar cover** | **Mean height (cm) cover for areas of similar cover** | **Mean Reefiness (Structure)** | **Linear Extent (m)** | **Area (m²)** | **Possible Incidences of Low Reef (Y/N)** | **Possible Incidences of Medium Reef (Y/N)** |
|  | 464 481 | 5 833 054 |  |  |  |  |  |  |  |  |
|  | 464 480<br>464 471 | 5 833 053<br>5 833 042 | Mottled medium reflectivity | 0 | 0 | No Reef | 16.2 | 205 | N | N |
| LL_90_TR_ADD | 464 022<br>464 039 | 5 832 476<br>5 832 499 | Mottled low reflectivity | 0.7 | 0.3 | Not a Reef | 31.2 | 763 | N | N |
| LL_90_TR_ADD | 464 040<br>464 059 | 5 832 501<br>5 832 531 | Mottled low reflectivity | 0.5 | 0.3 | Not a Reef | 37.4 | 1100 | N | N |
| LL_90_TR_ADD | 464 061<br>464 068 | 5 832 532<br>5 832 544 | See Patch 005 | | | | | | | |
| LL_90_TR_ADD | 464 070<br>464 077 | 5 832 547<br>5 832 556 | Mottled low reflectivity | 1.6 | 0.2 | Not a Reef | 15.3 | 183 | N | N |
| LL_90_TR | 463 920<br>463 980 | 5 832 513<br>5 832 518 | Mottled medium reflectivity | 2 | 0.5 | Not a Reef | 61.6 | 2981 | N | N |
| LL_90_TR | 463 981<br>464 019 | 5 832 518<br>5 832 519 | Mottled medium reflectivity | 0.4 | 0.2 | Not a Reef | 39.2 | 1205 | N | N |
| LL_90_TR | 464 020<br>464 039 | 5 832 520<br>5 832 521 | Mottled medium reflectivity | 1.9 | 0.8 | Not a Reef | 22.8 | 410 | N | N |
| LL_90_TR | 464 042<br>464 059 | 5 832 522<br>5 832 521 | Mottled medium reflectivity | 3.5 | 0.2 | Not a Reef | 21.7 | 370 | Y | N |
| LL_90_TR | 464 061<br>464 070 | 5 832 522<br>5 832 522 | See Patch 005 | | | | | | | |
| LL_90_TR | 464 072<br>464 074 | 5 832 522<br>5 832 522 | Mottled medium reflectivity | 0 | 0 | No Reef | 4.2 | 14 | N | N |
| LL_85_TR | 456 300<br>456 323 | 5 823 164<br>5 823 226 | Mottled low reflectivity | 0 | 0 | No Reef | 21.3 | 356 | N | N |
| LL_85_TR | 456 323<br>456 332 | 5 823 227<br>5 823 253 | Mottled low reflectivity | 12 | 1.7 | Not a Reef | 27.2 | 583 | Y | N |
| LL_84_TR | 455 146<br>455 133 | 5 821 941<br>5 821 939 | See Patch 008 | | | | | | | |
| LL_84_TR | 455 132<br>455 123 | 5 821 939<br>5 821 936 | Mottled low reflectivity | 0.2 | 0.4 | Not a Reef | 13.5 | 144 | N | N |
| LL_84_TR | 455 120<br>455 067 | 5 821 936<br>5 821 927 | See Patch 008 | | | | | | | |
| LL_84_TR | 455 065<br>455 016 | 5 821 926<br>5 821 913 | Mottled low reflectivity | 0.7 | 0.2 | Not a Reef | 55.5 | 2419 | Y | N |
| LL_84_TR | 455 013<br>454 974 | 5 821 913<br>5 821 902 | Mottled low reflectivity | 16.3 | 1.5 | Not a Reef | 45.2 | 1603 | Y | N |
| LL_84_TR | 454 972<br>454 969 | 5 821 900<br>5 821 901 | Mottled low reflectivity | 0 | 0 | No Reef | 4.0 | 12 | N | N |
| LL_82_TR | 454 623<br>454 589 | 5 821 241<br>5 821 219 | Mottled low reflectivity | 2.1 | 0.6 | Not a Reef | 42.9 | 1446 | Y | N |
| LL_82_TR | 454 587<br>454 574 | 5 821 218<br>5 821 208 | See Patch 009 | | | | | | | |
| LL_82_TR | 454 573<br>454 560 | 5 821 208<br>5 821 199 | Mottled low reflectivity | 0.8 | 0.3 | Not a Reef | 18.1 | 257 | N | N |
| LL_82_TR | 454 558<br>454 525 | 5 821 198<br>5 821 174 | See Patch 009 | | | | | | | |
| LL_82_TR | 454 524<br>454 514 | 5 821 174<br>5 821 167 | Mottled low reflectivity | 0.6 | 0.6 | Not a Reef | 13.3 | 138 | N | N |
| LL_81_TR | 454 519<br>454 498 | 5 820 782<br>5 820 810 | Mottled high reflectivity | 13.9 | 2.3 | Low Reef | 38.8 | 1181 | Y | N |
| LL_81_TR | 454 497<br>454 452 | 5 820 814<br>5 820 874 | Mottled low reflectivity | 0.5 | 0.2 | Not a Reef | 76.5 | 4599 | Y | N |
| LL_81_TR | 454 451<br>454 440 | 5 820 875<br>5 820 890 | Mottled medium reflectivity | 14.2 | 1.5 | Not a Reef | 21.2 | 353 | Y | N |
| LL_81_TR | 454 439<br>454 427 | 5 820 891<br>5 820 907 | Mottled low reflectivity | 0.6 | 0.4 | Not a Reef | 21.7 | 368 | N | N |
| LL_80_TR | 454 437<br>454 441 | 5 820 815<br>5 820 801 | Mottled low reflectivity | 1.2 | 0.4 | Not a Reef | 16.6 | 217 | Y | N |
| LL_80_TR | 454 442<br>454 453 | 5 820 799<br>5 820 743 | Mottled medium reflectivity | 15.6 | 2.1 | Low Reef | 60.6 | 2885 | Y | Y |
| LL_80_TR | 454 453<br>454 471 | 5 820 742<br>5 820 658 | Mottled low reflectivity | 0.9 | 0.2 | Not a Reef | 86.8 | 5911 | Y | N |
| LL_80_TR | 454 471<br>454 489 | 5 820 657<br>5 820 575 | Mottled medium reflectivity | 17.4 | 2 | Low Reef | 84.7 | 5632 | Y | Y |
| LL_79_TR | 454 030<br>454 038 | 5 820 296<br>5 820 302 | Mottled medium reflectivity | 14.6 | 3 | Low Reef | 11.1 | 97 | Y | N |
| LL_79_TR | 454 039<br>454 047 | 5 820 303<br>5 820 309 | Mottled low reflectivity | 0 | 0 | No Reef | 11.1 | 96 | N | N |
| LL_79_TR | 454 048<br>454 059 | 5 820 310<br>5 820 320 | See Patch 014 | | | | | | | |
| LL_79_TR | 454 061<br>454 096 | 5 820 321<br>5 820 350 | Mottled low reflectivity | 0.1 | 0 | Not a Reef | 48.8 | 1871 | N | N |
| LL_79_TR | 454 097<br>454 117 | 5 820 351<br>5 820 369 | Mottled low reflectivity | 11.1 | 1.8 | Not a Reef | 27.7 | 602 | Y | N |
| LL_79_TR | 454 118<br>454 140 | 5 820 370<br>5 820 387 | Mottled low reflectivity | 0 | 0.1 | Not a Reef | 32.9 | 851 | N | N |
| LL_79_TR | 454 142<br>454 150 | 5 820 389<br>5 820 395 | Mottled low reflectivity | 7.8 | 1.6 | Not a Reef | 9.8 | 75 | Y | N |
| LL_79_TR | 454 151<br>454 158 | 5 820 396<br>5 820 401 | Mottled low reflectivity | 1.7 | 0.7 | Not a Reef | 11.7 | 108 | N | N |
| LL_79_TR | 454 159<br>454 178 | 5 820 402<br>5 820 418 | Mottled medium reflectivity | 19.7 | 2.4 | Low Reef | 27.2 | 579 | Y | Y |
| LL_79_TR | 454 179<br>454 199 | 5 820 419<br>5 820 435 | Mottled low reflectivity | 0 | 0 | No Reef | 27.0 | 572 | N | N |

| Geodetics: ERTS 1989; Projection UTM 31N | | | | *Sabellaria* Reefiness (After Gubbay 2007) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Transect | Easting (m) | Northing (m) | SSS Reflectivity | Mean Sabellaria cover for areas of similar cover | Mean height (cm) cover for areas of similar cover | Mean Reefiness (Structure) | Linear Extent (m) | Area (m²) | Possible Incidences of Low Reef (Y/N) | Possible Incidences of Medium Reef (Y/N) |
| LL_78_TR | 455 988<br>455 967 | 5 819 831<br>5 819 904 | Mottled low reflectivity | 0 | 0 | No Reef | 76.9 | 4645 | N | N |
| | 455 966<br>455 940 | 5 819 905<br>5 819 992 | Mottled low reflectivity | 1.6 | 0.5 | Not a Reef | 92.2 | 6669 | N | N |
| | 455 940<br>455 933 | 5 819 993<br>5 820 021 | Mottled low reflectivity | 0 | 0 | No Reef | 30.0 | 709 | N | N |
| LL_77_TR | 454 082<br>454 065 | 5 820 166<br>5 820 148 | Mottled low reflectivity | 0.1 | 0.1 | Not a Reef | 27.1 | 576 | N | N |
| | 454 063<br>454 048 | 5 820 146<br>5 820 131 | See Patch 014 | | | | | | | |
| | 454 046<br>453 988 | 5 820 129<br>5 820 070 | Mottled low reflectivity | 0 | 0 | Not a Reef | 84.2 | 5571 | N | N |
| | 453 987<br>453 961 | 5 820 070<br>5 820 043 | Mottled low reflectivity | 3.2 | 0.8 | Not a Reef | 40.3 | 1275 | Y | N |
| | 453 959<br>453 946 | 5 820 040<br>5 820 028 | Mottled low reflectivity | 0.5 | 0.2 | Not a Reef | 21.3 | 355 | N | N |
| LL_76_TR | 453 633<br>453 646 | 5 820 144<br>5 820 145 | Mottled low reflectivity | 1.7 | 0.5 | Not a Reef | 14.5 | 166 | N | N |
| | 453 647<br>453 673 | 5 820 145<br>5 820 147 | Mottled low reflectivity | 3.1 | 1 | Not a Reef | 29.7 | 694 | Y | N |
| | 453 675<br>453 707 | 5 820 147<br>5 820 149 | Mottled low reflectivity | 0 | 0 | No Reef | 36.8 | 1066 | N | N |
| | 453 709<br>453 745 | 5 820 149<br>5 820 152 | See Patch 016 | | | | | | | |
| | 453 747<br>453 828 | 5 820 152<br>5 820 157 | Mottled low reflectivity | 0 | 0 | No Reef | 85.3 | 5709 | N | N |
| | 453 830<br>453 865 | 5 820 157<br>5 820 161 | Mottled low reflectivity | 15 | 1.5 | Not a Reef | 40.8 | 1310 | Y | N |
| | 453 869<br>453 877 | 5 820 161<br>5 820 161 | Mottled low reflectivity | 0.4 | 1 | Not a Reef | 9.7 | 74 | N | N |
| LL_75_TR | 453 729<br>453 727 | 5 820 231<br>5 820 071 | See Patch 016 | | | | | | | |
| | 453 727<br>453 728 | 5 820 069<br>5 820 002 | Mottled low reflectivity | 0 | 0 | No Reef | 69.2 | 3758 | N | N |
| LL_74_TR | 455 230<br>455 296 | 5 818 836<br>5 818 838 | Mottled low reflectivity | 2.2 | 0.6 | Not a Reef | 66.7 | 3495 | Y | N |
| | 455 297<br>455 313 | 5 818 838<br>5 818 838 | Mottled low reflectivity | 0.1 | 0.1 | Not a Reef | 17.0 | 227 | N | N |
| LL_73_TR | 453 496<br>453 490 | 5 819 442<br>5 819 440 | Mottled medium reflectivity | 0 | 0 | No Reef | 8.5 | 57 | N | N |
| | 453 488<br>453 431 | 5 819 439<br>5 819 421 | Mottled low reflectivity | 5.3 | 0.8 | Not a Reef | 64.3 | 3248 | Y | N |
| | 453 427<br>453 322 | 5 819 419<br>5 819 386 | Mottled low reflectivity | 0.8 | 0.2 | Not a Reef | 116.2 | 10609 | Y | N |
| | 453 320<br>453 267 | 5 819 385<br>5 819 370 | Mottled low reflectivity | 5.6 | 1.1 | Not a Reef | 59.0 | 2731 | Y | N |
| | 453 264<br>453 240 | 5 819 369<br>5 819 361 | Mottled low reflectivity | 0.1 | 0.1 | Not a Reef | 28.2 | 623 | N | N |
| LL_71_TR | 453 140<br>453 146 | 5 819 229<br>5 819 219 | Mottled low reflectivity | 0.6 | 0.5 | Not a Reef | 14.5 | 165 | N | N |
| | 453 147<br>453 220 | 5 819 217<br>5 819 096 | Mottled low reflectivity | 9.1 | 0.8 | Not a Reef | 144.5 | 16403 | Y | N |
| | 453 221<br>453 224 | 5 819 095<br>5 819 089 | Mottled low reflectivity | 1.2 | 0.3 | Not a Reef | 8.6 | 58 | N | N |
| LL_70_TR | 452 738<br>452 846 | 5 817 718<br>5 817 685 | Mottled low reflectivity | 4.2 | 0.6 | Not a Reef | 113.2 | 10055 | Y | N |
| LL_69_TR | 452 906<br>452 889 | 5 817 231<br>5 817 268 | Mottled low reflectivity | 0 | 0 | No Reef | 41.7 | 1367 | N | N |
| | 452 887<br>452 826 | 5 817 271<br>5 817 397 | Mottled low reflectivity | 2.5 | 0.5 | Not a Reef | 140.1 | 15414 | Y | N |
| LL_68_ADD | 452 968<br>453 036 | 5 817 163<br>5 817 174 | Mottled low reflectivity | 0.8 | 0.1 | Not a Reef | 69.0 | 3743 | Y | N |
| LL_68_TR | 453 085<br>453 066 | 5 816 985<br>5 816 985 | Mottled low reflectivity | 1.6 | 0.4 | Not a Reef | 21.5 | 364 | N | N |
| | 453 064<br>453 022 | 5 816 985<br>5 816 988 | Mottled low reflectivity | 13.6 | 1.1 | Not a Reef | 44.9 | 1582 | Y | N |
| | 453 021<br>453 002 | 5 816 988<br>5 816 989 | Mottled low reflectivity | 1.3 | 0.2 | Not a Reef | 19.7 | 306 | Y | N |
| LL_66_TR | 452 388<br>452 453 | 5 815 290<br>5 815 445 | Mottled low reflectivity | 6.2 | 0.7 | Not a Reef | 168.6 | 22313 | Y | N |
| | 452 453<br>452 469 | 5 815 445<br>5 815 479 | Mottled low reflectivity | 0 | 0 | No Reef | 37.9 | 1128 | N | N |
| LL_65_TR_A | 452 750<br>452 728 | 5 815 159<br>5 815 056 | Mottled low reflectivity | 0.2 | 0.2 | Not a Reef | 108.3 | 9209 | N | N |
| | 452 727<br>452 721 | 5 815 054<br>5 815 024 | Mottled low reflectivity | 0.7 | 0.5 | Not a Reef | 32.7 | 838 | N | N |
| LL_63_TR | 452 530<br>452 547 | 5 813 663<br>5 813 660 | Mottled medium reflectivity | 0 | 0 | No Reef | 20.1 | 316 | N | N |
| | 452 550<br>452 588 | 5 813 659<br>5 813 651 | Mottled medium reflectivity | 1.4 | 0.3 | Not a Reef | 44.0 | 1519 | N | N |
| | 452 590<br>452 621 | 5 813 651<br>5 813 645 | Mottled medium reflectivity | 0 | 0 | No Reef | 35.6 | 996 | N | N |
| | 452 623<br>452 737 | 5 813 645<br>5 813 622 | Mottled medium reflectivity | 1.8 | 0.3 | Not a Reef | 118.0 | 10927 | N | N |
| LL_62_TR | 452 422 | 5 811 987 | Mottled medium reflectivity | 11.3 | 1.1 | Not a Reef | 12.9 | 131 | Y | N |

| Geodetics: ERTS 1989; Projection UTM 31N | | | | *Sabellaria* Reefiness (After Gubbay 2007) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Transect | Easting (m) | Northing (m) | SSS Reflectivity | Mean Sabellaria cover for areas of similar cover | Mean height (cm) cover for areas of similar cover | Mean Reefiness (Structure) | Linear Extent (m) | Area (m²) | Possible Incidences of Low Reef (Y/N) | Possible Incidences of Medium Reef (Y/N) |
| | 452 432 | 5 811 982 | | | | | | | | |
| | 452 434<br>452 542 | 5 811 981<br>5 811 926 | Mottled low reflectivity | 8.2 | 0.8 | Not a Reef | 125.1 | 12291 | Y | N |
| | 452 544<br>452 549 | 5 811 925<br>5 811 922 | Mottled low reflectivity | 3.3 | 1 | Not a Reef | 7.0 | 39 | N | N |
| | 452 550<br>452 558 | 5 811 922<br>5 811 918 | Mottled low reflectivity | 7 | 0.6 | Not a Reef | 12.1 | 114 | N | N |
| | 452 560<br>452 561 | 5 811 917<br>5 811 916 | Mottled low reflectivity | 1.3 | 0.3 | Not a Reef | 4.5 | 16 | N | N |
| | 452 563<br>452 574 | 5 811 915<br>5 811 910 | Mottled low reflectivity | 8.5 | 0.7 | Not a Reef | 15.4 | 185 | N | N |
| | 452 575<br>452 585 | 5 811 909<br>5 811 904 | Mottled low reflectivity | 0 | 0 | No Reef | 13.1 | 135 | N | N |
| LL_61_TR | 452 426<br>452 371 | 5 810 971<br>5 810 958 | Mottled low reflectivity | 0 | 0 | Not a Reef | 58.8 | 2718 | N | N |
| LL_61_TR | 452 368<br>452 361 | 5 810 958<br>5 810 954 | Mottled low reflectivity | 1 | 0.8 | Not a Reef | 12.1 | 116 | N | N |
| LL_61_TR | 452 359<br>452 355 | 5 810 954<br>5 810 952 | Mottled low reflectivity | 0 | 0 | No Reef | 6.9 | 37 | N | N |
| LL_61_TR | 452 354<br>452 345 | 5 810 952<br>5 810 952 | Mottled low reflectivity | 1.7 | 0.8 | Not a Reef | 11.6 | 105 | N | N |
| LL_61_TR | 452 344<br>452 331 | 5 810 951<br>5 810 947 | Mottled low reflectivity | 0.2 | 0.2 | Not a Reef | 15.5 | 189 | N | N |
| LL_61_TR | 452 330<br>452 272 | 5 810 947<br>5 810 932 | Mottled low reflectivity | 0.6 | 0.3 | Not a Reef | 62.4 | 3059 | N | N |
| LL_61_TR | 452 271<br>452 256 | 5 810 932<br>5 810 926 | Mottled medium reflectivity | 0.2 | 0.2 | Not a Reef | 17.6 | 244 | N | N |
| LL_60_TR | 451 310<br>451 102 | 5 810 221<br>5 810 229 | Mottled low reflectivity | 3.4 | 0.4 | Not a Reef | 207.9 | 33945 | Y | N |
| LL_59_TR | 451 037<br>451 017 | 5 810 429<br>5 810 429 | Mottled low reflectivity | 0.4 | 0.1 | Not a Reef | 20.5 | 331 | N | N |
| LL_59_TR | 451 015<br>450 971 | 5 810 429<br>5 810 432 | Mottled low reflectivity | 1.6 | 0.2 | Not a Reef | 48.1 | 1814 | Y | N |
| LL_59_TR | 450 969<br>450 951 | 5 810 433<br>5 810 434 | Mottled low reflectivity | 2.7 | 0.5 | Not a Reef | 22.2 | 387 | Y | N |
| LL_59_TR | 450 948<br>450 913 | 5 810 434<br>5 810 438 | Mottled low reflectivity | 8.9 | 1 | Not a Reef | 39.6 | 1231 | Y | N |
| LL_59_TR | 450 911<br>450 899 | 5 810 438<br>5 810 439 | Mottled low reflectivity | 3.1 | 0.4 | Not a Reef | 15.7 | 192 | N | N |
| LL_59_TR | 450 897<br>450 880 | 5 810 439<br>5 810 440 | Mottled low reflectivity | 2.6 | 0.7 | Not a Reef | 19.9 | 311 | N | N |
| LL_59_TR | 450 879<br>450 858 | 5 810 440<br>5 810 441 | Mottled low reflectivity | 0 | 0 | No Reef | 22.9 | 410 | N | N |
| LL_58_TR | 449 569<br>449 501 | 5 809 770<br>5 809 786 | Mottled low reflectivity | 5.2 | 0.7 | Not a Reef | 70.8 | 3937 | Y | N |
| LL_58_TR | 449 499<br>449 491 | 5 809 786<br>5 809 788 | Mottled low reflectivity | 0 | 0 | No Reef | 11.2 | 98 | N | N |
| LL_56_TR | 448 294<br>448 285 | 5 809 303<br>5 809 305 | Mottled low reflectivity | 0.9 | 0.3 | Not a Reef | 9.7 | 73 | N | N |
| LL_56_TR | 448 283<br>448 271 | 5 809 305<br>5 809 306 | Mottled low reflectivity | 3.4 | 1.1 | Not a Reef | 13.8 | 149 | N | N |
| LL_56_TR | 448 268<br>448 258 | 5 809 306<br>5 809 306 | Mottled low reflectivity | 0.6 | 0.4 | Not a Reef | 12.7 | 127 | N | N |
| LL_56_TR | 448 257<br>448 190 | 5 809 306<br>5 809 312 | Mottled low reflectivity | 3.8 | 0.7 | Not a Reef | 68.6 | 3695 | Y | N |
| LL_53_TR | 444 954<br>444 965 | 5 807 614<br>5 807 612 | Mottled low reflectivity | 0 | 0 | No Reef | 11.3 | 100 | N | N |
| LL_53_TR | 444 967<br>445 067 | 5 807 613<br>5 807 604 | Mottled low reflectivity | 0.5 | 0.1 | Not a Reef | 101.8 | 8134 | N | N |
| LL_52_TR | 444 798<br>444 836 | 5 807 455<br>5 807 482 | Mottled low reflectivity | 0.1 | 0.1 | Not a Reef | 51.1 | 2052 | N | N |
| LL_52_TR | 444 840<br>444 850 | 5 807 484<br>5 807 492 | Mottled low reflectivity | 0.3 | 0.1 | Not a Reef | 17.5 | 240 | N | N |
| LL_50_TR | 442 902<br>442 923 | 5 807 159<br>5 807 116 | Mottled low reflectivity | 0 | 0 | No Reef | 49.5 | 1921 | N | N |
| LL_50_TR | 442 923<br>442 933 | 5 807 115<br>5 807 096 | Mottled low reflectivity | 0 | 0 | No Reef | 24.0 | 452 | N | N |
| LL_50_TR | 442 934<br>442 964 | 5 807 094<br>5 807 029 | Mottled low reflectivity | 0.3 | 0.1 | Not a Reef | 74.5 | 4358 | N | N |
| LL_49_TR | 441 794<br>441 817 | 5 807 033<br>5 807 030 | Mottled medium reflectivity | 0 | 0 | No Reef | 25.9 | 528 | N | N |
| LL_49_TR | 441 820<br>441 855 | 5 807 031<br>5 807 030 | Mottled low reflectivity | 1.5 | 0.4 | Not a Reef | 38.6 | 1170 | Y | N |
| LL_49_TR | 441 856<br>441 937 | 5 807 030<br>5 807 028 | Mottled medium reflectivity | 0 | 0 | No Reef | 82.3 | 5324 | N | N |
| LL_48_TR | 441 543<br>441 497 | 5 806 830<br>5 806 846 | Mottled low reflectivity | 0 | 0 | No Reef | 49.3 | 1910 | N | N |
| LL_48_TR | 441 496<br>441 464 | 5 806 846<br>5 806 858 | Mottled low reflectivity | 14 | 0.8 | Not a Reef | 33.5 | 883 | Y | N |
| LL_48_TR | 441 462<br>441 405 | 5 806 859<br>5 806 879 | Mottled low reflectivity | 0.1 | 0.1 | Not a Reef | 61.7 | 2986 | N | N |
| LL_48_TR | 441 404<br>441 390 | 5 806 880<br>5 806 886 | Mottled low reflectivity | 3.5 | 1 | Not a Reef | 19.6 | 302 | N | N |
| LL_48_TR | 441 387<br>441 346 | 5 806 886<br>5 806 901 | Mottled low reflectivity | 0.4 | 0.2 | Not a Reef | 46.0 | 1661 | N | N |

| Geodetics: ERTS 1989; Projection UTM 31N | | | | *Sabellaria* Reefiness (After Gubbay 2007) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Transect | Easting (m) | Northing (m) | SSS Reflectivity | Mean Sabellaria cover for areas of similar cover | Mean height (cm) cover for areas of similar cover | Mean Reefiness (Structure) | Linear Extent (m) | Area ($m^2$) | Possible Incidences of Low Reef (Y/N) | Possible Incidences of Medium Reef (Y/N) |
| LL_47_TR | 440 983<br>440 959 | 5 806 810<br>5 806 773 | Mottled low reflectivity | 0 | 0 | No Reef | 46.7 | 1716 | N | N |
| | 440 958<br>440 936 | 5 806 771<br>5 806 735 | Mottled low reflectivity | 0.5 | 0.3 | Not a Reef | 45.0 | 1590 | N | N |
| | 440 936<br>440 921 | 5 806 735<br>5 806 712 | Mottled low reflectivity | 0 | 0 | No Reef | 27.4 | 589 | N | N |
| LL_40_TR_ADD | 435 211<br>435 180 | 5 804 156<br>5 804 152 | Mottled low reflectivity | 0.5 | 0.2 | Not a Reef | 32.9 | 847 | N | N |
| | 435 178<br>435 144 | 5 804 152<br>5 804 146 | See Patch 023 | | | | | | | |
| | 435 142<br>435 101 | 5 804 146<br>5 804 143 | Mottled low reflectivity | 0 | 0 | - | 40.8 | 1307 | N | N |
| LL_40_TR_A | 435 159<br>435 160 | 5 804 183<br>5 804 175 | Mottled low reflectivity | 0 | 0 | - | 8.9 | 62 | N | N |
| | 435 160<br>435 164 | 5 804 174<br>5 804 136 | See Patch 023 | | | | | | | |
| | 435 164<br>435 172 | 5 804 134<br>5 804 078 | Mottled low reflectivity | 0 | 0 | - | 58.3 | 2672 | N | N |
| LL_39_TR_A | 434 535<br>434 507 | 5 803 934<br>5 803 960 | Mottled low reflectivity | 0 | 0 | Not a Reef | 40.5 | 1285 | N | N |
| | 434 505<br>434 427 | 5 803 961<br>5 804 035 | Mottled low reflectivity | 2.3 | 0.4 | Not a Reef | 110.5 | 9583 | N | N |
| | 434 426<br>434 394 | 5 804 036<br>5 804 067 | Mottled low reflectivity | 0 | 0 | Not a Reef | 46.6 | 1706 | N | N |
| LL_38_TR_A | 433 426<br>433 321 | 5 803 899<br>5 803 895 | Mottled low reflectivity | 1 | 0.3 | Not a Reef | 104.6 | 8592 | N | N |
| LL_36_TR | 431 929<br>431 935 | 5 803 723<br>5 803 718 | Mottled low reflectivity | 0.5 | 0.3 | Not a Reef | 9.9 | 76 | N | N |
| | 431 937<br>432 011 | 5 803 717<br>5 803 664 | Mottled low reflectivity | 3.6 | 0.7 | Not a Reef | 94.2 | 6966 | N | N |
| | 432 013<br>432 044 | 5 803 662<br>5 803 641 | Mottled low reflectivity | 0 | 0 | - | 34.0 | 909 | N | N |
| LL_35_TR | 431 503<br>431 414 | 5 803 727<br>5 803 681 | Mottled low reflectivity | 6.3 | 0.6 | Not a Reef | 101.1 | 8029 | N | N |
| | 431 413<br>431 387 | 5 803 680<br>5 803 667 | Mottled low reflectivity | 1 | 0.2 | Not a Reef | 18.8 | 279 | N | N |
| | 431 385<br>431 344 | 5 803 666<br>5 803 645 | Mottled low reflectivity | 10.3 | 0.9 | Not a Reef | 47.6 | 1778 | N | N |
| | 431 343<br>431 317 | 5 803 644<br>5 803 630 | Mottled low reflectivity | 1.1 | 0.3 | Not a Reef | 29.5 | 685 | N | N |
| LL_32_TR | 429 156<br>429 023 | 5 803 441<br>5 803 410 | Mottled low reflectivity | 0.6 | 0.2 | Not a Reef | 90.0 | 6359 | N | N |
| | 429 021<br>429 011 | 5 803 409<br>5 803 408 | Mottled low reflectivity | 0 | 0 | No Reef | 9.5 | 71 | N | N |
| LL_31_TR | 427 463<br>427 452 | 5 803 528<br>5 803 526 | Mottled low reflectivity | 0 | 0 | - | 12.9 | 131 | N | N |
| | 427 450<br>427 438 | 5 803 526<br>5 803 523 | Mottled low reflectivity | 2.5 | 1 | Not a Reef | 17.8 | 249 | N | N |
| | 427 434<br>427 336 | 5 803 523<br>5 803 504 | Mottled low reflectivity | 0 | 0 | - | 99.5 | 7781 | N | N |
| LL_26_TR | 423 106<br>423 068 | 5 803 526<br>5 803 527 | Mottled low reflectivity | 0 | 0 | No Reef | 40.4 | 1283 | N | N |
| | 423 065<br>423 041 | 5 803 527<br>5 803 526 | Mottled low reflectivity | 5.3 | 0.7 | Not a Reef | 26.9 | 567 | Y | N |
| | 423 039<br>423 017 | 5 803 526<br>5 803 528 | Mottled low reflectivity | 0 | 0 | No Reef | 23.8 | 443 | N | N |
| | 423 015<br>422 992 | 5 803 528<br>5 803 528 | Mottled low reflectivity | 0 | 0 | No Reef | 24.2 | 461 | N | N |
| | 422 991<br>422 929 | 5 803 528<br>5 803 530 | Mottled medium reflectivity | 2.3 | 0.8 | Not a Reef | 63.8 | 3,198 | Y | N |
| LL_25_TR | 422 486<br>422 480 | 5 803 349<br>5 803 350 | Mottled low reflectivity | 1 | 0.6 | Not a Reef | 8.7 | 59 | N | N |
| | 422 477<br>422 466 | 5 803 351<br>5 803 350 | Mottled low reflectivity | 17.6 | 1 | Not a Reef | 12.9 | 130 | N | N |
| | 422 464<br>422 458 | 5 803 350<br>5 803 351 | Mottled low reflectivity | 3.2 | 0.2 | Not a Reef | 10.0 | 78 | N | N |
| | 422 456<br>422 423 | 5 803 351<br>5 803 353 | Mottled low reflectivity | 10.4 | 1.1 | Not a Reef | 34.4 | 927 | N | N |
| | 422 422<br>422 413 | 5 803 353<br>5 803 355 | Mottled low reflectivity | 0.3 | 0.3 | Not a Reef | 10.0 | 78 | N | N |
| | 422 411<br>422 405 | 5 803 355<br>5 803 355 | Mottled low reflectivity | 11.6 | 1 | Not a Reef | 6.8 | 37 | N | N |
| | 422 404<br>422 390 | 5 803 355<br>5 803 356 | Mottled low reflectivity | 2.7 | 0.3 | Not a Reef | 15.8 | 197 | N | N |
| | 422 388<br>422 369 | 5 803 356<br>5 803 358 | Mottled medium reflectivity | 5.6 | 1 | Not a Reef | 23.1 | 418 | Y | N |
| | 422 367<br>422 356 | 5 803 358<br>5 803 359 | Mottled low reflectivity | 0 | 0 | No Reef | 12.4 | 162 | N | N |
| | 422 355<br>422 329 | 5 803 359<br>5 803 360 | Mottled low reflectivity | 0.5 | 0.2 | Not a Reef | 31.3 | 769 | N | N |
| | 422 327<br>422 322 | 5 803 361<br>5 803 361 | Mottled low reflectivity | 4 | 0.8 | Not a Reef | 6.6 | 34 | N | N |
| LL_20_TR | 417 402<br>417 338 | 5 800 838<br>5 800 886 | Mottled medium reflectivity | 3.7 | 0.5 | Not a Reef | 82.0 | 5,287 | Y | N |
| | 417 336 | 5 800 887 | Mottled low reflectivity | 0 | 0 | No Reef | 58.5 | 2,686 | N | N |

| **Geodetics: ERTS 1989; Projection UTM 31N** | | | | ***Sabellaria* Reefiness (After Gubbay 2007)** | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Transect** | **Easting (m)** | **Northing (m)** | **SSS Reflectivity** | **Mean Sabellaria cover for areas of similar cover** | **Mean height (cm) cover for areas of similar cover** | **Mean Reefiness (Structure)** | **Linear Extent (m)** | **Area (m²)** | **Possible Incidences of Low Reef (Y/N)** | **Possible Incidences of Medium Reef (Y/N)** |
| | 417 292 | 5 800 923 | | | | | | | | |
| LL_19_TR_E | 416 484 | 5 799 300 | Mottled low reflectivity | 1 | 0 | Not a Reef | 109.6 | 9,438 | N | N |
| | 416 375 | 5 799 300 | | | | | | | | |
| LL_19_TR_Da | 416 470 | 5 800 693 | Mottled low reflectivity | 1.4 | 0.2 | Not a Reef | 55.0 | 2,379 | N | N |
| | 416 415 | 5 800 692 | | | | | | | | |
| LL_19_Add_A | 416 567 | 5 800 358 | See Patch 024 | | | | | | | |
| | 416 648 | 5 799 977 | | | | | | | | |
| | 416 648 | 5 799 976 | Mottled low reflectivity | 0 | 0 | No Reef | 43.9 | 1,516 | N | N |
| | 416 665 | 5 799 896 | | | | | | | | |
| LL_19_TR | 416 437 | 5 800 145 | See Patch 024 | | | | | | | |
| | 416 443 | 5 800 141 | | | | | | | | |
| | 416 443 | 5 800 141 | Mottled medium reflectivity | 1.2 | 0.3 | Not a Reef | 59.7 | 2,795 | Y | N |
| | 416 498 | 5 800 123 | | | | | | | | |
| | 416 499 | 5 800 122 | See Patch 024 | | | | | | | |
| | 416 671 | 5 800 062 | | | | | | | | |
| | 416 675 | 5 800 062 | Mottled medium reflectivity | 0 | 0 | No Reef | 27.7 | 601 | N | N |
| | 416 701 | 5 800 051 | | | | | | | | |
| LL_19_ADD1 | 416 370 | 5 800 141 | See Patch 024 | | | | | | | |
| | 416 353 | 5 799 860 | | | | | | | | |
| | 416 353 | 5 799 858 | Mottled medium reflectivity | 0.5 | 0.2 | Not a Reef | 64.8 | 3,301 | N | N |
| | 416 349 | 5 799 795 | | | | | | | | |
| LL_18_TR | 415 751 | 5 799 766 | Mottled low reflectivity | 1.8 | 0 | Not a Reef | 37.7 | 1,114 | N | N |
| | 415 788 | 5 799 758 | | | | | | | | |
| | 415 789 | 5 799 758 | Mottled low reflectivity | 0.3 | 0.1 | Not a Reef | 349.6 | 95,983 | N | N |
| | 416 129 | 5 799 674 | | | | | | | | |

**Table 3-24 Summary of Transects/Patches with Average Structure Resemblance Using the Polygon Area Method**

| **Geodetics: ERTS 1989; Projection UTM 31N** | | | | | **Sabellaria Reefiness (After Gubbay 2007)** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Patch No.** | **Transect** | **Easting (m)** | **Northing (m)** | **SSS Reflectivity** | **Mean Sabellaria cover for areas of similar cover** | **Mean height (cm) cover for areas of similar cover** | **Mean Reefiness (Structure)** | **Area m2 (Area from polygons)** | **Possible Incidences of Low Reef (Y/N)** | **Possible Incidences of Medium Reef (Y/N)** |
| 1 | LL_102_TR | 472 207 | 5 847 409 | Mottled low reflectivity | 10 | 1.2 | Not a Reef | 10,340 | Y | N |
| | | 472 377 | 5 846 651 | | | | | | | |
| 3 | LL_92_TR_ADD | 464 653 | 5 833 082 | Mottled medium reflectivity | 16.9 | 1.7 | Not a Reef | 17,770 | Y | N |
| | | 464 588 | 5 833 174 | | | | | | | |
| | LL_92_TR_A | 464 594 | 5 833 180 | Mottled medium reflectivity | | | | | | |
| | | 464 588 | 5 833 174 | | | | | | | |
| 4 | LL_92_TR_ADD | 464 583 | 5 833 101 | Mottled medium reflectivity | 14.7 | 1.4 | Not a Reef | 11,590 | Y | N |
| | | 464 544 | 5 833 109 | | | | | | | |
| | LL_92_TR_A | 464 576 | 5 833 160 | Mottled medium reflectivity | | | | | | |
| | | 464 545 | 5 833 126 | | | | | | | |
| 5 | LL_90_ADD | 464 061 | 5 832 532 | Mottled low reflectivity | 29.9 | 2.2 | Low Reef | 5,110 | Y | N |
| | | 464 068 | 5 832 544 | | | | | | | |
| | LL_90_TR | 464 061 | 5 832 522 | Mottled medium reflectivity | | | | | | |
| | | 464 070 | 5 832 522 | | | | | | | |
| 8 | LL_84_TR | 455 146 | 5 821 941 | Mottled low reflectivity | 15.1 | 2 | Low Reef | 17,050 | Y | N |
| | | 455 067 | 5 821 927 | | | | | | | |
| 9 | LL_82_TR | 454 587 | 5 821 218 | Mottled low reflectivity | 18.3 | 2.11 | Low Reef | 8,800 | Y | N |
| | | 454 525 | 5 821 174 | | | | | | | |
| 17 | LL_79_TR | 454 030 | 5 820 296 | Mottled medium reflectivity | 14.6 | 3 | Low Reef | 1,136 | Y | N |
| | | 454 038 | 5 820 302 | | | | | | | |
| 14 | LL_79_TR | 454 159 | 5 820 402 | Mottled low reflectivity | 14.2 | 2 | Low Reef | 2,618 | Y | Y |
| | | 454 178 | 5 820 418 | | | | | | | |
| | LL_77_TR | 454 063 | 5 820 146 | Mottled low reflectivity | | | | | | |
| | | 454 048 | 5 820 131 | | | | | | | |
| 32 | LL_76_TR | 453 647 | 5 820 145 | Mottled low reflectivity | 3.1 | 1 | Not a Reef | 3,043 | Y | N |
| | | 453 673 | 5 820 147 | | | | | | | |
| 18 | LL_76_TR | 453 709 | 5 820 149 | Mottled medium reflectivity | 3.7 | 0.8 | Not a Reef | 5,590 | Y | N |
| | | 453 745 | 5 820 152 | | | | | | | |
| | LL_75_TR | 453 729 | 5 820 231 | Mottled medium reflectivity | | | | | | |
| | | 453 727 | 5 820 071 | | | | | | | |
| 33 | LL_76_TR | 453 830 | 5 820 157 | Mottled medium reflectivity | 15 | 1.5 | Not a Reef | 9,070 | Y | N |
| | | 453 865 | 5 820 161 | | | | | | | |
| 25 | LL_40_TR_ADD | 435 178 | 5 804 152 | Mottled low reflectivity | 4.3 | 0.8 | Not a Reef | 1,305 | Y | N |
| | | 435 144 | 5 804 146 | | | | | | | |
| | LL_40_TR_A | 435 160 | 5 804 174 | Mottled low reflectivity | | | | | | |
| | | 435 164 | 5 804 136 | | | | | | | |
| 24 | LL_19_ADD1 | 416 370 | 5 800 141 | Mottled low reflectivity | 4.7 | 0.7 | Not a Reef | 22,430 | Y | N |
| | | 416 353 | 5 799 860 | | | | | | | |
| | LL_19_TR | 416 437 | 5 800 145 | Mottled low reflectivity | | | | | | |
| | | 416 671 | 5 800 062 | | | | | | | |
| | LL_19_Add_A | 416 567 | 5 800 358 | Mottled low reflectivity | | | | | | |
| | | 416 648 | 5 799 977 | | | | | | | |
| 29 | LL_69_TR | 452 887 | 5 817 271 | Mottled medium reflectivity | 2.4 | 0.5 | Not a Reef | 129,500 | Y | N |
| | | 452 826 | 5 817 397 | | | | | | | |
| | LL_70_TR | 452 738 | 5 817 718 | Mottled medium reflectivity | 4.1 | 0.6 | Not a Reef | | | |
| | | 452 846 | 5 817 685 | | | | | | | |
| 30 | LL_71_TR | 453 147 | 5 819 217 | Mottled medium to high reflectivity | 9.1 | 0.8 | Not a Reef | 40,970 | Y | N |
| | | 453 220 | 5 819 096 | | | | | | | |

| **Geodetics: ERTS 1989; Projection UTM 31N** | | | | | **Sabellaria Reefiness (After Gubbay 2007)** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Patch No.** | **Transect** | **Easting (m)** | **Northing (m)** | **SSS Reflectivity** | **Mean Sabellaria cover for areas of similar cover** | **Mean height (cm) cover for areas of similar cover** | **Mean Reefiness (Structure)** | **Area m2 (Area from polygons)** | **Possible Incidences of Low Reef (Y/N)** | **Possible Incidences of Medium Reef (Y/N)** |
| 31 | LL_74_TR | 455 230<br>455 296 | 5 818 836<br>5 818 838 | Mottled medium to high reflectivity | 2.2 | 0.6 | Not a Reef | 28,700 | Y | N |
| 13 | LL_80_TR | 454 471<br>454 489 | 5 820 657<br>5 820 575 | Mottled medium reflectivity | 17.1 | 2 | Low Reef | 5,000 | Y | Y |
| 12 | LL_81_TR | 454 519<br>454 498 | 5 820 782<br>5 820 810 | Mottled low reflectivity | 13.9 | 2.3 | Low Reef | 1,510 | Y | N |
| 27 | LL_36_TR | 431 937<br>432 011 | 5 803 717<br>5 803 664 | Mottled low reflectivity | 3.6 | 0.7 | Not a Reef | 75,500 | N | N |
| 28 | LL_35_TR | 431 503<br>431 414 | 5 803 727<br>5 803 681 | Mottled low to medium reflectivity | 6.3 | 0.6 | Not a Reef | 72,300 | N | N |
| 34 | LL_49_TR | 441 820<br>441 855 | 5 807 031<br>5 807 030 | Mottled medium reflectivity | 1.5 | 0.4 | Not a Reef | 16,490 | Y | N |
| 35 | LL_53_TR | 444 967<br>445 067 | 5 807 613<br>5 807 604 | Mottled low to medium reflectivity | 0.5 | 0.1 | Not a Reef | 31,790 | N | N |
| 36 | LL_56_TR | 448 283<br>448 271 | 5 809 305<br>5 809 306 | Mottled medium reflectivity | 3.4 | 1.1 | Not a Reef | 1,670 | N | N |
| | | 448 257<br>448 190 | 5 809 306<br>5 809 312 | Mottled low reflectivity | 3.8 | 0.7 | Not a Reef | 44,820 | Y | N |
| 37 | LL_58_TR | 449 569<br>449 501 | 5 809 770<br>5 809 786 | Mottled medium reflectivity | 5.2 | 0.7 | Not a Reef | 1,529 | Y | N |
| 38 | LL_59_TR | 451 015<br>450 971 | 5 810 429<br>5 810 432 | Mottled low reflectivity | 1.6 | 0.2 | Not a Reef | 2,306 | Y | N |
| | | 450 948<br>450 913 | 5 810 434<br>5 810 438 | Mottled low to medium reflectivity | 8.6 | 1 | Not a Reef | 2,772 | Y | N |
| | | 450 897<br>450 880 | 5 810 439<br>5 810 440 | Mottled low to medium reflectivity | 2.6 | 0.7 | Not a Reef | 1,223 | N | N |
| | LL_60_TR | 451 310<br>451 102 | 5 810 221<br>5 810 229 | Mottled low to medium reflectivity | 3.4 | 0.4 | Not a Reef | 182,600 | Y | N |
| 39 | LL_62_TR | 452 422<br>452 432 | 5 811 987<br>5 811 982 | Mottled medium to high reflectivity | 11.3 | 1.1 | Not a Reef | 643 | Y | N |
| | | 452 434<br>452 542 | 5 811 981<br>5 811 926 | Mottled medium to high reflectivity | 8.2 | 0.8 | Not a Reef | 35,580 | Y | N |
| | | 452 550<br>452 558 | 5 811 922<br>5 811 918 | Mottled low to medium reflectivity | 7 | 0.6 | Not a Reef | 838 | N | N |
| | | 452 563<br>452 574 | 5 811 915<br>5 811 910 | Mottled low to medium reflectivity | 8.5 | 0.7 | Not a Reef | 643 | N | N |
| 40 | LL_65_TR_A | 452 750<br>452 728 | 5 815 159<br>5 815 056 | Mottled medium to high reflectivity | 0.2 | 0.2 | Not a Reef | 28,320 | N | N |
| 41 | LL_66_TR | 452 388<br>452 453 | 5 815 290<br>5 815 445 | Mottled low to medium reflectivity | 6.2 | 0.7 | Not a Reef | 29,880 | Y | N |
| 2 | LL_93_TR | 465 210<br>465 188 | 5 833 798<br>5 833 803 | Mottled medium to high reflectivity | 35.4 | 2.4 | Low Reef | 2,858 | Y | N |
| 42 | LL_80_TR | 454 442<br>454 453 | 5 820 799<br>5 820 743 | Mottled low to medium reflectivity | 15.6 | 2.1 | Low Reef | 1,187 | Y | Y |

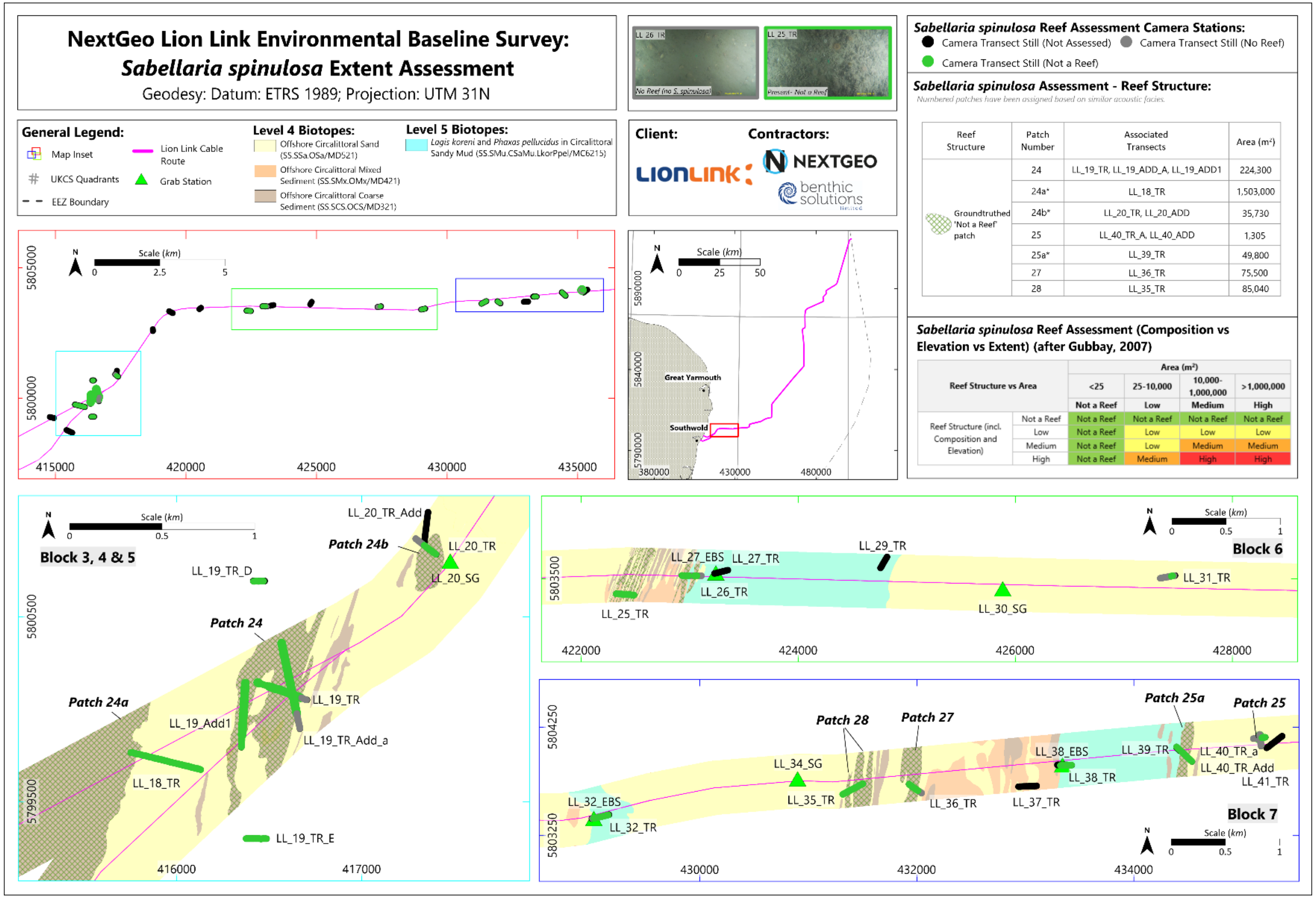



**Figure 3-51 *Sabellaria* Reef Assessment (Structure vs Extent) within Block 3 to Block 7**

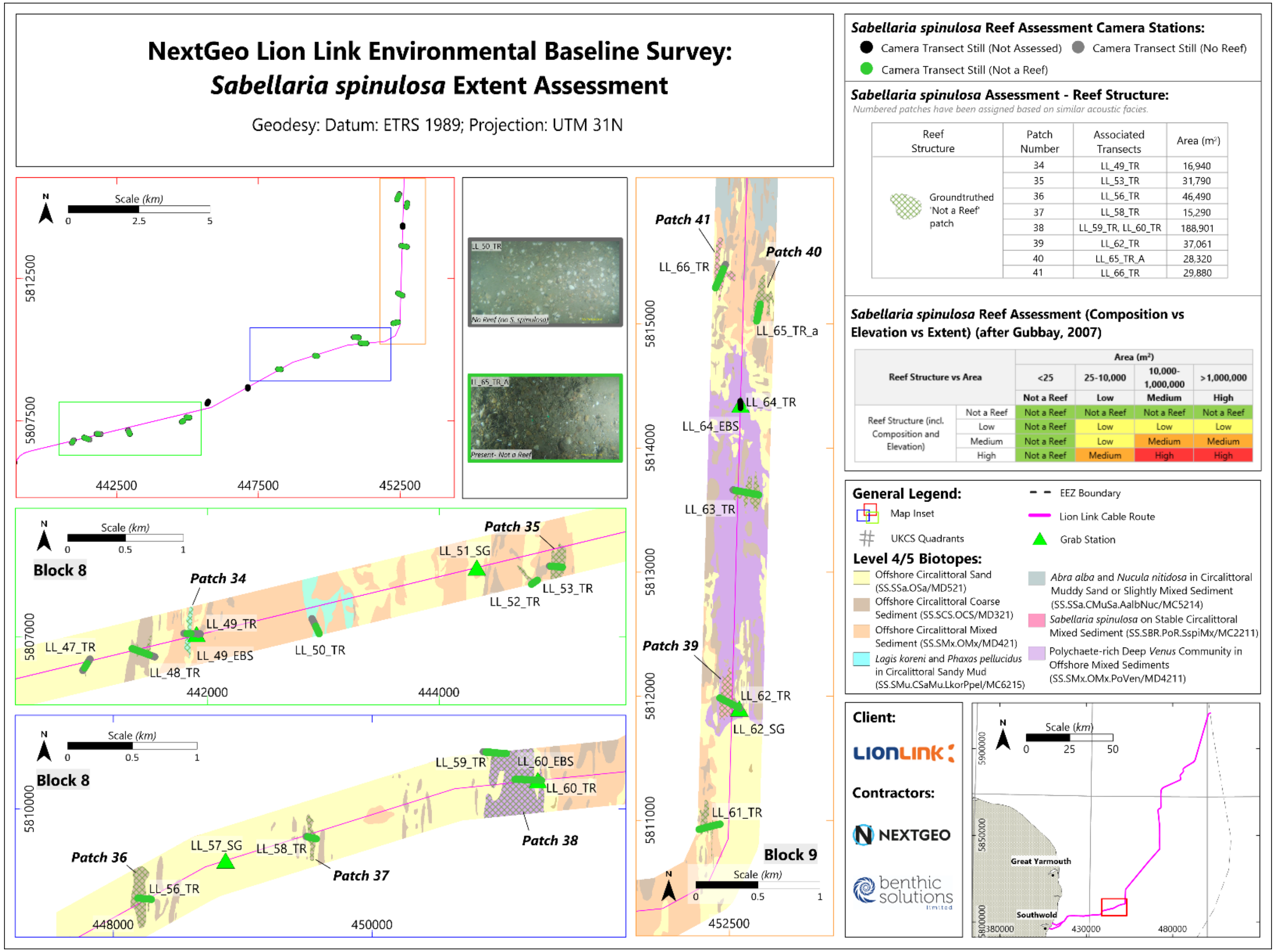



**Figure 3-52 *Sabellaria* Reef Assessment (Structure vs Extent) within Block 8 to Block 9**

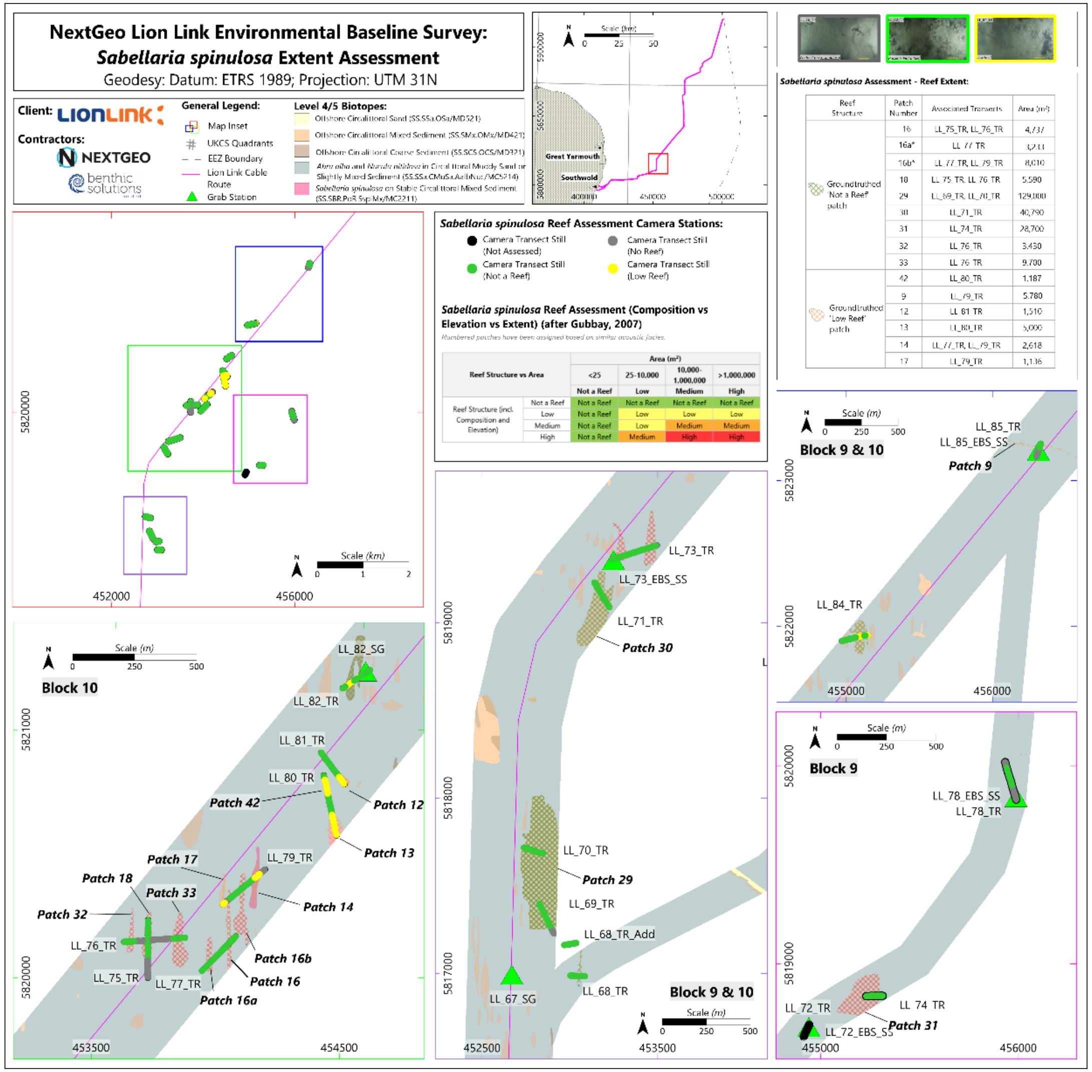
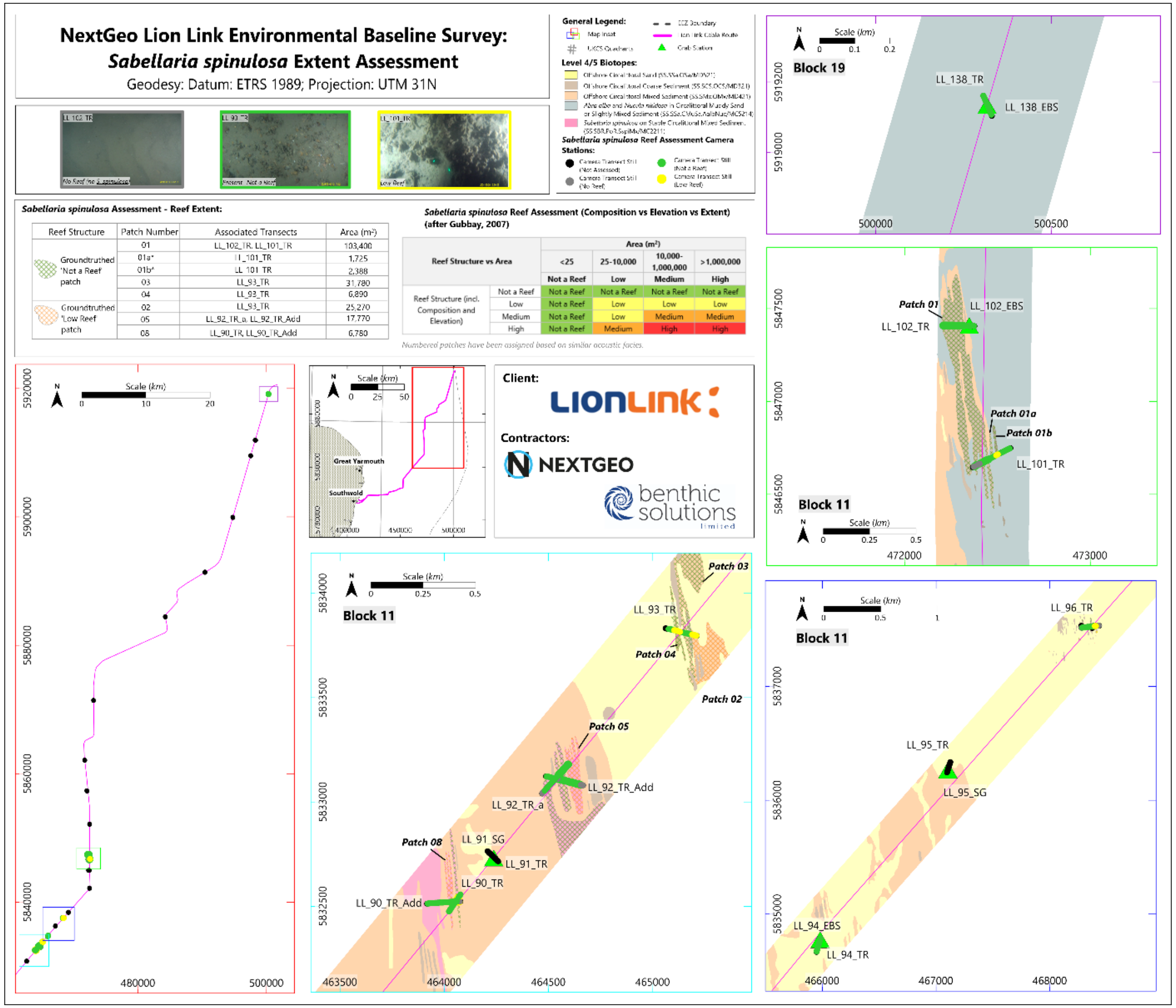



**Figure 3-53 *Sabellaria* Reef Assessment (Structure vs Extent) within Block 9 to Block 10**




| Reef Structure | Patch Number | Associated Transects | Area (m²) |
|---|---|---|---|
| Groundtruthed 'Not a Reef' patch | 01 | LL_102_TR, LL_101_TR | 103,400 |
| | 01a* | LL_101_TR | 1,725 |
| | 01b* | LL_101_TR | 2,388 |
| | 03 | LL_93_TR | 31,780 |
| | 04 | LL_93_TR | 6,890 |
| Groundtruthed 'Low Reef' patch | 02 | LL_93_TR | 25,270 |
| | 05 | LL_92_TR_a, LL_92_TR_Add | 17,770 |
| | 08 | LL_90_TR, LL_90_TR_Add | 6,780 |

| Reef Structure vs Area | | <25 | 25-10,000 | 10,000-1,000,000 | >1,000,000 |
|---|---|---|---|---|---|
| | | Not a Reef | Low | Medium | High |
| Reef Structure (incl. Composition and Elevation) | Not a Reef | Not a Reef | Not a Reef | Not a Reef | Not a Reef |
| | Low | Not a Reef | Low | Low | Low |
| | Medium | Not a Reef | Low | Medium | Medium |
| | High | Not a Reef | Medium | High | High |

Numbered patches have been assigned based on similar acoustic facies.

**Figure 3-54 *Sabellaria* Reef Assessment (Structure vs Extent) within Block 11 to Block 19**

#### 3.8.2.2 Annex I Stony Reefs

Hard substrates >64mm (i.e., cobbles ) were observed across the route, primarily concentrated in the troughs of sandwaves or within the scour of larger static features, such as epifaunal clusters. Despite this, no hard substrate features were identified that would necessitate further investigations to assess conformance with Annex I Stony reef status along the survey route.

#### 3.8.2.3 Raitt's Sandeel (*Ammodytes marinus*) Spawning and Nursery Grounds

Sandeels are small, thin eel-like fish that form large shoals and live most of their life buried in the seabed. They are considered an important component of marine food webs providing food for marine predators such as seabirds, mammals, and other fish (Furness, 1990; 2002). Of the five species of sandeels occurring in the North Sea, the Raitt's sandeel (*A. marinus*) is the most abundant and comprises over 90% of sandeel fishery catches (Fisheries Management Guidance, 2014). Sandbanks and other sandy areas are known to be important habitat for sandeel, which prefer habitats in water depths between 30m and 70m but are known to occur at depths of 15 m and 120 m (Holland *et al.,* 2005). These small fish burrow into the sediment, sand and use interstitial water to ventilate their gills (Holland *et al.,* 2005). They do not create a permanent opening when burrowed. Fine sediment has the potential to clog their gills and therefore, sandeel have a very specific habitat requirement, resulting in an often highly patchy distribution (Holland *et al.,* 2005; Jensen *et al.,* 2011).

Preferred sandeel habitat is a substrate which contains a high percentage of medium to coarse sand (particle size of 0.25 mm to 2 mm), with a mud content of less than 10% (particles <63 µm) (Wright *et al.,* 1998; Holland *et al.,* 2005). Sediments with a gravel component are also considered to be suitable for sandeel habitat. The inclusion of gravel means that using Folk classifications (Folk, 1954) to assess the habitat can overstate the suitability of habitat for sandeels. To determine areas of potential available habitat for sandeel grounds, the PSA results for the grab stations were compared to the parameters specified by Latto *et al.* (2013), with these groupings overlaid on a Folk Triangle scale in Figure 3-55.

**Table 3-25 Sandeel Ground Assessment Categories Specified by Latto *et al.* (2013)**

| Folk Categories | Habitat Preference |
|---|---|
| Sand | Preferred |
| Gravelly Sand | Preferred |
| Slightly Gravelly Sand | Preferred |
| Sandy Gravel | Marginal |
| Other | Unsuitable |

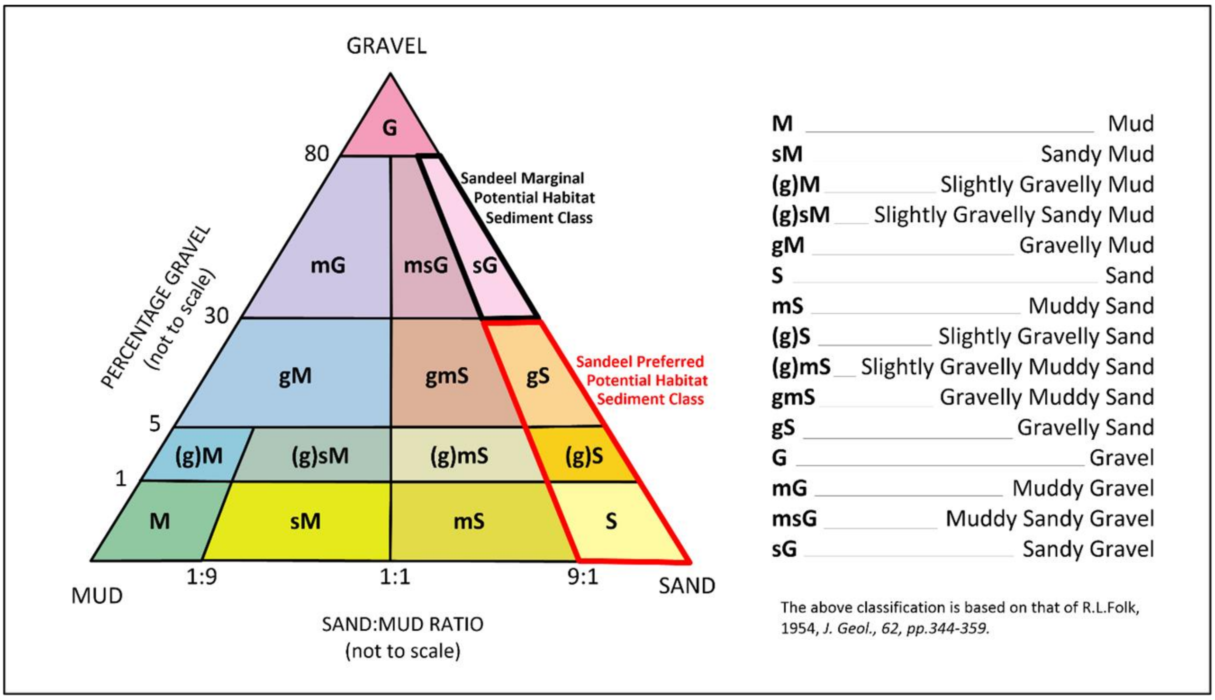



**Figure 3-55 Folk Sediment Triangle with Sandeel Preferred and Marginal Habitat Sediment Classes (Based on Latto *et al.*, 2011; adapted from Greenlink 2019)**

Results from analysis of PSA and assigned Folk scale data, using the method outlined in Latto *et al.* (2013) are outlined in Table 3-26. 'Preferred' sediments for sandeel grounds were identified at 46 stations, with the majority of station occurring along the northern extent of the route within the 'offshore circalittoral sand' habitat (Folk sediment classification: 'sand', 'slightly gravelly sand' and 'gravelly sand'; Table 3-26). Additionally, 'Marginal' conditions were identified at two stations (LL_03_TR and LL_42_SG) located within the 'offshore circalittoral sand' habitat, with various patches of 'offshore circalittoral coarse sediment' within the same area (Folk sediment classification: 'sandy gravel'). The remaining 36 stations were characterised as 'Unsuitable' for sandeel grounds due to the predominant proportions of muddy material and coarse sediments, which were assigned to the Folk classifications of 'muddy sand' and 'gravelly muddy sand' (Table 3-26; Figure 3-56 to Figure 3-59).

**Table 3-26 Sandeel ground assessment results using Latto et al. (2013)**

| Station | Water Depth (m) | Modified Folk Scale | Habitat Preference |
|---|---|---|---|
| LL_01_EBS | 5.0 | Gravelly Sand | Preferred |
| LL_02_TR | 8.0 | Muddy Gravel | Unsuitable |
| LL_03_TR | 6.0 | Sandy Gravel | Marginal |
| LL_04_TR_G | 9.7 | Sandy Mud | Unsuitable |
| LL_05_SG | 11.5 | Slightly Gravelly Sandy Mud | Unsuitable |
| LL_06_TR_G | 12.1 | Sandy Mud | Unsuitable |
| LL_07_TR_G | 12.4 | Sandy Mud | Unsuitable |
| LL_08_EBS | 14 | Gravelly Mud | Unsuitable |
| LL_09_TR_G | 18.4 | Sandy Mud | Unsuitable |
| LL_11_EBS | 19.6 | Sandy Mud | Unsuitable |

| | | | |
|---|---|---|---|
| LL_13_EBS | 11.8 | Sandy Mud | Unsuitable |
| LL_14_TR_G | 13.6 | Gravelly Mud | Unsuitable |
| LL_15_SG | 16.3 | Muddy Gravel | Unsuitable |
| LL_16_SG_ADD | 16 | Slightly Gravelly Sandy Mud | Unsuitable |
| LL_17_EBS | 15.5 | Sandy Mud | Unsuitable |
| LL_21_EBS | 21.4 | Sand | Preferred |
| LL_23_SG_SS | 35.1 | Slightly Gravelly Muddy Sand | Unsuitable |
| LL_27_EBS | 32 | Muddy Sandy Gravel | Unsuitable |
| LL_30_SG | 35.1 | Muddy Sand | Unsuitable |
| LL_32_EBS | 33.9 | Gravelly Muddy Sand | Unsuitable |
| LL_34_SG | 24 | Sand | Preferred |
| LL_38_EBS | 34.5 | Muddy Sand | Unsuitable |
| LL_42_SG | 37.3 | Sandy Gravel | Marginal |
| LL_44_EBS | 40.3 | Sand | Preferred |
| LL_45_SG_SS | 40.2 | Gravelly Sand | Preferred |
| LL_49_EBS | 44 | Muddy Sandy Gravel | Unsuitable |
| LL_51_SG | 38 | Muddy Sandy Gravel | Unsuitable |
| LL_55_EBS_SS | 38.6 | Slightly Gravelly Sand | Preferred |
| LL_57_SG | 38.8 | Slightly Gravelly Sand | Preferred |
| LL_60_EBS | 41.4 | Gravelly Sand | Preferred |
| LL_62_SG | 43.8 | Gravelly Sand | Preferred |
| LL_64_EBS | 46.4 | Gravelly Sand | Preferred |
| LL_67_SG | 43.7 | Slightly Gravelly Sand | Preferred |
| LL_72_EBS_SS | 43.9 | Gravelly Sand | Preferred |
| LL_73_EBS_SS | 45.8 | Slightly Gravelly Sand | Preferred |
| LL_78_EBS_SS | 41.6 | Gravelly Sand | Preferred |
| LL_82_SG | 47.6 | Gravelly Muddy Sand | Unsuitable |
| LL_85_EBS_SS | 45.6 | Slightly Gravelly Sand | Preferred |
| LL_86_SG | 48.3 | Slightly Gravelly Sand | Preferred |
| LL_87_EBS | 50.4 | Muddy Sand | Unsuitable |
| LL_88_SG | 51.3 | Slightly Gravelly Sand | Preferred |
| LL_89_EBS | 51.1 | Slightly Gravelly Sand | Preferred |
| LL_91_SG | 46.3 | Gravelly Muddy Sand | Unsuitable |
| LL_94_EBS | 47.7 | Slightly Gravelly Sand | Preferred |
| LL_95_SG | 47.2 | Gravelly Muddy Sand | Unsuitable |
| LL_97_EBS | 43.6 | Slightly Gravelly Sand | Preferred |
| LL_98_SG | 42.7 | Sand | Preferred |
| LL_99_EBS | 44 | Sand | Preferred |
| LL_100_SG | 43 | Slightly Gravelly Muddy Sand | Unsuitable |
| LL_102_EBS | 39.2 | Gravelly Muddy Sand | Unsuitable |
| LL_103_SG | 37.2 | Gravelly Sand | Preferred |
| LL_104_EBS | 36.1 | Gravelly Sand | Preferred |
| LL_105_SG | 37.5 | Slightly Gravelly Sand | Preferred |
| LL_106_EBS_SS | 35.9 | Slightly Gravelly Sand | Preferred |
| LL_107_SG | 36.6 | Slightly Gravelly Sand | Preferred |
| LL_108_EBS | 36.6 | Slightly Gravelly Sand | Preferred |
| LL_109_SG | 27.5 | Sand | Preferred |
| LL_110_SG | 27.1 | Muddy Sand | Unsuitable |
| LL_111_SG | 35.2 | Sand | Preferred |
| LL_112_EBS_SS | 34.3 | Sand | Preferred |
| LL_113_SG | 35.3 | Sand | Preferred |
| LL_114_SG | 38.5 | Sand | Preferred |

| | | | |
|---|---|---|---|
| LL_115_SG | 34.2 | Sand | Preferred |
| LL_116_EBS | 35.2 | Muddy Sand | Unsuitable |
| LL_117_SG | 24.7 | Muddy Sand | Unsuitable |
| LL_118_SG | 32.5 | Sand | Preferred |
| LL_119_SG | 23 | Sand | Preferred |
| LL_120_EBS | 34 | Gravelly Muddy Sand | Unsuitable |
| LL_121_SG | 32 | Slightly Gravelly Muddy Sand | Unsuitable |
| LL_122_SG | 20.7 | Sand | Preferred |
| LL_124_SG | 30.4 | Sand | Preferred |
| LL_125_EBS | 31.4 | Sand | Preferred |
| LL_126_SG | 30 | Sand | Preferred |
| LL_127_SG | 22.3 | Sand | Preferred |
| LL_128_SG | 30.4 | Gravelly Muddy Sand | Unsuitable |
| LL_129_EBS | 31 | Slightly Gravelly Sand | Preferred |
| LL_130_SG | 37.7 | Sand | Preferred |
| LL_131_SG | 28.6 | Muddy Sand | Unsuitable |
| LL_132_SG | 27.3 | Sand | Preferred |
| LL_133_EBS | 27.4 | Sand | Preferred |
| LL_134_SG | 29 | Sand | Preferred |
| LL_135_SG | 29 | Muddy Sand | Unsuitable |
| LL_137_SG | 29.7 | Muddy Sand | Unsuitable |
| LL_138_EBS | 29 | Muddy Sand | Unsuitable |

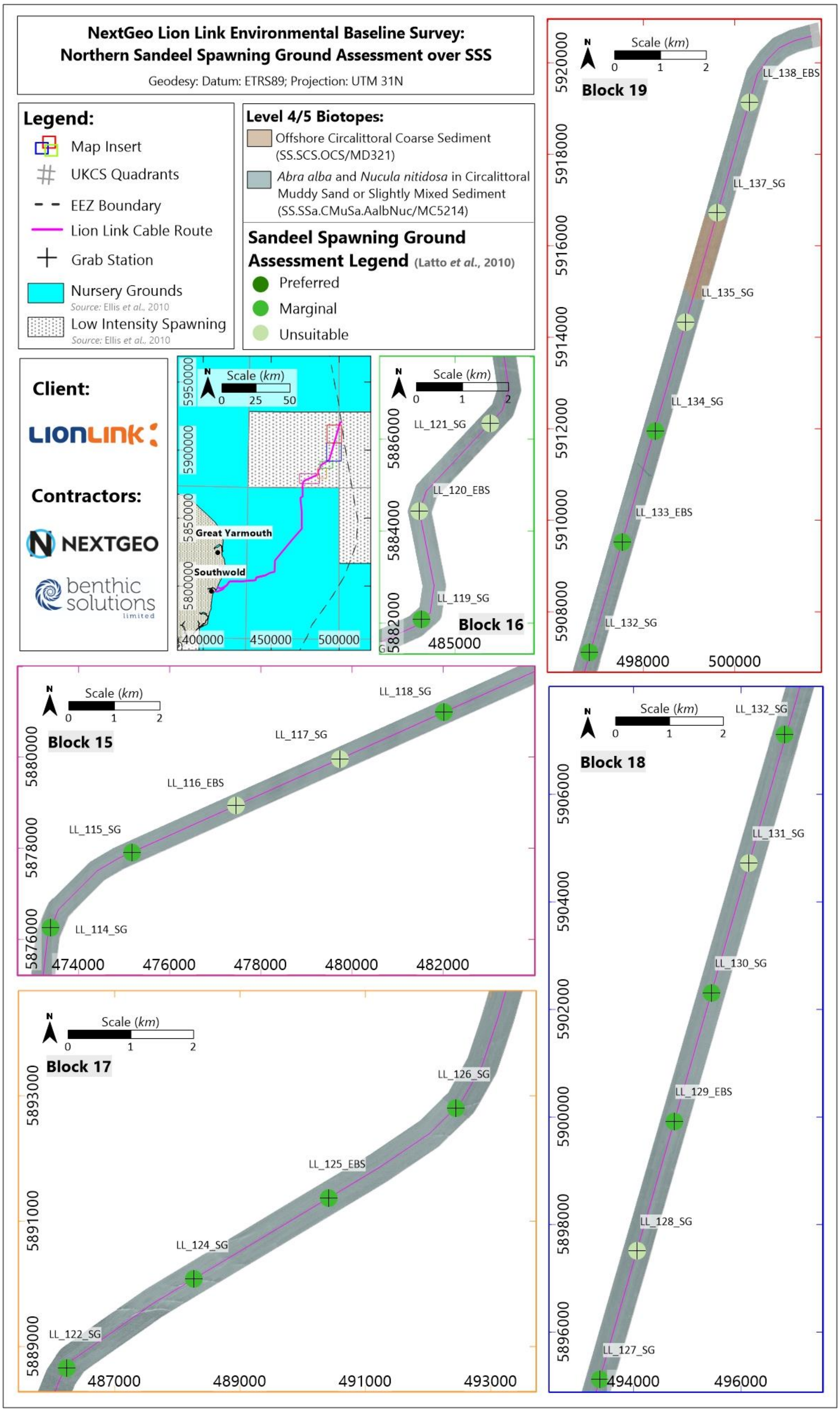



**Figure 3-56 Sandeel Spawning and Nursery Grounds per Latto et al (2013) within Block 19 to Block 15**

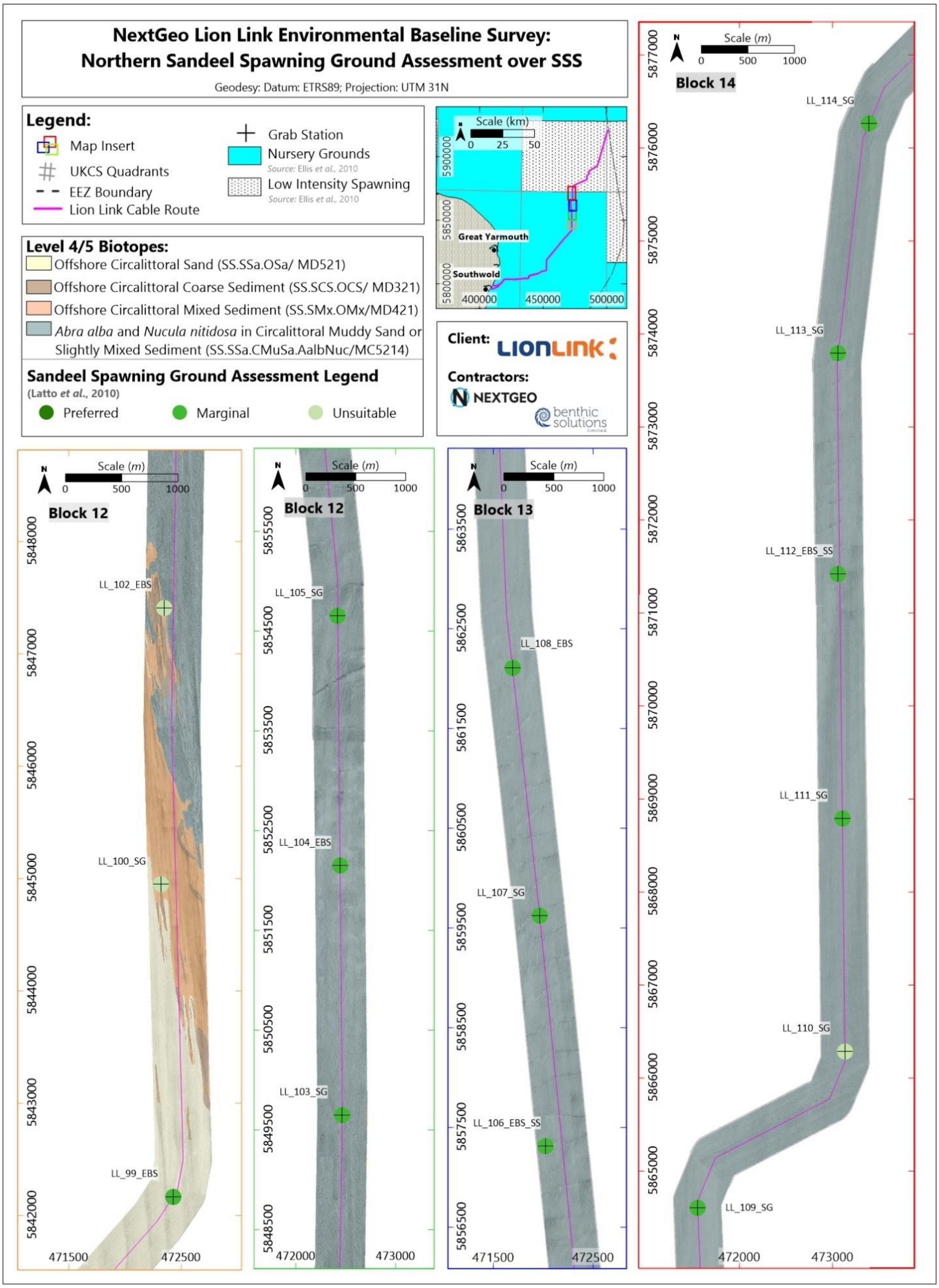



**Figure 3-57 Sandeel Spawning and Nursery Grounds per Latto et al (2013) within Block 14 to Block 12**

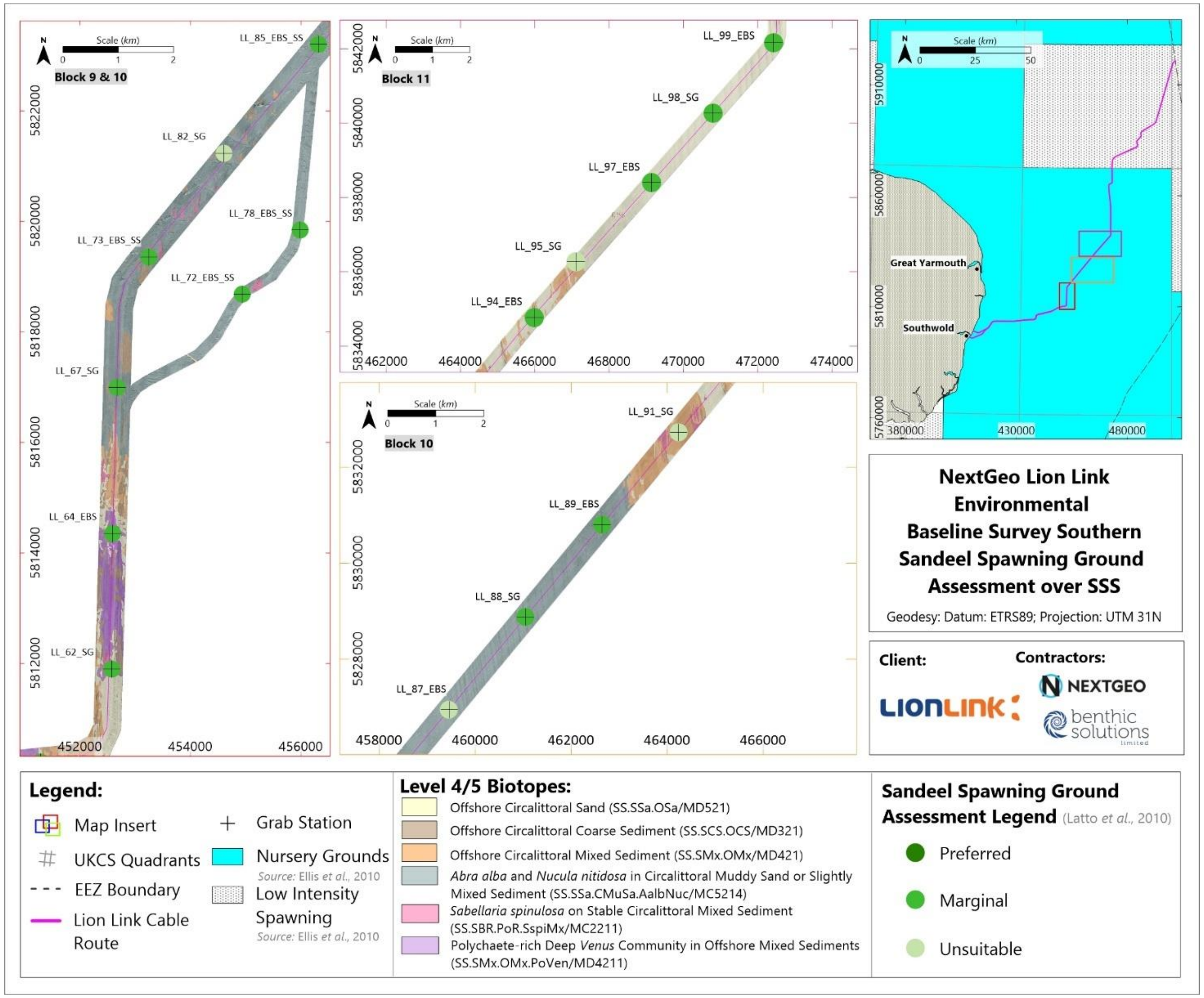



**Figure 3-58 Sandeel Spawning and Nursery Grounds per Latto et al (2013) within Block 11 to Block 9**

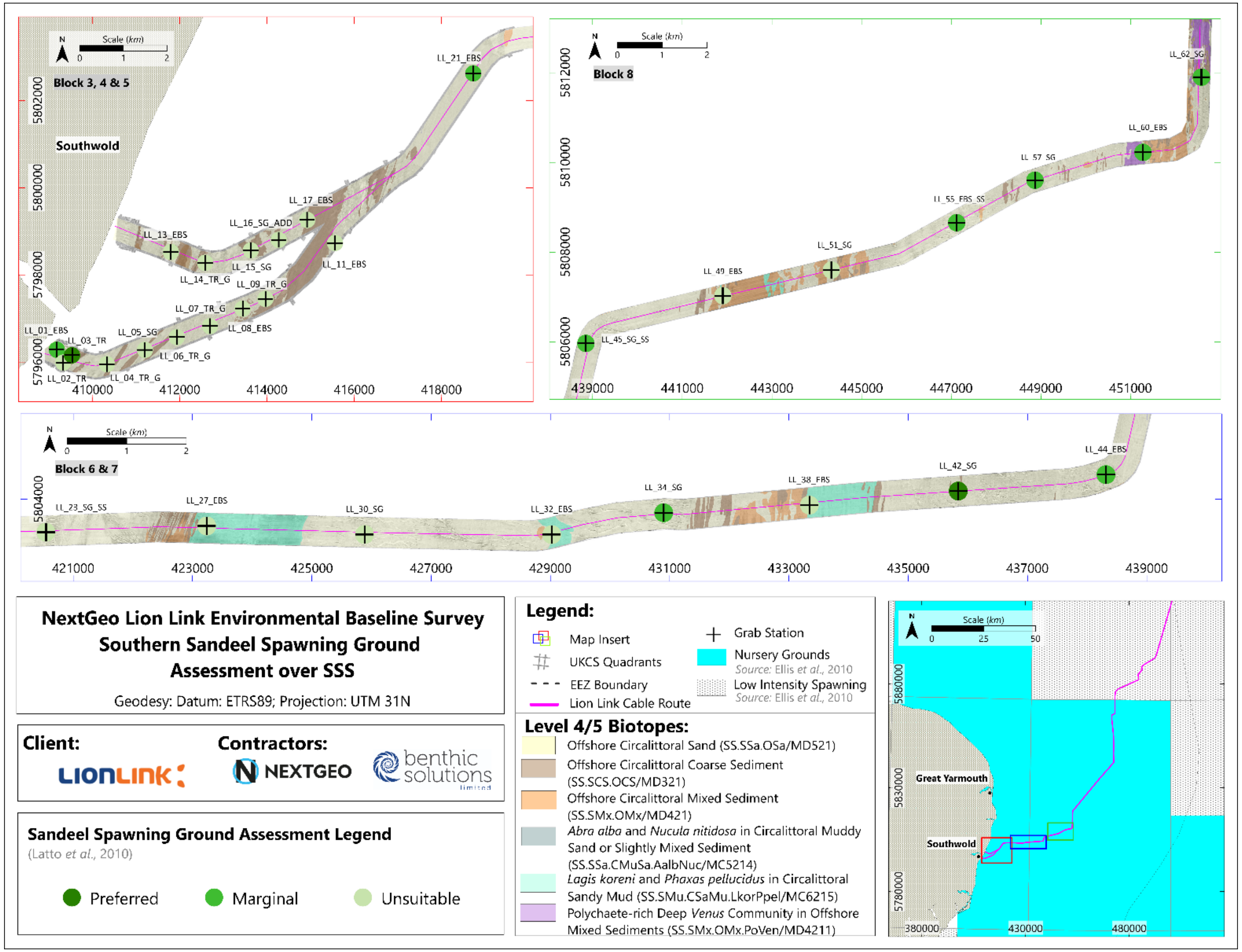



**Figure 3-59 Sandeel Spawning and Nursery Grounds per Latto et al (2013) within Block 9 to Block 3**

More specific definitions of sandeel preferred grounds using sediment particle size were provided by Greenstreet *et al.* (2010). This method utilises the percentage composition of the sediment by weight, which is split into two distinct fractions; silt and fine sand (particles >0.25mm), and medium to coarse sand (particles 0.25-2.0mm). The coarse >2mm fraction, which can often overstate sandeel habitat suitability, is not considered by this method. The sediment fraction data are then used to assess sandeel sediment preference for each station from Figure 3-60.

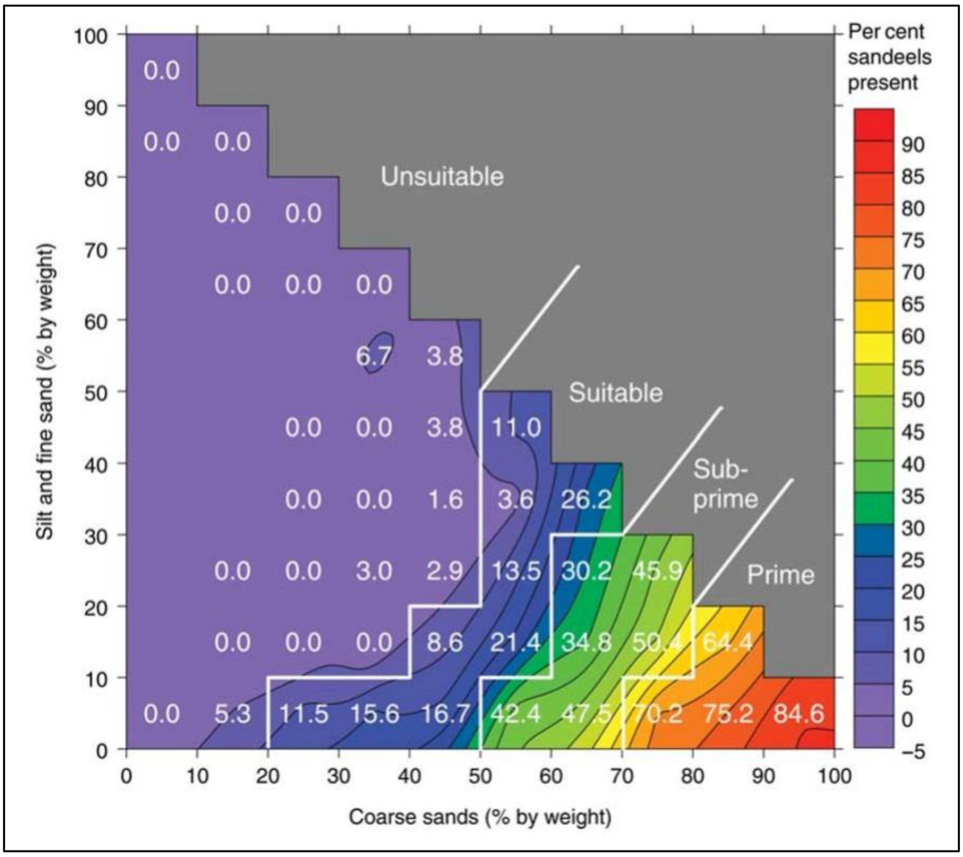



**Figure 3-60 Sandeel Sediment Preference Categories as per Greenstreet *et al.* (2010) (silt and fine sand refer to particle sizes >0.25mm, whilst medium to coarse sand refer to particle sizes 0.25 to 2.0mm)**

The results obtained using the Greenstreet *et al.* (2010) method indicated lower habitat suitability compared to the Latto *et al.*, (2013) method. Stations classified as 'Unsuitable' under Latto *et al.*, (2013) mostly remained 'Unsuitable' using the Greenstreet *et al.* (2010) approach. However, 13 stations previously identified as 'Unsuitable' by Latto *et al.*, 2013 were reclassified as 'Suitable', 'Sub-Prime' or 'Prime' under Greenstreet et al., (2010) due to the presence of coarser sands (Table 3-27; Figure 3-61 to Figure 3-64.

Of the 46 stations identified as 'Preferred' by Latto *et al.*, 2013, 35 retained a classification of 'Sub-Prime' to 'Prime' under the Greenstreet methodology. The remaining 11 stations were reclassified to 'Suitable' or 'Unsuitable', likely due to a significant proportion of fine sands and muddy material in those sediments. During video review across transects, 30 instances of sandeels were observed (Table 3-18), along with a single instance recorded during grab sampling at station LL_108_EBS. However, it is important to note that even in optimal habitats, sandeels may remain absent if populations are below the area's carrying capacity (Holland *et al.*, 2005).

**Table 3-27 Sandeel Ground Assessment Results using Greenstreet *et al.* (2010)**

| Station | Depth (m) | Silt and Fine Sands (% by weight) | Medium to Coarse Sands (% by weight) | Habitat Preference |
|---|---|---|---|---|
| LL_01_EBS | 5.0 | 50.1 | 52.3 | Unsuitable |
| LL_02_TR | 8.0 | 86.4 | 17.3 | Unsuitable |
| LL_03_TR | 6.0 | 39.1 | 63.0 | Suitable |
| LL_04_TR_G | 9.7 | 96.8 | 3.1 | Unsuitable |
| LL_05_SG | 11.5 | 95.0 | 0.1 | Unsuitable |
| LL_06_TR_G | 12.1 | 90.2 | 8.9 | Unsuitable |
| LL_07_TR_G | 12.4 | 91.9 | 8.0 | Unsuitable |
| LL_08_EBS | 14 | 78.3 | 15.7 | Unsuitable |
| LL_09_TR_G | 18.4 | 95.2 | 4.5 | Unsuitable |
| LL_11_EBS | 19.6 | 90.6 | 9.1 | Unsuitable |
| LL_13_EBS | 11.8 | 97.6 | 2.3 | Unsuitable |
| LL_14_TR_G | 13.6 | 82.8 | 10.9 | Unsuitable |
| LL_15_SG | 16.3 | 32.1 | 7.3 | Unsuitable |
| LL_16_SG_ADD | 16 | 85.7 | 13.2 | Unsuitable |
| LL_17_EBS | 15.5 | 99.9 | 0.1 | Unsuitable |
| LL_21_EBS | 21.4 | 81.4 | 18.6 | Unsuitable |
| LL_23_SG_SS | 35.1 | 37.8 | 59.9 | Suitable |
| LL_27_EBS | 32 | 38.8 | 28.7 | Unsuitable |
| LL_30_SG | 35.1 | 69.6 | 30.4 | Unsuitable |
| LL_32_EBS | 33.9 | 51.4 | 26.9 | Unsuitable |
| LL_34_SG | 24 | 8.3 | 91.7 | Prime |
| LL_38_EBS | 34.5 | 40.9 | 59.1 | Suitable |
| LL_42_SG | 37.3 | 14.6 | 46.8 | Suitable |
| LL_44_EBS | 40.3 | 12.2 | 87.6 | Prime |
| LL_45_SG_SS | 40.2 | 6.9 | 65.3 | Sub-Prime |
| LL_49_EBS | 44 | 15.6 | 42.6 | Suitable |
| LL_51_SG | 38 | 14.0 | 44.9 | Suitable |
| LL_55_EBS_SS | 38.6 | 1.8 | 94.3 | Prime |
| LL_57_SG | 38.8 | 1.6 | 93.9 | Prime |
| LL_60_EBS | 41.4 | 6.2 | 87.9 | Prime |
| LL_62_SG | 43.8 | 1.9 | 70.5 | Prime |
| LL_64_EBS | 46.4 | 15.9 | 73.6 | Sub-Prime |
| LL_67_SG | 43.7 | 0.1 | 97.0 | Prime |
| LL_72_EBS_SS | 43.9 | 3.5 | 90.4 | Prime |
| LL_73_EBS_SS | 45.8 | 3.1 | 94.2 | Prime |
| LL_78_EBS_SS | 41.6 | 0.2 | 93.1 | Prime |
| LL_82_SG | 47.6 | 27.6 | 61.7 | Sub-Prime |
| LL_85_EBS_SS | 45.6 | 0.9 | 96.6 | Prime |
| LL_86_SG | 48.3 | 14.4 | 84.5 | Prime |
| LL_87_EBS | 50.4 | 38.9 | 61.0 | Suitable |
| LL_88_SG | 51.3 | 22.5 | 74.9 | Sub-Prime |
| LL_89_EBS | 51.1 | 7.8 | 89.2 | Prime |
| LL_91_SG | 46.3 | 34.4 | 52.1 | Suitable |
| LL_94_EBS | 47.7 | 18.3 | 78.9 | Sub-Prime |
| LL_95_SG | 47.2 | 36.2 | 52.0 | Suitable |
| LL_97_EBS | 43.6 | 8.1 | 90.7 | Prime |
| LL_98_SG | 42.7 | 22.8 | 77.0 | Sub-Prime |
| LL_99_EBS | 44 | 12.3 | 87.0 | Prime |
| LL_100_SG | 43 | 60.9 | 36.0 | Unsuitable |
| LL_102_EBS | 39.2 | 28.6 | 63.1 | Sub-Prime |

| Station | Depth (m) | Silt and Fine Sands (% by weight) | Medium to Coarse Sands (% by weight) | Habitat Preference |
|---|---|---|---|---|
| LL_103_SG | 37.2 | 7.5 | 86.3 | Prime |
| LL_104_EBS | 36.1 | 15.9 | 77.1 | Sub-Prime |
| LL_105_SG | 37.5 | 9.2 | 88.4 | Prime |
| LL_106_EBS_SS | 35.9 | 10.0 | 88.1 | Prime |
| LL_107_SG | 36.6 | 6.8 | 92.1 | Prime |
| LL_108_EBS | 36.6 | 9.6 | 88.7 | Prime |
| LL_109_SG | 27.5 | 16.7 | 82.5 | Prime |
| LL_110_SG | 27.1 | 41.5 | 57.6 | Suitable |
| LL_111_SG | 35.2 | 8.0 | 91.2 | Prime |
| LL_112_EBS_SS | 34.3 | 15.7 | 83.3 | Prime |
| LL_113_SG | 35.3 | 11.6 | 88.2 | Prime |
| LL_114_SG | 38.5 | 20.7 | 78.4 | Sub-Prime |
| LL_115_SG | 34.2 | 25.6 | 74.0 | Sub-Prime |
| LL_116_EBS | 35.2 | 40.5 | 59.2 | Suitable |
| LL_117_SG | 24.7 | 40.0 | 60.0 | Suitable |
| LL_118_SG | 32.5 | 12.5 | 87.2 | Prime |
| LL_119_SG | 23 | 28.3 | 71.2 | Sub-Prime |
| LL_120_EBS | 34 | 49.2 | 38.0 | Unsuitable |
| LL_121_SG | 32 | 32.3 | 65.4 | Suitable |
| LL_122_SG | 20.7 | 20.2 | 79.7 | Sub-Prime |
| LL_124_SG | 30.4 | 31.1 | 68.8 | Suitable |
| LL_125_EBS | 31.4 | 41.6 | 57.5 | Suitable |
| LL_126_SG | 30 | 40.2 | 59.6 | Suitable |
| LL_127_SG | 22.3 | 46.0 | 53.7 | Suitable |
| LL_128_SG | 30.4 | 47.3 | 45.5 | Unsuitable |
| LL_129_EBS | 31 | 51.5 | 47.5 | Unsuitable |
| LL_130_SG | 37.7 | 54.7 | 45.3 | Unsuitable |
| LL_131_SG | 28.6 | 70.3 | 29.2 | Unsuitable |
| LL_132_SG | 27.3 | 59.8 | 39.4 | Unsuitable |
| LL_133_EBS | 27.4 | 56.8 | 43.2 | Unsuitable |
| LL_134_SG | 29 | 71.7 | 28.1 | Unsuitable |
| LL_135_SG | 29 | 82.5 | 17.2 | Unsuitable |
| LL_137_SG | 29.7 | 91.1 | 8.7 | Unsuitable |
| LL_138_EBS | 29 | 93.1 | 6.7 | Unsuitable |

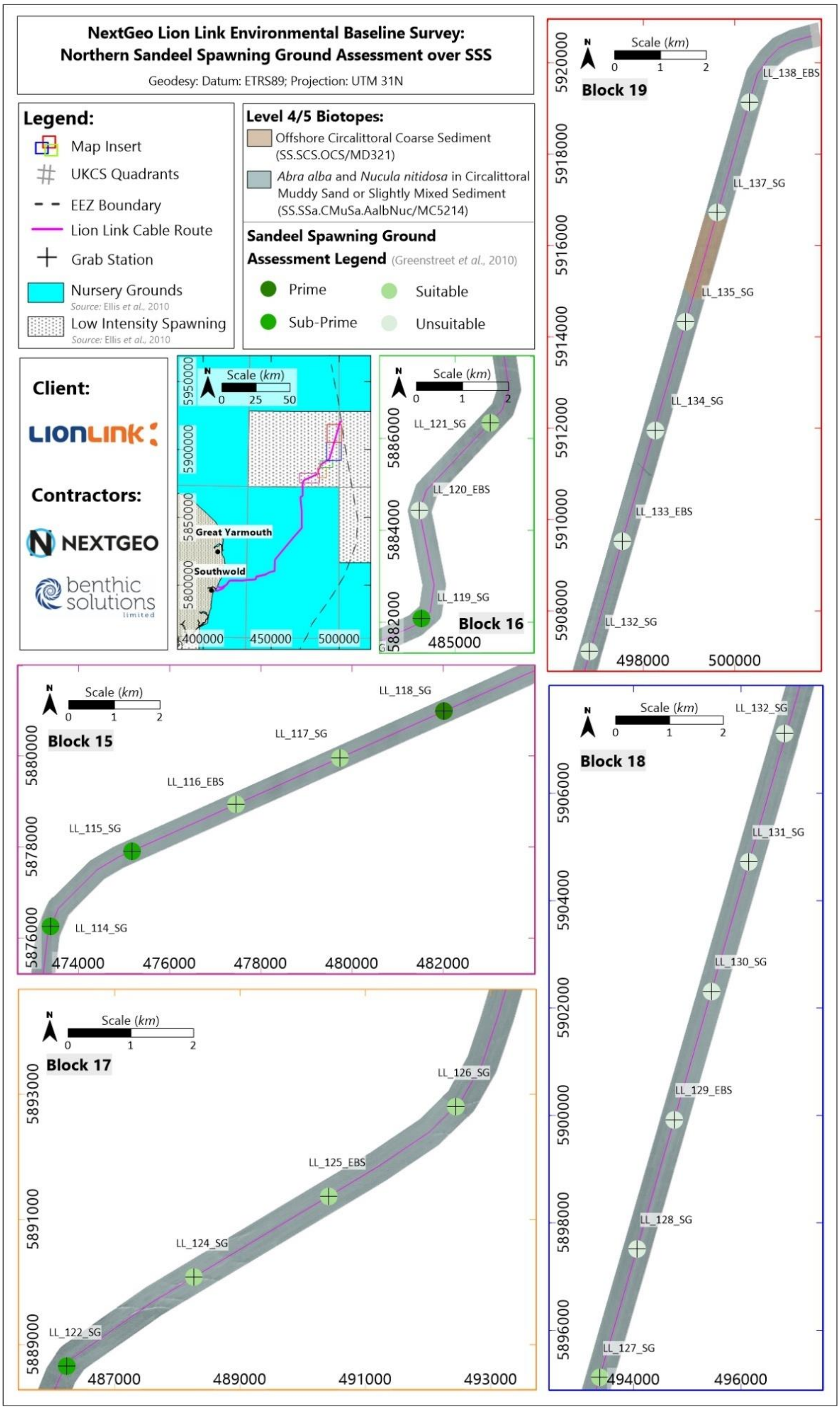



**Figure 3-61 Sandeel Spawning and Nursery Grounds per Greenstreet et al (2010) within Block 19 to Block 15**

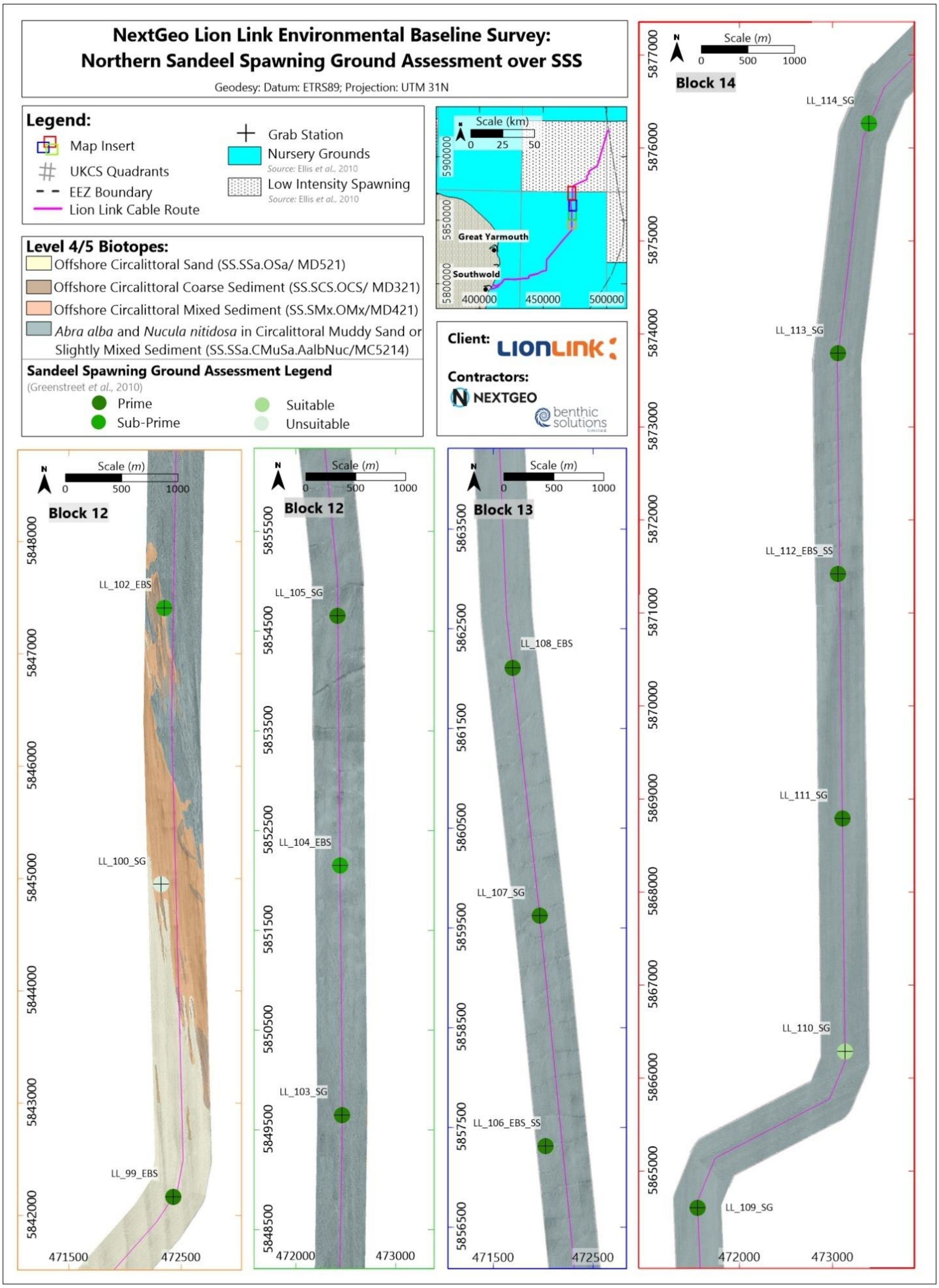



**Figure 3-62 Sandeel Spawning and Nursery Grounds per Greenstreet et al (2010) within Block 14 to Block 12**

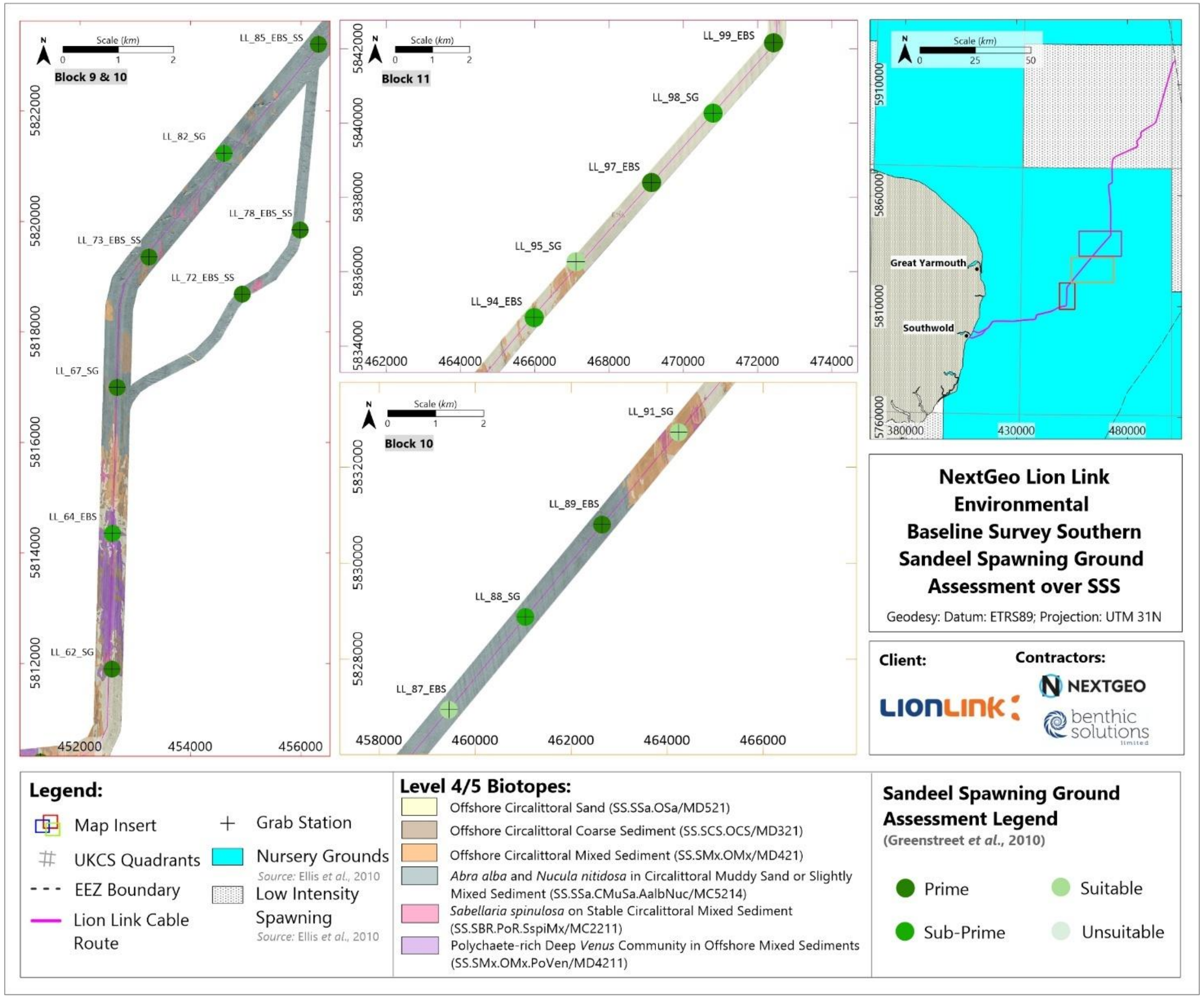



**Figure 3-63 Sandeel Spawning and Nursery Grounds per Greenstreet et al (2010) within Block 11 to Block 9**

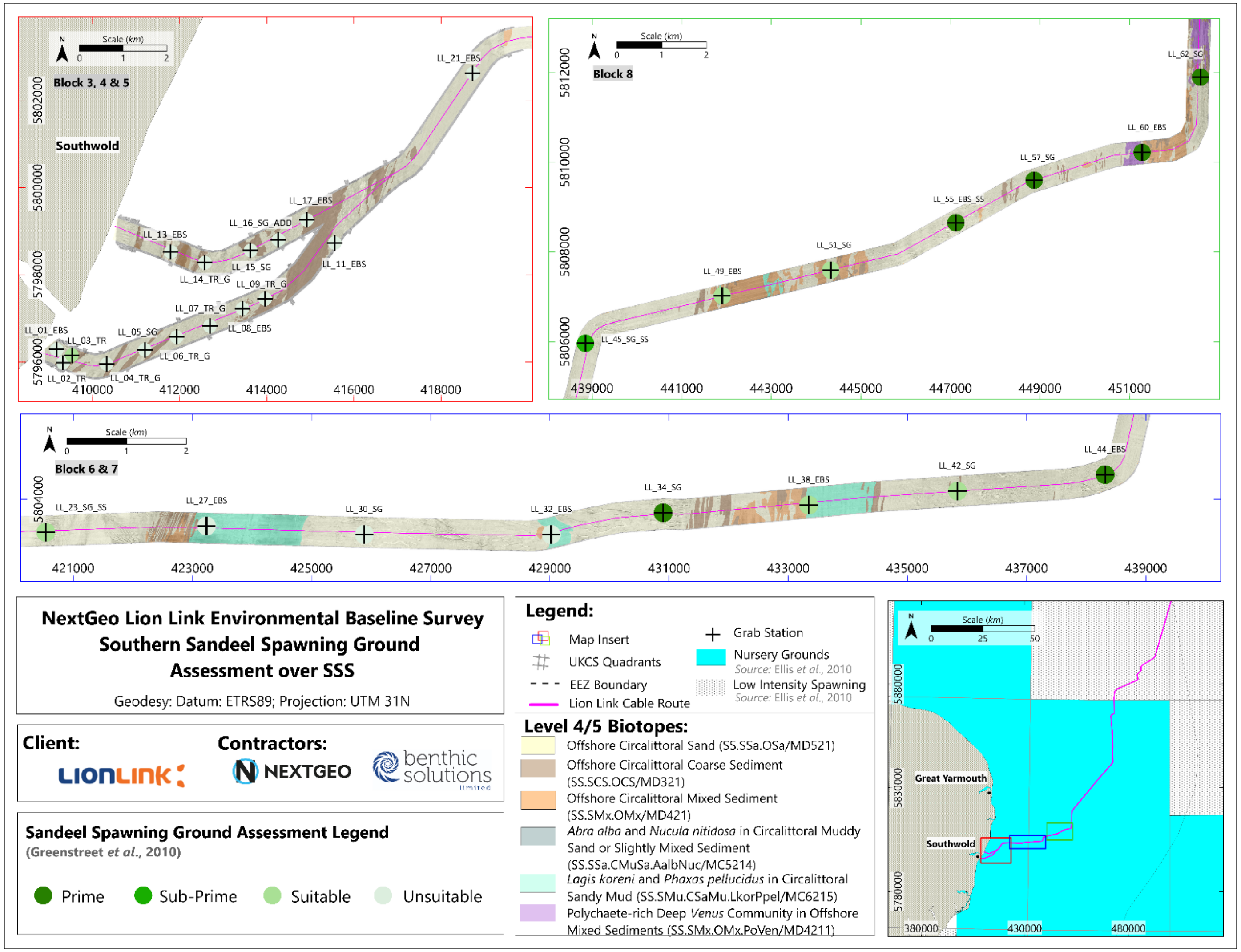



**Figure 3-64 Sandeel Spawning and Nursery Grounds per Greenstreet et al (2010) within Block 9 to Block 3**

#### 3.8.2.4 Atlantic Herring (Clupea harengus)

Herring spawning grounds (HSGs) and nursery grounds have been delineated by Cefas for UK waters. The cable route survey area lied within low intensity nursery grounds. Herring spawning occurs from August to October and suitable HSGs include sediments that are well oxygenated, allowing their sticky eggs to gestate for around three weeks before they hatch (Rogers & Stocks, 2001). Such sediments are limited to unimodal, unmixed very coarse sands and gravels with a low proportion of fines (Ellis *et al.*, 2012). Overexploitation and poor recruitment led to a decline in the North Sea herring spawning stock in the 1970s, forcing closure of the fishery in 1977. Due to the unique sedimentary requirement for HSGs and the stock's vulnerability to overfishing (Rogers & Stocks 2001), HSGs may be subject to protection if found. To determine whether any potential habitat for herring spawning exists within the survey area, the particle size analysis results from the grab sampling stations were assigned to the categories specified by Reach *et al.* (2013), as shown in Table 3-28.

**Table 3-28 Herring Spawning Ground Assessment Categories Specified by Reach *et al.*, (2013)**

| Percent Contribution of Mud & Gravel | Habitat Sediment Preference | Habitat Sediment Classification |
|---|---|---|
| <5% mud, >50% gravel | Prime | Preferred |
| <5% mud, >25% gravel | Sub-prime | Preferred |
| <5% mud, >10% gravel | Suitable | Marginal |
| >5% mud or <10% gravel | Unsuitable | Unsuitable |

Particle size distribution analysis indicated that a majority of stations were 'Unsuitable' as a consequence of <10% gravel and/or >5% mud (Table 3-29; Figure 3-65 to Figure 3-68). However, four stations (LL_03_TR, LL_42_SG, LL_45_SG_SS and LL_62_SG) were classified as 'Prime/Preferred' or 'Sub-Prime/Preferred' due to a higher proportion of gravel (>10%) and lower proportion of mud (>5%). These stations were typically characterised by a bimodal phi distribution, with peaks in phi occurring across the sand and gravel particle sizes. Therefore, herring spawning was unlikely occur across the majority of the route, with an increased likelihood at these aforementioned locations.

**Table 3-29 Herring Spawning Ground Assessment Results Using Reach et al (2013)**

| Station | Depth (m) | Fines (%) | Sands (%) | Gravel (%) | Modified Folk Scale | Habitat Sediment Preference | Habitat Sediment Classification |
|---|---|---|---|---|---|---|---|
| LL_01_EBS | 5.0 | 0.00 | 83.80 | 17.20 | Gravelly Sand | Suitable | Marginal |
| LL_02_TR | 8.0 | 33.10 | 20.20 | 46.70 | Muddy Gravel | Unsuitable | Unsuitable |
| LL_03_TR | 6.0 | 1.80 | 32.20 | 67.40 | Sandy Gravel | Prime | Preferred |
| LL_04_TR_G | 9.7 | 72.5 | 27.4 | 0.1 | Sandy Mud | Unsuitable | Unsuitable |
| LL_05_SG | 11.5 | 64.1 | 31.0 | 5.0 | Slightly Gravelly Sandy Mud | Unsuitable | Unsuitable |
| LL_06_TR_G | 12.1 | 53.9 | 45.2 | 0.9 | Sandy Mud | Unsuitable | Unsuitable |
| LL_07_TR_G | 12.4 | 63.8 | 36.1 | 0.1 | Sandy Mud | Unsuitable | Unsuitable |
| LL_08_EBS | 14.0 | 68.1 | 25.8 | 6.1 | Gravelly Mud | Unsuitable | Unsuitable |
| LL_09_TR_G | 18.4 | 71.4 | 28.3 | 0.3 | Sandy Mud | Unsuitable | Unsuitable |
| LL_11_EBS | 19.6 | 72.2 | 27.5 | 0.4 | Sandy Mud | Unsuitable | Unsuitable |
| LL_13_EBS | 11.8 | 77.8 | 22.2 | 0.1 | Sandy Mud | Unsuitable | Unsuitable |
| LL_14_TR_G | 13.6 | 59.1 | 34.6 | 6.3 | Gravelly Mud | Unsuitable | Unsuitable |
| LL_15_SG | 16.3 | 21.5 | 17.9 | 60.6 | Muddy Gravel | Unsuitable | Unsuitable |
| LL_16_SG_ADD | 16.0 | 57.3 | 41.6 | 1.1 | Slightly Gravelly Sandy Mud | Unsuitable | Unsuitable |
| LL_17_EBS | 15.5 | 74.0 | 26.0 | 0.0 | Sandy Mud | Unsuitable | Unsuitable |
| LL_21_EBS | 21.4 | 2.0 | 98.0 | 0.0 | Sand | Unsuitable | Unsuitable |
| LL_23_SG_SS | 35.1 | 14.7 | 83.1 | 2.3 | Slightly Gravelly Muddy Sand | Unsuitable | Unsuitable |
| LL_27_EBS | 32.0 | 22.5 | 45.0 | 32.5 | Muddy Sandy Gravel | Unsuitable | Unsuitable |
| LL_30_SG | 35.1 | 43.7 | 56.2 | 0.1 | Muddy Sand | Unsuitable | Unsuitable |
| LL_32_EBS | 33.9 | 30.9 | 47.4 | 21.7 | Gravelly Muddy Sand | Unsuitable | Unsuitable |
| LL_34_SG | 24.0 | 0.0 | 100.0 | 0.0 | Sand | Unsuitable | Unsuitable |
| LL_38_EBS | 34.5 | 13.7 | 86.3 | 0.0 | Muddy Sand | Unsuitable | Unsuitable |
| LL_42_SG | 37.3 | 4.0 | 57.4 | 38.6 | Sandy Gravel | Sub-prime | Preferred |
| LL_44_EBS | 40.3 | 0.0 | 99.9 | 0.1 | Sand | Unsuitable | Unsuitable |
| LL_45_SG_SS | 40.2 | 0.8 | 71.4 | 27.8 | Gravelly Sand | Sub-prime | Preferred |
| LL_49_EBS | 44.0 | 9.1 | 49.1 | 41.8 | Muddy Sandy Gravel | Unsuitable | Unsuitable |
| LL_51_SG | 38.0 | 6.1 | 52.8 | 41.1 | Muddy Sandy Gravel | Unsuitable | Unsuitable |
| LL_55_EBS_SS | 38.6 | 0.0 | 96.2 | 3.8 | Slightly Gravelly Sand | Unsuitable | Unsuitable |
| LL_57_SG | 38.8 | 0.0 | 95.5 | 4.5 | Slightly Gravelly Sand | Unsuitable | Unsuitable |
| LL_60_EBS | 41.4 | 1.3 | 92.8 | 5.9 | Gravelly Sand | Unsuitable | Unsuitable |
| LL_62_SG | 43.8 | 0.7 | 71.8 | 27.9 | Gravelly Sand | Sub-prime | Preferred |
| LL_64_EBS | 46.4 | 7.5 | 82.0 | 10.5 | Gravelly Sand | Unsuitable | Unsuitable |
| LL_67_SG | 43.7 | 0.0 | 97.0 | 3.1 | Slightly Gravelly Sand | Unsuitable | Unsuitable |
| LL_72_EBS_SS | 43.9 | 0.0 | 93.9 | 6.1 | Gravelly Sand | Unsuitable | Unsuitable |
| LL_73_EBS_SS | 45.8 | 2.5 | 94.8 | 2.9 | Slightly Gravelly Sand | Unsuitable | Unsuitable |
| LL_78_EBS_SS | 41.6 | 0.0 | 93.3 | 6.7 | Gravelly Sand | Unsuitable | Unsuitable |
| LL_82_SG | 47.6 | 15.1 | 74.2 | 10.7 | Gravelly Muddy Sand | Unsuitable | Unsuitable |
| LL_85_EBS_SS | 45.6 | 0.0 | 97.4 | 2.6 | Slightly Gravelly Sand | Unsuitable | Unsuitable |
| LL_86_SG | 48.3 | 0.9 | 98.1 | 1.1 | Slightly Gravelly Sand | Unsuitable | Unsuitable |
| LL_87_EBS | 50.4 | 17.4 | 82.5 | 0.1 | Muddy Sand | Unsuitable | Unsuitable |
| LL_88_SG | 51.3 | 7.3 | 90.1 | 2.6 | Slightly Gravelly Sand | Unsuitable | Unsuitable |
| LL_89_EBS | 51.1 | 0.1 | 96.9 | 2.9 | Slightly Gravelly Sand | Unsuitable | Unsuitable |

| Station | Depth (m) | Fines (%) | Sands (%) | Gravel (%) | Modified Folk Scale | Habitat Sediment Preference | Habitat Sediment Classification |
|---|---|---|---|---|---|---|---|
| LL_91_SG | 46.3 | 19.9 | 66.6 | 13.4 | Gravelly Muddy Sand | Unsuitable | Unsuitable |
| LL_94_EBS | 47.7 | 3.1 | 94.1 | 2.8 | Slightly Gravelly Sand | Unsuitable | Unsuitable |
| LL_95_SG | 47.2 | 26.0 | 62.2 | 12.0 | Gravelly Muddy Sand | Unsuitable | Unsuitable |
| LL_97_EBS | 43.6 | 0.0 | 98.7 | 1.3 | Slightly Gravelly Sand | Unsuitable | Unsuitable |
| LL_98_SG | 42.7 | 0.0 | 99.8 | 0.2 | Sand | Unsuitable | Unsuitable |
| LL_99_EBS | 44.0 | 0.0 | 99.4 | 0.6 | Sand | Unsuitable | Unsuitable |
| LL_100_SG | 43.0 | 42.8 | 54.1 | 3.1 | Slightly Gravelly Muddy Sand | Unsuitable | Unsuitable |
| LL_102_EBS | 39.2 | 15.1 | 76.6 | 8.2 | Gravelly Muddy Sand | Unsuitable | Unsuitable |
| LL_103_SG | 37.2 | 0.0 | 93.8 | 6.2 | Gravelly Sand | Unsuitable | Unsuitable |
| LL_104_EBS | 36.1 | 2.8 | 90.3 | 6.9 | Gravelly Sand | Unsuitable | Unsuitable |
| LL_105_SG | 37.5 | 0.0 | 97.7 | 2.3 | Slightly Gravelly Sand | Unsuitable | Unsuitable |
| LL_106_EBS_SS | 35.9 | 0.0 | 98.0 | 2.0 | Slightly Gravelly Sand | Unsuitable | Unsuitable |
| LL_107_SG | 36.6 | 0.0 | 98.9 | 1.1 | Slightly Gravelly Sand | Unsuitable | Unsuitable |
| LL_108_EBS | 36.6 | 0.0 | 98.2 | 1.8 | Slightly Gravelly Sand | Unsuitable | Unsuitable |
| LL_109_SG | 27.5 | 4.5 | 94.7 | 0.8 | Sand | Unsuitable | Unsuitable |
| LL_110_SG | 27.1 | 24.0 | 75.1 | 0.9 | Muddy Sand | Unsuitable | Unsuitable |
| LL_111_SG | 35.2 | 0.0 | 99.1 | 0.9 | Sand | Unsuitable | Unsuitable |
| LL_112_EBS_SS | 34.3 | 1.9 | 97.2 | 0.9 | Sand | Unsuitable | Unsuitable |
| LL_113_SG | 35.3 | 0.0 | 99.8 | 0.2 | Sand | Unsuitable | Unsuitable |
| LL_114_SG | 38.5 | 0.4 | 98.8 | 0.8 | Sand | Unsuitable | Unsuitable |
| LL_115_SG | 34.2 | 3.2 | 96.3 | 0.5 | Sand | Unsuitable | Unsuitable |
| LL_116_EBS | 35.2 | 13.1 | 86.6 | 0.3 | Muddy Sand | Unsuitable | Unsuitable |
| LL_117_SG | 24.7 | 14.6 | 85.3 | 0.0 | Muddy Sand | Unsuitable | Unsuitable |
| LL_118_SG | 32.5 | 0.0 | 99.7 | 0.3 | Sand | Unsuitable | Unsuitable |
| LL_119_SG | 23.0 | 0.0 | 99.6 | 0.4 | Sand | Unsuitable | Unsuitable |
| LL_120_EBS | 34.0 | 19.4 | 67.7 | 12.8 | Gravelly Muddy Sand | Unsuitable | Unsuitable |
| LL_121_SG | 32.0 | 10.2 | 87.4 | 2.4 | Slightly Gravelly Muddy Sand | Unsuitable | Unsuitable |
| LL_122_SG | 20.7 | 1.2 | 98.7 | 0.1 | Sand | Unsuitable | Unsuitable |
| LL_124_SG | 30.4 | 0.0 | 99.9 | 0.1 | Sand | Unsuitable | Unsuitable |
| LL_125_EBS | 31.4 | 1.7 | 97.4 | 0.9 | Sand | Unsuitable | Unsuitable |
| LL_126_SG | 30.0 | 2.7 | 97.1 | 0.2 | Sand | Unsuitable | Unsuitable |
| LL_127_SG | 22.3 | 2.3 | 97.4 | 0.3 | Sand | Unsuitable | Unsuitable |
| LL_128_SG | 30.4 | 14.8 | 77.9 | 7.2 | Gravelly Muddy Sand | Unsuitable | Unsuitable |
| LL_129_EBS | 31.0 | 6.5 | 92.5 | 1.0 | Slightly Gravelly Sand | Unsuitable | Unsuitable |
| LL_130_SG | 37.7 | 2.0 | 98.0 | 0.0 | Sand | Unsuitable | Unsuitable |
| LL_131_SG | 28.6 | 16.2 | 83.3 | 0.5 | Muddy Sand | Unsuitable | Unsuitable |
| LL_132_SG | 27.3 | 4.6 | 94.6 | 0.8 | Sand | Unsuitable | Unsuitable |
| LL_133_EBS | 27.4 | 3.9 | 96.0 | 0.1 | Sand | Unsuitable | Unsuitable |
| LL_134_SG | 29.0 | 8.7 | 91.1 | 0.2 | Sand | Unsuitable | Unsuitable |
| LL_135_SG | 29.0 | 18.3 | 81.4 | 0.3 | Muddy Sand | Unsuitable | Unsuitable |
| LL_137_SG | 29.7 | 32.2 | 67.6 | 0.2 | Muddy Sand | Unsuitable | Unsuitable |
| LL_138_EBS | 29.0 | 20.5 | 79.3 | 0.2 | Muddy Sand | Unsuitable | Unsuitable |

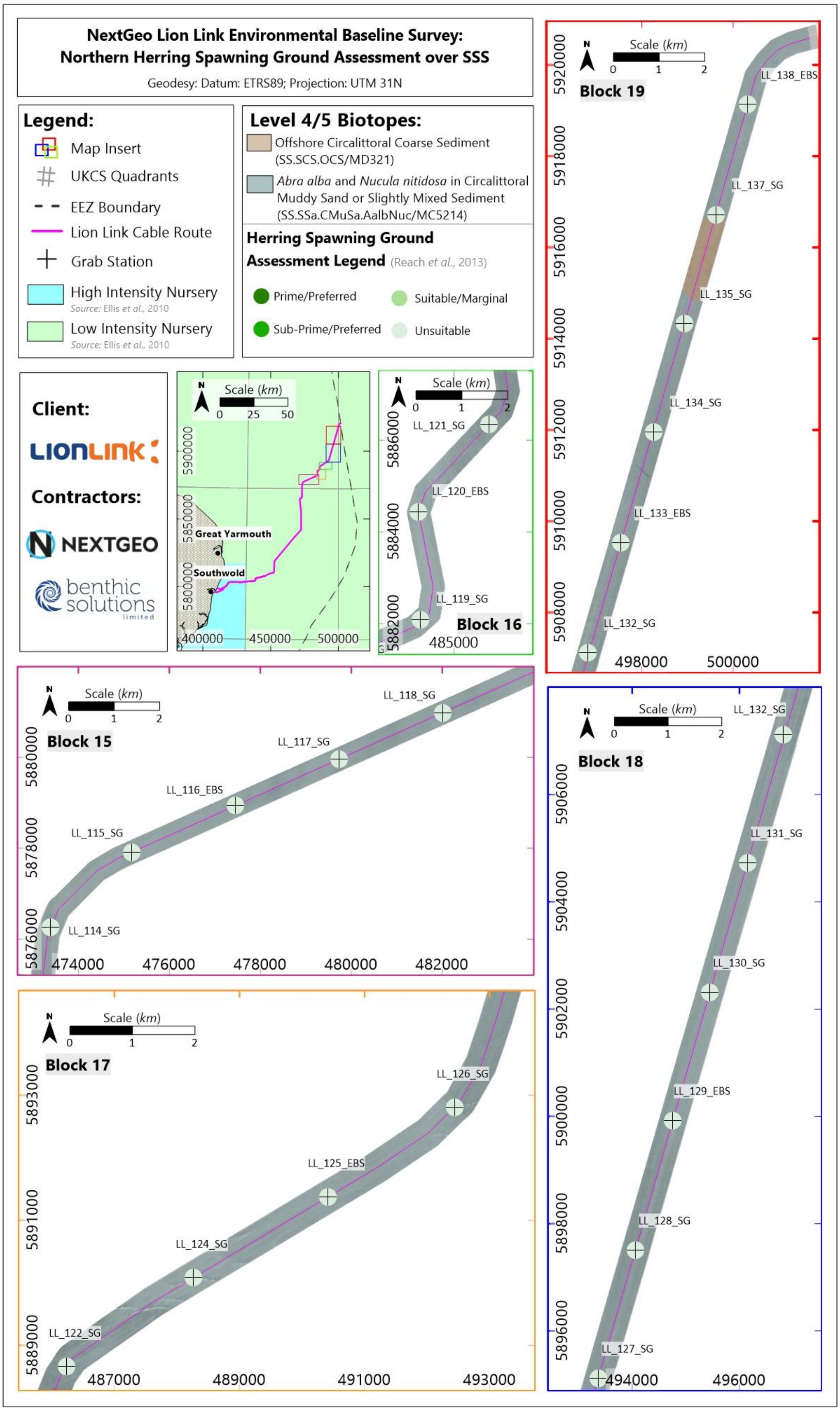



**Figure 3-65 Herring Spawning and Nursery Grounds per Reach et al (2013) within Block 19 to Block 15**

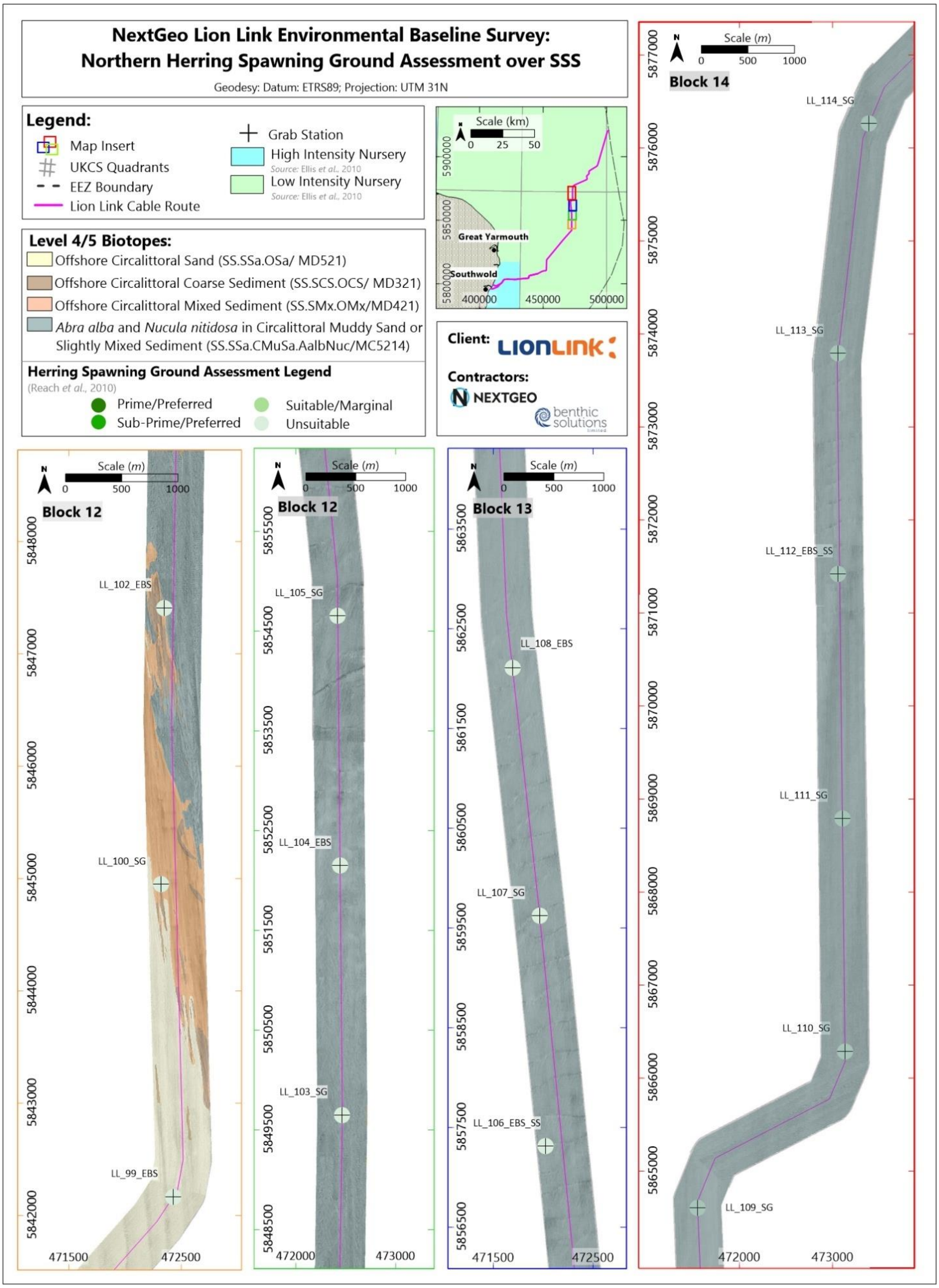



**Figure 3-66 Herring Spawning and Nursery Grounds per Reach et al (2013) within Block 14 to Block 12**

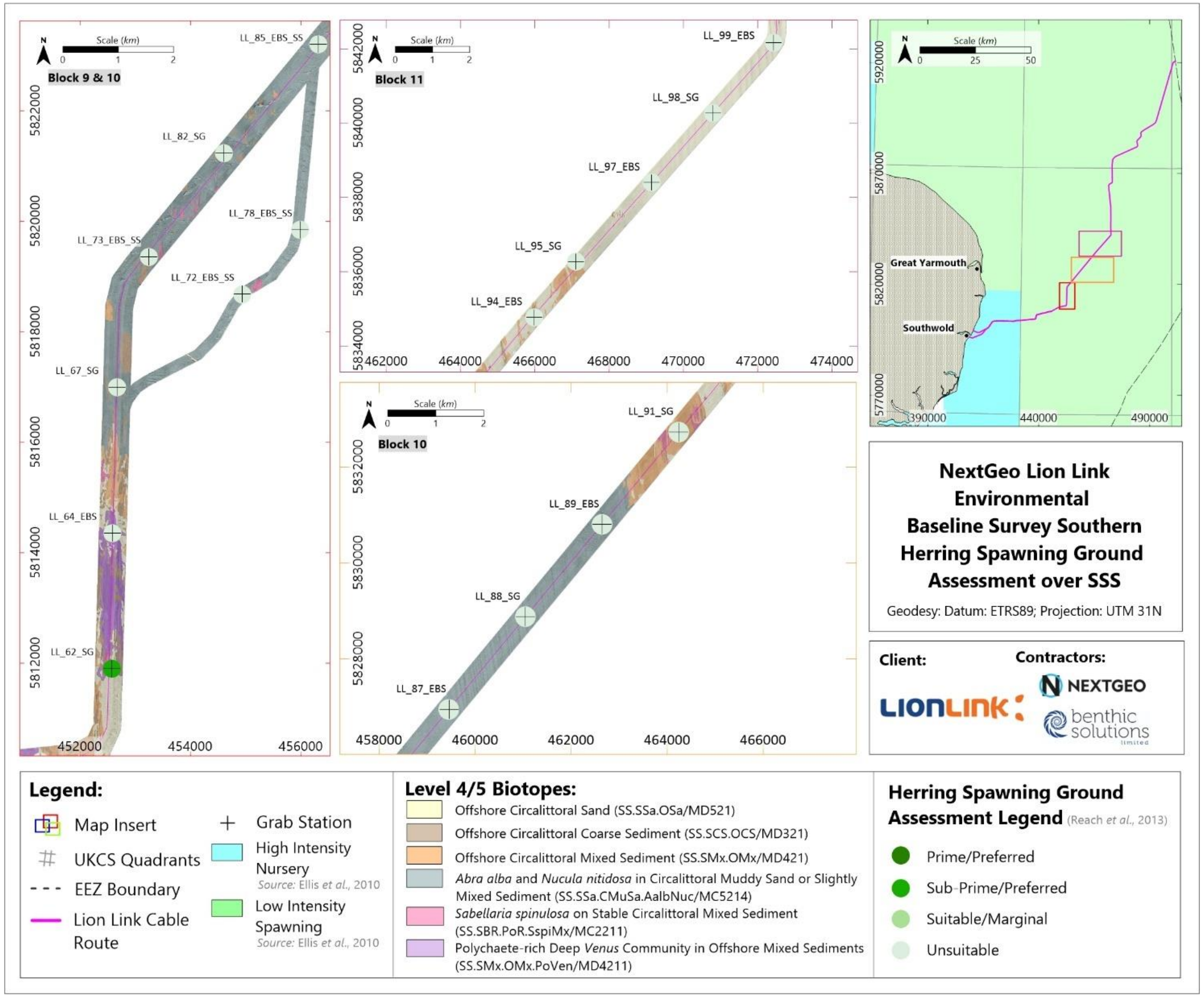



**Figure 3-67 Herring Spawning and Nursery Grounds per Reach et al (2013) within Block 11 to Block 9**

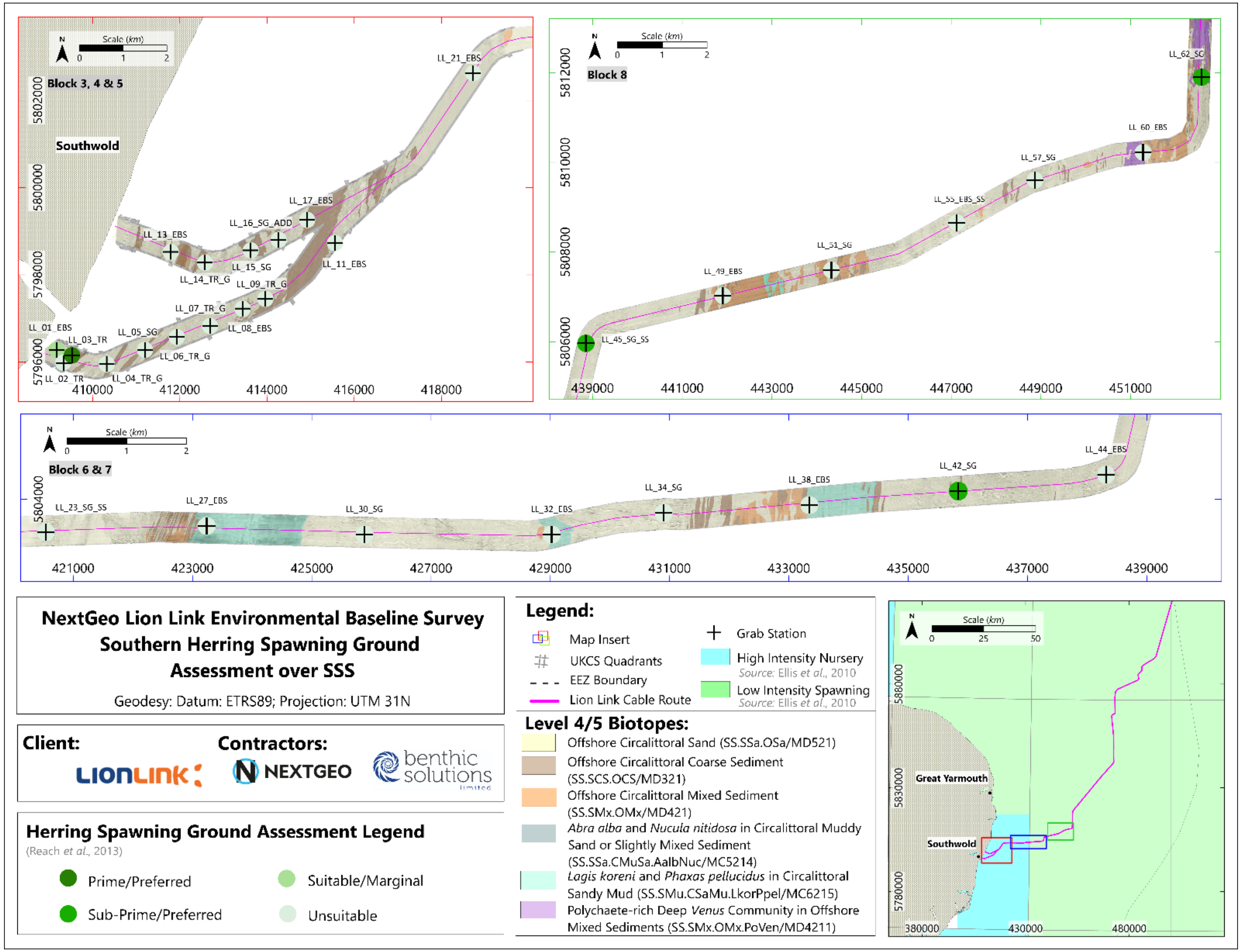



**Figure 3-68 Herring Spawning and Nursery Grounds per Reach et al (2013) within Block 9 to Block 3**

#### 3.8.2.5 Annex I Blue Mussel (*Mytilus edulis*) Beds

Blue mussel (*Mytilus edulis*) beds are recognised as a Habitat of Principal Importance under the Natural Environment and Rural Communities (NERC) Act 2006 with blue mussels having a role in coastal sediment dynamics, acting as a food source and providing enhanced biodiversity (JNCC, 2008). This habitat is threatened by commercial fisheries with the targeted removal of mussels as well as fishing causing physical damage to the beds, due to their feeding habits *Mytilus edulis* accumulate pollutants which can lead to sublethal or lethal responses and coastal development causing physical damage (OSPAR, 2015).

The video assessment identified small *M. edulis* at varying densities across two transects (LL_20_TR and LL_20_ADD). Their small size and the absence of a distinct SSS signature suggest that the mussel aggregations were either too sparse or too low-lying to be detected in the earlier sonar survey. Additionally, their ephemeral nature during early growth stages may have contributed to this absence. During these early stages, mussels are not yet firmly attached to hard substrates and can be easily dislodged by strong currents, as observed at the survey site, allowing them to resettle and mature elsewhere (Seed & Suchanek, 1992).

To assess the presence of mussels in these transects, a method was adopted incorporating the SACFOR scale alongside a grading system outlined in Roberts *et al.,* (2011). Stills were captured at 10 second intervals along the two transects to evaluate total mussel coverage. The stills were initially determined to resemble either a crust/meadow (single layer of mussels on sediment) or a massive/turf (several layers of mussel on a large scale). This classification would inform the application of the SACFOR scale based on coverage and therefore would enable the identification of its equivalent grading as adapted from Roberts *et al.* (2011), due to the low-lying nature of the observed mussels, only the crust/meadow classification is detailed in Table *3-30*.

**Table 3-30 Overview of Mussel (*Mytilus edulis*) Bed Assessment Categories**

| Coverage | Crust/Meadow SACFOR | BSL Grading adapted from Roberts *et al*, 2011 |
|---|---|---|
| >80% | Superabundant | 1 |
| 40-79% | Abundant | |
| 20-39% | Common | |
| 10-19% | Frequent | 2 |
| 5-9% | Occasional | |
| 1-5% | Rare | 3 |
| <1% | Less than Rare | |
| 0% | Absent | 4 |

The mussel beds analysed within the video footage and stills revealed crust/meadow environments were present within the survey area (a complete log of the assessment per still is provided in Appendix J – Blue Mussel Assessment). Of the 180 images analysed from two transects, 10 stills (5.6%) were classified as 'Common', 15 (8.3%) were classified as 'Frequent', 35 (19.4%) as 'Occasional', 30 (16.7%) as 'Rare' and 84 (46.7%) as 'Absent'. In total, just four images were classed as 'Not visible', where a clear visual of the seabed was not possible within the ten second interval (Table 3-31).

**Table 3-31 Overview of SACFOR Results for Blue Mussel Bed Assessment**

| SACFOR Scale | Stills | |
|---|---|---|
| | No. | % |
| Super abundant | 0 | 0.0 |
| Abundant | 0 | 0.0 |
| Common | 10 | 5.6 |
| Frequent | 15 | 8.3 |
| Occasional | 35 | 19.4 |
| Rare | 30 | 16.7 |
| Less than rare | 2 | 1.1 |
| Absent | 84 | 46.7 |
| Not visible | 4 | 2.2 |

When converting this SACFOR scale into the grading system by Roberts *et al.* (2011), it revealed that most images were considered Grade 4. A total of 10 stills (5.56%) were considered Grade 1, 50 (27.8%) were categorised as Grade 2, 32 (17.8%) were classed as Grade 3, 84 (46.7%) were classified as Grade 4. These findings can be summarised in Table 3-32 and illustrated in Figure 3-69 showing the spatial distribution.

**Table 3-32 Overview of BSL Grading of Blue Mussel Bed Assessment**

| Roberts *et al* (2011) Adapted BSL Grading | Unclear UW Still | | Grade 4 | | Grade 3 | | Grade 2 | | Grade 1 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % | No. | % | No. | % |
| Stills | 4 | 2.2 | 84 | 46.7 | 32 | 17.8 | 50 | 27.8 | 10 | 5.6 |

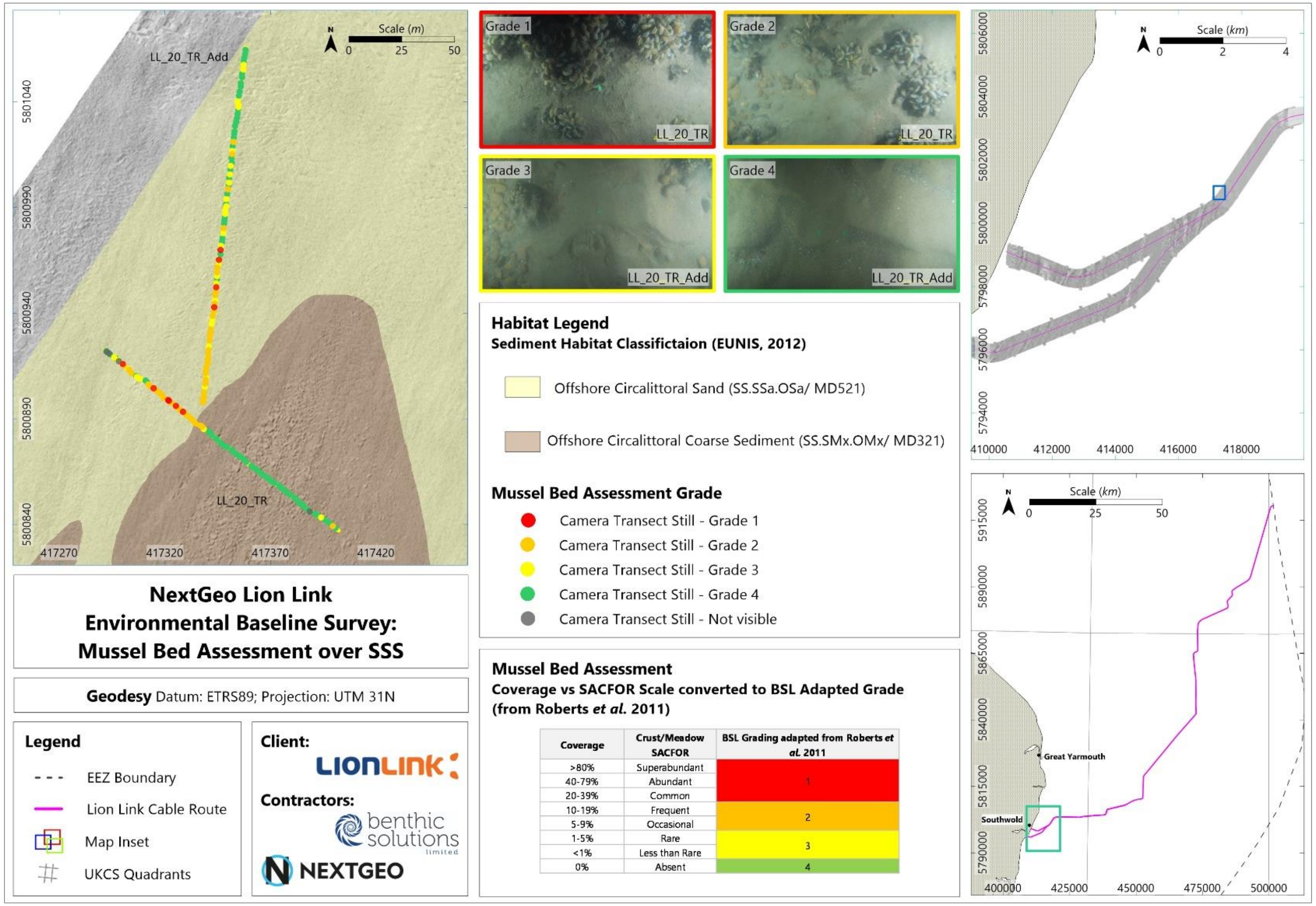



**Figure 3-69 Blue Mussel (*Mytilus edulis*) Bed Assessment (BSL Grading)**

This assessment revealed, stills classified as Grade 1 and Grade 2 were concentrated in the same location across both transects, towards the northwestern extent of LL_20_TR and southern extent of LL_20_ADD in 'Offshore Circalittoral Sand' with minimal rippling. Aggregations across both transects were patchy and mostly low in density. To calculate the estimated area of the mussel beds, an approximation of the aerial extent of each *M. edulis* patch was made from the transect length, as there was no distinct SSS signature to delineate an area, by assuming that reefs occupied circular areas of seabed (i.e. reef extent or distance equates to the diameter of a circle, whose area is calculated using $\pi r^2$).

Overall there were four patches classed as Grade 2, seven being classed as Grade 3 and 11 being classed as Grade 4. OSPAR definitions define a mussel bed as at least a 20% cover of subtidal sediments over an area of at least 25m² to qualify as a bed (OSPAR, 2010), using this definition patches can be estimated and those with an area of greater than 25m² and considered Grade 1 could be potential mussel beds. This revealed that all patches within this survey were not classed as an Annex I Mussel Bed under this definition with an overview of these patches is summarised in Table 3-33.

**Table 3-33 Blue Mussel Assessment Patches Extent Overview**

| Grading vs Extent | Total | Grade 1 | Grade 2 | Grade 3 | Grade 4 | Not Visible |
|---|---|---|---|---|---|---|
| Patches | 22 | 0 | 4 | 7 | 11 | 0 |

#### 3.8.2.6 Subtidal Sands and Gravels

The subtidal sands and gravel habitat is a priority habitat under the UK BAP and occurs in a wide variety of marine environments where sediments like sand, gravel and cobblestone accumulate. The habitat is home to a variety of species including polychaetes, crustaceans and fish which rely on the habitat for breeding, feeding and shelter. Offshore examples of these habitats are considered more diverse due to the reduction in natural disturbance and are characterised by a range of anemones, polychaetes, bivalves, amphipods as well as mobile and sessile epifauna. These areas support internationally important fish and shellfish fisheries and provides important ecosystem services by improving water quality and acting as a carbon sink. This habitat is at risk from pollutants in riverine discharge, trawling and dredging activities and aggregate extraction.

Illustrative biotopes of subtidal sands and gravels include 'Offshore Circalittoral Sand' (SS.SSa.OSa) and 'Offshore Circalittoral Coarse Sediment' (SS.SCS.CCS). Both were observed along the survey route and serve as representative examples of the Habitat of Principal Importance for subtidal sands and gravels (JNCC, 2024). Based on JNCC guidance, for a habitat to be classified as 'subtidal sands and gravel', the sediment composition must adhere to the following proportions: gravel ≥ 5%, sand ≥ 5% and <10% fines. Table 3-34 lists the stations conforming to this habitat designation, as well as the proportions of sediments present in each sample. Stations conforming to this habitat type were found in a depth range of 5-6m and 36-46m and had varying Modified Folk Scale Classifications including 'Sandy Gravel', 'Gravelly Sand', and 'Muddy Sandy Gravel'.

**Table 3-34 Sediment Sampling Stations Conforming to the Subtidal Sands and Gravels UK BAP Habitat**

| Station | Depth (m) | Fines (%) | Sands (%) | Gravel (%) | Modified Folk Scale |
|---|---|---|---|---|---|
| LL_01_EBS | 5 | 0.0 | 83.8 | 17.2 | Gravelly Sand |
| LL_03_TR | 6 | 1.8 | 32.2 | 67.4 | Sandy Gravel |
| LL_42_SG | 37 | 4.0 | 57.4 | 38.6 | Sandy Gravel |
| LL_45_SG_SS | 40 | 0.8 | 71.4 | 27.8 | Gravelly Sand |
| LL_49_EBS | 44 | 9.1 | 49.1 | 41.8 | Muddy Sandy Gravel |
| LL_51_SG | 38 | 6.1 | 52.8 | 41.1 | Muddy Sandy Gravel |
| LL_60_EBS | 41 | 1.3 | 92.8 | 5.9 | Gravelly Sand |
| LL_62_SG | 44 | 0.7 | 71.8 | 27.9 | Gravelly Sand |
| LL_64_EBS | 46 | 7.5 | 82.0 | 10.5 | Gravelly Sand |
| LL_72_EBS_SS | 44 | 0.0 | 93.9 | 6.1 | Gravelly Sand |
| LL_78_EBS_SS | 42 | 0.0 | 93.3 | 6.7 | Gravelly Sand |
| LL_103_SG | 37 | 0.0 | 93.8 | 6.2 | Gravelly Sand |
| LL_104_EBS | 36 | 2.8 | 90.3 | 6.9 | Gravelly Sand |

# 4 Conclusion

The seabed along the Lion Link cable route displayed variable gradients and sediment compositions. In the nearshore section, water depths ranged from 0.8m to 21m below LAT, with the seabed primarily consisting of 'sandy gravel', transitioning to 'sand' and 'gravelly sand'. Offshore, depths extended from 19.8m to 54.2m below LAT, where the seabed was predominantly composed of 'sand' and 'gravelly sand', gradually transitioning to coarser sediments.

The particle size distribution (PSD) showed variable seabed sediments along the cable route, with nearshore stations (LL_01_EBS to LL_17_EBS) having a higher proportion of fines (mean: 52.7%±26.0SD), smaller amounts of sand, and variable gravel content. Offshore stations (LL_21_EBS to LL_138_EBS) were sand-dominant, with sand content ranging from 45% to 100% and variable fines and gravel, consistent with features like sandwaves and ripples. Gravel content was highly variable, with notable peaks at LL_15_SG (60.6%), LL_02_TR (46.7%), LL_49_EBS (41.8%), and LL_51_SG (41.1%), associated with gravelly sands and pebbles. Nearshore stations spanned five Folk classifications, including 'Sandy Mud' and 'Muddy Gravel,' while offshore stations were more diverse, with 'Sand' being the most common.

Total organic matter (TOM) was highest in the nearshore area, with four of the five stations recording TOM levels exceeding the upper UKOOA threshold of 2.3%, correlating with the higher fines content in the sediment. Similarly, total organic carbon (TOC) was elevated in the nearshore regions and lower in offshore stations, reflecting the higher sand proportions offshore.

Total hydrocarbon content (THC) concentrations varied along the cable route, ranging from 0.18mg.kg$^{-1}$ (LL_78_EBS_SS) to 60.1mg.kg$^{-1}$ (LL_11_EBS). THC was highest in the nearshore stations, where four of five values exceeded the UKOOA (2001) 95$^{th}$ percentile threshold for the southern North Sea (SNS) (11.4 mg.kg$^{-1}$), attributed to the high fines content (>65%) in these sediments. Offshore, THC was lower, with 11 stations below the 95$^{th}$ percentile. A similar pattern was observed for total n-alkanes, with the highest concentration of 2.59mg.kg$^{-1}$ recorded at LL_11_EBS and the lowest concentrations at offshore stations. Gas chromatography (GC) traces revealed hydrocarbon signatures consistent with background sediments on the United Kingdom continental shelf, showing no evidence of anthropogenic contamination. A majority of nearshore stations exhibited a higher contribution of typical North Sea runoff and terrigenous material in the GC traces. Total PAH levels varied across the route, with the highest concentrations found within four nearshore stations. Four of five nearshore stations exceeded the UKOOA (2001) 95$^{th}$ percentile threshold of 0.336mg.kg$^{-1}$, and one station, LL_11_EBS, recorded a value of 4.39mg.kg$^{-1}$, surpassing the NOAA ERL of 4.02mg.kg$^{-1}$.

Organotin compounds (tributyltin and dibutyltin), organochlorine pesticides (OCPs) and polychlorinated biphenyls (PCBs) were all below their respective limits of detections at all nine stations they were analysed at. Extractable organic halogens (EOX) were below LOD (20mg.kg$^{-1}$) at all but one station (LL_01_EBS) recording a value of 70mg.kg$^{-1}$, likely attributed to its close proximity to the shore and mouth of River Blyth.

In the nearshore area, concentrations of seven metals (Ba, Cd, Cr, Cu, Pb, Ni, and Zn) exceeded the UKOOA SNS 50$^{th}$ percentile reference values at various stations, with Pb, Hg, and Zn surpassing the 95$^{th}$ percentile. In the offshore region, most stations reported lower metal concentrations compared to the nearshore area, with no metals exceeding the UKOOA 95th percentile thresholds. Arsenic concentrations exceeded the NOAA ERL reference value ($8.2mg.kg^{-1}$) at all but three stations (LL_01_EBS, LL_21_EBS and LL_87_EBS), and surpassed the Cefas cAL 1 ($20mg.kg^{-1}$) at 15 stations and the Cefas cAL 2 ($50mg.kg^{-1}$) at LL_89_EBS. Elevated arsenic levels in the SNS are linked to natural geological sources, anthropogenic activities, and riverine discharge, with mining, smelting, chemical manufacturing, and agricultural runoff from major rivers like the Rhine and Humber estuary contributing significantly. However, concentrations of most other metals were below Cefas cALs and OSPAR ERL levels at most stations, indicating minimal risk to marine life and no significant environmental impact.

Almost all chemical parameters exhibited a positive correlation with the proportion of fines and a negative correlation with water depth in the Spearman correlation table. This suggests that nearshore stations along the cable route typically had higher concentrations of organics, hydrocarbons, and heavy metals due to the finer sediments, compared to the sandier offshore stations.

Macrofaunal analysis revealed a total of 4,259 individuals, of which Annelida had the highest contribution to the total number of individuals. The species richness and abundance was more variable in the offshore region compared to the nearshore, showing generally lower values in the central region of the survey area where there was a dominance of sand and low fines content. Multivariate statistical analysis identified five significantly different macrofaunal groupings within the area with a slice overlain at 12% Bray-Curtis similarity level. Differences in macrofaunal composition were shown to significantly relate to sediment composition, organics, hydrocarbons and metals data. Although PSD showed the highest sample statistic revealing that sediment type is the primary driver of the distribution of benthic assemblages along the Lion Link route. The two predominant cluster groups also differentiated due the variations in the abundance of the mud-dwelling tube-building polychaete *Lagis koreni*, the sand-dwelling bristleworm *Nephtys cirrosa* and *Spiophanes bombyx*. Remaining clusters were differentiated due to low abundances of species and individuals.

Four level four JNCC/EUNIS habitats were designated across the survey route with a majority of the cable route assigned as 'Offshore circalittoral sands' (SS.SSa.Osa/ MD521), with 'Offshore circalittoral mixed sediment' (SS.SMx.OMx/ MD421) and 'Offshore circalittoral coarse sediment' (SS.SCS.OCS/ MD321), occurring in patches and the troughs of seabed mega-ripples. Occasional areas of 'Circalittoral muddy sand' (SS.SSa.CMuSa/ MD521) occurred at the furthermost north stations of the cable route (LL_138_TR & LL_134_TR) and interspersed between the variable mixed & coarse sediments in the southern coastal area. The biogenic level five communities comprised of *Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment (SS.SSa.CMuSa.AalbNuc / MC5214 and *Lagis koreni* and *Phaxas pellucidus* in circalittoral sandy mud (SS.SMu.CSaMu.LkorPpel / MC6215) in areas of MD521 and MC621. The level 5 biotope of Polychaete-rich deep *Venus* community in offshore circalittoral mixed sediment (SS.SMx.OMx.PoVen / MD4211) was present in areas of MD421.

The survey route revealed a heterogeneous presence of *Sabellaria spinulosa* aggregations, primarily found in scattered patches along the route, especially within Blocks 10, 11, and 12. These aggregations were most commonly associated with 'Offshore Circalittoral Mixed Sediment' and 'Offshore Circalittoral Coarse Sediment' habitats. However, despite the presence of *S. spinulosa*, the aggregations did not form Annex I reef structures, as the majority were classified as 'Low Reef' or 'Not a Reef'. Variability in sediment types and substrate stability influenced the reef classification, with mobile sands and smothering fines often preventing the formation of stable reef structures. Therefore, while *S. spinulosa* was present along the route, no significant *Sabellaria* reefs were identified.

There were no instances of Annex I stony reefs observed throughout video footage.

Based on the results from the sediment analysis, the survey route shows potential for sandeel nursery or spawning grounds, particularly along the northern extent of the route. The majority of stations identified as 'Preferred' for sandeel grounds were located within 'Offshore circalittoral sand'. Two stations weres classified with 'Marginal', and 36 stations were considered 'Unsuitable' due to the predominance of muddy or coarse sediments. While the Greenstreet *et al.* (2010) method showed lower habitat suitability compared to Latto *et al*. (2013), some areas previously deemed 'Unsuitable' were reclassified as 'Suitable' or better, primarily due to the presence of coarser sands. Furthermore, sandeels were observed during video transects and grab sampling, further supporting the potential suitability of the area.

The survey route shows limited potential for herring nursery or spawning grounds, as most stations were classified as 'Unsuitable' due to low gravel content (<10%) and high mud content (>5%). However, four stations (LL_03_TR, LL_42_SG, LL_45_SG_SS, and LL_62_SG) were classified as 'Prime/Preferred' or 'Sub-Prime/Preferred' due to a higher proportion of gravel and lower mud content, with bimodal particle size distributions indicating more favourable conditions.

Mussel aggregations were concentrated in specific areas, particularly towards the northwestern extent of LL_20_TR and the southern extent of LL_20_ADD in the 'Offshore Circalittoral Sand' habitat. However, these aggregations were patchy and low in density, with no patch meeting the required 20% cover of subtidal sediments over at least 25m$^2$. Consequently, while mussel beds were present, they did not qualify as significant Annex I mussel beds as per the OSPAR definition.

Both the 'Offshore Circalittoral Sand' (SS.SSa.OSa) and 'Offshore Circalittoral Coarse Sediment' (SS.SCS.CCS) biotopes were present along the survey route and can be considered representative examples of the UK-BAP subtidal sands and gravels habitat.

Several UK protected species were observed along the route, including the dog whelk (*Nucella lapillus*), thumbnail crab (*Thia scutellata*), European plaice (*Pleuronectes platessa*), sand goby (*Pomatoschistus minutus*), thornback ray (*Raja clavata*), and the IUCN Least Concern small spotted catshark (*Scyliorhinus canicula*). However, no ocean quahog (*Arctica islandica*) was found in video reviews or grab samples.

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## Appendix A – Field Operations

Appendix I presents a summary of the different methods employed in the field. For additional information, please refer to the Environmental Field Reports (National Grid document code: LLK1-NGS-REP-REP-000026, Next document code: P2066-010-REP-014).

### Seabed Video

Seabed video footage was acquired at each sampling station to provide ground-truthing of sediments. Station selection was aided by using geophysical data to ensure sufficient coverage of all habitat types present across the Lion Link cable route. Camera transects were often also co-located with the grab stations, with additional camera transects proposed to ground truth features of interest not covered by grab sampling

Camera transects were carried out using a BSL MOD 4.1 and 4.5 camera system which could be mounted in a specialist BSL developed freshwater lens in areas of poor visibility, deployed of the starboard side of the vessel. At stations experiencing high currents, drop down video footage was attempted at the grab locations. In a number of nearshore stations, highly turbid waters rendered the visibility so poor that no video footage could be acquired. Here, grab samples were take to ground truth seabed sediments and are marked with the suffix '_TR_G'. In total, 99 successful transects were completed.

**Deployment of MOD 4.1 Camera Setup in Freshwater Lens with Vessel Crane**

**Environmental Baseline Seabed Sampling**

The survey strategy for Lion Link was broadly split into three main categories: environmental baseline (EBS), sandeel & herring spawning ground (SG) and sand sweeping (SS) stations.

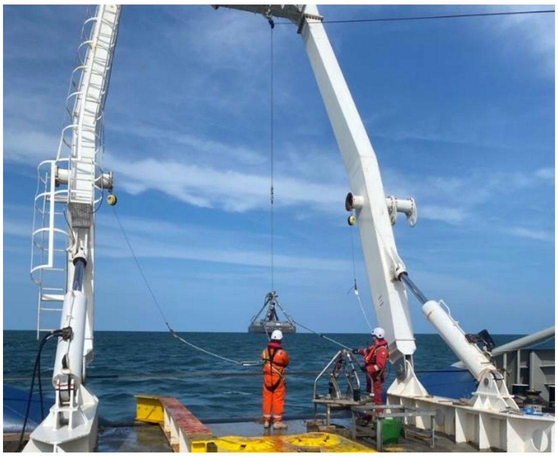
A BSL Double Grab (Dual Van Veen) was used as the primary sample device in areas of soft sediments, sands and shallow still clays and consists of 2 x 0.1m$^2$ galvanised steel samplers set into a ballasted frame. In areas of coarser sediments the BSL mini Hamon grab (1 x 0.1 m$^2$) was deployed. At MMO sampling stations, only the Duel Van Veen was used.

Pre-deployment procedures included cleaning the inner stainless grab buckets, cable and shackles so that they were generally grease free. Samples were subject to quality control on retrieval and were retained in the following circumstances:

- Water above the sample was undisturbed;
- Bucket closure complete allowing no sediment washout;
- Sampler access doors had closed properly enclosing the sample;
- No disruption of the sample through striking the side of the vessel;
- Sample was taken within the acceptable target range of <10m;
- Sample represented greater than 40% capacity;
- No hagfish or other mucus coagulants were found in the sample;
- There was no obvious contamination from equipment or the vessel, etc.;
- The sample was acceptable to the principal scientist.

Upon recovery, each sample was inspected, described, and photographed prior to processing. Key observations from samples included colour, sediment classification, layering, smell (including the presence of $H_2S$), obvious fauna, evidence of bioturbation and evidence of anthropogenic debris. Two successful deployments of the DVV (four successful 0.1m$^2$ replicates) were required per EBS station to acquire enough material for two macrofauna replicates and sub-sampling of physico-chemistry from the remaining sample. The macrofaunal replicates were processed on-board over a 1.0 mm aperture mesh by BSL scientists using a *Wilson* Auto-siever and fixed in 5-10% buffered formalin.

**Deployment of the BSL Duel Van Veen**



**Deployment of the BSL Mini Hamon Grab**

## Appendix B – Data Presentation, Laboratory and Statistical Analyses

### Environmental Data Presentation

To aid in the interpretation and presentation of the environmental information acquired for this report, both hydrographic and environmental variables were processed using contouring and 3D surface mapping software (Surfer v19). This software allows a digital terrain model (DTM), or grid, to be interpolated from irregularly spaced geographical information (XYZ data) using a kriging interpolation algorithm. When large quantities of data are used (such as in swathe bathymetry), the level of interpolation is limited only to small spaces in between the data points. However, when processing environmental variables, a diagrammatic circle has been used to colour illustrate the parameter level at each relevant site. It should be remembered that this is done for presentation purposes only and that these data values are "not representative" for the whole of the geographical area covered by the circle. No interpolation is required in this instance except where these circles overlap due to the scaling of the figure.

### Particle Size Distribution

The samples recovered from each site were analysed by BSL which is accredited under the National Marine Biological Association Quality Control scheme (NMBAQC) for PSD analysis.

The sample was homogenised and split into a small sub-sample for laser diffraction and the remaining material was sieved through stainless steel sieves with mesh apertures from 63mm down to 1mm. In most cases almost the entire sample would pass through the sieve stack, but any material retained on the sieve, such as small shells, shell fragments and stones were removed, and the weight was recorded.

The smaller sub-sample was wet screened through a 1mm sieve and determined using a Malvern Mastersizer 3000 particle sizer according to Standard Operating Procedures (SOP). The results obtained by a laser sizer have been previously validated by comparison with independent assessment by wet sieving (Hart, 1996). The range of sieve sizes, together with their Wentworth classifications, is given in Table I.II. For additional quality control, all datasets were run through the Mastersizer in triplicate and the variations in sediment distributions assessed to be within the 95 % percentile.

The separate assessments of the fractions above and below 1mm were combined using a computer programme. This followed a manual input of the sieve results for fractions >63mm, 63mm-45mm, 45mm-31.5mm, 31.5mm-22.4mm, 22.4mm-16mm, 16mm-11.2mm, 11.2mm-8mm, 8mm-5.6mm, 5.6mm-4mm, 4mm-2.8mm, 2.8mm-2mm, 2mm-1.4mm and 1.4mm-1mm fractions and the electronic data captured by the Mastersizer below 1mm.

This method defines the particle size distributions in terms of Phi mean, median, fraction percentages (i.e., coarse sediments, sands and fines), sorting (mixture of sediment sizes) and skewness (weighting of sediment fractions above and below the mean sediment size; Folk 1954).

Formulae and classifications for particle calculations made are given below:

- **Graphic Mean (M)** - a very valuable measure of average particle size in Phi units (Folk and Ward, 1957).

$$M = \frac{\o 16 + \o 50 + \o 84}{3}$$

*Where* *M = The graphic mean particle size in Phi*

*ø = the Phi size of the 16th, 50th and 84th percentile of the sample*

**Phi and Sieve Apertures with Wentworth Classifications**

| Microns (µm) | | Phi (φ) | | Sediment Description | |
|---|---|---|---|---|---|
| **Aperture** | **Sediment Retained** | **Aperture** | **Sediment Retained** | | |
| 63000 | ≥ 63000 | -6 | <-6 | Cobbles & Boulders | Gravel |
| 45000 | 45000 < 63000 | -5.5 | -5.5 < -6 | Very Coarse Pebble | |
| 31500 | 31500 < 45000 | -5 | -5 < -5.5 | | |
| 22400 | 22400 < 31500 | -4.5 | -4.5 < -5 | Coarse Pebble | |
| 16000 | 16000 < 22400 | -4 | -4 < -4.5 | | |
| 11200 | 11200 < 16000 | -3.5 | -3.5 < -4 | Medium Pebble | |
| 8000 | 8000 < 11200 | -3 | -3 < -3.5 | | |
| 5600 | 5600 < 8000 | -2.5 | -2.5 < -3 | Fine Pebble | |
| 4000 | 4000 < 5600 | -2 | -2 < -2.5 | | |
| 2800 | 2800 < 4000 | -1.5 | -1.5 < -2 | Very Fine Pebble | |
| 2000 | 2000 < 2800 | -1 | -1 < -1.5 | | |
| 1400 | 1400 < 2000 | -0.5 | -0.5 < -1 | Very Coarse Sand | Sands |
| 1000 | 1000 < 1400 | 0 | 0 < -0.5 | | |
| 710 | 710 < 1000 | 0.5 | 0.5 < 0 | Coarse Sand | |
| 500 | 500 < 710 | 1 | 1 < 0.5 | | |
| 355 | 355 < 500 | 1.5 | 1.5 < 1 | Medium Sand | |
| 250 | 250 < 355 | 2 | 2 < 1.5 | | |
| 180 | 180 < 250 | 2.5 | 2.5 < 2 | Fine Sand | |
| 125 | 125 < 180 | 3 | 3 < 2.5 | | |
| 90 | 90 < 125 | 3.5 | 3.5 < 3 | Very Fine Sand | |
| 63 | 63 < 90 | 4 | 4 < 3.5 | | |
| 44 | 44 < 63 | 4.5 | 4.5 < 4 | Coarse Silt | Fines (Silts) |
| 31.5 | 31.5 < 44 | 5 | 5 < 4.5 | | |
| 22 | 22 < 31.5 | 5.5 | 5.5 < 5 | Medium Silt | |
| 15.6 | 15.6 < 22 | 6 | 6 < 5.5 | | |
| 11 | 11 < 15.6 | 6.5 | 6.5 < 6 | Fine Silt | |
| 7.8 | 7.8 < 11 | 7 | 7 < 6.5 | | |
| 5.5 | 5.5 < 7.8 | 7.5 | 7.5 < 7 | Very Fine Silt | |
| 3.9 | 3.9 < 5.5 | 8 | 8 < 7.5 | | |
| 2.8 | 2.8 < 3.9 | 8.5 | 8.5 < 8 | Clay | Fines (Clays) |
| 2 | 2 < 2.8 | 9 | 9 < 8.5 | | |
| 1.4 | 1.4 < 2 | 9.5 | 9.5 < 9 | | |
| 1 | 1 < 1.4 | 10 | 10 < 9.5 | | |
| <1 | <1 | 10.5 | ≥ 10.5 | | |

- **Sorting (D)** – the inclusive graphic standard deviation of the sample is a measure of the degree of sorting (Table II.II).

$$D = \frac{\phi 84 + \phi 16}{4} + \frac{\phi 95 + \phi 5}{6.6}$$

*where* *D = the inclusive graphic standard deviation*

*ø = the Phi size of the 84th, 16th, 95th and 5th percentile of the sample*

**Sorting Classifications**

| Sorting Coefficient (Graphical Standard Deviation) | Sorting Classifications |
|---|---|
| 0 < 0.35 | Very well sorted |
| 0.35 < 0.50 | Well sorted |
| 0.50 < 0.71 | Moderately well sorted |
| 0.71 < 1.00 | Moderately sorted |
| 1.00 < 2.00 | Poorly sorted |
| 2.00 < 4.00 | Very poorly sorted |
| 4.00 + | Extremely poorly sorted |

- **Skewness (S)** – the degree of asymmetry of a frequency or cumulative curve (Table II.III).

$$S = \frac{\phi 84 + \phi 16 - (\phi 50)}{2(\phi 84 - \phi 16)} + \frac{\phi 95 + \phi 5 - 2(\phi 50)}{2(\phi 95 - \phi 5)}$$

*where* *S = the skewness of the sample*

*ø = the Phi size of the 84th, 16th, 50th, 95th and 5th percentile of the sample*

**Skewness Classifications**

| Skewness Coefficient | Mathematical Skewness | Graphical Skewness |
|---|---|---|
| +1 > +0.30 | Strongly positive | Strongly coarse skewed |
| +0.30 > +0.10 | Positive | Coarse skewed |
| +0.10 > -0.10 | Near symmetrical | Symmetrical |
| -0.10 > -0.30 | Negative | Fine skewed |
| -0.30 > -1 | Strongly negative | Strongly fine skewed |

- **Graphic Kurtosis (K) –** The degree of peakedness or departure from the 'normal' frequency or cumulative curve (Table II.IV).

$$K = \frac{\phi 95 - \phi 5}{2.44\,(\phi 75 - \phi 25)}$$

*Where* *K = Kurtosis*

*ø = the Phi size of the 95$^{th}$, 5$^{th}$, 75$^{th}$ and 25$^{th}$ percentile of the sample*

**Kurtosis Classifications**

| Kurtosis Coefficient | Kurtosis Classification | Graphical meaning |
|---|---|---|
| 0.41 < 0.67 | Very Platykurtic | Flat-peaked; the ends are better sorted than the centre |
| 0.67 < 0.90 | Platykurtic | |
| 0.90 < 1.10 | Mesokurtic | Normal; bell shaped curve |
| 1.11 < 1.50 | Leptokurtic | Curves are excessively peaked; the centre is better sorted than the ends. |
| 1.50 < 3 | Very Leptokurtic | |
| 3 + | Extremely Leptokurtic | |

**Sediment Analyses**

*Similarity Matrices and Hierarchical Agglomerative Clustering (CLUSTER)*

A similarity matrix is used to compare every individual sample station with each other. The coefficient used in this process is based upon Euclidean distance considered to be the most suitable for environmental data. These are subsequently assigned into groups according to their level of similarity and clustered together based upon a Group Average Method into a dendrogram of similarity.

*Similarity Profiling (SIMPROF)*

Analyses data for significant clusters that show evidence of a multivariate pattern in data that are *a priori* unstructured, i.e. single samples from each site. The test works by comparing samples which have been ranked and ordered by resemblance against an expected profile which is obtained by permuting random variables across the set of samples, a mean of 1000 permutations is taken to produce an expected result for null structure with rare and common species displaying the same pattern. If the actual data deviates outside the 95% limits of the expected profile, then there is evidence for significant structure and vice versa. The 'significant structure' is well represented on a dendrogram which will also show the clusters containing that lack significant differentiation (null structure), (Clarke & Gorley, 2006).

*Principle Component Analyses (PCA)*

This analysis is used to reduce the number of variables of larger data sets to smaller ones while still preserving as much information as possible. The PCA looks for patterns in the data and detects similarities or correlations between variables and brings out the strongest pattern in the data set which can then be further explored.

**Sediment TOC**

TOC was analysed using an Eltra combustion method. This method is used for total carbon analysis of dried, crushed rock powder and environmental soil samples. The samples are previously treated with 10% HCl to remove inorganic carbon (Carbonates) before washing to remove residual acids and further dried. The Carbon

Analyser heats the sample in a flow of oxygen and any carbon present is converted to carbon dioxide which is measured by infra-red absorption. The percentage carbon is then calculated with respect to the original sample weight. The range for the method is 0.01% - 100%.

**Hydrocarbon Concentrations (Total hydrocarbon Concentrations and Aliphatics)**

**General Precautions**

High purity solvents were used throughout the analyses. Solvent purity was assessed by evaporating an appropriate volume to 1ml and analysing the concentrate by GC for general hydrocarbons, target n-alkanes and aromatics. All glassware and extraction sundries were cleaned prior to use by thorough rinsing with hydrocarbon-free deionised water followed by two rinses with dichloromethane. All glassware was heated in a high temperature oven at 450ºC for 6 hours.

**Extraction Procedure for Hydrocarbons**

Each analytical sample (15±0.1g) was spiked with an internal standard solution containing the following components: aliphatics - heptamethylnonane, 1-chlorooctadecane and squalene. The sample was then wet vortex extracted using three successive aliquots of DCM/Methanol. The extracts were combined and water partitioned to remove the methanol and any excess water from the sample.

Solvent extracts were chemically dried and then reduced to approximately 1ml using a Kuderna Danish evaporator with micro Snyder.

**Column fractionation for Aliphatic and Aromatic Fractions**

The concentrated extract was transferred to a pre-conditioned flash chromatography column containing approximately 1g of activated Silica gel. The compounds were eluted with 3ml of Pentane/DCM (2:1). An aliquot of the extract was then taken and analysed for total hydrocarbon (THC) content and individual n-alkanes by large volume injection GC-FID.

**Quality Control Samples**

The following quality control samples were prepared with the batches of sediment samples:

- A method blank comprising 15±0.1g of baked anhydrous sodium sulphate (organic free) treated as a sample.
- A matrix matched standard sample consisting of 15±0.1g baked sand spiked with Florida mix and treated as sample.
- A sample duplicate - any one sample from the batch, dependent upon available sample mass, analysed in duplicate.

**Hydrocarbon Analysis**

Analysis of total hydrocarbons and aliphatics was performed by using an Agilent 6890 with an FID detector. Appropriate column and GC conditions were used to provide sufficient chromatographic separation of all analytes and the required sensitivity.

### Carbon Preference Index

The carbon preference index is calculated as follows:

$$CPI = \frac{\text{odd homologues } (nC_{11} \text{ to } nC_{35})}{\text{even homologues } (nC_{10} \text{ to } nC_{34})}$$

### Petrogenic/Biogenic or (P/B) Ratio

The Petrogenic/Biogenic Ratio is calculated as follows:

$$P/B\ \text{Ratio} = \frac{P = \text{sum of } nC_{10} \text{ to } nC_{20}}{B = \text{sum of } nC_{21} \text{ to } nC_{35}}$$

### Calibration and Calculation

GC techniques require the use of internal standards in order to obtain quantitative results. The technique requires addition of non-naturally occurring compounds to the sample, allowing correction for varying recovery.

Target analytes concentrations were calculated by comparison with the nearest eluting internal standards. A relative response factor was applied to correct the data for the differing responses of target analytes and internal standards. Response factors were established prior to running samples, from solutions containing US EPA(16) PAHs + Dibenzothiophene (DBT) for the GCMS, Florida mix (even n-Alkanes $nC_{10}$-$nC_{40}$) for individual GC-FID targets and a diesel/mineral oil mix for total oil determination.

### Heavy and Trace Metal Concentrations

Sediment samples were homogenised and a 50g portion of each sample was air dried at room temperature. Each sample was then ground down to a fine powder (<100µm) by hand using a metal free mortar and pestle. A clean sand sample was hand ground prior to preparation of the field samples as a blank.

### Sample Digestion Procedure

Total Metals by ICPSOIL (Aqua Regia Extractable Metals - Ba, Li, Al):

1g of the air-dried sediment sample is digested for one hour with Aqua Regia. Once cooled the extract is filtered before being analysed. Analysis is performed by ICP-OES and quantified by comparing the results against a calibration curve for each of the target analytes.

Total Metals by ICPMSS (Aqua Regia Extractable Metals - Cr, Cu, Ni, As, Hg, Pb, Sn & Cd):

1g of air-dried sediment sample is digested for one hour with Aqua Regia. Once cooled the extract is filtered and pre-diluted before being analysed. Analysis is performed by ICP-MS and quantified comparing the results against a calibration curve for each of the target analytes.

The mean detection limits are given in the table below for Aqua Regia extractable metals.

**Heavy Metals – Limits of Detection (LOD)**

| Analyte | Unit | MDL |
|---|---|---|
| Al | mg.kg$^{-1}$ | 10 |
| As | mg.kg$^{-1}$ | 0.5 |
| Ba | mg.kg$^{-1}$ | 0.5 |
| Cd | mg.kg$^{-1}$ | 0.04 |
| Cr | mg.kg$^{-1}$ | 0.5 |
| Cu | mg.kg$^{-1}$ | 0.5 |
| Pb | mg.kg$^{-1}$ | 0.5 |
| Li | mg.kg$^{-1}$ | 2 |
| Hg | mg.kg$^{-1}$ | 0.01 |
| Ni | mg.kg$^{-1}$ | 0.5 |
| Sn | mg.kg$^{-1}$ | 0.5 |
| Zn | mg.kg$^{-1}$ | 2 |
| ICPMSS | | ICPSOIL |

**Analytical Methodology**

*Inductively Coupled-Plasma Optical Emission Spectrometry*

The instrument is calibrated using dilutions of the 1ml (=10mg) spectroscopic solutions. The final calibration solutions are matrix matched with the relevant acids. The calibration line consists of five standards.

*Inductively Coupled Plasma- Mass Spectrometry*

The instrument is calibrated using dilutions of the 1ml (=10mg) spectroscopic solutions. The calibration line consists of seven standards.

The analytes are scaled against internal standards to take account of changes in plasma conditions as a result of matrix differences for standards and samples. The internal standards have a similar mass and ionisation properties to the target metals.

**Macro-invertebrate Analysis**

**Methodology**

All macrofaunal determination was carried by BSL or BSL contracted specialist taxonomist with extensive experience in the identification of macrofaunal samples undertaken in shallow and deep-water environments (such as Southern North Sea, Channel Island, Ireland, Scotland, Faroes, and sub-Antarctic waters) and the survey region. Benthic sediment samples were thoroughly washed with freshwater on a 500µm sieve to remove traces of formalin, placed in gridded, white trays and then hand sorted by eye followed by binocular microscope, to remove all fauna. Sorted organisms were preserved in 70% IMS and 5% glycerol. Where possible, all organisms were identified to species level according to appropriate keys for the region. Colonial and encrusting organisms were recorded by presence alone and, where colonies could be identified as a single example, these were also recorded, although these datasets have not been considered in the overall statistical analysis of the material. The presence of anthropogenic components was also recorded where relevant.

All taxa were distinguished by species but identified to at least family level where possible. Nomenclature for species names were allocated either when identity was confirmed, allocated as "cf." when apparently identifying to a known species but confirmation was not possible (for example, incomplete specimens or descriptions), or allocated as "aff." when close to but distinct from a described species. The terms "indet." refers to being unable to identify to a lower taxon and "juv" as a juvenile to that species, genus, or family.

**Quality Assurance**

BSL is committed to total quality control from the start of a project to its completion. All samples taken or received by the company were given a unique identification number. All analytical methods were carried out according to recognised standards for marine analyses. All taxonomic staff are fully qualified to post-doctorate level. Documentation is maintained that indicates the stage of analysis that each sample has reached. A full reference collection of all specimens has been retained for further clarification of putative species groups where/if required. BSL is a participant in the NMBAQC quality assurance scheme.

Digital datasets are kept for all sites in the form of excel spreadsheets (by sample and by station) on BSL's archive computer. This system is duplicated onto a second archive drive in case of electronic failure. These datasets will be stored in this way for a minimum of 3 years or transferred to storage disk (data CD or DVD).

**Biological Data Standardisation and Analyses**

In accordance with OSPAR Commission (2004) guidelines, all species falling into juvenile, colonial, planktonic or meiofaunal taxa are excluded from the full analyses within the dataset (this is discussed further within the text of Section 2.9). This helps to reduce the variability of data undertaken during different periods within the year, or where minor changes may occur or where some groups may only be included in a non-quantitative fashion, such as presence/absence.

Certain taxa, such as the Nematoda, normally associated with meiofauna, were included where individuals greater than 10mm were recorded. The following primary and univariate parameters were calculated for each all data by stations and sample.

**Primary and Univariate Parameter Calculations**

| Variable | Parameter | Formula | Description |
|---|---|---|---|
| Total Species | S | Number of species recorded | Species richness |
| Total Individuals | N | Number of individuals recorded | Sample abundance |
| Shannon-Wiener Index | H(s) | $H(s) = -\sum_{i=1}^{s} (Pi)(\log_2 Pi)$ where s = number of species & Pi = proportion of total sample belonging to *i*th species. | Diversity: using both richness and equitability, recorded in log 2. |
| Simpsons Diversity | 1-Lambda | $Lambda = \sum \left( \frac{ni(ni-1)}{N(N-1)} \right)$ where ni = number of individuals in the *i*th species & N = total number of individuals | Evenness, related to dominance of most common species (Simpson, 1949) |

| Variable | Parameter | Formula | Description |
|---|---|---|---|
| Pielou's Equitability | J | $$J = \frac{H(s)}{(\log S)}$$ where s = number of species & H(s) = Shannon-Wiener diversity index. | Evenness or distribution between species (Pielou, 1969) |
| Margalef's Richness | $D_{Mg}$ | $$D_{Mg} = \frac{(S-1)}{(\log N)}$$ where s = number of species & N = number of individuals. | Richness derived from number of species and total number of individuals (Clifford and Stevenson, 1975) |

In addition to univariate methods of analysis, data for both sample replicates and stations were analysed using multivariate techniques. These serve to reduce complex species-site data to a form that is visually interpretable. A multivariate analysis was based on transformed data (square root) to detect any improved relationships when effects of dominance were reduced. The basis for multivariate analyses was based upon the software PRIMER (Plymouth Routines In Multivariate Ecological Research).

*Similarity Matrices and Hierarchical Agglomerative Clustering*

A similarity matrix is used to compare every individual sample replicate and/or stations with each other. The coefficient used in this process is based upon Bray Curtis (Bray and Curtis, 1957), considered to be the most suitable for community data. These are subsequently assigned into groups of replicates and/or stations according to their level of similarity and clustered together based upon a Group Average Method into a dendrogram of similarity.

*Non-Metric Multi-dimensional Scaling (nMDS)*

nMDS is currently widely used in the analysis of spatial and temporal change in benthic communities (e.g. Warwick and Clarke, 1991). The recorded observations from data were exposed to computation of triangular matrices of similarities between all pairs of samples. The similarity of every pair of sites was computed using the Bray-Curtis index on transformed data. Clustering was by a hierarchical agglomerative method using group average sorting, and the results are presented as a dendrogram and as a two-dimensional ordination plot. The degree of distortion involved in producing an ordination gives an indication of the adequacy of the nMDS representation and is recorded as a stress value as outlined in the table below.

**Inference from nMDS Stress Values**

| nMDS Stress | Adequacy of Representation for Two-Dimensional Plot |
|---|---|
| ≤0.05 | Excellent representation with no prospect of misinterpretation. |
| >0.05 to 0.1 | Good ordination with no real prospect of a misleading interpretation. |
| >0.1 to 0.2 | Potentially useful 2-d plot, though for values at the upper end of this range too much reliance should not be placed on plot detail; superimposition of clusters should be undertaken to verify conclusions. |
| >0.2 to 0.3 | Ordination should be treated with scepticism. Clusters may be superimposed to verify conclusions, but ordinations with stress values >2.5 should be discarded. A 3-d ordination may be more appropriate. |
| >0.3 | Ordination is unreliable with points close to being arbitrarily placed in the 2-d plot. A 3-d ordination should be examined. |

*Similarity Percentages Analysis (SIMPER)*

The nMDS clustering program is used to analyse differences between sites. SIMPER enables those species responsible for differences to be identified by examining the contribution of individual species to the similarity measure.

*Bioaccumulation Curve Estimates using Chao-1*

This is a formula that estimates how many additional species would be needed to sample all of the asymptotic species richness of a region, based on the samples acquired. It calculates this by comparing the number of species that occur in one sample with those that occur in two samples where;

$S^*_1 = S_{obs} + (a^2/2b)$

$\mathbf{S_{obs}}$ is the number of species observed

**a** is the number of species observed just once

**b** is the number of species observed just twice

*Relationship Testing (RELATE)*

A non-parametric Mantel test that looks at the relationship between 2 matrices (often biotic and environmental). This shows the degree of seriation, an alternative to cluster analysis, which looks for a sequential pattern in community change. The test computes Spearman's rank correlation coefficient ($\rho$) between the corresponding elements of each pair of matrices to produce a correlation statistic present between the two datasets, the significance of the correlation determined by a permutation procedure (Clarke and Gorley, 2006).

*Analysis of Similarity (ANOSIM)*

Non-parametric, multivariate test often used in community ecology that calculates Bray-Curtis coefficient (for biological data) or Euclidean distance (for environmental data) based on permutations of ranked data. It produces an *R* value which is an effect level on a scale of 0-1; *R*=1 where all differences between sites are greater than any differences within site, *R*=0 when there is no separation between groups. *P* value (<5%) is the likelihood of arriving at that *R* value by chance, this significance value is determined by a permutation procedure (Clarke and Gorley, 2006).

*Similarity Profiling (SIMPROF)*

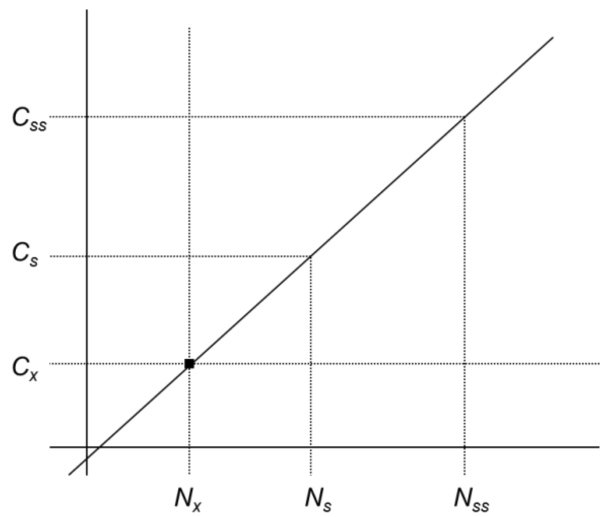
Analyses data for significant clusters that show evidence of a multivariate pattern in data that are *a priori* unstructured, i.e. single samples from each site, this differs from the ANOSIM tests which permutes data based on a grouping factor such as 'site' or 'year'. The test works by comparing samples which have been ranked and ordered by resemblance against an expected profile which is obtained by permuting random species (variables) across the set of samples, a mean of 1000 permutations is taken to produce an expected result for null structure with rare and common species displaying the same pattern. If the actual data deviates outside the 95% limits of the expected profile, then there is evidence for significant structure and vice versa. The 'significant structure' is well represented on a dendrogram which will also show the clusters containing that lack significant differentiation (null structure; Clarke and Gorley, 2006).

**Normalisation**

Normalisation is a procedure used here to correct concentrations for the influence of the natural variability in sediment composition (i.e. grain size, organic matter and mineralogy). Natural and anthropogenic contaminants tend to show a much higher affinity to fine particulate matter compared to coarse (OSPAR, 2009) due to the increased adsorption capacity of organic matter and clay minerals. In sites where there is variability in grain size between stations, effects of sources of contamination will at least partly be obscured by grain size differences.

Normalisation can be performed through linear regression or by simple contaminant/normaliser ratios.

Linear regression normalisation takes into account the possible presence of contaminants and co-factors. The binding capacity of the sediments can be related to the content of fines (primary co-factor) in the sediments. The level of fines can be represented by the contents of major elements of the clay fraction such as aluminium (secondary co-factor). Figure II.I represents the general model for normalisation of the contaminants.




**Relationship between the contaminant C and the cofactor N**

Cx and Nx represent the contaminant and the co-factor contents, respectively, in pure sand. The regression line will always originate from this point and pivot depending on the sampled contaminant concentrations (Cs and Ns). These 'pivot values' are derived from statistical analysis of contaminant concentrations in pure sand.

The linear relationship between the pivot point and the sampled concentrations allows determination of the contaminant content for any preselected co-factor content (Nss) by interpolation and extrapolation. When comparing to the OSPAR BCs and BACs the secondary cofactors for normalisation are 52ppm of Li for metals and 2.5% TOC when normalising organics. The slope of the regression line (PL) can be represented by Equation 1, which can then be re-arranged to give the contaminant content Css that is normalised to Nss in Equation 2.

$$PL = \frac{dC}{dN} = \frac{C_s - C_x}{N_s - N_x} = \frac{C_{ss} - C_x}{N_{ss} - N_x}$$

**Equation 1: Slope of the regression line expressed in terms of $N_{ss}$**

$$C_{ss} = (C_s - C_x)\frac{N_{ss} - N_x}{N_s - N_x} + C_x$$

**Equation 2: Rewritten equation giving the contaminant content $C_{ss}$ normalised to $N_{ss}$**

*Normalisation of Metals*

This method is limited by the sampled concentration of the contaminant. If a measured concentration falls below the Cx 'pivot value' for that metal or if the concentration of Li falls below the Nx 'pivot value', the method will give a skewed result (often a negative concentration). The pivot values for the contaminants are given in table below.

**Pivot Values for Metals with OSPAR Background Concentrations (CSEMP, 2013)**

| Metal | Li | Al | As | Cd | Cr | Cu | Hg | Ni | Pb | Z |
|---|---|---|---|---|---|---|---|---|---|---|
| $N_x$ or $C_x$ (mg.kg$^{-1}$) | 4 | 4,000 | 3 | 0.03 | 13 | 1 | 0 | 2.5 | 2 | 8 |

If a metal is found to be below these values the alternative method of a simple ratio between contaminant/normaliser can be used (Equation 3).

$$C_{ss} = \frac{N_{ss}}{N_s} C_s$$

**Equation 3: Ratio method for the normalisation of a contaminant.**

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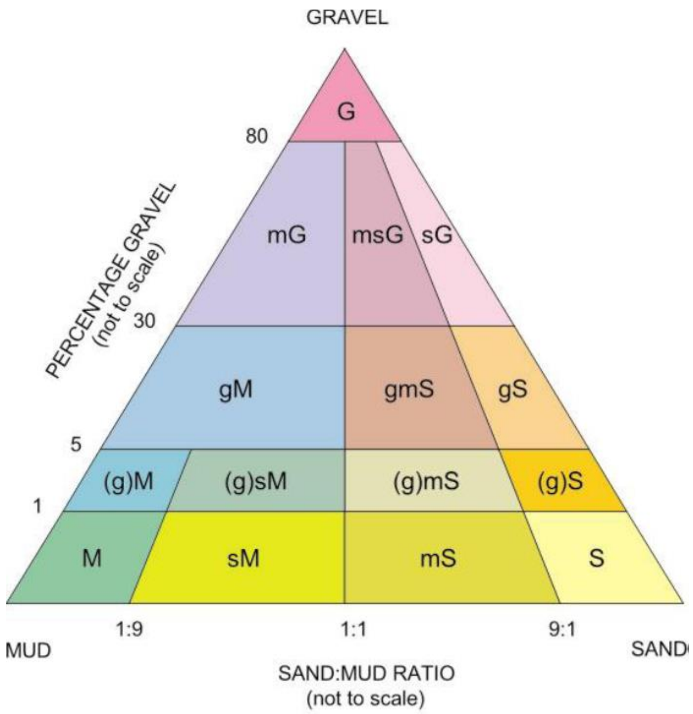
## Appendix C – Particle Size Distribution

Individual particle size distribution plots provided in a separate PDF.

**Modified Folk Classification**




M — Mud
sM — Sandy mud
(g)M — Slightly gravelly mud
(g)sM — Slightly gravelly sandy mud
gM — Gravelly mud
S — Sand
mS — Muddy sand
(g)S — Slightly gravelly sand
(g)mS — Slightly gravelly muddy sand
gmS — Gravelly muddy sand
gS — Gravelly sand
G — Gravel
mG — Muddy gravel
msG — Muddy sandy gravel
sG — Sandy gravel

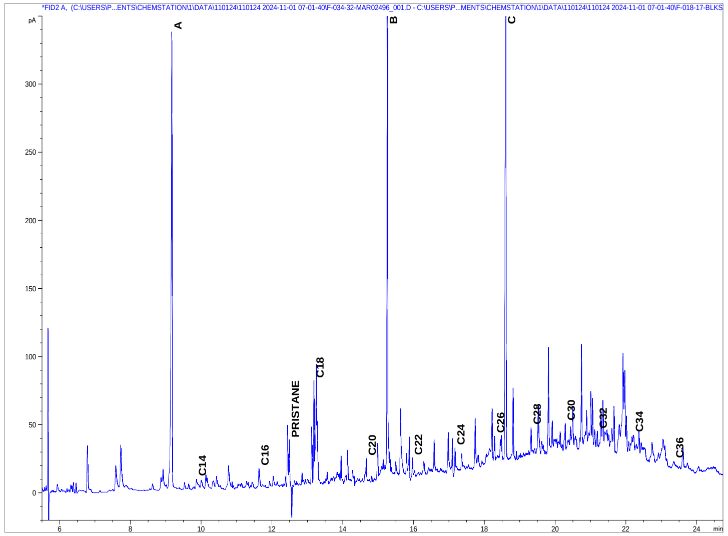
## Appendix D – Total Aliphatic Concentrations by Station (µg.kg$^{-1}$)

| Station | LL_01_EBS | LL_08_EBS | LL_11_EBS | LL_13_EBS | LL_17_EBS | LL_21_EBS | LL_27_EBS | LL_32_EBS | LL_38_EBS | LL_44_EBS | LL_49_EBS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| nC10 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| nC11 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| nC12 | <1 | 10.62 | <1 | 24.19 | 15.08 | <1 | <1 | <1 | <1 | <1 | <1 |
| nC13 | <1 | 47.38 | 17.86 | 64.36 | 47.58 | 3.40 | 4.01 | <1 | <1 | <1 | <1 |
| nC14 | <1 | 39.57 | 30.57 | 57.96 | 39.69 | 2.46 | 3.51 | <1 | <1 | <1 | <1 |
| nC15 | <1 | 95.06 | 141.29 | 75.75 | 75.18 | 9.27 | 2.09 | <1 | 3.67 | <1 | <1 |
| nC16 | <1 | 87.92 | 84.60 | 81.10 | 60.82 | 2.88 | 6.31 | 3.28 | 4.22 | <1 | <1 |
| nC17 | <1 | 166.86 | 139.91 | 196.84 | 141.86 | 11.88 | 14.57 | 7.81 | 9.15 | <1 | 6.03 |
| Pristane | <1 | 123.86 | 139.64 | 128.6 | 113.74 | 11.42 | 13.58 | 6.59 | 11.71 | <1 | 6.37 |
| nC18 | <1 | 97.05 | 138.90 | 128.45 | 87.80 | 8.47 | 10.31 | 4.35 | 9.57 | <1 | 3.69 |
| Phytane | <1 | 99.14 | 40.85 | 49.22 | 44.09 | 3.75 | 16.22 | 4.43 | 7.72 | <1 | <1 |
| nC19 | <1 | 57.35 | 61.97 | 64.62 | 50.22 | 3.99 | 9.42 | 2.40 | 5.99 | <1 | 4.16 |
| nC20 | <1 | 60.33 | 64.87 | 54.94 | 41.32 | 4.50 | 4.81 | 2.08 | 2.67 | <1 | 2.16 |
| nC21 | <1 | 27.93 | 99.75 | 64.27 | 57.33 | 5.63 | 3.57 | 1.51 | 4.51 | <1 | <1 |
| nC22 | <1 | 32.53 | 55.40 | 47.36 | 33.98 | 5.43 | 2.71 | <1 | 2.77 | <1 | 1.84 |
| nC23 | <1 | 57.92 | 90.03 | 74.85 | 60.78 | 3.15 | 4.88 | 1.65 | 8.12 | <1 | 4.00 |
| nC24 | <1 | 45.77 | 94.63 | 58.80 | 46.05 | 7.42 | 6.64 | 5.41 | 4.39 | <1 | 1.79 |
| nC25 | <1 | 118.98 | 230.78 | 128.38 | 95.37 | 15.02 | 15.36 | 4.84 | 11.03 | <1 | 6.10 |
| nC26 | <1 | 57.57 | 89.52 | 57.21 | 42.58 | 9.25 | 37.85 | 11.26 | 6.73 | <1 | 5.61 |
| nC27 | <1 | 156.85 | 192.96 | 126.3 | 95.68 | 14.58 | 16.50 | 7.97 | 16.01 | <1 | 8.81 |
| nC28 | <1 | 52.99 | 96.78 | 51.30 | 42.12 | 5.59 | 13.23 | 5.45 | 5.23 | <1 | 4.70 |
| nC29 | <1 | 249.11 | 342.33 | 169.63 | 137.99 | 19.42 | 22.55 | 15.15 | 26.81 | 2.01 | 15.9 |
| nC30 | <1 | 73.61 | 63.95 | 28.22 | 32.56 | 6.31 | 3.75 | 3.14 | 3.64 | <1 | 2.86 |
| nC31 | <1 | 215.27 | 296.59 | 118.01 | 98.33 | 14.96 | 21.72 | 6.62 | 19.62 | <1 | 10.2 |
| nC32 | <1 | 44.06 | 51.20 | 15.98 | 23.17 | 1.30 | <1 | <1 | 2.69 | <1 | <1 |
| nC33 | <1 | 104.05 | 133.82 | 51.16 | 37.31 | 5.49 | 7.82 | <1 | 9.28 | <1 | 3.43 |
| nC34 | <1 | 5.04 | 28.37 | 8.14 | 2.19 | 3.84 | 1.44 | <1 | 2.19 | <1 | 1.53 |
| nC35 | <1 | 13.16 | 31.03 | 8.25 | 4.91 | 2.76 | 2.00 | <1 | 1.70 | <1 | <1 |
| nC36 | <1 | 6.73 | 6.71 | 2.14 | <1 | 1.33 | <1 | <1 | 1.69 | <1 | <1 |
| nC37 | <1 | 6.76 | 6.80 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| **Total Oil** | **69** | **36,834** | **60,061** | **34,497** | **28,030** | **7,437** | **7,675** | **4,520** | **4,332** | **427** | **2,480** |
| **Total n-alkanes** | **0.0** | **1,930.5** | **2,590.6** | **1,758.3** | **1,369.9** | **168.36** | **215.06** | **82.9** | **161.68** | **2.01** | **82.8** |

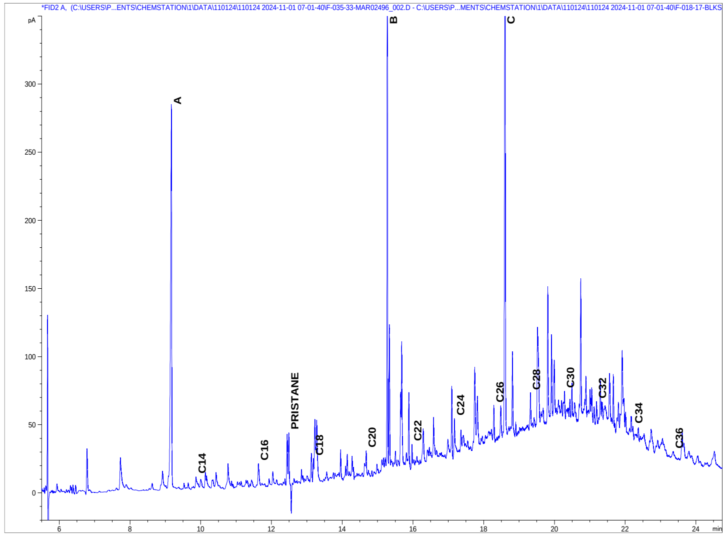
| Station | LL_60_EBS | LL_64_EBS | LL_87_EBS | LL_89_EBS | LL_94_EBS | LL_97_EBS | LL_99_EBS | LL_102_EBS | LL_104_EBS | LL_108_EBS | LL_116_EBS | LL_120_EBS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| nC10 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| nC11 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| nC12 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| nC13 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | 8.44 |
| nC14 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | 2.61 |
| nC15 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | 2.86 | <1 | <1 | <1 | 11.6 |
| nC16 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | 2.27 | <1 | <1 | <1 | 6.23 |
| nC17 | <1 | 4.66 | 3.92 | <1 | <1 | <1 | <1 | 8.68 | 1.92 | <1 | 3.87 | 14.3 |
| Pristane | <1 | 7.70 | 5.14 | <1 | <1 | <1 | <1 | 7.31 | 3.34 | <1 | 3.43 | 17.2 |
| nC18 | <1 | 1.47 | <1 | <1 | <1 | <1 | <1 | 4.49 | <1 | <1 | <1 | 6.98 |
| Phytane | <1 | <1 | <1 | <1 | <1 | <1 | <1 | 1.61 | <1 | <1 | <1 | 4.39 |
| nC19 | <1 | 2.68 | 3.14 | <1 | <1 | <1 | <1 | 7.21 | 1.29 | <1 | 1.46 | 8.95 |
| nC20 | <1 | 1.95 | <1 | <1 | <1 | <1 | <1 | 3.41 | <1 | <1 | <1 | 4.78 |
| nC21 | <1 | <1 | <1 | 2.13 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | 4.57 |
| nC22 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | 2.95 | <1 | <1 | <1 | 3.36 |
| nC23 | <1 | 2.82 | 1.55 | 2.40 | <1 | <1 | <1 | 7.06 | 2.39 | <1 | <1 | 5.29 |
| nC24 | <1 | 2.03 | <1 | <1 | <1 | <1 | <1 | 4.54 | <1 | <1 | 1.59 | 7.01 |
| nC25 | <1 | 6.55 | 10.1 | 2.16 | 1.68 | <1 | <1 | 12.6 | 5.11 | <1 | 1.72 | 4.82 |
| nC26 | <1 | 1.95 | 4.82 | 2.08 | <1 | <1 | <1 | 5.84 | 1.72 | <1 | <1 | 14.4 |
| nC27 | 1.60 | 11.3 | 4.21 | 7.31 | 1.75 | <1 | <1 | 19.5 | 4.58 | <1 | 3.24 | 16.5 |
| nC28 | <1 | 3.33 | 3.38 | <1 | <1 | <1 | <1 | 5.46 | 2.20 | 1.29 | <1 | 10.1 |
| nC29 | 2.50 | 13.6 | 6.47 | 4.95 | 4.28 | 1.25 | 1.48 | 30.8 | 6.21 | 2.97 | 3.65 | 23.6 |
| nC30 | <1 | 3.78 | <1 | <1 | <1 | <1 | <1 | 6.08 | <1 | <1 | 2.89 | 8.94 |
| nC31 | 2.22 | 14.4 | 3.46 | 1.67 | 3.79 | <1 | <1 | 17.9 | 4.48 | 2.96 | 4.64 | 20.0 |
| nC32 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | 2.22 | <1 | <1 | 2.62 | 4.38 |
| nC33 | 1.28 | 3.26 | 1.53 | <1 | <1 | <1 | <1 | 2.59 | 1.34 | <1 | 3.07 | 2.98 |
| nC34 | <1 | <1 | <1 | 3.21 | <1 | <1 | <1 | 2.57 | <1 | <1 | 2.64 | 4.49 |
| nC35 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | 2.11 | <1 | <1 | 3.45 | 2.39 |
| nC36 | <1 | <1 | 8.26 | <1 | <1 | <1 | <1 | 1.67 | <1 | <1 | 1.79 | <1 |
| nC37 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| **Total Oil** | **719** | **3,309** | **1,982** | **1,040** | **869** | **394** | **857** | **4,341** | **1,059** | **703** | **2,591** | **6,888** |
| **Total n-alkanes** | **7.60** | **73.8** | **50.9** | **25.9** | **11.5** | **1.25** | **1.48** | **153** | **31.2** | **7.21** | **36.6** | **197** |

| Station | LL_125_EBS | LL_129_EBS | LL_133_EBS | LL_138_EBS | LL_55_EBS_SS_HM | LL_72_EBS_SS_HM | LL_73_EBS_SS_HM | LL_78_EBS_SS_HM | LL_85_EBS_SS_HM | LL_106_EBS_SS_HM | LL_112_EBS_SS_HM |
|---|---|---|---|---|---|---|---|---|---|---|---|
| nC10 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| nC11 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| nC12 | <1 | <1 | <1 | 1.53 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| nC13 | <1 | 5.40 | <1 | 16.8 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| nC14 | <1 | 4.01 | <1 | 9.58 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| nC15 | <1 | 15.8 | <1 | 34.2 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| nC16 | <1 | 6.97 | <1 | 7.20 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| nC17 | 3.63 | 14.1 | 6.58 | 17.4 | <1 | <1 | <1 | <1 | <1 | <1 | 4.52 |
| Pristane | 2.75 | 16.8 | 5.04 | 19.7 | 3.94 | <1 | 17.2 | <1 | <1 | <1 | 4.50 |
| nC18 | <1 | 11.11 | 2.52 | 14.1 | <1 | <1 | 2.41 | <1 | <1 | <1 | 1.51 |
| Phytane | <1 | 9.15 | 1.28 | 11.3 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| nC19 | <1 | 10.8 | 4.19 | 10.1 | <1 | <1 | 2.73 | <1 | <1 | <1 | 2.06 |
| nC20 | <1 | 6.04 | 1.23 | 5.15 | <1 | <1 | 3.28 | <1 | <1 | <1 | <1 |
| nC21 | <1 | 2.77 | 2.18 | 16.4 | <1 | <1 | 4.31 | <1 | <1 | <1 | <1 |
| nC22 | <1 | 4.47 | <1 | 5.91 | <1 | <1 | 3.81 | <1 | <1 | <1 | <1 |
| nC23 | 1.92 | 7.16 | 1.96 | 8.99 | 2.00 | <1 | 6.22 | <1 | <1 | <1 | 2.12 |
| nC24 | <1 | 6.62 | 2.15 | 7.04 | <1 | <1 | 4.79 | <1 | <1 | <1 | <1 |
| nC25 | 2.25 | 3.22 | 15.2 | 20.1 | 2.74 | <1 | 8.40 | <1 | <1 | 2.48 | 2.25 |
| nC26 | <1 | 7.34 | 2.04 | 10.4 | 2.16 | <1 | 7.65 | <1 | <1 | <1 | 1.82 |
| nC27 | 4.34 | 18.5 | 9.82 | 39.2 | 2.63 | <1 | 10.7 | <1 | <1 | <1 | 4.59 |
| nC28 | 1.57 | 7.50 | 1.35 | 8.43 | <1 | <1 | 7.51 | <1 | <1 | 1.23 | <1 |
| nC29 | 5.60 | 21.1 | 8.34 | 21.3 | 3.29 | <1 | 9.98 | <1 | 1.24 | 1.74 | 7.62 |
| nC30 | 2.65 | 5.94 | 3.75 | 4.70 | <1 | <1 | 5.00 | <1 | <1 | <1 | 1.40 |
| nC31 | 8.04 | 16.0 | 5.15 | 12.2 | 1.99 | <1 | 7.10 | <1 | <1 | 2.13 | 2.36 |
| nC32 | 4.50 | 1.75 | 1.43 | 2.80 | <1 | <1 | 2.13 | <1 | <1 | <1 | <1 |
| nC33 | 5.13 | 6.68 | 1.67 | 2.16 | <1 | <1 | 3.31 | <1 | <1 | <1 | <1 |
| nC34 | 3.03 | 2.46 | <1 | 2.84 | <1 | <1 | 2.90 | <1 | <1 | <1 | <1 |
| nC35 | 3.75 | 1.73 | <1 | 2.01 | <1 | <1 | 2.58 | <1 | <1 | <1 | <1 |
| nC36 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| nC37 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| **Total Oil** | **3,751** | **5,929** | **3,527** | **8,894** | **878** | **303** | **866** | **175** | **462** | **388** | **1,855** |
| **Total n-alkanes** | **46.4** | **187** | **69.5** | **281** | **14.8** | **0.00** | **94.9** | **0.00** | **1.24** | **7.58** | **30.3** |

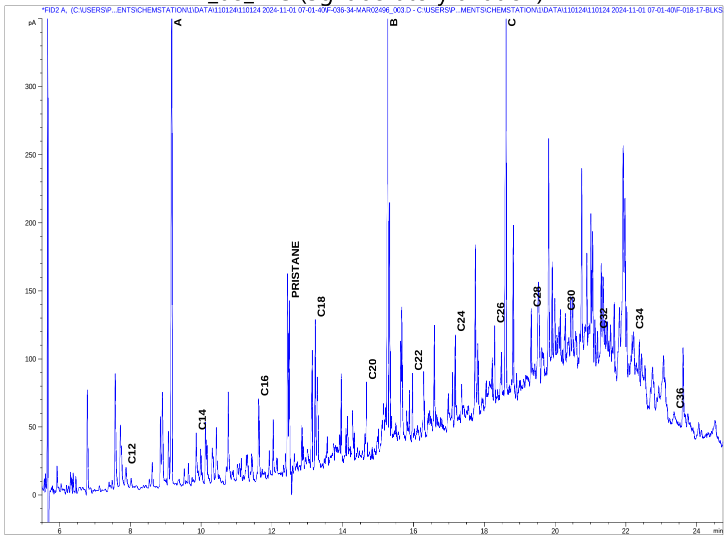
## Appendix E – GC FID Traces (Saturates)



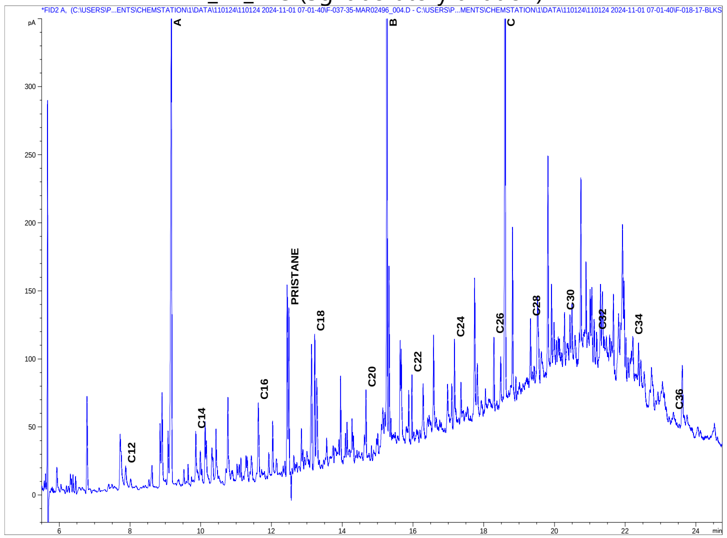

LL_08_EBS (5g laboratory dilution)



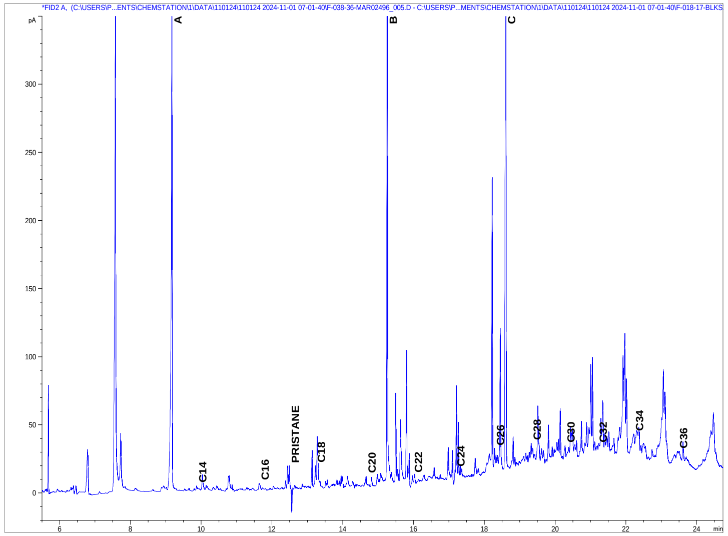

LL_11_EBS (5g laboratory dilution)



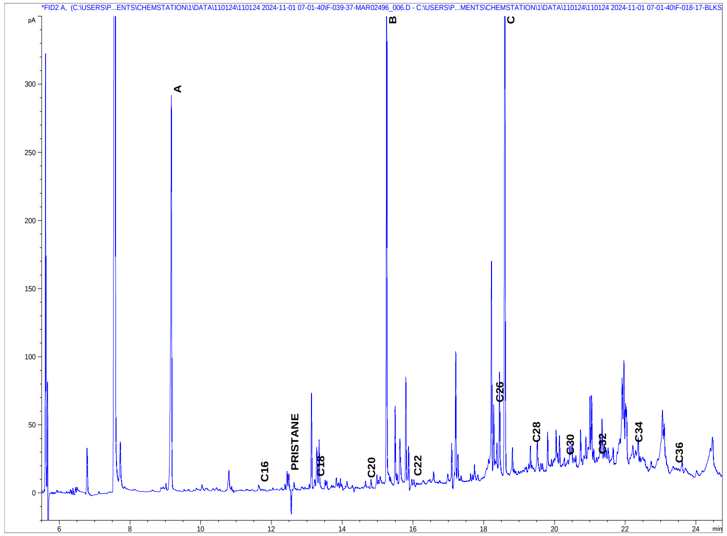

LL_13_EBS



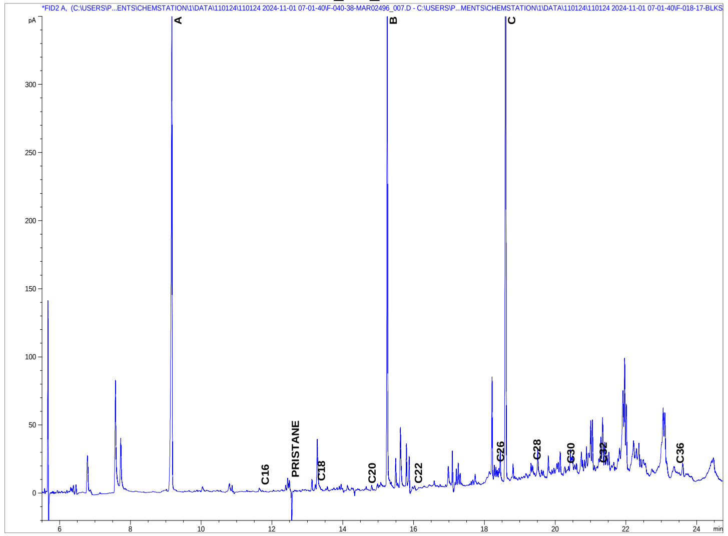

LL_17_EBS



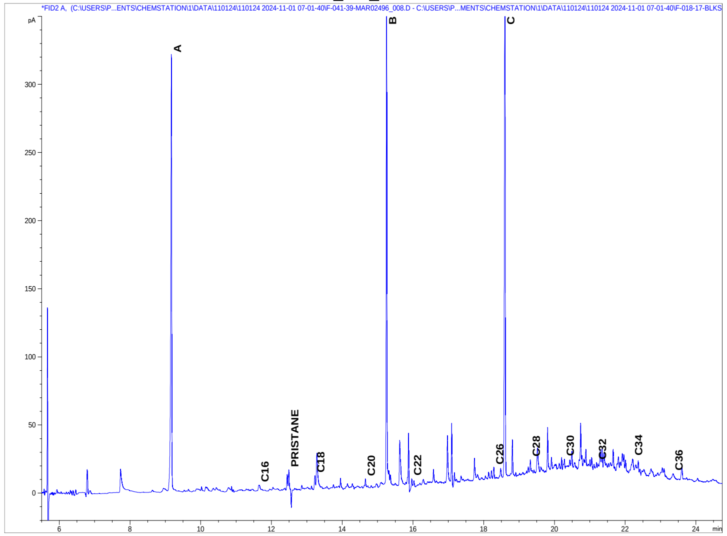
LL_21_EBS



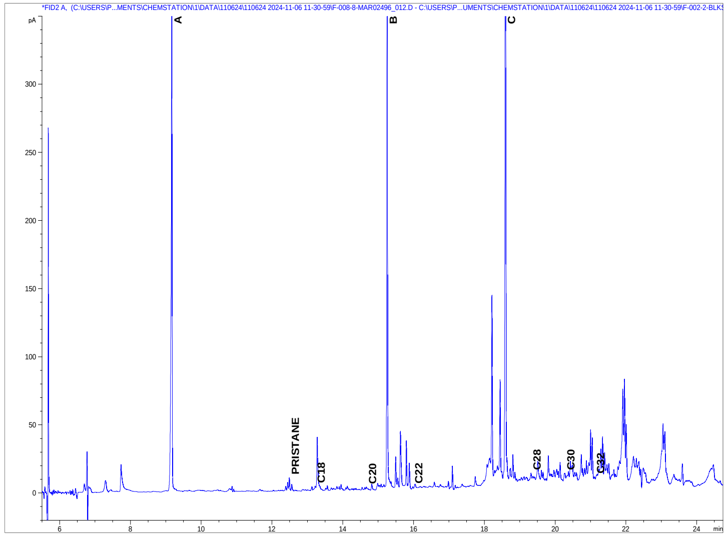
LL_27_EBS



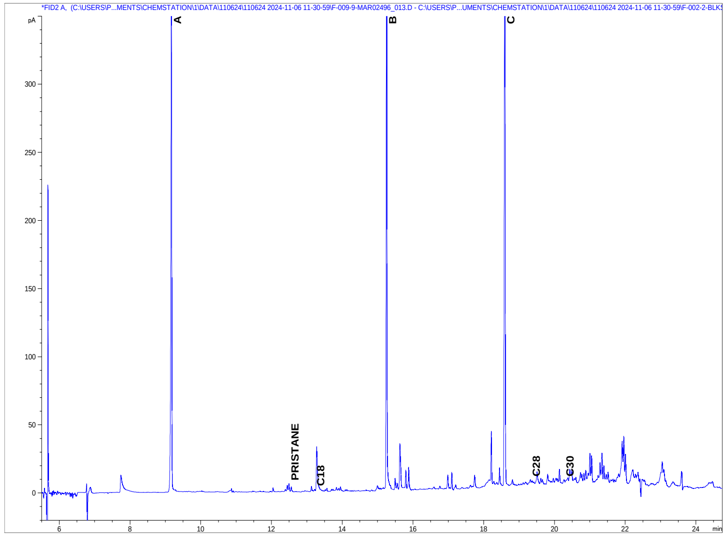
LL_32_EBS



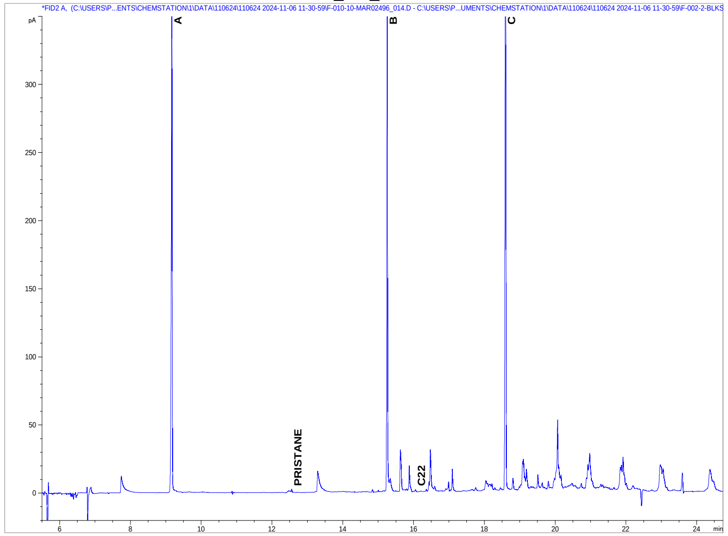
LL_38_EBS



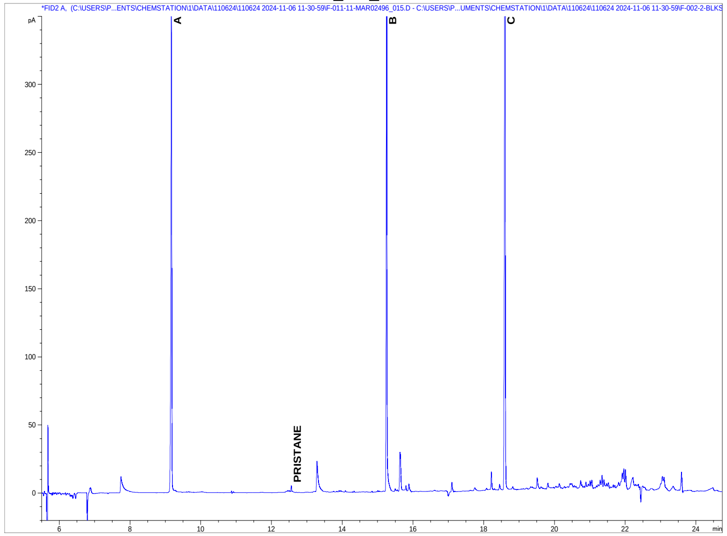

LL_64_EBS



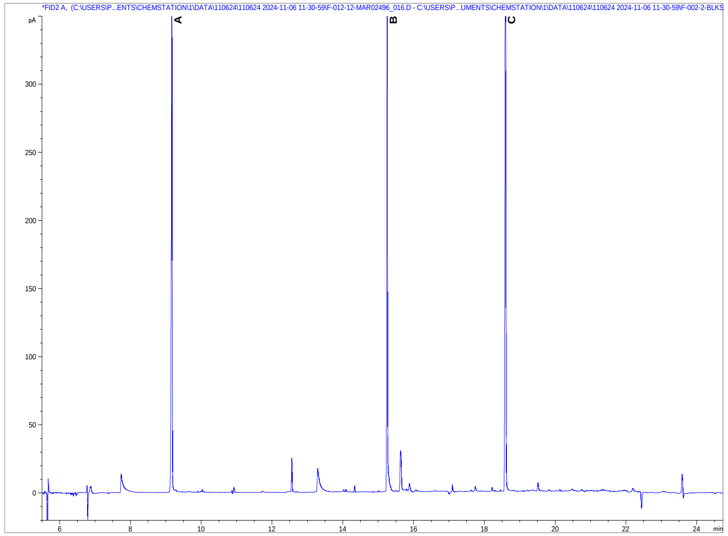

LL_87_EBS



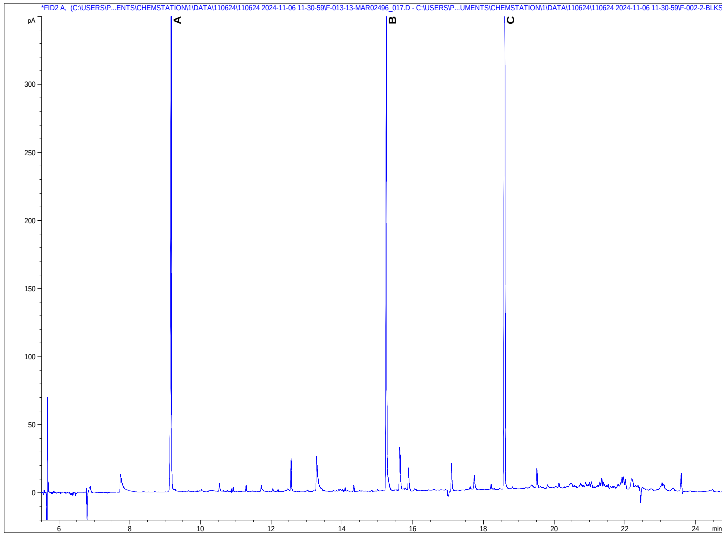

LL_89_EBS



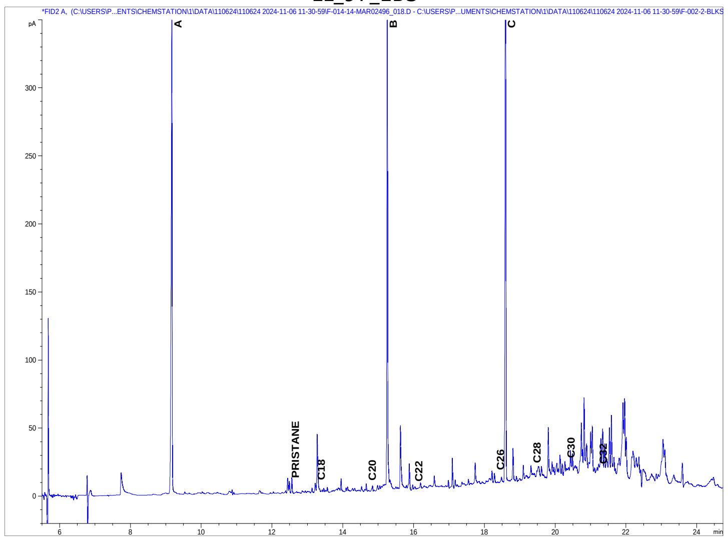

LL_94_EBS



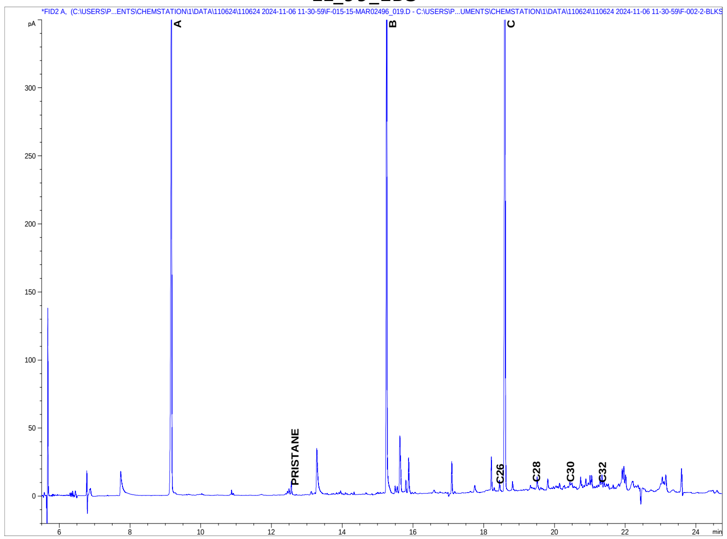

LL_97_EBS



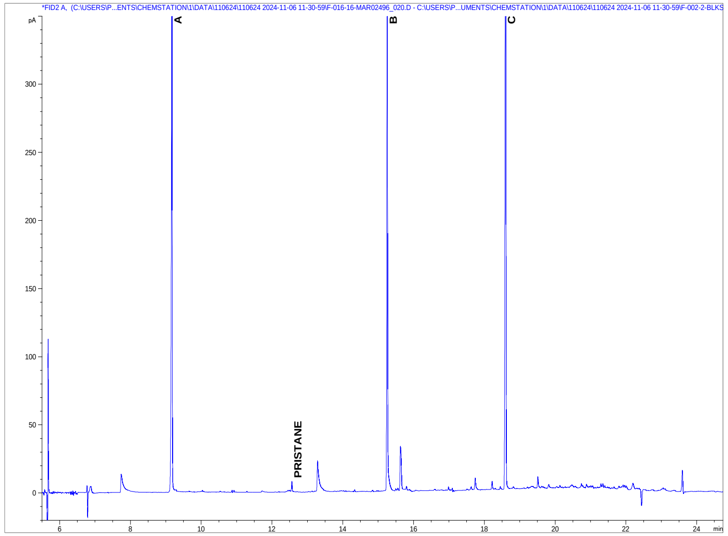

LL_99_EBS



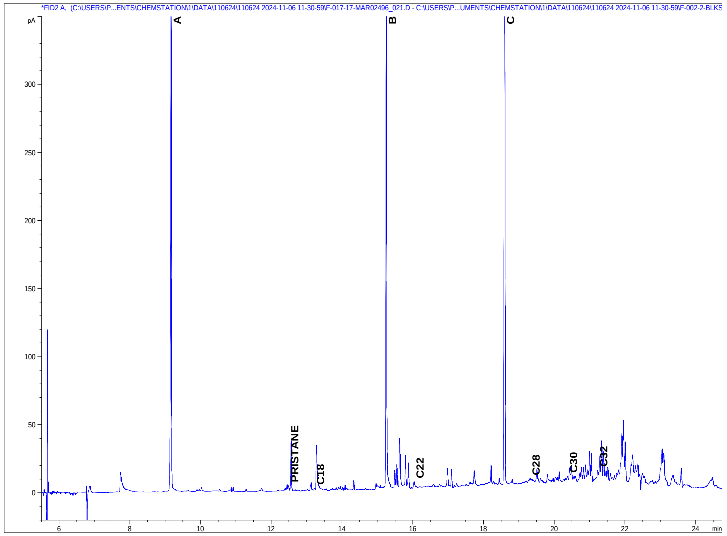

LL_102_EBS



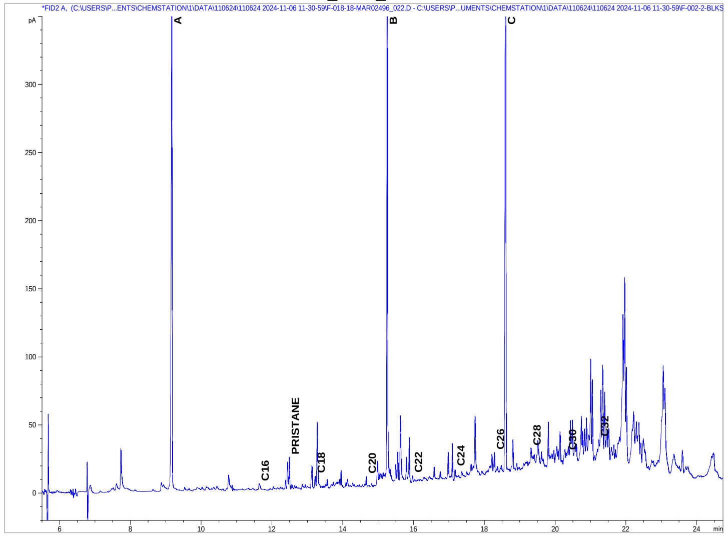

LL_104_EBS



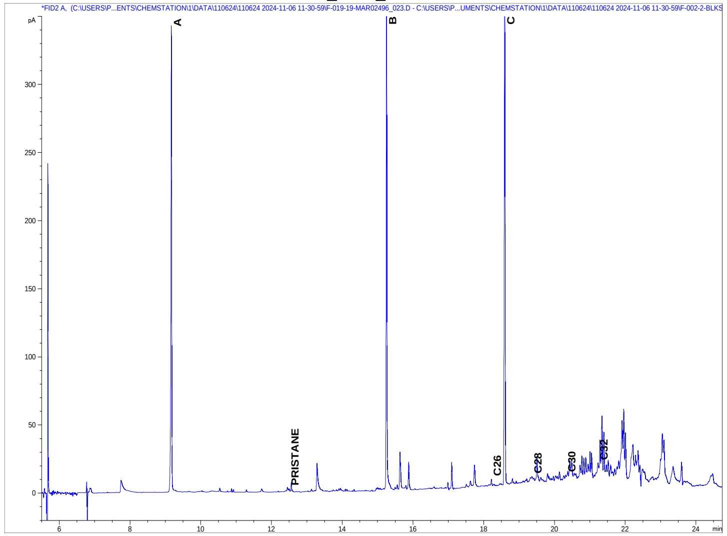
LL_108_EBS



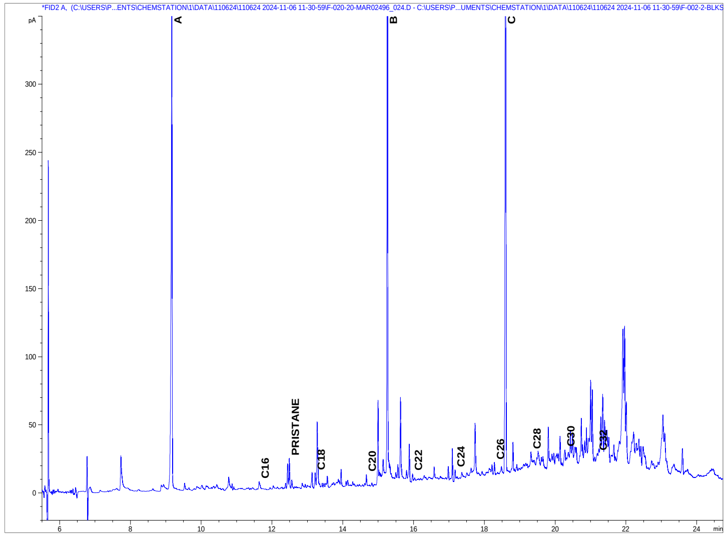
LL_116_EBS



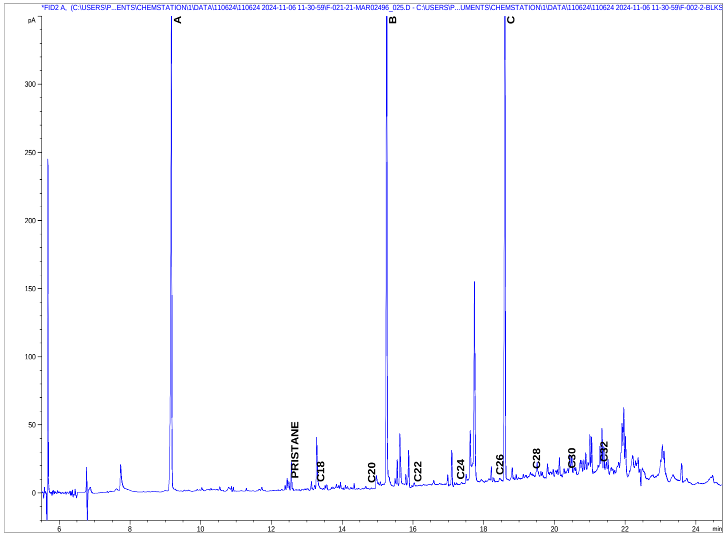
LL_120_EBS



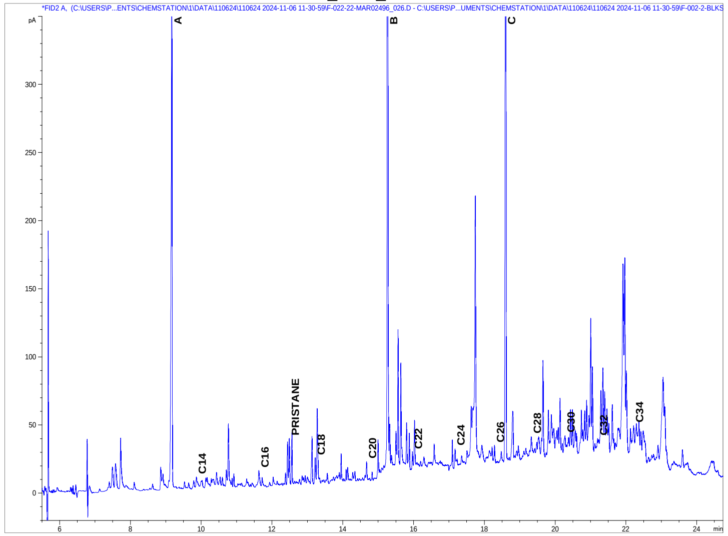
LL_125_EBS



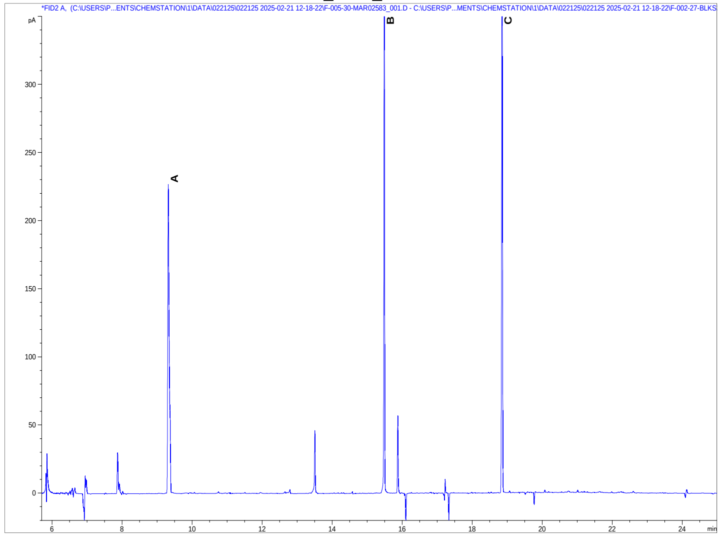

LL_129_EBS




LL_133_EBS




LL_138_EBS




LL_01_EBS

*Notes:*
5g = Due to matrix effects in the sample, 5g of sediment was used in the extraction step to prepare the sample for GC analysis.

## Appendix F – Polycyclic Aromatic Hydrocarbon Concentrations (μg.kg$^{-1}$)

| Station | LL_01_EBS | LL_08_EBS | LL_11_EBS | LL_13_EBS | LL_17_EBS | LL_21_EBS | LL_27_EBS | LL_32_EBS | LL_38_EBS | LL_44_EBS |
|---|---|---|---|---|---|---|---|---|---|---|
| Naphthalene | <1 | 39.5 | 50.8 | 41.2 | 29.2 | 3.7 | 3.8 | 2.0 | 4.9 | <1 |
| C1 Naphthalenes | <1 | 124.5 | 151.5 | 121.3 | 98.6 | 10.4 | 12.9 | 6.5 | 14.0 | <1 |
| C2 Naphthalenes | <1 | 116.1 | 145.1 | 116.2 | 93.9 | 11.9 | 12.5 | 5.9 | 13.3 | <1 |
| C3 Naphthalenes | <1 | 102.8 | 137.5 | 123.1 | 91.3 | 9.3 | 10.8 | 5.3 | 13.4 | <1 |
| C4 Naphthalenes | <1 | 53.1 | 69.1 | 54.0 | 53.7 | 6.7 | 7.0 | 4.2 | 5.9 | <1 |
| Sum Naphthalenes | 0.00 | 435.9 | 553.9 | 455.8 | 366.7 | 41.9 | 46.9 | 24.0 | 51.4 | 0.0 |
| Phenanthrene / Anthracene | 0.00 | 75.2 | 173.9 | 99.6 | 62.5 | 13.3 | 5.8 | 3.0 | 8.3 | 0.0 |
| C1 178 | <1 | 74.3 | 158.2 | 87.6 | 65.7 | 9.5 | 6.7 | 3.3 | 8.7 | <1 |
| C2 178 | <1 | 74.1 | 115.6 | 80.1 | 67.0 | 7.2 | 7.2 | 3.0 | 7.4 | <1 |
| C3 178 | <1 | 43.3 | 72.4 | 48.1 | 40.8 | 4.6 | 4.4 | 2.0 | 5.2 | <1 |
| Sum 178 | 0.00 | 266.9 | 520.1 | 315.5 | 236.0 | 34.7 | 24.0 | 11.4 | 29.6 | 0.0 |
| Dibenzothiophene | <1 | 5.9 | 11.5 | 6.6 | 5.0 | <1 | <1 | <1 | <1 | <1 |
| C1 Dibenzothiophenes | <1 | 10.4 | 15.9 | 12.0 | 10.0 | 1.4 | <1 | <1 | 1.4 | <1 |
| C2 Dibenzothiophenes | <1 | 11.9 | 17.6 | 14.2 | 10.8 | 1.4 | 1.5 | <1 | 1.6 | <1 |
| C3 Dibenzothiophenes | <1 | 7.4 | 9.9 | 9.9 | 10.3 | <1 | <1 | <1 | <1 | <1 |
| Sum Dibenzothiophenes | 0.00 | 35.6 | 54.9 | 42.8 | 36.1 | 2.8 | 1.5 | 0.0 | 2.9 | 0.0 |
| Fluoranthene / Pyrene | 0.00 | 122.2 | 521.1 | 189.8 | 115.5 | 22.8 | 11.9 | 5.3 | 16.6 | 0.0 |
| C1 202 | <1 | 72.6 | 185.8 | 87.8 | 64.3 | 8.6 | 6.6 | 3.2 | 8.6 | <1 |
| C2 202 | <1 | 79.3 | 149.3 | 87.7 | 67.0 | 8.8 | 7.9 | 3.6 | 9.0 | <1 |
| C3 202 | <1 | 63.5 | 98.2 | 70.9 | 46.1 | 6.9 | 5.1 | 2.4 | 6.5 | <1 |
| Sum 202 | 0.00 | 337.7 | 954.5 | 436.3 | 293.0 | 47.0 | 31.5 | 14.6 | 40.7 | 0.0 |
| Benzoanthracene / Chrysene | 0.00 | 77.3 | 298.0 | 109.2 | 64.0 | 11.4 | 6.9 | 3.7 | 10.1 | 0.0 |
| C1 228 | <1 | 50.8 | 130.4 | 63.1 | 39.8 | 6.0 | 4.8 | 2.5 | 7.2 | <1 |
| C2 228 | <1 | 54.8 | 122.5 | 68.7 | 45.5 | 6.0 | 4.4 | 1.9 | 6.1 | <1 |
| Sum 228 | 0.00 | 183.0 | 550.9 | 241.0 | 149.3 | 23.5 | 16.2 | 8.1 | 23.4 | 0.0 |
| Benzofluoranthenes / Benzopyrenes | 0.00 | 177.7 | 824.3 | 235.3 | 143.7 | 24.4 | 15.6 | 9.4 | 23.8 | 0.0 |
| C1 252 | <1 | 83.2 | 236.9 | 102.6 | 67.8 | 10.0 | 7.6 | 4.6 | 11.5 | <1 |
| C2 252 | <1 | 72.9 | 145.2 | 68.9 | 53.8 | 8.6 | 5.9 | 3.3 | 8.4 | <1 |
| Sum 252 | 0.00 | 333.8 | 1206.5 | 406.8 | 265.2 | 43.0 | 29.1 | 17.4 | 43.7 | 0.0 |
| Dibenzoanthracene / Indenopyrene / Benzoperylene | 0.00 | 94.3 | 419.1 | 119.4 | 78.3 | 12.2 | 8.1 | 4.9 | 13.7 | 0.0 |
| C1 276 | <1 | 15.4 | 59.7 | 19.8 | 13.8 | 2.3 | 1.8 | <1 | 2.9 | <1 |
| C2 276 | <1 | 31.6 | 73.5 | 24.9 | 30.8 | 3.9 | 2.5 | <1 | 4.5 | <1 |
| Sum 276 | 0.00 | 141.3 | 552.3 | 164.1 | 123.0 | 18.4 | 12.4 | 4.9 | 21.2 | 0.0 |
| **Sum of all PAHs** | **0** | **1734** | **4393** | **2062** | **1469** | **211** | **162** | **80** | **213** | **0** |
| **Sum of NPD fraction** | **0** | **738** | **1129** | **814** | **639** | **79** | **72** | **35** | **84** | **0** |

| Station | LL_49_EBS | LL_60_EBS | LL_64_EBS | LL_87_EBS | LL_89_EBS | LL_94_EBS | LL_97_EBS | LL_99_EBS | LL_102_EBS |
|---|---|---|---|---|---|---|---|---|---|
| Naphthalene | 2.1 | <1 | 1.6 | <1 | <1 | <1 | <1 | <1 | 2.3 |
| C1 Naphthalenes | 5.6 | <1 | 3.3 | 1.6 | <1 | <1 | <1 | <1 | 6.9 |
| C2 Naphthalenes | 5.3 | <1 | 3.4 | 3.7 | <1 | <1 | <1 | <1 | 8.1 |
| C3 Naphthalenes | 4.9 | <1 | 3.2 | 1.3 | <1 | <1 | <1 | <1 | 5.9 |
| C4 Naphthalenes | 2.4 | <1 | 1.6 | <1 | <1 | <1 | <1 | <1 | 2.7 |
| Sum Naphthalenes | 20.2 | 0.0 | 13.1 | 6.6 | 0.0 | 0.0 | 0.0 | 0.0 | 26.0 |
| Phenanthrene / Anthracene | 2.7 | 0.0 | 1.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 4.3 |
| C1 178 | 3.3 | <1 | 2.0 | 1.3 | <1 | <1 | <1 | <1 | 7.8 |
| C2 178 | 2.8 | <1 | 2.0 | <1 | <1 | <1 | <1 | <1 | 3.5 |
| C3 178 | 1.5 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | 2.2 |
| Sum 178 | 10.3 | 0.0 | 5.7 | 1.3 | 0.0 | 0.0 | 0.0 | 0.0 | 17.7 |
| Dibenzothiophene | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| C1 Dibenzothiophenes | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| C2 Dibenzothiophenes | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| C3 Dibenzothiophenes | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| Sum Dibenzothiophenes | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Fluoranthene / Pyrene | 4.4 | 0.0 | 2.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 10.3 |
| C1 202 | 2.5 | <1 | 1.6 | <1 | <1 | <1 | <1 | <1 | 4.2 |
| C2 202 | 2.4 | <1 | 1.6 | <1 | <1 | <1 | <1 | <1 | 4.0 |
| C3 202 | 1.9 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | 2.6 |
| Sum 202 | 11.1 | 0.0 | 6.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 21.1 |
| Benzoanthracene / Chrysene | 1.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 4.5 |
| C1 228 | 1.7 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | 2.6 |
| C2 228 | 1.4 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | 2.2 |
| Sum 228 | 4.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 9.3 |
| Benzofluoranthenes / Benzopyrenes | 4.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 10.3 |
| C1 252 | 2.7 | <1 | 1.7 | <1 | <1 | <1 | <1 | <1 | 4.0 |
| C2 252 | 2.1 | <1 | 1.5 | <1 | <1 | <1 | <1 | <1 | 3.0 |
| Sum 252 | 9.0 | 0.0 | 3.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 17.3 |
| Dibenzoanthracene / Indenopyrene / Benzoperylene | 1.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 4.9 |
| C1 276 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| C2 276 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| Sum 276 | 1.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 4.9 |
| **Sum of all PAHs** | **57** | **0** | **28** | **8** | **0** | **0** | **0** | **0** | **96** |
| **Sum of NPD fraction** | **30** | **0** | **19** | **8** | **0** | **0** | **0** | **0** | **44** |

| Station | LL_104_EBS | LL_108_EBS | LL_116_EBS | LL_120_EBS | LL_125_EBS | LL_129_EBS | LL_133_EBS | LL_138_EBS | LL_55_EBS_SS_HM |
|---|---|---|---|---|---|---|---|---|---|
| Naphthalene | <1 | <1 | <1 | 4.4 | <1 | 5.2 | 1.4 | 5.4 | <1 |
| C1 Naphthalenes | <1 | <1 | 2.0 | 11.1 | 1.5 | 12.3 | 4.2 | 16.0 | <1 |
| C2 Naphthalenes | 1.5 | <1 | 2.3 | 12.9 | 1.8 | 15.1 | 4.6 | 23.3 | <1 |
| C3 Naphthalenes | <1 | <1 | 1.6 | 10.3 | 1.6 | 11.2 | 3.9 | 15.8 | <1 |
| C4 Naphthalenes | <1 | <1 | <1 | 4.2 | <1 | 4.8 | 1.8 | 7.1 | <1 |
| Sum Naphthalenes | 1.5 | 0.0 | 5.8 | 42.8 | 5.0 | 48.6 | 15.9 | 67.5 | 0.0 |
| Phenanthrene / Anthracene | 0.0 | 0.0 | 0.0 | 5.2 | 0.0 | 5.6 | 1.9 | 8.8 | 0.0 |
| C1 178 | <1 | <1 | <1 | 8.4 | <1 | 8.5 | 2.2 | 14.5 | <1 |
| C2 178 | <1 | <1 | <1 | 5.7 | <1 | 6.1 | 2.1 | 8.8 | <1 |
| C3 178 | <1 | <1 | <1 | 3.8 | <1 | 3.9 | 1.2 | 5.7 | <1 |
| Sum 178 | 0.0 | 0.0 | 0.0 | 23.1 | 0.0 | 24.0 | 7.5 | 37.8 | 0.0 |
| Dibenzothiophene | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| C1 Dibenzothiophenes | <1 | <1 | <1 | <1 | <1 | <1 | <1 | 1.6 | <1 |
| C2 Dibenzothiophenes | <1 | <1 | <1 | <1 | <1 | <1 | <1 | 1.6 | <1 |
| C3 Dibenzothiophenes | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| Sum Dibenzothiophenes | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 3.2 | 0.0 |
| Fluoranthene / Pyrene | 0.0 | 0.0 | 0.0 | 8.8 | 0.0 | 9.2 | 3.2 | 13.6 | 0.0 |
| C1 202 | <1 | <1 | <1 | 5.0 | <1 | 5.7 | 1.9 | 8.6 | <1 |
| C2 202 | <1 | <1 | <1 | 5.8 | <1 | 6.4 | 2.2 | 8.8 | <1 |
| C3 202 | <1 | <1 | <1 | 3.8 | <1 | 4.7 | 1.5 | 5.9 | <1 |
| Sum 202 | 0.0 | 0.0 | 0.0 | 23.4 | 0.0 | 25.9 | 8.7 | 36.9 | 0.0 |
| Benzoanthracene / Chrysene | 0.0 | 0.0 | 0.0 | 5.1 | 0.0 | 5.5 | 0.0 | 8.0 | 0.0 |
| C1 228 | <1 | <1 | <1 | 3.6 | <1 | 4.8 | 1.4 | 5.7 | <1 |
| C2 228 | <1 | <1 | <1 | 3.2 | <1 | 3.3 | <1 | 5.2 | <1 |
| Sum 228 | 0.0 | 0.0 | 0.0 | 11.9 | 0.0 | 13.5 | 1.4 | 18.8 | 0.0 |
| Benzofluoranthenes / Benzopyrenes | 0.0 | 0.0 | 0.0 | 12.0 | 0.0 | 12.7 | 2.6 | 18.4 | 0.0 |
| C1 252 | <1 | <1 | <1 | 5.7 | <1 | 6.4 | 2.3 | 8.1 | <1 |
| C2 252 | <1 | <1 | <1 | 4.9 | <1 | 5.5 | 1.8 | 5.9 | <1 |
| Sum 252 | 0.0 | 0.0 | 0.0 | 22.5 | 0.0 | 24.7 | 6.7 | 32.4 | 0.0 |
| Dibenzoanthracene / Indenopyrene / Benzoperylene | 0.0 | 0.0 | 0.0 | 5.6 | 0.0 | 6.1 | 1.3 | 8.7 | 0.0 |
| C1 276 | <1 | <1 | <1 | <1 | <1 | 1.6 | <1 | 1.5 | <1 |
| C2 276 | <1 | <1 | <1 | 1.5 | <1 | <1 | <1 | 1.8 | <1 |
| Sum 276 | 0.0 | 0.0 | 0.0 | 7.0 | 0.0 | 7.7 | 1.3 | 12.1 | 0.0 |
| **Sum of all PAHs** | **1** | **0** | **6** | **131** | **5** | **144** | **41** | **209** | **0** |
| **Sum of NPD fraction** | **1** | **0** | **6** | **66** | **5** | **73** | **23** | **108** | **0** |

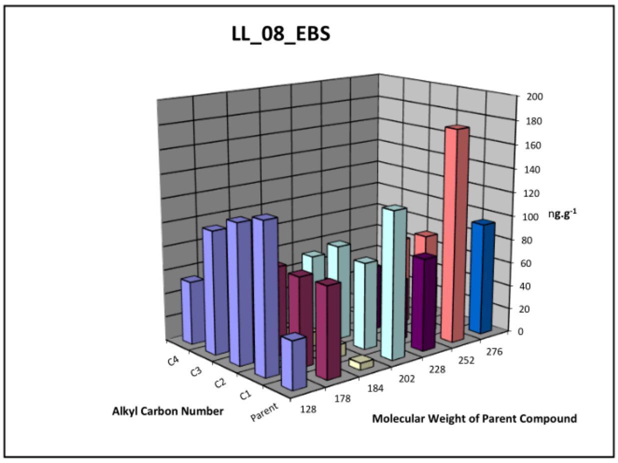
| Station | LL_72_EBS_SS_HM | LL_73_EBS_SS_HM | LL_78_EBS_SS_HM | LL_85_EBS_SS_HM | LL_106_EBS_SS_HM | LL_112_EBS_SS_HM |
|---|---|---|---|---|---|---|
| Naphthalene | <1 | <1 | <1 | <1 | <1 | <1 |
| C1 Naphthalenes | <1 | <1 | <1 | <1 | <1 | 2.6 |
| C2 Naphthalenes | <1 | 1.4 | <1 | <1 | <1 | 2.8 |
| C3 Naphthalenes | <1 | 1.8 | <1 | <1 | <1 | 2.2 |
| C4 Naphthalenes | <1 | 1.3 | <1 | <1 | <1 | <1 |
| Sum Naphthalenes | 0.0 | 4.4 | 0.0 | 0.0 | 0.0 | 7.6 |
| Phenanthrene / Anthracene | 0.0 | 2.2 | 0.0 | 0.0 | 0.0 | 1.4 |
| C1 178 | <1 | 2.1 | <1 | <1 | <1 | 2.0 |
| C2 178 | <1 | 1.7 | <1 | <1 | <1 | 1.5 |
| C3 178 | <1 | <1 | <1 | <1 | <1 | <1 |
| Sum 178 | 0.0 | 6.1 | 0.0 | 0.0 | 0.0 | 4.9 |
| Dibenzothiophene | <1 | <1 | <1 | <1 | <1 | <1 |
| C1 Dibenzothiophenes | <1 | <1 | <1 | <1 | <1 | <1 |
| C2 Dibenzothiophenes | <1 | <1 | <1 | <1 | <1 | <1 |
| C3 Dibenzothiophenes | <1 | <1 | <1 | <1 | <1 | <1 |
| Sum Dibenzothiophenes | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Fluoranthene / Pyrene | 0.0 | 2.7 | 0.0 | 0.0 | 0.0 | 4.2 |
| C1 202 | <1 | 1.5 | <1 | <1 | <1 | 2.0 |
| C2 202 | <1 | 2.4 | <1 | <1 | <1 | 1.7 |
| C3 202 | <1 | 2.0 | <1 | <1 | <1 | <1 |
| Sum 202 | 0.0 | 8.6 | 0.0 | 0.0 | 0.0 | 7.9 |
| Benzoanthracene / Chrysene | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.5 |
| C1 228 | <1 | <1 | <1 | <1 | <1 | <1 |
| C2 228 | <1 | <1 | <1 | <1 | <1 | <1 |
| Sum 228 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.5 |
| Benzofluoranthenes / Benzopyrenes | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| C1 252 | <1 | 1.3 | <1 | <1 | <1 | 1.8 |
| C2 252 | <1 | <1 | <1 | <1 | <1 | <1 |
| Sum 252 | 0.0 | 1.3 | 0.0 | 0.0 | 0.0 | 1.8 |
| Dibenzoanthracene / Indenopyrene / Benzoperylene | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| C1 276 | <1 | <1 | <1 | <1 | <1 | <1 |
| C2 276 | <1 | <1 | <1 | <1 | <1 | <1 |
| Sum 276 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **Sum of all PAHs** | **0** | **20** | **0** | **0** | **0** | **24** |
| **Sum of NPD fraction** | **0** | **10** | **0** | **0** | **0** | **13** |

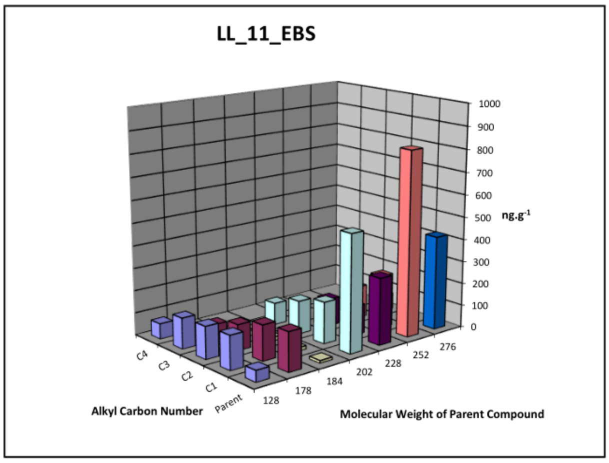
## Appendix G – Polycyclic Aromatic Hydrocarbon Concentrations: EPA 19 (μg.kg$^{-1}$)

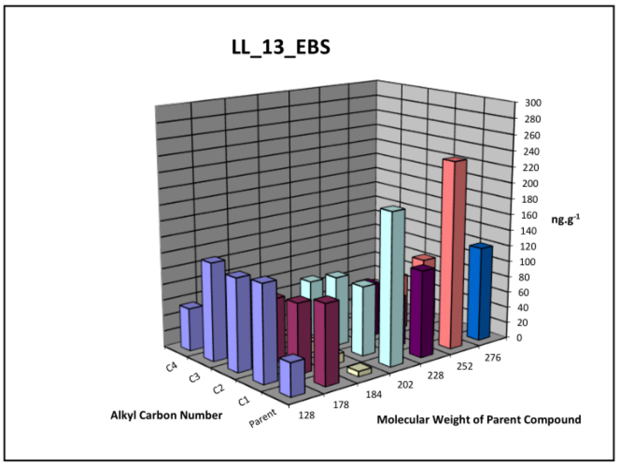
| Station | LL_01_EBS | LL_11_EBS | LL_13_EBS | LL_17_EBS | LL_21_EBS | LL_27_EBS | LL_32_EBS | LL_38_EBS | LL_44_EBS |
|---|---|---|---|---|---|---|---|---|---|
| Naphthalene | <1 | 39.5 | 50.8 | 41.2 | 29.2 | 3.7 | 3.8 | 2 | 4.9 |
| Acenaphthylene | <1 | 4 | 25.5 | 6.6 | 3.4 | 1 | 1 | 1 | 1 |
| Acenaphthene | <1 | 4.6 | 9.6 | 5.3 | 4.2 | 1 | 1 | 1 | 1 |
| Fluorene | <1 | 9.5 | 19 | 13 | 8.6 | 1.5 | 1 | 1 | 1.2 |
| Phenanthrene | <1 | 66.2 | 141.7 | 82.3 | 55.6 | 11.7 | 5.8 | 3 | 8.3 |
| Dibenzothiophene | <1 | 5.9 | 11.5 | 6.6 | 5 | 1 | 1 | 1 | 1 |
| Anthracene | <1 | 9 | 32.1 | 17.3 | 6.9 | 1.7 | 1 | 1 | 1 |
| Fluoranthene | <1 | 63.9 | 248.9 | 101.3 | 60 | 12.3 | 6.3 | 2.8 | 8.5 |
| Pyrene | <1 | 58.3 | 272.2 | 88.6 | 55.5 | 10.5 | 5.7 | 2.5 | 8.1 |
| Benzo[a]anthracene | <1 | 31.5 | 139.4 | 48.3 | 27 | 4.9 | 2.7 | 1.4 | 4.1 |
| Chrysene | <1 | 45.8 | 158.6 | 60.8 | 37 | 6.6 | 4.2 | 2.2 | 6 |
| Benzo[b]fluoranthene | <1 | 47.7 | 236.4 | 67.2 | 42.6 | 6.6 | 5.1 | 2.8 | 6.3 |
| Benzo[k]fluoranthene | <1 | 47 | 210.1 | 54.8 | 32.6 | 6.5 | 3.4 | 2.3 | 6 |
| Benzo[e]pyrene | <1 | 42.3 | 170.1 | 52.5 | 33.8 | 5.2 | 3.8 | 2.3 | 5.7 |
| Benzo[a]pyrene | <1 | 40.7 | 207.6 | 60.8 | 34.7 | 6 | 3.4 | 2 | 5.9 |
| Perylene | <1 | 17.5 | 54.6 | 25.1 | 16.1 | 2.5 | 1.9 | 1 | 2.3 |
| Indeno[123,cd]pyrene | <1 | 35.4 | 184 | 46.7 | 30.8 | 5.8 | 3.4 | 2 | 5.5 |
| Dibenzo[a,h]anthracene | <1 | 8 | 34.2 | 10.5 | 7 | 1 | 1 | 1 | 1.2 |
| Benzo[ghi]perylene | <1 | 50.9 | 200.9 | 62.2 | 40.5 | 6.4 | 4.7 | 2.9 | 7 |
| **Station** | **LL_49_EBS** | **LL_60_EBS** | **LL_64_EBS** | **LL_87_EBS** | **LL_89_EBS** | **LL_94_EBS** | **LL_97_EBS** | **LL_99_EBS** | **LL_102_EBS** |
| Naphthalene | 1 | 2.1 | 1 | 1.6 | 1 | 1 | 1 | 1 | 1 |
| Acenaphthylene | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Acenaphthene | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Fluorene | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Phenanthrene | 1 | 2.7 | 1 | 1.7 | 1 | 1 | 1 | 1 | 1 |
| Dibenzothiophene | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Anthracene | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Fluoranthene | 1 | 2.2 | 1 | 1.5 | 1 | 1 | 1 | 1 | 1 |
| Pyrene | 1 | 2.1 | 1 | 1.4 | 1 | 1 | 1 | 1 | 1 |
| Benzo[a]anthracene | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Chrysene | 1 | 1.4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Benzo[b]fluoranthene | 1 | 1.3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Benzo[k]fluoranthene | 1 | 1.5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Benzo[e]pyrene | 1 | 1.3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Benzo[a]pyrene | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Perylene | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Indeno[123,cd]pyrene | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Dibenzo[a,h]anthracene | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Benzo[ghi]perylene | 1 | 1.5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

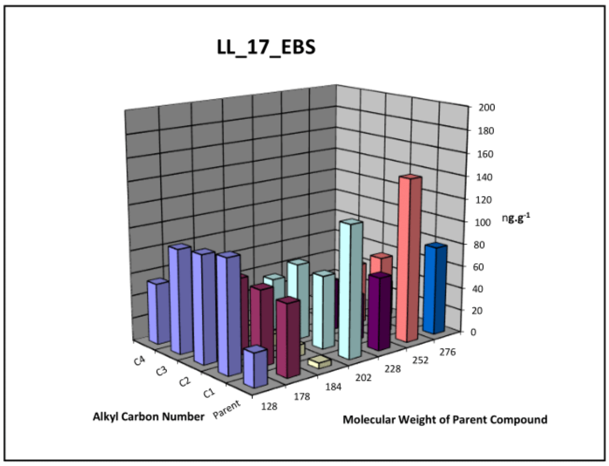
| **Station** | **LL_104_EBS** | **LL_108_EBS** | **LL_116_EBS** | **LL_120_EBS** | **LL_125_EBS** | **LL_129_EBS** | **LL_133_EBS** | **LL_138_EBS** | **LL_55_EBS_SS** |
|---|---|---|---|---|---|---|---|---|---|
| Naphthalene | 2.3 | 1 | 1 | 1 | 4.4 | 1 | 5.2 | 1.4 | 5.4 |
| Acenaphthylene | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Acenaphthene | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Fluorene | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1.4 |
| Phenanthrene | 4.3 | 1 | 1 | 1 | 5.2 | 1 | 5.6 | 1.9 | 8.8 |
| Dibenzothiophene | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Anthracene | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Fluoranthene | 5.5 | 1 | 1 | 1 | 4.7 | 1 | 4.9 | 1.7 | 7.2 |
| Pyrene | 4.8 | 1 | 1 | 1 | 4.1 | 1 | 4.3 | 1.5 | 6.3 |
| Benzo[a]anthracene | 1.7 | 1 | 1 | 1 | 1.8 | 1 | 2 | 1 | 2.8 |
| Chrysene | 2.8 | 1 | 1 | 1 | 3.2 | 1 | 3.5 | 1 | 5.2 |
| Benzo[b]fluoranthene | 3 | 1 | 1 | 1 | 3.6 | 1 | 3 | 1.3 | 5.6 |
| Benzo[k]fluoranthene | 2.7 | 1 | 1 | 1 | 3.7 | 1 | 4 | 1.3 | 5.1 |
| Benzo[e]pyrene | 2.4 | 1 | 1 | 1 | 2.6 | 1 | 3 | 1 | 4.2 |
| Benzo[a]pyrene | 2.2 | 1 | 1 | 1 | 2.1 | 1 | 2.8 | 1 | 3.5 |
| Perylene | 2.6 | 1 | 1 | 1 | 1.7 | 1 | 1 | 1 | 1.6 |
| Indeno[123,cd]pyrene | 2.4 | 1 | 1 | 1 | 2.2 | 1 | 2.5 | 1 | 3.7 |
| Dibenzo[a,h]anthracene | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Benzo[ghi]perylene | 2.5 | 1 | 1 | 1 | 3.4 | 1 | 3.6 | 1.3 | 5 |
| **Station** | **LL_72_EBS_SS** | **LL_73_EBS_SS** | **LL_78_EBS_SS** | **LL_85_EBS_SS** | **LL_106_EBS_SS** | **LL_112_EBS_SS** | | | |
| Naphthalene | <1 | <1 | <1 | <1 | <1 | <1 | | | |
| Acenaphthylene | <1 | <1 | <1 | <1 | <1 | <1 | | | |
| Acenaphthene | <1 | <1 | <1 | <1 | <1 | <1 | | | |
| Fluorene | <1 | <1 | <1 | <1 | <1 | <1 | | | |
| Phenanthrene | <1 | <1 | 9.7 | <1 | <1 | <1 | | | |
| Dibenzothiophene | 0 | 0 | 0 | 0 | 0 | 0 | | | |
| Anthracene | <1 | <1 | <1 | <1 | <1 | <1 | | | |
| Fluoranthene | <1 | <1 | 2.4 | <1 | <1 | <1 | | | |
| Pyrene | <1 | <1 | 3 | <1 | <1 | <1 | | | |
| Benzo[a]anthracene | <1 | <1 | 1.5 | <1 | <1 | <1 | | | |
| Chrysene | <1 | <1 | 3.9 | <1 | <1 | <1 | | | |
| Benzo[b]fluoranthene | <1 | <1 | 1.2 | <1 | <1 | <1 | | | |
| Benzo[k]fluoranthene | <1 | <1 | <1 | <1 | <1 | <1 | | | |
| Benzo[e]pyrene | 0 | 0 | 0 | 0 | 0 | 0 | | | |
| Benzo[a]pyrene | <1 | <1 | <1 | <1 | <1 | <1 | | | |
| Perylene | <1 | <1 | <1 | <1 | <1 | <1 | | | |
| Indeno[123,cd]pyrene | <1 | <1 | <1 | <1 | <1 | <1 | | | |
| Dibenzo[a,h]anthracene | <1 | <1 | <1 | <1 | <1 | <1 | | | |
| Benzo[ghi]perylene | <1 | <1 | 1.3 | <1 | <1 | <1 | | | |

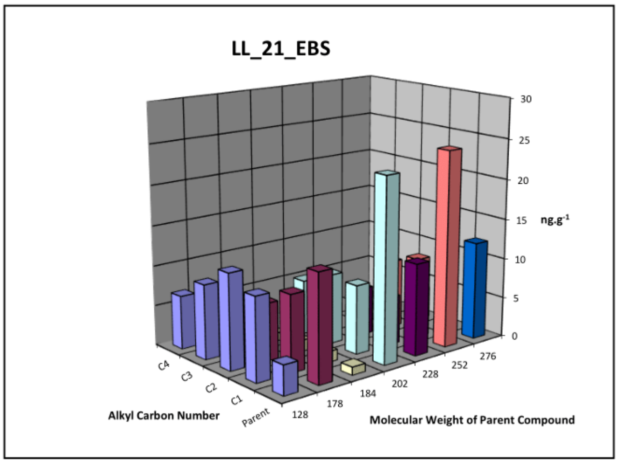
## Appendix H – Polycyclic Aromatic Hydrocarbon: Parents Compounds and Alkyl Derivatives

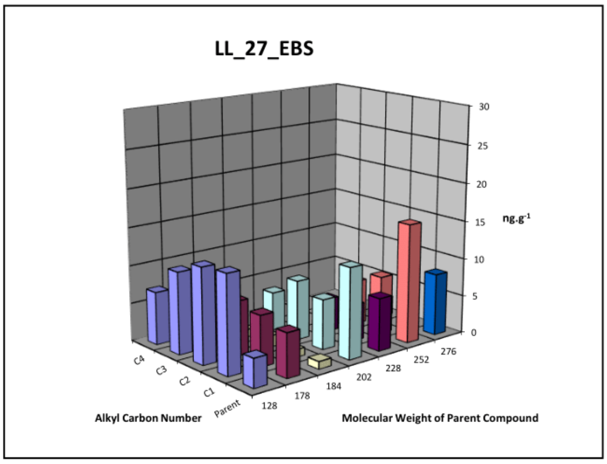


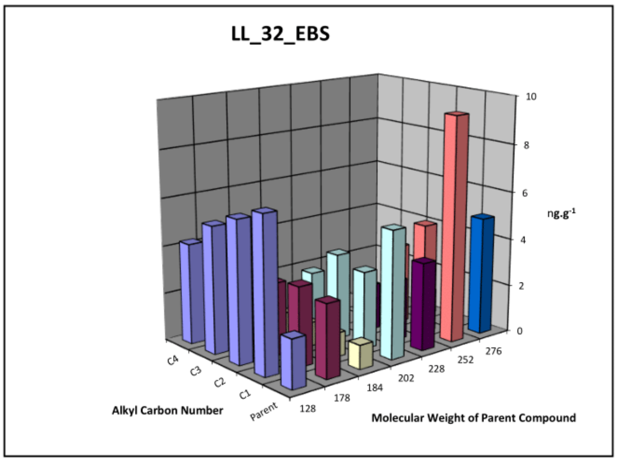

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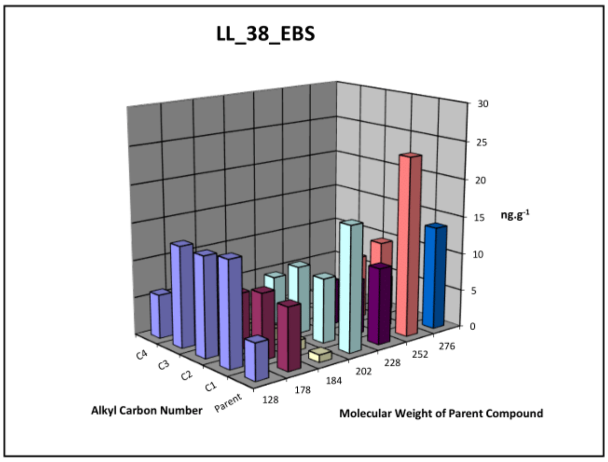
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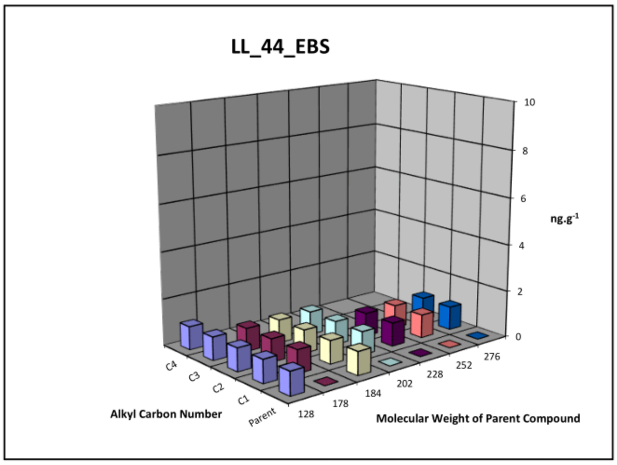
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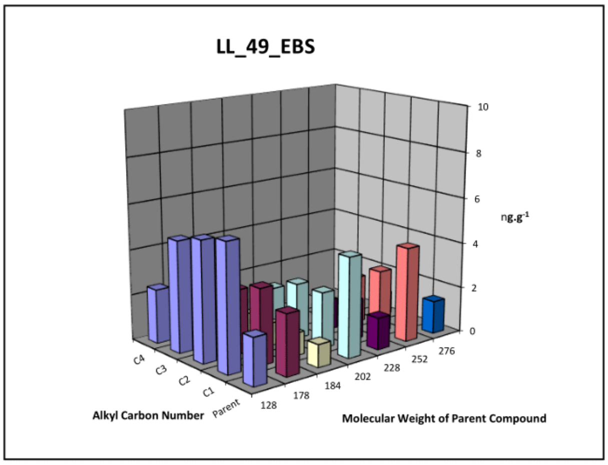
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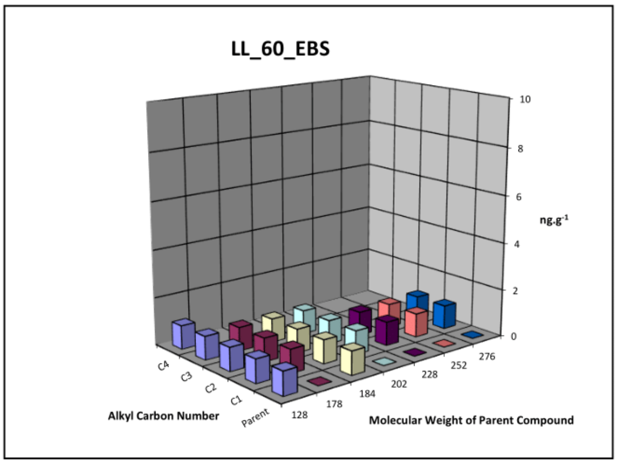
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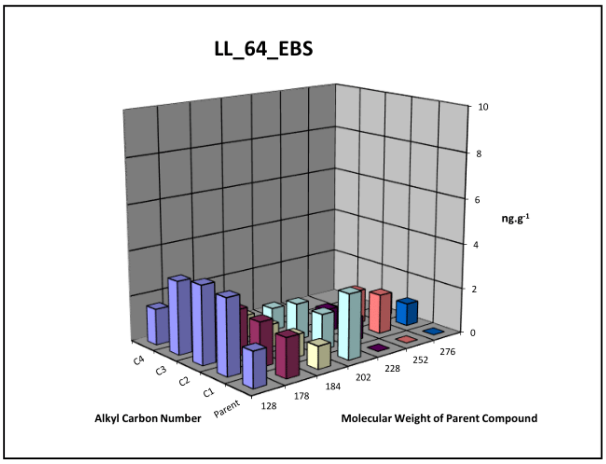
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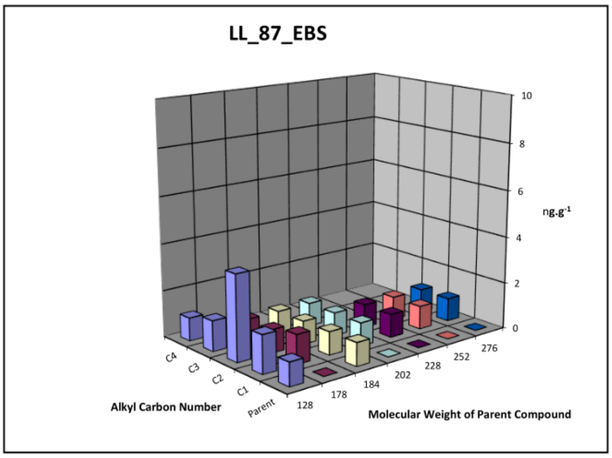
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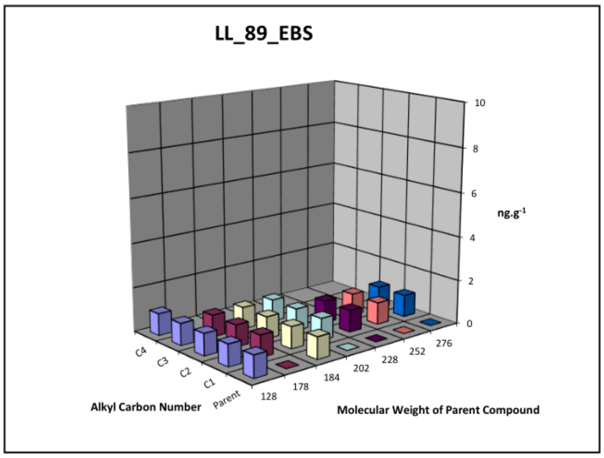
Molecular Weight of Parent Compound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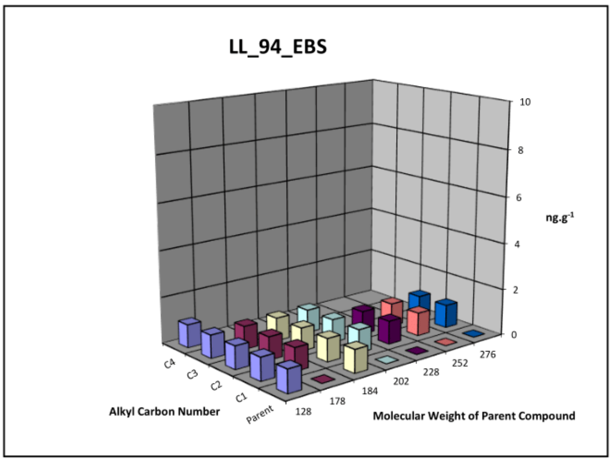
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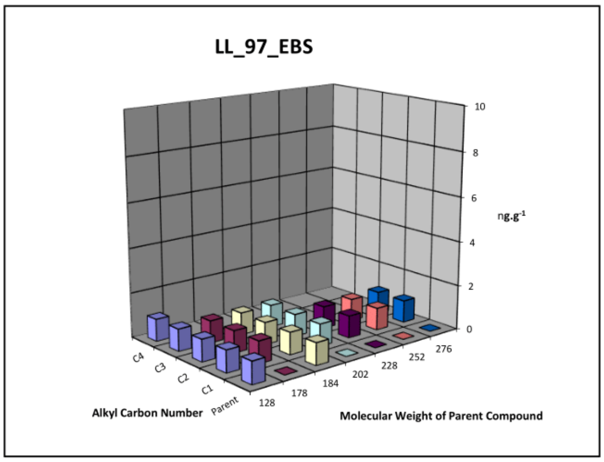
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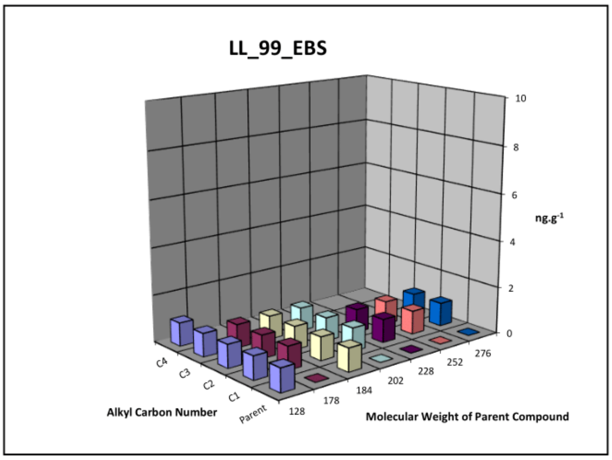
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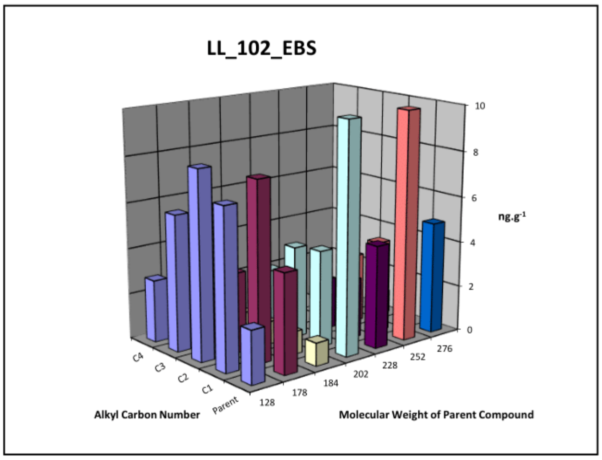
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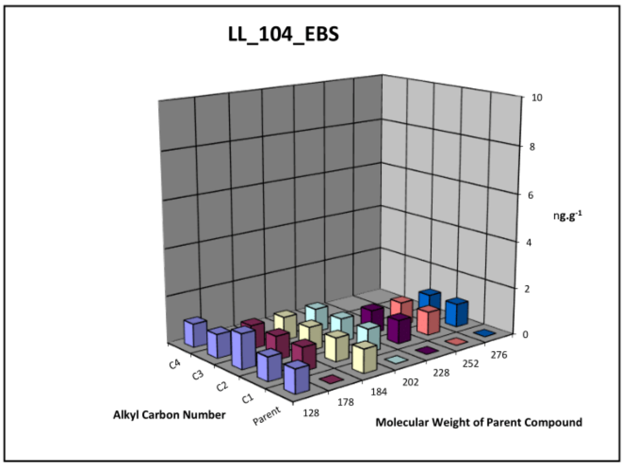
Molecular Weight of Parent Compound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C3
C2
C1
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178
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202
228
252
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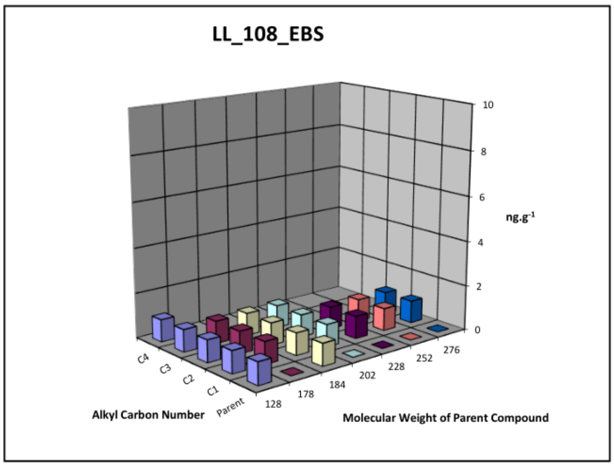
Alkyl Carbon Number
Molecular Weight of Parent Compound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Alkyl Carbon Number
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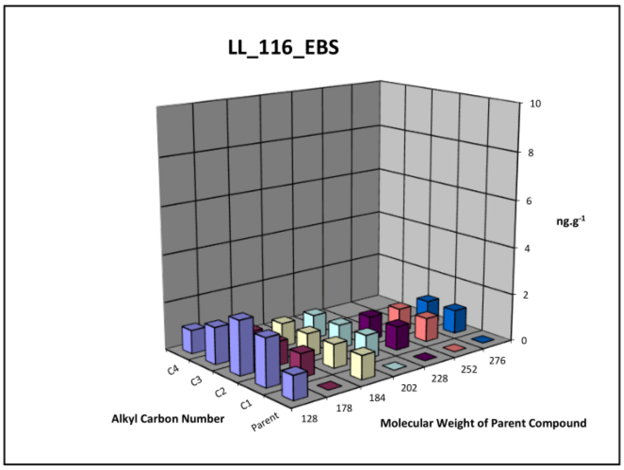
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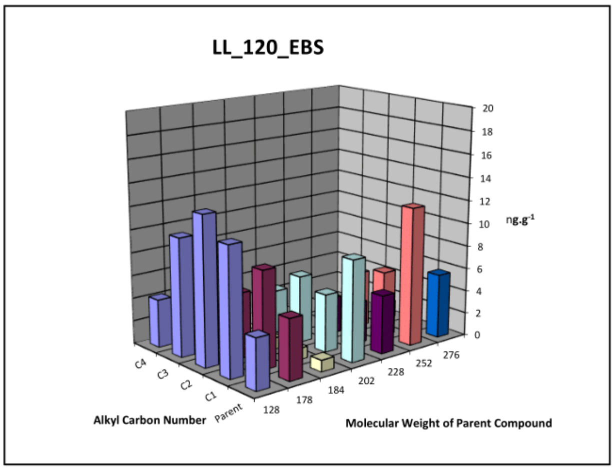
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202
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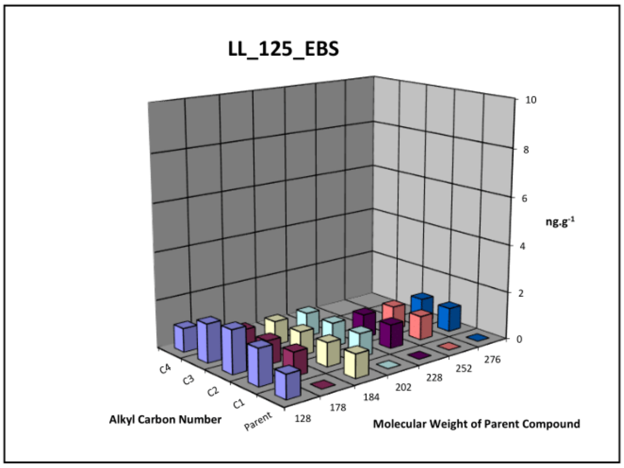
Alkyl Carbon Number
Molecular Weight of Parent Compound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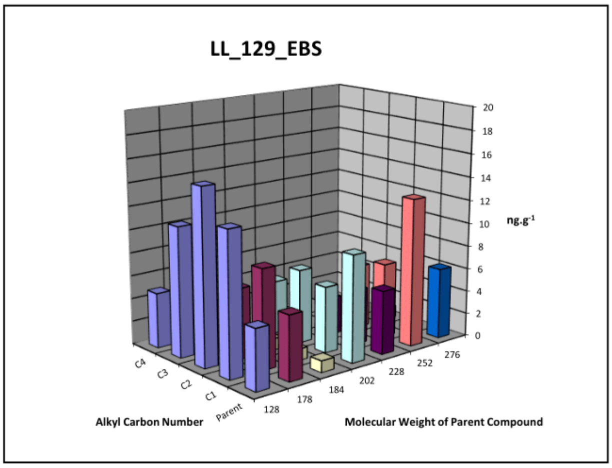
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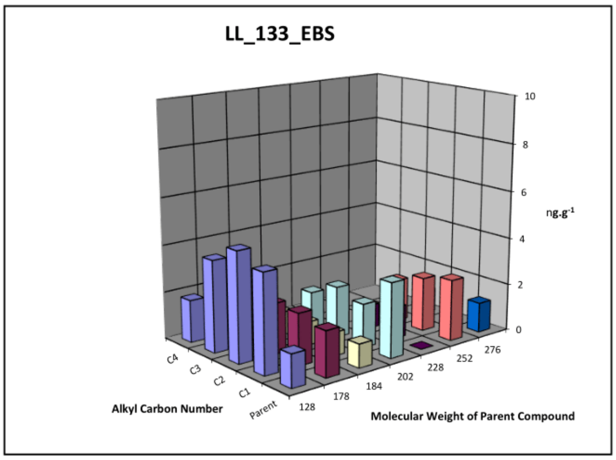
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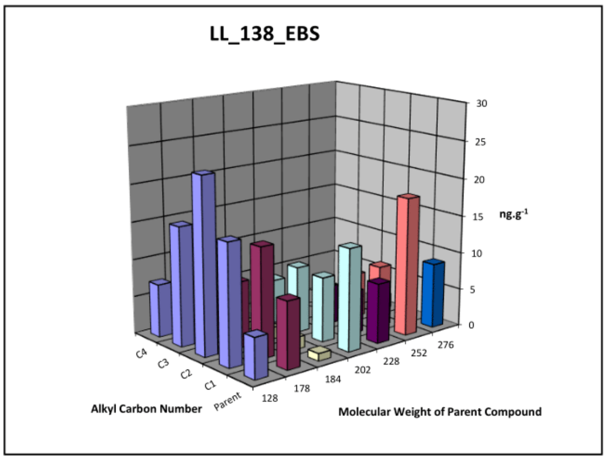
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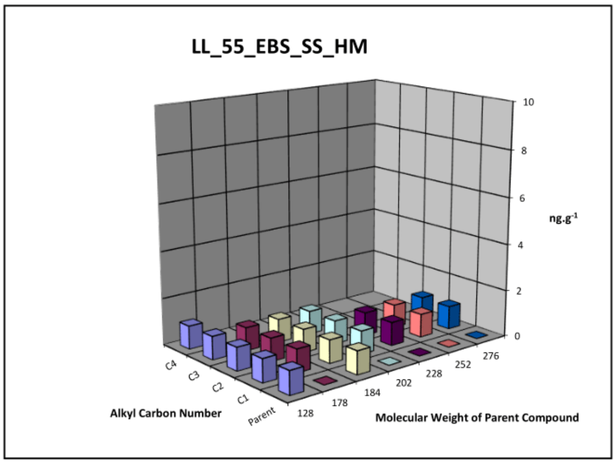
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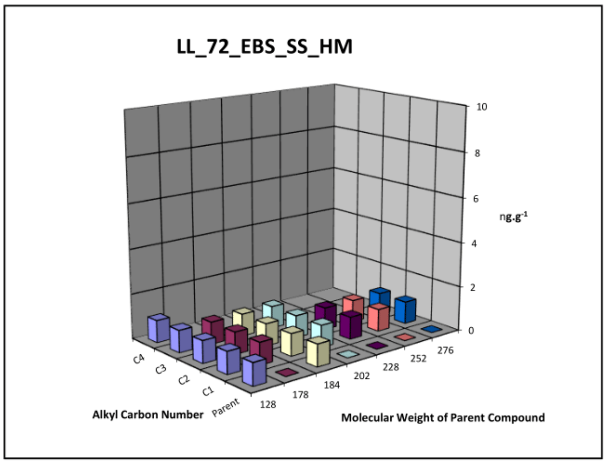
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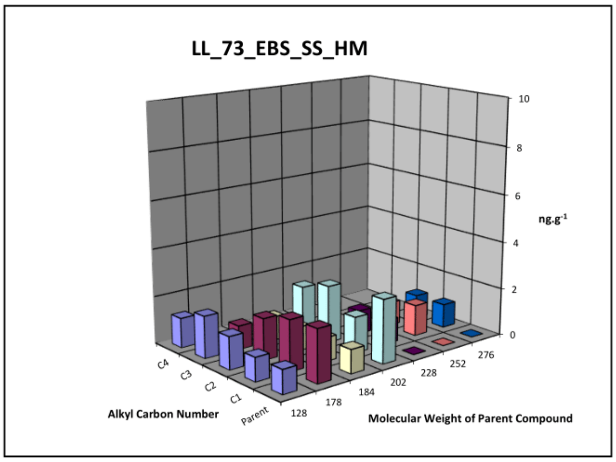
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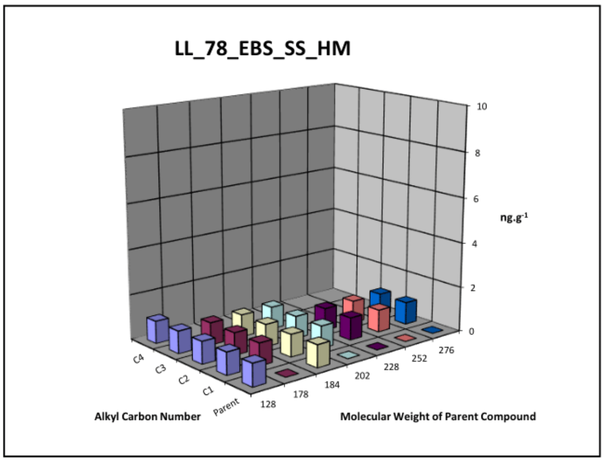
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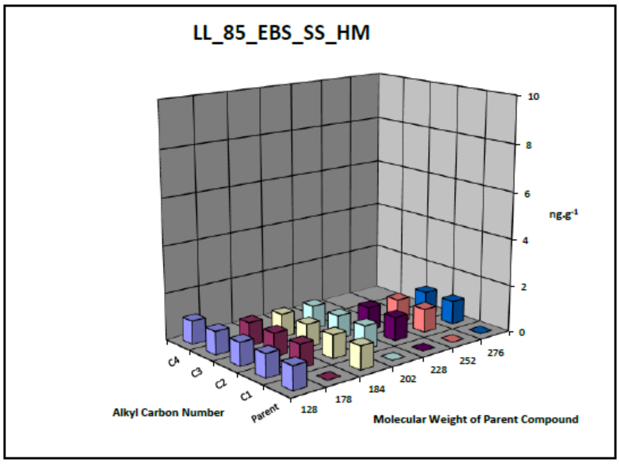
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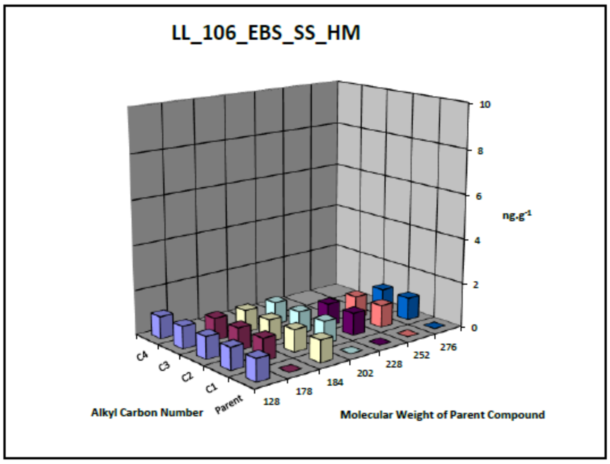
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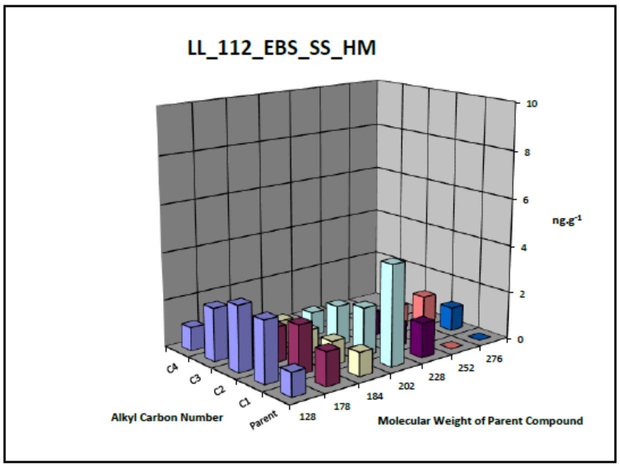
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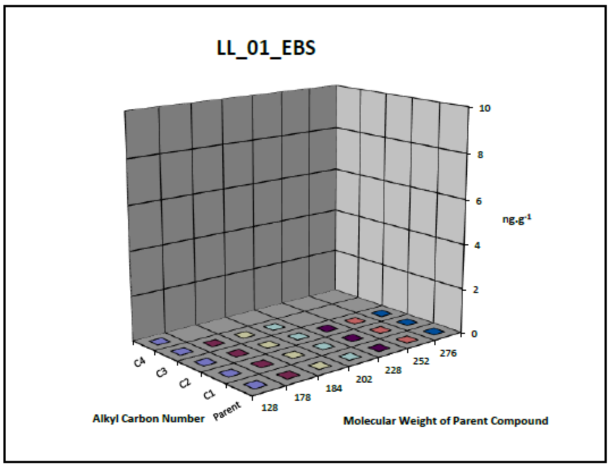
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276

## Appendix I – Macrofaunal Species Lists

Benthic macrofauna infauna and epifauna taxa list provided in a separate PDF.

## Appendix J – Blue Mussel Assessment

Blue mussel (*Mytilus edulis*) assessment provided in a separate excel file.

## Appendix K –*Sabellaria spinulosa* Reef Assessment

Ross worm (*Sabellaria spinulosa*) assessment provided in a separate excel file.

## Appendix L –Subtidal Sampling Log Sheets

Sampling log sheets from the field survey provided in a separate excel file.

## Appendix M – Camera Transect Log Sheets

Underwater video footage log provided in a separate excel file.

## Appendix N – Spearman's Correlation

Spearman's correlation of the physico-chemical and benthic macrofauna data provided in a separate excel file.

## Appendix O – Sample and Seabed Photographs

Example seabed images for each transect are provided in a separate PDF.

## Appendix P – Management of Change Reports

Management of change reports from the field survey provided in a separate PDF.

## Appendix Q – Environmental Concession Reports

Environmental Concession reports from the field survey provided in a separate PDF.

## Appendix R– AQC Certification of Laboratories

Laboratory analytical quality control certification provided in a separate PDF.

## Appendix S – Service Warranty

This report, with its associated works and services, has been designed solely to meet the requirements of the contract agreed with you, our client. If used in other circumstances, some or all of the results may not be valid and we can accept no liability for such use. Such circumstances include different or changed objectives, use by third parties, or changes to, for example, site conditions or legislation occurring after completion of the work. In case of doubt, please consult Benthic Solutions Limited. Please note that all charts, where applicable should not be used for navigational purposes.

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