Cefas contract report: SLAB5

Dredged Material Disposal Site Monitoring Around the Coast of England: Results of Sampling (2014)

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Executive Summary

- This report presents the scientific findings and future monitoring implications that result from dredged material disposal site monitoring conducted under SLAB5 around the coast of England during 2014.
- The main aims of this report are: to aid the dissemination of the monitoring results; to assess whether observed changes resulting from dredged material dispsoal are in line with those expected; to compare the results with those of previous years (where possible); and to facilitate our improved understanding of the impacts of dredged material disposal at both a site-specific and a national (i.e. non site-specific) level.
- Targeted monitoring was conducted at six disposal sites during 2014, these were: Inner Tees; Outer Tees; South Falls; Nab Tower; Rame Head South; and Site Y.
- Parameters monitored varied between sites (governed by site-specific issues) but included multibeam bathymetry and backscatter acoustic techniques, sediment particle size, sediment organic carbon and the assessment of a range of sediment contaminants including polycyclic aromatic hydrocarbons (PAHs), organohalogens (e.g., pesticides, flame retardants) and trace metals.
- Variations (both spatially and temporally) in the concentrations of the various contaminant types were somewhat site-specific, and, in general, indicated that concentrations remain temporally stable or show a slight decline.
- Acoustic (multibeam and/or sidescan) data acquired allowed the successful determination regarding the fate of large increases in the quantities of deposited material at three sites (South Falls, Nab Tower and Site Y).
- The implications of these findings for each site are discussed with respect to the need for subsequent monitoring under SLAB5. However, these data do not represent the sole basis of such final decisions regarding monitoring; in addition, up-to-date intelligence regarding potential changes to the disposal regime and/or concerns raised from stakeholders are all embraced within the selection process for disposal site monitoring under this project.

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1. INTRODUCTION

1.1 Regulation of disposal activity in England

Disposal of waste at sea is strictly regulated through the licensing requirements of the Marine and Coastal Access Act 2009 (MCAA). The MCAA provides the principal statutory means by which the UK complies with EU law, such as the Water Framework Directive (WFD, 2000/60/EC), the Habitats and Species Directive (92/43/EEC), the Wild Birds Directive (79/409/EEC) and international obligations such as under the OSPAR Convention and the London Protocol, in relation to disposals at sea.

Pursuant to the OSPAR Convention and the London Protocol, only certain wastes or other matter are permitted for disposal at sea. During the 1980s and 1990s, the UK phased out sea disposal of most types of waste, including industrial waste and sewage sludge. Since then, dredged material from ports and harbours, and a small amount of fish waste, has been the only type of material routinely licensed for disposal at sea.

The Marine Management Organisation (MMO) regulates and is responsible for licensing activities in the marine area around England including the disposal of dredged material at sea. The MMO assesses the suitability of dredged material for disposal at sea in line with the OSPAR Guidelines for the management of dredged material (OSPAR, 2014). These guidelines provide generic guidance on determining the conditions under which dredged material may (or may not) be deposited at sea and involve the consideration of alternative uses, disposal sites and the the suitability of the dredged material for disposal to sea including the presence and levels of contaminants in the dredged material, along with perceived impacts on any sites of conservation value in the vicinity of disposal.

One of the roles of Cefas is to provide scientific advice to the MMO on the suitability of the material for sea disposal at the application stage and, once a licence is granted, to provide technical advice on any monitoring undertaken as a result of licence conditions. Advice on the licensing of dredged material disposal at sea is provided by Cefas' Regulatory Assessment Team (RAT), work conducted under SLAB5 helps underpin the scientific rationale for such advice (see Section 1.3).

1.2 Disposal sites around England

There are approximately 155 open sites designated for dredged material disposal around the coast of England, not all of which are used in any one year. While the majority of these are located on the coast of the mainland, generally within a few miles of a major port or estuary entrance, a significant number are positioned within estuaries (e.g., Humber) or on intertidal mudflats as part of beneficial use schemes (Bolam et al., 2006).

In total, approximately 40 Mt (wet weight) are annually disposed to coastal sites around England, although this can vary from 28 to 57 Mt (wet weight) (data for the period between 1986 and 2010). Individual quantities licensed may range from a few hundred to several million tonnes, and the nature may vary from soft silts to boulders or even crushed rock according to origin, although the majority consists of finer material (Bolam et al., 2006).

1.3 Overview of Cefas / MMO MoU contract SLAB5 'Monitoring of dredged material disposal sites'

In England, SLAB5 is one of several contracts funded by the MMO under a non-R&D MoU. The project provides field evaluations ('baseline' monitoring and 'trouble-shooting' surveys) at dredged material disposal sites round the coast of England. A major component of the project is, therefore, the commissioning of sea-going surveys at targeted disposal sites. Such field evaluations under SLAB5 are designed to ensure that:

- environmental conditions at newly designated sites are suitable for the commencement of disposal activities;
- predictions for established sites concerning limitations of effects continue to be met; and,
- disposal operations conform with licence conditions.

The outcomes of such surveys contribute directly to the licensing/enforcement process by ensuring that any evidence of unacceptable changes or practices is rapidly communicated and acted upon. As such, there are inherently strong links and ongoing discussions between the approaches and findings of this project with the work carried out by Cefas' RAT. One of the key roles of the latter is to advise the licensing authority (i.e., the MMO) of the appropriateness of current licences and the suitability of any new licence applications. The scientific outcomes of work undertaken within SLAB5 are circulated to the Cefas RAT *via* a number of routes including peer-reviewed publications (including both activity-specific and site-specific findings), internal documents, direct discussions and internal and external presentations. The production of this report, within which a summary of the annual findings is presented (Section 2), forms an important element of such scientific communication. It is not the purpose of this report to present a detailed appraisal of the processes giving rise to impacts at a particular site (this is more the role of, for example, peer-review outcomes) but to encapsulate the essence of the impacts associated with this activity in its entirety round the coast of England (see Section 1.5).

1.4 Sites monitored

To aid with determining which disposal sites should be selected for sampling in any one year, Cefas has derived a tier-based approach that classifies a number of possible issues or environmental concerns that may be associated with dredged material disposal into a risk-based framework (Bolam

et al., 2009; Birchenough et al., 2010). The issues that pertain to a particular disposal site, and where these lie within the tiering system (i.e., their perceived environmental risk) depict where that site lies within the tiered system. This ultimately determines whether that site is considered for sampling during a particular year. It is intended that this approach should increase the transparency of the decision-making process regarding disposal site selection for SLAB5 monitoring, i.e., it establishes a model for site-specific decisions regarding sampling.

A tiered survey design and site assessment system, therefore, facilitates the prioritisation of dredge material disposal sites in terms of the need for, and the scale of, monitoring required at each site. In practice, this method will provide a scientifically valid rationale for the assessment of risks associated with relinquished, current and proposed disposal sites to the surrounding environment and amenities.

The disposal sites targeted for Cefas monitoring during 2014 are listed in Table 1.1. These sites were identified following consultation between Cefas case officers within the RAT and scientists in a number of key disciplines (e.g., benthic ecology, sediment contaminants). Additionally, these sites have been selected based on information from dredged material licence applications, consultation with the MMO and through concerns identified by stakeholders including conservation agencies and the general public.

Table 1.1. Dredged material disposal sites targeted for monitoring under SLAB5 during 2014. The Inner and Outer Tees disposal sites are both monitored through a single survey that encompasses both sites.

Disposal site	**Geographical location off English coast**	**Code**	**Prioritisation assessment: Tier**
Inner Tees	Northeast	TY160	1
Outer Tees	Northeast	TY150	2
South Falls	Southeast	TH070	1
Nab Tower	South	WI060	1
Rame Head South	Southwest	PL031	1
Site Y	Northwest	IS150	1

1.5 Aims and structure of this report

This report does not aim to present a critique of the processes leading to observed changes at dredged material disposal sites around the coast of England. Such appraisals are conducted *via* other reporting routes, either *via* discussions with Cefas case officers, presentations and subsequent publications at national and international conferences, and *via* papers in peer-reviewed journals (e.g.

Bolam and Whomersley, 2005; Bolam et al., 2006; Birchenough et al., 2006; Bolam, 2014; Bolam et al., 2014a; Rumney et al., 2015). The aims of this report are:

- To present the results of sampling undertaken during 2014 under SLAB5, thereby aiding the dissemination of the findings under this project;
- To indicate whether the results obtained are in line with those expected for each disposal site, or whether subsequent investigations should be conducted;
- Where possible, to compare the 2014 results with those of previous years to provide a temporal assessment (see Bolam et al., 2009; 2011a; 2012a; 2012b; 2014b; 2015 for reports of previous years' monitoring);
- To facilitate our improved understanding of the impacts of dredged material disposal at both a site-specific level and a national level; and,
- To promote the development of scientific (or other) outputs under SLAB5.

Within previous SLAB5 reports, an appraisal of the findings of each data component (e.g., acoustics, sediment granulometry, macrofauna, contaminants) for each site was presented followed by a summary of the implications of such information for subsequent monitoring under SLAB5. Due to the inherent length of the former, the key outcomes of the report were perhaps not sufficiently prominent to the reader. Thus, in accordance with the format first established for Bolam et al. (2011a), and that used within subsequent reports (Bolam et al., 2012a; 2012b; 2014b; 2015), the conclusions for each site are contained within Section 2 (below). The presentation of the more detailed scientific data is deferred to Appendix 2. For background information and impact hypotheses regarding each disposal site monitored during 2014, the reader is directed towards this appendix. Appendix 1 contains, as per the previous reports, information regarding the analytical and numerical methods used during the assessments of sediment contaminants (the reader may need to consult these whilst appraising Section 2).

2. CONCLUSIONS AND IMPLICATIONS FOR FURTHER MONITORING

The main findings of the monitoring data for each site are presented within this section (see Appendix 2 for more detail), together with their implications regarding the need for subsequent monitoring under SLAB5. However, it should be noted that these data do not represent the sole basis of such final decisions regarding monitoring; up-to-date intelligence regarding potential changes to the disposal regime and/or concerns raised from any stakeholder are all embraced within the selection process for disposal site monitoring under this project. Thus, the recommendations for monitoring presented here for each site, although representing a major component of the decision-making process, may or may not be altered by other site-specific factors.

2.1 Tees (Inner; TY150 and Outer; TY160)

SLAB5 monitoring at the two Tees disposal sites has been conducted annually for a number of years and, as such, a good temporal dataset to draw upon when making contemporary assessments is available. Frequent monitoring here reflects the large amounts of material being disposed (especially to the Inner site) and the high concentrations of certain contaminants of the source material relative to those dredged around other parts of the English coast.

TBT was not determined at Tees during 2014 as previous data under SLAB5 indicated that concentrations of this compound were low (below limit of detection at most sampling stations; Bolam et al., 2015). Concentrations of CBs at all stations were below Cefas action level 1. According to the OSPAR guidelines, most of the 16 stations sampled displayed 'good' environmental status for all ICES7 CBs and 'good' status overall. One station was classed as 'bad' environmental status for CB118 but 'good' status overall. No stations were regarded as 'bad' status overall.

Enrichment of trace metals concentrations relative to those of the regional baseline values was mainly observed for the Inner Tees site. Such enrichment was mainly seen when concentrations were assessed according to OSPAR BACs; metals concentrations were either not enriched or slightly enriched (1-2 times background) using the regional baseline approach. Two stations were moderately enriched (2-5 times higher than background) for copper according to the regional baseline approach. The high trace metals concentrations naturally occurring for this region of the English coastline means that the regional baseline values are more appropriate than the OSPAR background assessment concentrations (BACs) for trace metals assessments of these disposal sites.

Subsequent monitoring should focus on assessments of contaminant concentrations at the Inner Tees site, unless disposal activity to the Outer Tees site increases. Given the good temporal data regarding contaminants data within the region of the disposal site, monitoring every two or three years would suffice over annual monitoring.

2.2 South Falls (TH070)

The South Falls disposal site is a large disposal site off the north-eastern coast of Kent. This site was the focus of previous monitoring under the auspices of SLAB5 during 2013 when the physical and biological characteristics during a large (i.e. 6Mt) capital disposal campaign were assessed.

The acoustic survey undertaken during November 2014 at South Falls revealed the site is composed of slightly gravelly sands, with large sand waves running across the area, interspersed with mega-ripples, which follow the predominant local sediment transport pathway. The backscatter data provided

evidence of disposed material, appearing as regions of higher backscatter return, on the bed within the licensed boundary of the site. These materials were a mixture of silt/clay to the north and gravel to the south of the disposal site.

Disposal activity on the seabed was evident across the whole of the site. Activity was less evident in the areas of coarser sediment in the east of the site, however this may be a result of the disposal material having a similar acoustic signature to the surrounding seabed. High intensity disposal activity (as defined by the presence of gravelly muddy sand on the seabed) was evident across much of the site; outside of these areas, smaller patches of disposal material were evident leading to a classification of moderate intensity disposal activity for the rest of the site.

The faunal samples acquired at South Falls (from the same stations as those sampled in 2013) were not processed during 2014, and it would be advisable to prioritise their processing during 2015 to allow these biological data to be compared with those from 2013. No further (acoustic) data acquisition is regarded as being required.

2.3 Nab Tower (WI060)

Nab Tower is an open and active disposal site approximately 13 km southwest of Bembridge, Isle of Wight, at a depth of approximately 30 – 40 m. The site is the main recipient of maintenance and capital material from ports, harbours, berths and navigational channels in Southampton, Portsmouth and the Isle of Wight. Acoustic bathymetry and backscatter data, together with sediment granulometric data, were obtained from within the Nab Tower disposal site during November 2014 to assess the physical nature of the seabed resulting from a large increase in disposal activity to the site.

Sediment particle size results illustrate that, in general, finer sediments occur within the licensed area compared to those outside, and is dominated by muddy gravelly sand with occasional gravelly muddy sand and muddy sandy gravel being observed. Outside of the licensed area, muddy sandy gravel and sandy gravel are the dominant sediments with occasional muddy gravelly sand and gravelly sand. Disposal activity (as observed on the seabed) was discernible throughout the majority of the disposal site. A gradient in disposal activity could be defined, with the NNW section of the site receiving the most intense activity, the mid-centre region of the site receiving moderate activity, and the SSE region of the site appearing a low or no disposal activity. Isolated patches of high disposal activity were, however, evident in the latter region.

While subsequent acoustic data acquisition during 2015 is not regarded as a high priority, the macrofaunal samples taken during 2014 should be processed. These biological data can be compared with historic data for this site acquired under SLAB5 during 2003 and 2004.

2.4 Rame Head South (PL031)

Rame Head South is an open and active disposal site with a depth of between 18 and 38 m. The site, located approximately 2 km west of Rame Head and 6 km west of the entrance to Plymouth Sound, is used for dredged material disposal mostly during the winter months. The site has been used for almost 100 years although during the early part of this period it was additionally used for munitions disposal.

This site was the recipient of relatively intensive monitoring during the early part of this century, with a large amount of physical, biological and contaminants data collected between 2000 and 2009. Data collected during 2014 around Rame Head South were from previously-sampled stations and focussed on contaminants to allow an assessment of any temporal changes in the vicinity of the site. TBT was not determined for Rame Head South during 2014 as earlier monitoring revealed that this compound is present at very low concentrations (Bolam et al., 2011a). The range of summed PAH concentrations across the stations sampled in 2014 are generally comparable with those previously observed for this site and are low relative to the concentrations observed around a number of other disposal sites off the coast of England.

The summed ICES7 CB concentrations for seven of the 16 stations sampled at Rame Head South were below the limit of detection (i.e. 0.7 µg kg^{-1} dry weight), with the highest concentration (4.6 µg kg^{-1} dry weight) being observed at a station to the southeast of the disposal site. Concentrations of CBs at all stations were below Cefas action level 1, and, according to the OSPAR guidelines, eight stations showed 'good' environmental status for all ICES 7 CBs, and 'good' status overall. Five stations were classed as 'bad' environmental status for CB118, but 'good' status overall. Two stations were exceptions, classed as 'bad' environmental status for CB118 and CB101, and therefore 'bad' status overall. These findings are similar to the results obtained when samples from Rame Head South were last analysed in 2009 (Bolam et al., 2011a).

When assessed compared to the regional baseline values, most trace metals showed no or little enrichment relative to background concentrations, a situation which is comparable to that observed for this site in previous years.

Unless the disposal regime regarding Rame Head South changes from that of recent years, annual monitoring is not required as the concentrations of contaminants observed under SLAB5 appear temporally consistent and, as biological data have been monitored in the past, such concentrations do not result in significant ecological (i.e., at the community level) changes (Bolam et al., 2011a; 2011b).

2.5 Site Y (IS150)

An acoustic survey of the whole of the Site Y disposal site was conducted during September 2014 aboard the RV *Prince Madog*. The aim of this survey was to acquire data to determine the physical characteristics of the seabed within the site following the disposal of large amounts of maintenance dredged material. The survey follows a previous SLAB5 survey conducted during December 2013 which took place following the placement of large quantities of cohesive, capital material at the site (Bolam et al., 2015).

The data acquired in 2014 indicated that the physical characteristics of the seabed within the disposal site was largely comparable to that observed during December 2013. The large numbers of disposal mounds resulting from the previously-deposited cohesive material could still be easily discerned within the site (see Bolam et al. 2015 for an assessment of these features). A large area of more homogenous seabed sediment consisting of finer material could, however, be seen over the most southern portion of the disposal site in 2014. It is likely that this material represents the disposal of the finer, maintenance dredged material which was deposited following the capital disposal campaign.

The data collected thus far from the two SLAB5 surveys indicate that subsequent acoustic data acquisition is not particularly warranted. However, as some of the material dredged within the Mersey contains elevated contaminants (although careful management of this, and the use of onshore disposal of the most contaminated material, has been conducted) further sampling to assess the concentrations of sediment-bound contaminants at Site Y would appear prudent.

3. Acknowledgements

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APPENDICES

Appendix 1. Assessment methods for sediment contaminants

1.1 PAHs

1.1.1 Methodology

Sediment samples, collected in glass jars, were frozen immediately after collection and not defrosted until required for analysis. Each homogenised wet sediment sample was extracted using alkaline saponification followed by liquid/liquid extraction. A sample of sediment was taken for a total solids determination as all results are reported on a dry weight (DW) basis. The sample extract was then passed through an alumina chromatography column in order to remove polar compounds, concentrated to 1 ml and sealed in a vial. A suite of alkylated and parent PAH were then determined using coupled gas chromatography/mass spectrometry (GC/MS). Quantification was by means of deuterated internal standards added prior to digestion, with analytical quality control samples being run within each sample batch. Full details can be found in Kelly *et al*. (2000).

1.1.2 Method used for assessment

Cefas currently has action level limits for contaminants such as trace elements and PCBs but none currently exist for PAHs. Reviews of what has been investigated in other countries has indicated that the most promising of the currently available co-occurrence methods is the Effects Range Low/Effects Range Median (ERL/ERM) methodology which is founded on a large database of sediment toxicity and benthic community information (Long *et al*., 1998).

The ERL/ERM methodology derives SQGs representing, respectively, the 10^{th} and 50^{th} percentiles of the effects dataset and can be derived for individual PAH compounds. In a regulatory context, where SQGs are to be used as informal (non-regulatory) benchmarks to aid in the interpretation of sediment chemistry (Long *et al*., 1998), this becomes complicated where a large number for individual PAH are determined, as is usually the case. This has led to separate ERL/ERM derived SQGs being set for “Low molecular weight PAHs” and “High molecular weight PAHs”. In this context;

LMW PAHs include 2- and 3-ring PAH compounds;

- Naphthalene
- monomethyl naphthalenes
- acenaphthene
- acenaphthylene
- fluorine
- phenanthrene
- anthracene

HMW PAHs include the 4- and 5-ring PAH compounds;

- fluoranthene
- pyrene
- benz[*a*]anthracene
- chrysene
- benzo[*a*]pyrene
- dibenz[*a,h*]anthracene

Although a wider suite of PAH is determined routinely for both licensing and monitoring purposes, these can be considered as toxicity markers for the PAH as a whole. The ERL and ERM concentrations applied are given in Table A1.1.1.

Table A1.1.1. ERL and ERM concentrations for LMW and HMW PAHs in sediments. The limits for LMW PAH are lower than those for HMW PAH as they carry a higher acute toxicity.

PAH compounds	**ERL** (µg kg^{-1} DW)	**ERM** (µg kg^{-1} DW)
LMW PAH	552	3,160
HMW PAH	1,700	9,600

1.2 Organohalogens

Full details of the analytical methodology are given in Allchin *et al*. (1989) and de Boer *et al*. (2001).

1.2.1 Sample extraction

Sediment samples were air dried and sieved (<2mm) in a controlled environment. 10 g of dried sediment were mixed with sodium sulphate, transferred to a glass Soxhlet thimble and topped with 1 cm of sodium sulphate. ^{13}C-labelled BDE209 was added as internal standard to all samples prior to the extraction step. Samples were extracted over a 6 h period using 50:50 hexane:acetone, with an average of 9 - 10 cycles h^{-1}. Sulphur residues were removed at this stage with copper filings.

1.2.2 Sample extract clean-up

An aliquot of the Soxhlet extract was cleaned up and fractionated using alumina (5% deactivated) and silica (3% deactivated) columns, respectively. The silica column fractionation results in two fractions, the first fraction containing polychlorinated biphenyls (PCBs) and BDE209, the second fraction

containing polybrominated diphenylethers (PBDEs), with organochlorine pesticides (OCs) split across the two fractions.

1.2.3 Analysis of PCBs and OCs by GC-ECD

After addition of internal standard CB53, PCB and OC concentrations were determined with an Agilent 6890 GC with µECD, with separate injections for PCBs and OCs. The separation of analytes was performed on a 50.0 m × 200 µm, 0.33-µm-film-thickness DB-5 capillary column (J&W). The carrier and ECD make-up gas were hydrogen (32.2 psi constant pressure, initial velocity 50 cm/s) and argon/methane (95:5), respectively. The initial oven temperature was 90°C, held for 2.00min, then increased to 165°C at 15°C/min, to 285°C at 2°C/min, and finally held for 23 min. The injector temperature and detector temperature was 270°C and 300°C, respectively. A 1-µl extract was injected in splitless mode with a purge time of 2 min.

1.2.4 Analysis of PBDEs by GC-MS

After addition of internal standard CB200, PBDE concentrations were determined with an Agilent 6890 GC with 5973 MS in negative chemical ionisation (NCI) mode. The separation of analytes was performed on a 50.0 m × 250 µm, 0.25-µm-film-thickness DB-5 capillary column (J&W). The carrier gas was helium (30 psi constant pressure, average velocity 40 cm/s) and the reagent gas was methane (40 psi). The initial oven temperature was 90°C, held for 2.00min, then increased to 200°C at 30°C/min, to 295°C at 2.5°C/min, and finally held for 31.33 min. The injector temperature and detector temperature was 270°C and 200°C, respectively. A 2-µl extract was injected in splitless mode with a purge time of 2 min.

1.2.5 Analysis of BDE209 by GC-MS

BDE209 concentrations were determined with an Agilent 6890 GC with 5973 MS in NCI mode. The separation of analytes was performed on a 15.0 m x 250 µm, 0.1-µm-film-thickness DB-1 capillary column (J&W). The carrier gas was helium (1.3ml/min constant flow, average velocity 59 cm/s) and the reagent gas was methane (40 psi). The initial oven temperature was 90°C, held for 1.00min, then increased to 200°C at 25°C/min, to 295°C at 10°C/min, and finally held for 20 min. The injector temperature and detector temperature was 250°C and 200°C, respectively. A 2-µl extract was injected in pulsed splitless mode with a 20psi pulse until 1 min and a purge time of 2 min.

1.2.6 Quantitation methods

The identification of PCBs and OCs was based on the retention time of individual standards in the calibration mixtures. Quantitation was performed using internal standards and 7 calibration levels (range 0.5 – 100 ng/ml). The PCB standard solutions contained the following 27 compounds in iso-octane (IUPAC designations): Hexachlorobenzene; *p,p'*-DDE; CB101; CB105; CB110; CB118; CB128; CB138; CB141; CB149; CB151; CB153; CB156; CB158; CB170; CB18; CB180; CB183; CB187; CB194;

CB28; CB31; CB44; CB47; CB49; CB52; CB66. The OC standard solutions contained the following 6 compounds in iso-octane: alpha-HCH; beta-HCH; gamma-HCH; dieldrin; *p,p'*-TDE; *p,p'*-DDT.

Quantitation for PBDEs was performed using internal standards and 8 calibration levels (range 0.1 – 50 ng/ml). The PBDE standard solutions contained the following 11 compounds (IUPAC designations) in iso-octane: BDE17; BDE28; BDE47; BDE66; BDE100; BDE99; BDE85; BDE154; BDE153; BDE138; BDE183; together with the internal standard CB200.

Quantitation of BDE209 was performed using an internal standard and 7 calibration levels (range 0.5 – 500 ng/ml). The BDE209 standard solutions contained IUPAC BDE209 in iso-octane, together with the internal standard $^{13}C_{12}$- labelled IUPAC BDE209.

1.2.7 Quality assurance / quality control procedures

AQC procedures included reagents purification, method blanks, and use of control charts created from repeated analysis of the SETOC 770 Certified Reference Material (CRM).

PCB and OCP concentrations were determined in the sediments and reported on a dry weight (DW) basis. The ∑ICES 7 CBs (CB28, CB52, CB118, CB153, CB138, CB 170, CB183), and the sum of all 25 measured CBs (∑CBs) were calculated. Where individual congener concentrations were below the limit of detection (LOD) of 0.2 µg/kg, a value of half the LOD was inserted for calculation of summed concentrations. The CB congener distribution was calculated from the proportion of the sum of ∑CBs that contained 3 chlorines (CB18, CB28, CB31), 4 chlorines (CB44, CB47, CB49, CB52, CB66), 5 chlorines (CB105, CB110, CB101, CB118), 6 chlorines (CB128, CB158, CB141, CB149, CB153, CB138, CB151, CB156), 7 chlorines (CB170, CB180, CB183, CB187), and 8 chlorines (CB194), respectively. Congener profiles at different stations were compared to identify stations with different sources.

The Total Organic Carbon (TOC) content in the <2 mm fraction determined at a number of representative sampling stations was used to additionally calculate the contaminant concentration normalised to 2.5% TOC content. The TOC data from the representative stations was used to estimate the TOC content at adjacent stations for which this value was lacking.

Concentrations of PCBs in the sediment were compared with various action limits, to investigate whether any adverse effects in benthic biota were likely to be expected as a consequence of their presence. The current Cefas ALs for dredge disposal are: AL1 if ∑ICES7 CBs > 10 µg/kg, ∑CBs > 20 µg/kg, and AL2 if ∑CBs > 200 µg/kg. Concentrations are expressed on a DW basis. According to the work of McDonald *et al.*; (2000), consensus-based TECs (Threshold effect concentrations), i.e. below which harmful effects are unlikely to be observed, are: ∑CBs <59.8 µg/kg; and consensus-based PECs (Predicted effect concentrations), i.e. above which harmful effects are likely to be observed (∑CBs

>277 µg/kg). Concentrations are expressed on a DW basis. OSPAR have set criteria for Background Assessment Concentrations (BAC) and Environmental Assessment Concentrations (EAC) for the ICES7 CBs in sediments (see Table A1.3.1). Concentrations are expressed in µg/kg DW normalised to 2.5% organic carbon. Concentrations below BACs would be considered to have high environmental status. Concentrations significantly below EACs could be considered to have good environmental status and those above, bad environmental status. The station is deemed to have 'bad' environmental status if 'bad' status occurs for more than one ICES7 CB congener.

Table A1.2.1. OSPAR assessment criteria for CBs in sediment from CP2.

Sediment (µg/kg DW, normalised to 2.5% TOC)		
Compound	**BAC**	**EAC**
CB28	0.22	1.7
CB52	0.12	2.7
CB101	0.14	3.0
CB118	0.17	0.6
CB138	0.15	7.9
CB153	0.19	40
CB180	0.10	12

1.3 Trace Metals

1.3.1 Methodology

The sediment samples were collected in plastic bags and were frozen immediately after collection. The samples were collected for PSA and metal analyses on the <63µm fraction. Details on obtaining the <63µm sediment fraction can be found in the Particle Size Analysis technical report.

The sample is digested in a mixture of hydrofluoric, hydrochloric and nitric acids using enclosed vessel microwave, the digest is made up in 1% nitric acid and further diluted prior to analysis by Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) and Inductively Coupled Plasma-Mass Spectroscopy (ICP-AES). Quantification of Al, As, Cd, Cr, Cu, Fe, Li, Mn, Ni, Pb, Rb and Zn is done using external calibration with Indium as internal standard. A certified reference material is run within each sample batch for quality control. Results are reported in mg kg^{-1} (ppm).

Some samples contained insufficient silt/clay (<63µm) for trace metals determination. Values lower than the detection limits were omitted from the dataset. This is because several detection limits were higher than real values, causing spurious elevations.

1.3.2 Numerical assessments

1.3.2.1 Raw data

Two approaches were carried out on the raw data:

1. Data comparison between the stations located inside the disposal sites and those that are situated outside the disposal site. The average concentration is obtained over a number of years and sites to allow data comparison. This data is averaged and so might not reflect the true observed trend for individual stations.
2. Temporal trend is also assessed for stations within the disposal sites and outside the disposal site. The average concentration is calculated for each year to carry out temporal trend analysis.

1.3.2.2 Enrichment factors

In order to assess relative level of trace metal contamination for a sampled station, enrichment to a baseline is required. This report presents two assessment methods; (i) comparisons with OSPAR Background Assessment Concentrations (BACs) as in previous reports, and (ii) comparisons with regional baseline concentrations.

$$\text{Enrichment ratio is defined as: } \frac{\text{Metal raw value}}{\text{OSPAR BAC or proposed baseline value}}$$

Enrichment is arbitrary defined in 4 levels:

0-1: no enrichment

1-2: slight enrichment

2-5: moderate enrichment

>5: high enrichment

The two assessment methods are detailed below (but refer to Cefas (2011) for a fuller explanation).

1.3.2.2.1 OSPAR BACs

OSPAR (BACs) are defined for Clean Seas Environment Monitoring Programme (CSEMP) assessment to determine temporal trends in concentrations (OSPAR, 2008). They are derived from Background Concentrations (BCs) which are based on concentrations recorded in 'pristine' areas.

Normalisation of metal concentrations is required to account for differences caused by different sediment types present in the area surveyed. Normalisation of the metal concentrations to 5% aluminium using a pivot point is completed to derive the OSPAR BACs, using pivot point data defined in the assessment manual for contaminants in sediment and biota (OSPAR, 2008). Aluminium and lithium are both commonly used to normalise metal concentrations. Correlations between all trace metals, at each site, were completed to determine the best normaliser to use.

For most sites, there were no clear correlations between the trace metals and correlations values of aluminium and lithium indicate that the relationship between the normaliser and trace metals was not strong enough to endorse the use of Al or Li for normalisation.

As trace metal concentrations used for in this study were measured on the fine fraction of sediment (<63µm), normalisation to some extent has already been completed, therefore all enrichment calculation were based on the raw data.

1.3.2.2.2 Regional baselines

The above-mentioned Background Concentrations (BCs) are based on concentrations recorded in 'pristine' areas. There is only one set of values assigned by OSPAR for the whole North Atlantic (http://www.ospar.org). However, trace metal concentrations are known to show regional variation in the UK, largely related to the variable geology around the coast and historical industrial activity in the early 19th Century which has caused localised elevated levels (Ridgeway *et al*, 2003; Rowlatt and Lovell, 1994; Cefas, 2005). Therefore, for assessing enrichments at disposal sites, Cefas have developed regional baselines utilising various spatial datasets around England and Wales. Recently, an extensive study was carried out on 8 regions defined in the Clean Seas and Environment Programme (CSEMP) (Figure A1.3.1) and the proposed metals baselines concentration derived from this study have additionally been used in this report as a validation tool to i/ compare with OSPAR BACs values and ii/ to assess the credibility of using those proposed baselines values instead of the OSPAR BACs values when studying for metals enrichment. The proposed baselines for the areas are given in Table A1.3.1, along with the corresponding OSPAR BACs values for each metal (OSPAR, 2006).

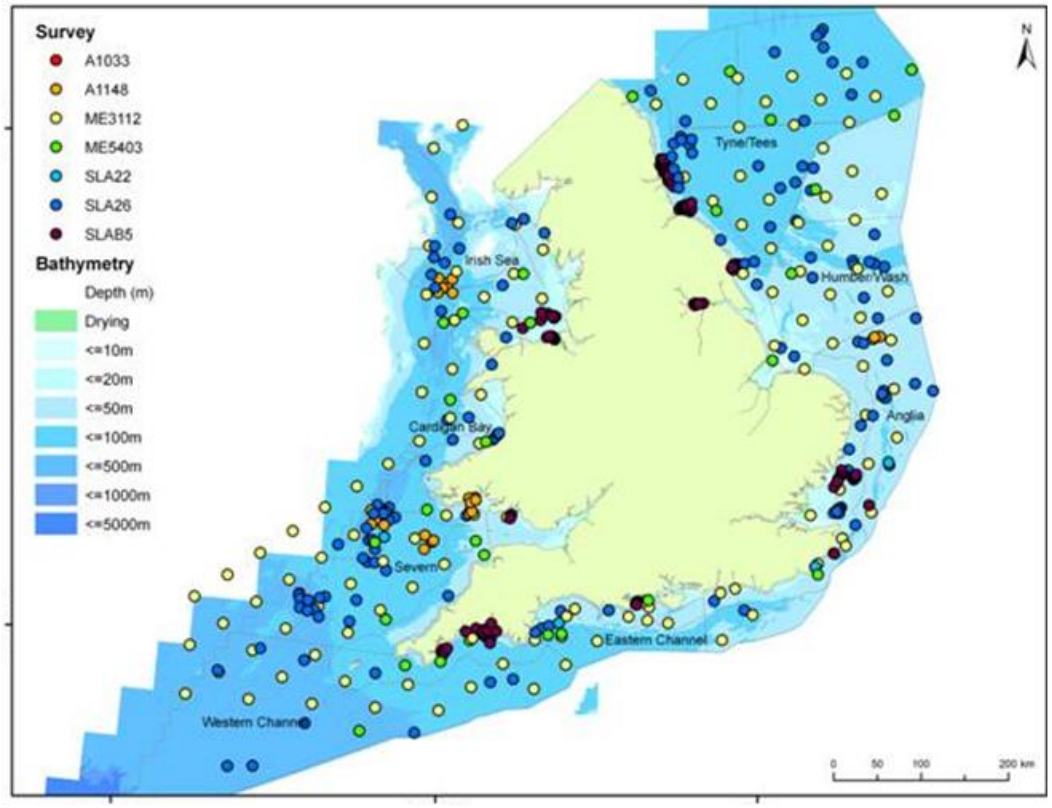


Figure A1.3.1. Location of stations sampled to provide metals data as part of the regional baseline approach.

Table A1.3.1. OSPAR BACs (in red) with proposed baselines for regions covered in disposal site assessment in 2010.

	As (mg/kg)	Cd (mg/kg)	Cr (mg/kg)	Cu (mg/kg)	Hg (mg/kg)	Ni (mg/kg)	Pb (mg/kg)	Zn (mg/kg)
Anglia	33	0.2	115	40	0.16	56	46	130
Cardigan Bay	26	0.29	103	26	0.12	44	73	145
Eastern Channel	23	0.18	90	26	0.12	31	45	107
Humber Wash	30	0.17	109	31	0.21	44	67	129
Irish Sea	21	0.29	115	38	0.43	47	77	240
Severn	21	0.2	81	27	0.1	36	47	135
Tyne/Tees	27	0.31	135	29	0.35	55	131	171
West Channel	34	0.19	105	72	0.77	50	108	153
OSPAC BAC	25	0.31	81	27	0.07	36	38	122

Appendix 2. Results

2.1 Tees (Inner and Outer)

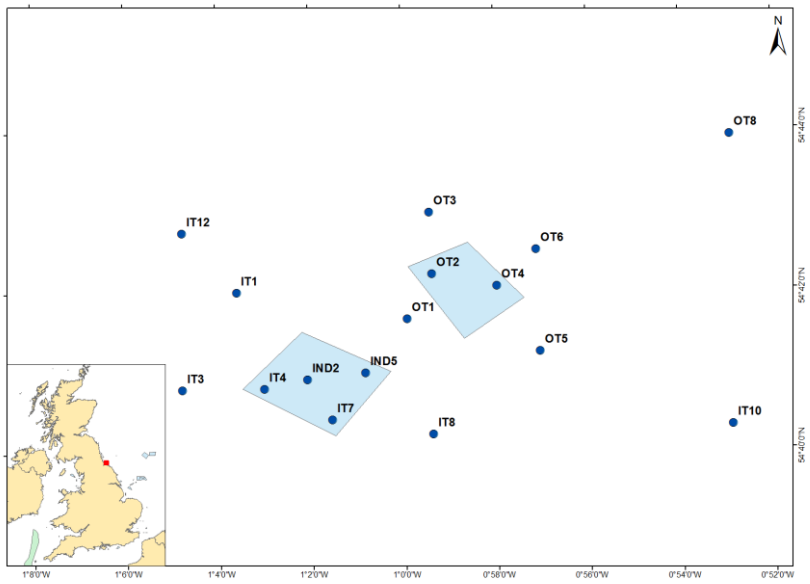


Figure A2.1.1. Stations sampled at Tees (Inner and Outer) disposal sites during 2014.

2.1.1 Background

The Inner and Outer Tees dredged material disposal sites are located within close proximity to the mouth of the Tees (Figure A2.1.1) and receive large quantities of material dredged from the ports of the Tees Estuary. These sites have both been the recipient of monitoring under SLAB5 for a number of years (Bolam et al., 2009; 2011a; 2012; 2014b). The Inner Tees disposal site has been shown to have a very homogeneous substrate of muddy sand with occasional small lumps of black mud and black flecks indicative of coal particles (Bolam et al., 2009; 2011a). This site receives most of the 2.7 Mt of maintenance dredged material per year from the Tees Estuary, the Seaton Channel and Hartlepool. In recent years the material disposed of to this site was seen to shoal at the western edge. In response to this, the operators, PD Teesport, offered to divide the disposal area into twelve sectors during 2006 and dispose to each on a monthly basis. Material disposed to Outer Tees is usually comprised of capital dredged material. This is a more mobile site and the port places more consolidated (i.e. clay) dredged material at this site rather than to Inner Tees. This is often at the discretion of the operator based on observations of the material being dredged.

There have been a number of high profile construction and disposal at sea applications made with regard to the Tees sites over recent years. In addition to the 2.7 Mt of maintenance dredge material licensed annually for sea disposal, permission has also been granted for the Northern Gateway container terminal which will include dredging of turning circles and berth pockets in the Tees resulting in a 2 Mt dredge. Due to the physical nature of some of the material, it is anticipated that

this material would be divided between the two Tees disposal sites. This project is yet to be implemented, with the potential for commencement in 2015, a marine licence will be required. Work which commenced in 2014 on improvements to the Tees Dock No. 1 Quay, which includes a requirement for capital dredging of up to approximately 327,000m^3, is currently ongoing. The limited capital dredging component of AV Dawson- North Sea Supply base was completed in 2014.

Various other projects incorporating a smaller scale capital dredge component have also been consented but not yet commenced such as at Vopak Jetty No.4, and Conocco Phillips on the north bank and from the Queen Elizabeth II berth. The Harbour facilities of the York Potash (a Nationally Significant Infrastructure Project) include an associated capital dredging requirement in order to create a berthing pocket, but the Development Consent Order for these works is yet to be submitted to the Secretary of State.

The Tees has a large quantity of chemical industries which have, in combination with its highly-mineralised catchment, resulted in contaminants within dredged sediments. ICI, TiOxide factories and brominated flame retardant producers have all discharged into the Tees. Within the Tees Estuary there has also historically been a breach in the half-tide embankment allowing erosion of the enclosed mudflat; sediments of which have been contaminated with high levels of lead and zinc. Construction works to repair this breach were subsequently licenced and undertaken. Analysis of dredged material from the Tees has displayed some of the highest levels of PAHs found in UK marine sediments.

RAT prioritisation assessment: Tier 1

- where a significant increase in the quantity of material disposed of has occurred.
- where there is the potential for the occurrence of elevated contaminant concentrations (between Cefas AL1 and AL2 in proposed dredge sediments) (Appendix 1) arising from historical or current activities at source (especially heavily urbanised/industrialised estuaries).
- where the material to be disposed of is very different (sediment type) to the receiving environment.
- with agreed increases in quantities of material (including changes in material and contaminant loadings).

2.1.2 Parameters to be assessed:

Sediment particle size

Sediment organic carbon

Sediment contaminants (organohalogens, trace metals)

Assessments of the status of, and impacts at, the two Tees disposal sites are conducted based on data derived from a single survey that comprises stations within each licensed boundary, together with a number of stations located at varying distance outside each site.

2.1.3 Results

2.1.3.1 Sediment particle size

Inner Tees sediments are predominantly muddy sands and unimodal sands, with small but varying amounts of gravel (Table A2.1.1). Temporal changes in sediment group are shown in Table A2.1.2 for each sample code from 2006 to 2014. Most stations showed very little change in sediment group in 2014 from that of previous years, being either in the same or an adjacent sediment group. The only exceptions to this were IT7 (within the disposal site on southern edge) which has an increased sand component, and IT4, within the disposal site on the edge closest to shore, and to a lesser extent IT10, which have become muddier in composition.

Table A2.1.1 Average sediment descriptions and statistics for each sediment group at Inner Tees.

Sediment group	Number of samples	Sample Type	Sediment description
InT1a	2	Bimodal, Extremely Poorly Sorted	Gravelly Mud
InT2	4	Polymodal, Very Poorly Sorted	Gravelly Muddy Sand
InT3a	9	Bimodal, Poorly Sorted	Slightly Gravelly Muddy Sand
InT3b	9	Bimodal, Very Poorly Sorted	Slightly Gravelly Muddy Sand
InT3c	11	Unimodal, Poorly Sorted	Slightly Gravelly Muddy Sand
InT3d	29	Unimodal, Poorly Sorted	Slightly Gravelly Muddy Sand
InT4a	22	Unimodal, Moderately Sorted	Slightly Gravelly Sand
InT4b	12	Unimodal, Moderately Well Sorted	Slightly Gravelly Sand

Sediment group	Gravel (%)	Sand (%)	Silt/clay (%)	Very coarse sand (%)	Coarse sand (%)	Medium sand (%)	Fine sand (%)	Very fine sand (%)
InT1a	20.14	7.10	72.76	0.89	0.70	1.16	2.46	1.90
InT2	17.66	64.09	18.25	12.92	17.12	9.82	8.34	15.90
InT3a	0.49	56.07	43.43	0.68	1.53	3.77	11.98	38.11
InT3b	3.13	76.28	20.59	4.11	8.61	12.92	32.54	18.10
InT3c	0.53	81.50	17.97	0.46	0.93	2.25	11.39	66.47
InT3d	0.40	85.51	14.08	0.67	1.85	5.64	35.25	42.10
InT4a	1.16	94.05	4.79	1.50	3.66	10.48	51.45	26.96
InT4b	0.20	97.63	2.17	0.70	3.15	18.59	64.50	10.68

Table A2.1.2 Sediment groups for each sample code between 2006 and 2014 inclusive at Inner Tees.

	Year								
Sample code	2006	2007	2008	2009	2010	2011	2012	2013	2014
IND1	InT3d	InT3d	InT4a	InT3d	InT3d	InT3d	n	InT4a	n
IND2	InT4a	InT4a	InT4a	InT1a	InT3b	InT4a	n	InT1a	InT1a
IND4	n	InT4a	InT3d	InT3d	InT4a	InT3d	InT4a	n	n
IND5	n	InT4a	InT4b	InT4b	InT4b	InT4a	InT4b	n	InT4b
IT1	InT3d	InT3d	n	InT3c	InT3c	InT2	InT3a	InT3a	InT3a
IT2	n	n	n	InT4b	InT4b	n	n	n	n
IT3	InT4a	InT3a	InT4b	n	InT3a	InT4b	InT3b	InT4b	InT4b
IT4	InT3d	InT3d	InT3d	InT3d	InT3d	InT3d	InT3d	InT4a	InT3d
IT5	InT4a	InT3d	InT4a	InT4a	InT3d	InT4a	InT4a	InT3d	n
IT6	InT4a	InT3b	InT3b	InT3d	InT4a	InT4a	InT4a	n	n
IT7	InT3d	InT4a	InT3d	InT3d	InT3d	InT3d	InT3d	InT3a	InT3d
IT8	InT3c	InT3c	InT3c	InT3c	InT3c	InT3c	InT3c	InT3c	InT3c
IT10	InT3b	InT3b	InT2	InT3b	InT2	InT3b	n	InT2	InT3b
IT11	n	n	n	n	n	n	InT3a	n	n
IT12	n	n	n	n	n	n	InT3a	n	InT3a

IND1, IND4, IT2, IT5, IT6, and IT11 were not sampled in 2014.

Figure A2.1.2 demonstrates the predominantly sandy nature of the sediment across this survey area in 2014 with some stations displaying an increased silt/clay component (Figure A2.1.3). Silt/clay content in a subset of dredge sediments for licensing applications to dispose of at Inner Tees was 66% (+/- 8 %, 95% CI). Most monitoring samples contained less silt/clay than this, except sediments in sediment group InT1, tentatively indicating that the finer fractions of the material disposed are being dispersed from within the disposal site.

Sediments at Outer Tees, in parallel with those of Inner Tees, are predominantly muddy sands, with some gravelly sands and unimodal sands (Table A2.1.3). Table A2.3.4 indicates that there have been minimal changes in sediment groups since 2006 at Outer Tees. At OT2, in 2014 the sediment returned to levels of silt/clay similar to those observed prior to 2013. Slight increases in fines have occurred at OT1, west of the disposal site, and at OT6, east of the disposal site. Pie charts of gravel, sand and silt/clay for 2013 are shown in Figure A2.1.2 and silt/clay content is presented in Figure A2.1.3; the former confirming the sediments to be predominantly sandy with increased proportions of gravel at some stations (e.g. OT3).

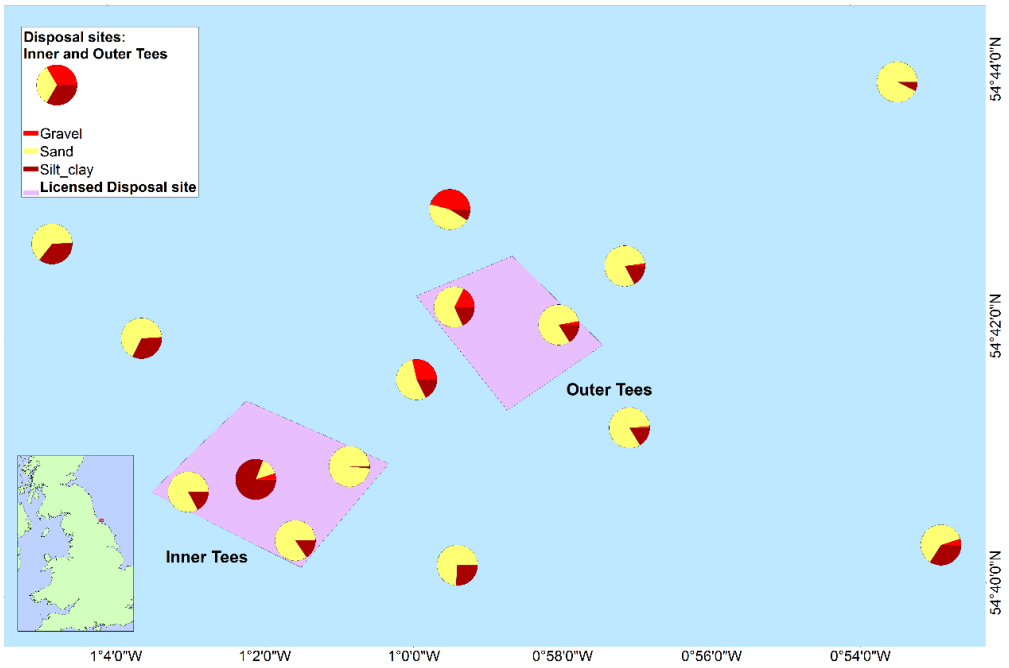


Figure A2.1.2. Pie charts of gravel, sand and silt/clay at Inner Tees (Tees Bay A) and Outer Tees (Tees Bay C) in 2014.

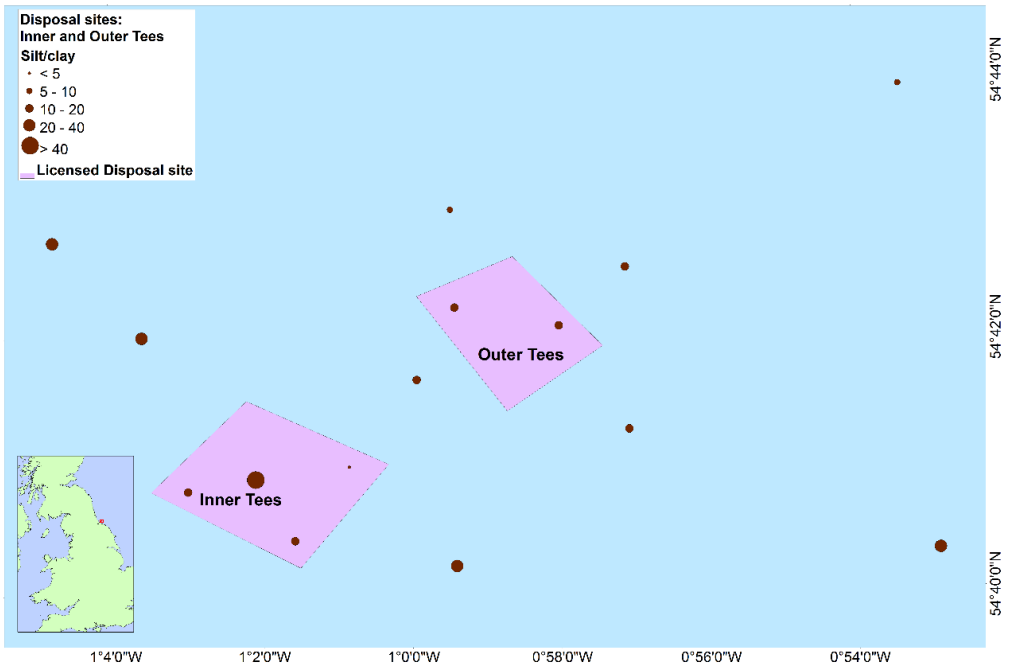


Figure A2.1.3. Silt/clay (%) at Inner Tees and Outer Tees in 2014.

Table A2.1.3. Average sediment descriptions and statistics for each sediment group at Outer Tees.

Sediment group	Number of samples	Sample Type	Sediment description
OuT1	14	Bimodal, Poorly Sorted	Slightly Gravelly Muddy Sand
OuT2	15	Polymodal, Very Poorly Sorted	Gravelly Muddy Sand
OuT3	14	Unimodal, Moderately Sorted	Slightly Gravelly Sand
OuT4	16	Unimodal, Poorly Sorted	Slightly Gravelly Sand

Sediment group	Gravel (%)	Sand (%)	Silt/clay (%)	Very coarse sand (%)	Coarse sand (%)	Medium sand (%)	Fine sand (%)	Very fine sand (%)
OuT1	0.81	69.38	29.81	1.09	1.74	4.95	29.27	32.33
OuT2	19.96	63.53	16.52	13.13	12.30	10.80	15.99	11.32
OuT3	0.37	90.24	9.39	0.49	1.85	6.06	55.59	26.25
OuT4	3.79	88.43	7.77	4.78	7.53	17.47	47.86	10.78

Table A2.1.4. Sediment groups for each station sampled between 2006 and 2014 inclusive at Outer Tees.

	Year							
Sample code	2006	2007	2008	2009	2010	2011	2013	2014
OT1	OuT4	OuT4	OuT4	OuT4	OuT4	OuT4	OuT4	OuT2
OT2	OuT2	OuT2	OuT4	OuT2	OuT2	OuT2	OuT1	OuT2
OT3	OuT1	OuT4	OuT4	OuT2	OuT4	OuT2	OuT2	OuT2
OT4	OuT4	OuT1	OuT2	OuT4	OuT4	OuT2	OuT4	OuT4
OT5	OuT1	OuT1	OuT1	OuT1	OuT1	OuT1	OuT1	OuT1
OT6	OuT3	OuT3	OuT3	OuT3	OuT1	OuT3	OuT3	OuT1
OT7	n	OuT2	OuT1	n	OuT2	n	n	n
OT8	OuT3	OuT3	OuT3	OuT3	OuT3	OuT3	OuT3	OuT3

2.1.3.2 Sediment organic carbon and nitrogen

In 2014, organic carbon values (on the <63µm sediment fraction) at Inner Tees ranged from 1.73 to 5.45 % (Figure A2.1.4), and 1.04 to 5.84% on the <2mm fraction (Figure A2.1.5). In general, sediment organic carbon contents for the Inner Tees stations were similar to those obtained in previous years (Bolam et al., 2009; 2011a).

For the Outer Tees site, organic carbon values (on the <63µm sediment fraction) ranged from 2.41 to 4.65 % (Figure A2.1.4), and 0.42 to 4.34% on the <2mm fraction. As for the Inner site, these are similar to those observed in previous years.

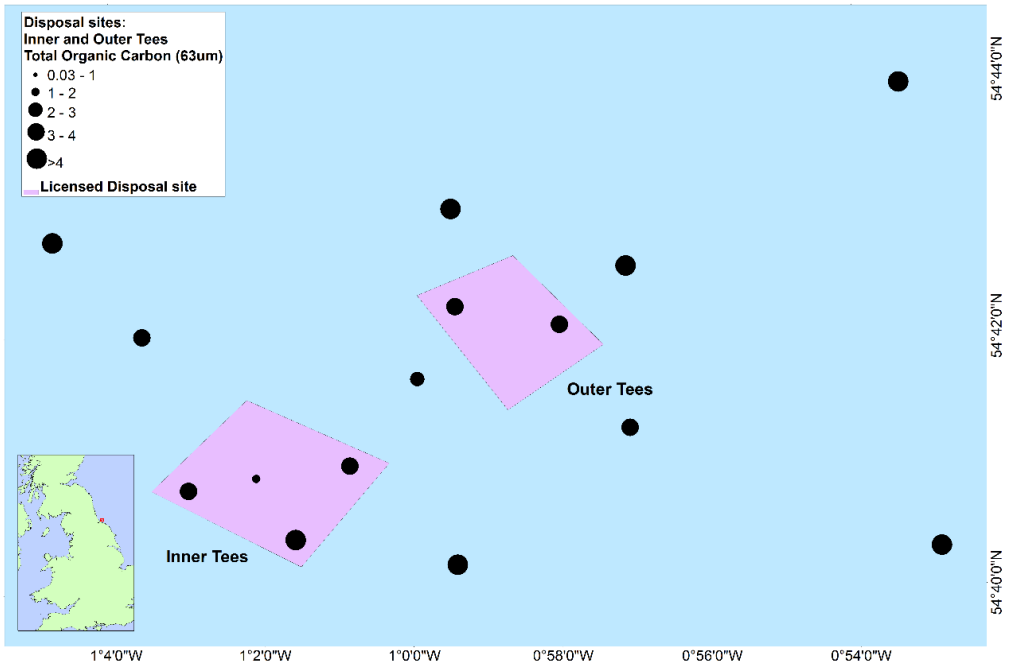


Figure A2.1.4. Organic carbon (%) in the silt/clay fraction (<63µm) at Inner Tees and Outer Tees, 2014.

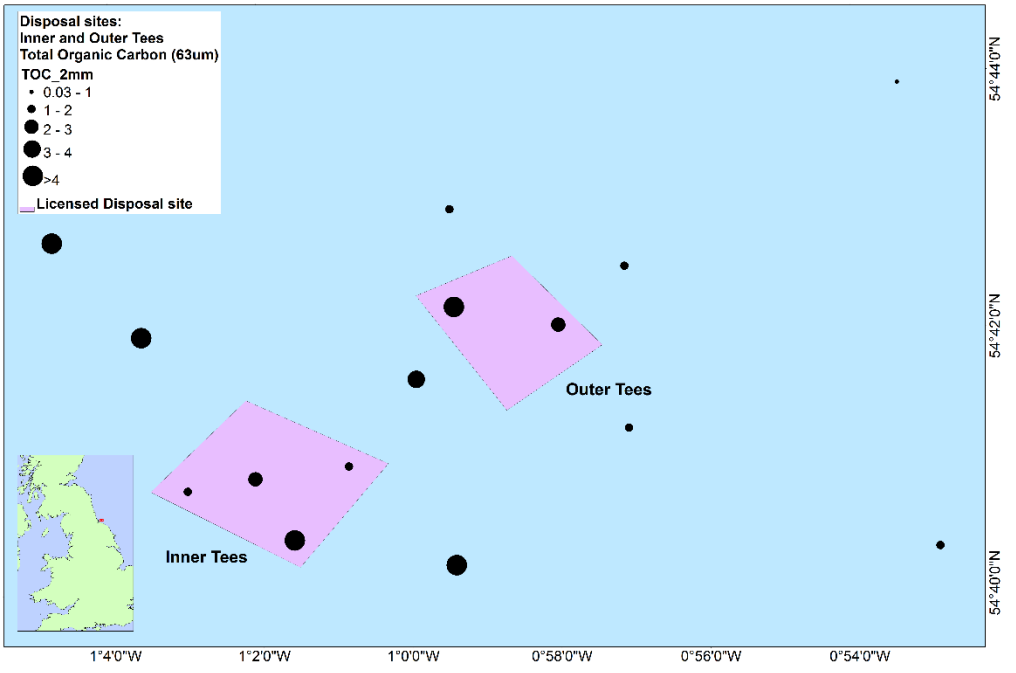


Figure A2.1.5. Organic carbon (%) in the <2mm fraction at Inner Tees and Outer Tees, 2014.

2.1.3.3 Sediment contaminants

2.1.3.3.1 Organohalogens

At Tees, CBs were detected at nine of the 16 stations sampled in 2014, with higher concentrations for the Inner Tees (∑ICES7 CBs range <0.7-4.7 µg/kg DW) compared to the Outer Tees (∑ICES7 CBs range

<0.7-2.1 µg/kg DW) (Figure A2.1.6). At Inner Tees, three of the four highest ∑ICES 7 CB concentrations (4.7, 2.9 and 2.7 µg/kg DW) were found outside of the disposal site (at IT8, IT12 and IT1 respectively), with a high value of 2.0 µg/kg DW also at IT4 within the disposal site (Figure A2.1.6). At Outer Tees, the two highest ∑ICES 7 CB concentrations (2.1 and 1.7 µg/kg DW) were observed inside the disposal site, at OT2 and OT4, respectively. All ICES7 CBs were below LOD (i.e. 0.7 µg/kg DW) at two of the Inner Tees stations (IT3 and IND5) and five of the outer Tees stations (OT1, OT3, OT5, OT6 and OT8).

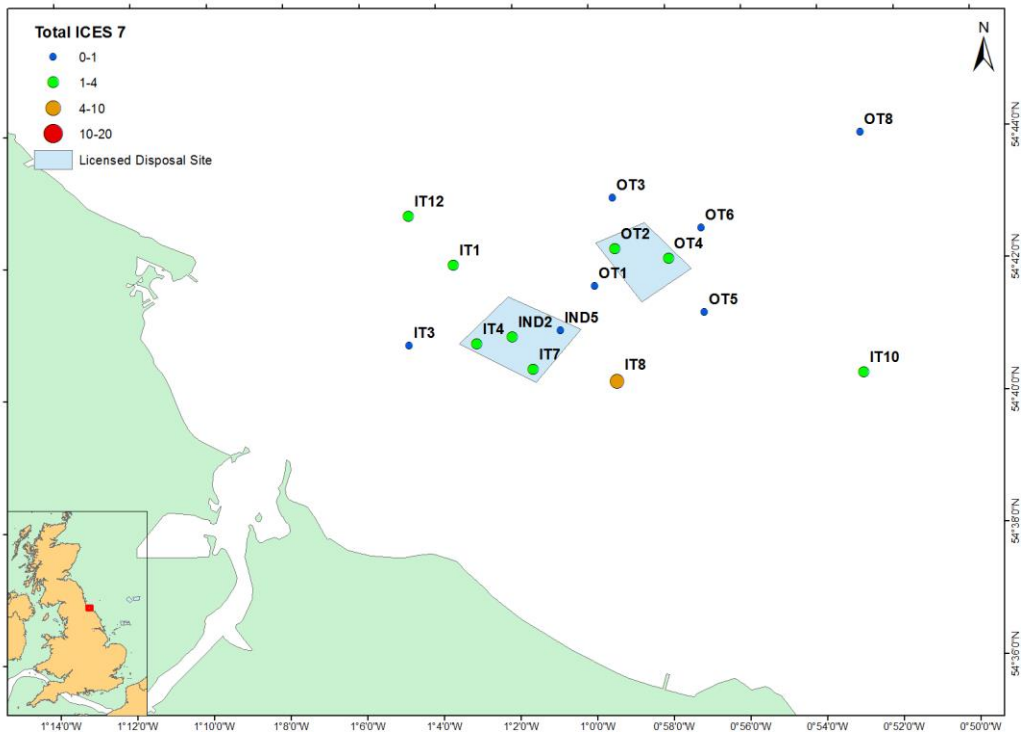


Figure A2.1.6. ∑ ICES7 CB concentrations for the Inner and Outer Tees Stations, 2014.

BDEs were detected in sediments sampled at all 16 stations (∑11 BDEs range 0.29-5.8 µg/kg DW at Inner Tees and 0.99-2.8 µg/kg DW at Outer Tees; Figure A2.1.7). The highest ∑11 BDEs concentration was within the Inner Tees disposal site at IT4 (5.8 µg/kg DW), while the next highest values of 3.5 and 3.0 µg/kg DW were outside the disposal site at IT12 and IT1, respectively. Highest ∑11 BDEs concentrations in the Outer Tees area were 2.8 µg/kg DW within the disposal boundary at OT2, and 2.7 µg/kg DW to the north of the disposal site at OT3. Two congeners, BDEs 99 and 47, were responsible for 47-72% of the ∑11 BDEs concentrations. BDE183 was detected at 12 of the 16 stations which is indicative of widespread use of the octa or deca BDE technical mixes.

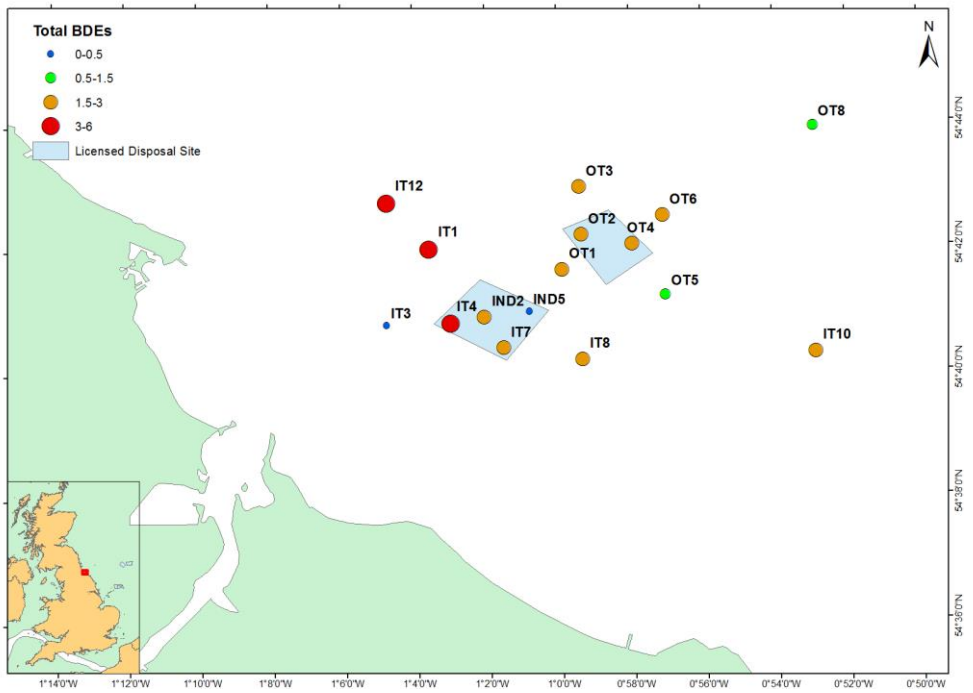


Figure A2.1.7. ∑ 11 BDEs concentrations for the Inner and Outer Tees Stations, 2014.

BDE209 was detected at all of the 16 stations sampled and was at higher concentrations than the other measured organohalogens (range 0.86-105 µg/kg DW at Inner Tees and 1.9-9.4 µg/kg DW at Outer Tees; Figure A2.1.8). The highest concentration (105 µg/kg DW) was detected at IT71 within the Inner Tees disposal site, with 31 µg/kg DW at IT4 also within the disposal site. High BDE209 values were also found outside the disposal site, e.g. 17 µg/kg DW at IT1 and 10 µg/kg DW at IT12 and IT8 (Figure A2.1.8). Concentrations of BDE209 were much lower at Outer Tees, 9.7 and 5.4 µg/kg DW at OT2 and OT4, respectively, being the highest observed. Additionally, a BDE209 concentration 9.4 µg/kg DW was found at OT6, to the east of the Outer site. When included with the other BDEs, BDE209 made up 73-98% of the BDEs present at the Inner Tees stations, and 70-85% of ∑12 BDEs at the Outer Tees stations. BDE209 is indicative of the deca BDE technical mixture, which had been in use more recently than the other technical mixtures, although its use has now been restricted in the EU since 2008.

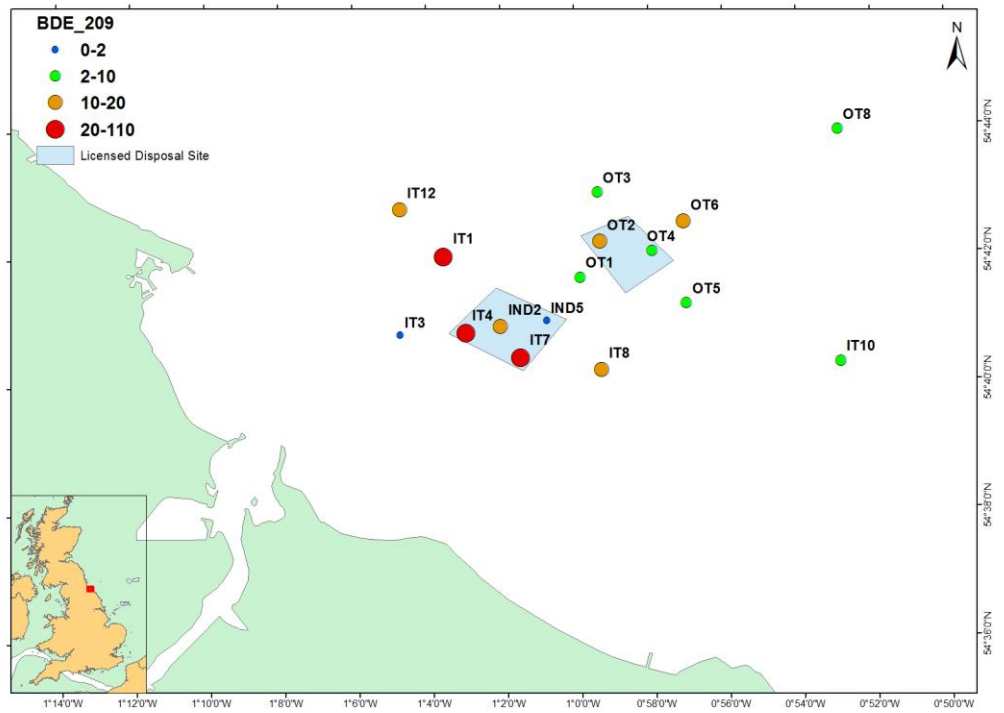


Figure A2.1.8. BDE209 concentrations for the Inner and Outer Tees Stations, 2014.

Concentrations of CBs at all stations were below Cefas action level 1. No Cefas action levels exist for BDEs including BDE209. According to the OSPAR guidelines, most stations had 'good' environmental status for all ICES 7 CBs and 'good' status overall. IT4 had 'bad' environmental status for CB118 but 'good' status overall. No stations had 'bad' status overall. No OSPAR guidelines exist for BDEs at present.

There are data available to allow an evaluation of temporal trends in organohalogen contaminants for the Tees sites (Tables A2.1.5 to A2.1.7). At Inner Tees, CB concentrations in 2014 were more-or-less similar to those observed since 2008, although the highest concentration sampled in 2014 (4.7 µg/kg DW) at IT8 represents a significant increase for this station. At Outer Tees, there is generally a decreasing trend in CB concentrations, except for station OT2 in the disposal site, where CB concentrations increased from the concentrations measured in 2011.

Table A2.1.5. Temporal trends (2003-2014) of ∑ICES 7 CBs concentration (in µg/kg DW) at the Inner and Outer Tees stations.

Station code	∑ ICES 7 CBs concentration (in µg/kg DW)								
	2003	2006	2007	2008	2009	2010	2011	~	2014
IT2	*0.7*				*0.7*	*0.7*			
IT1		0.83	1.54		2.13	2.04			2.71
IND1		*0.7*	*0.7*	*0.7*	1.96	*0.7*	1.46		
IT3	*0.7*	*0.7*	5.09	*0.7*		4.58	*0.7*		*0.7*
IT4	26.4	*0.7*	2.8	*0.7*	2.75	2.03	1.42		2.04
IND2		*0.7*		*0.7*	*0.7*	2.72	*0.7*		*1.19*
IT5	*0.7*	*0.7*		0.92	*0.7*	1.21	1.27		
IND4			4.62	1.76	2.15	*0.7*	1.23		
IT12									2.85
IT7	24.1	*0.7*	1.7	*0.7*	1.04	1.6	1.6		1.09
IT6	*0.7*	*0.7*	0.82	2.2	2.39	*0.7*	*0.7*		
IND 5			0.95	*0.7*	*0.7*	*0.7*	*0.7*		*0.7*
IT8	*0.7*	*0.7*	1.5	1.64	1.79	1.13	1.23		4.67
OT1		*0.7*		*0.7*	*0.7*	*0.7*	*0.7*		*0.7*
OT2		*0.7*		*0.7*	*0.7*	0.91	0.86		2.1
OT3		0.9	*0.7*	*0.7*	*0.7*	1.17	0.84		*0.7*
OT4		1.28	5.8	1.5	1.61	*0.7*	*2.4*		1.67
OT6		0.83		1.81	*0.7*	1.81	0.82		*0.7*
OT5		0.83	3.49	4.19	1.25	4.24	1.82		*0.7*
IT10	*0.7*			1.08	0.93	1.85	1.0		1.37
OT7				6.12		1.27			
OT8		*0.7*		*0.7*	*0.7*	*0.7*	*0.7*		*0.7*

Concentrations in italic represent estimates of concentrations for samples where all ICES 7 congener concentrations were below LODs

For BDEs, data are available from 2006-2014 for the two Tees sites. At Inner Tees, there is no clear trend regarding BDE concentrations, with some stations increasing and others decreasing. Stations IT3, IT4, IND2 and IT8 all had higher concentrations in 2014 than in 2011 (the previous survey year), whereas IT7 and IND5 presented lower concentrations. Concentrations at all stations sampled in 2014 were in the range previously observed. At Outer Tees, as for the Inner Tees, there was no clear overall trend, with some stations increasing and others decreasing. Stations OT1, OT2, OT3, OT6 and IT10 all had higher concentrations in 2014 than in 2011, whereas OT4, OT5 and OT8 all had lower concentrations. However, OT1, OT2 and OT3 all had the highest ∑11 BDEs concentrations in 2014 of the whole period for which data was available, which is a possible cause for concern, although levels remain lower than at Inner Tees.

Table A2.1.6. Temporal trends (2003-2014) of ∑11 BDEs concentration (in µg/kg DW) for the Inner and Outer Tees stations.

Station code	∑11 BDEs concentration (in µg/kg DW)							
	2006	2007	2008	2009	2010	2011	~	2014
IT2				0.30	5.44			
IT1	3.75	2.43		1.75	2.73			3.03
IND1	2.85	0.92	0.50	2.10	1.27	1.75		
IT3	1.08	9.55	0.36		7.76	0.21		0.29
IT4	3.17	6.19	1.99	4.13	6.41	2.17		5.76
IND2	1.02		0.22	*0.11*	29.4	0.43		2.51
IT5	1.04		1.84	1.45	1.87	2.54		
IND4		3.31	2.99	2.57	1.18	1.27		
IT12								3.51
IT7	1.32	1.20	0.64	1.40	3.04	3.11		2.34
IT6	1.61	1.46	2.80	3.67	0.58	0.72		
IND 5		1.19	0.20	0.20	0.19	2.68		0.32
IT8	1.22	2.51	0.95	1.66	1.19	1.89		2.20
OT1	0.84		0.18	0.23	0.53	0.46		2.05
OT2	1.06		0.38	0.43	1.24	1.08		2.84
OT3	1.71	1.04	0.73	0.26	1.26	1.15		2.69
OT4	2.04	9.91	0.82	1.26	0.74	2.29		1.93
OT6	1.55		0.87	0.63	2.17	1.0		1.71
OT5	1.56	8.21	3.41	0.89	5.45	2.12		0.99
IT10			0.60	0.68	2.85	1.42		2.27
OT7			5.57		2.61			
OT8	0.96		0.79	0.35	0.58	0.60		0.52

Concentrations in italic represent estimates of concentrations for samples where all 11 BDE congener concentrations were below LODs. Limits of detection for BDEs improved between 2007 and 2008 and therefore values assigned to congeners below LOD are lower from 2008 onwards, resulting in a step decrease in ∑11 BDEs concentration for samples with congeners below LODs.

For BDE209, temporal data are available from 2008-2014 (Table A2.1.7). There is a general increase in BDE209 concentration at Inner Tees, with most stations displaying higher concentrations in 2014 compared to those seen in previous years (Table A2.1.7). The exception was at IND5, which showed a marked decrease since 2011. In 2014, IT7, IT4 and IT8 had the highest BDE209 concentration that has been measured at the site since 2008, but all other stations were in their typically observed range. For the Outer Tees, BDE209 concentrations also increased at all stations between 2008 and 2014, and seven of the eight stations exhibited the highest concentration ever measured there, although levels remain lower than at Inner Tees.

Table A2.1.7. Temporal trends (2008-2014) of BDE209 concentration (in µg/kg DW) for the Inner and Outer Tees stations.

Station code	BDE209 concentration (in µg/kg DW)					
	2008	2009	2010	2011	~	2014
IT2		0.87	2.96			
IT1		20.9	9.16			17.3
IND1	1.46	9.65	3.29	17.4		
IT3	1.17		31.0	0.05		0.86
IT4	13.3	26.6	12.3	3.11		31.9
IND2	*0.05*	*0.05*	32.4	2.21		
IT5	7.42	2.16	10.0	8.71		8.79
IND4		9.95	2.65	3.22		
IT12						10.1
IT7	1.76	5.27	10.5	12.71		105
IT6	39.8	37.9	1.75	1.11		
IND 5		*0.05*	*0.05*	10.1		0.88
IT8		5.89	3.54	7.74		10.1
OT1	0.58	0.70	2.35	0.26		7.4
OT2	1.27	1.38	2.56	0.56		9.7
OT3	2.37	0.80	3.57	0.71		6.26
OT4	3.81	3.13	1.45	1.26		5.38
OT6	3.42	2.29	7.85	0.41		9.43
OT5	19.0	3.86	20.0	2.66		5.12
IT10	2.19	1.97	6.43	1.36		7.45
OT7	84.3		5.53			
OT8	0.75	*0.05*	1.53	0.30		1.86

The Inner Tees disposal site received a large amount of dredged material in 2012 and 2013, which may explain the observed general increase in organohalogen concentrations.

2.1.3.3.2 Trace metals

During the 2014 survey, sediment samples for trace metals analysis were collected at nine and seven stations at Inner and Outer Tees disposal sites, with four and two located respectively within the Inner and Outer Tees disposal site boundaries. Levels of enrichment for Inner and Outer Tees stations using OSPAR BAC and regional baseline values are represented in Figure A2.1.8.

When assessed against the OSPAR BAC approach, slight enrichment in Cr is observed for all stations at Outer Tees disposal site. This enrichment is not observed when assessed using the baseline method. This is due to the fact that the proposed baseline value for Cr is much higher than the OSPAR BAC value for this region (see Table A1.3.1). Cr enrichment in 2014 appears less pronounced than that found during 2013. The temporal data depict a decreased Cr concentration in 2014 relative to that measured in 2013 (Figures A2.1.9 & A2.1.10).

All stations show slight enrichment for Ni with the OSPAR BAC approach at the Inner and Outer Tees disposal sites. When using the baseline approach, all concentrations are below the regional baseline values. This observation is similar to those obtained from the previous years' survey. No specific temporal trend is recorded during the sampling period from 2008-2014 for Ni. Similar observations were found for Zn.

Arsenic is slightly enriched for most stations at the Inner Tees disposal site when using both assessment approaches. Levels of As are relatively higher at the Inner Tees disposal site than at the Outer Tees disposal site. This observation was also apparent following the 2013 survey. The temporal data show a slight decrease of As (from stations located inside and outside of both Inner and Outer Tees disposal sites) from 2011 onwards.

The majority of stations show slight enrichment of Cu when using the baseline approach for both Inner and Outer disposal sites, with the exception of IT4 and IT10 where moderate enrichment was observed. Similar observations are recorded for the OSPAR BAC assessment method, although enrichment is slightly more enhanced for station IT8.

Enrichment comparison for Cd is similar with both assessment approaches for both Inner and Outer disposal sites, with stations being classed as slightly or not enriched, with the exception of IT10 where Cd was found to be moderately enriched.

Pb shows a moderate enrichment for most stations at Tees disposal sites, while OT8 (northeast of the Outer Tees disposal site) displays a very enriched Pb concentrations when assessment is conducted using the OSPAR BAC approach. Most stations, however, remain slightly or not enriched according to the regional baseline method. This is similar to the findings observed in the 2013 survey.

As was the situation for the 2013 survey data, the difference in enrichment factors between the two assessment approaches was more pronounced for Hg. For example, apart from stations with concentrations below the limit of detection (IT1, IND2, OT1 and OT3), Hg shows a moderate to high enrichment, with four very enriched stations located within the Inner and Outer Tees disposal sites (IT4, IT7, OT2 and OT4) according to the OSPAR numerical approach. These stations, however, were found to be only slightly enriched according to the regional baseline assessment, with no enrichment observed for the remaining stations. This is due to the fact that the proposed baseline value for Hg is much higher than the OSPAR BAC value (see Table A1.3.1).

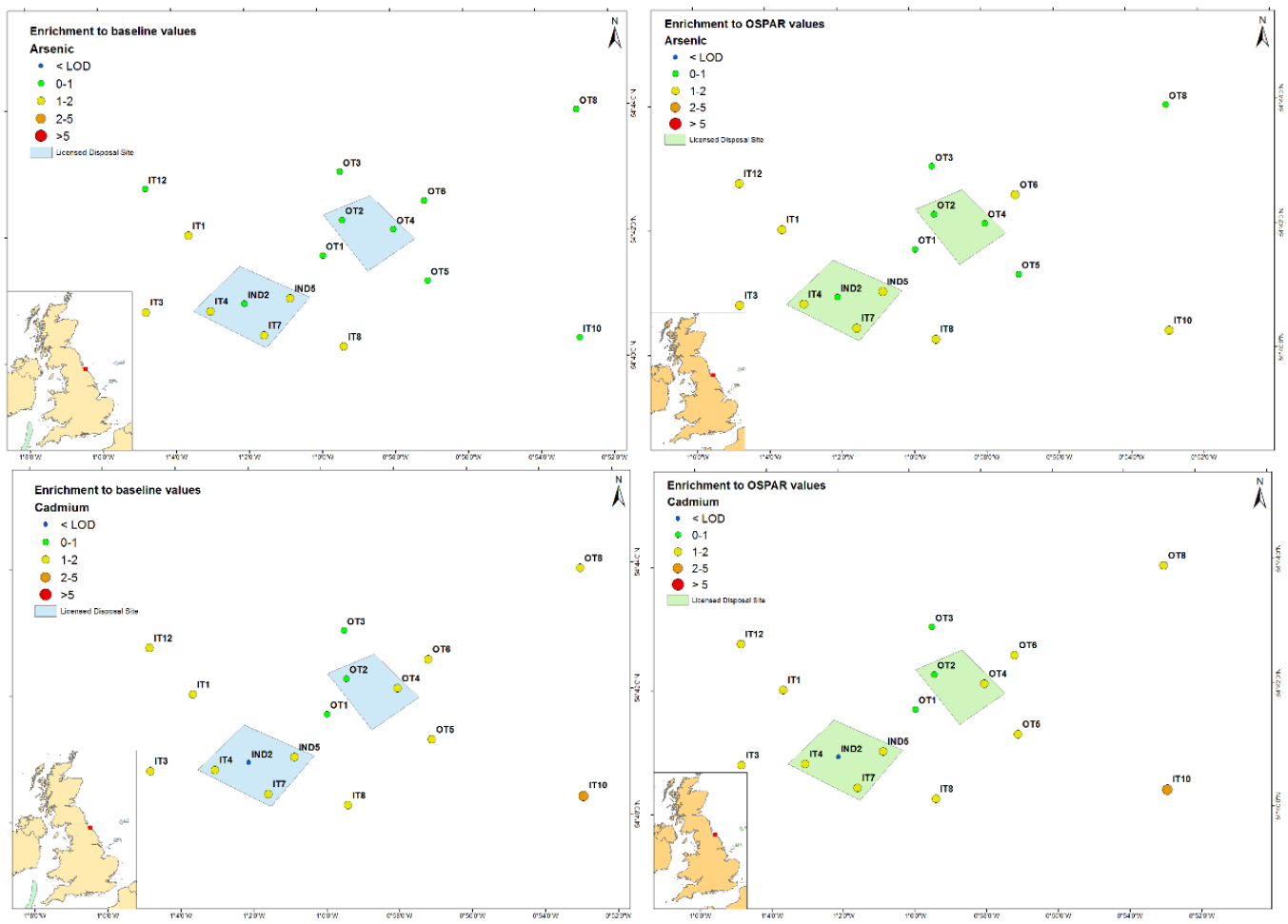


Figure A2.1.8. Enrichment to regional baseline values (left) and OSPAR BACs (right) at Inner and Outer Tees for As, Cd, Cr, Cu, Hg, Ni, Pb and Zn, 2014.

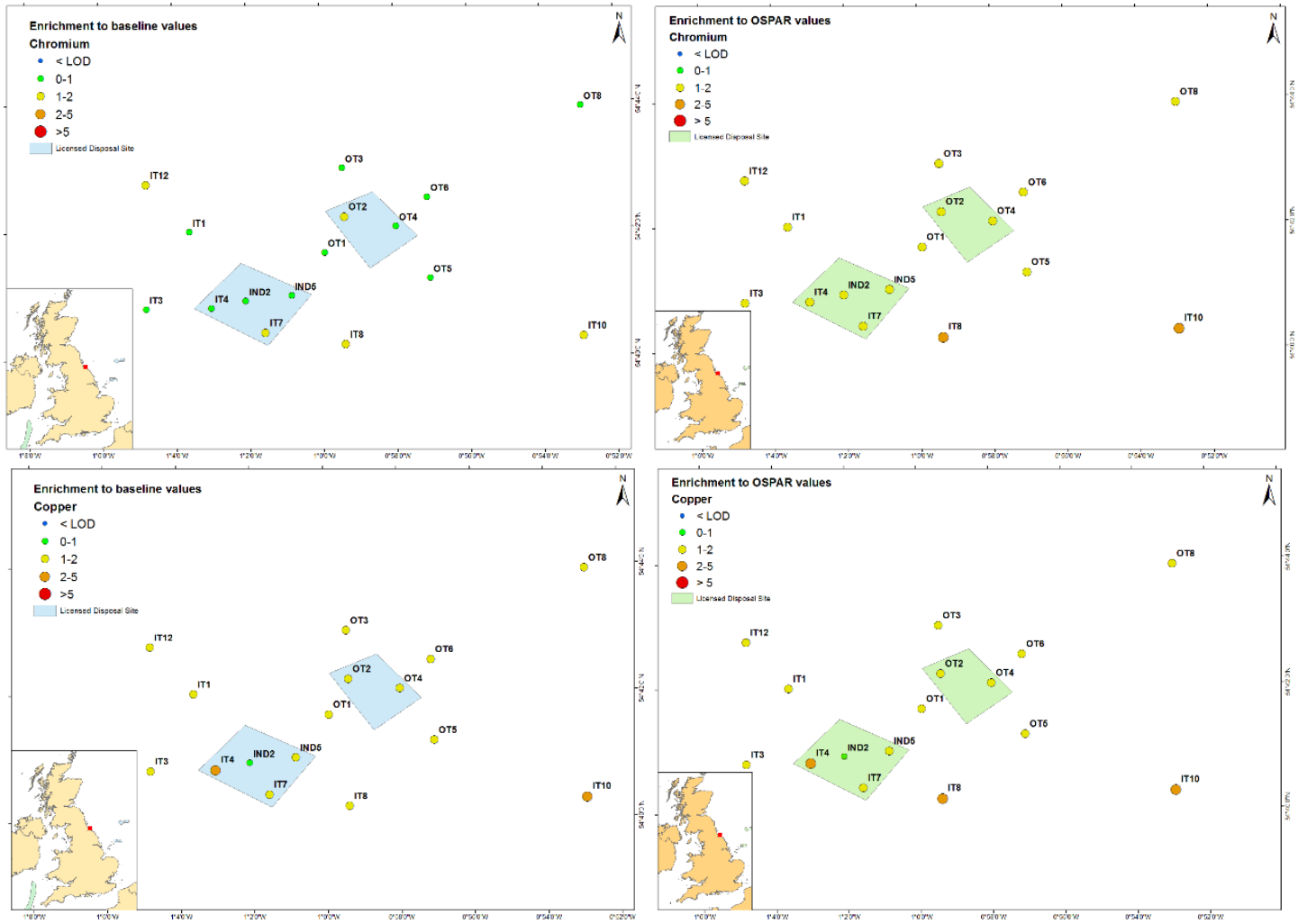
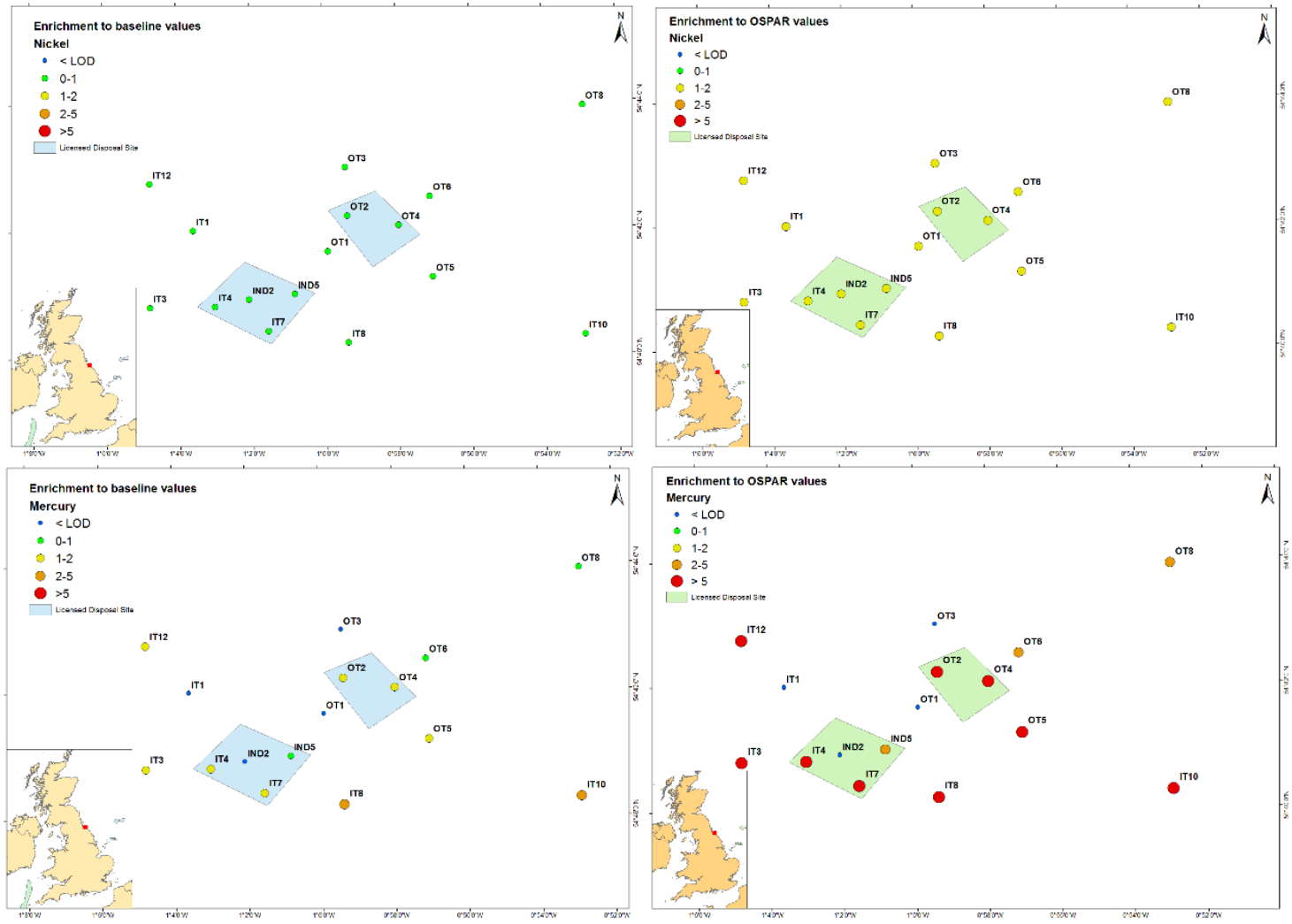


Figure A2.1.8. Continued.



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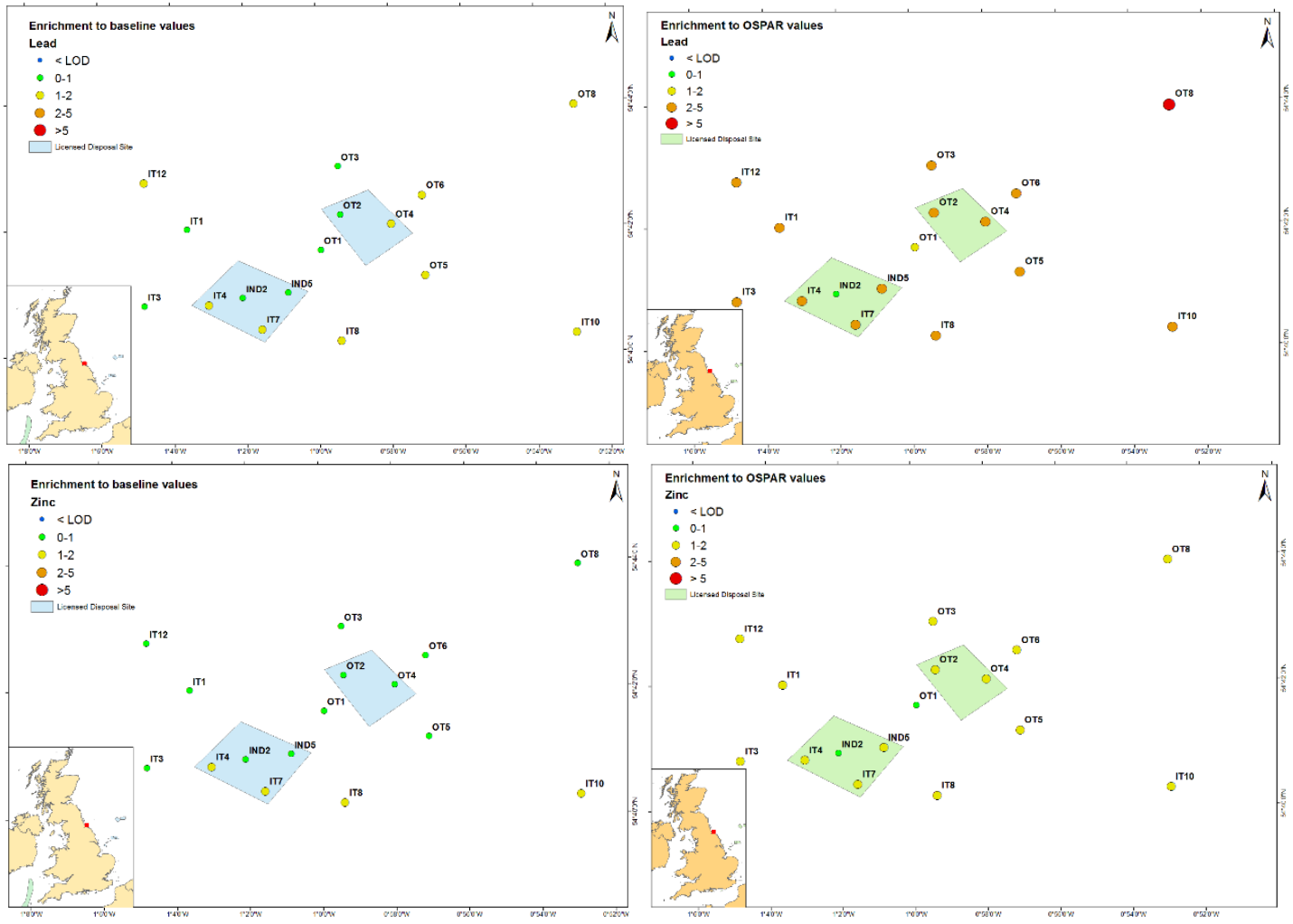
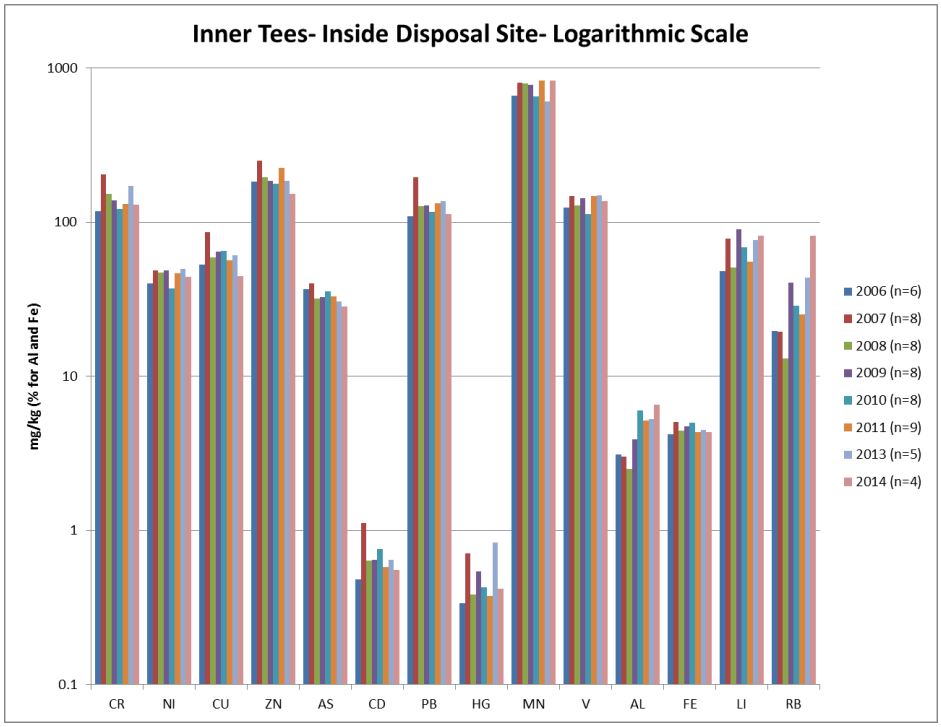


Figure A2.1.8. Continued.



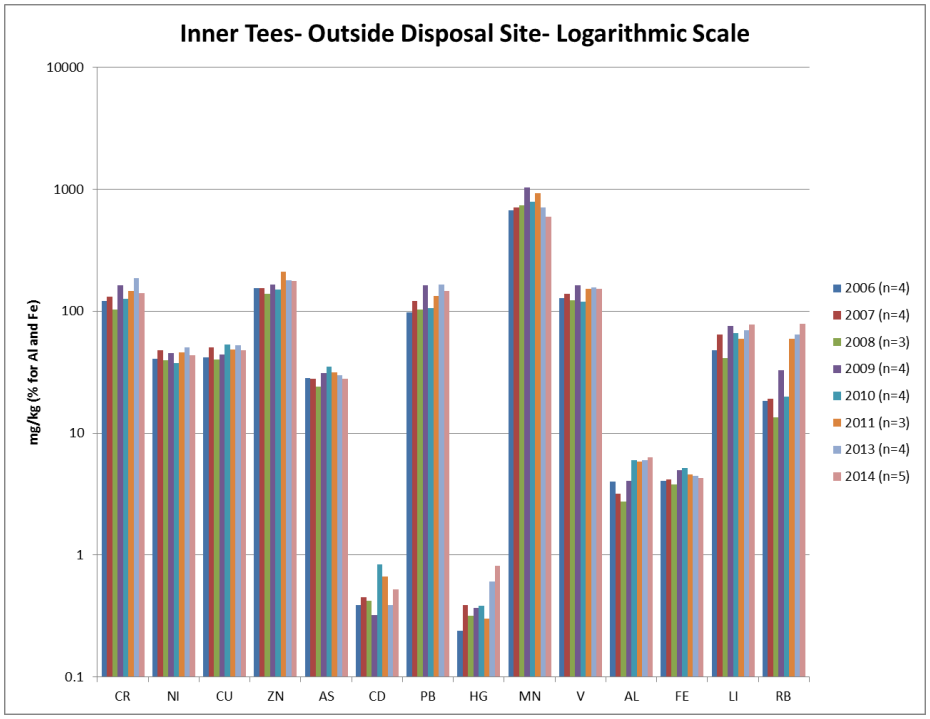
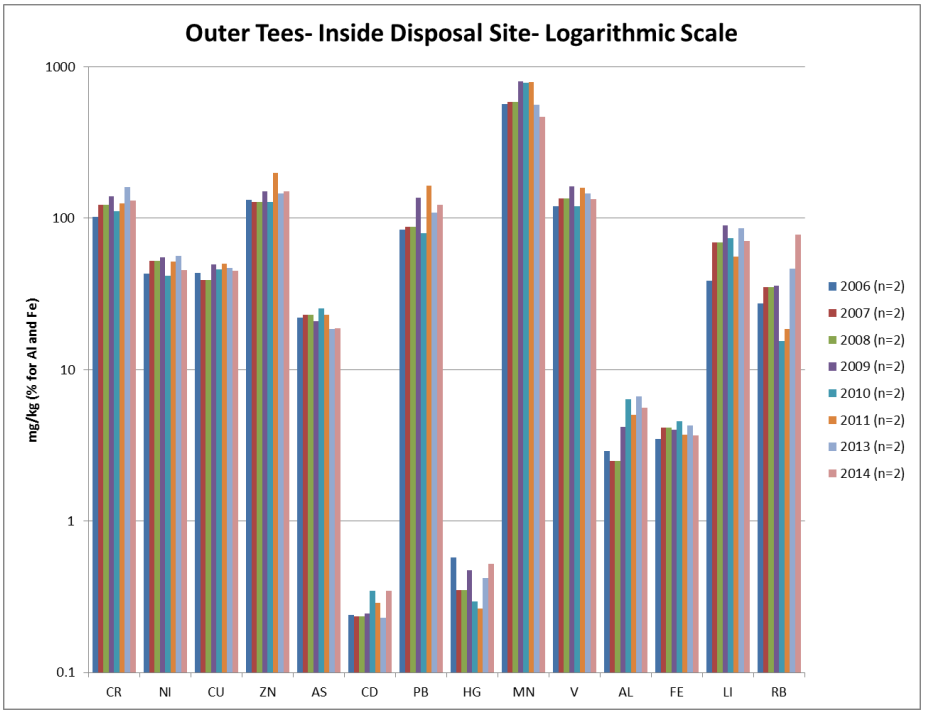


Figure A2.1.9. Inner Tees (inside and outside) temporal metals data, 2006-2014.



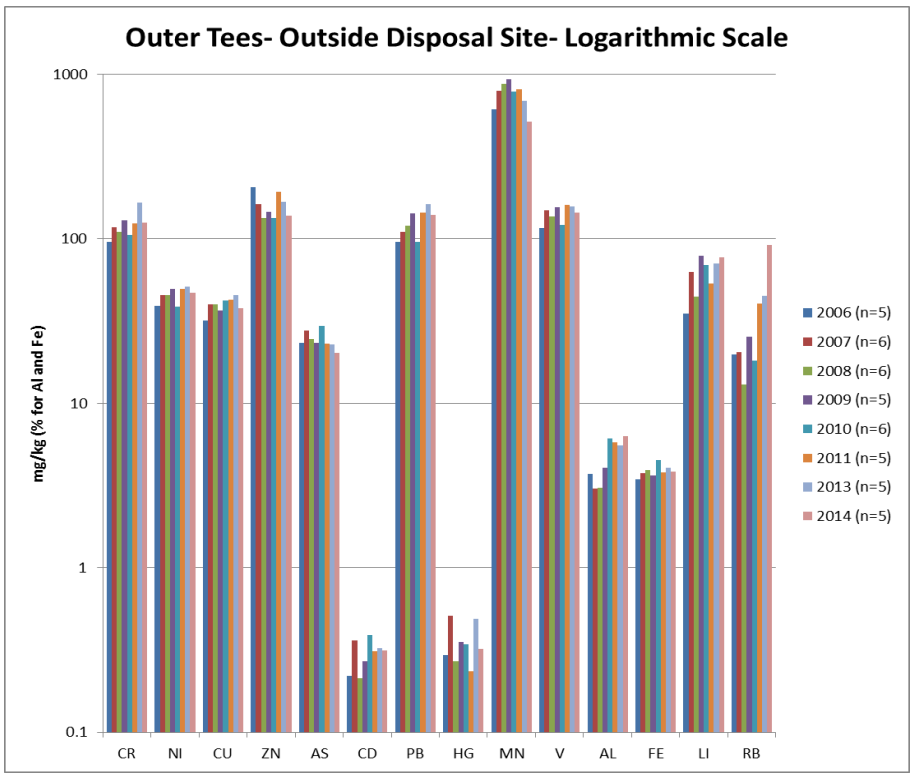


Figure A2.1.10. Outer Tees (inside and outside) temporal metals data, 2006-2014.

2.2 South Falls

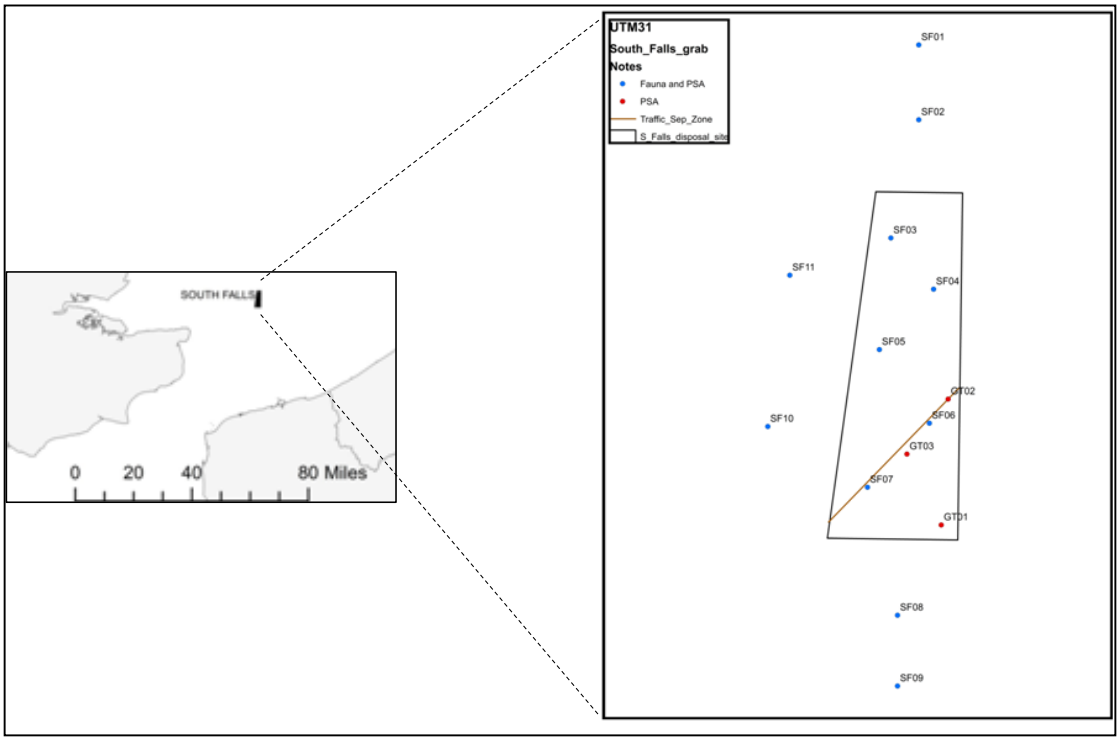


Figure A2.2.1. Location of sampling stations at South Falls, 2014.

2.2.1 Background

South Falls (TH070) is a designated dredged material disposal site located in the southern North Sea, approximately 110 km east of Gravesend. The licensed site has an area of approximately 27 km^2 in a roughly trapezoidal shape (Figure A2.2.1), a depth of approximately 55 m, and experiences a tidal range of 4.6 m with maximum current velocities of 1.1 m/s. The bed sediments in the vicinity of South Falls are fine to medium sand, becoming progressively finer towards the south.

South Falls receives both capital and maintenance dredged material. Currently, the site is receiving maintenance dredged silts and sand from the River Medway with a total permitted quantity of 280,000 t per annum of silt, and a further operator from the Thames area has been licensed to dispose of coarse sand on a periodic basis. During 1993/1994, the Port of Ramsgate was licensed to dispose up to 0.7 Mt of capital material, and, in 2000/2001, Medway Port held a licence to dispose of up to 0.8 Mt of capital material. More recently, the annual disposal quantity has varied from 1,000 t to over 0.2 Mt.

Recently, Dredging International applied to dispose of approximately 6 Mt (3 Mm^3) of capital dredged material from the approach channel to the London Gateway Port development in the Thames Estuary.

This material comprised a mixture from silty sand to London clay. The total tonnage estimated for the different material types were as follows; clay (1.48 Mt); silty sand (3.28 Mt); gravelly sand (1.26 Mt). Following consultation, the licence was issued and disposal of this material to TH070 commenced during June 2013. The total amount of material the site is expected to receive under this licence obviously represents a significant increase for this site, and, thus, monitoring under SLAB5 was initially conducted during December 2013. At the time of this survey, 4 Mt of the anticipated 6 Mt had been deposited. The focus of the 2013 monitoring was on the physical characteristics (depth and sediment granulometry) of the seabed and of the biological assemblages. Thus, the results obtained (Bolam et al., 2015) allow an assessment of the characteristics during the disposal regime and subsequent monitoring (i.e. during 2014) was required to assess these features after the cessation of the disposal campaign.

RAT prioritisation assessment: Tier 1

2.2.2 Parameters monitored:

Acoustics and sediment particle size assessment

Macrofaunal assemblages (retained)

2.2.3 Results

2.2.3.1 Acoustic and sediment particle size

Acoustic data, along with ground-truthing samples, from the South Falls dredged disposal site were collected to enable the characterisation of the site and identify the intensity of the disposal activity within the licensed area. Good quality multibeam data were collected using a Kongsberg EM2040 multibeam echo sounder on board the RV *Cefas Endeavour* between 1st and 5th November 2014. Due to time constraints, it was not possible to achieve acoustic data acquisition for the whole of the licensed area, the south-eastern section (south of the traffic separation scheme) was not surveyed. Bathymetric data were processed using CARIS HIPS and SIPS while backscatter mosaics were produced using QPS Fledermaus Geocoder Toolkit (FMGT) software.

Ground-truthing samples were collected to support the interpretation of the acoustic data and were collected using a 0.1 m^2 Hamon grab. A total of 14 stations (Figure A2.2.1) were sampled from the wider area with eight stations falling within the licensed disposal area covered by the acoustic data.

The acquired data revealed that the seabed is dominated by large sandwaves, with the crests running northwest to southeast, with wavelengths of between 150 m and 300 m (Figure A2.2.2). These large features are interspersed with mega-ripples with wavelengths between 10 m and 15 m which cover the large majority of the seabed within the site. The general bathymetry across the site deepens from

south to north with sandwaves present throughout. The largest sandwaves were identified in the southern shallower areas of the site (Figure A2.2.2).

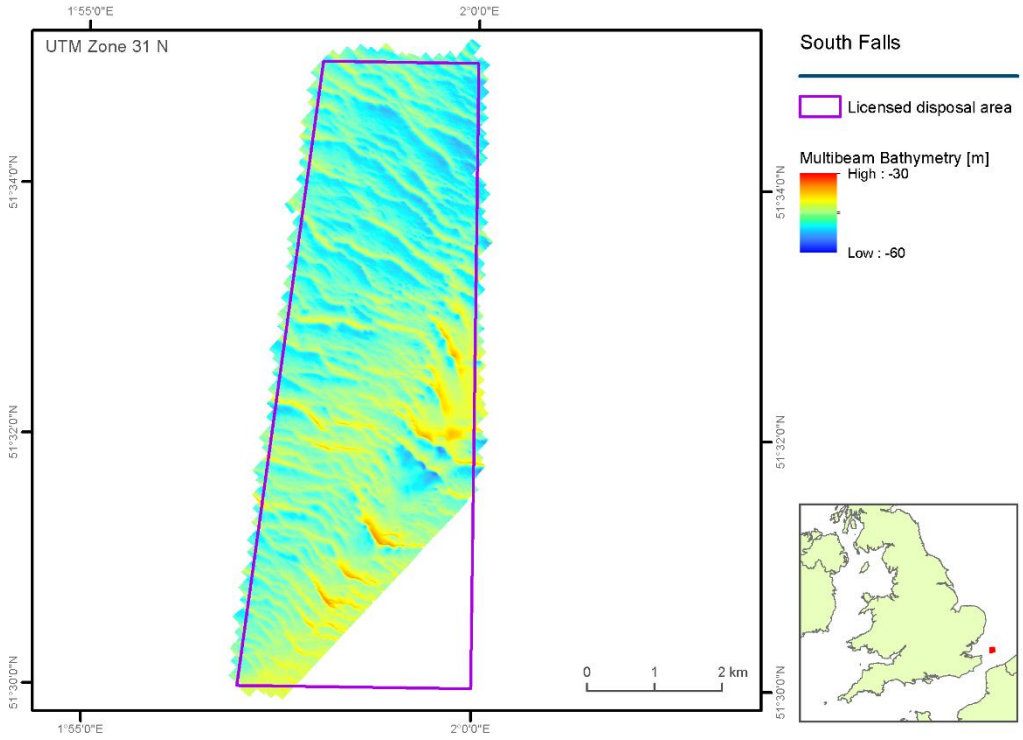


Figure A2.2.2. MBES bathymetry data acquired at South Falls, November 2014.

Backscatter returns were relatively varied across the site, with a seabed of medium intensity backscatter and patches of higher intensity (Figure A2.2.3). The east of the site was dominated by a large area of higher intensity backscatter which protruded into the centre of the site in a northeast to southwest direction. The mega-ripples identified from the bathymetry were clearly visible on the backscatter data with low reflectivity peaks and higher intensity troughs, indicating coarser material between the peaks of the ripples (Figure A2.2.3).

The patches of higher intensity backscatter were identified as the areas of deposits and are likely to contain a higher proportion of coarse material than the surrounding seabed. These patches generally followed a similar form and are indicative of the deposit and subsequent plumes of dredged material.

Results from the particle size analysis of the sediments sampled for ground-truthing indicate a seabed made up predominantly of sand, with varying but small proportions of gravel and mud (Figure A2.2.4). The ground-truthing samples corroborate the interpretation of the acoustic data with the low intensity backscatter seabed corresponding to the samples of 'slightly gravelly SAND' and the areas of higher intensity backscatter relating to samples with higher proportions of gravel.

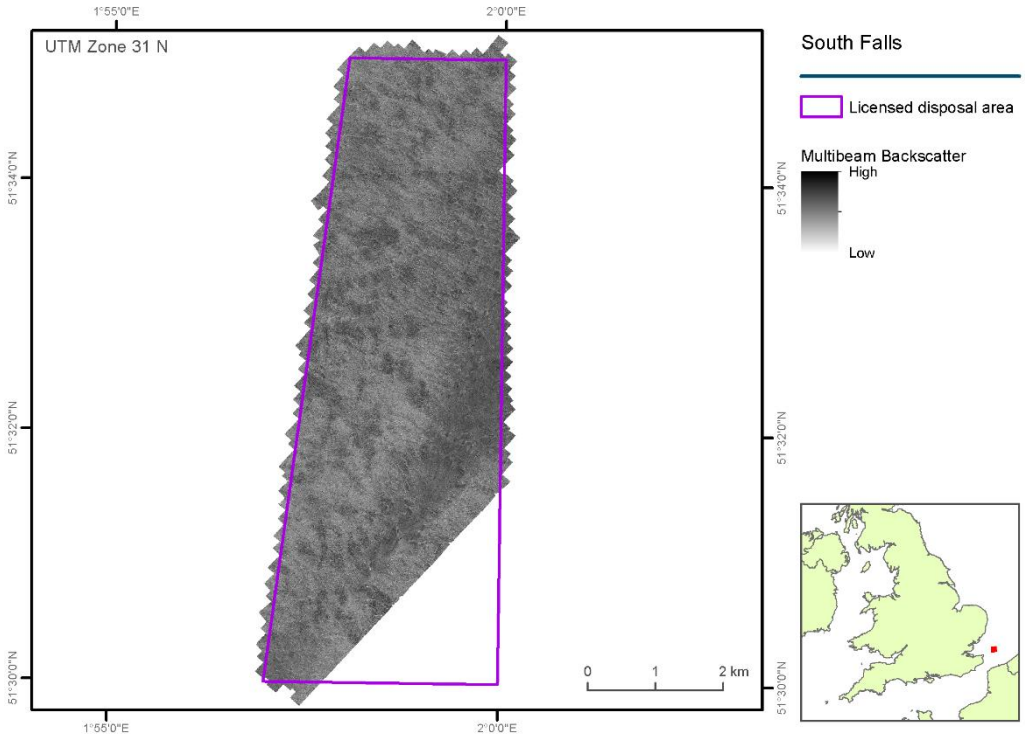


Figure A2.2.3. MBES backscatter data acquired at South Falls, November 2014.

Manual interpretation of the acoustic and ground-truthing data was carried out in ArcMap 10.1 to map the sediment boundaries and the intensity of the disposal activity. The majority of the seabed was classified as 'slightly gravelly SAND' with the patches of disposal material being classified as a mixture of 'gravelly SAND' and 'gravelly muddy SAND' (Figure A2.2.5). The area of higher backscatter in the eastern part of the disposal site, and protruding into the centre, was identified as 'gravelly SAND' and corresponded to the larger sand waves identified from the bathymetry data. Areas of disposal material may not have been identified in the area of 'gravelly SAND' due to the similarity in the backscatter intensities between the two sediment types.

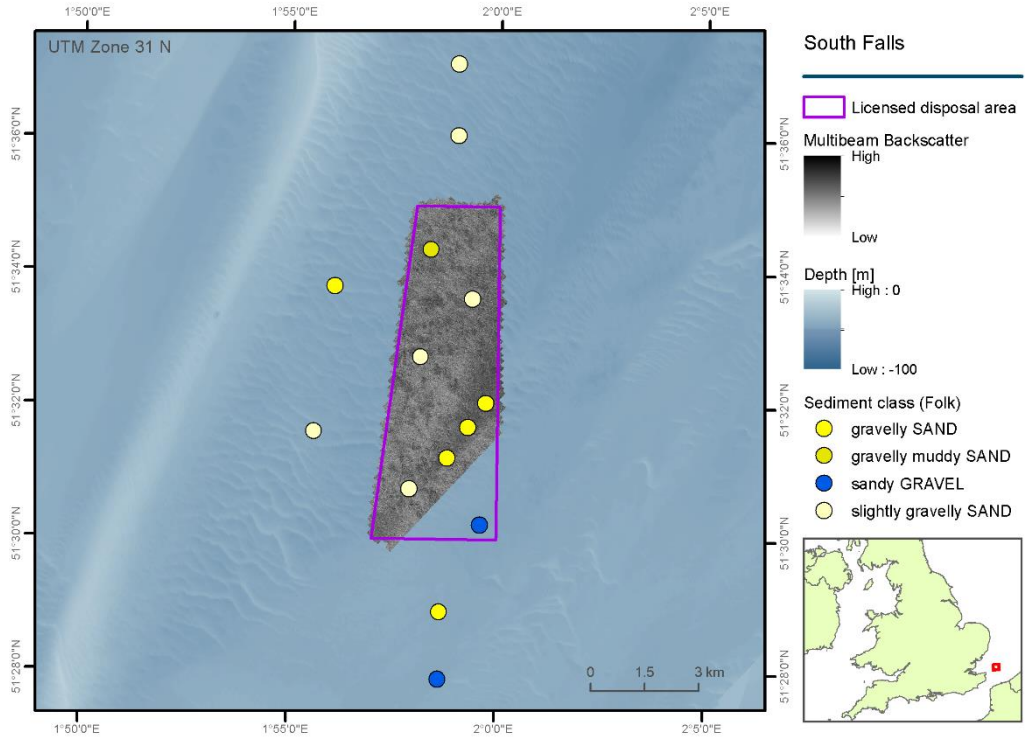


Figure A2.2.4. Sediment classes (Folk) of the ground-truthing stations sampled around the South Falls, November 2014.

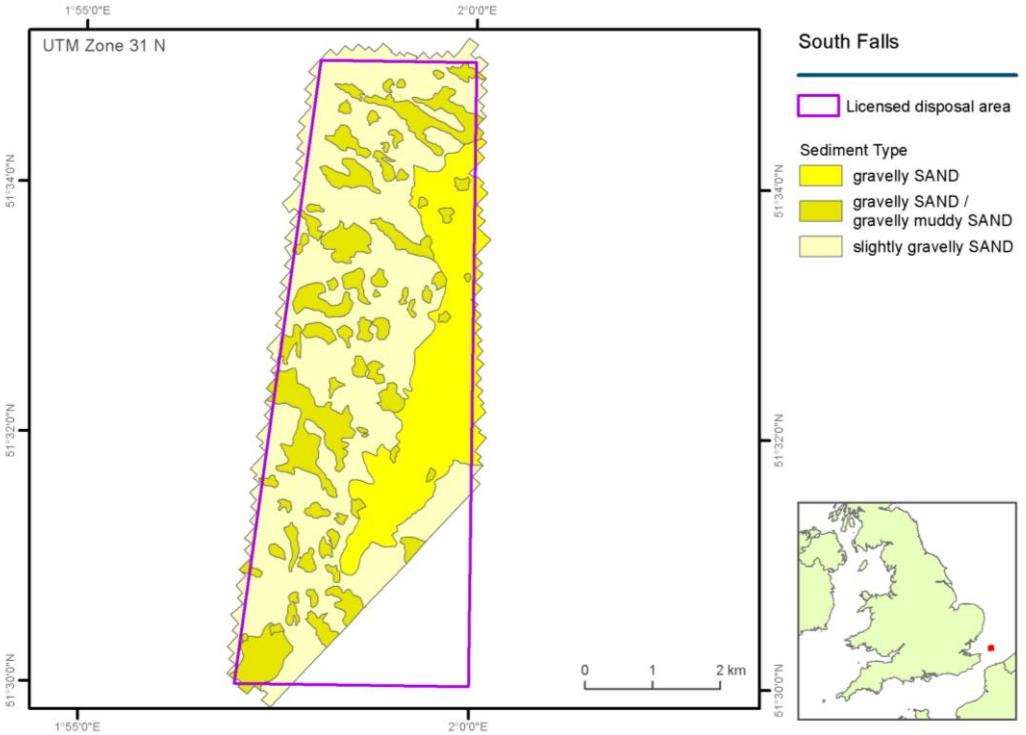


Figure A2.2.5. Classification of substrata at the South Falls disposal site, November 2014.

Disposal activity on the seabed was evident across the whole of the site. Activity was less evident in the areas of coarser sediment (i.e., the area of 'gravelly SAND'), however this may be as a result of the disposal material having a similar acoustic signature to that of the surrounding seabed. The intensity of disposal activity was mapped (Figure A2.2.6) to reveal that high intensity of disposal activity was evident across much of the site. Outside of these areas, smaller patches of disposal material were evident leading to a classification of moderate intensity disposal activity for the rest of the site.

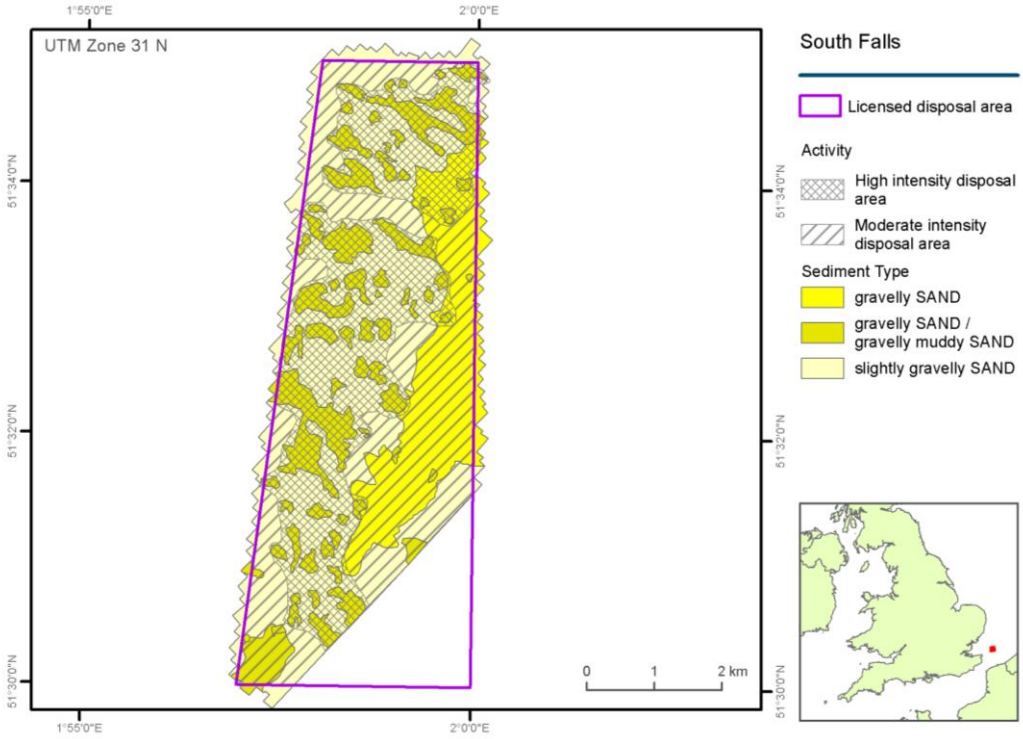


Figure A2.2.6. Relative intensity of disposal activity at the South Falls disposal site, November 2014.

2.3 Nab Tower

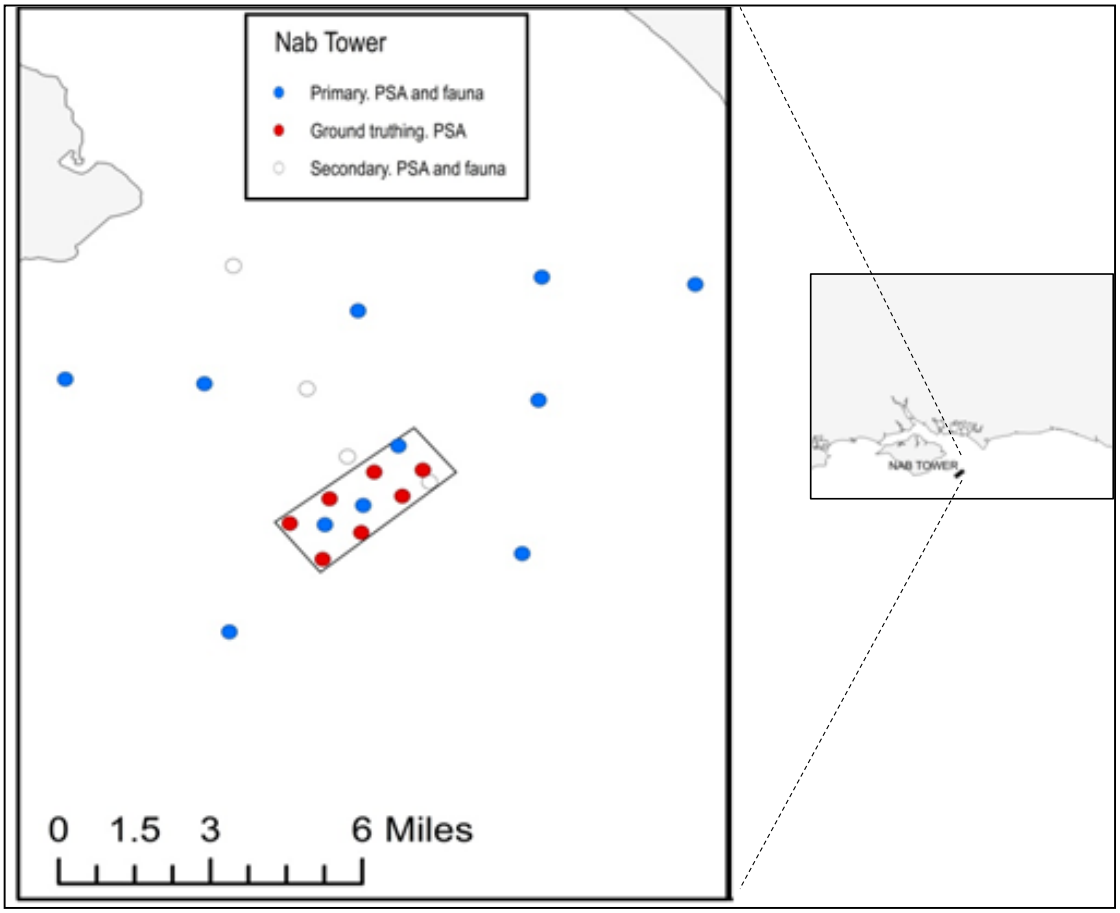


Figure A2.3.1. Location of Nab Tower disposal site, English Channel and the stations sampled under SLAB5, November 2014.

2.3.1 Background

Nab Tower is an open and active disposal site approximately 13 km southwest of Bembridge, Isle of Wight (Figure A2.3.1) with a depth of approximately 30 – 40 m. It is used as the main site for disposal of both maintenance and capital material from ports, harbours, berths and navigational channels in Southampton, Portsmouth and the Isle of Wight. Between 1990 and 2010, over 28 million tonnes of material have been disposed of at the site. The disposal of maintenance dredged material is usually in the range of 500,000 to 750,000 tonnes per annum, however, there have been annual peaks over 1 million tonnes in 1999, 2001 and 2004. The largest capital campaigns were in 1995 and 1996 when 5.3 million and 6.3 million tonnes (respectively) were disposed to Nab Tower.

Recently, there have been two applications for larger scale capital disposals to Nab Tower. The first from the Cowes Outer Harbour Development Project which resulted in 241,000 tonnes of capital material dredged disposed to the site over a 15 to 20 week period. Secondly, the Southampton

Approach Channel Deepening project is expected to create over 16 million tonnes of material over approximately 16 months, all of which would be destined for Nab Tower. It is also expected that a similar deepening project will be proposed for Portsmouth HMNB in the next couple of years resulting in a disposal of approximately 6.3 million tonnes.

Monitoring under the auspices of SLAB5 at Nab Tower during 2014 focused on the acquisition of multibeam acoustic bathymetry and backscatter data, together with sediment samples for ground-truthing of the acoustic data. These data will be used as a contemporary assessment of the physical nature of the seabed within the site resulting from this increased disposal activity. Previous monitoring at Nab Tower under SLAB5, which focussed solely on acoustic data acquisition, was conducted in 2011 (Bolam et al., 2012b), and the data obtained provide a suitable reference to which compare the data acquired in 2014.

2.3.2 Parameters monitored

Acoustics and sediment particle size

Macrofauna (not processed)

2.3.3 Results

2.3.3.1 Acoustics and sediment particle size

Nab Tower dredge disposal licensed area was monitored under the auspices of SLAB5 during November 2014 by *RV Cefas Endeavour*. The survey acquired acoustic and ground-truthing data to enable characterisation of sediments and disposal activities relating to license conditions within the site. Multibeam echosounder (MBES) data were acquired using a Kongsberg EM2040 system. MBES bathymetry data were processed using *CARIS HIPS* and *SIPS v9.08* to produce a cleaned bathymetric surface corrected to Chart Datum. MBES backscatter data were processed using *QPS Fledermaus Geocoder ToolBox v7.4.3* to produce a cleaned backscatter mosaic. Maps were then produced using *ArcGIS v10.1*. Ground-truthing samples were collected using a 0.1 m^2 Hamon grab from both within and without the licensed area (Figure A2.3.1). These were sub-sampled for particle size analysis (PSA) before being sieved over 5 mm and 1 mm mesh sieves. Fauna retained on the sieves were fixed in 4% Formalin solution for taxonomic analysis (samples retained for processing in due course).

MBES bathymetry data illustrate a series of shallow, branching channels through the centre of the site with a rapidly shoaling ridge to the west and sediment wave features along the southern boundary (Figure A2.3.2). A series of pockmark features were also observed (Figure A2.3.2), these are most evident in the northwest part of the disposal site becoming less numerous but more discrete towards the south east of the licensed area (Figure A2.3.2).

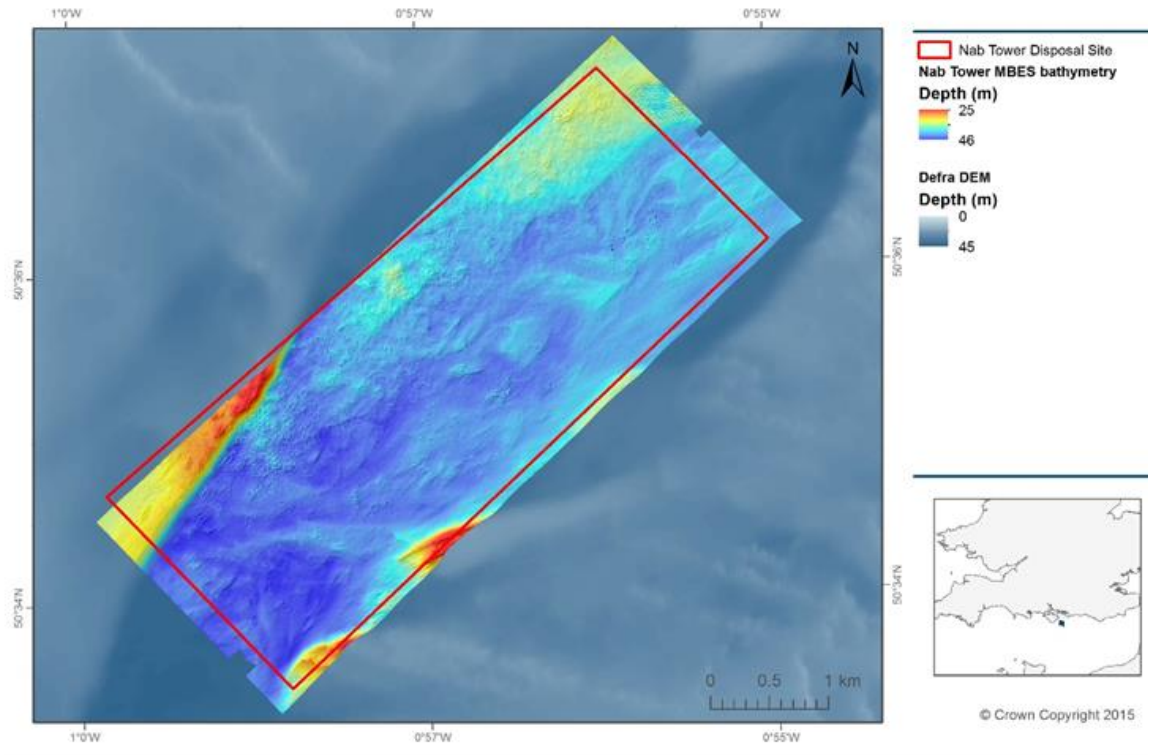


Figure A2.3.2. MBES bathymetry data acquired at Nab Tower licensed area, November 2014.

MBES backscatter data illustrate a matrix of high and low intensity areas within the licensed area suggesting a range of hard and soft sediments in the site (Figure A2.3.3). Linear patterns orientated SWW-NEE are evident, indicating sediment transport across the site, suggesting relatively high tidal activity. No obvious relationship with backscatter intensity and the pockmark features was observed (Figure A2.3.3).

Particle size data of the sediments sampled for ground-truthing illustrate that, in general, finer sediments occur within the licensed area (Figure A2.3.4). The site is dominated by muddy gravelly sand with occasional gravelly muddy sand and muddy sandy gravel samples (Figure A2.3.4). Outside of the licensed area, muddy sandy gravel and sandy gravel are the dominant sediments with occasional muddy gravelly sand and gravelly sand (Figure A2.3.4).

Following comparison of the particle size data with the acoustic returns using *ArcGIS v10.1*, the backscatter data were classified into three ranges to enable manual delineation of substrata. Backscatter values above -18 dB were used to delineate muddy sandy gravel. Values between -21 and -18 dB were used to delineate gravelly muddy sand and values below -21 dB were used to delineate muddy gravelly sand (Figure A2.3.5). These values were used as guides and not absolute limits of substrata distribution with expert judgement used to review backscatter against particle size data throughout the interpretation.

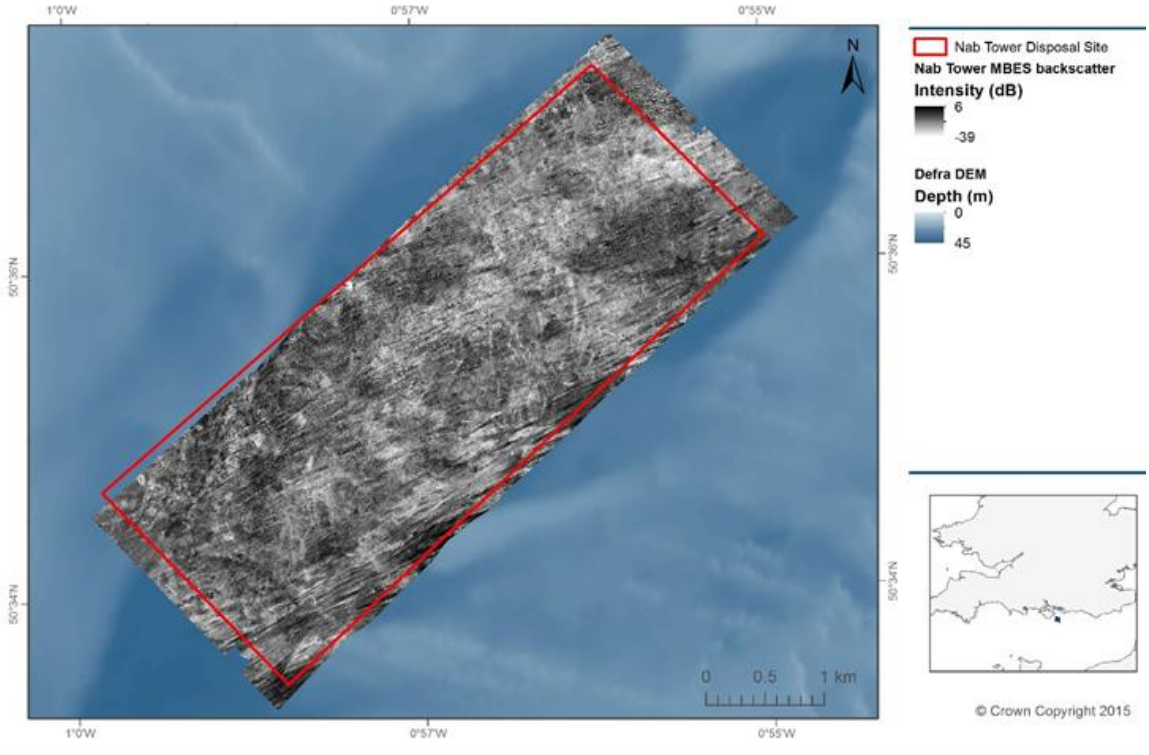


Figure A2.3.3. MBES backscatter data acquired at NabTower licensed area, November 2014.

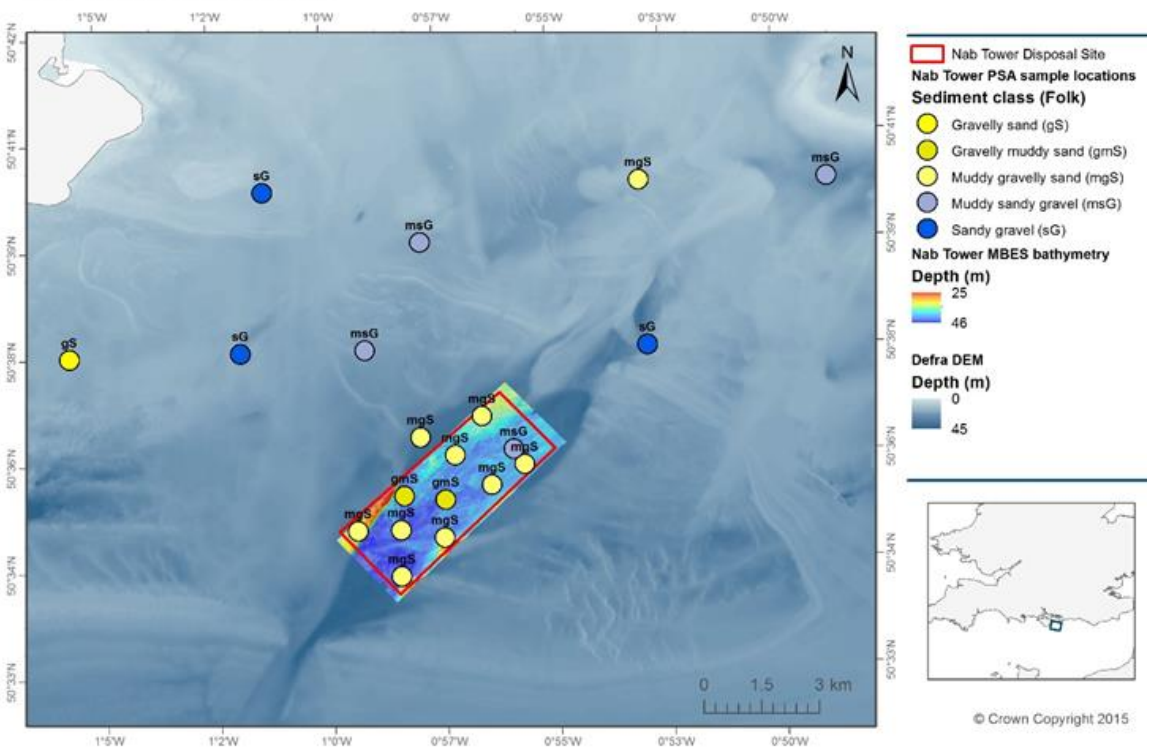


Figure A2.3.4. Sediment types (Folk classes) of the ground-truth sample stations around Nab Tower disposal site, November 2014.

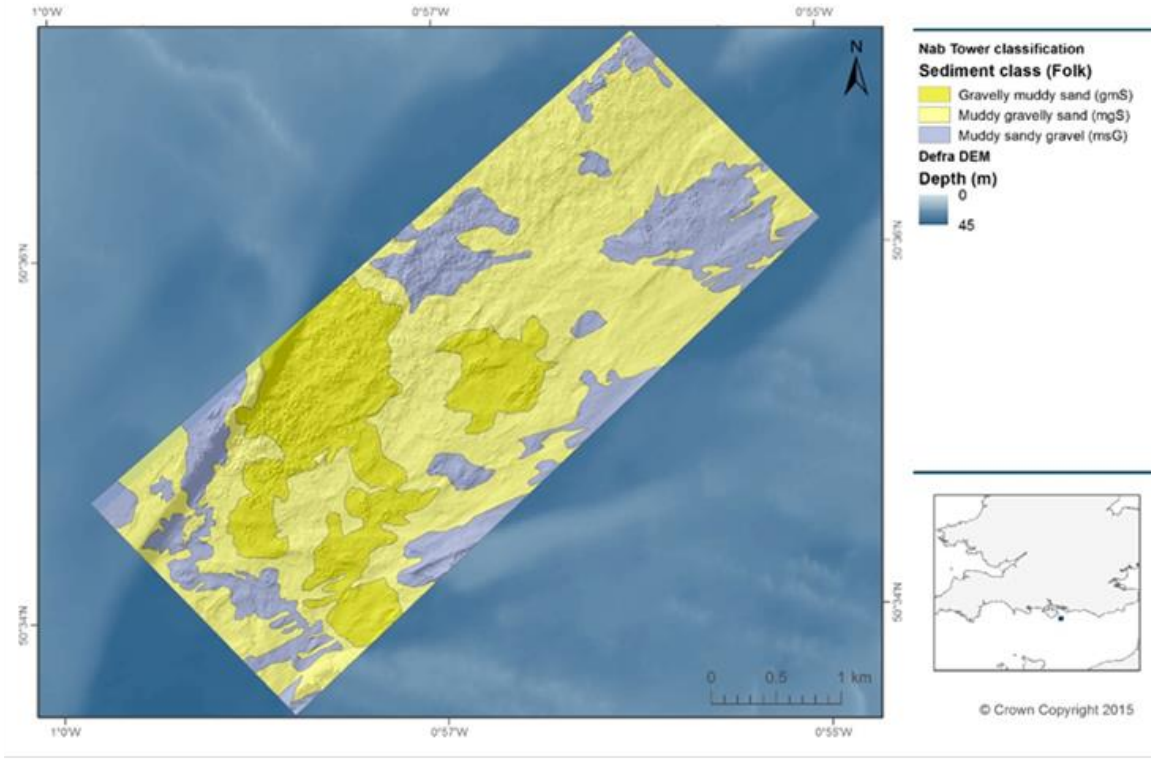


Figure A2.3.5. Classification of substrata at Nab Tower disposal site, November 2014.

An interpretation of relative disposal intensity was carried out for the Nab Tower site. Following the assumption that the pockmark features observed in acoustic data are directly related to disposal activity and not a natural occurrence, regions were delineated based upon the structure and number of features observed (Figure A2.3.6). Regions of high intensity were delineated where pockmarks were most numerous and structurally distinct. Regions of moderate intensity were delineated where features were more sparsely distributed and less morphologically defined. Low intensity regions were delineated where very little or no evidence of pockmark features was observed (Figure A2.3.6). Towards the north east of the site, aggregate extraction scars were also observed (Figure A2.3.6). This approach revealed that disposal activity, as observed on the seabed, was discernible throughout the majority of the disposal site (Figure A2.3.6). A gradient in disposal activity could, however, be defined, with the NNW section receiving the most intense activity, the mid-centre region of the site receiving moderate activity, and the SSE region of the site appearing as an area of low or no disposal activity. Isolated patches of high disposal activity were, however, evident in the latter region. Finally, as no acoustic data were acquired beyond the limits of the disposal site licensed area, we cannot indicate whether disposed material is present outside of the disposal site.

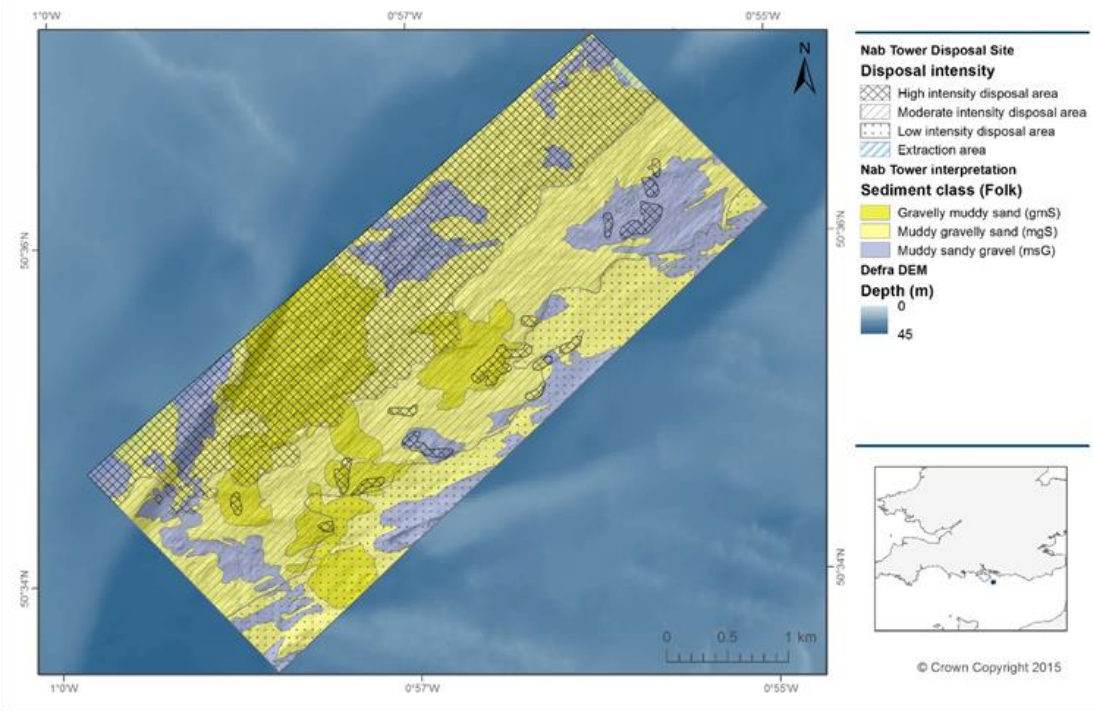


Figure A2.3.6. Relative intensity of disposal activity at Nab Tower licensed area, November 2014.

2.4 Rame Head South (PL031)

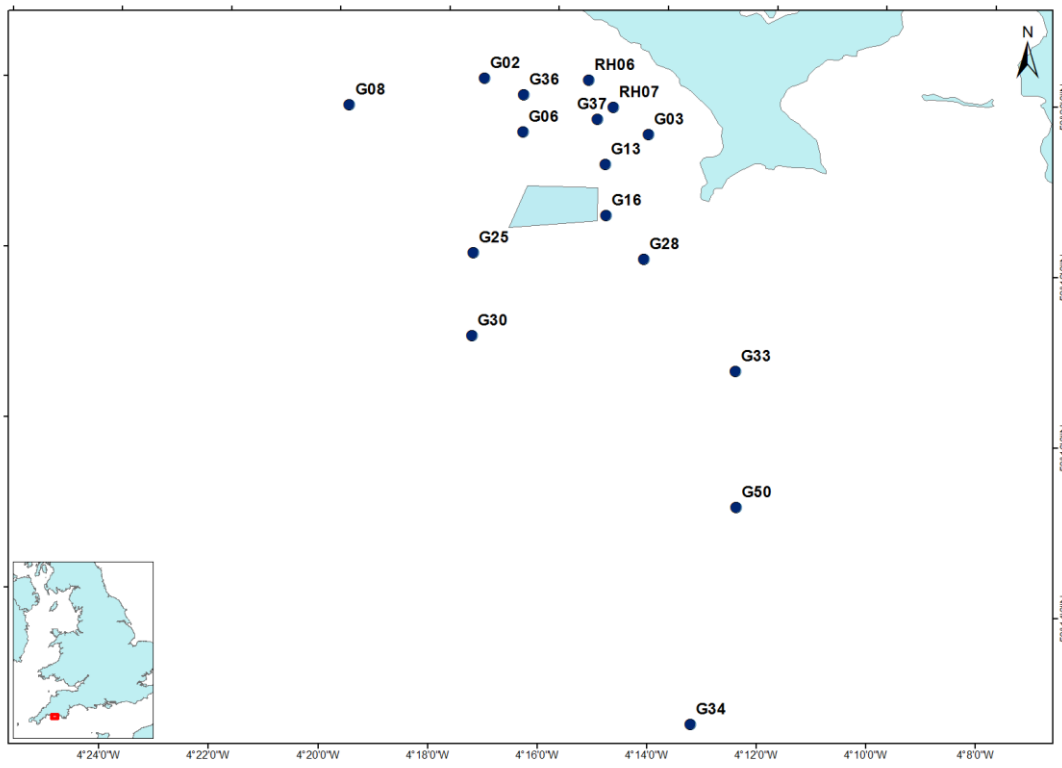


Figure A2.4.1. Location of stations sampled at Rame Head South, July 2014.

2.4.1 Background

Rame Head South is an open and active disposal site with a depth of 18 – 38 m. The site, located approximately 2 km west of Rame Head and 6 km west of the entrance to Plymouth Sound, is used for dredged material disposal mostly during the winter months. The site has been used for almost 100 years although during the early part of this period it was primarily used for munitions disposal. Dredged material disposed originates from the ports, harbours, berths and navigation channels in and alongside the rivers Tamar and Plym and the Sound, with principle locations being Devonport Dockyard and associated Ministry of Defence (MoD) areas. The site, thus, receives material from a variety of sources. Between 1976 and 2005, over 5 million tonnes of material was disposed of, being composed typically of sandy mud, with > 70 % silt/clay fraction.

Over the last 30 years, the amount of material being disposed of at this disposal site has slowly decreased with exception of two peaks in 1986 and 2001. The 2001 disposal activity was subject to specific licence conditions requiring the licence holder to take all reasonable precautions to remove anthropogenic debris from the material.

The coastal region within which the disposal site is located is important for a wide range of stakeholders including those associated with diving, fisheries and shellfisheries. There are also a large number of sewage and storm-water discharges in the locality. There has been a large public and media interest regarding the impacts associated with dredged material disposal at Rame Head South: concerns have primarily been based around the potential of the disposed material as a source of contamination at Polhawn Cove and of turbidity around the dive sites (e.g., HMS *Scylla*) in Whitsand Bay. A large amount of litter being found along the intertidal areas of the disposal site has also been alleged to have been derived from the disposal activity.

Rame Head South, partly in response to the relatively high level of public interest regarding impacts associated with disposal activity to it, has been the recipient of monitoring under SLAB5 from 2000 onwards. In January 2011, the MMO published a report (Elliott and Mazik, 2011) documenting the results of an independent review regarding the ecological impacts associated with the disposal activity at Rame Head South, including an appraisal of the monitoring work that has been undertaken under SLAB5. One recommendation of the Elliott and Mazik (2011) report was that if placements were located in the slightly deeper water off the southeast boundary of the disposal site, the potential for subsequent sediment movement would be reduced. In response to this, in July 2011 Cefas acquired acoustic data in this proposed extension area to allow an assessment of the physical characteristics of that region (Bolam et al., 2012).

Monitoring undertaken during 2014 under SLAB5 focussed on determining the concentrations of sediment contaminants at a number of stations which have previously been monitored, to allow an assessment regarding any indication of temporal change. As previous monitoring has demonstrated that sediment tri-butyl tin (or TBT) in this area is very low (below LOD for most sampling stations; Bolam et al., 2010), this compound was not included in the suite of contaminants measured in 2014.

2.4.2 Parameters monitored: Sediment particle size
Sediment organic carbon
Sediment contaminants (PAHs, organohalogens, trace metals)

2.4.3 Results

2.4.3.1 Sediment particle size

The sediments in the vicinity of the Rame Head South disposal site are predominantly muddy sands and unimodal sands, with some gravelly sands, gravelly muddy sands and muddy sandy gravels (Table A2.4.1). The temporal data revealed that very few of the 16 stations sampled in 2014 have shown any change regarding their sediment groups (Table A2.4.2). At G33, south of the disposal site, there was a significant increase in silt/clay in 2014 (to RaH1). In contrast, the increase in silt/clay content that was

observed in 2009 for G08 and G30 (both RaH2) no longer appears to be present, the sediments of both stations in 2014 are classed according to groups more in line with those prior to 2009 (i.e. RaH4 and RaH5 for G08 and G30 respectively; Table A2.4.2). The sediment at G13 is less gravelly in 2014 compared to that observed during 2008 and 2009 (Table A2.4.2).

Table A2.4.1 Average sediment descriptions (top) and statistics (bottom) for each sediment group at Rame Head South.

Sediment group	Number of samples	Sample Type	Sediment description
RaH1	48	Bimodal, Very Poorly Sorted	Slightly Gravelly Muddy Sand
RaH2	27	Polymodal, Very Poorly Sorted	Gravelly Muddy Sand
RaH3	10	Polymodal, Very Poorly Sorted	Muddy Sandy Gravel
RaH4	22	Unimodal, Poorly Sorted	Gravelly Sand
RaH5a	23	Unimodal, Poorly Sorted	Slightly Gravelly Sand
RaH5b	40	Unimodal, Moderately Well Sorted	Slightly Gravelly Sand

Sediment group	Gravel (%)	Sand (%)	Silt/clay (%)	Very coarse sand (%)	Coarse sand (%)	Medium sand (%)	Fine sand (%)	Very fine sand (%)
RaH1	2.38	57.95	39.67	1.28	2.92	4.09	10.04	39.63
RaH2	19.50	63.16	17.34	7.94	11.93	11.48	14.72	17.09
RaH3	60.56	27.57	11.87	7.72	6.44	4.22	4.58	4.61
RaH4	29.81	67.08	3.11	29.84	25.52	8.20	2.46	1.07
RaH5a	0.93	93.40	5.67	1.74	11.37	38.70	34.37	7.22
RaH5b	0.37	97.40	2.23	0.77	2.66	11.30	64.55	18.12

Table A2.4.2 Sediment groups for each station sampled between 2001 and 2014 inclusive at Rame Head South.

Sample code	2001	2002	2003	2005	2006	2007	2008	2009	2014
G02	RaH1	RaH1	RaH2	n	n	RaH1	RaH1	RaH1	RaH1
G03	n	RaH5b	RaH5b	n	RaH5b	RaH5b	RaH5b	RaH5b	RaH5b
G06	n	n	n	n	RaH1	RaH1	RaH1	RaH2	RaH1
G08	n	RaH4	RaH2	RaH4	RaH4	RaH4	RaH4	RaH2	RaH4
G13	n	RaH4	RaH3	RaH5a	RaH4	RaH3	RaH4	RaH4	RaH5a
G16	RaH5a	RaH3	RaH4	n	RaH3	n	n	n	RaH1
G25	n	RaH1	RaH1	n	RaH1	n	RaH1	RaH1	RaH1
G28	n	RaH1	RaH2	RaH1	RaH1	RaH2	RaH1	RaH1	RaH1
G30	n	n	n	n	n	RaH5a	RaH5a	RaH2	RaH5b
G33	n	RaH2	RaH2	RaH2	RaH2	RaH2	RaH2	RaH2	RaH1
G34a	n	n	n	RaH5a	RaH5a	RaH5a	RaH5a	RaH5a	RaH5a
G36	n	n	RaH1	n	n	RaH1	RaH1	RaH1	RaH1
G37	n	n	RaH5b	n	RaH2	RaH1	RaH5b	RaH5b	RaH5b
G50	n	n	n	n	n	RaH2	RaH5a	RaH5a	RaH5b
RH06	n	n	RaH5b	RaH5b	n	RaH5b	RaH5b	RaH5b	RaH5b
RH07	n	n	RaH5b	RaH5a	n	RaH4	RaH5b	RaH5b	RaH5b

The spatial variation in the proportional representation of gravel, sand and silt/clay for each sampling station in 2014 is shown in Figure A2.4.2 and the percentages of silt/clay content in Figure A2.4.3. The high gravel content of RaH4 (at G08, to the west) and the high silt/clay components of the stations classed as RaH1 (e.g. G2, G25, G33) are visually discernible.

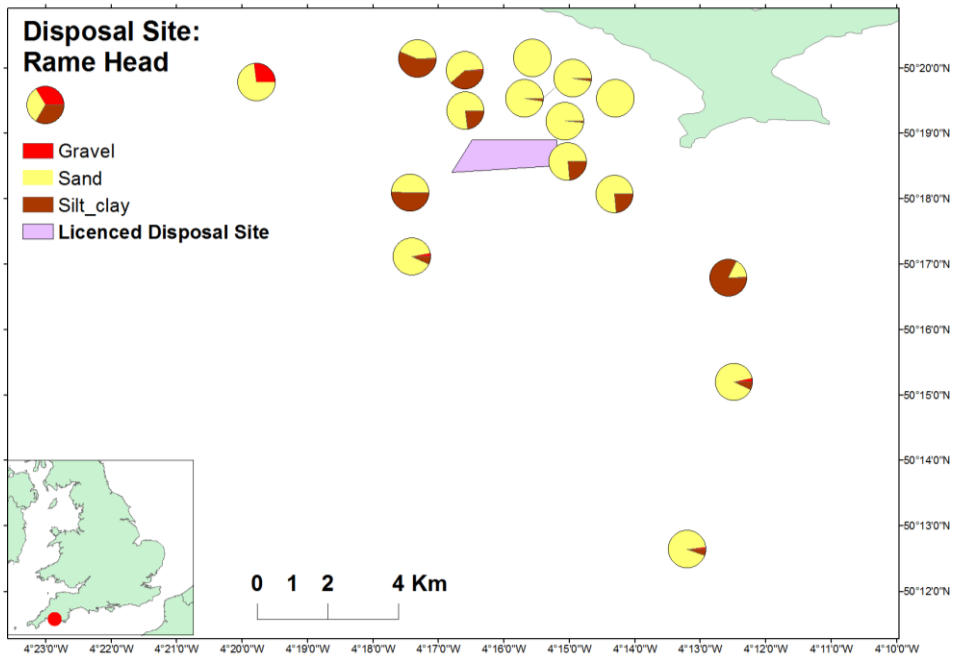


Figure A2.4.2. Pie charts of gravel, sand and silt/clay at Rame Head South in 2014.

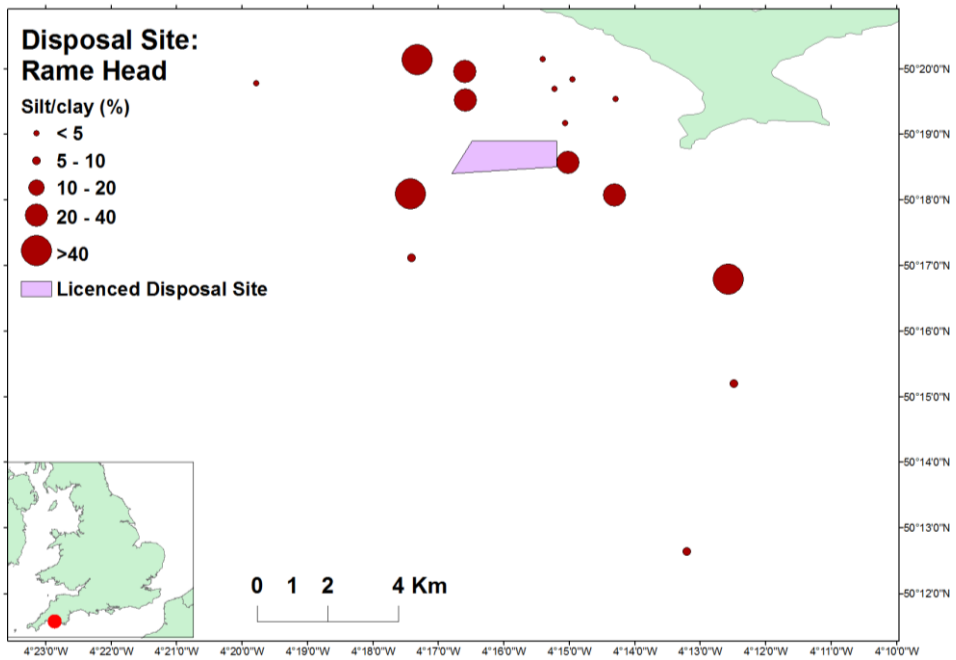


Figure A2.4.3. Silt/clay content (%) of sediments sampled at Rame Head South in 2014.

2.4.3.2 Sediment organic carbon

Organic carbon values (in the <63µm sediment fraction) of the sediments sampled at Rame Head South in 2014 range from 1.54 to 3.23% (Figure A2.4.4). G03, G08, G13, G37, RH06 and RH07 all displayed low silt/clay content (<3 % silt/clay; Figure A2.4.3) which prevented the opportunity to measure the organic carbon for these stations. Organic carbon values (in the <2mm sediment fraction) range from 0.18 to 1.65 % (Figure A2.4.5). These concentrations are similar to those observed in previous years at Rame Head South (Bolam et al., 2009; 2011a).

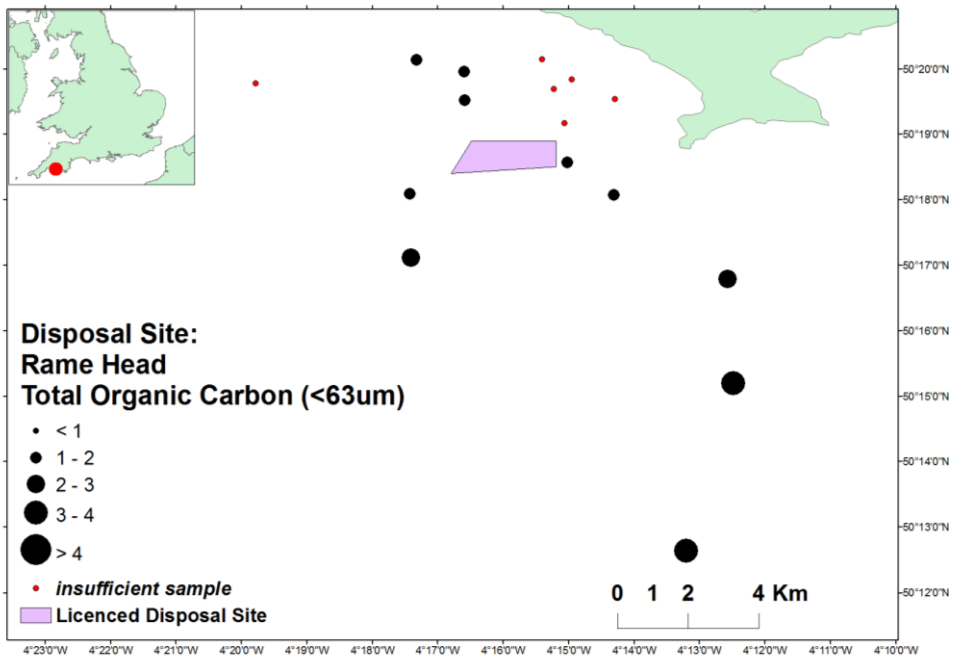


Figure A2.4.4. Organic carbon (%) in the silt/clay fraction (<63µm) at Rame Head South in 2014.

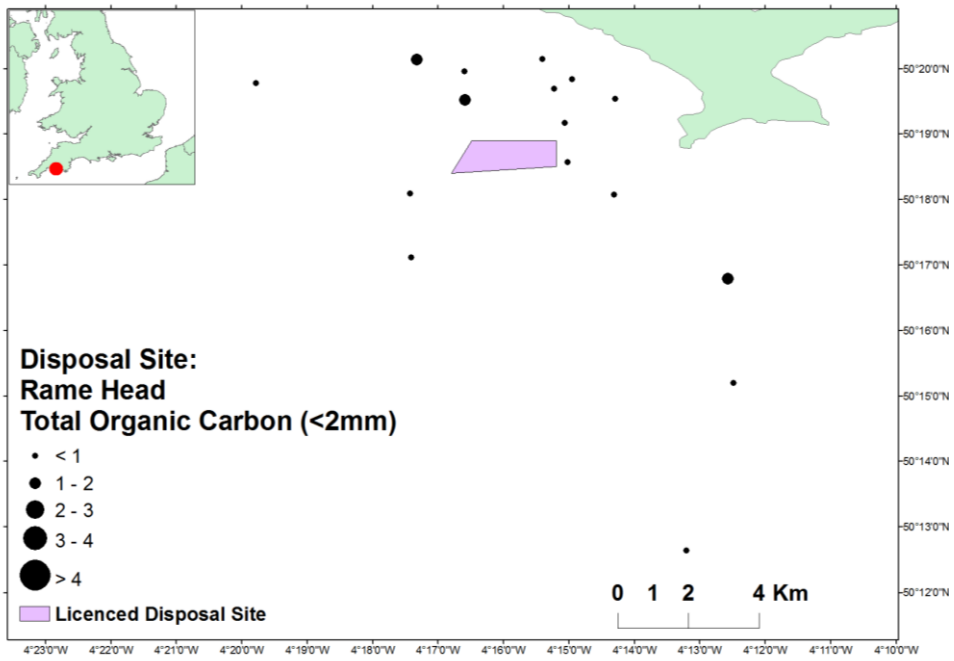


Figure A2.4.5. Organic carbon (%) in the <2mm fraction at Rame Head South in 2014.

2.4.3.3 Sediment contaminants

2.4.3.3.1 PAHs

The highest summed PAH concentration in 2014 was at G28 (4,230 µg kg^{-1} dry weight), approximately 1.5 km southeast from the edge of the disposal site (Figure A2.4.6). The second highest concentration in 2014 was at G6 (3,550 µg kg^{-1} dry weight), located at approximately 1.5 km to the north of the disposal site. In 2009, when Rame Head South was last sampled under the auspices of SLAB5 for sediment contaminants, the highest concentration then was similarly observed at G6 with a summed PAH concentration of 5,940 µg kg^{-1} dry weight and the second highest being at G28 (4,250 µg kg^{-1} dry weight). In this respect, the 2014 data for Rame Head South are, therefore, generally comparable with those obtained in 2009.

Summed PAH concentrations of 2,920 µg kg^{-1} and 2,700 µg kg^{-1} dry weight were found respectively at RH06, 2 km north of the disposable site, and G3, 1.5 km to the northeast towards the intertidal area (Figure A2.4.6). The lowest summed PAH concentration (40 µg kg^{-1} dry weight) was observed at G8, approximately 4.3 km to the northwest of the disposal site (Figure A2.4.6). This compares with the previous sampling data from 2009 at this sampling station which measured 65 µg kg^{-1} dry weight. This result is consistent with previous years; this lower concentration is directly comparable with those found in deeper offshore sites at G34 and G50 where concentrations <100 µg kg^{-1} dry weight are observed (Figure A2.4.6 and A2.4.7).

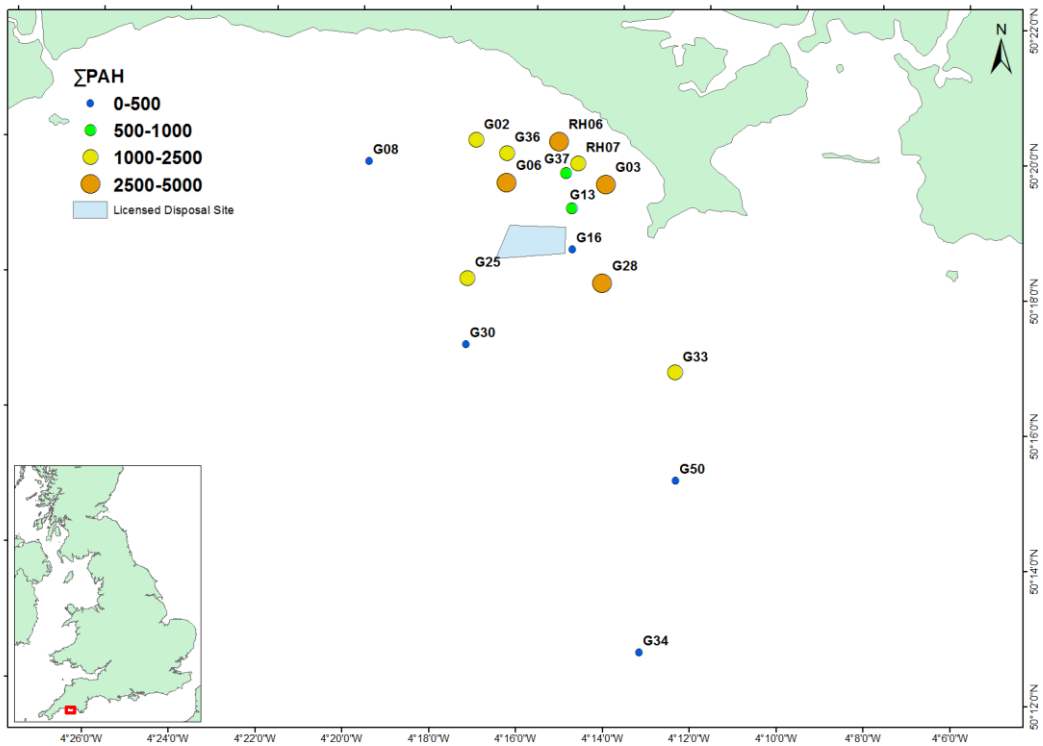


Figure A2.4.6 . Summed PAH concentrations (µg kg^{-1} dry weight) for stations sampled at Rame Head South in 2014.

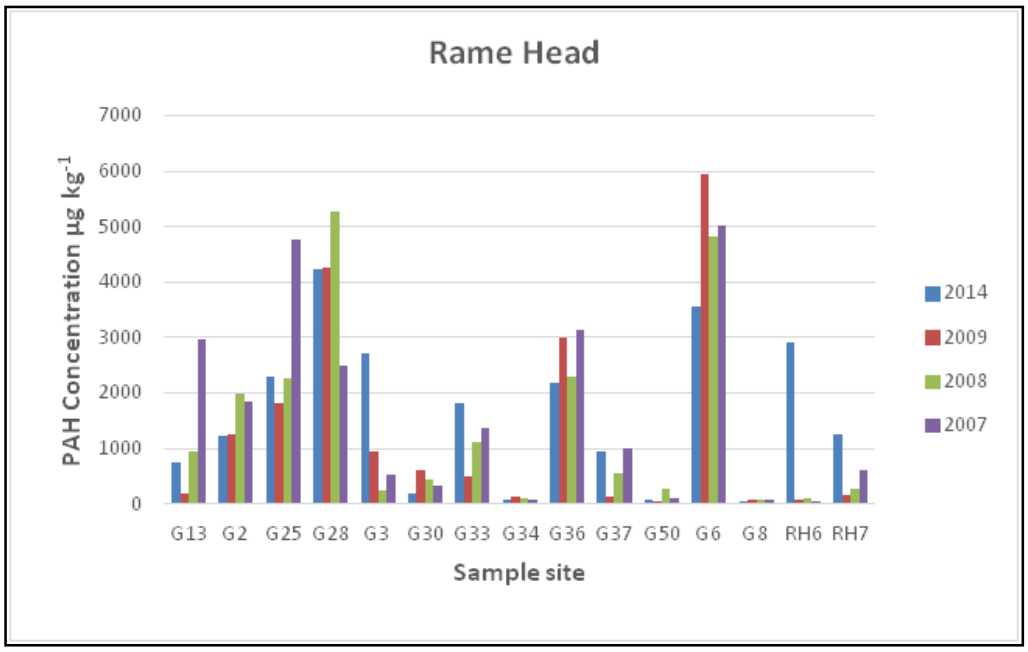


Figure A2.4.7. Temporal trends in summed PAH concentrations (µg kg^{-1} dry weight) for stations sampled at Rame Head South, 2007-2014.

No sediment samples collected in this survey in 2014 exceeded the ERL or ERM for low molecular weight (LMW) and high molecular weight (HMW) PAHs. Additionally, further evaluation of the PAH data indicated that the source in all the sediment samples were of mixed sources, generally with approximately 60% of the PAH content arising from combustion sources and approximately 40% of the PAH content arising from oil sources.

Summed PAH values found at Rame Head South between 2007 and 2014 have never exceeded 6,000 µg kg^{-1}, and concentrations are often observed to be as low as background levels, e.g. 40 µg kg^{-1}, at some stations. These levels are low compared to those found at other disposal sites around UK waters, with concentrations one order of magnitude greater than those of Rame Head South found off northeast sites such as North Tyne, and two orders of magnitude greater being observed off the Tees disposal sites (e.g. Bolam et al., 2015).

2.4.3.3.2 Organohalogens

At Rame Head South, ∑ICES7 CBs concentrations range from <0.7 to 4.6 µg/kg DW. A total of seven of the 16 stations had ∑ICES 7 CB concentrations below LODs (i.e. 0.7 µg/kg DW); these stations are those to the northwest of the disposal site and to the extreme south of the sampling area (Figure A2.4.8). The highest ∑ICES 7 CB concentration, 4.6 µg/kg DW, was measured at G28 to the southeast of the disposal site, while G33, further along the main dispersion axis from the disposal site, displayed a moderate ∑ICES 7 CB concentration of 2.2 µg/kg DW. The three stations to the northwest of the

disposal site; G6, G2 and G36, similarly exhibited moderate ∑ICES 7 CB concentrations (2.5, 1.8 and 1.6 µg/kg DW, respectively).

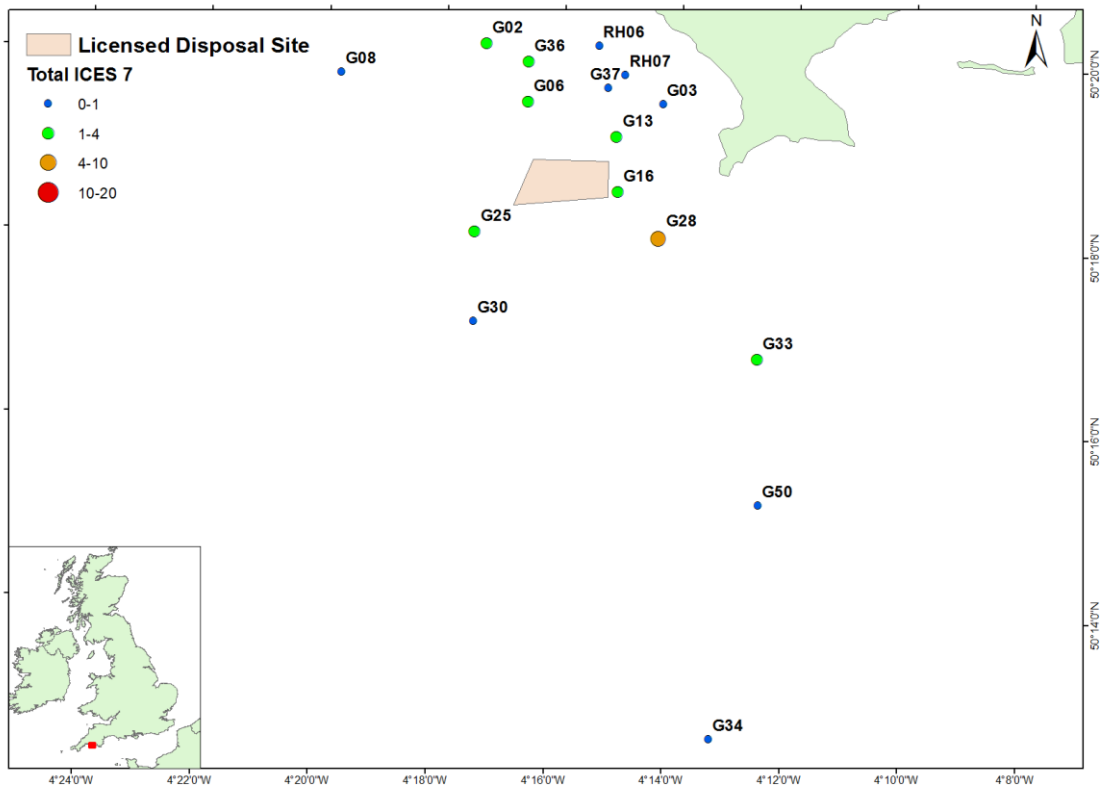


Figure A2.4.8. Summed ICES7 CB concentrations (µg/kg DW) for the Rame Head South stations, 2014. Limit of detection (LOD) concentration is 0.7 µg/kg DW.

BDE concentrations at Rame Head South are low, generally at or below limits of detection (∑11 BDEs range <0.11-0.40 µg/kg DW; Figure A2.4.9). The three stations to the northwest of the disposal site (G36, G2 and G6) had the highest ∑11 BDEs concentrations of 0.40, 0.36 and 0.23 µg/kg DW, respectively, although these can also be considered to be low.

BDE209 was detected at 15 of the 16 stations (the exception was RH06) and was at higher concentrations than the other measured organohalogens (range <0.1-8.9 µg/kg DW). The highest concentration, 8.9 µg/kg DW, was found at G25 to the southwest of the disposal site, with 6.2, 2.7 and 2.3 µg/kg DW measured at G33, G50 and G28, respectively (Figure A2.4.10). The three stations to the northwest of the disposal site, G6, G2 and G36, possessed moderately high BDE209 concentrations of 4.0, 3.5 and 2.2 µg/kg DW, respectively. Akin to the situation observed for ICES7 CBs, the inshore stations to the northeast of the disposal area displayed the lowest BDE209 concentrations.

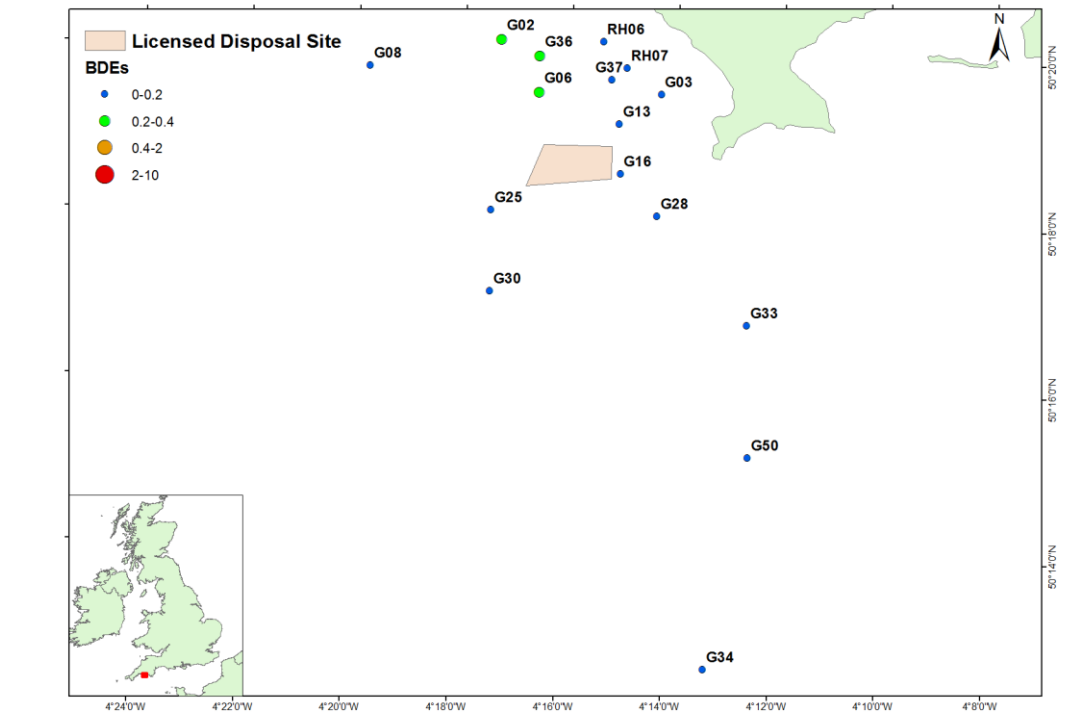


Figure A2.4.9. Summed 11 BDEs concentrations (µg/kg DW) for the Rame Head South stations, 2014. Limit of detection is 0.11 µg/kg DW.

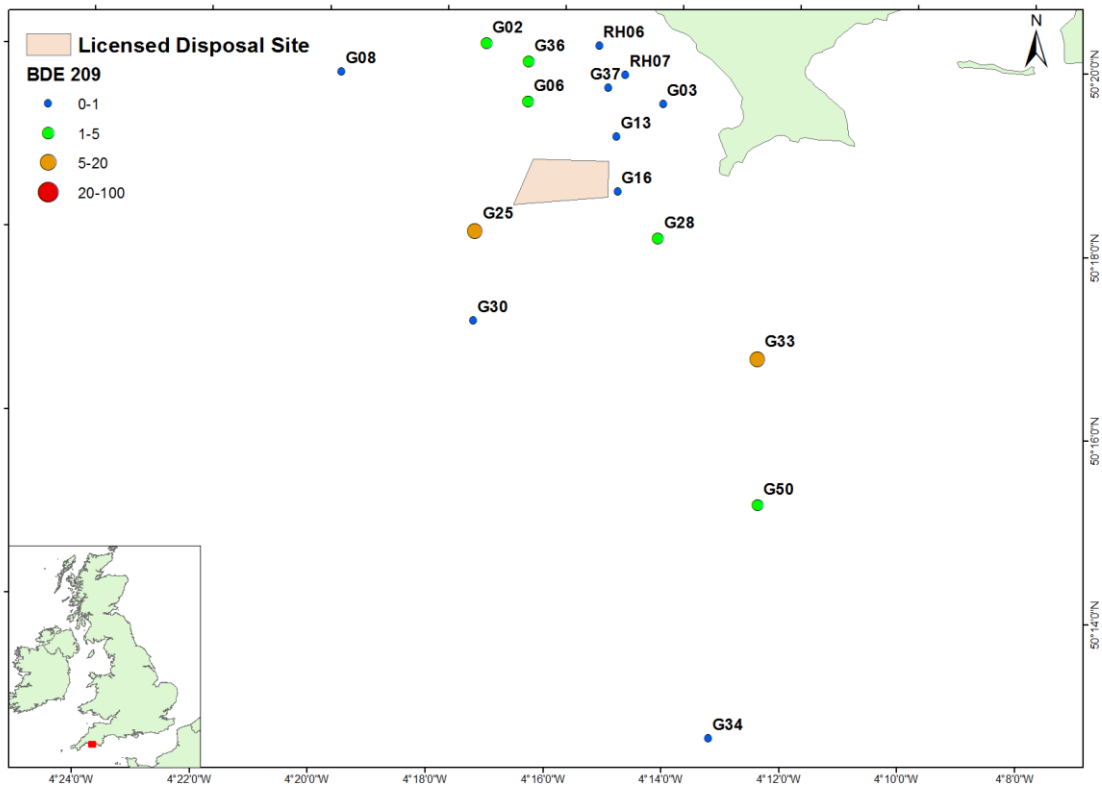


Figure A2.4.10. BDE209 concentrations (µg/kg DW) for the Rame Head South stations, 2014.

Concentrations of CBs at all stations were below Cefas action level 1. No Cefas action levels exist for BDEs and BDE209. According to the OSPAR guidelines, stations G3, G34, G37, G50, G8, G30, RH6 and RH7 had 'good' environmental status for all ICES 7 CBs, and 'good' status overall. Stations G25, G33, G2, G36 and G6 had 'bad' environmental status for CB118, but 'good' status overall. The exceptions were stations G28 and G16 which had 'bad' environmental status for CB118 and CB101, and therefore 'bad' status overall. These findings are similar to the results obtained when Rame Head South samples were last analysed in 2009 (Bolam et al., 2011). No OSPAR guidelines exist for BDEs at present.

The temporal data regarding contaminant concentrations at Rame Head South suggest that ∑ICES7 CB concentrations were lower in most stations in 2014 than they were in 2009 (Table A2.4.3). The exceptions were G2, G13 and G50, although levels at these stations were within the range or close to concentrations previously obtained.

Table A2.4.3. Temporal trends (2002-2014) of ∑ICES 7 CBs concentration (in µg/kg) at Rame Head South stations.

Station	∑ICES 7 CBs concentration (in µg/kg)									
	2002	2003	2004	2005	2006	2007	2008	2009	~	2014
G34		*0.7*		*0.7*	*0.7*	2.1	*0.7*	*0.7*		*0.7*
G50							*0.7*	*0.7*		0.89
G33	*0.7*	14.2	7.67	2.37	4.08	4.26	7.87	2.46		2.19
G28	64.6	57.9	4.78	8.55	10.2	9.86	71.9	10.2		4.59
G30						3.69	*0.7*	1.27		*0.7*
G25	23.9	19.7			2.07		2.6	1.83		1.44
G21	28.4	12.3				5.42	4.76			
G18	81.9	90.8	62.5	6.7	7.11		18.8			
KH1						40.6	1.37			
G20						1.8	6.6			
G19	194	15.9	202	24.7	1.43	1.34	13.1			
G16										1.18
G13	*0.7*	*0.7*	1.47	*0.7*	*0.7*	384	1.83	*0.7*		1.34
G3	*0.7*	*0.7*			*0.7*	0.95	*0.7*	*0.7*		*0.7*
RH7		*0.7*		*0.7*		*0.7*	*0.7*	*0.7*		*0.7*
G37		*0.7*			1.33	0.89	*0.7*	*0.7*		*0.7*
RH6		*0.7*		*0.7*		*0.7*	*0.7*	*0.7*		*0.7*
G6					2.75	3.85	0.82	3.26		2.53
G36		*0.7*				1.8	1.82	2.79		1.55
G2	*0.7*	5.1				1.19	1.58	*0.7*		1.78
G8	5.2	7.4	0.86	*0.7*	*0.7*	*0.7*	*0.7*	*0.7*		*0.7*

Concentrations in italic represent estimates of concentrations for samples where all ICES 7 congener concentrations were below LODs.

Concentrations of ∑11 BDEs at Rame Head South have always been close to limits of detection over the period 2003-2014, and results obtained in 2014 were very similar to those previously acquired (Table A2.4.4).

BDE209 has only previously been analysed for at Rame Head South in 2008 and 2009 (Table A2.4.5). The data indicate that BDE209 concentrations are slightly increasing in the area with the concentration at 11 of the 16 stations in 2014 being the highest measured there (based on data from 2008 and 2009 only; Table A2.4.5). However, concentrations are still low as, for six of these stations, their concentrations are still close to limits of detection. The largest increases were at G33, G25 and G2, which are not located close to each other.

Table A2.4.4. Temporal trends (2003-2014) of ∑11 BDEs concentration (in µg/kg) at Rame Head South.

Station	∑11 BDEs concentration (in µg/kg)								
	2003	~	2005	2006	2007	2008	2009	~	2014
G34	*0.69*		*0.69*	*0.69*	*0.69*	*0.11*	*0.11*		*0.11*
G50					*0.69*	0.13	*0.11*		*0.11*
G33			*0.69*	0.69	*0.69*	*0.11*	0.12		0.18
G28	*0.69*		*0.69*	*0.69*	*0.69*	0.18	0.12		0.14
G30					*0.69*	*0.11*	0.12		0.13
G25	0.79			0.88		*0.11*	0.13		0.13
G21	0.80				*0.69*	0.12			
G18	1.18		*0.69*	0.84		*0.11*			
KH1					*0.69*	*0.11*			
G20					*0.69*	*0.11*			
G19	0.74		*0.69*	0.78	*0.69*	0.12			
G16									*0.11*
G13	0.81		*0.69*	0.77	*0.69*	*0.11*	*0.11*		*0.11*
G3	0.79			0.82	*0.69*	*0.11*	*0.11*		0.13
RH7	0.73		*0.69*		*0.69*	0.12	*0.11*		*0.11*
G37	0.75			0.76	*0.69*		*0.11*		*0.11*
RH6	*0.69*		*0.69*		*0.69*	0.13	*0.11*		*0.11*
G6				0.96	*0.69*	0.53	0.12		0.23
G36	1.27				*0.69*	*0.11*	0.12		0.40
G2	0.72				*0.69*	0.51	0.49		0.36
G8	0.79		*0.69*	0.94	*0.69*	0.23	0.12		0.19

Concentrations in italic represent estimates of concentrations for samples where all 11 BDE congener concentrations were below LODs. Limits of detection for BDEs improved between 2007 and 2008 and therefore values assigned to congeners below LOD are lower in 2008 and 2009, resulting in a step decrease in ∑11 BDEs concentration for samples with congeners below LODs.

Table A2.4.5. Temporal trends (2008-2014) of BDE209 concentration (µg/kg) at Rame Head South.

Station	BDE209 concentration (µg/kg)			
	2008	2009	~	2014
G34	*0.05*	*0.05*		0.28
G50	1.05	2.16		2.71
G33	2.55	0.65		6.22
G28	1.22	5.25		2.34
G30	0.62	1.82		0.56
G25	5.31	1.89		8.87
G21	5.42			
G18	3.25			
KH1	2.96			
G20	4.21			
G19	0.77			
G16				0.29
G13	*0.05*	*0.05*		0.17
G3	0.10	*0.05*		0.22
RH7	*0.05*	*0.05*		0.28
G37		*0.05*		0.23
RH6	*0.05*	*0.05*		*0.05*
G6		3.83		3.95
G36	1.05	1.53		2.17
G2	1.10	0.94		3.47
G8	*0.05*	*0.05*		0.49

2.4.3.3.3 Trace metals

Levels of enrichment for Rame Head South stations using OSPAR BAC and regional baseline (West Channel; see Table A1.3.1) values are represented in Figure A2.4.11. Assessment of metals enrichment shows that all stations were found to be slightly enriched for As using the OSPAR BAC method, except for G06 where moderate enrichment is recorded. Arsenic enrichment is less pronounced with the baseline numerical approach with nine of the 16 stations sampled showing no enrichment (Figure A2.4.11). Arsenic is naturally present in high concentrations within this region; mining in the Tamar catchment in the late 1800s was producing half of the worlds As.

Although a number of stations displayed slight or moderate enrichment for Cr, Ni, Cu, Pb and Zn according to the OSPAR approach, no enrichment for these metals was observed for the majority of the stations sampled using the regional baseline approach method.

Cadmium levels are mostly either below the limit of detection or below the OSPAR BAC value, with station G06 showing a moderate enrichment level. Assessment with the baseline numerical approach gives a slightly higher enrichment. This is due to Cd baseline value for the West Channel area is lower than the OSPAR BAC value for Cd (refer to Table A1.3.1).

Regional variability is even more noticeable for Hg as the derived regional baseline value is 10 times that of the OSPAR BAC for the West Channel (Table A1.3.1), resulting in an important difference in enrichment factors between the two assessment approaches. While most stations sampled at Rame Head South were found to be >5 times the OSPAR BAC value, their enrichment levels were reduced 1-2 times the derived regional baseline value for stations G06 and G13, with the remaining stations being lower than the baseline value (Figure A2.4.11).

Since stations within the Rame Head South disposal site boundary have not been sampled since 2009, Figure A2.4.12 only shows temporal series of stations located outside the disposal site for the years 2006, 2007, 2008 and 2014. Overall, no specific temporal trend is observed for most elements, except for Cr and Ni where a slight increase can be seen, while other metals, such as Zn, Cd, Pb, and Hg have declined since 2006.

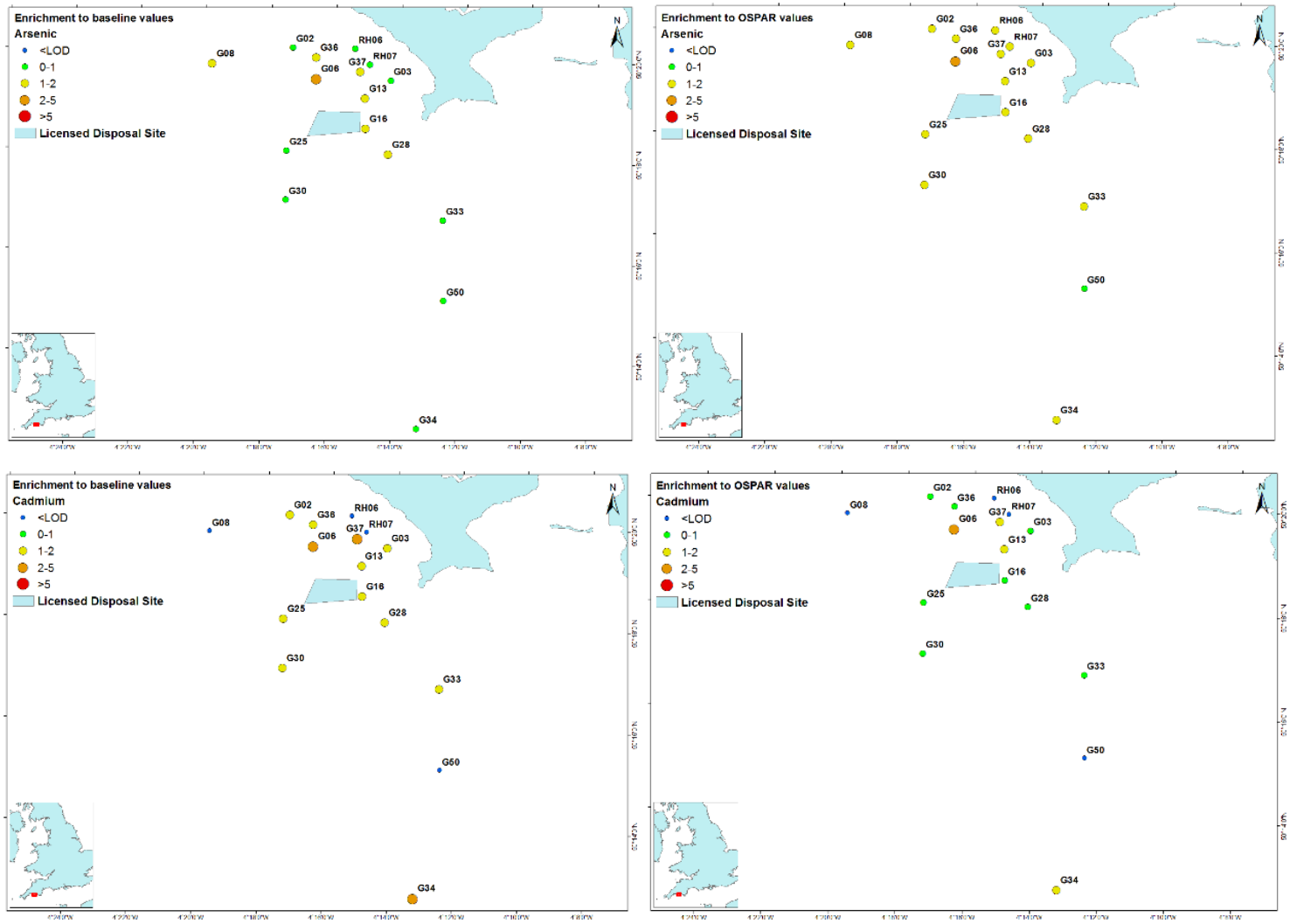


Figure A2.4.11. Enrichment to regional baseline values (left) and OSPAR BACs (right) at Rame Head South for As, Cd, Cr, Cu, Hg, Ni, Pb and Zn.

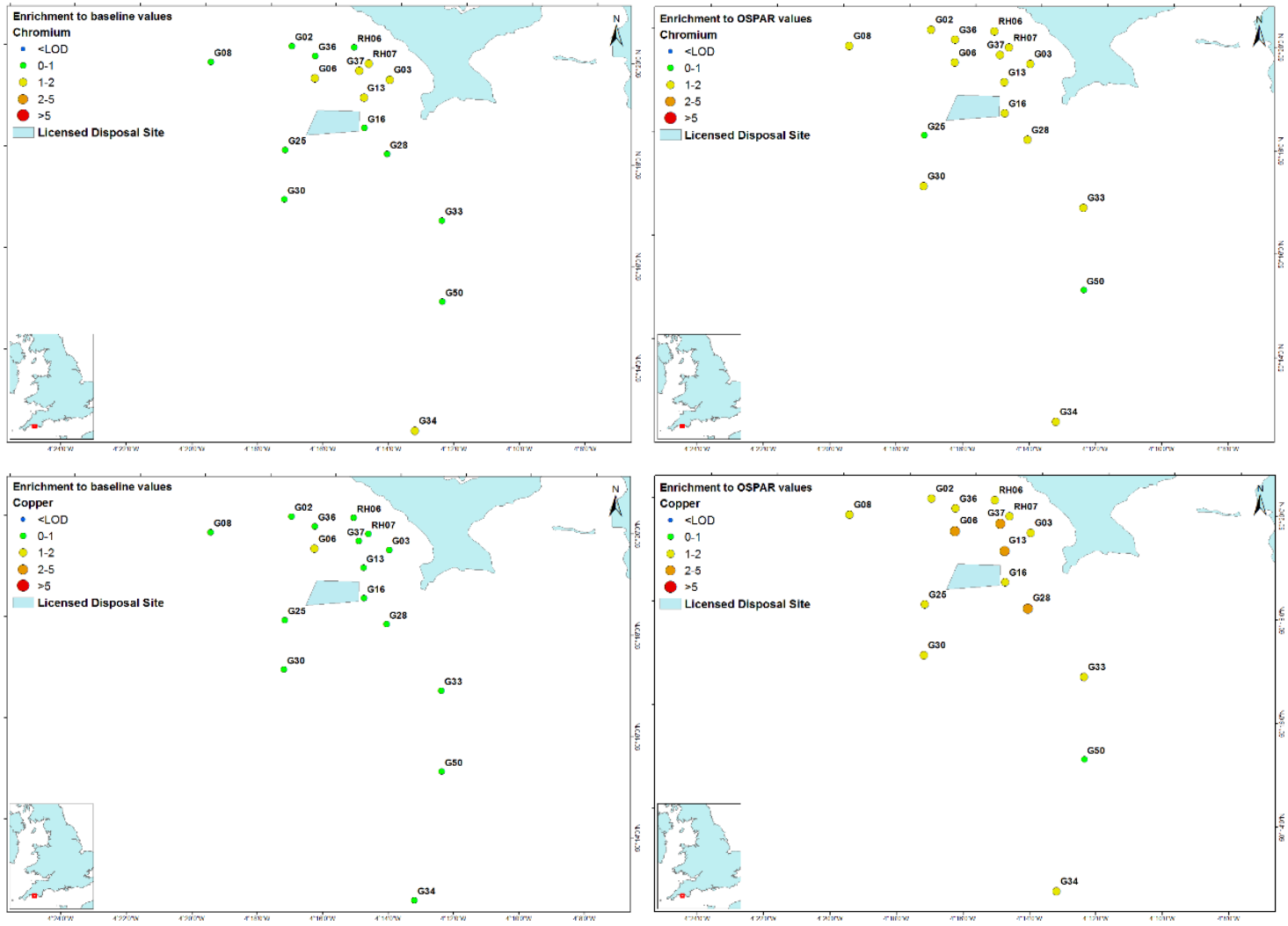


Figure A2.4.11. Continued.

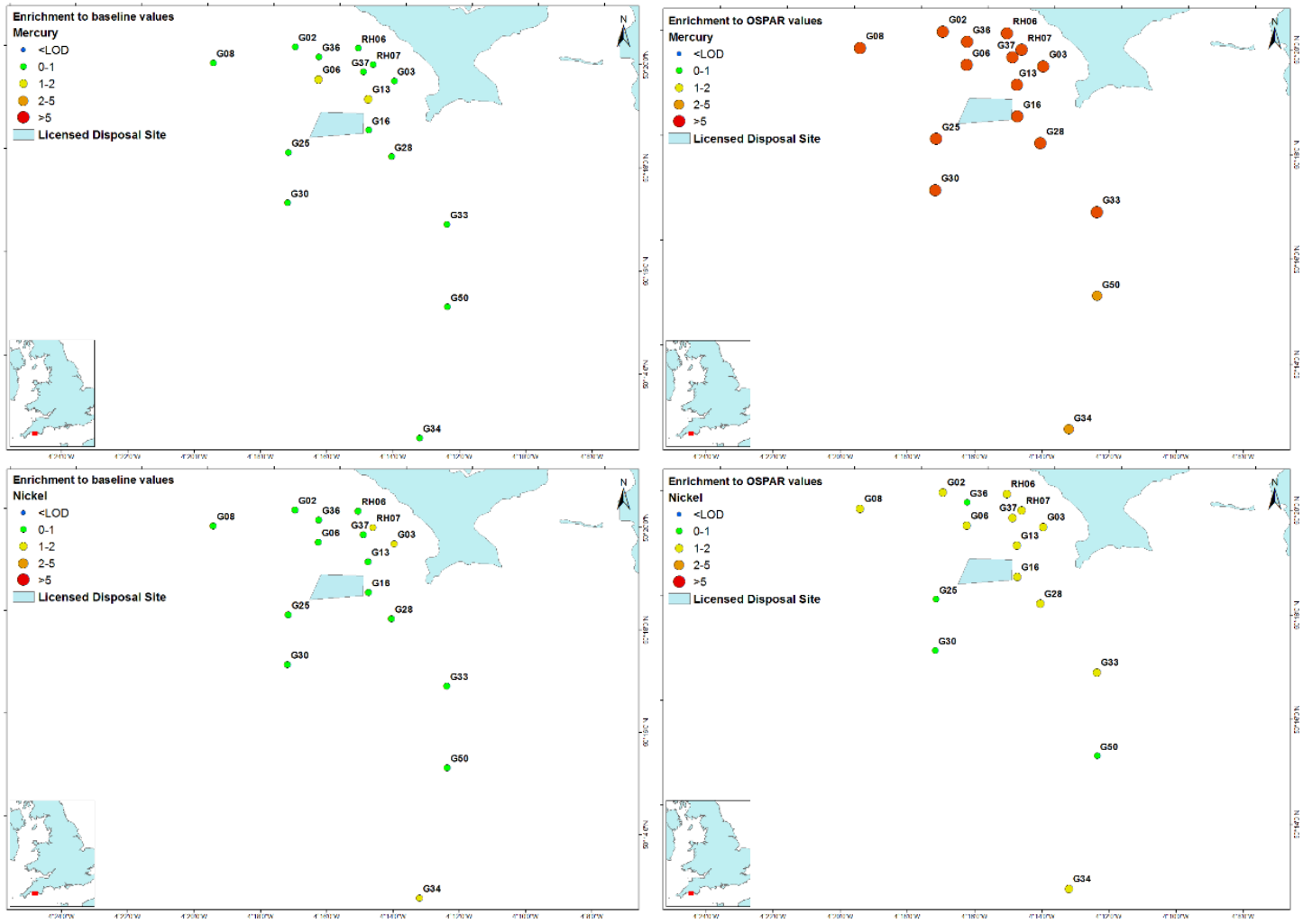


Figure A2.4.11. Continued.

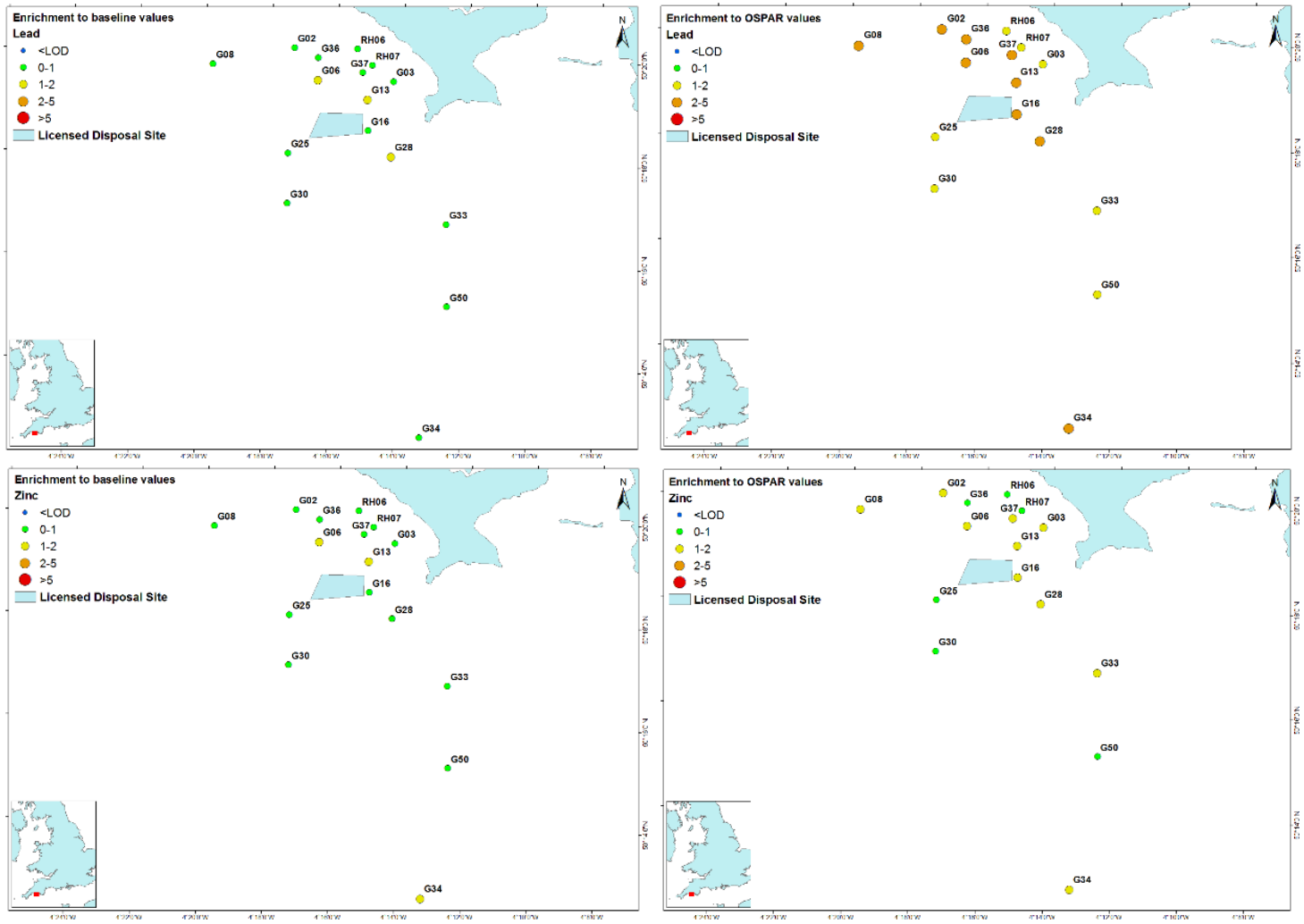


Figure A2.4.11. Continued.

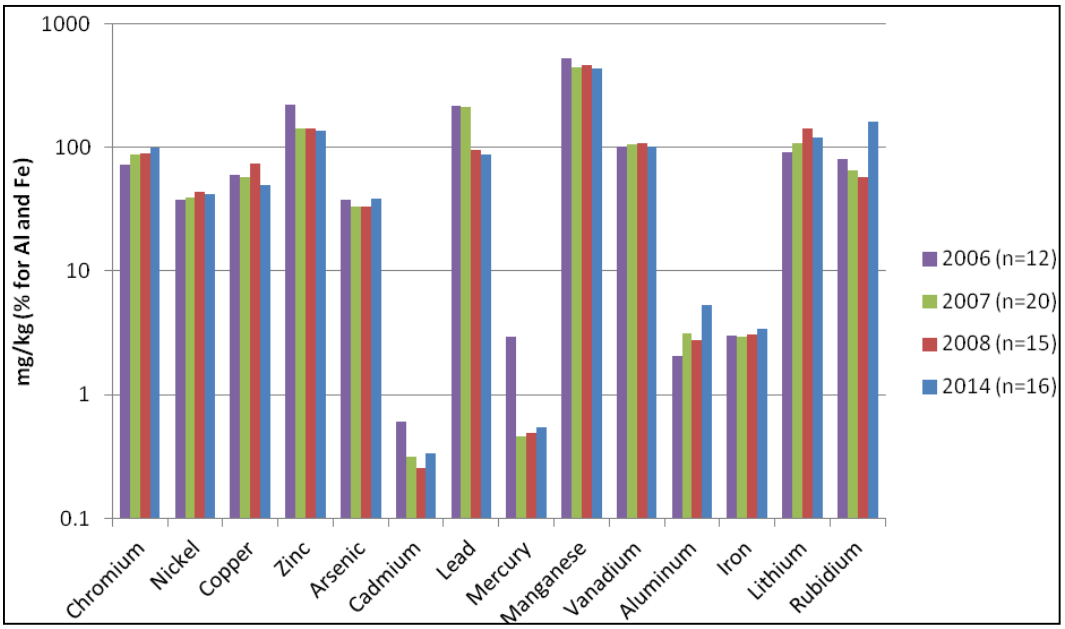


Figure A2.4.12. Temporal data of trace metals concentrations averaged across all Rame Head South sampling stations, 2006-2014.'n' values refer to the number of stations upon which data are based for each year.

2.5 Site Y

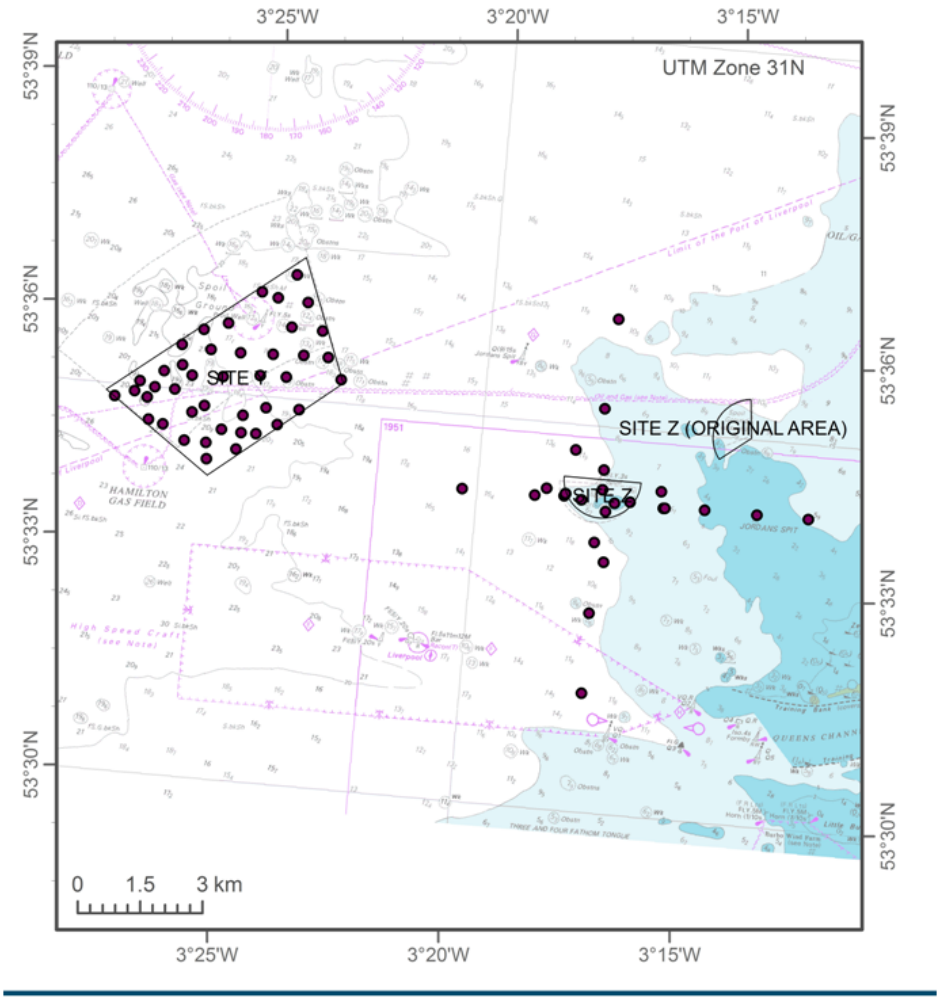


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Figure A2.5.1. Location of the sampling stations for ground-truthing at Site Y, 2014. Location of Site Z (and historic SLAB5 sampling stations) is also shown to reveal the close proximity of the two disposal sites.

2.5.1 Background

Site Y and Site Z are situated within Liverpool Bay on the west coast of the UK (Figure A2.5.1). Both sites are licensed to receive dredged material resulting from dredging of the maintenance docks and navigation channels, and that of capital projects, in the Mersey Channel. Wave action in the area results principally from south westerly winds. Furthermore, residual bottom currents flow in a predominantly landward (eastward) direction; thus causing the deposited dredged material to potentially shoal.

Site Y (IS150), the larger of the two sites by area, has a seabed sloping to its south-western perimeter, with large sand waves, orientated north to south, to the western side of the site. The average water depth for the disposal site is 20 m below Chart Datum with the north-eastern section shallowing to approximately 16 m, while the deeper waters (27 m below Chart Datum) can be found in the southwest. The sediments within this site are generally moderately well sorted, slightly gravelly sand.

Approximately 1.8 MT (wet weight) of capital dredged material was disposed of to Site Y during 2013; this material was derived from the construction of the new deep water container terminal, Liverpool II, at the old Seaforth docks. To prevent shoaling at Site Y, the stiff, consolidated material was licensed to be disposed of in a grid fashion, with the subsequent finer maintenance dredged material to be disposed as evenly as possible over the disposal site. As the disposal site is bisected by the Hamilton pipeline, a buffer of 500 m was imposed as another condition of the disposal licence. Although the capital material from Liverpool II is geological and, therefore, not expected to pose a contamination risk, there are issues associated with its non-dispersive characteristics leading to potential shoaling, or from the formation of clay balls that have the potential to interfere with fishing gear in the area.

This disposal site was initially monitored under SLAB5 during December 2013 via an acoustic and seabed sampling survey. This survey provided valuable data regarding the physical nature of the seabed following the large disposal campaign of the capital material (Bolam et al., 2015). However, subsequent data are required to determine the physical characteristics of the seabed following the subsequent placement of the more erodable, maintenance material that was disposed of to Site Y.

2.5.2 Parameters monitored

Acoustics and sediment particle size

2.5.3 Results

2.5.3.1 Acoustics and sediment particle size

The multibeam bathymetry data collected across the whole of the Site Y disposal site during September 2014 were of good quality. The data confirmed that the seabed deepens from the north of the site towards the south-west, with depths ranging from approximately 15.9 m to 27.3 m below Chart Datum (Figure A2.5.2). Shallower depths were recorded but were associated with wrecks or other seabed obstructions. The seabed is dominated by large sand wave formations trending north to south across the site. The sediment resulting from the capital dredged material disposal campaign could easily be discerned from the bathymetry data as craters, approximately 35 m in diameter, in the southern part of the site (Bolam et al., 2015).

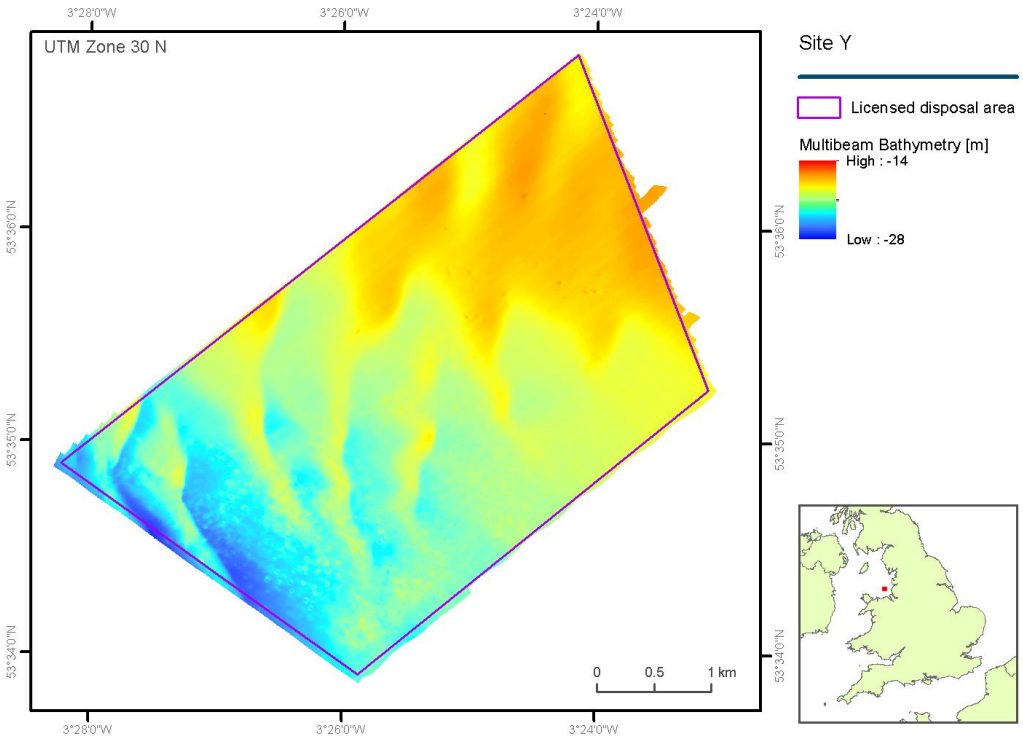

Figure A2.5.2. Multibeam bathymetry (m) of the Site Y disposal site, September 2014.

Multibeam backscatter data displayed a largely homogeneous seabed with small patches of low reflectivity within the central area (Figure A2.5.3). The deposal material is clearly visible in the southern half of the site as rings of high backscatter with low backscatter centres. Areas of higher intensity backscatter were identified in both the western corner and the southern limit of the disposal site. The sand-waves which dominate the bathymetry of the site are clearly visible from the backscatter data as areas of lower backscatter trending north to south across the site.

The majority of seabed samples recovered from the northern half of the site were predominantly 'slightly gravelly SAND' with the majority having greater than 80% sand by proportion (Figure A2.5.4). These samples tended to be either moderately sorted or moderately well sorted. In the southern areas, where the majority of the disposal material was identified, sediments were found to have much more variable in the proportions of sand, gravels and muds and were classed either as poorly sorted or very poorly sorted.

Sediment boundaries within Site Y were delineated by manual interpretation of the acoustic data and informed by the sediment samples. The majority of the central and northern parts of the site were classified as 'slightly gravelly SAND' (Figure A2.5.5). The areas of deposal activities to the south have been classified as 'gravelly muddy SAND'.

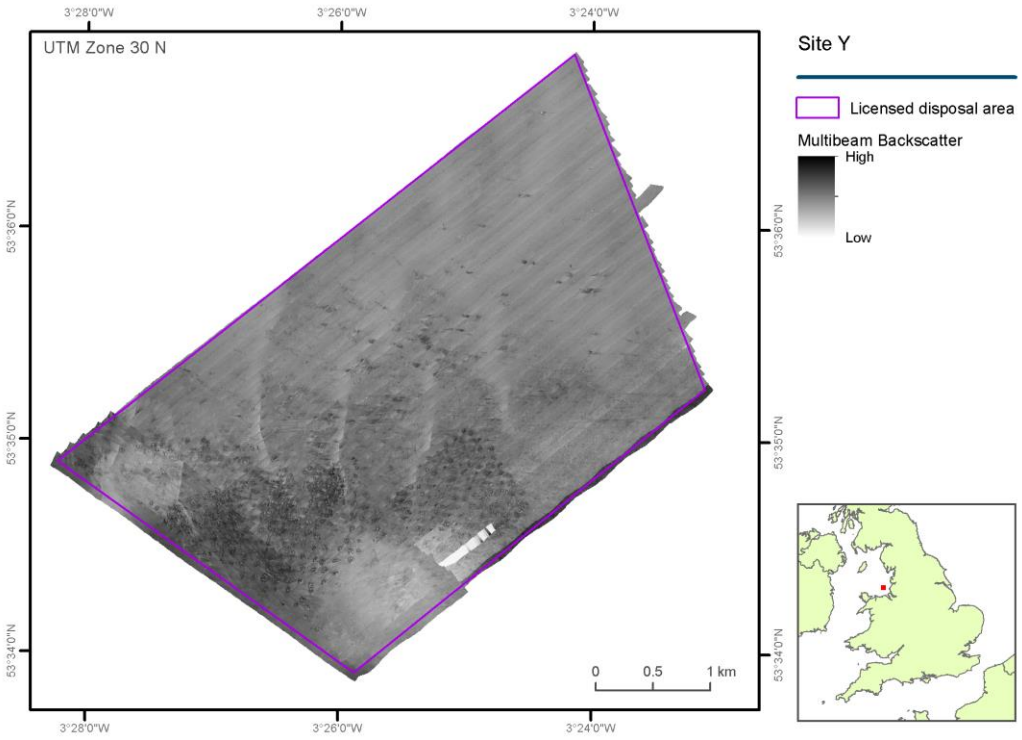

Figure A2.5.3. Multibeam backscatter data for the Site Y disposal site, September 2014. Note, the white, rectangular region running parallel to the south-eastern boundary of the site represents missing data as opposed to low backscatter return.

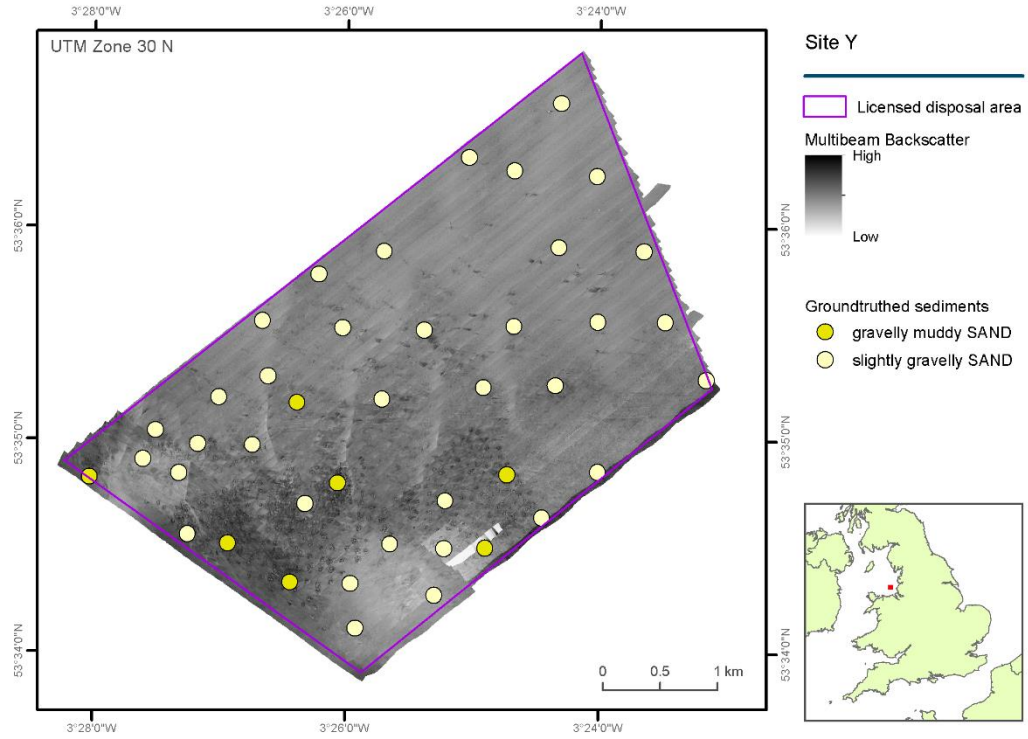

Figure A2.5.4. PSA sample stations around the Site Y disposal site, September 2014.

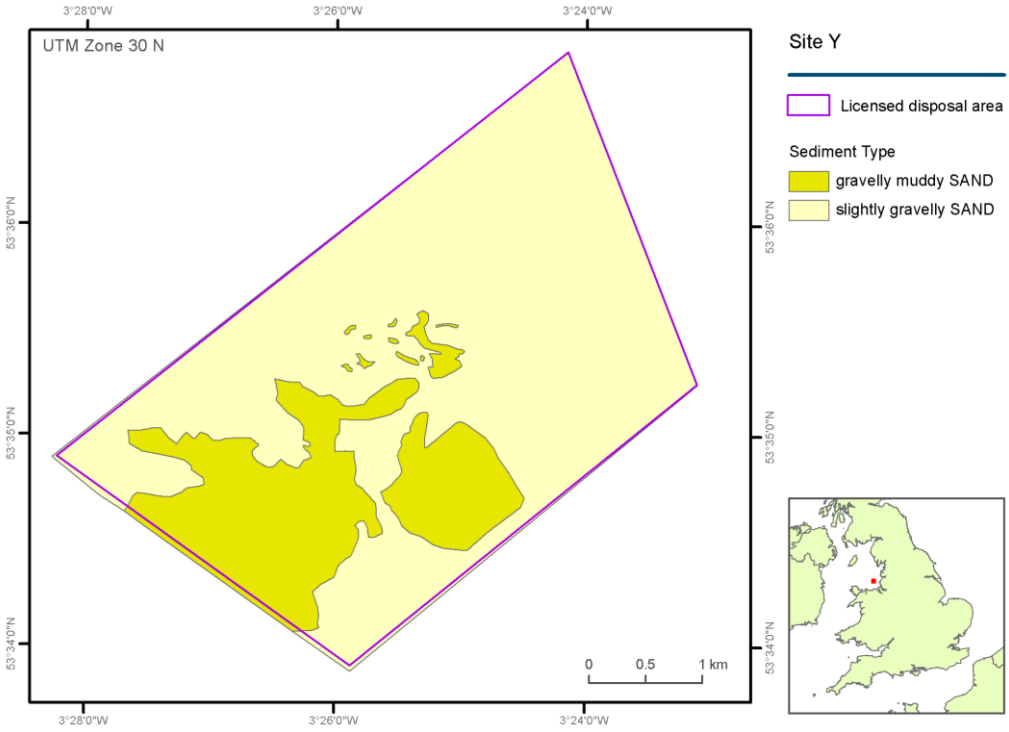

Figure A2.5.5. Classification of substrata at the Site Y licensed disposal site, September 2014.

The intensity of the disposal activity across the site is clearly visible due to the distinct impact craters which have been created during deposition. The highest intensities of disposal activity occurred in the southern half of the site in two distinct groups which are displayed in Figure A2.5.6. Moderate intensity disposal areas were identified in the areas of randomly deposited material to the north and south of the areas of high intensity. The majority of the northern half of the site was designated as having a low intensity of disposal activity with only the occasional deposit being identified.

The data previously collected under SLAB5 for Site Y during December 2013 indicated that the disposal mounds and impact craters were visually discernible from the acoustic data all over the deeper, southern portion of the disposal site (Bolam et al., 2015). However, in 2014 this region appears as a homogeneous area of low backscatter return with no evidence of impact mounds due to the deposits of capital material (Figure A2.5.4). It is likely that this depicts the region where the finer, maintenance material can be found on the bed, smothering the impact craters previously seen in 2013. This would imply that the disposal of the maintenance dredged material has been centred on the deeper, southern part of the disposal site, as requested under the disposal licence.

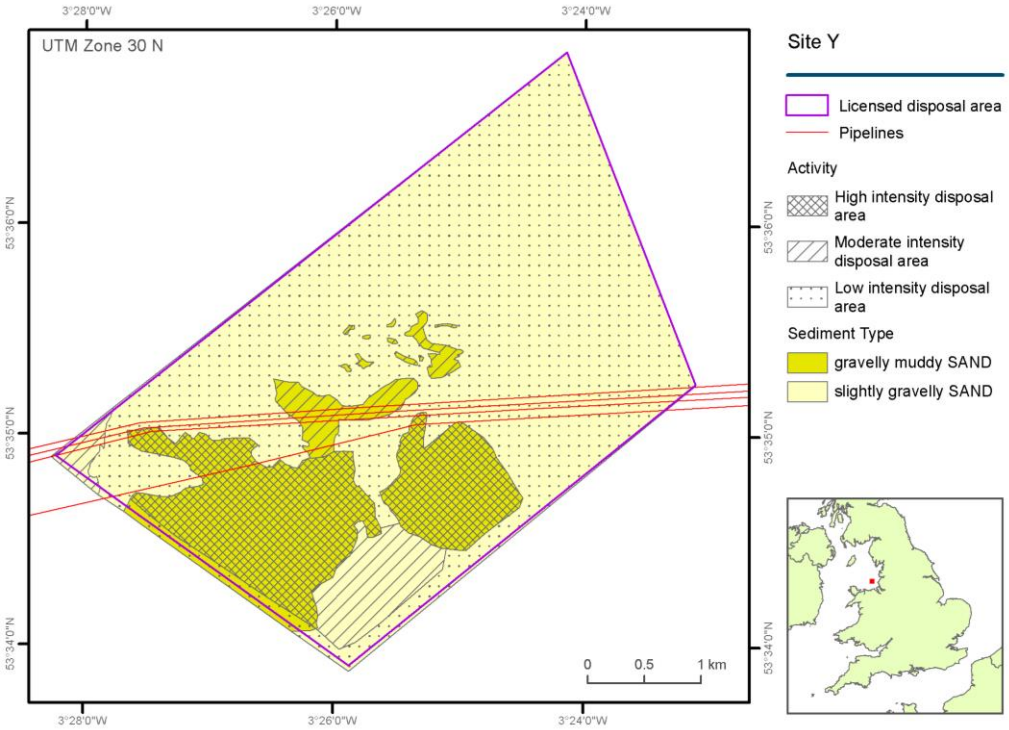

Figure A2.5.6. Relative intensity of disposal activity at the Site Y disposal site, September 2014.

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