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Dredged Material Disposal Site Monitoring Around the Coast of England: Results of Sampling (2011)

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Executive Summary

- This report presents the scientific findings and monitoring implications of dredged material disposal site monitoring under SLAB5 around the coast of England during 2011.
- The main aims of this report are to aid the dissemination of the monitoring results, to assess whether observed changes 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.
- Parameters monitored varied between sites (governed by site-specific issues) but included multibeam and sidescan sonar acoustic techniques, sediment particle size assessments, sediment organic carbon and nitrogen, macrofaunal communities, sediment profile imaging (SPI) and the assessment of a range of sediment contaminants including tri-butyl tin (TBT), polycyclic aromatic hydrocarbons (PAHs), organohalogens (e.g., pesticides, flame retardants) and trace metals.
- Elevations in the concentrations of the various contaminant types were somewhat site-specific.
- Acoustic (multibeam and/or sidescan) data acquired allowed the successful determination regarding the capacity of disposal sites in the Humber Estuary and the fate of deposited material at a number of other sites.
- 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 any stakeholder 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

Until recently, the deposit of substances and articles in the sea, principally the disposal of dredged material, was controlled by a system of licences issued under Part II of FEPA. However, the responsibility for the licensing function in England and Wales on 1st April 2010 transferred from the Marine and Fisheries Agency to the Marine Management Organisation (MMO) for England and to the Welsh Government for Wales. The marine licensing provisions of the Marine and Coastal Access Act 2009 that came into force on 1st April 2011 have thus taken over from Part II of FEPA for the licensing function in England and Wales.

In licensing the disposal of dredged material at sea, numerous conditions associated with the relevant national and international agreements (e.g., the London Convention 1972 (LC72) and London Protocol of 1996 (LP96), the OSPAR Convention, the Environmental Impact Assessment Directive (97/11/EEC), the Habitats and Species Directive (92/43/EEC), the Wild Birds Directive (79/409/EEC), and the Water Framework Directive (WFD, 2000/60/EC)), must be considered to determine whether likely impacts arising from the dredging and disposal are acceptable (MEMG, 2003). Criteria considered under the various conventions and directives include the presence and levels of contaminants in the materials to be disposed of, along with perceived impacts on any sites of conservation value in the vicinity of disposal. Additional potential beneficial usage of the materials must be considered prior to a disposal consent being issued (MEMG, 2003).

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 check that disposal licence conditions are met and that no unexpected effects occur. 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 150 sites designated for dredgings 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 million wet tonnes are annually disposed of to coastal sites around England, although this can vary from 28 to 57 million wet tonnes (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 No. 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 2011 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.

	Geographical location off English coast	**Code**	**Prioritisation assessment: Tier**
North Tyne	Northeast	TY070	1
Souter Point	Northeast	TY081	1
Tees Bay A	Northeast	TY160	1
Tees Bay C	Northeast	TY150	2
Goole Reach	East	HU041	1
Humber Estuary	East	HU081, HU082, HU083	1
Inner Gabbard East	Southeast	TH056	2
Rame Head	Southwest	PL031	2

Table 1.1. Dredged material disposal sites targeted for monitoring under SLAB5 during 2011.

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 et al., 2011). The aims of this report are:

- To present the findings of the results of sampling undertaken during 2011 under SLAB5, thereby aiding the dissemination of the findings under this project;
- To indicate whether the results obtained are in line with those expected, or whether subsequent investigations should be conducted;
- Where possible, to assess the 2011 results in line with those of previous years to provide a temporal assessment (see Bolam et al., 2009 and Bolam et al., 2011 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 last year's report (Bolam et al., 2011), the conclusions for each site are contained within a new section within the present report (i.e., Section 2, below); the presentation of all the scientific data has remained as previous but deferred to an appendix (Appendix 2). For background information and impact hypotheses regarding each disposal site monitored during 2011, 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 North Tyne

Monitoring at the North Tyne dredged material disposal site has been conducted under SLAB5 for a number of consecutive years. As such, a good understanding of the spatial variation in the biology, sediments and contaminants following disposal activity at this site has been acquired. Temporal data previously attained for the macrofauna suggested that impacts are consistently localised and, as such, the biota was not the subject of monitoring under SLAB5 during 2011.

The sediment monitoring data indicated that while TBT concentrations remain low, PAHs remain elevated although showing a general reduction relative to previous years. While most stations exceeded the ERL for LMW PAHs, the ERM for HMW PAHs was not breached. Regarding organohalogens (OHs), concentrations of CBs were mostly below FEPA AL1 and most stations displayed a ‘good’ environmental status for OSPAR ICES 7 CBs under OSPAR guidelines. Some stations exhibited concentrations depicting ‘bad’ status for CB101 and CB118. Overall, OH concentrations appear to remain stable over time at North Tyne. Assessments of trace metals concentrations are shown to be most appropriately conducted by comparisons with regional background concentrations as opposed to OSPAR background assessments concentrations (BACs); concentrations observed indicate slight enrichment for most metals (except for Cr and Ni).

While intelligence regarding potential changes to the disposal regime must be utilised, monitoring data acquired during 2011 suggests that future monitoring at North Tyne should continue and focus primarily on assessing concentrations of PAHs, OHs and trace metals.

2.2 Souter Point

Monitoring at Souter Point dredged material disposal site has been conducted annually for a number of years, aiming primarily to determine the physical integrity of the cap over the contaminated sediment (See section 2.2.1 of Appendix 2 for further information) and ensure that impacts of ongoing disposals are limited to within the vicinity of the disposal site. A number of complementary approaches (e.g., grabbing, coring, acoustics, SPI) have been adopted at this site to achieve these aims.

The 2011 data indicate that the cap can be distinguished, akin to previous surveys, by the acquired acoustic data; the sandy cap currently appears smaller and more centralised in shape relative to previous years. TBT was detectable at all stations sampled within the disposal site (although all below Cefas AL1), and PAHs were found to be elevated within the disposal site only. The latter breached both the ERL and ERM for LMW PAHs and the ERL for HMW PAHs. Surficial sediment OHs showed CBs to be mainly below FEPA ALs and of ‘good’ environmental status for ICES 7 CBs. Temporal comparisons reveal no noticeable shift in OH concentrations since 2005. Trace metals (especially Hg and Pb) remain noticeably enriched (although primarily restricted to within the disposal site boundary) even when assessed against the more appropriate regional background concentrations.

Sediment depth-profiling for TBT, PAHs and OHs, in combination, revealed variable data regarding cap thickness for the various stations targeted. Based on the data acquired here during 2011, future monitoring at Souter Point should focus on assessing cap thickness; assessing cap integrity for a larger number of stations than that to date. While sub-bottom profiling techniques were unsuccessful during 2011 due to the nature of the underlying sediments impeding the successful operation of the adopted ground-truthing approach, future work should perhaps rely on deeper coring devices and the slicing of visually-distinct regions (as has been the approach taken to date).

2.3 Tees (Inner and Outer)

Analogous to the situation for North Tyne and Souter Point, SLAB5 monitoring at the Tees disposal sites has been conducted annually for a number of years and, as such, we have a good temporal dataset to draw upon when making contemporary assessments.

While there have been no deposits at Outer Tees during the year subsequent to the 2010 survey, ongoing disposal activity to the Inner site resulted in data typical of a site receiving maintenance material. Although TBT levels remain low (only detectable at two sampling stations), albeit perhaps elevated relative to previous years, summed PAH concentrations were higher in 2011 (for a number of stations) compared to previous years. Consequently, nearly all stations exceeded the ERL and ERM for LMW PAHs and the ERL for HMW PAHs: one station within the disposal site also exceeded the ERM for HMW PAHs. OH concentrations at the Inner site were generally comparable to those seen in previous years while those seen at the Outer site showed a declining trend. CB concentrations were all below FEPA ALs while those of DDT were above FEPA AL1 at four stations. Most stations exhibited ‘good’ environmental status for all ICES 7 CBs except two stations which displayed a ‘bad’ status within the Inner site.

Subsequent monitoring should focus on assessments of contaminant concentrations at the Inner Tees site, unless disposal activity to the Outer Tees site has, is or likely to, be resumed.

2.4 Goole

The monitoring conducted along the River Ouse which spans from the west of Goole Reach to the east of Whitgift Bight has again demonstrated that while TBT concentrations remain low (TBT was only detected at two of the 13 sampling stations), those of PAHs remain fairly static: decreasing at some stations (particularly those upstream stations) and increasing at others (especially those surrounding Whitgift Bight disposal site). The ERL and ERM for LMW PAHs were breached at seven, and two, sampling stations respectively, while four stations exceeded the ERL for HMW PAHs.

Regarding OHs, most stations were classed as 'good' environmental status for all ICES 7 CBs and 'good' status overall. Data since 2008 indicate that for all OHs there have been both increases and decreases in concentrations for various stations: no overall detectable trend is thus discernible. Relative to 2010, trace metals in 2011 show a slight increase in enrichment for As, Cr and Ni while that of other metals (e.g., Cd, Hg, Pb, Zn) remain generally comparable. Cd continues to display significantly elevated concentrations: > 5 that of the regional baseline value for two stations and 2 – 5 times at all other stations.

As the data reveal continued high concentrations of sediment contaminants at Goole, further monitoring should be conducted, targeting specifically on assessments of the concentrations of PAHs, OHs and trace metals.

2.5 Humber Estuary

Three disposal sites (HU081, HU082 & HU083) within the Humber Estuary were targeted for acoustic data acquisition in 2011: this represented the first time these sites have been selected for monitoring under SLAB5. The sole purpose of this monitoring was to attain appropriate data from which the capacity of various bed depressions within these licensed sites could be estimated.

The successful bathymetric survey (conducted in association with the Geomatics division of the Environment Agency) indicated that the contemporary capacities of HU081, HU082 and HU083 totalled 64,800 m^3, 63,900 m^3 and 15,100 m^3 respectively. Decisions regarding whether subsequent acoustic (or otherwise) monitoring is necessary will need to be based on the need to understand the nature and magnitude of changes in such capacities following any subsequent deposits.

2.6 Inner Gabbard East

The acoustic-based monitoring conducted at the Inner Gabbard East (IGE) site in 2009, 2010 and 2011 has provided important data from which assessments regarding granulometric and bathymetric changes can be made and, consequently, indications regarding the fate of material deposited. Acoustic data attained in 2011 for IGE and its environs revealed that the centre of the disposal site has a lower acoustic return than that of the surrounding seabed sediments with areas of higher backscatter strength bordering. These data imply that disposal activity is currently being contained within the licensed disposal site boundary. Additionally, there has been very little change in the distribution of the detected disposal material, although the spatial extent observed in 2011 appears larger than that observed using the same approach in 2010.

2.7 Nab Tower

An acoustic survey was undertaken at Nab Tower in July 2011 to obtain sedimentary and bathymetric data prior to the placement of some large potential deposits destined for this licensed site in subsequent years. The data revealed that the disposal site currently displays an array of backscatter returns, although strong returns tend to predominate. The northern part of the licensed boundary tends to show lower acoustic returns with isolated marks of weaker returns, the latter are likely to represent isolated disposal events.

2.8 Rame Head

An acoustic survey was conducted at Rame Head during 2011 to acquire data to allow assessments of the bathymetric and sedimentological characteristics of the region to the south and southeast of the current licensed boundary. It is intended that this information will feed into the decision-making process regarding the feasibility of a potential extension to the licensed boundary.

The survey data indicated that the seabed to the south of the disposal site has a lighter backscatter return associated with sandy or muddy sediments. Additionally, the backscatter returns indicated that the bed here lies at a depth of 40m to 50m. The far southeast corner of the acoustic survey region displays a mixture of high intensity returns with distinct patches of low returns, indicating an assortment of sediments.

Sediment trace metals concentrations for this region to the south of the current site support the use of regional background concentrations relative to the OSPAR BACs; the latter artificially inflate enrichment factors as they do not incorporate the naturally elevated concentrations of most metals (especially Hg) for this part of the English coast. As such, trace metals are generally either less than or slightly above (enrichment factors between one and two) regional background concentrations.

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APPENDICES

Appendix 1. Assessment methods for sediment contaminants

1.1 TBT

1.1.1 Methodology

The sediment samples were collected in hexane-rinsed glass jars and were frozen immediately after collection. The samples were collected for organics analyses, mainly organotins (TBT and DBT), organohalogens and hydrocarbons analyses. The whole (wet) sediment sample is homogenised then sub-sampled for the determination of the total solid content and for organotins analysis.

Sample extraction is initially carried out by alkaline saponification, the organotins compounds are then converted into their hydrides forms with the addition of sodium borohydride. The organotins hydrides are finally extracted back in hexane by liquid-liquid extraction. Analysis is undertaken using a Gas Chromatography-Flame Photometric Detector (GC-FPD) and quantification is done using external calibration. A certified reference material is run within each sample batch for quality control. Results are reported in mg kg^{-1} (ppm) dw.

1.1.2 Method used for assessment

In this report, since the method is similar to that used for the dredged materials analysis, direct comparison can be made and therefore we assess the organotins data against the actions levels used by the Regulatory Assessment Team (Table A1.1.1). In general, contaminant levels in dredged material below Action Level 1 are of no concern and are unlikely to influence the licensing decision. However, dredged material with contaminant levels above Action Level 2 is generally considered unsuitable for sea disposal. The latter situation most often applies only to a part of a proposed dredging area and so that area can be excluded from disposal at sea and disposed of by other routes e.g. landfill. Dredged material with contaminant levels between Action Levels 1 and 2 requires further consideration and testing before a decision can be made.

ACTION LEVELS	Action Level 1 (mg/kg)	Action Level 2 (mg/kg)
Organotins; TBT/ DBT/ MBT	0.1	1

Table A1.1.1. Actions levels for organotins compounds.

1.2 PAHs

1.2.1 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).

1.2.2 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 10th and 50th 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 A1.2.1.

Table A1.2.1. 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

1.3 Organohalogens

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

1.3.1 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.

1.3.2 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.

1.3.3 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.

1.3.4 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.

1.3.5 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.

1.3.6 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.

1.3.7 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 A1.3.1. 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

1.4 Trace Metals

1.4.1 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.

1.4.2 Numerical assessments

1.4.2.1 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.

1.4.2.2 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.

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

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).

1.4.2.2.1 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.

1.4.2.2.2 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 A1.4.1) 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 A1.4.1, along with the corresponding OSPAR BACs values for each metal (OSPAR, 2006).

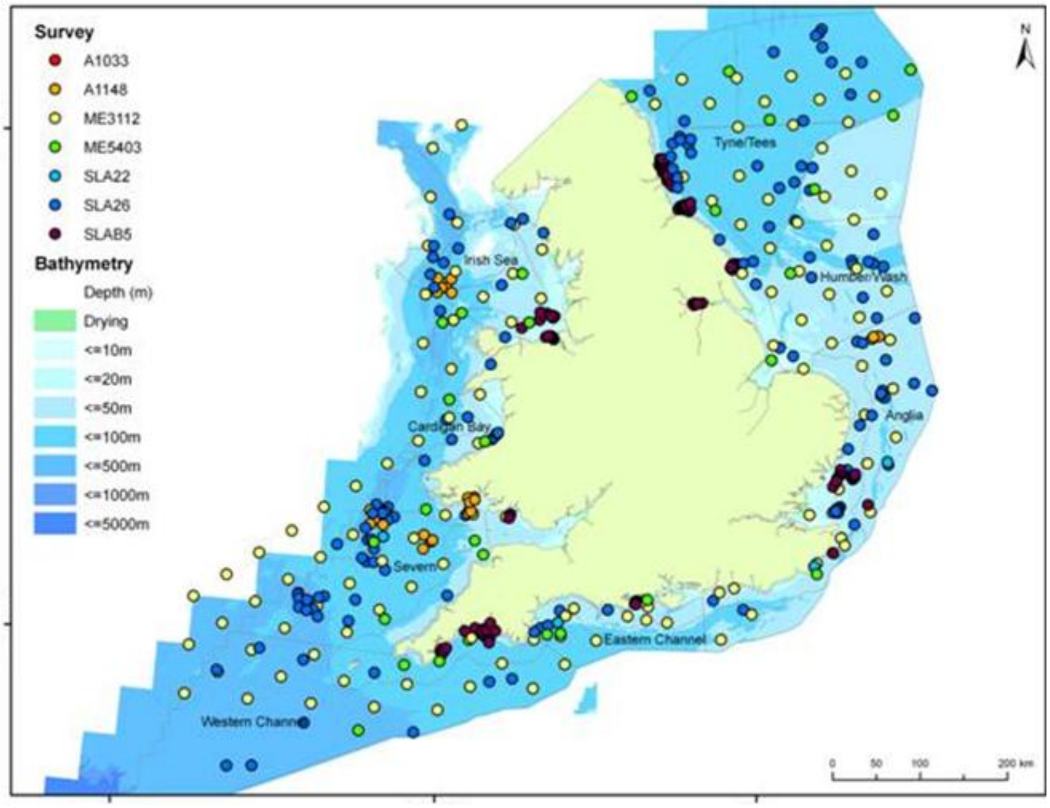


Figure A1.4.1. Location of stations sampled to provide metals data as part of the regional baseline approach.

Table A1.4.1. 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 North Tyne (TY070)

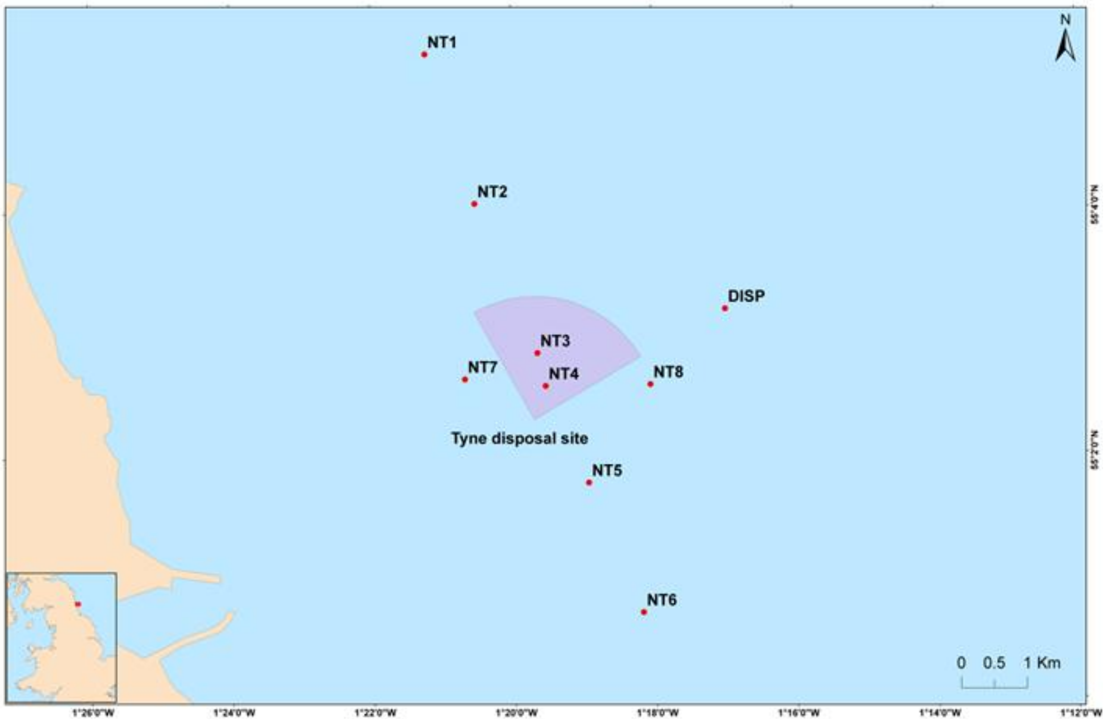


Figure A2.1.1. Locations of monitoring stations at North Tyne disposal site during 2011.

2.1.1 Background

Material disposed of to North Tyne is made up of predominantly silt and sand. In the past the site was used for capital and maintenance dredgings, minestone mine-tailings and fly-ash from power stations. An application for the disposal of significant quantities of capital material (up to 1.3 million tonnes) from the Tyne navigational channel and deepening of berths was recently licensed with disposal activity scheduled for early 2011. Some material under this application was excluded from sea disposal; some used for land reclamation while the portion accepted for sea disposal can be used to top up the cap at Souter Point. The total licensed for sea disposal is approximately 1 million tonnes which will be apportioned to North Tyne and Souter Point. The applicant is to provide a dredged disposal management plan detailing a grid system for disposal to avoid shoaling and interference with the capping region at Souter Point.

The relatively contaminated nature of the dredge material potentially destined for the North Tyne site is a result of the region’s industrial background. For example, the mining industry has resulted in elevated levels of heavy metals, and historical ship-building on the Tyne together with large volumes of shipping traffic in and out of the wharves have contributed to a legacy of TBT and hydrocarbon contamination.

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 AL 1 and AL 2 in proposed dredged sediments) arising from historical or current activities at source (especially heavily urbanised/industrialised estuaries).

2.1.2 Impact hypotheses

- Any elevations in the concentrations of chemical contaminants directly attributable to dredged material disposal will be confined to within and the near vicinity of the disposal site, principally along the tidal axis
- Any elevations in the concentrations of chemical contaminants directly attributable to dredgings disposal will be within acceptable limits
- Any changes to the physical habitat will be confined to within and the near vicinity of the disposal site, principally along the tidal axis

2.1.3 Parameters monitored

Sediment particle size distribution
Sediment organic carbon and nitrogen
Macrofaunal communities (samples retained)
Sediment contaminants (TBT, PAHs, organohalogens, trace metals).

2.1.4 Results

2.1.4.1 Sediment particle size

North Tyne sediments are predominantly muddy sands, with some unimodal sands and some gravels and muds (Table A2.1.1). Sediment groups derived in 2011 are similar to those of 2010 (note, groups 1, 2a and 2b reflect changes caused by addition of 2011 samples) (Table A2.1.2).

Table A2.1.1 Average sediment descriptions and statistics for each sediment group at North Tyne.

Sediment group	Number of samples	Sample Type	Sediment description	MODE 1 (µm):	MODE 2 (µm):	MODE 3 (µm):
NoT1	2	Bimodal, Very Poorly Sorted	Slightly Gravelly Sandy Mud	26.7	76.5	
NoT2a	12	Unimodal, Poorly Sorted	Slightly Gravelly Muddy Sand	152.5		
NoT2b	13	Bimodal, Poorly Sorted	Slightly Gravelly Muddy Sand	215.0	26.7	
NoT3	3	Polymodal, Very Poorly Sorted	Gravelly Muddy Sand	215.0	1700.0	107.5
NoT4	6	Polymodal, Very Poorly Sorted	Muddy Sandy Gravel	26950.0	215.0	1700.0
NoT5	5	Unimodal, Moderately Sorted	Slightly Gravelly Sand	302.5		

Sediment group	Gravel (%)	Sand (%)	Silt/clay (%)	Very coarse sand (%)	Coarse sand (%)	Medium sand (%)	Fine sand (%)	Very fine sand (%)
NoT1	1.10	39.01	59.89	1.37	1.93	5.95	13.84	15.93
NoT2a	3.62	76.39	19.99	2.76	4.84	11.33	29.64	27.83
NoT2b	3.30	79.23	17.47	1.90	3.84	23.04	34.78	15.67
NoT3	24.07	62.78	13.15	12.84	11.85	12.56	14.85	10.67
NoT4	41.46	49.02	9.53	11.56	7.49	9.45	12.36	8.16
NoT5	1.40	93.03	5.57	1.06	4.27	47.90	33.94	5.86

On the whole, temporal changes in sediment groups for those stations sampled since 2006 are minimal, with a maximum of two step group changes at most sampling stations, except within the disposal site at NT4 and to a lesser extent at NT3, as well as south of the site at NT5 where larger changes occurred during 2007-08 (Table A2.1.2). The greater temporal variation in sediment granulometry at stations within the disposal site may perhaps reflect changes in the nature of sediments being disposed, or variations caused by the differences in the proximity of samples to recent disposal events.

Table A2.1.2 Sediment groups for each sample code between 2006 and 2011 inclusive at North Tyne.

	Year					
Sample code	2006	2007	2008	2009	2010	2011
NT1	NoT2a	NoT2a	NoT2a	NoT2a	NoT2a	NoT2a
NT2	NoT2a			NoT3	NoT2a	NoT2a
NT3		NoT5	NoT5	NoT2b	NoT5	NoT2b
NT4	NoT1	NoT5	NoT5	NoT2b	NoT1	NoT2b
NT5	NoT4	NoT1	NoT2a	NoT2a	NoT2b	NoT2b
NT6	NoT4	NoT3	NoT4		NoT4	
NT7	NoT4	NoT4			NoT3	
NT8	NoT2b	NoT2b	NoT2b	NoT2b	NoT2b	NoT2b

The spatial variation in the proportional representation of gravel, sand and silt/clay for each sampling station in 2011 is shown in Figure A2.1.2 and the percentages of silt/clay content in Figure A2.1.3. All 2011 sediments are in the same sediment group (group 2: muddy sands;

Table A2.1.2). NT4 (within the disposal site) has the highest silt/clay content (33%) in 2011, as was the case for 2010. This may be linked to a recent disposal event. Silt/clay contents at all the other sampling stations range between 14% at NT8 to 25% at NT2 (Figure A2.1.2). In 2011, the Hamon grab was unsuccessful (despite many attempts) at sampling NT6 (extreme south) and NT7 (west), both of which displayed notable proportions of gravel in 2010 (Bolam et al., 2011). It is likely that these two stations remain gravelly, resulting in unsuccessful deployment of the Hamon grab this year.

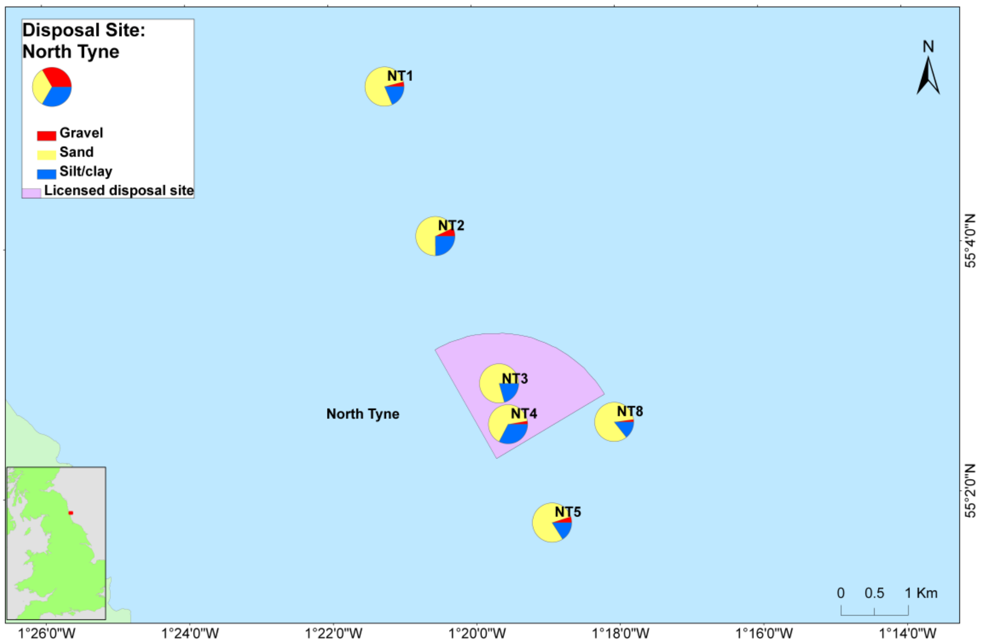


Figure A2.1.2 Pie charts of gravel, sand and silt/clay at North Tyne in 2011.

Silt/clay content in a subset of dredge sediments for licensing applications to dispose of at North Tyne was 61% +/-10. As in 2010, all the monitoring samples contained significantly less silt/clay than those of the dredged sediments (except those in sediment group NoT1). This supports the notion that silt/clay is dispersing away from the site, either immediately from the plume, and/or during subsequent erosion of the deposited material.

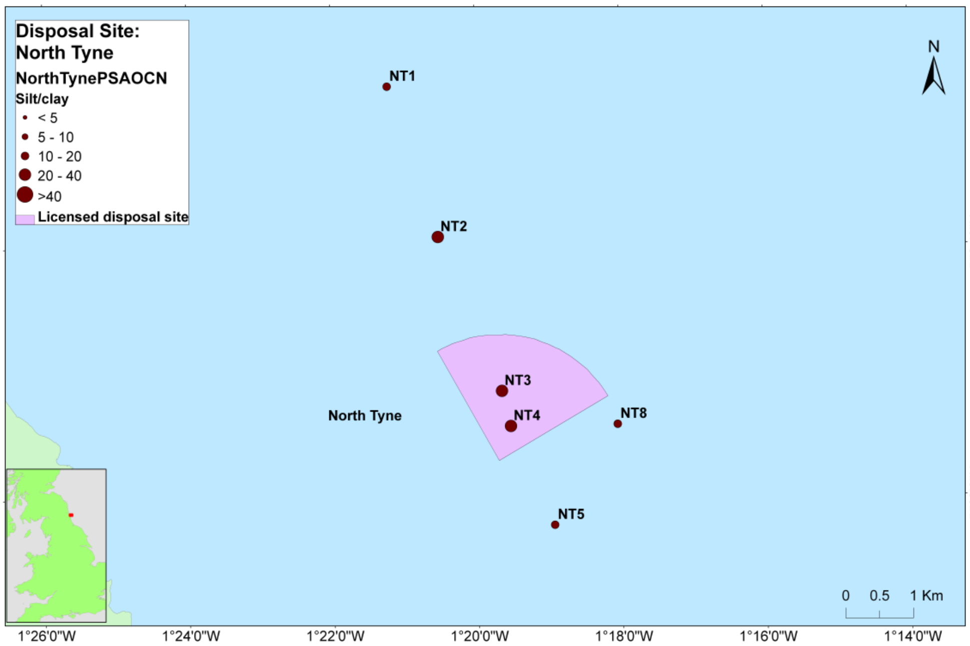


Figure A2.1.3 Silt/clay content (%) of sediments sampled at North Tyne in 2011.

2.1.4.2 Sediment organic carbon & nitrogen

Organic carbon values (in the <63µm sediment fraction) in 2011 ranged from 3.26 to 4.63 %m/m and 0.28 to 0.32 %m/m for nitrogen. Organic carbon values (in the <2mm sediment fraction) ranged from 1.62 to 6.0 %m/m and 0.09 to 0.27 %m/m for nitrogen. These are similar to those observed between 2006 and 2010 (Bolam et al., 2009, 2011). Figure A2.1.4 indicates that the higher organic carbon contents were exclusively found at stations within the licensed boundary of the disposal site (i.e., at NT3 and NT4).

As was the case in 2010, several samples have higher levels of organic carbon present in the <2mm fraction than the <63µm fraction; some of the organic carbon for this area is present in coarser sediment, possibly as coal.

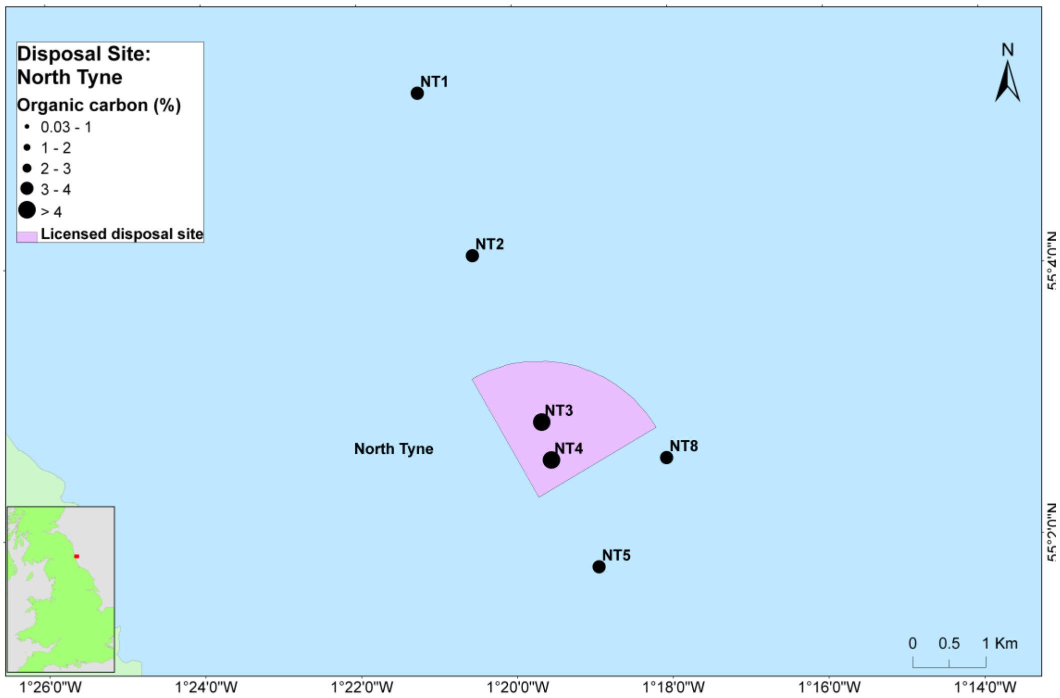


Figure A2.1.4. Organic carbon (%m/m) in the silt/clay fraction (<63µm) at North Tyne in 2011.

2.1.4.3 Sediment contaminants

2.1.4.3.1 TBT

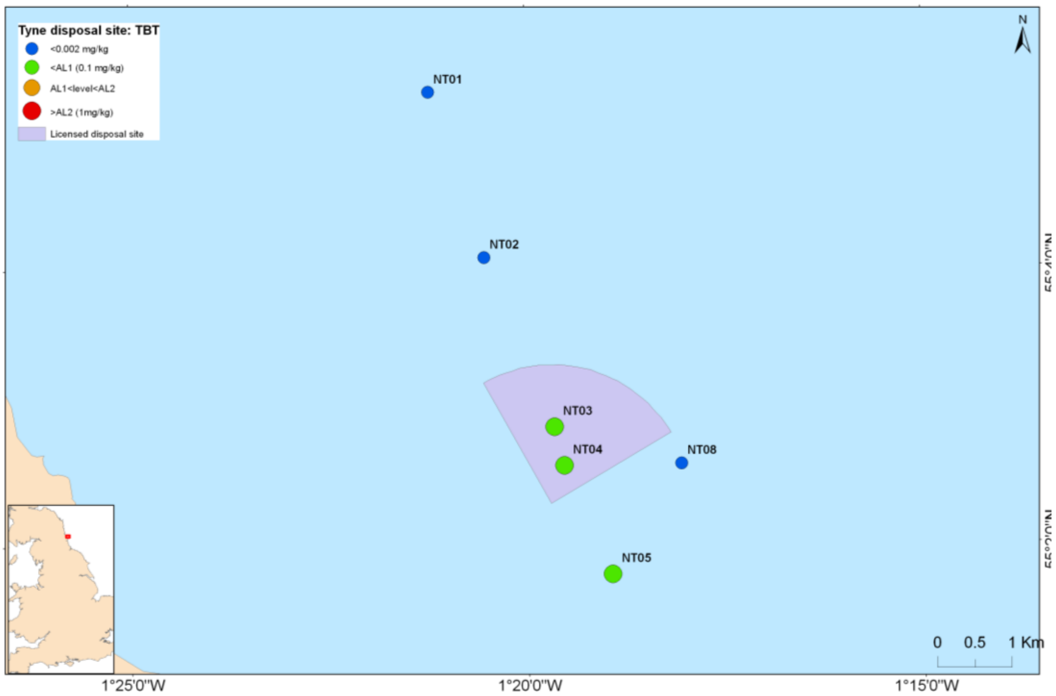


Figure A2.1.5. TBT at North Tyne disposal site in 2011.

TBT was detected at NT3 and NT4, both located within the disposal site, and at station NT5 (south of the disposal site). Levels of TBT recorded for these stations remained below Cefas AL 1 (Figure A2.1.5). When compared to concentrations observed in 2010 (Bolam et al., 2011), TBT at NT4 was found to be similar, whereas a slight increase in TBT is observed for NT5.

Levels of TBT and DBT were below the method limit of detection (0.002mg/kg) for stations outside the disposal site (NT1, NT2 and NT8; Figure A2.1.5); this observation is consistent with that for the last 5 years. The total loading of TBT disposed to North Tyne (either from capital or maintenance dredging) halved from 2009 to 2010.

Overall, the findings are very similar to previous years in terms of TBT concentrations for this region.

2.1.4.3.2 PAHs

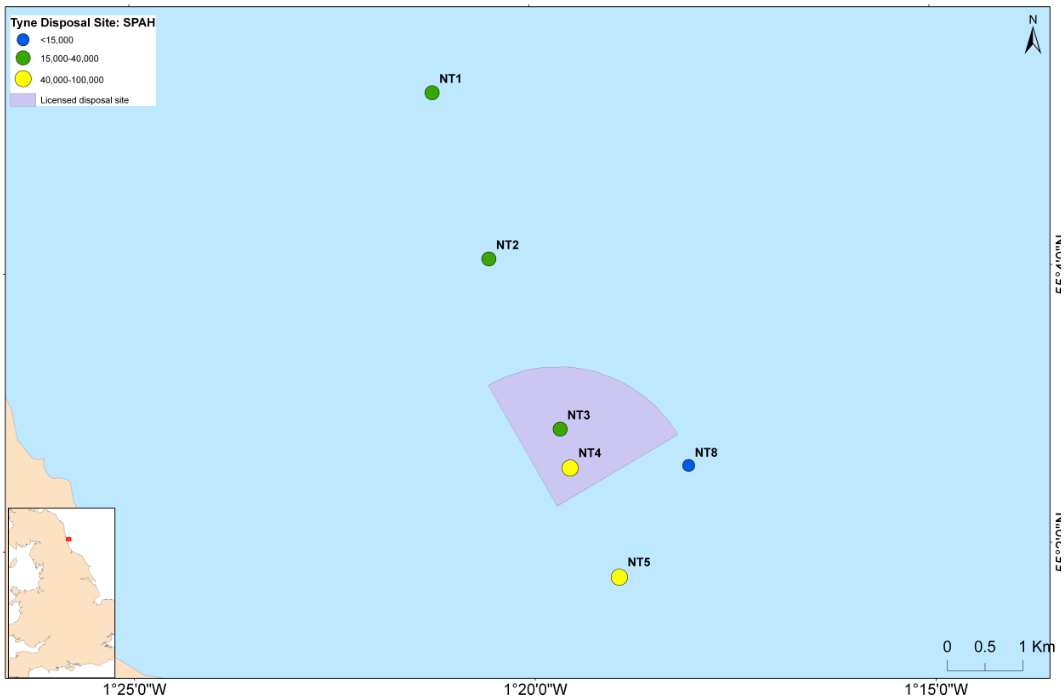


Figure A2.1.6. Summed PAH concentrations (µg kg^{-1}dry weight) for stations sampled in 2011 at North Tyne.

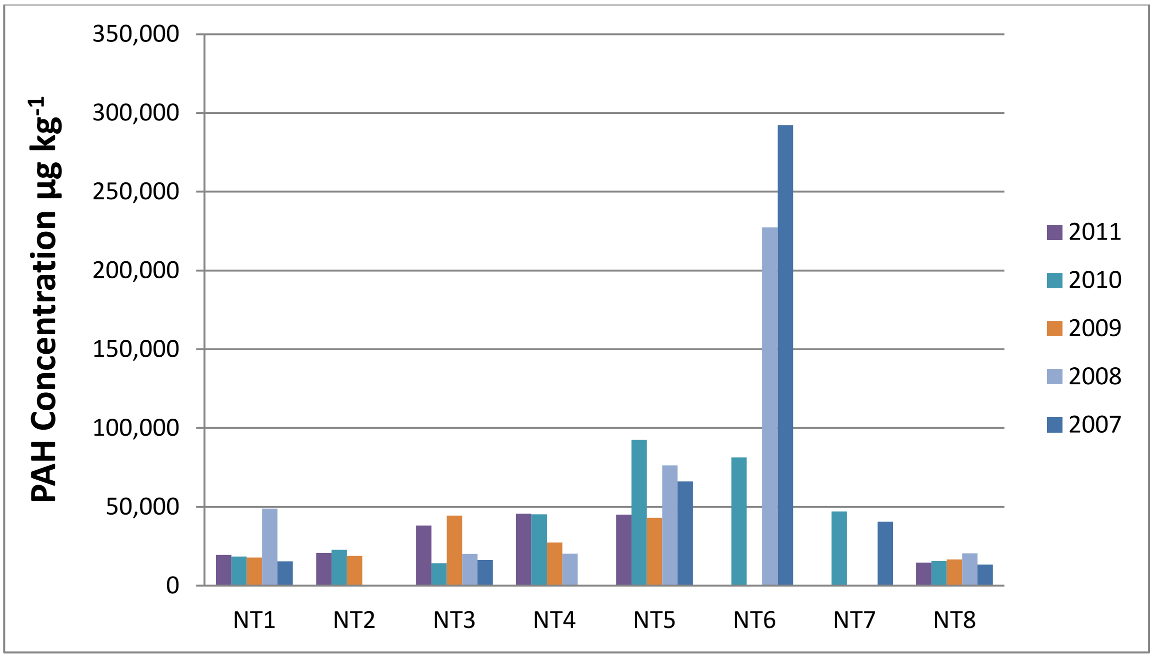


Figure A2.1.7. Summed PAH concentrations (µg kg^{-1}dry weight) for North Tyne stations sampled during 2007 to 2011.

The highest summed PAH concentration observed in 2011 at North Tyne was 45,700 µg kg^{-1}, at NT4 (within the disposal site; Figure A2.1.6)). This is very similar to the concentration found at this station in 2010, i.e., 45,200 µg kg^{-1} dry weight (Figure A2.1.7) (Bolam et al., 2011). The highest concentration found in 2010 (at NT5, south of the disposal site) was 92,500 µg kg^{-1} dry weight. In 2011, concentration at this station was reduced (45,100 µg kg^{-1} dry weight), albeit approximately the same as that found at NT4.

The concentrations found at NT1 and NT2 have not changed since last year's sampling survey, potentially indicating that there is little movement of deposited material to the north of the disposal site. Concentrations of approximately 20,000 µg kg^{-1} dry weight were found to the north of the disposal site, consistent with concentrations seen in previous years (Figure A2.1.7). Compared to 2010, summed PAH concentrations have increased at NT3 while decreased at NT5. This could be simply due to material actually being disposed more centrally within the disposal site.

The lowest summed PAH concentration in 2011 was 14,700 µg kg^{-1} dry weight found at NT8 off the eastern corner of the disposal site: this is consistent with concentrations found there in previous years (Figure A2.1.7). This may imply there is little easterly movement of disposed material off the disposal site.

It is perhaps unfortunate that samples could not successfully be taken at NT6 or NT7; the former has displayed very high values in the past (during 2007 & 2008) although concentrations found in 2010 were relatively lower (although still high) and comparable to those found at NT5 in that year.

All sediment samples collected in 2011 at North Tyne exceeded the ERL for low molecular weight (LMW) PAHs. Sediments from NT3, NT4 and NT5 also exceeded the ERM for LMW PAHs. All sites sampled, except NT8, exceeded the ERL for the high molecular weight (HMW) PAHs, but no sites exceeded the ERM for the HMW PAHs. Evaluation of the data indicated that the PAH source in all the sediment samples was predominantly petrogenic, generally with > 80 % of the PAH content arising from oil sources.

2.1.4.3.3 Organohalogens

At North Tyne, CBs were detected at all stations (∑ICES7 CBs ranged 1.1-11.9 µg/kg dw). Concentrations of CBs were lowest to the north of the disposal site, generally close to LODs, with low concentrations also east of the disposal site at NT8 (Figure A2.1.8). The highest CB concentration was found at NT3 within the disposal site (∑ICES7 CBs 11.9 µg/kg dw) with the next highest concentrations also found within the licensed boundary at NT4 (∑ICES7 CBs 5.8 µg/kg dw).

BDEs were detected at all stations (∑11 BDEs ranged 1.4-7.1 µg/kg dw). In harmony with ∑ICES7 CBs, concentrations of BDEs were also lowest to the north and east of the disposal zone (Figure A2.1.9). In contrast to ∑ICES7 CBs, however, BDE concentrations at NT3 (within the disposal site) were relatively low. The highest concentration of 7.1 µg/kg dw was found at NT4 inside the disposal site.

BDE47 and BDE99 are the dominant congeners present, indicative of the pentaBDE technical mixture, but BDE183 was also detected, suggesting that the octaBDE or decaBDE technical mixture was also in use. Penta and octa technical mixtures are no longer in use, having been banned in the EU since 2004. Looking at levels over the wider area, the Tyne disposal site has higher BDE concentrations than the Souter Point disposal site.

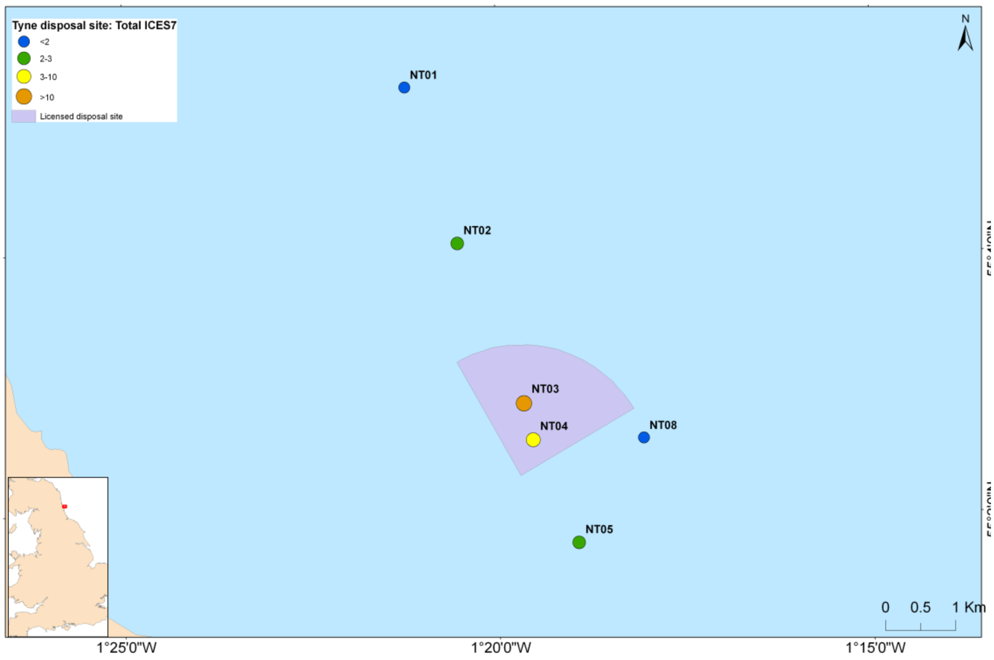


Figure A2.1.8. ∑ ICES7 CB concentrations for the North Tyne Stations, 2011.

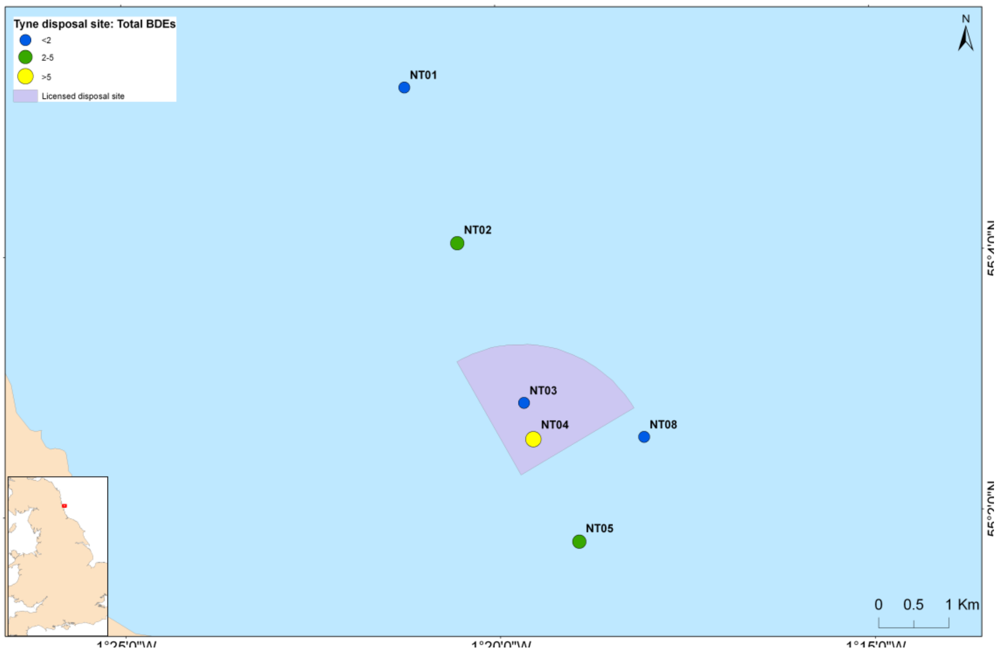


Figure A2.1.9. ∑ 11 BDEs concentrations for the North Tyne Stations, 2011.

BDE209 was detected at all stations (Figure A2.1.10) and at higher concentrations than the other measured organohalogens (range 7.2-108 µg/kg dw). When included with the other BDEs, BDE209 made up >80 % of the BDEs present (range 79-95 %). BDE209 is indicative of the decaBDE technical mixture which has been in use more recently than the other technical mixtures, although its use has also now been restricted in the EU (since 2008). The highest concentration of 108 µg/kg dw was detected at NT4 within the disposal site (Figure A2.1.10). The next highest concentration of 43 µg/kg dw was found to the south of the disposal site at NT5, with 22 µg/kg dw found at NT3 within the disposal site. Other stations were all <11 µg/kg dw.

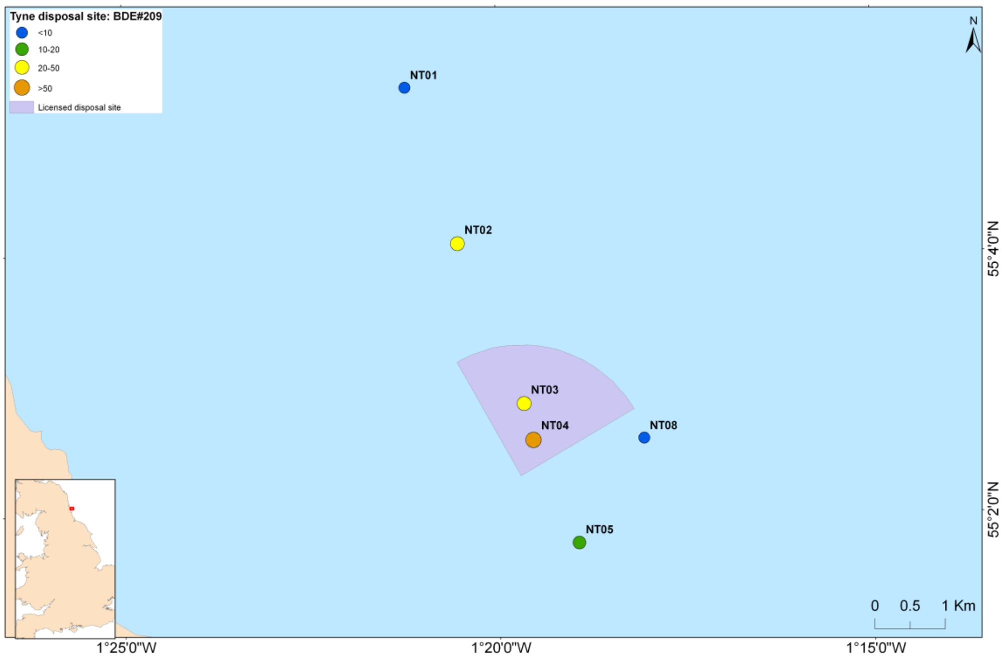


Figure A2.1.10. BDE209 concentrations for the North Tyne Stations, 2011.

Concentrations of CBs were mostly below FEPA action levels (ALs). The exception was NT4 which was above AL 1 for CBs. No FEPA AL exists for BDEs including BDE209. According to the OSPAR guidelines, most stations had 'good' environmental status for all ICES 7 CBs and 'good' status overall. NT4 and NT5 had 'bad' environmental status for CB118 but 'good' status overall. NT3 had 'bad' environmental status for CB118 and CB101, and therefore 'bad' status overall. No OSPAR guidelines exist for BDEs at present.

There are sufficient data available to analyse temporal trends in organohalogens from 2006 to 2011 (Tables A2.1.3 – A2.1.5). For CBs there are no clear trends, with some stations showing increases and other showing decreases. Levels of CBs at stations NT1 and NT8 are very similar to previous years, and levels at NT4 have halved since last measurements were made. However, levels at NT2 and NT3 are the highest they have been over this period. ∑11 BDEs show slight increases since 2010 for all stations except NT8. BDE209 also increased at all stations except for NT8, with a threefold increase at NT2 and NT3.

Table A2.1.3. Temporal trends (2006-2011) of ∑ICES 7 CBs concentration (in µg/kg dw) at North Tyne.

Station code	∑ICES 7 CBs concentration (in µg/kg dw)					
	2006	2007	2008	2009	2010	2011
NT1	1.54	0.97	2.11	0.93	0.98	1.13
NT2				1.69	1.63	2.66
NT3	1.48	2.03	1.79	4.12	1.63	11.9
NT4	7.21		*0.7*	4.58	11.0	5.84
NT8	5.21	2.03	0.81	*0.7*	1.12	1.10
NT5	2.7	7.59	6.05	3.24	11.9	2.72
NT6	2.44	2.54	3.88		2.09	
NT7		1.55			1.76	

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

Table A2.1.4. Temporal trends (2006-2011) of ∑11 BDEs concentration (in µg/kg dw) at North Tyne.

Station code	∑11 BDEs concentration (in µg/kg dw)					
	2006	2007	2008	2009	2010	2011
NT1	1.56	1.68	1.27	0.95	0.93	1.92
NT2	5.28			1.27	1.84	2.12
NT3	1.72	1.54	0.49	2.55	0.52	1.84
NT4	13.2		0.28	1.27	4.18	7.10
NT8	1.86	2.84	1.42	0.74	1.65	1.40
NT5	2.18	4.49	0.96	5.89	1.31	2.10
NT6	7.69	4.12	1.18		1.34	
NT7		1.77			0.84	

Note, 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

Table A2.1.5. Temporal trends (2008-2011) of BDE209 concentration (in µg/kg dw) at North Tyne.

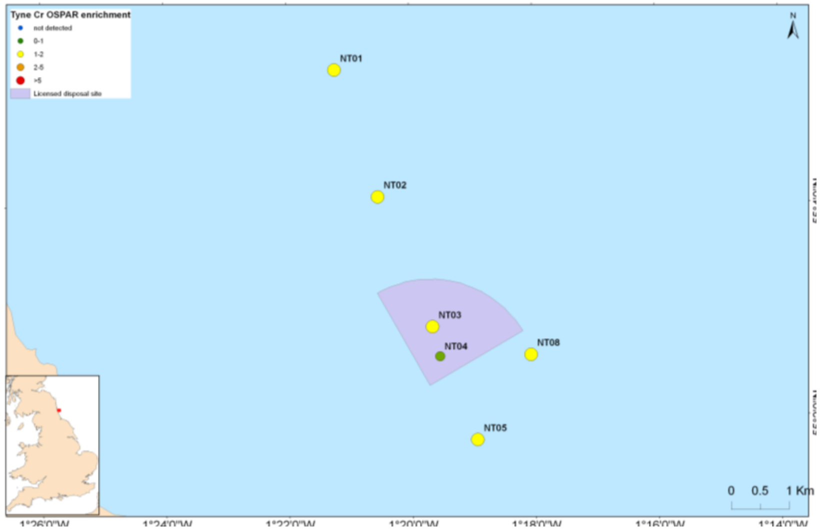
Station code	BDE209 concentration (in µg/kg dw)			
	2008	2009	2010	2011
NT1	104.2	11.46	3.93	7.33
NT2		12.23	12.2	42.9
NT3	2.72	48.54	7.91	21.6
NT4	0.78	36.11	95.5	108
NT5	6.21	11.94	6.64	10.6
NT6	6.15		8.69	
NT7			17.5	
NT8	8.03	8.95	20.1	7.21

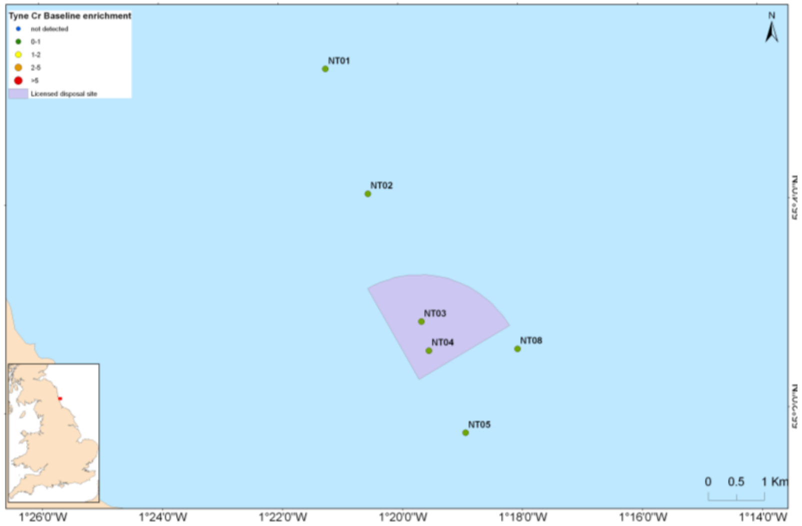
2.1.4.3.4 Trace metals

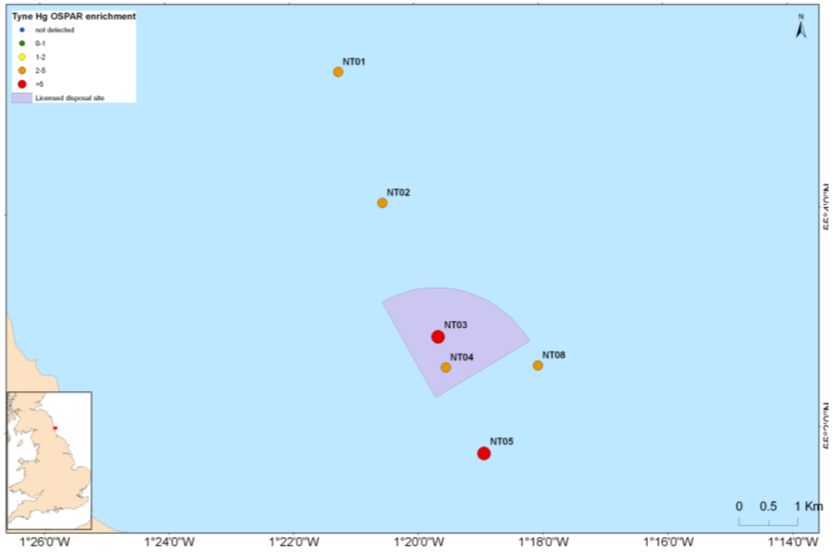
Assessment of metals enrichment shows that slight enrichment is observed for As at NT3 within the disposal site; no enrichment is recorded for any other station. Both methods, OSPAR BAC and baseline values, show similar observations. A transect of Cr enrichment is observed from north to south of the disposal site, with peaked enrichment at NT3. As for As, both OSPAR BAC and baseline values show similar observations. Cr (Figure A2.1.11) and Ni are slightly enriched with the OSPAR assessment but since the baseline values for this region are higher than the OSPAR BAC value (refer to Table A1.4.1 in Appendix 1), stations within and south of the disposal site show no enrichment when using the regional baseline approach. Cu is slightly enriched at NT3 (within the disposal site) while not enriched elsewhere for both assessment approaches.

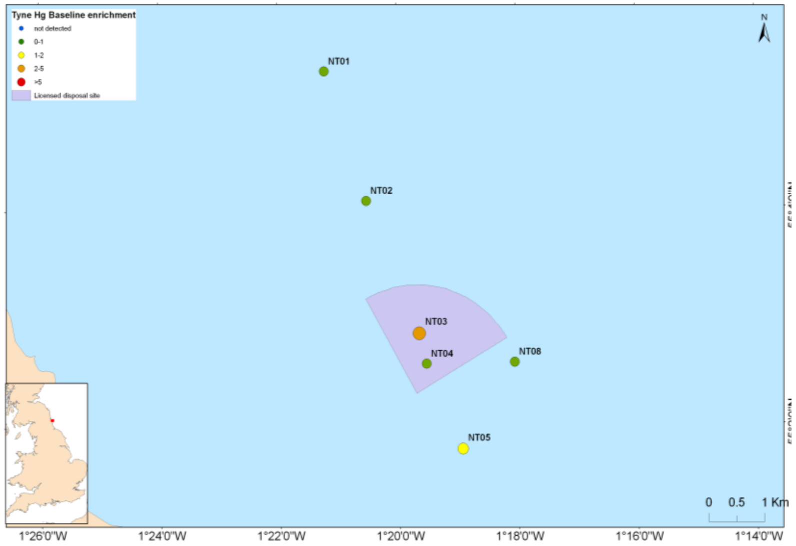
Hg (Figure A2.1.11) is moderately to highly enriched according to OSPAR BAC. However, when compared to the regional baseline values, only NT3 displays any enrichment. Similarly, enrichment (from moderate to high) is observed for Pb and Zn (Figure A2.1.11) at most stations when assessed against OSPAR BACs; the regional baseline approach only depicts enrichment at stations within the disposal site.

Thus, metals concentrations tend to be much higher than the OSPAR BAC values especially for Hg, Pb and Zn. This is generally due to the legacy from the historical and current industrial activities of the area and the elevated concentrations reflecting the natural mineralogy of the region. When assessing these concentrations against the proposed baseline values, which were derived by taken into account for regional variability, enrichment is occasionally observed, but to a significantly reduced level. These findings are comparable with those observed during 2010 for this disposal site.


Tyne Cr OSPAR enrichment
not detected
0-1
1-2
2-5
>5
Licensed disposal site
N
NT01
NT02
NT03
NT04
NT08
NT05
0 0.5 1 Km


Tyne Cr Baseline enrichment
not detected
0-1
1-2
2-5
>5
Licensed disposal site
N
NT01
NT02
NT03
NT04
NT08
NT05
0 0.5 1 Km
1°26'0"W
1°24'0"W
1°22'0"W
1°20'0"W
1°18'0"W
1°16'0"W
1°14'0"W


Tyne Hg OSPAR enrichment
not detected
0-1
1-2
2-5
>5
Licensed disposal site
N
NT01
NT02
NT03
NT04
NT08
NT05
0 0.5 1 Km
1°26'0"W
1°24'0"W
1°22'0"W
1°20'0"W
1°18'0"W
1°16'0"W
1°14'0"W


Tyne Hg Baseline enrichment
not detected
0-1
1-2
2-5
>5
Licensed disposal site
N
NT01
NT02
NT03
NT04
NT08
NT05
0 0.5 1 Km
1°26'0"W
1°24'0"W
1°22'0"W
1°20'0"W
1°18'0"W
1°16'0"W
1°14'0"W

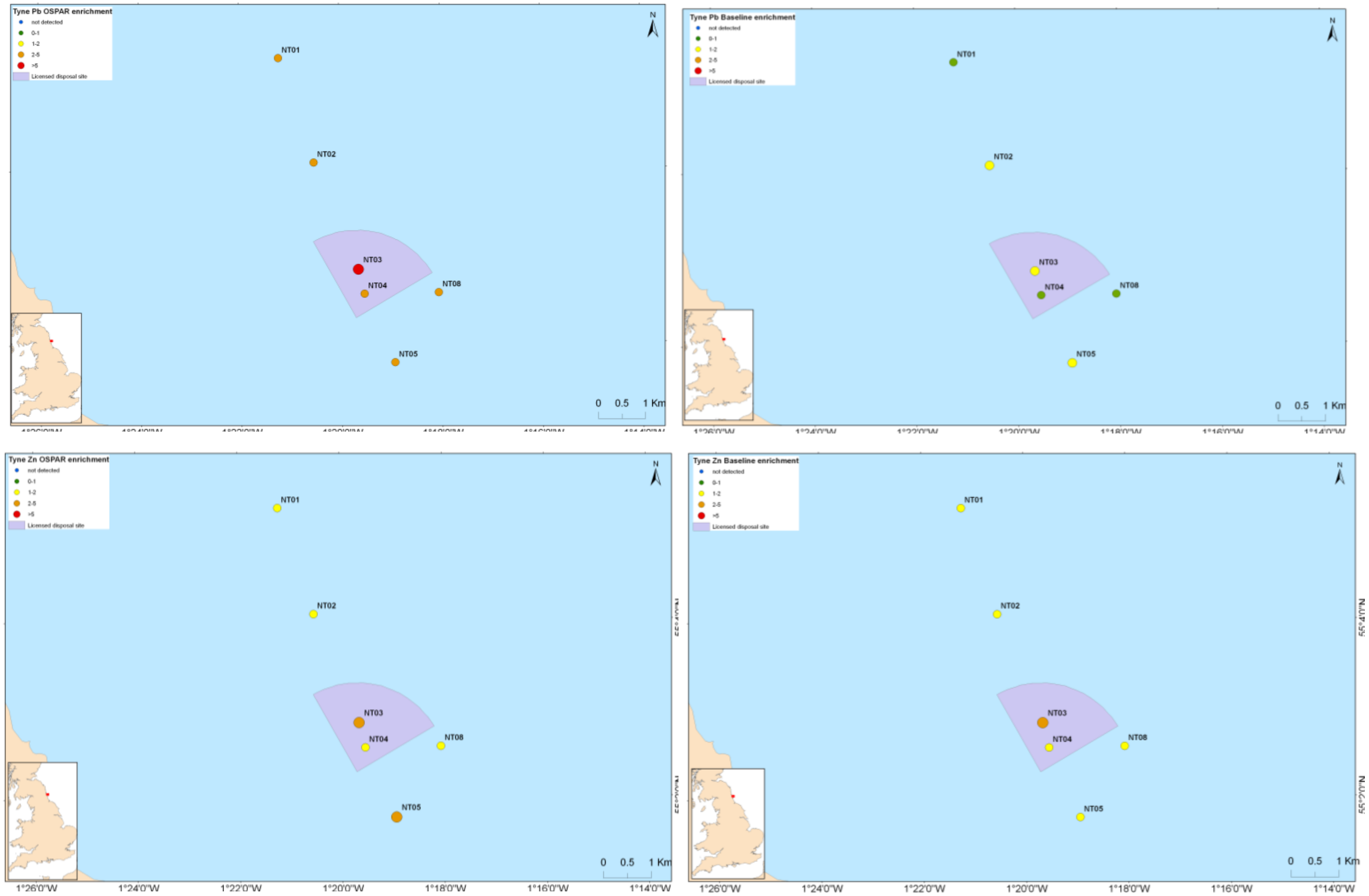


Figure A2.1.11. Enrichment to OSPAR BACs (left) and Baseline values (right) at North Tyne for Cr, Hg, Pb and Zn.

2.2 Souter Point (TY081)

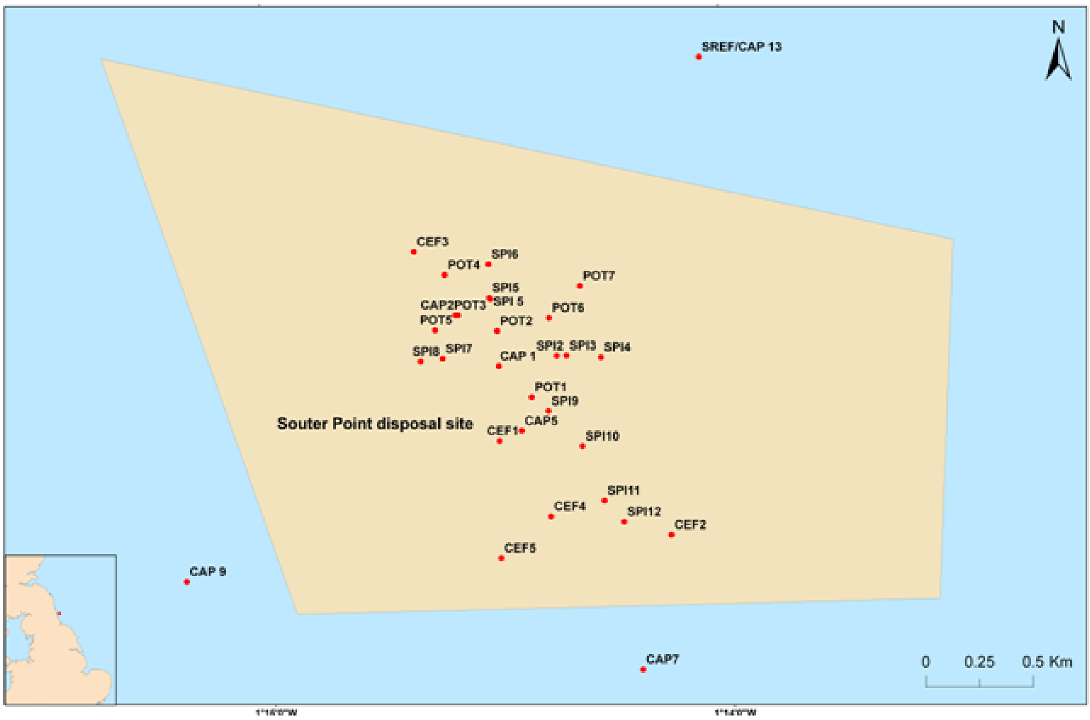


Figure A2.2.1. Location of sampling stations at Souter Point, 2011.

2.2.1 Background

The sediments within the vicinity of Souter Point are muddy sands. However, sediments may vary to a large extent from this following dredged material disposal and in response to its history of solid industrial wastes discharged inshore. The disposal site is located at a depth of approx. 40m, but this shallows by up to 5 m at the inshore end due to historical accumulations of minestone and fly-ash concretions. Tidal currents in the environs of the site are moderate in strength and run generally parallel with the coastline with a net residual drift southwards.

Between December 2004 and April 2005, a trial level bottom-capping project was undertaken within the centre of the disposal site. The Port of Tyne disposed 60,000 m^3 of contaminated dredged material (CDM), which was to be covered with 100,000 m^3 of silt and around 60,000 m^3 of sand. On placement of the silt around 80% was siphoned off, leaving a 1.5m cap; 90,000 m^3 of sand was later placed on top. Further material was deposited in 2006 and 2007 to attempt to ensure isolation of the CDM. During this time the maintenance dredged material from the Tyne was disposed of to the North Tyne site (TY070). As detailed briefly in Section 2.1.1 regarding North Tyne, material dredged from the Tyne under a new three-year licence is expected at Souter Point during early 2011; a phased management plan will be devised to minimise the potential of this material interfering with the cap.

RAT prioritisation assessment: Tier 1

- where there is the potential for the occurrence of elevated contaminant concentrations (between Cefas action levels of 1 and 2 in proposed dredge sediments) (Appendix 1) arising from historical or current activities at source (especially heavily urbanised/industrialised estuaries).
- that have been observed or pose an increased risk to the surrounding area and receptors.
- identified as 'sites of local concern' by public, pressure groups, NGO's etc.

Concerns:
Following the trial capping project undertaken at this site (see above), there are current concerns regarding the integrity of the cap, specifically related to cap thickness.

2.2.2 Impact hypotheses

- No migration of cap material outside original disposal footprint, measurable using acoustic data (SSS,SPI Multibeam) to show no long-term movement of the cap
- Cap integrity is maintained with no leakage of CDM to surrounding area
- Any adverse effects on the benthic biota will be confined to within and the near vicinity of the disposal site, principally along the tidal axis
- Effects within the disposal site will be limited to periodic and localised reductions in the densities/diversity of the benthos, *i.e.*, the disposal site will at no time be characterised as azoic
- The wider dispersal of fine particulates arising from dredgings disposal, including any wave-induced shoreward transport, will have no adverse consequences for the marine biota or for recreational/amenity interests

2.2.3 Parameters monitored

Sidescan sonar (SSS) and multibeam (MB)
Sediment particle size distribution
Sediment organic carbon and nitrogen
Macrofaunal communities
Sediment Profiling Imaging (SPI)
Sediment contaminants (TBT, PAHs, organohalogens, trace metals).

2.2.4 Results

2.2.4.1 Sidescan and multibeam

The Souter Point dredged disposal site was surveyed utilising a Kongsberg EM3002D multibeam echosounder and Edgetech 4200FS sidescan sonar in June 2011. The acquired data indicated that the seabed within the licensed boundary is relatively flat with an average water depth of 40 m. The northwest corner of the site is shallower than the surrounding seabed, with depths reducing to 37 m; the site deepens to the east reaching a maximum depth of 52 m (Figure A2.2.2). Muddy sands dominate the area with a central cap of fine sand. The acoustic survey did not span the entire extent of the disposal site, however 100% coverage of the area surrounding the cap was achieved (Figure A2.2.2).

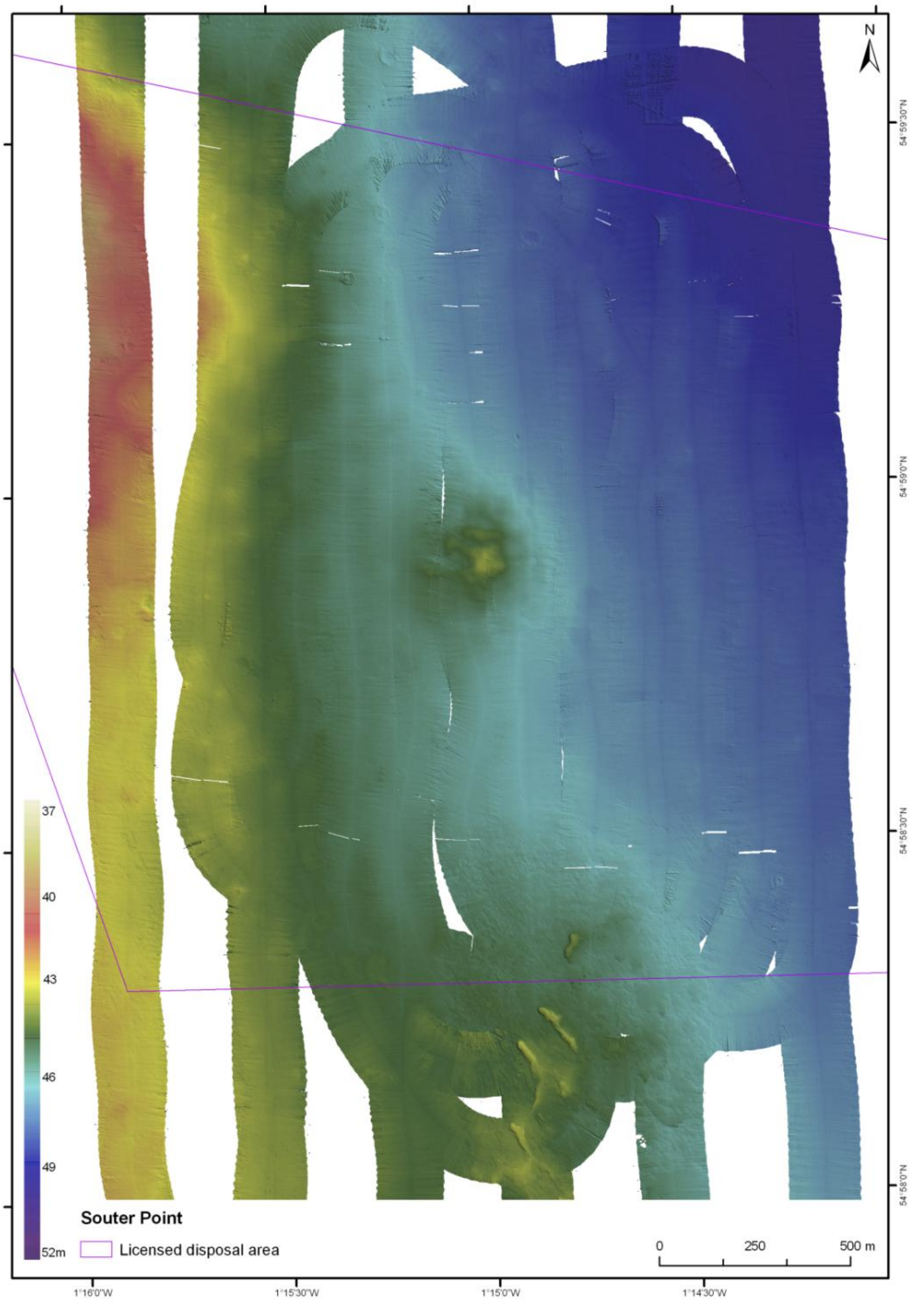


Figure A2.2.2 Multibeam bathymetry collected at Souter Point June 2011.

Particle size analysis (PSA) samples were collected using a Day Grab. These PSA samples were used to aid interpretation of the acoustic data, including the multibeam backscatter and sidescan sonar. The backscatter derived from the multibeam has a stronger return directly on the capping area with the surrounding sediments emitting a slightly weaker strength return. There are patches of higher return in the northern section of the acoustic coverage and also directly south of the cap. The cap is distinguishable from that of the surrounding sediments and the sidescan sonar data also highlight the central sandy cap of the disposal site (Figure A2.2.3).

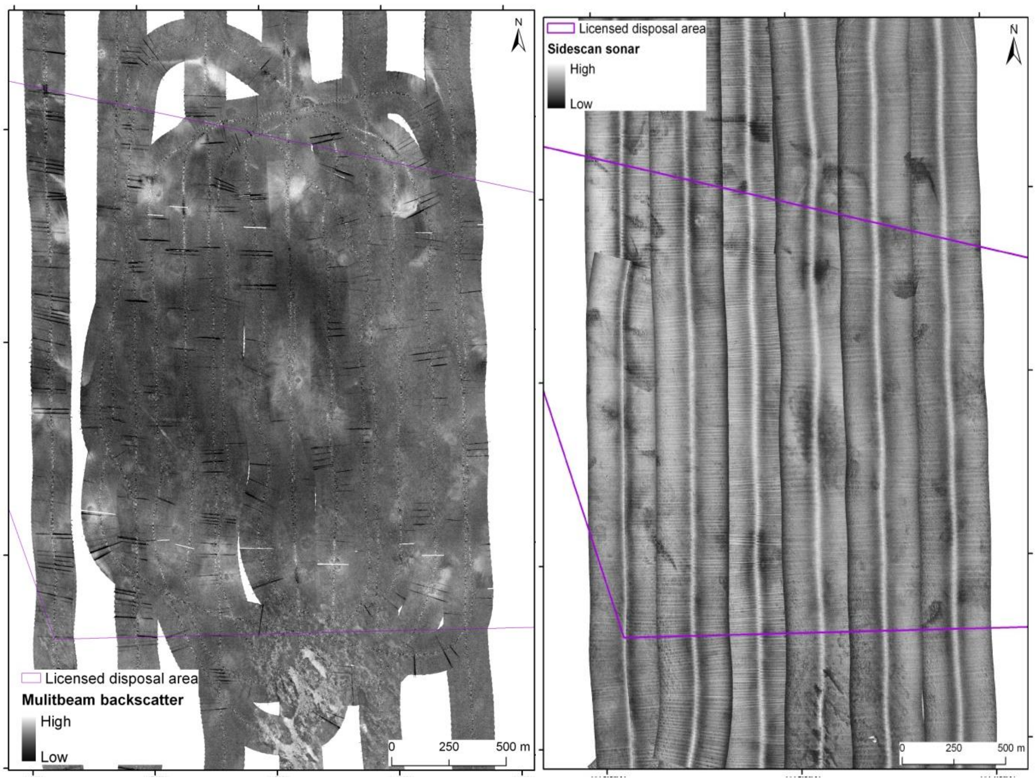


Figure A2.2.3. Multibeam backscatter (left) and sidescan sonar (right) collected in June 2011.

Figure A2.2.4 presents the interpretation of the acoustic data. The central cap consists of sand with slightly gravelly muddy sand surrounding it; this sandy cap has a strong backscatter return and high relief on the bathymetry. The majority of the sediments outside of the sandy cap are muddy sands with the northern section of the acoustic area having patches of muddy gravelly sands in pockets. The southern section of the site is dominated by sandy mud and muddy gravelly sand. The higher backscatter returns linked to gravelly sediments are easily indentified on the acoustic data.

Figure A2.2.4 also includes the cap limits during 2005 and 2010 as identified from interpretation of data acquired at the time. Inter-annual comparisons must be made with caution as survey conditions and processing settings may have an influence. However, with this in mind, it appears that the sand associated with the capping layer in 2011 is smaller in extent compared to previous years, and is more centralised in shape (Figure A2.2.4).

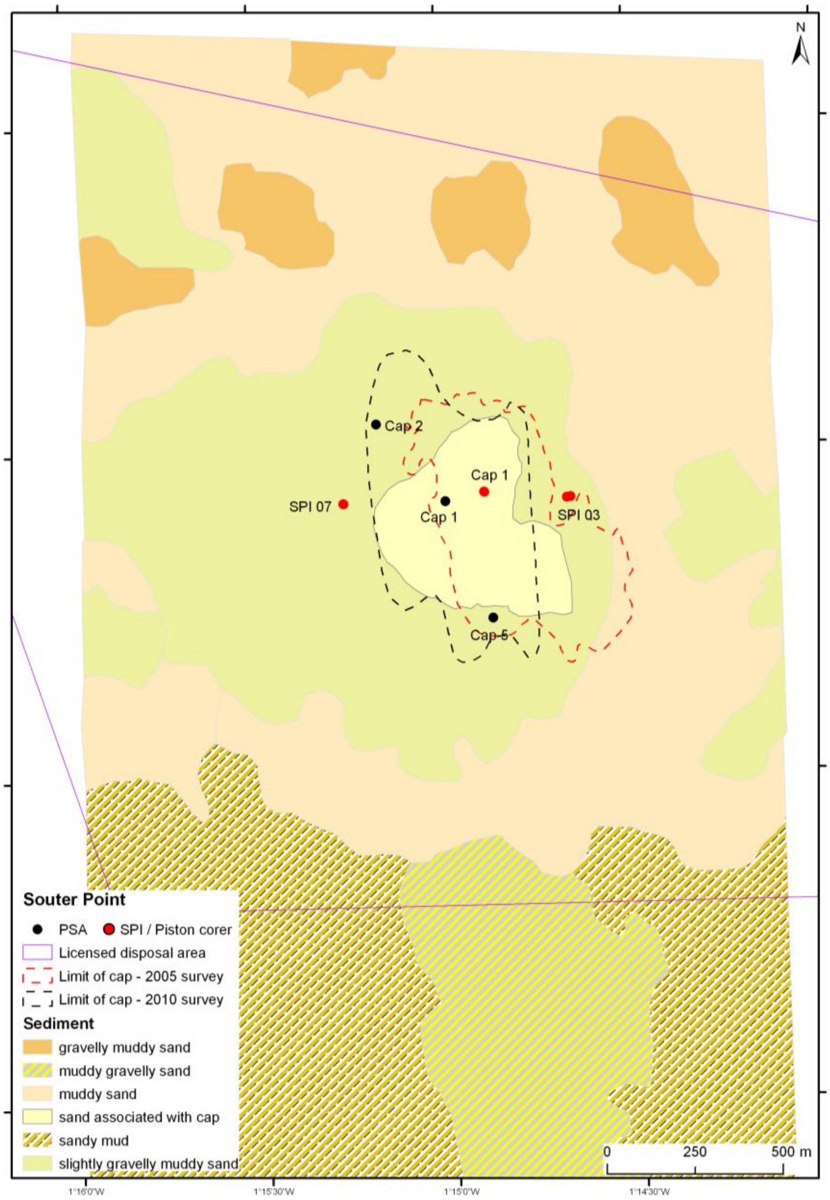


Figure A2.2.4. Interpretation of the multibeam backscatter and sidescan sonar data from 2011 at Souter Point. Limits of cap identified from acoustic surveys during 2005 and 2010 are also superimposed.

Figure A2.2.5 illustrates the bathymetric differences between the 2005 and 2011 acoustic surveys. Note, the placement of the trial cap was completed in April 2005 and the 2005 acoustic data collected in June. Unsurprisingly, the results indicate that there has been an accretion of material in the locality of the disposal cap. It must be noted that the multibeam system used to acquire the data and the tidal correction models applied post survey may account for some differences.

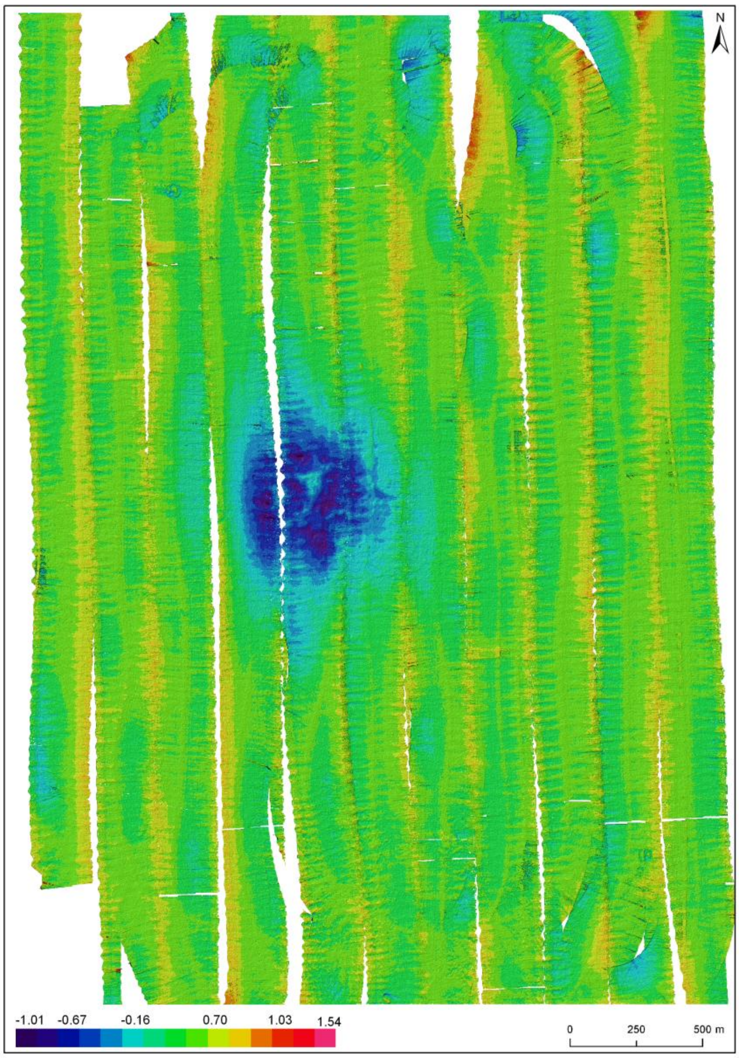


Figure A2.2.5 Bathymetry difference between 2005 and 2011 Souter Point surveys.

The depth scale on Figure A2.2.5 implies removal of sediments from 2011 relative to that of in 2005. Overall, however, the surface statistics indicate that there has been a mean accumulation of 0.36m between the 2005 and 2011 surveys. Comparison with previous year's survey to the 2011 bathymetric survey suggests that there have been obvious changes to the sediment regime in the area. The sandy cap has changed in shape and covers a much smaller footprint compared to preceding years.

<u>2.2.4.2 Sediment particle size</u>

Souter Point sediments are predominantly muddy sands, with some gravelly sands, unimodal sands and muds (Table A2.2.1). Sediment groups derived in 2011 for the stations sampled are largely similar to those for 2010, the biggest change being observed for CAP9 (Table A2.2.2). Pie charts of gravel, sand and silt/clay are shown for 2011 data in Figure A2.2.6 and silt/clay content in Figure A2.2.7. Sediment group Sp7 (slightly gravelly sand) is expected to represent the sand cap, and this sediment group is exclusively found at CAP1, CAP2, CAP5 and NEWCAP; all within the capping area. In 2007 and subsequent years, sediment at CAP1 and CAP5 are more mixed with a higher gravel content, possibly reflecting the addition of further capping material. In 2011 at CAP5, the sediment is classed as group Sp7 suggesting further addition of capping sand; the silt/clay content has also reduced from >10 % in 2010 to <8 % in 2011 (Figure A2.2.7).

Table A2.2.1 Average sediment descriptions and statistics for each sediment group at Souter Point.

Sediment group	Number of samples	Sample Type	Sediment description	MODE 1 (µm):	MODE 2 (µm):	MODE 3 (µm):
Sp1	6	Bimodal, Poorly Sorted	Slightly Gravelly Sandy Mud	107.5	26.7	
Sp2	19	Bimodal, Poorly Sorted	Slightly Gravelly Muddy Sand	107.5	26.7	
Sp3	26	Trimodal, Very Poorly Sorted	Gravelly Muddy Sand	107.5	215	26.7
Sp4	30	Unimodal, Poorly Sorted	Slightly Gravelly Muddy Sand	215.0		
Sp5a	3	Polymodal, Very Poorly Sorted	Gravelly Muddy Sand	107.5	1700	215
Sp5b	2	Polymodal, Very Poorly Sorted	Muddy Sandy Gravel	107.5	19200	427.5
Sp6	11	Unimodal, Poorly Sorted	Gravelly Sand	215		
Sp7	23	Unimodal, Moderately Well Sorted	Slightly Gravelly Sand	152.5		

Sediment group	Gravel (%)	Sand (%)	Silt/clay (%)	Very coarse sand (%)	Coarse sand (%)	Medium sand (%)	Fine sand (%)	Very fine sand (%)
Sp1	0.32	44.55	55.12	0.42	1.14	6.16	17.50	19.34
Sp2	1.95	75.05	23.00	1.49	3.82	11.84	30.78	27.12
Sp3	8.43	72.42	19.16	4.75	8.62	15.70	18.90	24.45
Sp4	1.31	84.54	14.15	1.25	4.87	21.95	37.19	19.28
Sp5a	24.42	58.29	17.30	14.35	7.95	8.96	10.72	16.30
Sp5b	33.56	52.69	13.75	5.08	5.69	9.81	11.05	21.06
Sp6	10.23	84.35	5.42	3.71	7.97	25.85	38.57	8.24
Sp7	1.47	96.51	2.03	0.76	3.21	15.13	65.68	11.73

Table A2.2.2 Sediment groups for each sample code between 2005 and 2011 inclusive at Souter Point.

	Year						
Sample code	2005	2006	2007	2008	2009	2010	2011
CAP1	Sp7	Sp7	Sp6	Sp6	Sp6	Sp6	Sp6
CAP2	Sp7	Sp7	Sp7	Sp7	Sp2	Sp4	Sp4
CAP4	Sp4	Sp4	Sp4	Sp6	Sp3	Sp4	
CAP5	Sp7	Sp7	Sp6	Sp6	Sp4	Sp6	Sp7
CAP7	Sp4	Sp4	Sp2	Sp3	Sp4		
CAP9	Sp2	Sp2	Sp2	Sp5a	Sp2	Sp5b	Sp3
NEWCAP	Sp7						
CEF2				Sp4			
POT6				Sp2			
SPI10				Sp2			
SPI5						Sp4	
SPI6						Sp4	
TC2	Sp3	Sp3	Sp3		Sp3	Sp3	
TC3	Sp4	Sp4	Sp4	Sp4	Sp4	Sp4	Sp4
TC4	Sp3	Sp3	Sp3	Sp3	Sp3	Sp3	Sp3

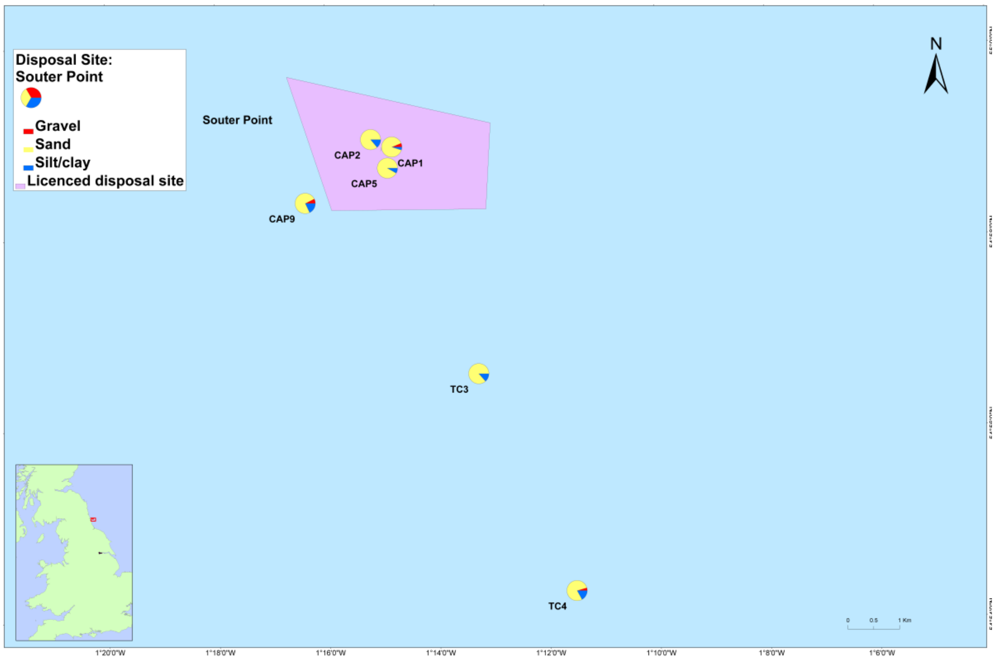


Figure A2.2.6. Pie charts of gravel, sand and silt/clay at Souter Point, 2011.

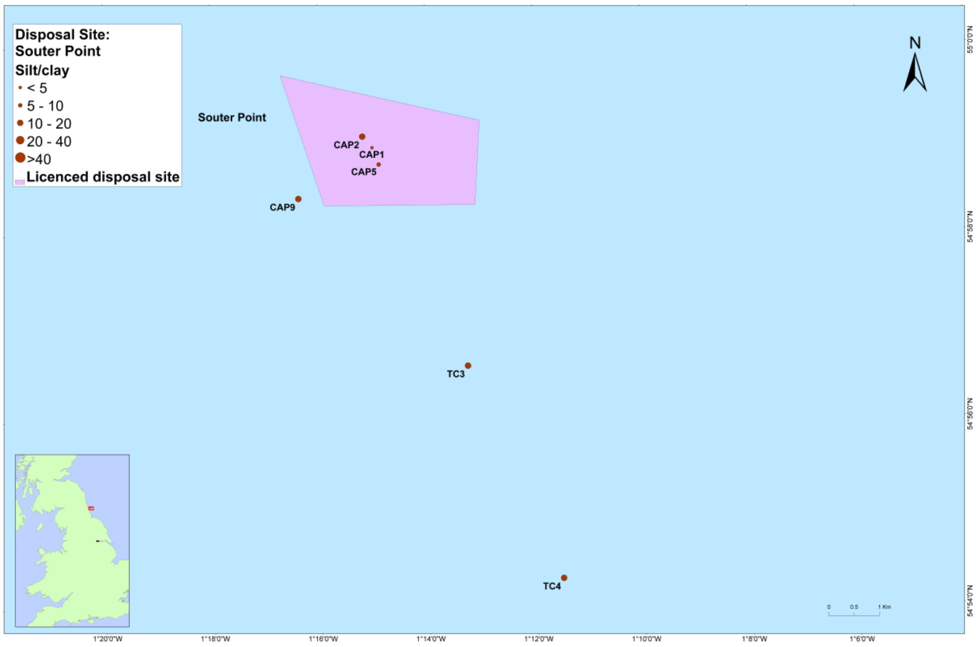


Figure A2.2.7. Silt/clay (%) at Souter Point, 2011.

2.2.4.3 Sediment organic carbon and nitrogen

Sediment organic carbon values (in the <63µm sediment fraction) in 2011 ranged from 3.31 % to 4.2 % m/m (Figure A2.2.8) and 0.26 to 0.33% m/m for nitrogen. These are similar to those obtained between 2006 and 2010 (Bolam et al., 2009; 2011). Sediment organic carbon values (in the <2mm sediment fraction) in 2011 ranged from 1.31 to 6.23% m/m and 0.07 to 0.19% m/m for nitrogen. As observed in 2010, the percentages in the <2 mm fraction are higher than in the <63 µm fraction for some samples, implying that a significant proportion of the organic carbon for this area is present in coarser sediment, possibly as coal.

2.2.4.4 Macrofaunal communities

Macrofaunal analysis identified a total of 2489 individuals and 61 taxa at Souter Point from the six samples collected during 2011 (one replicate for each station). The main taxonomic groups were represented by Annelida (56%), Echinodermata (23%), Mollusca (11%), Miscellanea (5%) and Crustaceans (5%) (Figure A2.2.9). The total abundance of individuals ranged from 101 to 324 per 0.1 m^2 across the study area in 2011. Although some stations (e.g., CAP9, TC3, TC4) showed significantly higher total abundances than other stations, many stations from within and outside the disposal site exhibited comparable numbers of individuals, between 275 and 324 per 0.1 m^2 (Figure A2.2.10a). The total number of species at TC3 was double that sampled at Cap 1 (Figure A2.2.10b). Note, as these data are based on single replicates, some caution must be used in their interpretation (as with the multivariate data below).

Multivariate analyses showed clear separation of Cap1 located in the centre of the disposal site with Cap2 and Cap5, which were also in the disposal area. The benthic communities of the south reference stations (TC3 and TC4) shared some similarity with that of Cap9 (outside the disposal site) (Figure A2.2.11) as observed in previous years (Bolam et al., 2011). This general observation regarding the spatial variability in macrofaunal community structure showed a different pattern, however, when compared to the sampling conducted in 2010, with communities of some of the disposal stations showing similarities with those of the reference stations.

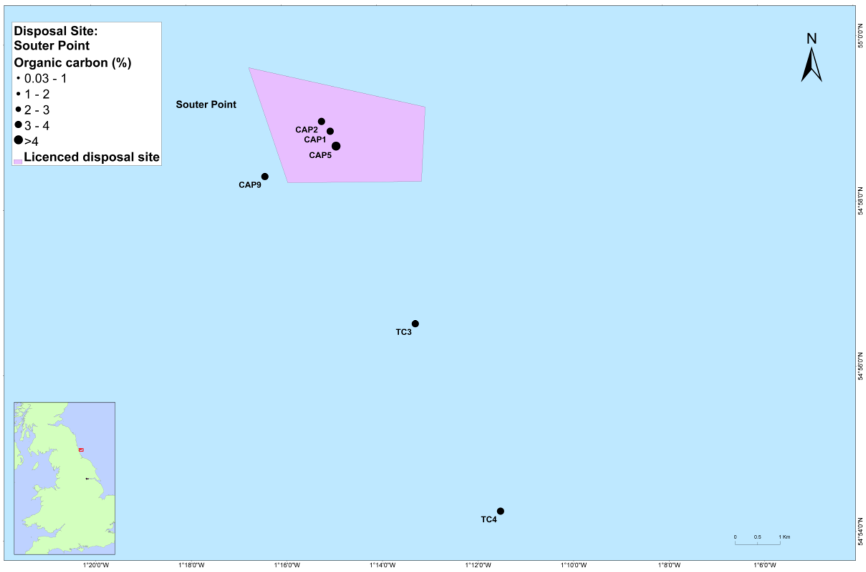


Figure A2.2.8. Organic carbon (% m/m) in the silt/clay fraction (<63 µm) at Souter Point, 2011.

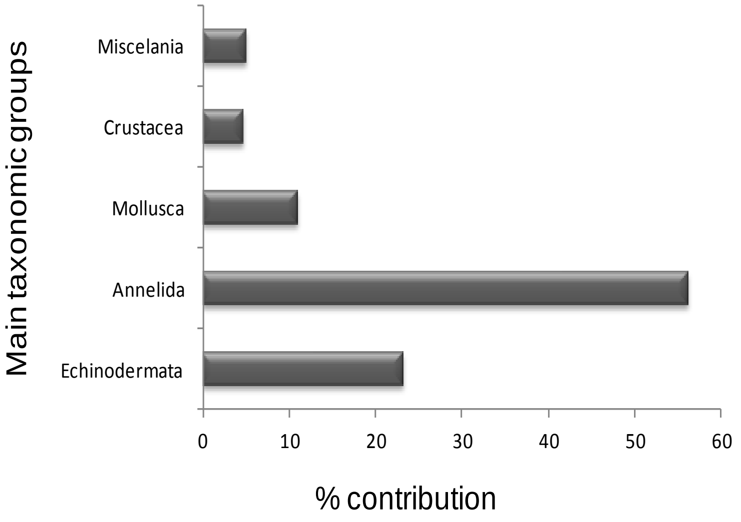


Figure A2.2.9. Percentage numerical contributions of the main taxonomic groups sampled at Souter Point, 2011.

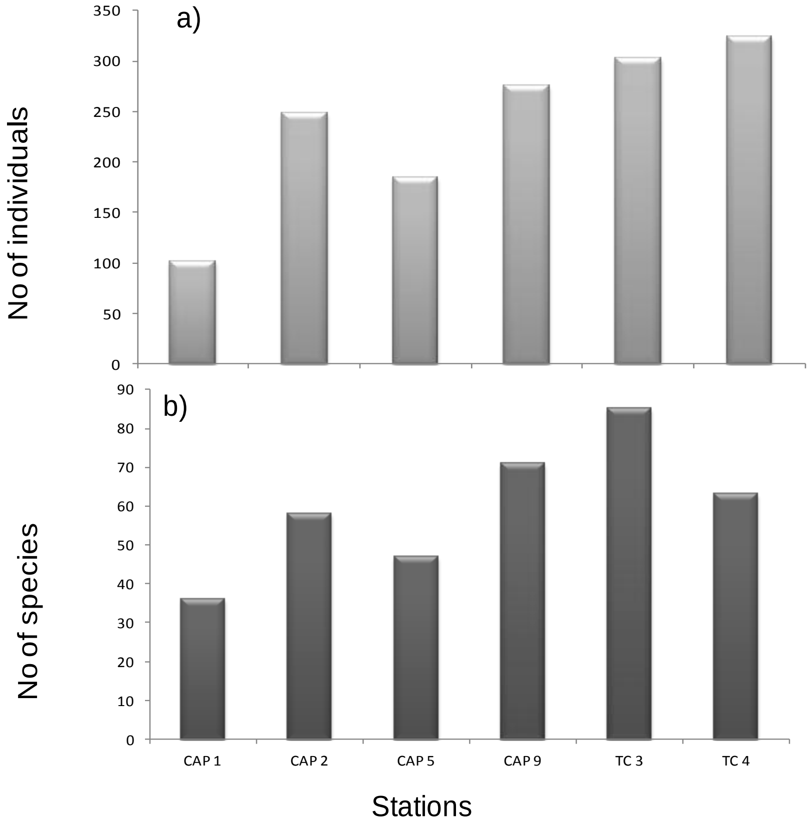


Figure A2.2.10 (a & b). Values (n=1) per 0.1 m^2 for a) total number of individuals and b) total number of taxa for Souter Point, 2011.

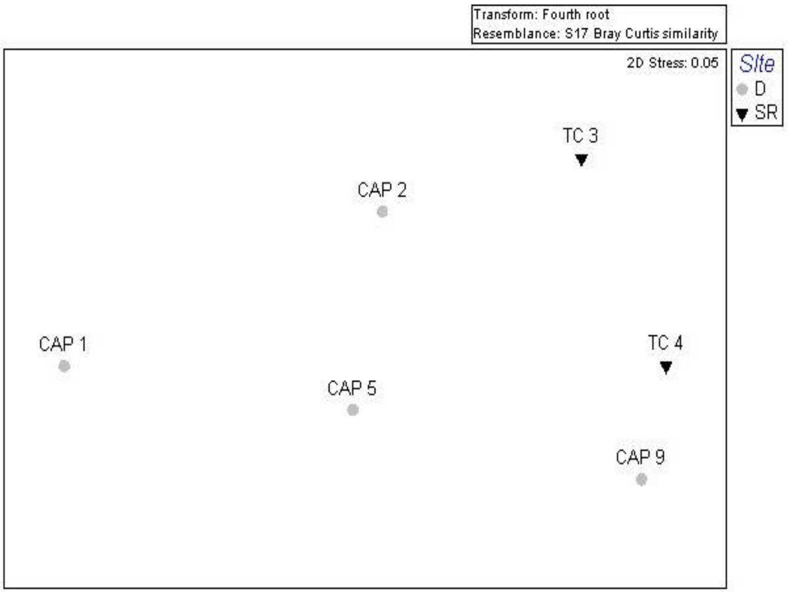


Figure A2.2.11. Multidimensional scaling ordination (based on Bray-Curtis similarity of abundance data following a fourth-root transformation) for macrofauna at Souter Point, 2011.

2.2.4.5 Sediment Profiling Imaging (SPI)

The SPI images obtained during 2011 confirmed the presence of dredged material layers and thin layers of silt and sand in the centre of the disposal site (Figure A2.2.12b-c). There was a limited SPI penetration at Cap1, mainly due to the compacted nature of the sediment layers. There was also some coal fragments observed on the surface of the sediment (Figure A2.2.12a). At Cap7 (located immediately outside the disposal site) there was indication of muddy sediments with the presence of fauna at the sediment surface (*tentative identification corresponds to the bryozoan *Alcyonidium diaphanum*) (Figure A2.2.12d), together with signs of the burrowing echinoderm *Ophiura* sp.

The station POT4 (located north of the disposal site) showed clear evidence of the presence of benthic burrowing infaunal polychaetes and also attached serpulid polychaetes (*tentative identification corresponds to *Pomatoceros* sp.) (Figure A2.2.12e). At SPI12 (one of the southern reference stations) there was also obvious signs of infauna, with burrowing activity in the top surface of the image (Figure A2.2.12f). Data collected at southern stations further away from the cap centre (TC3) showed the presence of fine sediments, surface fauna (e.g. sea pen; *tentative identification corresponds to *Virgularia mirabilis*) and feeding voids observed at sediment depths of 3-4 cm (Figure A2.2.12g).

The overall aRPD calculation ranged from 2.0 to 6.0 cm across the stations (Figure A2.2.12a-g), demonstrating shallow aRPD layers in the disposal site area. There are clear deep aRPD layers at the stations located north and south of the disposal area. The aRPD measured at the reference station was over 5 cm, which corresponded to the biological activity (Figure A2.2.12 f-g).

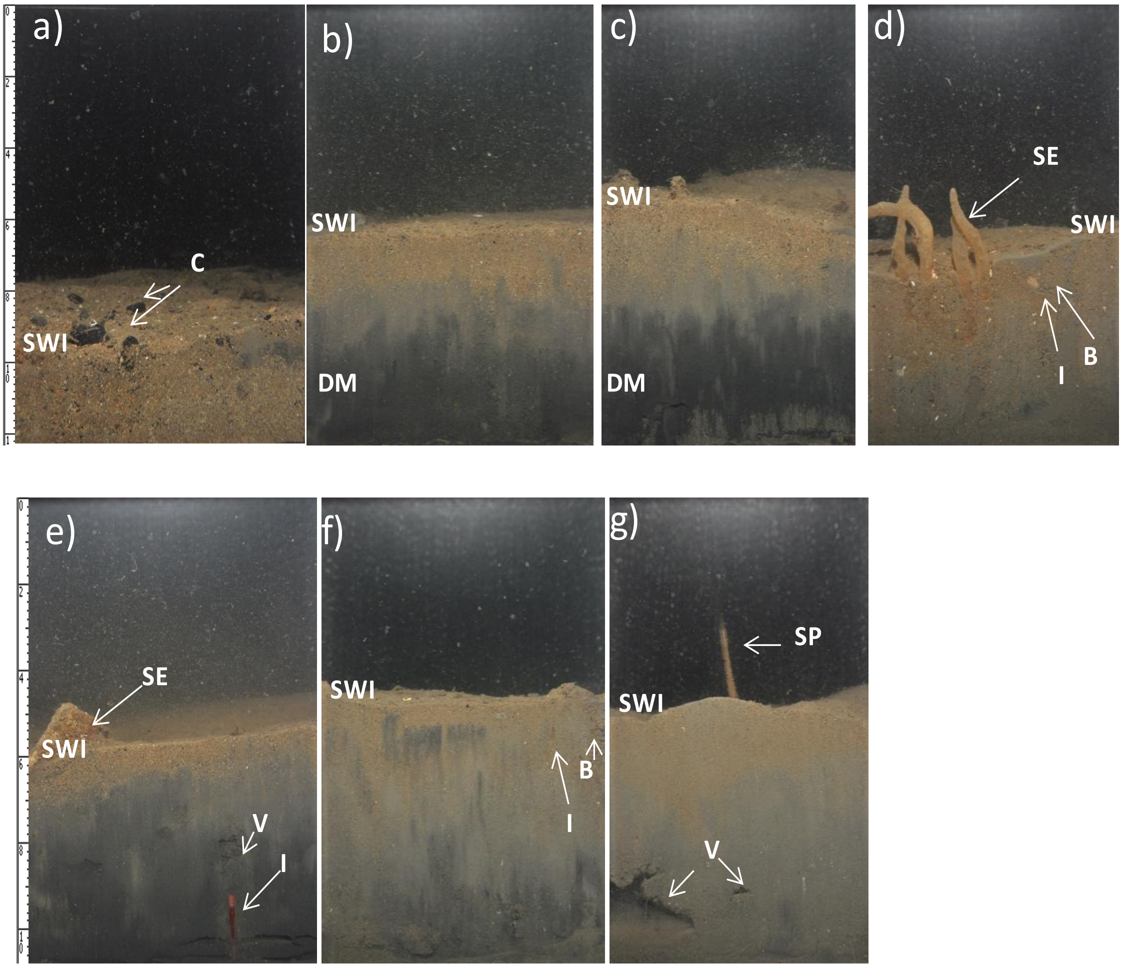


Figure A2.2.12 (a - f). Sediment profile images (SPI) collected at Souter Point disposal site, 2011. Stations are a) Cap1, b) Cap2, c) Cap5, d) Cap7, e) POT04, f) SPI12 and g) TC3. SWI=sediment water interface, DM= dredged material, SE=surface fauna, I=infaunal polychaete, v=void and B= burrow, C=coal fragments. Scales on left-hand side are 2 cm intervals.

<u>2.2.4.6 Sediment contaminants</u>

2.2.4.6.1 TBT

In 2011, contaminants samples were collected at seven stations; four (CAP1, CAP2, CAP5 and SPI8) located within the disposal site, two reference stations (TC3 and TC4) situated south of the disposal site and CAP9 (off the western boundary of the disposal site) (Figure A2.2.13). Additional to these surficial samples collected from the grab, sediment slices from NIOZ cores were also sampled and analysed for TBT profiling at TC3, CAP1, CAP2, CAP5 and SPI8.

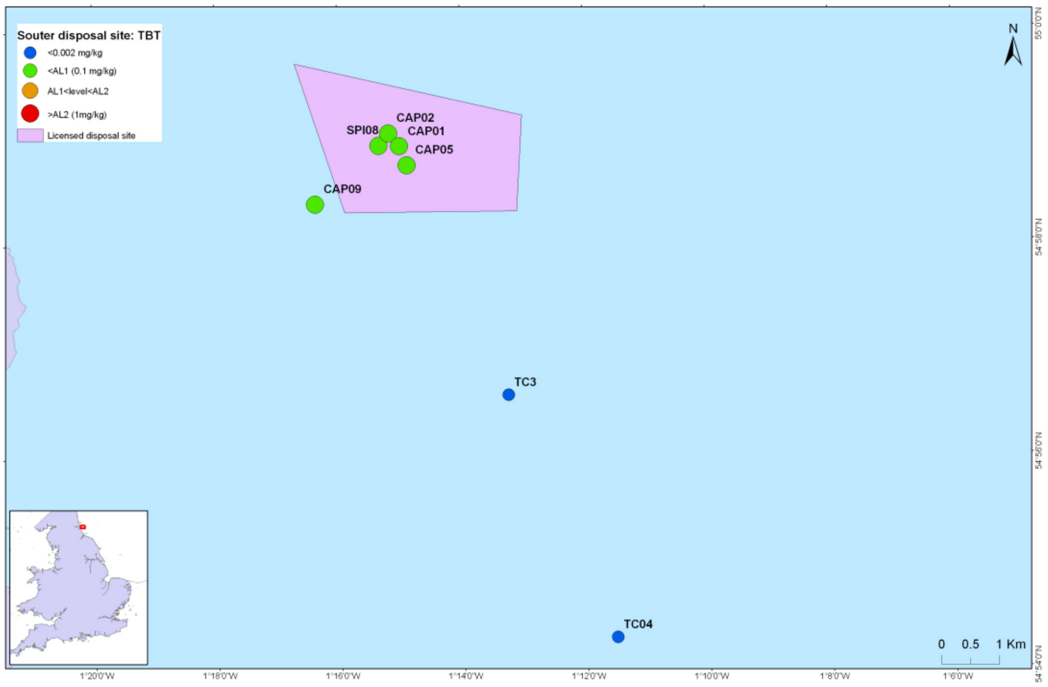


Figure A2.2.13. TBT at Souter Point disposal site in 2011.

Of the surficial samples derived from the grabs, all stations within the disposal site (including CAP9) displayed detectable levels of TBT (Figure A2.2.13). These concentrations, however, were all below AL 1 for TBT. Reference stations (i.e., TC3 and TC3) depicted levels of TBT below the method limit of detection (LOD).

A temporal comparison with previous years data revealed that the reference stations have continually displayed TBT concentrations below LOD over the last 4 years (Bolam et al., 2011). However, while the levels of TBT were mostly below LOD from 2008 - 2010 at CAP5 and CAP9, this year's survey has shown a slight increase in TBT with a recorded concentration of 0.009 mg/kg and 0.012 mg/kg, respectively.

Observations for CAP1 and CAP2 are also consistent over the last 4 years with levels of TBT below the detection limit in 2008 and 2010 and presence of TBT recorded in 2009 and 2011 surveys. It is worth noting that when TBT concentrations were detected, its levels remained below AL 1.

The total loading of TBT disposed of to Souter Point (either from capital or maintenance dredging) has remained constant over the last 2 years. Overall, there has been a small increase in TBT concentrations, however the difference in concentrations is small and, in general, TBT levels are similar to those displayed in previous years.

In addition to the (above) grab survey data, NIOZ cores were used to ascertain the depth profiles of TBT at a number of stations within and outside the capping and disposal site. Core photos and TBT core profiles for CAP 2 and CAP 5 over the 4 year period (2008-2011) are displayed in Figures A2.2.13 to A2.2.15. The preliminary photos reveal that the visually-discernable layers of the cores tend to correspond with the TBT depth profile (Figure A2.2.16), i.e., lower TBT in the coarser layers and more elevated TBT in the fined-grained sediment layers. This was also found to be the case in previous years (Bolam et al., 2011).

At CAP2, TBT concentration in 2011 peaked at 14cm depth with 0.14mg/kg of TBT. This concentration is above AL1 but below AL2. Level of TBT decreased to 0.06mg/kg at 20cm depth. Compared with 2010, this shows a decline in TBT at a comparable depth (Figure A2.2.13). At CAP5, when compared with the previous year’s data, a similar depth profile can be observed; all TBT concentrations down the sediment profile at CAP5 are below AL1. As previously suggested (Bolam et al., 2011), the low TBT concentration from the core might confirm that the contaminated dredged material (CDM) was not present within the top 20cm. Although this conclusion may indicate that the thickness of the cap could be greater than 20cm, it may equally imply that CDM was simply not present initially at CAP5 (or its 100 m sampling radius). Obviously, only the acquisition of samples from deeper within the sediment matrix may confirm which is the most likely.

In 2011, sediment profile samples were taken at SPI8 for the first time; the results are presented in Figure A2.2.17. The TBT profile at SPI8 peaked (0.2 mg/kg) around 8cm depth to a level just above AL1. As for CAP2 and CAP5, SPI8 shows layers of different granulometry which can be due to a number of factors (dynamics, storms, remobilisation and possible dredged material disposal etc).

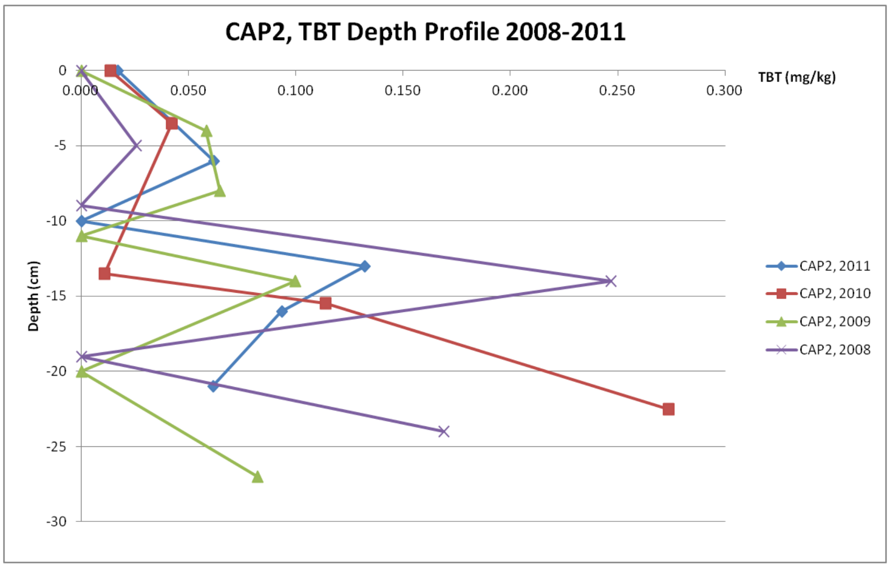


Figure A2.2.13. TBT depth profile at CAP2, 2008-2011.

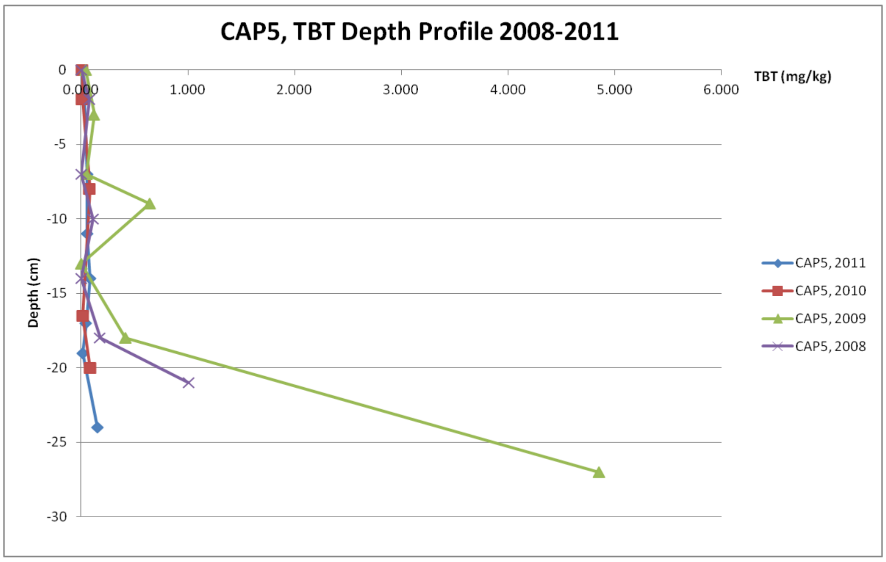


Figure A2.2.14. TBT depth profile at CAP5, 2008-2011.

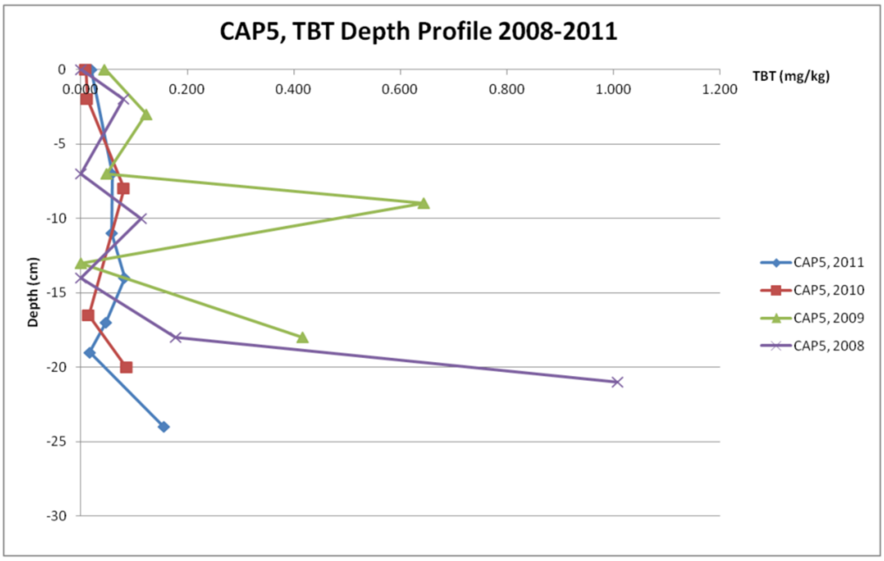


Figure A2.2.15. TBT depth profile at CAP5, 2008-2011 (as A2.2.14 but peak at 2009 removed).

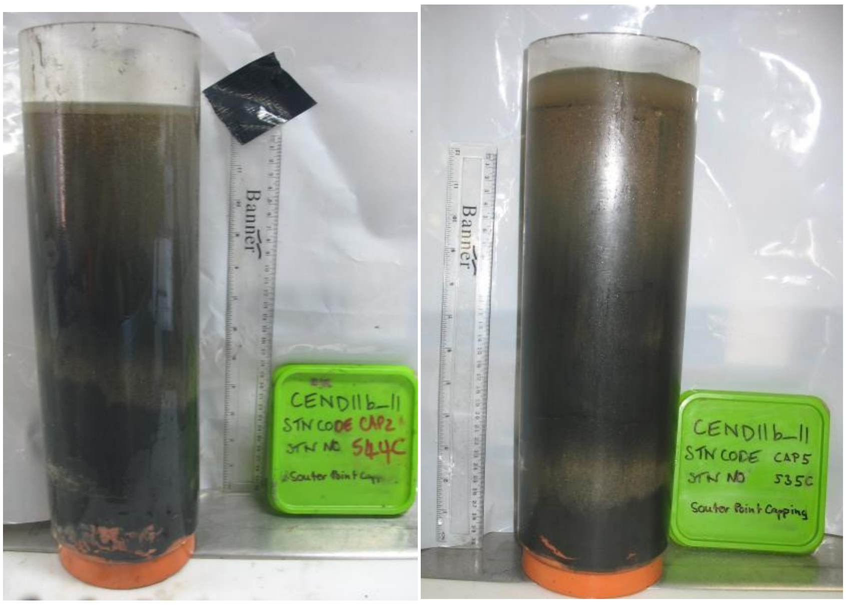


Figure A2.2.16. Core photos CAP2 (left) and CAP5 (right), 2011.

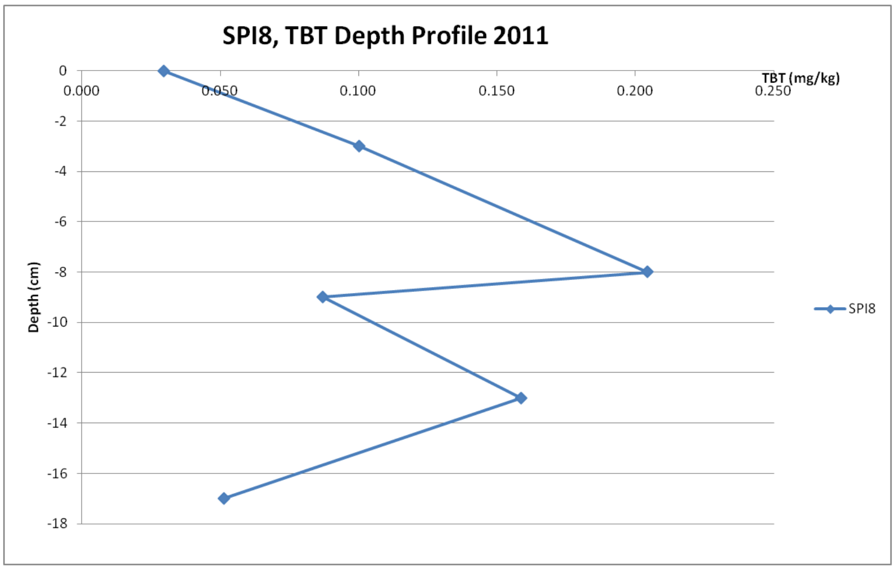


Figure A2.2.17. TBT depth profile at SPI8, 2011.

2.2.4.6.2 PAHs

The highest summed PAH concentration observed at Souter Point during 2011 was at CAP2 (49,400 µg kg^{-1} (dw)), near to the centre of the disposal site (Figure A2.2.18). In 2010, the highest concentration was found at CAP9, (50,600 µg kg^{-1} (dw); Figure A2.2.19), just outside the south-west boundary of the disposal ground. In 2011, this station exhibited the second highest summed PAH concentration, at a similar concentration (48,100 µg kg^{-1} (dw); Figure A2.2.19).

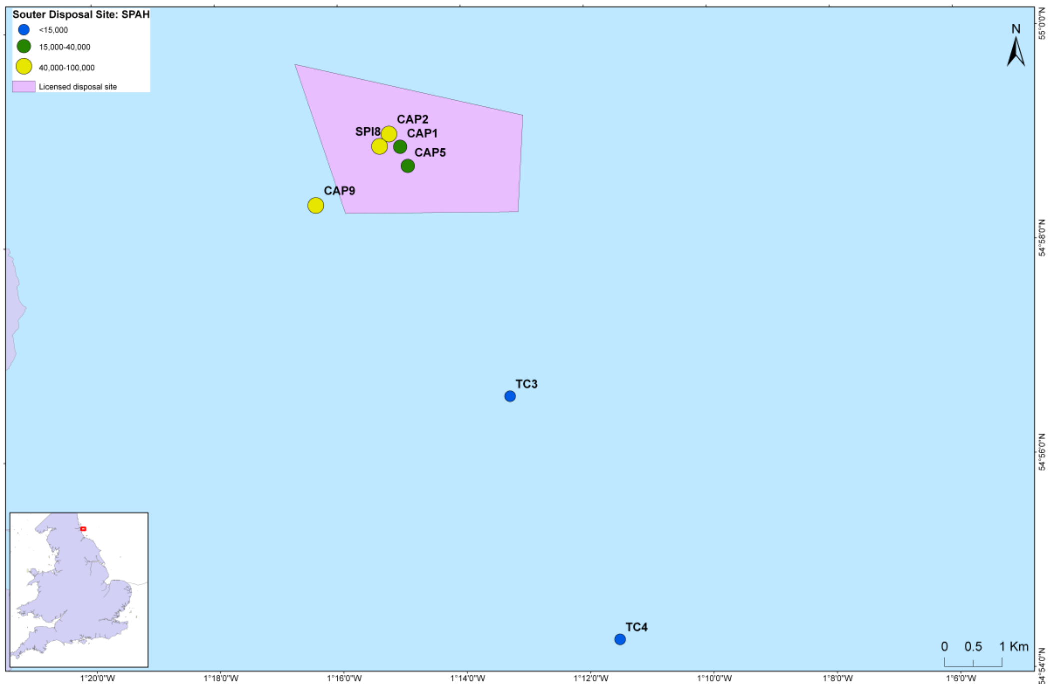


Figure A2.2.18. Summed PAH concentrations (µg kg^{-1} dry weight) for Souter Point stations sampled in 2011.

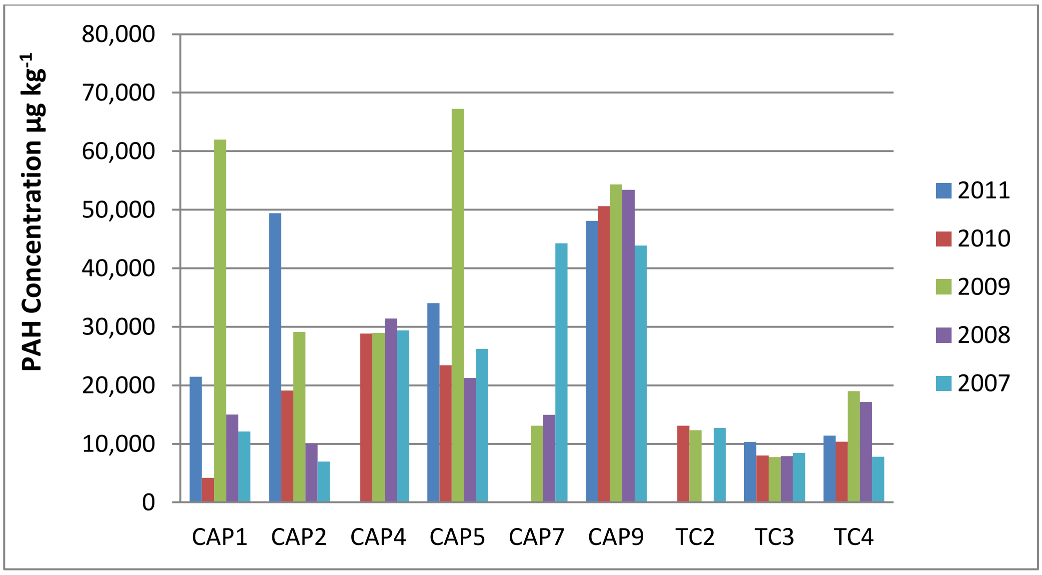


Figure A2.2.19. Summed PAH concentrations observed between 2007 and 2011 at Souter Point.

Summed PAH concentrations at CAP1 and CAP5, located within the disposal ground, were found to be higher (21,400 and 34,000 µg kg^{-1} (dw), respectively) than in 2010 (4,190 and 23,400 µg kg^{-1} (dw), respectively). However, these elevated concentrations in 2011 are still much lower than were observed for them in 2009 (Figure A2.2.19). Small increases in summed PAH concentrations were also noted at the more southerly sampling stations, outside the disposal site at TC3 and TC4. No samples were taken from CAP4, CAP7 and TC2 during this year's survey.

Concentrations of summed PAHs at all stations were found to exceed the ERL for LMW PAHs, with the ERM for LMW PAHs also being exceeded at CAP1 CAP2, CAP5 and CAP9, which are situated either within (CAP1 CAP2, CAP5) or to the south-west of (CAP9) the disposal site. The ERL for the HMW PAH was also breached at these four sampling stations. No site exceeded the ERM for the HMW PAHs.

The Tyne Estuary has previously been shown to have high levels of sediment PAH (Woodhead et al., 1999). Evaluation of the PAH data indicated that the source in all of the sediment samples was predominantly petrogenic; generally with > 80% of the PAH content arising from oil sources.

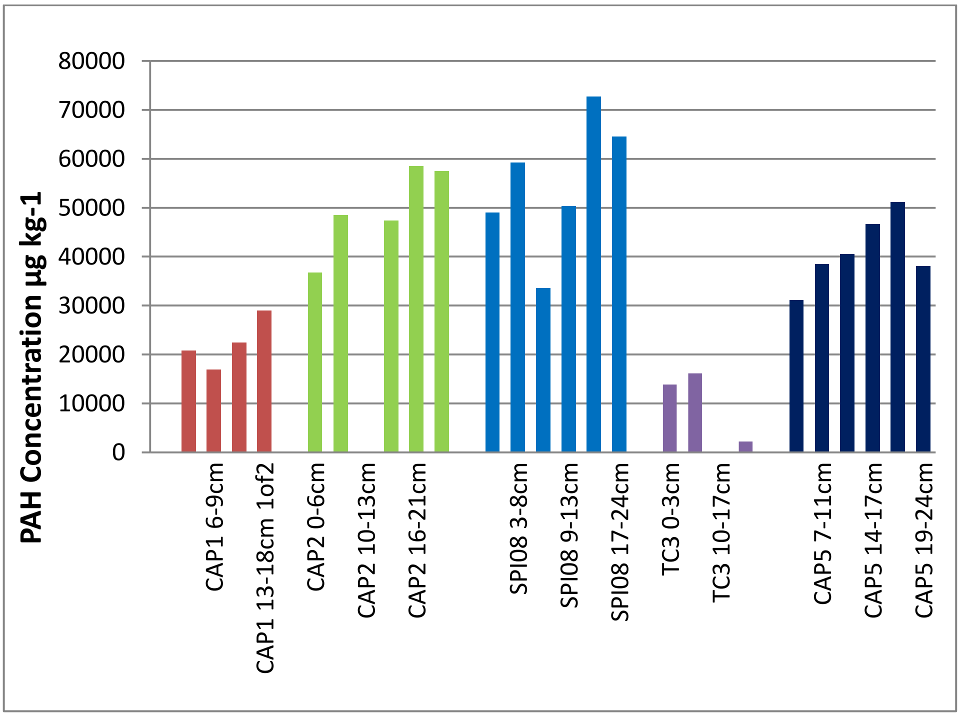


Figure A2.2.20. Summed PAH concentrations at various sediment depths for the five stations sampled with a Nioz corer, Souter Point, 2011.

Profile analysis of PAH concentrations was undertaken for a number of stations in 2011; with the exception of TC3 (which is located to the south of the disposal site), all these stations are located within the disposal site. At TC3, where the lowest summed PAH concentrations were found, PAH concentrations increase slightly with depth from the surface (13,800 µg kg^{-1} (dw)) but decrease at approx 20cm depth to 315 µg kg^{-1} (dw) (a concentration around 40 times lower than that at the surface). At CAP1, the concentration slightly declines from 20,800 µg kg^{-1} (dw) at the surface to 16,900 µg kg^{-1} (dw) at approximately 9cm depth, before increasing again to 29,000 µg kg^{-1} (dw) at 18cm depth. At CAP2, the concentration increased from 36,700 µg kg^{-1} (dw) at the surface to 48,500 µg kg^{-1} (dw) at approximately 10cm depth, before rising to 58,500 µg kg^{-1} (dw) at 20cm depth. At SPI08 the concentration increased from 49,100 µg kg^{-1} (dw) at the surface to 59,200 µg kg^{-1} (dw) at approx 8cm depth, falling to 33,600 µg kg^{-1} (dw) at 9cm depth before increasing again to 72,700 µg kg^{-1} (dw) at 15cm depth. At CAP5, the concentration increased from 31,100 µg kg^{-1} (dw) at the surface to 51,200 µg kg^{-1} (dw) at approx 18cm depth, then decreased to 38,200 µg kg^{-1} (dw) at 24cm depth. Thus, the summed PAH concentrations at various sediment depths showed no confident indication that CDM was being represented in any sample. That is, at no station did the summed PAH concentration appear significantly higher than that seen in more surficial sediment (including that from the grab samples).

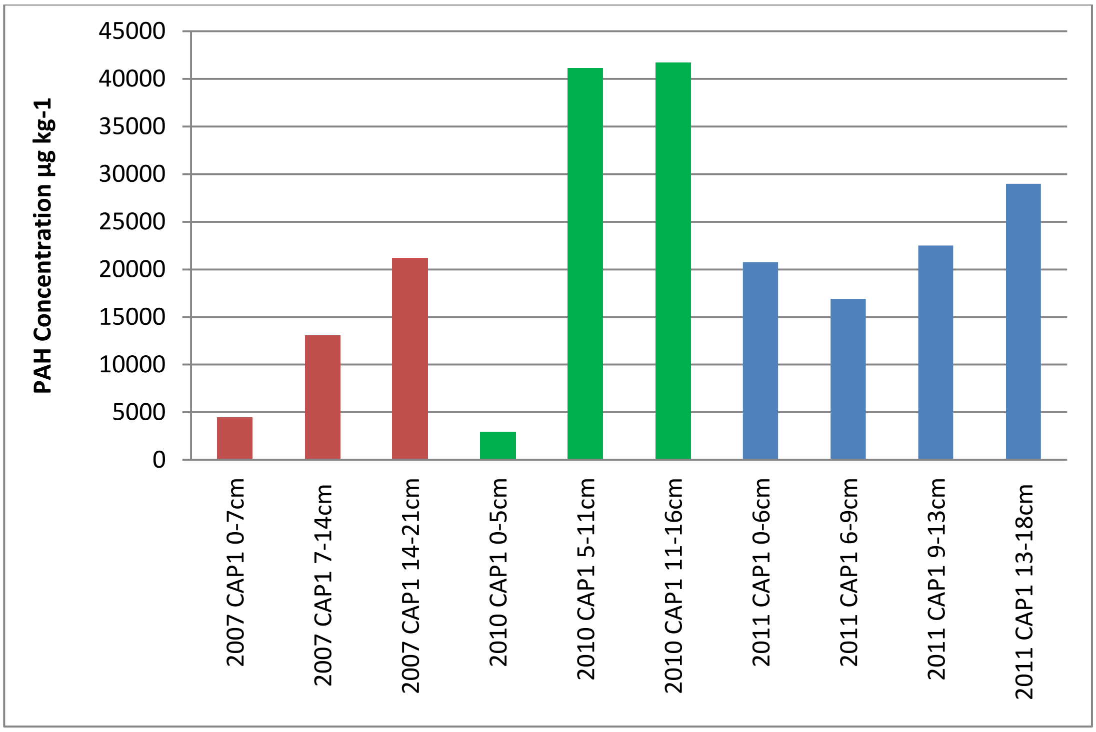


Figure A2.2.21. Summed PAH concentrations at various sediment depths at CAP1 during 2007, 2010 and 2011, Souter Point.

CAP1 showed the lowest surface sediment concentrations found in the cores taken from within the disposal site. In 2007, surface concentrations for summed PAHs were 4,470 µg kg^{-1} (dw) whilst in 2010, a slightly lower concentration of 2,970 µg kg^{-1} (dw) was observed. In 2011, the surface concentration was much higher (20,800 µg kg^{-1} (dw)), with a maximum concentration of 29,000 µg kg^{-1} (dw) being found at 13-18cm depth. Concentrations in the deeper portions of the cores were found to be much higher in 2010, ca. 40,000 µg kg^{-1} (dw) in slices from both 5-11cm and 11-16cm depth, whereas, in 2007, the concentrations were more directly correlated with depth, as indicated in the sub surface profile for 2011.

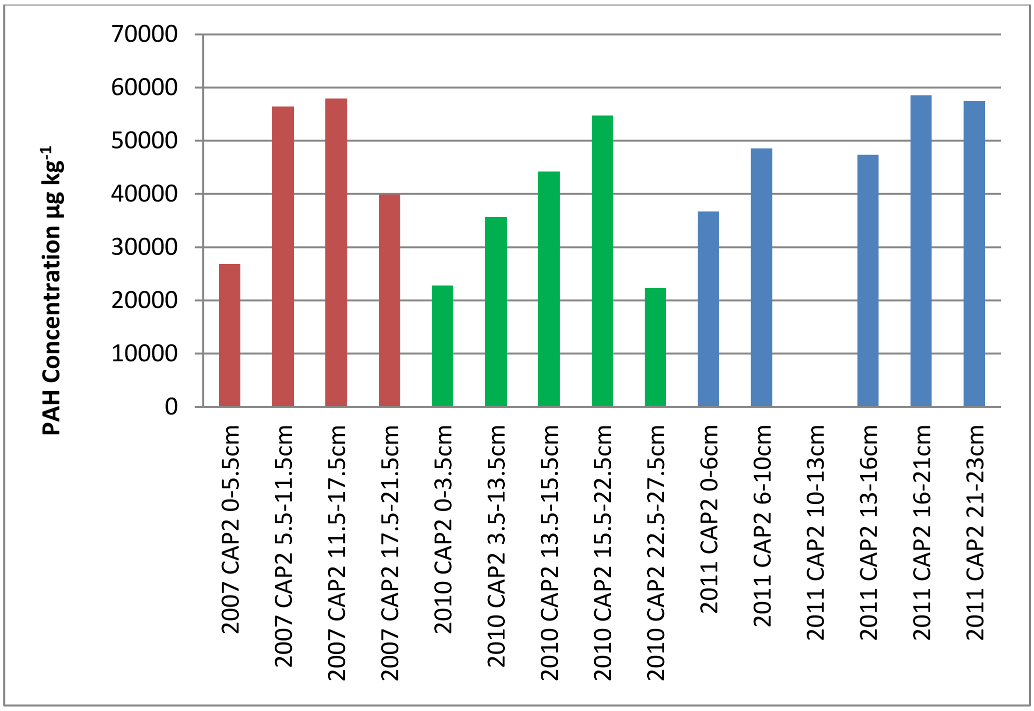


Figure A2.2.22. Summed PAH concentrations at various sediment depths at CAP2 during 2007, 2010 and 2011, Souter Point.

In 2007, the summed PAH concentration in the surface slice of the core at CAP2 was 26,800 µg kg^{-1} (dw), similar to that seen in 2010 (22,800 µg kg^{-1} (dw)). In 2011, this concentration had increased to 36,700 µg kg^{-1} (dw). The cores were sliced at slightly different intervals in the two years, making it difficult to make direct comparisons. However, the maximum observed concentrations remained very similar, with summed PAH concentrations in 2007 at 11.5-17.5cm depth found to be 57,900 µg kg^{-1} (dw) and in 2010 at 15.5-22.5cm depth found to be 54,800 µg kg^{-1} (dw) and 58,500 µg kg^{-1} (dw) in 2011. In 2011, there did not appear to have been any significant change in concentration at the 23cm depth from 2010 to 2011. No sample material for PAH analysis was available at 10-13cm depth or was taken at greater than 23cm depth.

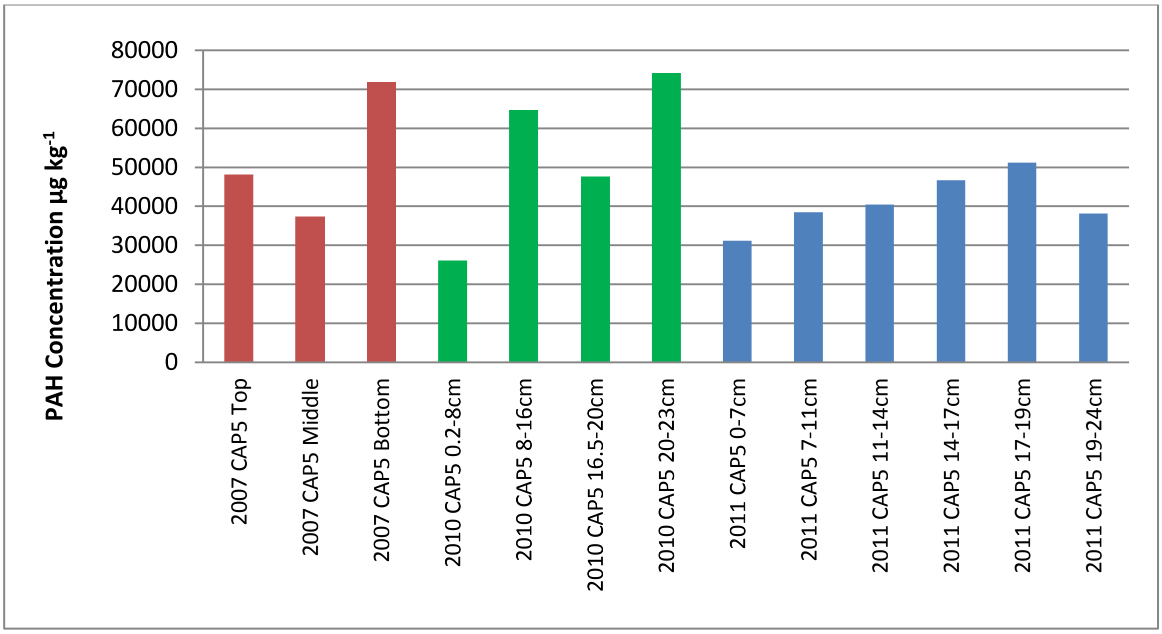


Figure A2.2.23. Summed PAH concentrations at various sediment depths at CAP5 during 2007, 2010 and 2011, Souter Point.

At CAP5, the cores were sliced at slightly different intervals, making it difficult for direct comparisons to be made. Surface concentrations in the 2011 core sample were lower than in 2007 and slightly higher than in 2010, with a summed PAH concentration of 31,100 µg kg^{-1} (dw) in 2011, 26,000 µg kg^{-1} (dw) in 2010, and 48,200 µg kg^{-1} (dw) in 2007. The maximum observed PAH concentrations remained very similar in 2007 and 2010, with summed PAH concentrations at the bottom of the core in 2007 of 71,800 µg kg^{-1} (dw), and of 74,200 µg kg^{-1} (dw) at 20-23 cm depth in 2010. However, concentrations were much lower in 2011, with the maximum seen at 17-19cm depth, only 51,200 µg kg^{-1} (dw), although this was not greatly dissimilar to the concentration found at 16.5-20cm in 2010 of 47,700 µg kg^{-1} (dw). Observing the core profile with depth in 2011, there appears to be less variation in concentrations.

There has been no previous core profiling at sites TC3 and SPI08, so it is not possible to examine any trends or integrity of sediment core profiles over time.

2.2.4.6.3 Organohalogens

At Souter Point, CBs were detected at all stations, except at CAP1 (∑ICES7 CBs range <0.7-5.2 µg/kg dw). Concentrations of CBs were lowest at CAP1 within, and TC3 to the south of, the disposal site. Highest ∑ICES 7 concentrations of 5.2 and 4.5 µg/kg dw were found at CAP 9 to the west of the disposal site and SPI8 within it, respectively (Figure A2.2.24).

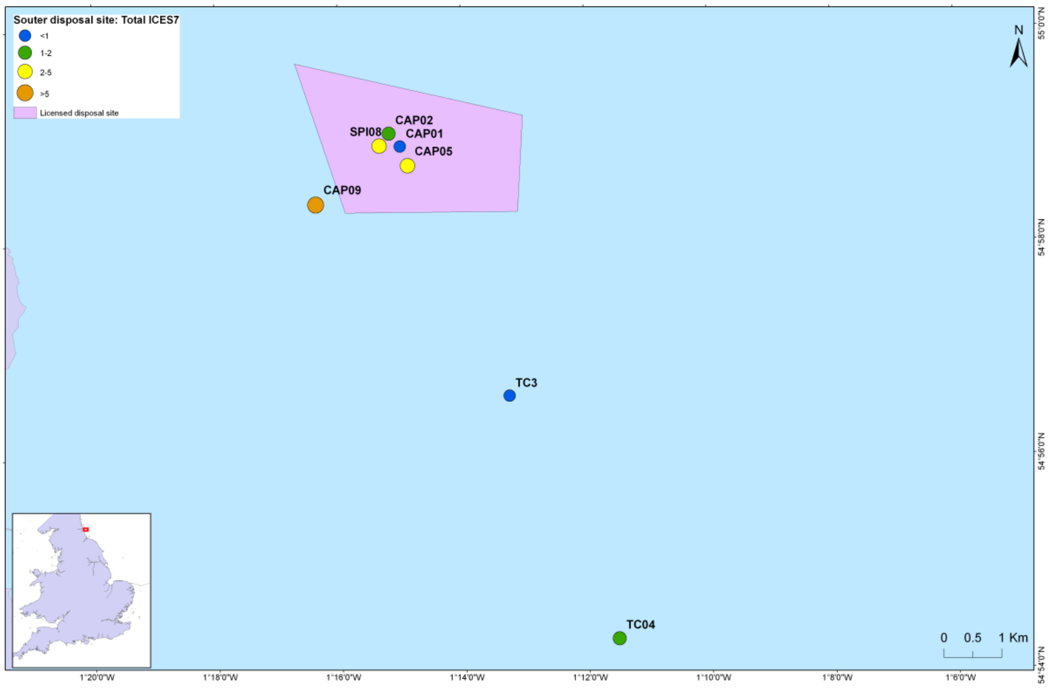


Figure A2.2.24. ∑ ICES7 CB concentrations for the Souter Point stations, 2011.

BDEs were detected at all stations (∑11 BDEs range 0.39 - 3.6 µg/kg dw). The highest concentration was found at CAP9 to the west of the disposal site (Figure A2.2.25). Akin to that observed for CBs, concentrations of BDEs were lowest at stations CAP1 and CAP2 within the disposal site, with concentrations of 0.39 and 0.97 µg/kg dw, respectively. BDE47 and BDE99 are the dominant congeners present, indicative of the pentaBDE technical mixture, but BDE183 was also detected at TC3 and CAP9, suggesting that the octaBDE or decaBDE technical mixture had also been in use.

BDE209 was detected at all stations and displayed higher concentrations than those of the other measured organohalogens (range 3.0 - 43 µg/kg dw) (Figure A2.2.26). When included with the other BDEs, BDE209 made up >67 % of the BDEs present (range 67 – 95 %). BDE209 is indicative of the deca BDE technical mixture, which had been in use more recently than the other technical mixtures, although it's use has now been restricted in the EU since 2008. The highest concentration of 43 µg/kg dw was detected at SPI8 within the disposal site, with 11.9 µg/kg dw at CAP9 to the west of the disposal site. Other stations were all in the range 2.9 - 6.4 µg/kg dw.

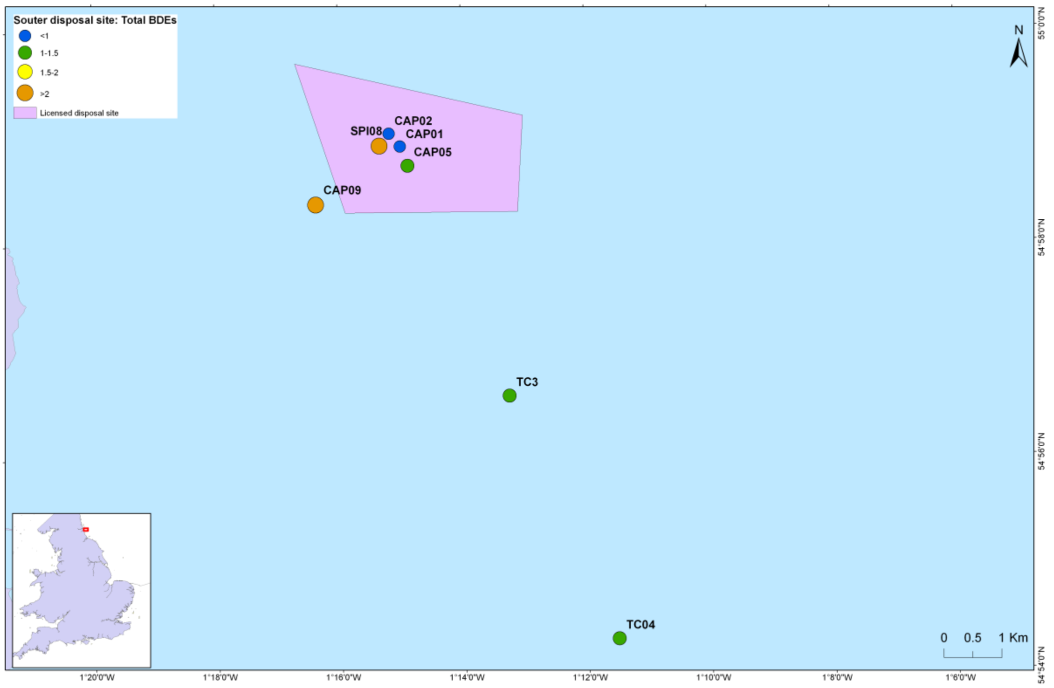


Figure A2.2.25. ∑ 11 BDE concentrations for the Souter Point stations, 2011.

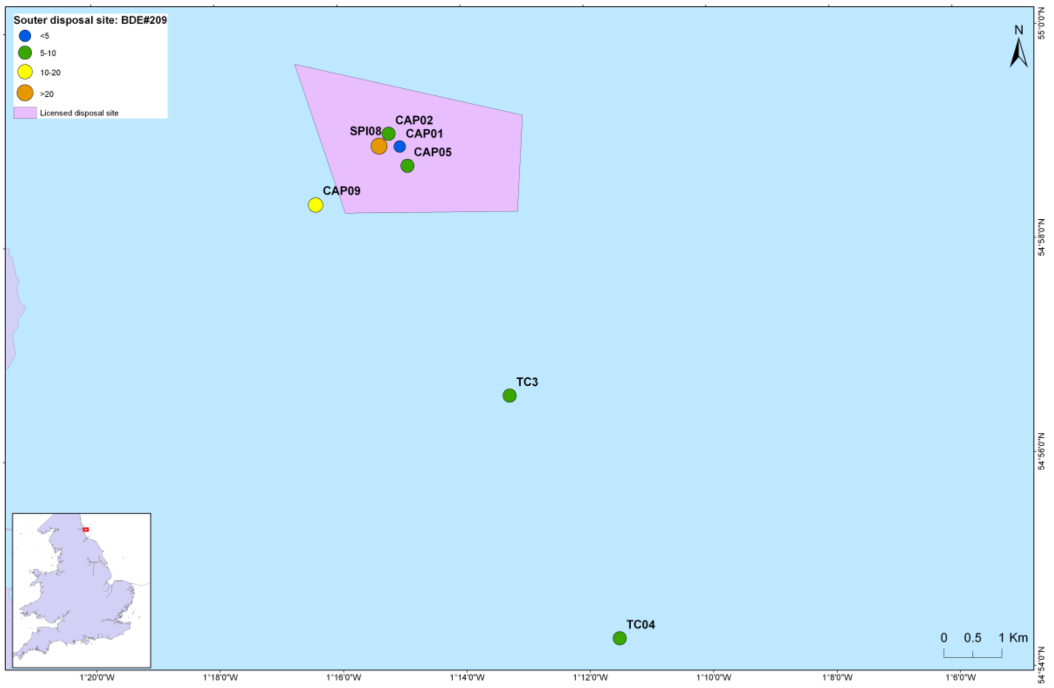


Figure A2.2.26. BDE209 concentrations for the Souter Point stations, 2011.

Sediment surface concentrations of CBs at most stations were all below FEPA action levels. Concentrations of CBs in some of the deeper core layers were above AL 1 but below AL 2, including the 14-17 and 24-25 cm layers at CAP5, the 9-13 cm, 13-17cm and 17-24 cm layers at SPI8, and the 13-18 cm layer at CAP2. No FEPA ALs exist for BDEs. According to the OSPAR guidelines, most stations had ‘good’ environmental status for all ICES 7 CBs and ‘good’ status overall. Exceptions were CAP9 and SPI8 which had CB118 with ‘bad’ environmental status while ‘good’ overall status. A number of the deeper core layers from CAP2 (3 layers), CAP5 (2 layers) and SPI8 (4 layers) would have been classed as ‘bad’ status overall, due to having up to 5 of the ICES7 CBs with ‘bad’ environmental status. No OSPAR guidelines exist for BDEs at present.

There are sufficient data available to investigate temporal trends of contaminants from 2005 to 2011 (Tables A2.2.3 – A2.2.5). At Souter Point, CB concentrations displayed variable temporal trends, with CAP9 and CAP5 increasing, and CAP2 continuing the decreasing trend of recent years. For BDEs, most stations were at similar concentrations to 2010, with the exception of CAP5 and CAP9 which showed increases. For BDE209, there were increases at stations CAP1, CAP5 and CAP9 and a decrease at CAP2. In 2010, the Souter Point disposal site received around a hundred thousand tonnes of material from maintenance dredges, which is a similar figure to that during 2009.

Table A2.2.3. Temporal trends (2005-2011) of ∑ICES 7 CBs concentration (in µg/kg dw) at Souter Point.

Station code	∑ICES 7 CBs concentration (in µg/kg dw)						
	2005	2006	2007	2008	2009	2010	2011
TC2		6.2	2.58		1.54	1.47	
CAP4	3.7	3.6	2.35	3.39	3.11	1.50	
CAP2	0.83	1.01	*0.7*	*0.7*	7.23	2.96	1.41
CAP1	1.1	0.84	*0.7*	0.96	1.88	*0.7*	*0.7*
CAP5	1.1	0.86	0.7	3.22	1.11	0.8	2.15
CAP9	4.97	2.91	2	2.84	3.25	3.13	5.23
CAP7	1.34	1.12	2.23	1.51	1.24		
TC3	0.96	1.19	*0.7*	*0.7*	0.96	*0.7*	0.96
TC4	1.17	1.14	*0.7*	2.62	1.3	1.09	

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

Table A2.2.4. Temporal trends (2005-2011) of ∑11 BDEs concentration (in µg/kg dw) at Souter Point.

Station code	∑11 BDEs concentration (in µg/kg dw)						
	2005	2006	2007	2008	2009	2010	2011
TC2	3.95	8.30	2.94		1.36	2.16	
CAP4	5.84	2.15	2.57	1.37	1.18	1.95	
CAP2	1.11	1.01	0.79	0.41	1.55	1.24	0.97
CAP1	0.83	0.80	0.96	0.26	0.62	0.28	0.39
CAP5	1.13	1.07	0.91	0.41	0.54	0.88	1.19
CAP9	3.77	12.6	5.92	1.02	1.92	1.95	3.60
CAP7	1.94	2.37	3.96	0.85	0.80		
TC3	1.45	5.96	1.36	0.55	0.73	1.45	1.23
TC4	1.78	8.59	1.51	0.82	0.86	1.34	1.44

Note, 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.

Table A2.2.5. Temporal trends (2008-2011) of BDE209 concentration (in µg/kg dw) at Souter Point.

Station code	BDE209 concentration (in µg/kg dw)			
	2008	2009	2010	2011
TC2		9.00	6.68	
CAP4	3.37	3.88	7.63	
CAP2	0.90	49.2	17.8	6.36
CAP1	0.77	7.49	0.89	2.95
CAP5	2.75	12.0	3.79	6.35
CAP9	4.08	13.6	5.08	11.9
CAP7	3.72	3.92		
TC3				6.14
TC4				5.68

The NIOZ cores collected at Souter Point in 2011 allow the organohalogens depth profile in the sediment to be characterised, as was undertaken for TBT and PAHs (Table A2.2.6).

Levels at CAP1 were low at most depths for all contaminants, but with higher levels being found at a depth of 12-18 cm. In all the other core samples, BDE209 was found at higher concentrations than the other contaminants, similar to the surface samples discussed above. CAP2 had two more contaminated layers at depth, separated by a relatively ‘clean’ layer from 10-13cm. This pattern was found for all contaminants. The lower layer at 16-21cm had the highest concentrations, similar to findings in cores collected in 2010. Highest ∑ICES 7 CBs and BDE209 concentrations at Souter Point were in the deepest layer at CAP2. Station CAP5 also had two more contaminated layers at depth, separated by a relatively ‘clean’ layer at 19-14 cm. For both these stations, highest concentrations were in the deepest layers. At station SPI8, in the 5 sections of core, highest levels were found in the 5th layer for BDEs, but in the 6th layer for CBs. Contaminant distribution was more unimodal, without a layer of low contamination in the mid-depth region. Highest ∑11 BDEs concentrations at Souter Point were in the deep layer at 13-17cm depth. The reference station TC3 had similar concentrations at all depths, apart from a slightly less contaminated layer between 10 and 17 cm.

Table A2.2.6. Concentration (in µg/kg dw) of contaminants in the Souter Point capping survey NIOZ core samples, 2011.

Station code	Core layer	Concentration (in µg/kg dw)		
		∑ICES 7 CBs	∑11 BDEs	BDE209
CAP2	0-6 cm	3.81	1.25	8.98
	6-10 cm	8.1	3.61	38.5
	10-13 cm	2.17	0.86	5.45
	13-16 cm	30.7	3.27	42.8
	16-21 cm	6.54	6.41	127
	21-23 cm	2.14	1.08	4.87
CAP1	0-6 cm	*0.7*	*0.2*	1.09
	6-9 cm	3	0.33	1.49
	9-13 cm	2.29	0.41	2.58
	13-18 cm	6.75	1.34	10.5
CAP5	0-7 cm	5.27	1.20	29.7
	7-11 cm	8.02	4.58	36.2
	11-14 cm	5.62	3.94	53.5
	14-17 cm	12.5	6.24	87.0
	17-19 cm	5.09	1.80	21.4
	19-24 cm	1.99	0.57	2.93
	24-25 cm	9.15	9.55	91.1
TC3	0-3 cm	2.04	2.52	5.09
	3-10 cm	1.99	2.14	6.15
	10-17 cm	0.81	0.73	1.17
	17-24 cm	2.04	1.36	2.99
SPI08	0-3 cm	4.53	2.11	42.9
	3-8 cm	7.54	6.20	78.6
	8-9 cm	4.3	3.27	73.5
	9-13 cm	9.4	6.65	91.5
	13-17 cm	12.3	12.1	117
	17-24 cm	13.7	8.24	25.5

2.2.4.6.4 Trace metals

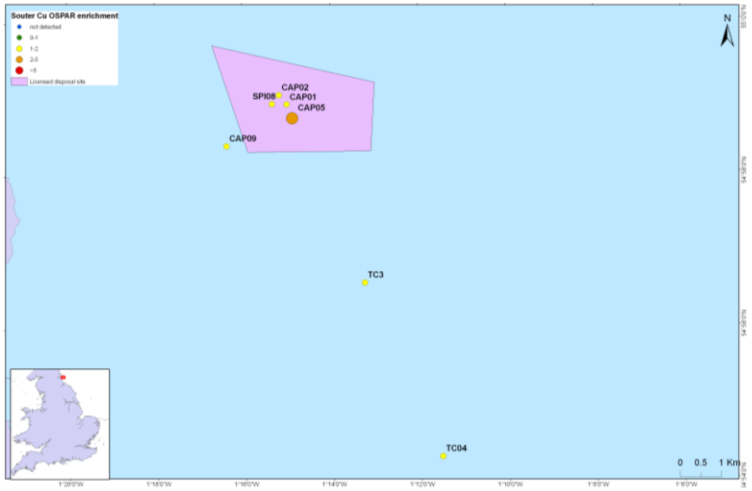
Samples for trace metals analysis were collected at seven stations, four of which (CAP1, CAP2, CAP5 and SPI8) were located within the disposal site. When assessing metals concentration within the Souter Point area, As showed no enrichment when assessed using both OSPAR BAC and baseline approaches. The reference station (TC4, south of the disposal site), however, showed some degree of enrichment with both methods.

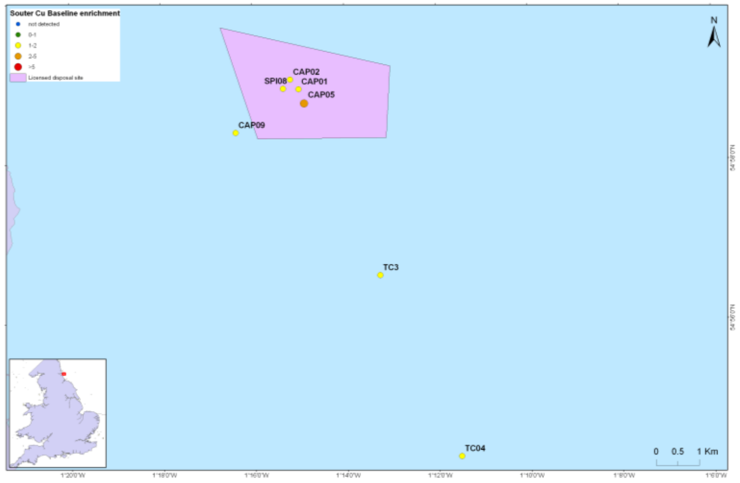
With the exception of SPI8 and TC4, moderate enrichment is observed for Cd using both assessment methods. In 2010, this metal was found to be only slightly enriched using these assessment methods; thus, there is a general increase in concentrations at these stations. Cr and Ni were found to be slightly enriched with the OSPAR BAC approach but not with the baseline method; this was also the finding in 2010 (Bolam et al., 2011).

According to OSPAR BAC values, Cu and Zn at most stations are found to be slightly enriched; Pb appears more enriched. However, these metals for these stations were less enriched, or not enriched, when compared with the baseline values (Figure A2.2.27).

Hg shows the highest enrichment ratio (5 times above the OSPAR BAC value) for all stations within the disposal site, with the exception of SPI8 (Figure A2.2.27). Enrichment is still found to be present, yet to a lesser extent (between 2-5 times of the value of the OSPAR level) at stations outside the disposal site. Notably, enrichment appeared reduced when Hg is assessed against the proposed baseline values; only slight enrichment is observed for stations within the disposal site while no enrichment is recorded elsewhere.

In conclusion, as was observed for North Tyne, most of the proposed baselines values are higher than the current OSPAR BACs values; the latter does not take regional geographical variations in metals concentration into account. Therefore, using OSPAR BACs as a tool to assess metal enrichment could be misleading for some metals, in particular Cu, Zn, Hg and Pb. The proposed baselines give a more accurate level of enrichment for the Tyne/Tees region. When compared to previous data, similar observations are apparent with the exception of Cd which has depicted a slight increase in enrichment since 2010.


Souter Cu OSPAR enrichment
● not detected
● 0-1
● 1-2
● 2-5
● >5
▨ Licensed disposal site
N
CAP02
SPI08
CAP01
CAP05
CAP09
TC3
TC04
0 0.5 1 Km
1°20'0"W
1°18'0"W
1°16'0"W
1°14'0"W
1°12'0"W
1°10'0"W
1°8'0"W
1°6'0"W


Souter Cu Baseline enrichment
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● >5
▨ Licensed disposal site
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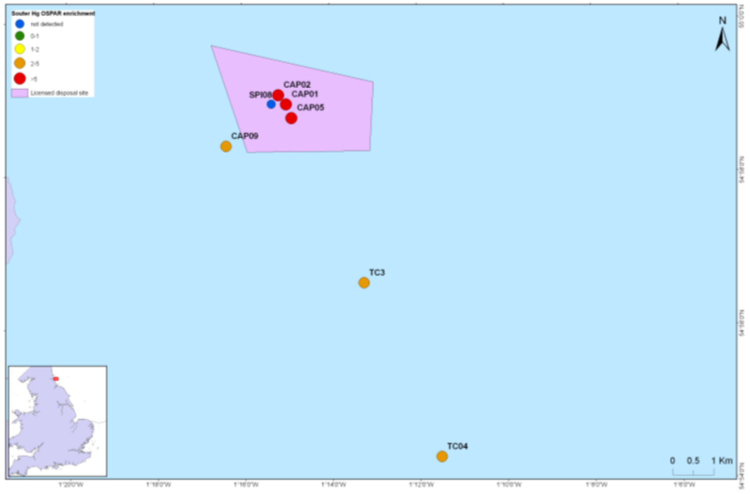
TC3
TC04
0 0.5 1 Km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CAP09
TC3
TC04
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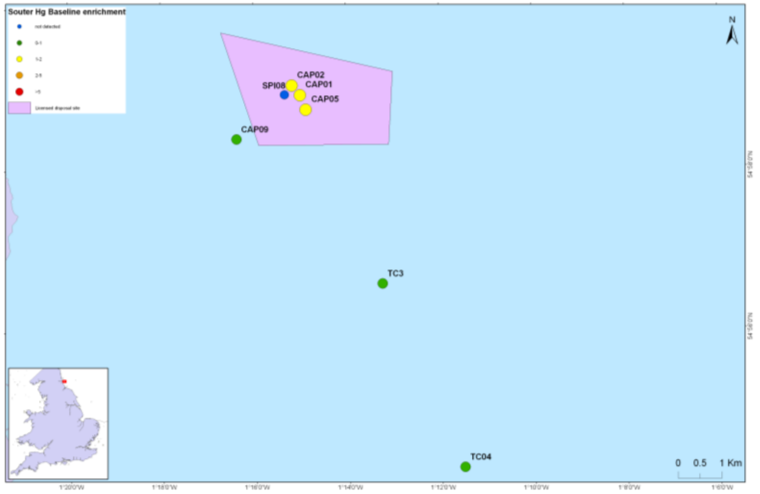
Souter Hg Baseline enrichment
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● 1-2
● 2-5
● >5
▨ Licensed disposal site
N
CAP02
SPI08
CAP01
CAP05
CAP09
TC3
TC04
0 0.5 1 Km

Figure A2.2.27. Enrichment to OSPAR BACs (left) and Baseline values (right) at Souter Point for Cu, Hg Pb and Zn.

2.3 Tees (Inner and Outer, TY160 & TY150)

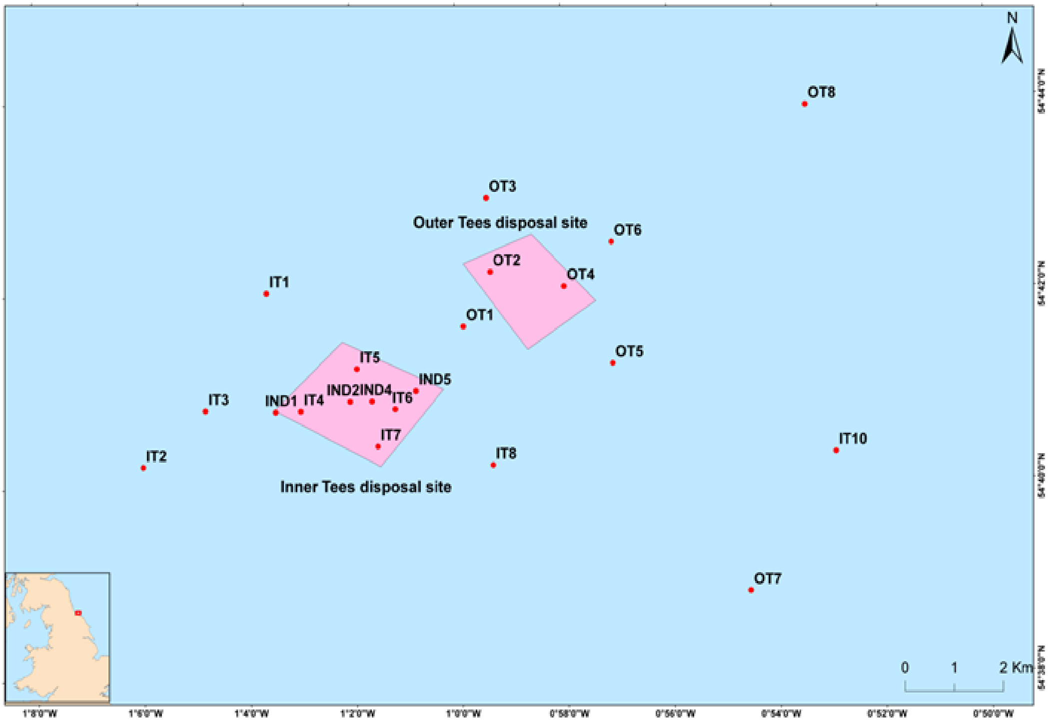


Figure A2.3.1. Location of sample stations at Inner and Outer Tees, 2011.

2.3.1 Background

Previous surveys of the Inner Tees disposal site have shown the area 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; 2011). This site receives most of the 2.7 million tonnes 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. The operators, PD Teesport, therefore, offered to divide the disposal area into twelve sectors during 2006 and dispose to each on a monthly basis.

Material disposed of to Outer Tees is usually comprised of capital dredgings. This is a more mobile site and the port places more consolidated 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.

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).

Concerns:
There have been a number of high profile construction and disposal at sea applications made with regards to the Tees over recent years. In addition to the 2.7 million tonnes of maintenance dredge material licensed annually for sea disposal there are also several small scale capital projects ongoing although it is anticipated that the nature of the material arising will be largely ‘soft’ capital which will be disposed of to the Tees Bay Inner (TY160) site.

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 million tonne 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.

The Tees has a large quantity of chemical industries which have 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 have subsequently been licensed and are currently near completion. Analysis of dredged material from the Tees has displayed some of the highest levels of hydrocarbons found in UK marine sediments.

2.3.2 Impact hypothesis:

- Any elevations in the concentrations of chemical contaminants directly attributable to dredged material disposal will be confined to within and the near vicinity of the disposal site, principally along the tidal axis
- Any elevations in the concentrations of chemical contaminants directly attributable to dredgings disposal will be within acceptable limits
- Any changes to the physical habitat will be confined to within and the near vicinity of the disposal site, principally along the tidal axis

2.3.3 Parameters to be assessed:

Sediment particle size
Sediment organic carbon and nitrogen
Sediment contaminants (TBT, PAHs, organohalogens, trace metals)

Assessments of the status of, and impacts at, the two 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.

2.3.4 Results

2.3.4.1 Sediment particle size

Sediments at Inner Tees are predominantly muddy sands and unimodal sands, with small but varying amounts of gravel (Table A2.3.1). The grab was unsuccessful at sampling IT2 and OT7 in 2011 (hard/coarse ground) and, thus, data are missing for these stations. Temporal changes in sediment groups are shown in Table A2.3.2 for each station sampled between 2006 and 2011 inclusive. Most stations have shown very little change in sediment group in 2011 compared to 2009 / 2010, being either in the same or of an adjacent sediment group. The only exception was IT3 to the west of the site (InT1 in 2010, InT4b in 2011) which has become less muddy (>60 % in 2010, <2 % in 2011). Figure A2.3.2 demonstrates the predominantly sandy nature of the sediment across this survey area in 2011.

Table A2.3.1 Average sediment descriptions and statistics for each sediment group at Inner Tees.

Sediment group	Number of samples	Sample Type	Sediment description	MODE 1 (µm):	MODE 2 (µm):	MODE 3 (µm):
InT1a	1	Unimodal, Poorly Sorted	Slightly Gravelly Mud	6.7		
InT1b	3	Bimodal, Very Poorly Sorted	Slightly Gravelly Sandy Mud	76.5	26.7	
InT2	5	Polymodal, Very Poorly Sorted	Gravelly Muddy Sand	605.0	152.5	76.5
InT3a	26	Unimodal, Poorly Sorted	Slightly Gravelly Muddy Sand	107.5		
InT3b	6	Unimodal, Moderately Sorted	Slightly Gravelly Muddy Sand	107.5		
InT4a	19	Unimodal, Poorly Sorted	Slightly Gravelly Sand	152.5		
InT4b	10	Unimodal, Moderately Well Sorted	Slightly Gravelly Sand	215.0		

Sediment group	Gravel (%)	Sand (%)	Silt/clay (%)	Very coarse sand (%)	Coarse sand (%)	Medium sand (%)	Fine sand (%)	Very fine sand (%)
InT1a	0.04	0.35	99.61	0.03	0.02	0.03	0.13	0.14
InT1b	0.03	47.05	52.91	0.40	3.44	7.32	12.47	23.42
InT2	15.21	69.24	15.56	11.06	15.62	11.68	15.67	15.20
InT3a	0.44	84.96	14.60	0.63	1.82	5.47	33.61	43.43
InT3b	0.39	85.63	13.99	0.34	0.85	1.98	10.09	72.37
InT4a	1.26	91.41	7.33	1.85	4.71	12.03	47.93	24.89
InT4b	0.15	98.05	1.81	0.45	1.88	14.28	67.01	14.44

Table A2.3.2 Sediment groups for each sample code between 2006 and 2011 inclusive at Inner Tees.

	Year					
Sample code	2006	2007	2008	2009	2010	2011
IND1	InT3a	InT3a	InT4a	InT3a	InT3a	InT3a
IND2	InT4b	InT4a	InT4b	InT1a	InT4a	InT4b
IND4		InT4a	InT3a	InT3a	InT4a	InT3a
IND5		InT4a	InT4b	InT4b	InT4b	InT4b
IT1	InT3a	InT3a		InT3a	InT3a	InT2
IT2				InT4b	InT4b	
IT3	InT4a	InT1b	InT4a		InT1b	InT4b
IT4	InT3a	InT3a	InT3a	InT3a	InT3a	InT3a
IT5	InT4a	InT3a	InT4a	InT4a	InT3a	InT4a
IT6	InT4a	InT1b	InT4a	InT3a	InT4a	InT4a
IT7	InT3a	InT4a	InT3a	InT3a	InT3a	InT3a
IT8	InT3b	InT3b	InT3b	InT3b	InT3b	InT3b
IT10	InT2	InT4a	InT2	InT4a	InT2	InT2

Silt/clay content in a subset of dredge sediments for licensing applications to dispose of at Inner Tees was 66 % (+/- 8 %, 95 % CI). The notably lower silt/clay contents of stations sampled within and surrounding the disposal site (Figure A2.2.3) would tend to support the notion that this is a dispersive region and fine material is transported away.

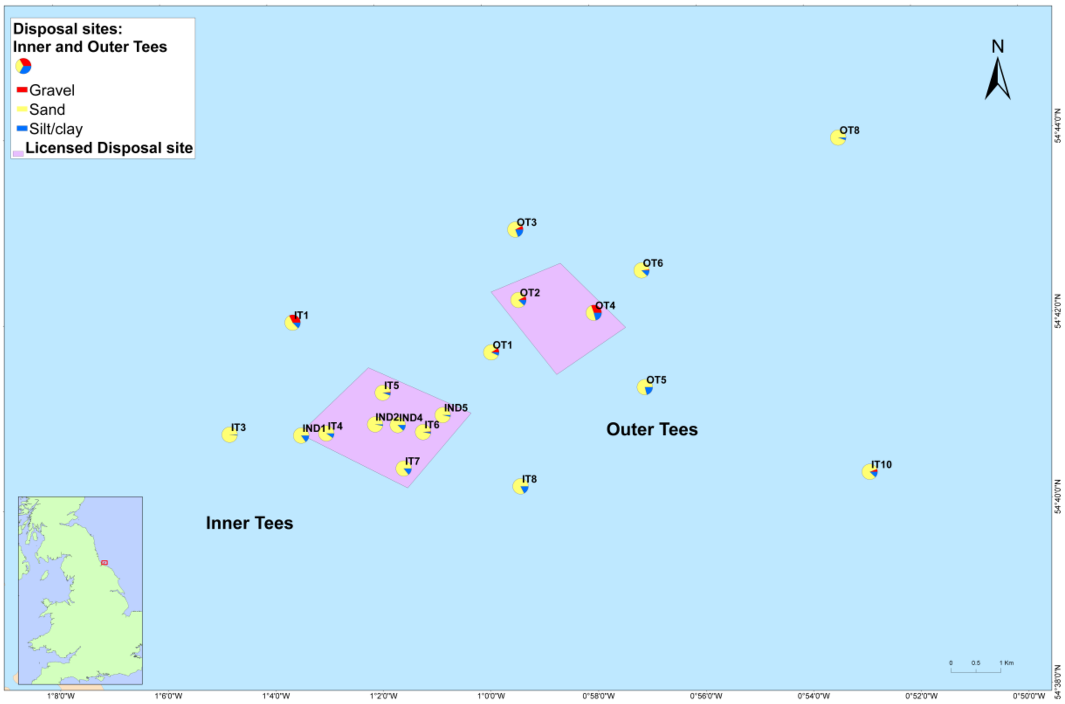


Figure A2.3.2. Pie charts of gravel, sand and silt/clay at Inner Tees (Tees Bay A) and Outer Tees (Tees Bay C) in 2011.

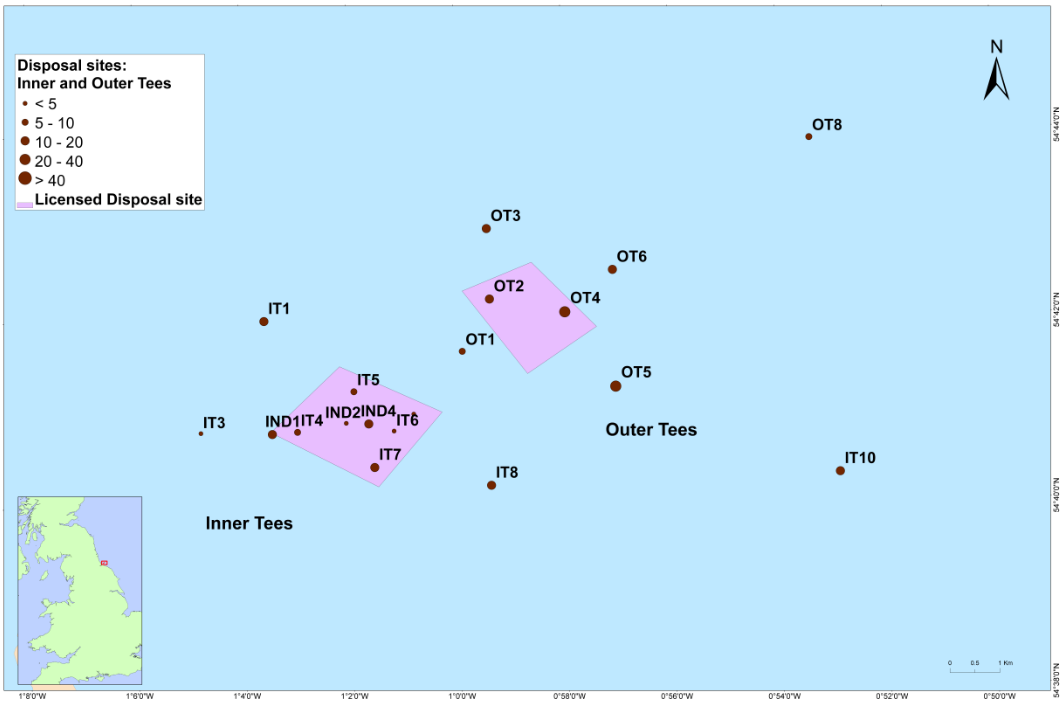


Figure A2.3.3. Silt/clay (%) at Inner Tees and Outer Tees in 2011.

Sediments at Outer Tees, in parallel with those of Inner Tees, are predominantly muddy sands, with some gravelly sands and unimodal sands (Table A2.3.3). Table A2.3.4 indicates that there have been minimal changes in sediment groups over the last year at Outer Tees. At OT4, the sediment is more mixed in 2011 compared to 2010 due to an increase in gravel and silt/clay. At OT6, there has been a slight reduction in silt/clay content in 2011. A pie chart of gravel, sand and silt/clay for 2011 is shown in Figure A2.3.2 and silt/clay content is presented in Figure A2.3.3. The former figure indicates that the sediments are predominantly sandy with occasional increased proportions of gravel (e.g., OT4) or silt/clay (OT4, OT5).

Table A2.3.3. Average sediment descriptions and statistics for each sediment group at Outer Tees

Sediment group	Number of samples	Sample Type	Sediment description	MODE 1 (µm):	MODE 2 (µm):	MODE 3 (µm):
OuT1	13	Bimodal, Poorly Sorted	Slightly Gravelly Muddy Sand	152.5	26.7	
OuT2	11	Polymodal, Very Poorly Sorted	Gravelly Muddy Sand	215.0	1200.0	76.5
OuT3	8	Unimodal, Moderately Sorted	Slightly Gravelly Sand	152.5		
OuT4	13	Unimodal, Poorly Sorted	Gravelly Sand	215.0		

Sediment group	Gravel (%)	Sand (%)	Silt/clay (%)	Very coarse sand (%)	Coarse sand (%)	Medium sand (%)	Fine sand (%)	Very fine sand (%)
OuT1	0.33	73.92	25.75	0.63	1.43	4.38	32.65	34.82
OuT2	15.40	66.47	18.13	13.34	13.53	11.86	15.13	12.61
OuT3	0.43	91.76	7.81	0.54	2.09	7.06	61.31	20.75
OuT4	5.73	87.86	6.41	4.65	7.80	18.03	47.95	9.44

Table A2.3.4. Sediment groups for each station sampled between 2006 and 2011 inclusive at Outer Tees.

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

2.3.4.2 Sediment organic carbon and nitrogen

In 2011, organic carbon values (on the <63µm sediment fraction) at Inner Tees ranged from 2.78 to 4.92 % m/m (Figure A2.3.4) and 0.12 to 0.27 % m/m for nitrogen. Organic carbon values (on the <2mm sediment fraction) ranged from 0.42 to 6.71 % m/m and for nitrogen, 0.06 to 0.42 %m/m. IT3 had a low silt/clay content (<1 % silt/clay) and so it was not possible to measure the organic carbon on this fraction. In general, sediment organic carbon contents were similar to those obtained in previous years (Bolam et al., 2009; 2011). As in 2009 and 2010, several samples from the Inner Tees survey possessed higher levels of organic carbon in the <2mm fraction than the <63µm fraction, indicating that some organic carbon for this area is present in coarser sediment, possibly as coal (akin to the situation at North Tyne and Souter Point).

For the Outer Tees site, organic carbon values (on the <63µm sediment fraction) ranged from 3.07 to 3.98 % m/m (Figure A2.3.4) and 0.2 to 0.35 % m/m for nitrogen. Organic carbon values (on the <2mm sediment fraction) ranged from 0.75 to 2.99 %m/m and 0.05 to 0.12 %m/m for nitrogen. As for the Inner site, these are similar to those observed in previous years.

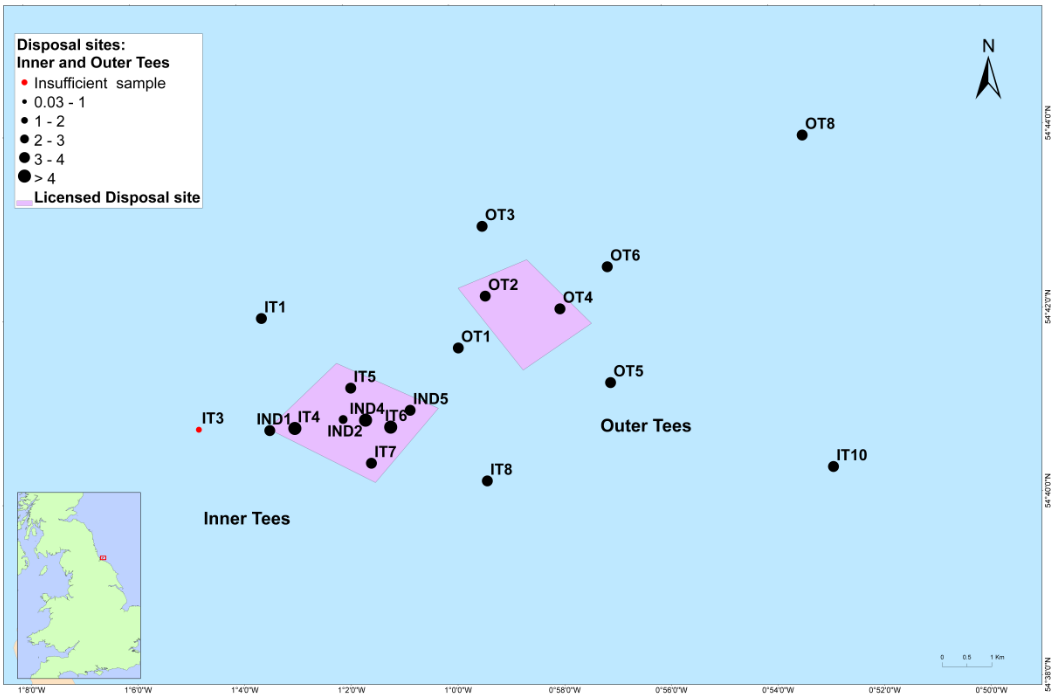


Figure A2.3.4. Organic carbon (%m/m) in the silt/clay fraction (<63µm) at Inner Tees and Outer Tees, 2011.

2.3.4.3 Sediment contaminants

2.3.4.3.1 TBT

During the 2011 survey, samples were collected at 12 (eight within the licensed boundary) and seven (two within) stations at Inner and Outer Tees disposal sites, respectively (Figure A2.3.5).

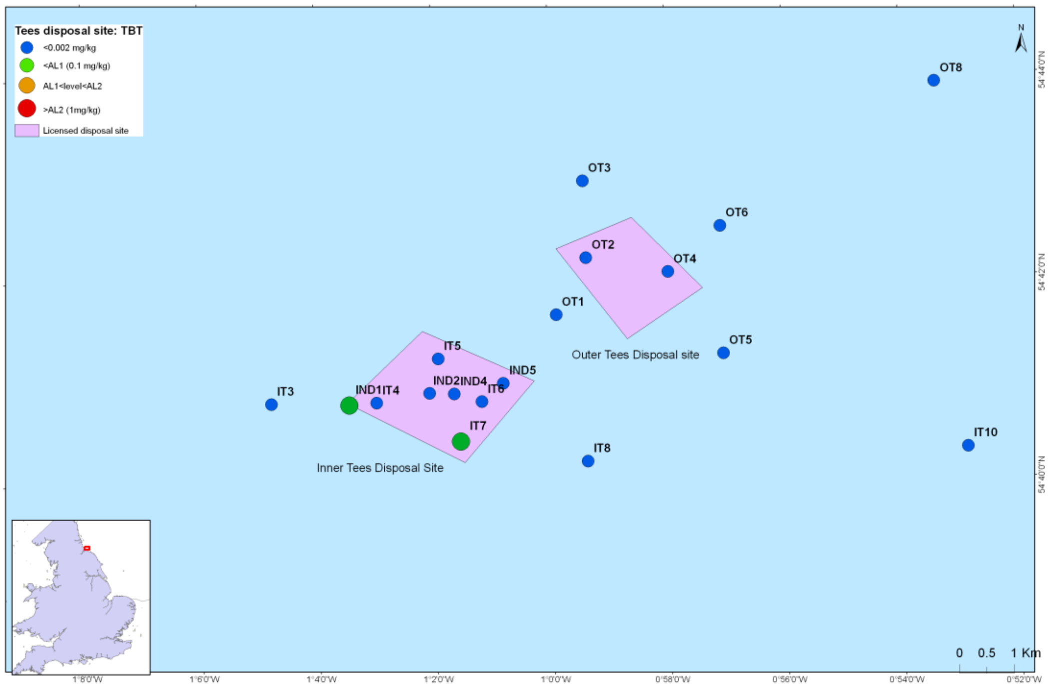


Figure A2.3.5. TBT at (Inner and Outer) Tees disposal sites in 2011.

Apart from stations IND1 and IT7 (respectively located at the edge, and within, the Inner Tees disposal site) which recorded TBT concentrations of 0.02 mg/kg and 0.009 mg/kg respectively, TBT values were below the LOD for all stations at Inner Tees. This represented a slight increase from the previous year where TBT was not detected using the current analytical method for all the stations surveyed stations (Figure 3.3.2).

Similarly, all seven stations sampled as part of the Outer Tees survey recorded results below the detection limit. This observation is consistent with that of the last 5 consecutive years.

Similar to the situation for Souter Point, the total loading of TBT (either from capital or maintenance dredging) has remained constant over the last 2 years.

2.3.4.3.2 PAHs

The highest summed PAH concentrations in 2011 were found within (e.g., IT5, IT7) and at the western edge (IND1) of the Inner Tees disposal area (Figure A2.3.6). The highest concentration was found at IT7 at the southerly tip of the disposal site (132,000 µg kg^{-1} dw) (Figure A2.3.7). In 2010, the highest concentration was found at IND1 at the western corner of the disposal site (87,500 µg kg^{-1} dw). High summed PAH concentrations were also found at two nearby sites, IT5 and IND1: 120,000 and 106,000 µg kg^{-1} dry weight, respectively. The lowest summed PAH concentration was found to the west of the disposal site, indicating no movement of deposited material off the disposal site in this direction between the 2010 and 2011 surveys. All sampling sites were found to exceed the ERL for LMW PAHs, with the ERM for LMW PAHs being exceeded at all sites except IT3 and IT10, which are located outside the disposal site. The ERL for the HMW PAH was breached at all sites except IT3 and IT10, which are located outside the disposal site, and at IND5 within the disposal ground. IND4 exceeded the ERM for the HMW PAHs.

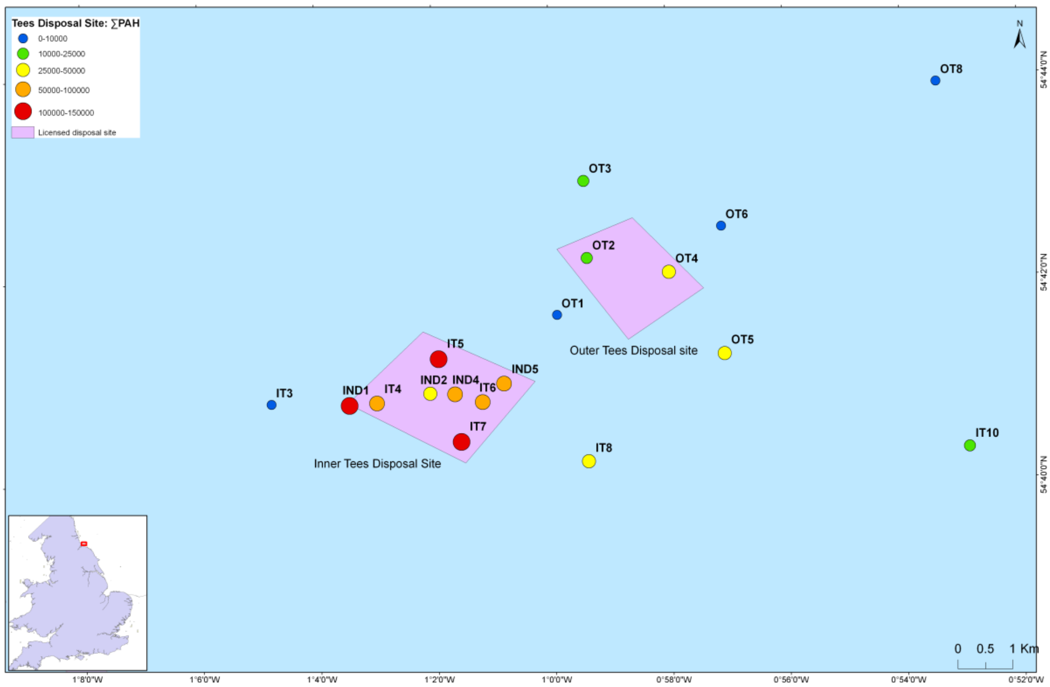


Figure A2.3.6. Summed PAH concentrations (µg kg^{-1}dry weight) for stations sampled in 2011 around the Tees Inner and Outer disposal sites.

Disposal to this Inner site has increased slightly over the previous year, by approximately 240,000 tonnes of predominantly capital dredging material, from a total of 2,204,000 tonnes in 2010 to 2,450,000 tonnes of wet disposed material in 2011.

Evaluation of the PAH data indicated that the predominant source in all the sediment samples was petrogenic, generally with > 87% of the PAH content arising from oil sources (except at IND4, 80 %) of the PAH content arising from oil sources. The phenanthrene/anthracene (P/A) ratio was greater than 10 at all sampling sites except IND1, IND4, IT8 and IT10, which is also indicative of a predominantly petrogenic source.

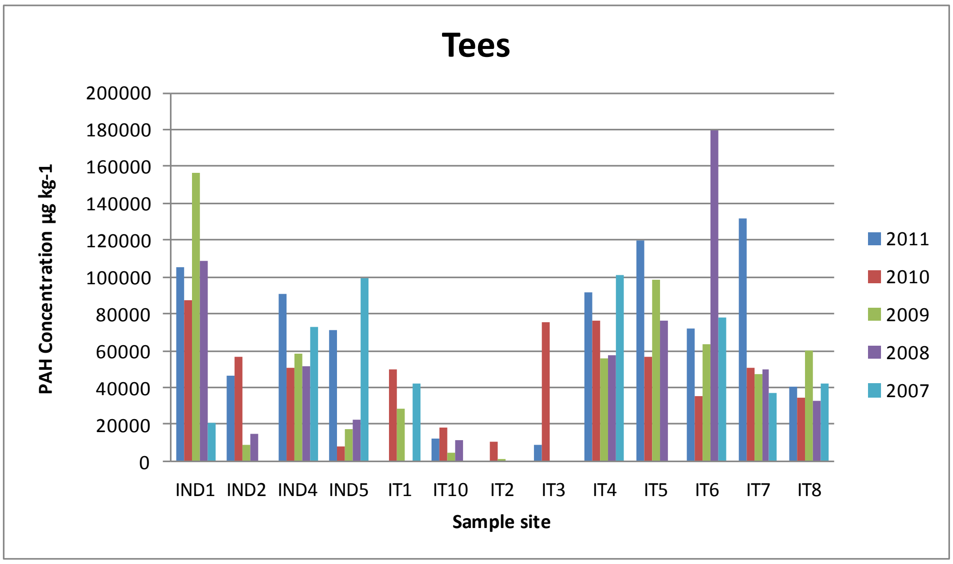


Figure A2.3.7. Summed PAH concentrations observed during 2007-2011 at the Inner Tees disposal site.

The Outer Tees disposal site area has often displayed much lower summed PAH concentrations than the Inner Tees disposal site area. The highest summed PAH concentration was seen at OT5, to the south-east of the disposal site (34,800 µg kg^{-1} dw) (Figure A2.3.8), which was lower than in 2010 when the highest concentration found at this site was 66,900 µg kg^{-1} dw (Figure A2.3.8). The lowest concentration found in the Outer Tees disposal site area was at the offshore sampling point to the north east of the site, OT8, where the summed PAH concentration was 2,600 µg kg^{-1} dw. Concentrations at all sampling sites (except OT8) were found to exceed the ERL for LMW PAHs, with the ERM for LMW PAHs being exceeded at OT5, OT4 and OT3. The ERL for the HMW PAH was breached also at OT5, OT4 and OT3, along a south-east to north-west transect through the disposal ground. No station exceeded the ERM for the HMW PAHs.

There has been no disposal of capital or maintenance dredging to Outer Tees during 2010, which may account for the drop in concentrations from those seen from the 2010 sampling survey. Evaluation of the PAH data indicated that the source in all the sediment samples was predominantly petrogenic, generally with > 80% of the PAH content arising from oil sources. As for the Tyne, the Tees Estuary is known to exhibit elevated PAH concentrations in sediments due to historical contamination from industry (Woodhead et al., 1999).

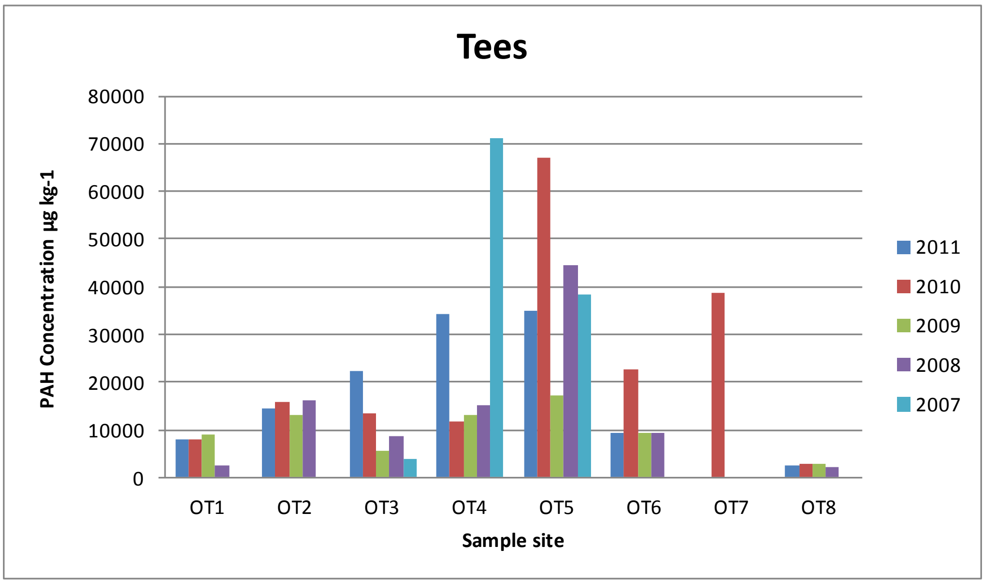


Figure A2.3.8. Summed PAH concentrations observed during 2007-2011 at the Outer Tees disposal site.

2.3.4.5.3 Organohalogens

CBs were detected at 15 of the 18 stations sampled as part of the Tees survey: the highest concentrations in the Inner Tees area (∑ICES7 CBs range <0.7-2.4 µg/kg dw) (Figure A2.3.9). Highest ∑ICES 7 CB concentrations of 2.4 and 1.8 µg/kg dw were found at OT4 in the Outer Tees disposal site and OT5 to the southeast. Highest ∑ICES 7 CB concentrations in the Inner Tees area were found within the disposal site, with concentrations of 1.6, 1.5, 1.4, 1.3 and 1.2 µg/kg dw at IT7, IND1, IT4, IT5 and IND4, respectively. All ICES 7 CBs were below LODs at four of the Inner Tees stations (IT3, IND2, IND5 and IT6) and two of the Outer Tees stations (OT and OT8).

BDEs were detected in all of the 18 stations (∑11 BDEs range 0.21-3.1 µg/kg dw), with BDEs 47 and 99 detected at all stations (Figure A2.3.10). Concentrations around the Inner Tees site were comparable to those of Outer Tees. Highest ∑11 BDEs concentrations in the inner Tees disposal area were 3.1 and 2.7 µg/kg dw for IT7 and IND5 respectively, with 2.5 and 2.2 µg/kg dw also found at IT5 and IT2 within the disposal area (Figure A2.3.10). Highest ∑11 BDEs concentrations in the Outer Tees area were 2.3 µg/kg dw at OT4, within the disposal site, and 2.1 µg/kg dw at OT5 to the south east of the disposal site. Two congeners, BDEs 99 and 47, were responsible for 57-72 % of the ∑11 BDEs concentrations. BDE183 was detected at 12 of the 19 stations which is indicative of widespread use of the octa or deca BDE technical mixes.

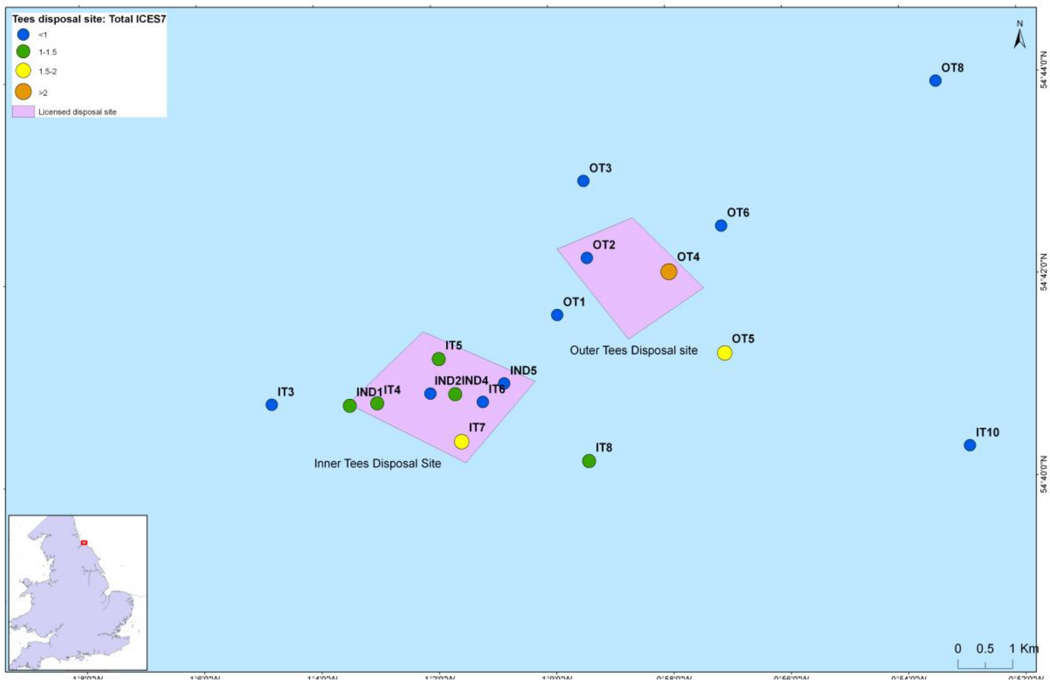


Figure A2.3.9. ∑ ICES7 CB concentrations for the Inner and Outer Tees Stations, 2011.

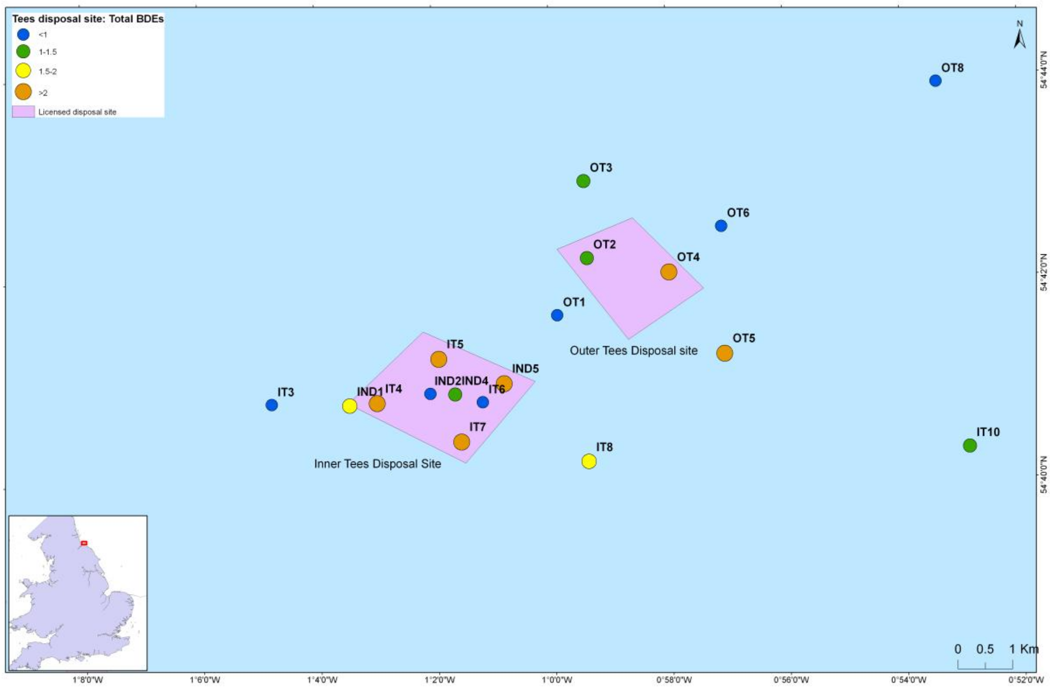


Figure A2.3.10. ∑ 11 BDEs concentrations for the Inner and Outer Tees Stations, 2011.

BDE209 was detected at 17 of the 18 stations (with IT3 the exception) and was at higher concentrations than the other measured organohalogens (range <0.05-17 µg/kg dw) (Figure A2.3.11). The highest concentration of 17 µg/kg dw was detected at IND1 within the Inner Tees disposal site, with 13 µg/kg dw at IT7 also within the disposal site. In the Inner Tees area, other notable values inside the disposal site were 10 µg/kg dw for IND5 and 8.7 µg/kg dw for IT5. In the Outer Tees disposal site, levels were much lower, <1.3 µg/kg dw (Figure A2.3.11). However, a BDE209 concentration 2.7 µg/kg dw was found at OT5, to the southeast of the disposal site.

When included with the other BDEs, BDE209 made up 29-55 % of the BDEs present in the Outer Tees stations, and 59-91 % of ∑12 BDEs in the Inner Tees Stations. BDE209 is indicative of the deca BDE technical mixture, which had been in use more recently than the other technical mixtures, although it’s use has now been restricted in the EU since 2008.

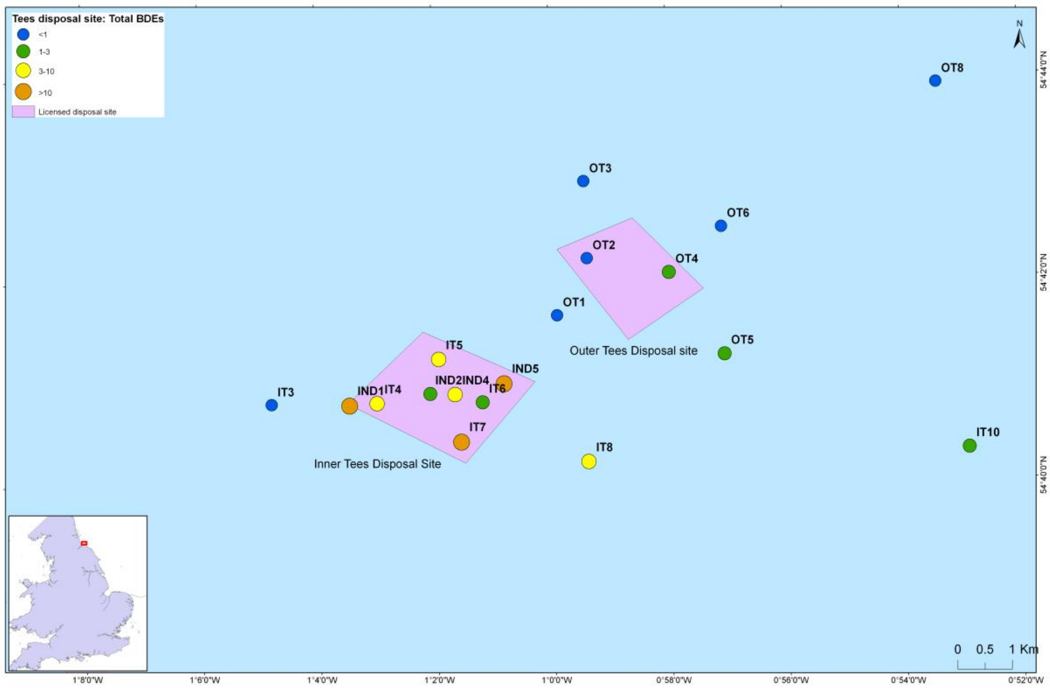


Figure A2.3.11. BDE209 concentrations for the Inner and Outer Tees Stations, 2011.

OCs were present at low concentrations <1 µg/kg dw when detected. In the Inner Tees area, IT7, IT8, IT5 and IND4 had ∑ DDT concentrations of 1.1, 1.0, 0.99 and 0.93 µg/kg dw, respectively, most of which was DDT metabolites (Figure A2.3.12). In the Outer Tees area, ∑ DDT concentrations of 1.2, 1.1, 0.85 and 0.84 µg/kg dw were found for OT4, OT5, OT3 and OT2, respectively. Dieldrin was detected at 16 out of 18 stations at concentrations ranging from <0.1-0.39 µg/kg dw and HCB was detected at 14 out of 18 stations (from <0.1 to 0.67 µg/kg dw). HCHs were below LODs at all 18 stations.

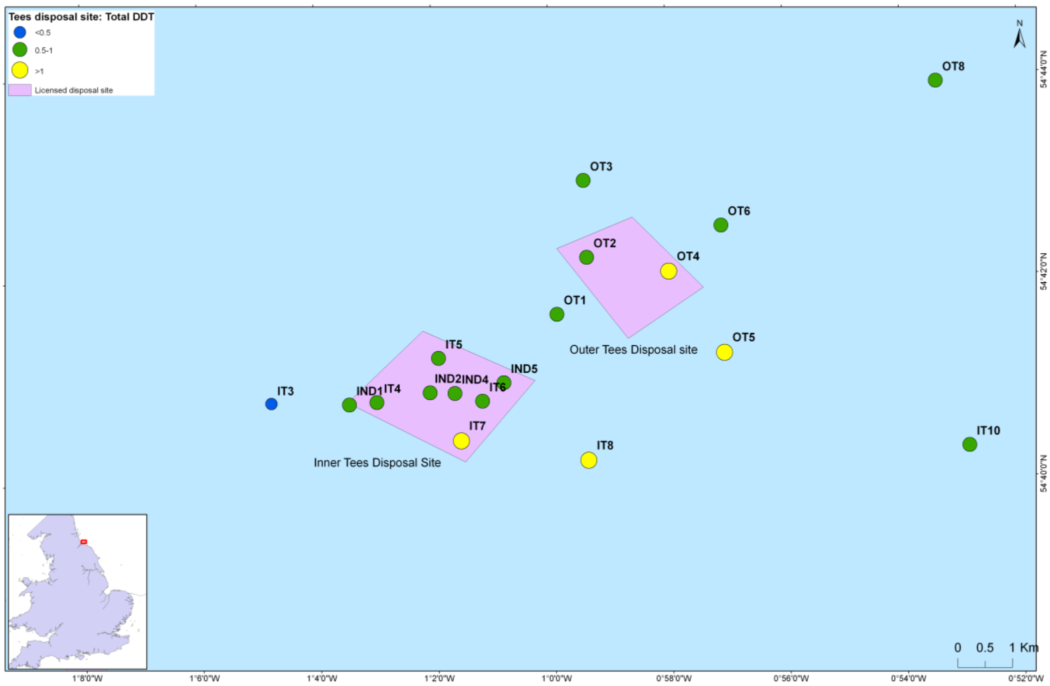


Figure A2.3.12. ∑ DDTs concentrations for the Inner and Outer Tees Stations, 2011.

Concentrations of CBs were below FEPA action levels at all stations. Concentrations of DDTs were above FEPA AL1 at stations IT7, IT8, OT4 and OT5 while no AL2 exists for DDTs. No FEPA 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. Exceptions were IT4 and IT7 which had CB118 with 'bad' environmental status but with 'good' status overall. No OSPAR guidelines exist for BDEs at present.

There are sufficient data available assess temporal trends of contaminants from 2003 to 2011 (See Tables A2.3.5 – A2.3.8). At Inner Tees, 2011 CB concentrations were generally similar those observed in 2010 (Table A2.3.5). Exceptions were at IT3 and IT4 where concentrations decreased, and at IND1 and IND4 where, the previously below LOD CBs, were at detectable levels in 2011. At Outer Tees, there is generally a decreasing trend, except for OT4 (within the disposal site) where CB concentrations increased from levels observed in 2010.

Table A2.3.5. Temporal trends (2003-2011) of ∑ICES 7 CBs concentration (in µg/kg dw) at Tees.

Station code	∑ ICES 7 CBs concentration (in µg/kg dw)						
	2003	2006	2007	2008	2009	2010	2011
IT2	*0.7*				*0.7*	*0.7*	
IT1		0.83	1.54		2.13	2.04	
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
IT4	26.4	*0.7*	2.8	*0.7*	2.75	2.03	1.42
IND2		*0.7*		*0.7*	*0.7*	2.72	*0.7*
IT5	*0.7*	*0.7*		0.92	*0.7*	1.21	1.27
IND4			4.62	1.76	2.15	*0.7*	1.23
IT7	24.1	*0.7*	1.7	*0.7*	1.04	1.6	1.6
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*
IT8	*0.7*	*0.7*	1.5	1.64	1.79	1.13	1.23
OT1		*0.7*		*0.7*	*0.7*	*0.7*	*0.7*
OT2		*0.7*		*0.7*	*0.7*	0.91	0.86
OT3		0.9	*0.7*	*0.7*	*0.7*	1.17	0.84
OT4		1.28	5.8	1.5	1.61	*0.7*	*2.4*
OT6		0.83		1.81	*0.7*	1.81	0.82
OT5		0.83	3.49	4.19	1.25	4.24	1.82
IT10	*0.7*			1.08	0.93	1.85	1.0
OT7				6.12		1.27	
OT8		*0.7*		*0.7*	*0.7*	*0.7*	*0.7*

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

For BDEs, there are sufficient data to investigate temporal trends from 2006-2011 (Table A2.3.6). At Inner Tees, there is no discernable trend: some stations increasing and others decreasing. Stations IND1, IT5, IND5 and IT8 all had higher concentrations in 2011 than in 2010, whereas IT3, IT4 and IND2 all had lower concentrations. The decreases at IT3 and IND2 were quite large. At Outer Tees, there was generally a decreasing trend, except for station OT4 in the disposal site, where BDE concentrations increased from the levels found in 2010.

Table A2.3.6. Temporal trends (2003-2011) of ∑11 BDEs concentration (in µg/kg dw) at Tees.

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

Note, 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.

At Inner Tees, there is no apparent trend in BDE209 concentrations: some stations increasing and others decreasing (Table A2.3.7). Stations IND1, IND4, IT7, IND5 and IT8 for example, all had higher concentrations in 2011 than in 2010, whereas IT3, IT4, IND2, IT5 and IT6 all had lower concentrations. IND2 and IT3 had large decreases from ~30 to <2 µg/kg dw, whereas IND5 and IND1 had large increases from below LOD to 10 µg/kg dw and 3.3 to 17 µg/kg dw, respectively. In the Outer Tees, BDE209 concentrations decreased at all stations between 20010 and 2011, with largest decreases at OT5 and OT6.

Table A2.3.7. Temporal trends (2008-2011) of BDE209 concentration (in µg/kg dw) at Tees.

Station code	BDE209 concentration (in µg/kg dw)			
	2008	2009	2010	2011
IT2		0.87	2.96	
IT1		20.9	9.16	
IND1	1.46	9.65	3.29	17.4
IT3	1.17		31.0	0.05
IT4	13.3	26.6	12.3	3.11
IND2	<0.1	<0.1	32.4	2.21
IT5	7.42	2.16	10.0	8.71
IND4		9.95	2.65	3.22
IT7	1.76	5.27	10.5	12.71
IT6	39.8	37.9	1.75	1.11
IND 5		<0.1	<0.1	10.1
IT8		5.89	3.54	7.74
OT1	0.58	0.70	2.35	0.26
OT2	1.27	1.38	2.56	0.56
OT3	2.37	0.80	3.57	0.71
OT4	3.81	3.13	1.45	1.26
OT6	3.42	2.29	7.85	0.41
OT5	19.0	3.86	20.0	2.66
IT10	2.19	1.97	6.43	1.36
OT7	84.3		5.53	
OT8	0.75	<0.1	1.53	0.30

Regarding *∑DDTs*, there is no clear trend apparent at Inner Tees, with small increases and decreases being exhibited for most stations (Table A2.3.8). At Outer Tees, there was generally a clear decreasing trend, except for stations IT10 and OT8, where DDT concentrations increased slightly from the levels found in 2010.

The Outer Tees disposal site did not receive dredged material during 2010, which may explain why concentrations generally decreased in that region. In contrast, the Inner Tees disposal site received a large amount of material in 2010.

Table A2.3.8. Temporal trends (2003-2011) of ∑DDTs concentration (in µg/kg dw) at Tees.

Station code	∑DDTs concentration (in µg/kg dw)								
	2003	2004	2005	2006	2007	2008	2009	2010	2011
IT2	0.60							*0.3*	
IT1				1.43	2.01			1.01	
IND1				0.85	0.99	1.12		0.47	0.80
IT3	0.41			0.64	3.73	0.63		1.95	0.44
IT4	0.55			0.88	1.63	0.88		0.89	0.78
IND2				0.58		0.45		0.95	0.76
IT5	0.41			0.65		1.55		1.15	0.99
IND4					2.02	1.17		*0.3*	0.93
IT7	3.65			0.60	1.4	0.81		1.58	1.14
IT6	*0.3*			0.98	1.62	1.72		0.71	0.79
IND 5					1.81	0.41		*0.3*	0.68
IT8	0.45			0.65	1.91	0.71		0.91	1.04
OT1				0.58		0.64		1.12	0.67
OT2				0.81		0.66		2.08	0.84
OT3				0.88	1.4	0.73		2.11	0.85
OT4				0.93	4.4	0.92		1.87	1.17
OT6				1.01		0.85		2.42	0.74
OT5				1.05	2.81	2.27		2.45	1.1
IT10	*0.3*					0.89		0.84	0.93
OT7						2.88		0.71	
OT8				0.78		0.65		*0.3*	0.62

2.3.4.4.4 Trace metals

In 2011, samples for trace metals analysis were collected at 12 (eight within the licensed boundary) and seven (two within) stations at the Inner and Outer Tees disposal sites respectively (Figure A2.3.13). Cr and Ni show similar enrichment factors; a slight enrichment is observed at most stations based on the OSPAR BAC approach (see Figure A2.3.13 for Ni). This enrichment is slightly reduced when assessed using the baseline method. This is due to the fact that the proposed baseline values for the above metals are higher than the OSPAR BAC value, to take into consideration regional variability.

Enrichment in As can be observed at stations located at the inner Tees disposal site only, no enrichment was recorded for stations at the outer Tees disposal site. The same applies to Cd, although at a more pronounced enrichment (i.e. 2-5 times higher). Both assessment methods lead to the same observation. Similarly, enrichment for Cu (Figure A2.3.13) is relatively higher at Inner Tees than at Outer Tees using both assessment approaches.

Enrichment comparison for Zn is similar with both assessment approaches with overall slightly enriched stations, with the exception of IND4 where Zn was found to be moderately enriched when comparing against the OSPAR BAC value.

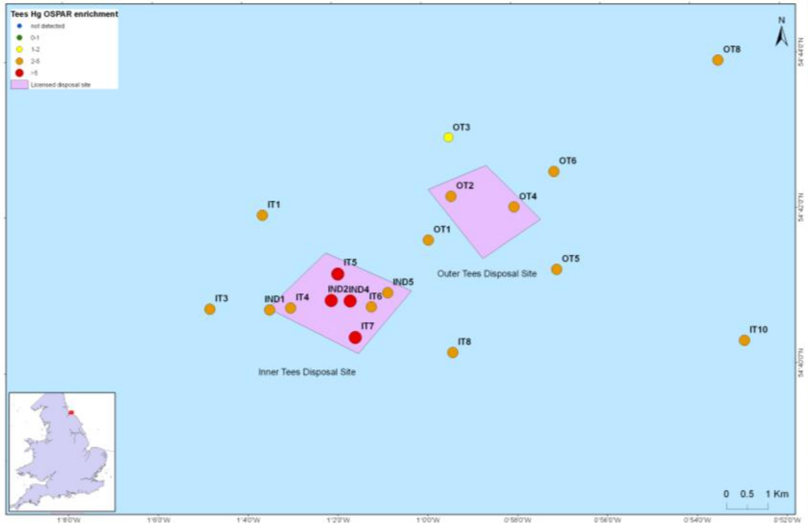
Pb shows a moderate enrichment for most stations at Tees disposal sites, with two very enriched stations OT4 (located within the Outer Tees disposal site) and OT8 (northeast of the Outer Tees disposal site) when assessment was conducted using the OSPAR BAC approach. Notably, most stations remain either slightly enriched or not enriched according to the regional baseline method (Figure A2.3.13).

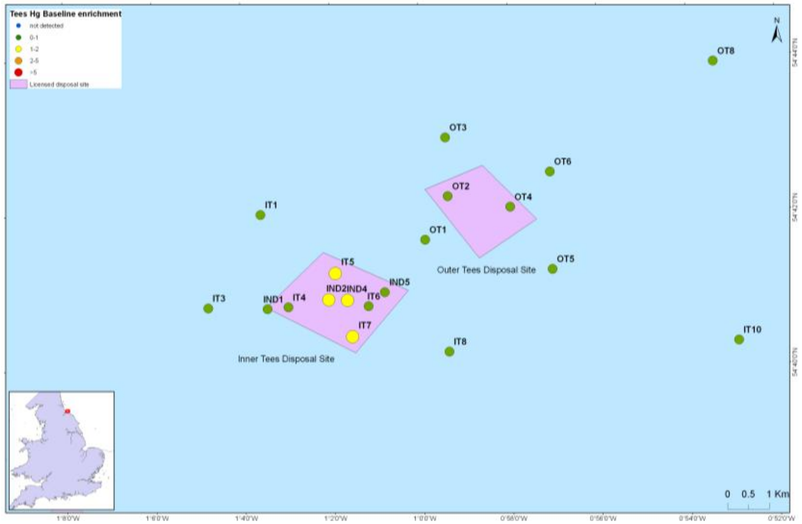
The difference in enrichment factors between the two assessment approaches was more pronounced for Hg (Figure A2.3.13). For example, Hg shows a moderate enrichment for most stations, with four ‘very enriched’ stations located within the Inner Tees disposal site with the OSPAR BAC approach whereas the same highly enriched stations were found to be slightly enriched according to the regional baseline assessment method, with no enrichment observed for the remaining stations.

Despite the fact that the Tees has a large quantity of chemical industries which have resulted in contaminants within dredge sediments (ICI, Tioxzide factories have all discharged into the Tees) and currently, within the Tees there is an eroding mudflat which is contaminated with high levels of Pb and Zn, the findings show that the extent of enrichment of Pb and Zn still remain low.


Tees Cu OSPAR enrichment
not detected
0-1
1-2
2-5
>5
Licensed disposal site
N
OT8
OT3
OT6
OT2
OT4
IT1
OT1
IT5
OT5
Outer Tees Disposal Site
IND5
IND2
IND4
IT6
IT3
IND1
IT4
IT7
IT10
IT8
Inner Tees Disposal Site
0 0.5 1 Km


Tees Cu Baseline enrichment
not detected
0-1
1-2
2-5
>5
Licensed disposal site
N
OT8
OT3
OT6
OT2
OT4
IT1
OT1
IT5
OT5
Outer Tees Disposal Site
IND5
IND2
IND4
IT6
IT3
IND1
IT4
IT7
IT10
IT8
Inner Tees Disposal Site
0 0.5 1 Km


Tees Hg OSPAR enrichment
not detected
0-1
1-2
2-5
>5
Licensed disposal site
N
OT8
OT3
OT6
OT2
OT4
IT1
OT1
OT5
IT5
Outer Tees Disposal Site
IND5
IND2
IND4
IT6
IT3
IND1
IT4
IT7
IT10
IT8
Inner Tees Disposal Site
0 0.5 1 Km


Tees Hg Baseline enrichment
not detected
0-1
1-2
2-5
>5
Licensed disposal site
N
OT8
OT3
OT6
OT2
OT4
IT1
OT1
IT5
OT5
Outer Tees Disposal Site
IND5
IND2
IND4
IT6
IT3
IND1
IT4
IT7
IT10
IT8
Inner Tees Disposal Site
0 0.5 1 Km

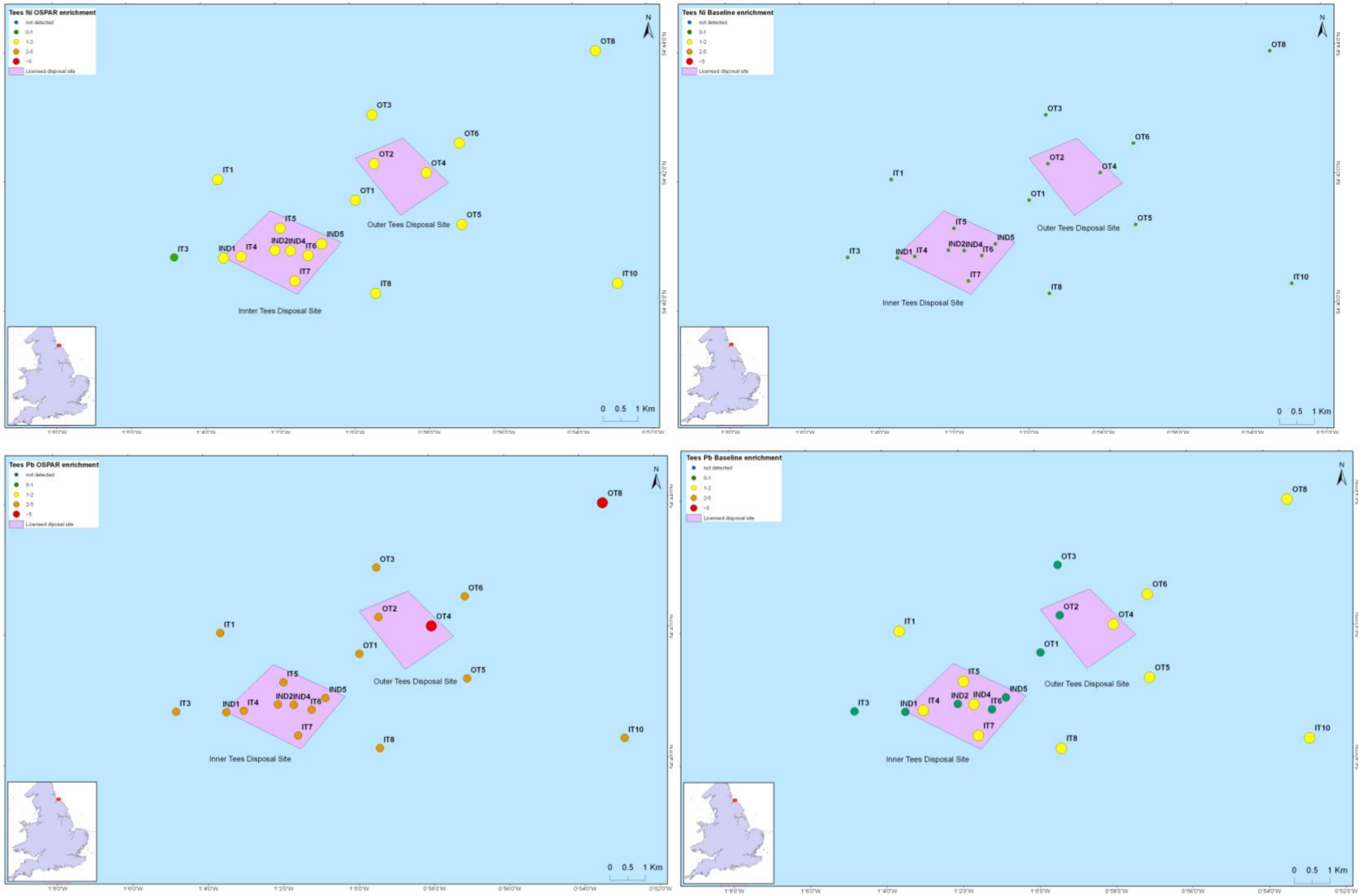


Figure A2.3.13. Enrichment to OSPAR BACs (left) and Baseline values (right) at Inner and Outer Tees in for Cu, Hg, Ni and Pb.

2.4 Goole (HU041)

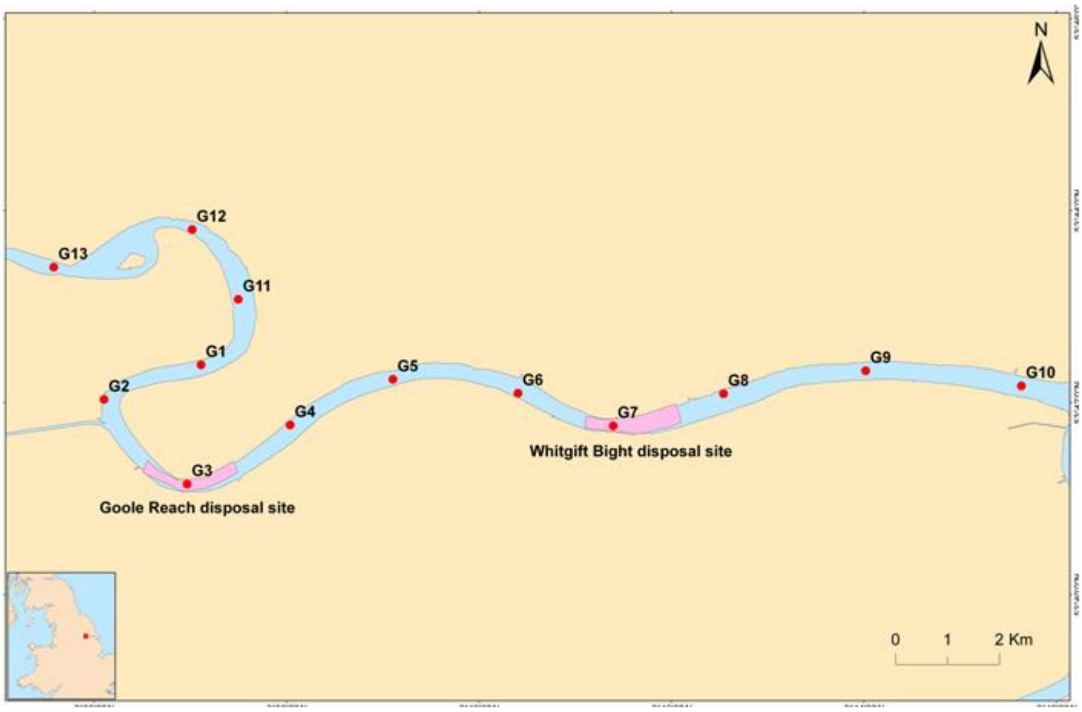


Figure A2.4.1. Location of the sampling stations at Goole, 2011.

2.4.1 Background

Goole Reach (HU041) and Whitgift Bight (HU040) dredged material disposal sites are both located on the River Ouse on the upper reaches of the Humber Estuary. These sites are located within hydrodynamic stretches of the river; material is rapidly dispersed both upstream and downstream (depending on the tidal state at disposal) following disposal.

HU040 was opened in 1982, although no disposal too place until 1984. HU041 was opened in 1990 with disposal in that same year. These sites solely receive maintenance dredged material from Goole docks: generally silt/sand material with an approximate specific gravity of 1.3.

Goole Docks have a current licence for the disposal of 49,000 tonnes (37,690 m^3) of maintenance dredged material. Dredging operations take place prior to high tide with deposition taking place around high water, with the disposal of approximately 1100 tonnes per tide.

RAT prioritisation assessment: Tier 1

- Where there is the potential for the occurrence of elevated contaminant concentrations (between Cefas action levels of 1 and 2 in proposed dredge sediments) arising from historical or current activities at source.

Concerns:

These disposal sites have been selected for sampling as material from Goole docks is known to exhibit elevated levels of PAH. Sampling at and adjacent to the disposal sites under SLAB5 during 2008 revealed high levels of DDT: further sampling under this project is needed to improve our understanding of the potential source of this contaminant (i.e., disposal activities or otherwise). The catchment area of this river is predominantly agricultural; high levels of DDT observed in the sediments may be a result of the historical use of DDT in agricultural practices.

2.4.2 Impact hypotheses:

- Any elevations in the concentrations of chemical contaminants directly attributable to dredged material disposal will be confined to within and the near vicinity of the disposal site, principally along the tidal axis
- Any elevations in the concentrations of chemical contaminants directly attributable to dredgings disposal will be within acceptable limits

2.4.3 Parameters monitored (via non-Cefas charter vessel):

Sediment particle size
Sediment organic carbon and nitrogen
Sediment contaminants (TBT, PAHs, organohalogens, trace metals)

2.4.4 Results

2.4.4.1 Sediment particle size

The sediments around Goole are predominantly muddy sands and sands (Table A2.4.1). Changes in sediment groups from 2008 to 2011 are shown in Table A2.4.2: such changes have been minimal except for a reduction of fines at G1 (upstream stations), G7 (within HU040) and increase of fines at G8 (east of HU040) and at G10 (at the entrance to the narrow part of the Humber). Pie charts of gravel, sand and silt/clay for 2011 are shown in Figure A2.4.2 and silt/clay contents in Figure A2.4.3. These Figures reinforce the above findings of the predominantly sandy nature of the sediments, with increased proportions of silt/clay at several stations (i.e., those in sediment group G01).

Table A2.4.1 Average sediment descriptions and statistics for each sediment group at Goole.

Sediment group	Number of samples	Sample Type	Sediment description	MODE 1 (μm):	MODE 2 (μm):	MODE 3 (μm):
Go1	11	Bimodal, Poorly Sorted	Slightly Gravelly Muddy Sand	76.5	37.75	
Go2	13	Unimodal, Moderately Well Sorted	Slightly Gravelly Muddy Sand	107.5		
Go3a	9	Unimodal, Moderately Well Sorted	Slightly Gravelly Sand	152.5		
Go3b	3	Unimodal, Moderately Well Sorted	Slightly Gravelly Sand	302.5		

Sediment group	Gravel (%)	Sand (%)	Silt/clay (%)	Very coarse sand (%)	Coarse sand (%)	Medium sand (%)	Fine sand (%)	Very fine sand (%)
Go1	0.01	54.04	45.95	0.06	0.30	0.81	4.86	48.02
Go2	0.00	88.15	11.85	0.01	0.05	1.53	13.59	72.96
Go3a	0.01	96.66	3.34	0.02	0.12	4.11	56.86	35.55
Go3b	0.13	96.69	3.19	0.18	3.19	55.39	32.93	5.00

Table A2.4.2 Sediment groups for each station sampled in 2008, 2010 and 2011 at Goole.

	Year		
Sample code	2008	2010	2011
G1	Go3a	Go1	Go3a
G2	Go2	Go1	Go1
G3	Go2	Go2	Go1
G4	Go3a	Go3b	Go3a
G5	Go2	Go1	Go1
G6	Go3b	Go3a	Go1
G7	Go2	Go2	Go3a
G8	Go3a	Go2	Go1
G9	Go3b	Go3a	Go3a
G10	Go1	Go2	Go1
G11		Go1	Go2
G12		Go2	Go2
G13		Go2	Go2

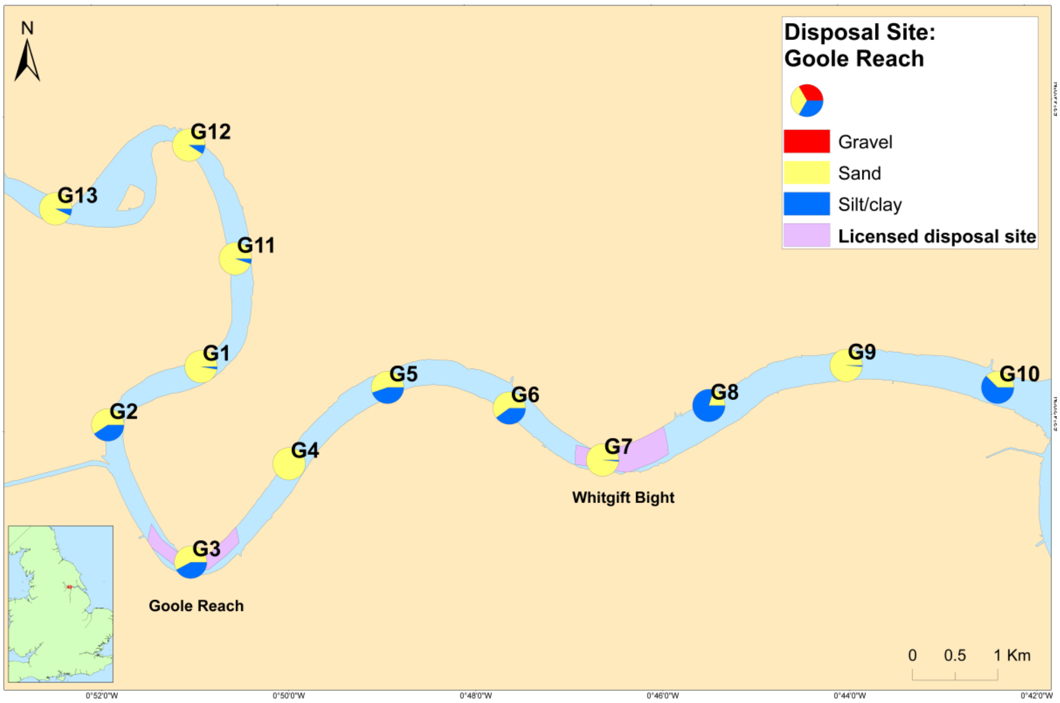


Figure A2.4.2 Pie charts of gravel, sand and silt/clay at Goole in 2011.

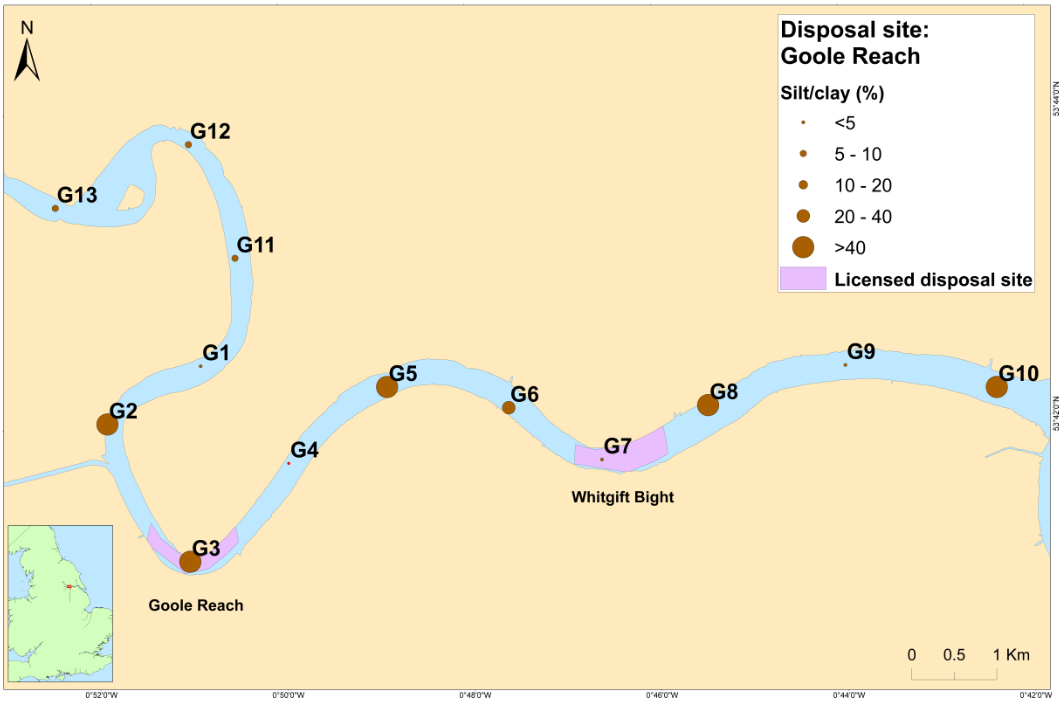


Figure A2.4.3 Silt/clay (%) at Goole in 2011.

2.4.4.2 Sediment organic carbon and nitrogen

In 2011, organic carbon values (in the <63µm sediment fraction) ranged from 0.72 to 2.21 % m/m (Figure A2.4.4) and for nitrogen 0.05 to 0.17 % m/m. Organic carbon values (in the <2mm sediment fraction) ranged from 0.1 to 3.01 % m/m and <0.03 to 0.18 % m/m for nitrogen. G1, G4, G7 and G9 have low silt/clay content (<3% silt/clay) and so it was not possible to measure the organic carbon for these stations. These data indicate that organic carbon contents are similar to concentrations measured in 2010 (Bolam et al., 2011).

As in 2008 and 2010, some samples displayed higher levels of organic carbon present in the <2 mm fraction than the <63 µm fraction, showing that organic carbon is also present in coarser sediment, probably as coal.

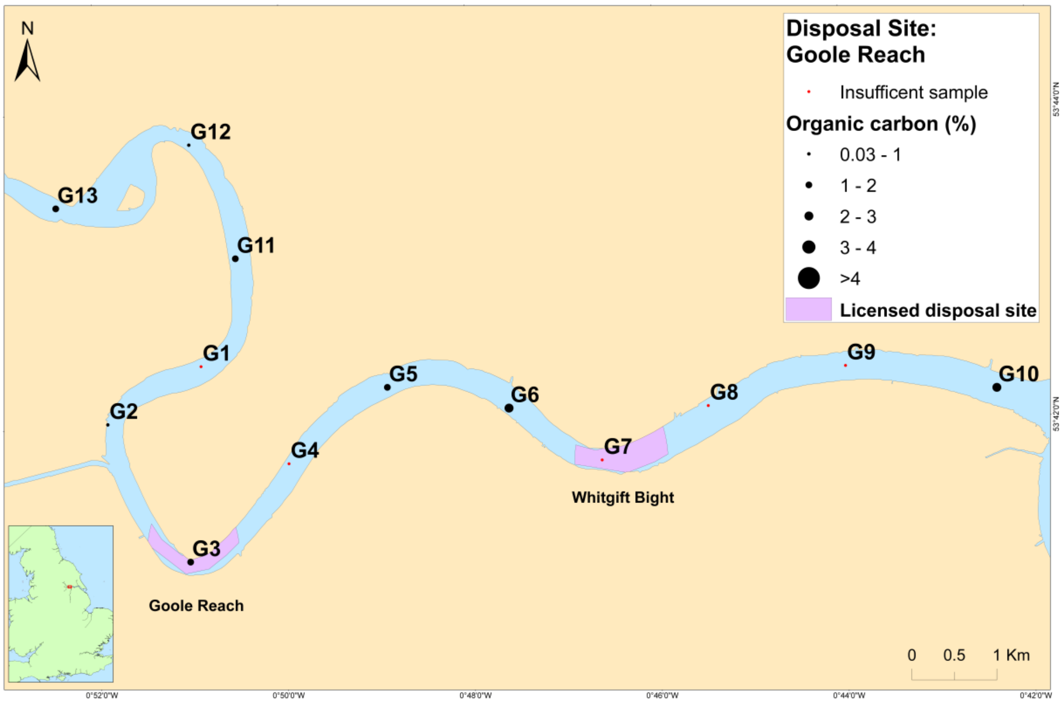


Figure A2.4.4. Organic carbon (%m/m) in the silt/clay fraction (<63µm) at Goole in 2011.

2.4.4.3 Sediment contaminants

2.4.4.3.1 TBT

Concentrations of TBT throughout the Goole survey were below the method limit of detection except for G5 and G8, located either sides of the disposal sites (Figure A2.4.5). G5 and G8 exhibited similar TBT concentrations (0.012 and 0.016 mg/kg) which remain below Cefas AL1. When compared with previous year's findings, concentrations of TBT have remained generally consistent.

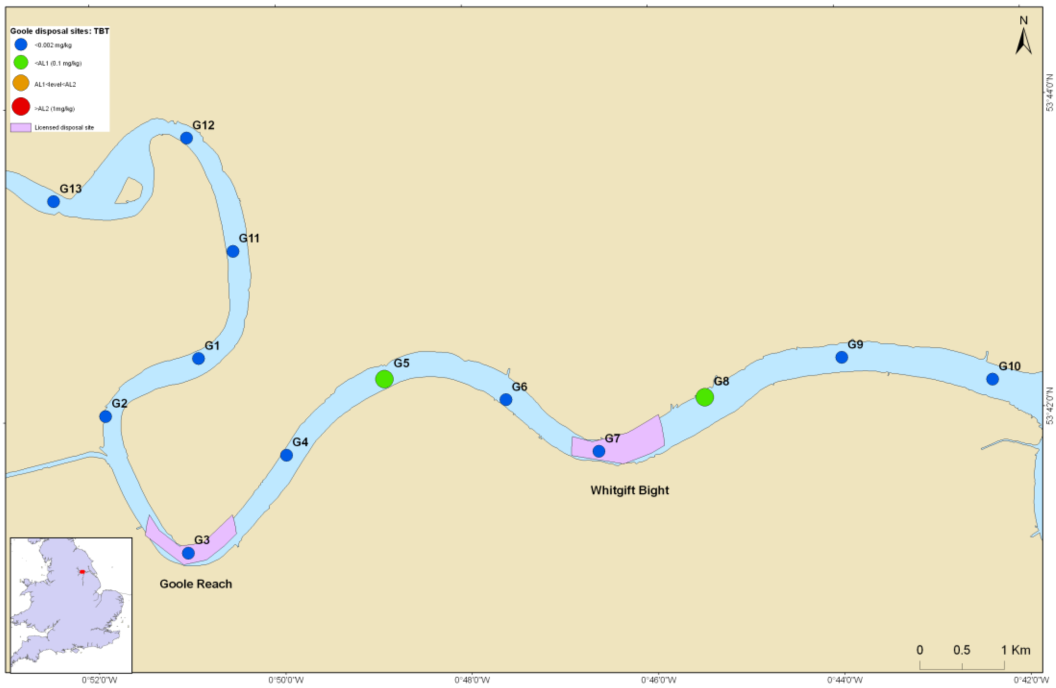


Figure A2.4.5. TBT at Goole disposal site in 2011.

2.4.4.3.2 PAHs

The highest summed PAH concentration was found at G5 (26,100 µg kg^{-1} dry weight) situated midway between the two disposal sites (Figures A2.4.6 & A2.4.7). The second highest was found at G8, to the east of the disposal site HU040 at Whitgift Bight. This is in contrast to previous years, when the highest concentration was found at G2 immediately outside the locks entrance to Goole Docks and downstream of the disposal site situated at G3. Because this area is affected by strong tidal currents, concentrations may reflect redistribution of both sea-bed sediments and material from dredgings disposal at both disposal sites, at Goole Reach and Whitgift Bight.

Disposal of dredged material to HU041 (Goole Reach) decreased in 2010 to 5,720 tonnes, from 17,000 tonnes in 2009. Similarly, disposal to HU040 (Whitgift Bight) also decreased, from 5,800 tonnes to 2,230 tonnes. This decrease in disposal possibly accounts for the decrease in concentrations of summed PAHs found at this site.

The ERL for LMW PAHs was exceeded at G2, G3, G5, G6, G8 G10 and G13, where the summed PAH concentrations were greater than 4,800 µg kg^{-1} dw, while the ERM for LMW PAHs was exceeded at G5 and G8 only. The ERL for HMW PAHs was exceeded at G2, G3, G5, and G8: all stations were below the ERM for HMW PAHs. The source of PAH was found to be >70% oil-derived at G2, G3, G5, G12 and G8.

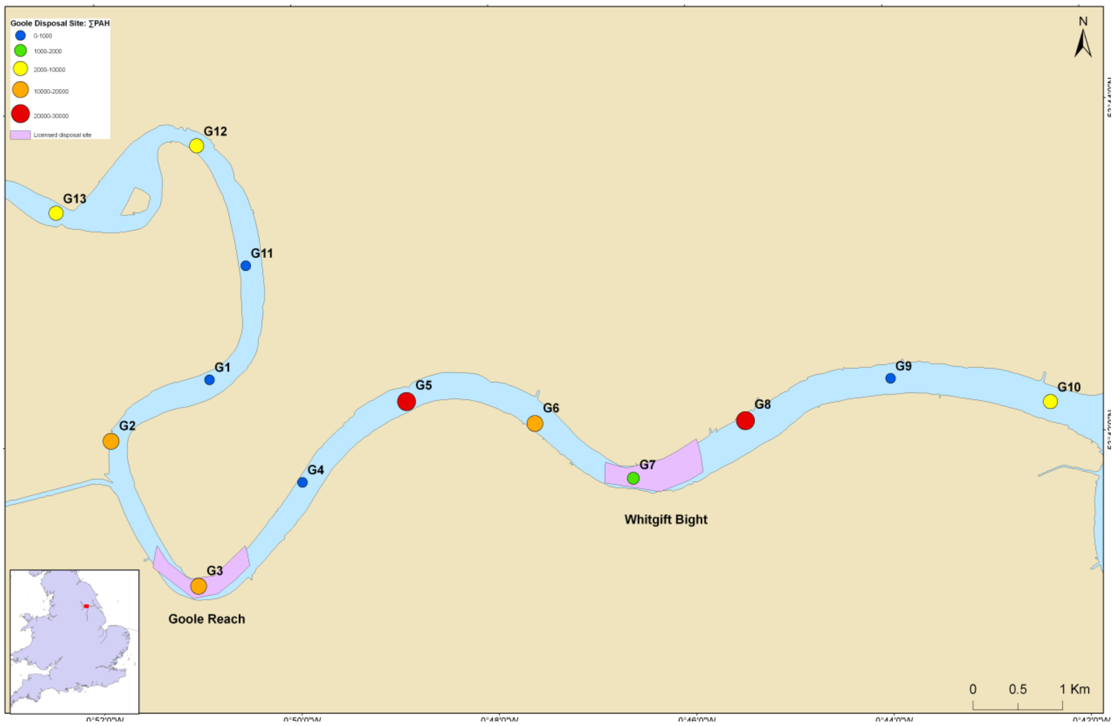


Figure A2.4.6. Summed PAH concentrations (µg kg^{-1} dw) for stations sampled in 2011 at Goole.

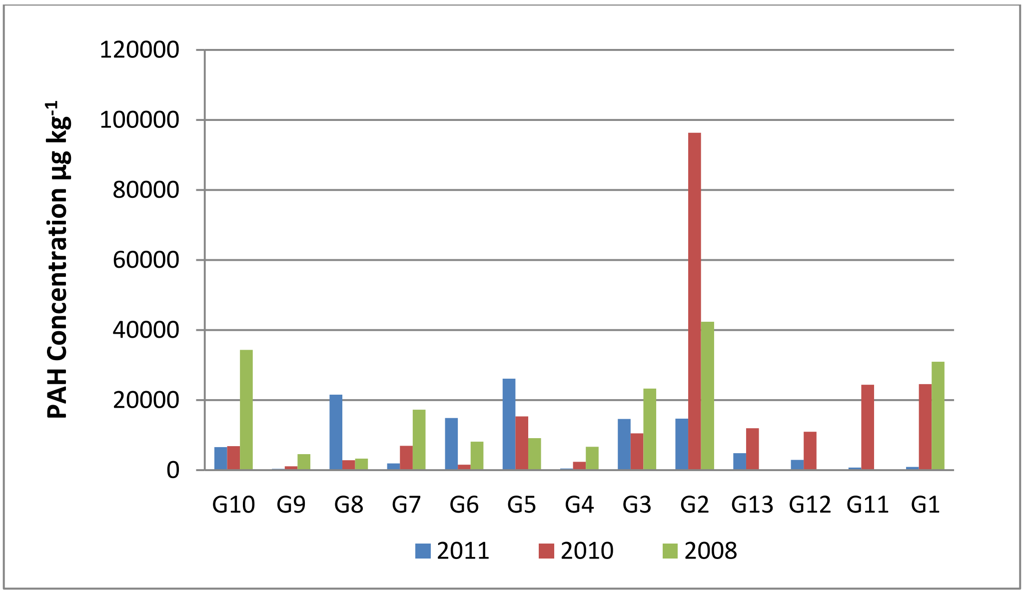


Figure A2.4.7. Summed PAH concentrations observed in 2008, 2010 and 2011 at Goole sampling stations.

2.4.4.3.3 Organohalogens

At Goole, CBs were detected at 11 out of the 13 stations sampled, only G9 and G11 did not contain detectable levels of CBs (∑ ICES 7 CBs range <0.7-8.5 µg/kg dw). The highest ∑ ICES 7 CBs value of 8.3 µg/kg dw was at G5, located between the two disposal sites (Figure A2.4.8). G6 and G8 had the next highest concentrations of 6.4 and 7.0 µg/kg dw, respectively. The concentration of 4.5 µg/kg dw at G3 within the Goole Reach disposal site and 1.2 µg/kg dw at G7 within the Whitgift Bight disposal site, however was lower.

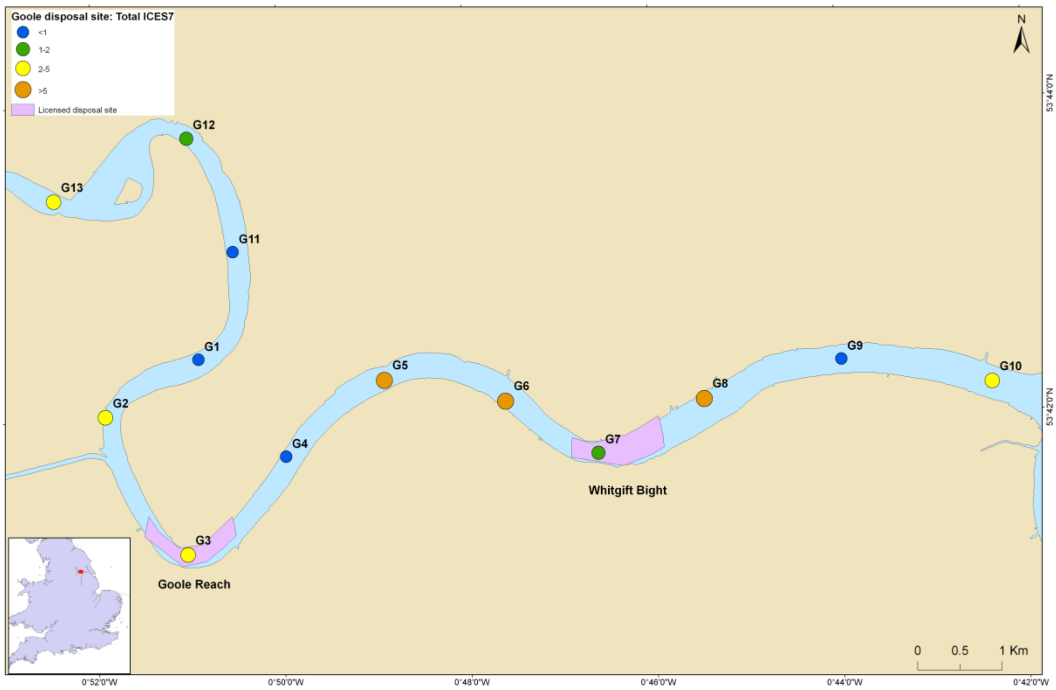


Figure A2.4.8. ∑ ICES7 CB concentrations for the Goole stations, 2011.

BDEs were detected at all stations in the Goole survey (∑ 11 BDEs range 0.4-32 µg/kg dw). The highest ∑ 11 BDEs value of 32 µg/kg dw was at G5, between the two disposal sites (Figure A2.4.9). As for ∑ ICES 7 CBs, G6 and G8 displayed the next highest concentrations of BDEs of 5.6 and 7.3 µg/kg dw, respectively. G2, upriver of the Goole Reach disposal site, and G10, the most downriver station in the survey area, had ∑ 11 BDEs concentrations of 3.7 and 2.1 µg/kg dw, respectively. BDE47 and BDE 99 were detected in all stations and were the dominant congeners present. BDE183 was only detected in 4 out of 11 stations, coinciding with high BDE209 values, indicating that the decaBDE technical mixture was its likely source.

BDE209 was detected at all 13 stations and was generally at higher concentrations than the other measured organohalogens (range 0.2-94 µg/kg dw) (Figure A2.4.10). When included with the other BDEs, BDE209 made up >32 % of the BDEs present (range 32-91 %). BDE209 is indicative of the decaBDE technical mixture, which has been in use more recently than the other technical mixtures, although it's use has been restricted in the EU since 2008. The highest concentration (94 µg/kg dw) was again detected at G5, with 45 µg/kg and 41 µg/kg dw at G8 and G6, respectively. Levels within the disposal sites were lower, with 35 µg/kg and 1.0 µg/kg dw measured at G3 and G7. G2, upriver of the Goole Reach disposal site, and G10, the most downriver station in the survey area, had BDE209 concentrations of 40 µg/kg and 17 µg/kg dw, respectively.

p,p'-DDT was detected at six of the 13 stations (range <0.2-4.3 µg/kg dw), with its metabolites being detected at all stations in the Goole survey area (range <0.2-11 µg/kg dw). ∑ DDT concentrations were consistently high, with seven out of 13 stations >5 µg/kg dw (range 1.6-15 µg/kg dw). Highest concentrations were again in the stations around the Whitgift Bight disposal site, where 15 µg/kg, 14 µg/kg and 14 µg/kg dw was observed at G5, G6 and G8, respectively (Figure A2.4.11), although levels within the site were lower (3.5 µg/kg dw). The Goole Reach disposal site had a higher total DDT concentration of 9.4 µg/kg dw. HCH concentrations were low, with only δ-HCH detected in one of the 13 stations. HCB was detected at nine of 13 stations, with levels mostly <0.6 µg/kg dw, except at G5, G8 and G10, where concentrations of 0.66, 1.9 and 1.5 µg/kg dw, respectively were recorded. Dieldrin was detected at all stations, with highest levels either side of the Whitgift Bight disposal site, where 1.2 µg/kg, 1.2 µg/kg and 1.0 µg/kg dw was observed at G5, G6 and G8, respectively, whereas within it Whitgift Bight dieldrin concentration was 0.48 µg/kg dw.

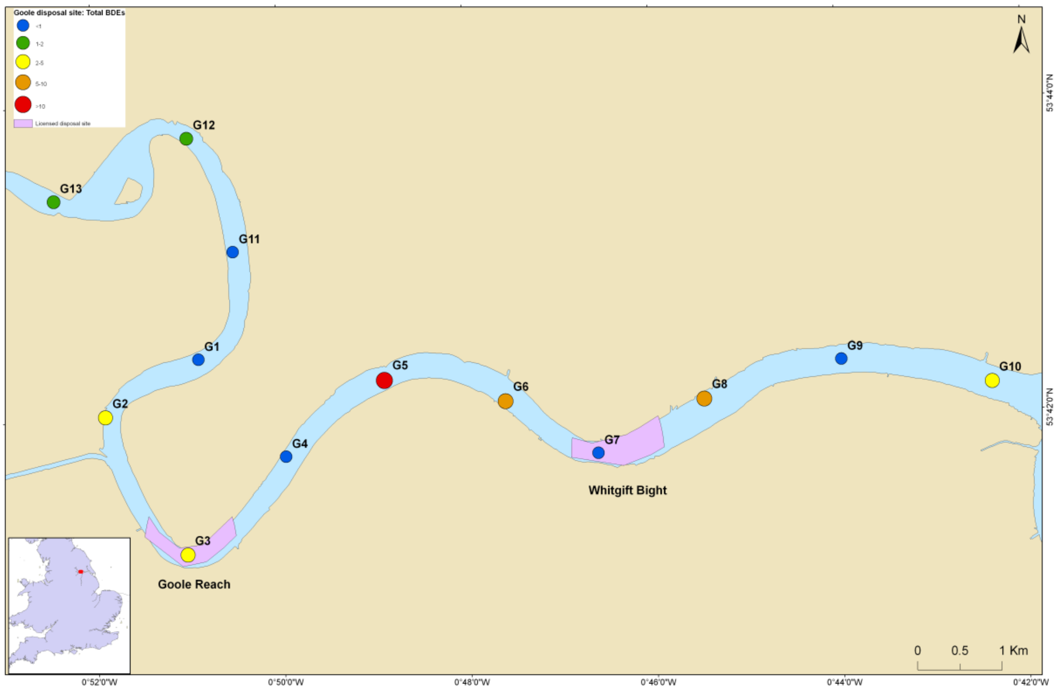


Figure A2.4.9. ∑ 11 BDEs concentrations for the Goole stations, 2011.

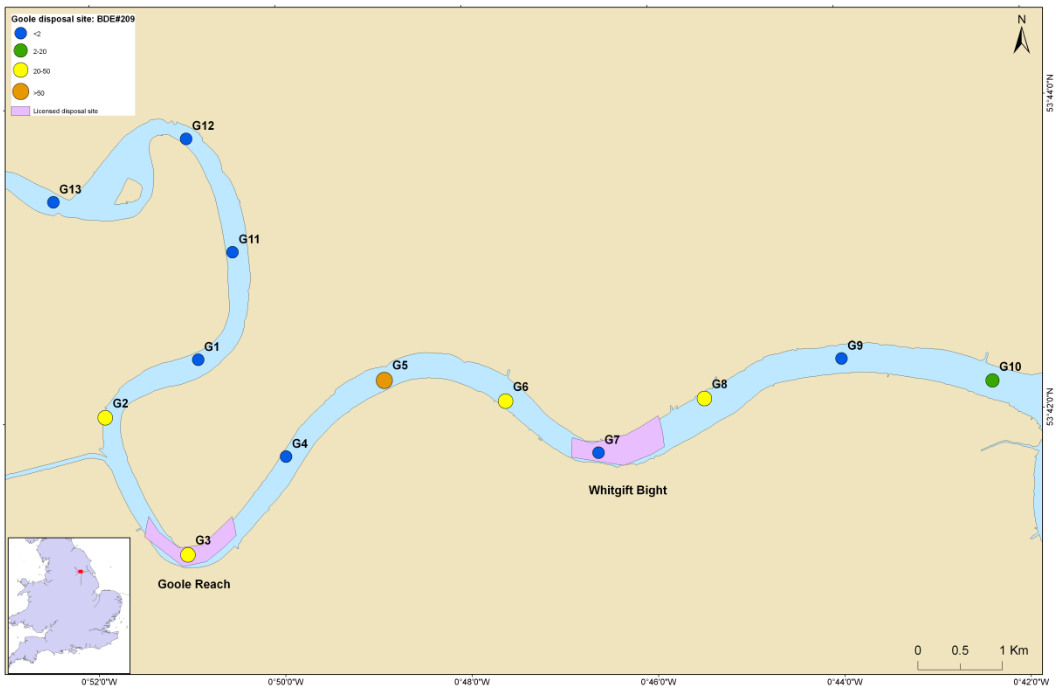


Figure A2.4.10. BDE209 concentrations for the Goole stations, 2011

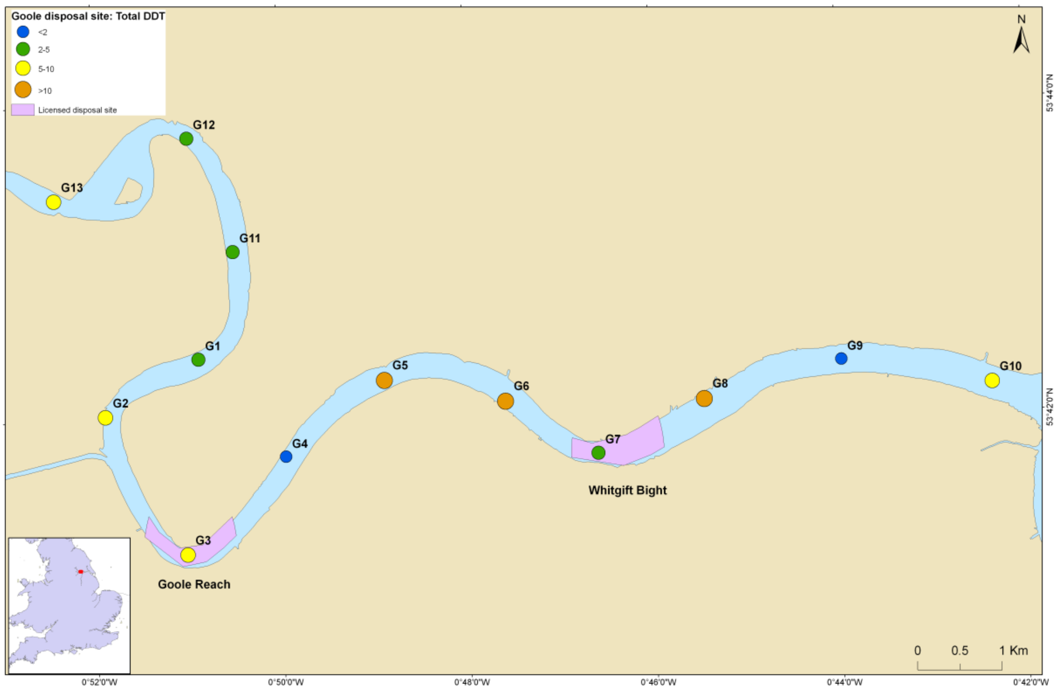


Figure A2.4.11. ∑ DDTs concentrations for the Goole stations, 2011.

Concentrations of CBs at most stations were below FEPA action levels, however, those of DDTs were above FEPA AL1 at all stations: no AL2 exists for DDTs. Concentrations of dieldrin were above FEPA AL1 at stations G5, G6 and G8: again, no AL 2 exists for dieldrin. No Fepa 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. Exceptions were one CB concentration with 'bad' environmental status but 'good' status overall at G5 and G8 (for CB118). No OSPAR guidelines exist for BDEs and OCs at present.

There is sufficient data available for Goole to allow assessments of the temporal changes in organohalogen concentrations (Tables A2.4.3 to A2.4.6). For all contaminants, levels in 2011 increased within the Goole Reach disposal site and decreased within the Whitgift Bight disposal site when compared to those observed in 2010. Both the amounts of sediment and its contaminant load disposed to Goole Reach in 2010 were higher than those disposed of to Whitgift Bight. Levels of all contaminants increased at stations G5, G6 and G8 between 2010 and 2011. The River Ouse is tidal and is a very dynamic location, with sediments likely to be transported up and down the river, so these elevated levels may have originated from the disposal site, or from areas lining the river. At stations upriver of the Goole Reach disposal site, contaminant levels generally declined, sometimes by large amounts. All contaminants decreased at stations G1, G11 and G12, sometimes by factors of 10 or more. Similarly, all contaminants except for BDE209 decreased at station G2. The most upriver station, G13, however lacked this clear pattern, with CBs and OCs increasing and BDEs, including BDE209, decreasing. The causes of decreases in the upriver area are unknown. It may be that disposed sediments have been dispersed downstream, possibly contributing to the increases observed at G5, G6 and G8.

Table A2.4.3. Temporal trends (2008-2011) of ∑ICES 7 CBs concentration (in µg/kg dw) at Goole.

Station code	∑ICES 7 CBs concentration (in µg/kg dw)			
	2008	2009	2010	2011
G1	3.85		*5.58*	*0.7*
G2	4.95		12.7	4.04
G3	3.88		2.33	4.51
G4	2.07		0.7	*0.7*
G5	1.83		5.35	8.49
G6	*0.7*		0.82	6.44
G7	2.32		2.46	1.20
G8	1.19		1.63	6.97
G9	*0.7*		0.83	*0.7*
G10	5.21		3.83	3.07
G11			6.83	*0.7*
G12			3.07	1.97
G13			2.82	3.06

Table A2.4.4. Temporal trends (2008-2011) of ∑11 BDEs concentration (in µg/kg dw) at Goole.

Station code	∑11 BDEs concentration (in µg/kg dw)			
	2008	2009	2010	2011
G1	3.68		*8.06*	*0.69*
G2	5.29		20.2	3.69
G3	3.78		2.76	4.18
G4	1.75		0.18	0.47
G5	1.73		6.47	32.2
G6	5.45		1.35	5.64
G7	4.53		3.56	0.93
G8	1.00		1.83	7.31
G9	15.6		0.66	0.40
G10	7.17		2.00	2.11
G11			16.8	0.70
G12			3.05	1.30
G13			2.51	1.88

Table A2.4.5. Temporal trends (2008-2011) of BDE209s concentration (in µg/kg dw) at Goole.

Station code	BDE209 concentration (in µg/kg dw)			
	2008	2009	2010	2011
G1	*10.2*		*81.3*	0.41
G2	7.16		38.2	36.7
G3	4.44		14.3	35.1
G4	*0.05*		*0.05*	0.22
G5	3.36		48.6	93.6
G6	5.29		8.24	40.8
G7	1.96		18.7	1.05
G8	*0.05*		*0.05*	45.2
G9	*0.05*		*0.05*	1.02
G10	34.2		7.24	17.1
G11			310	0.69
G12			*0.05*	1.93
G13			3.34	1.65

Table A2.4.6. Temporal trends (2008-2011) of ∑DDTs concentration (in µg/kg dw) at Goole.

Station code	∑DDTs concentration (in µg/kg dw)			
	2008	2009	2010	2011
G1	28.46		11.24	2.38
G2	22.8		22.2	8.75
G3	12.52		5.46	9.40
G4	8.87		0.88	1.60
G5	19.79		15.39	15.47
G6	4.85		1.88	13.9
G7	6.39		10.71	3.52
G8	5.25		3.62	14.3
G9	3.22		2.17	1.23
G10	13.34		6.72	5.81
G11			21.94	2.10
G12			6.70	4.75
G13			5.69	7.43

2.4.4.3.4 Trace metals

Levels of As are comparable for both OSPAR BAC and baseline methods, with only 3 stations expressing ‘no enrichment’ in As (G12, G1 and G9). Slight enrichment is observed elsewhere, including both stations located within the disposal sites (G3 and G7). When compared to 2010, levels of As have slightly increased as most stations were found to be not enriched in 2010 (Bolam et al., 2011).

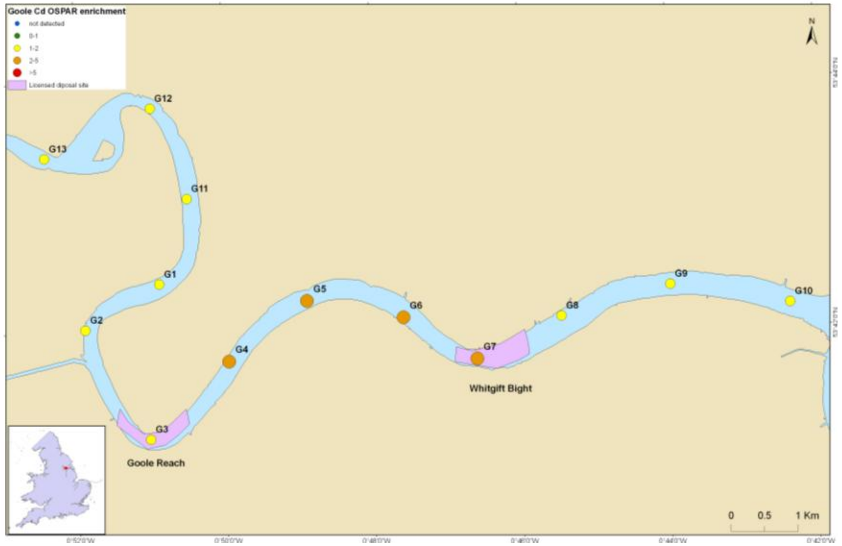
Cd, however, exhibited a slight to moderate enrichment at all stations when assessing against the OSPAR values. Cd is found to be more elevated at stations G4, G5, G6 and G7, all located between the two disposal sites at Goole (Figure A2.4.12). Interestingly, the baseline value for this region is lower than the OSPAR BAC value, making enrichment even higher using the regional baseline approach, particularly at G4 and G5, both located between the two disposal sites. These findings were also seen in 2010, but to a lesser degree of enrichment (Bolam et al., 2011).

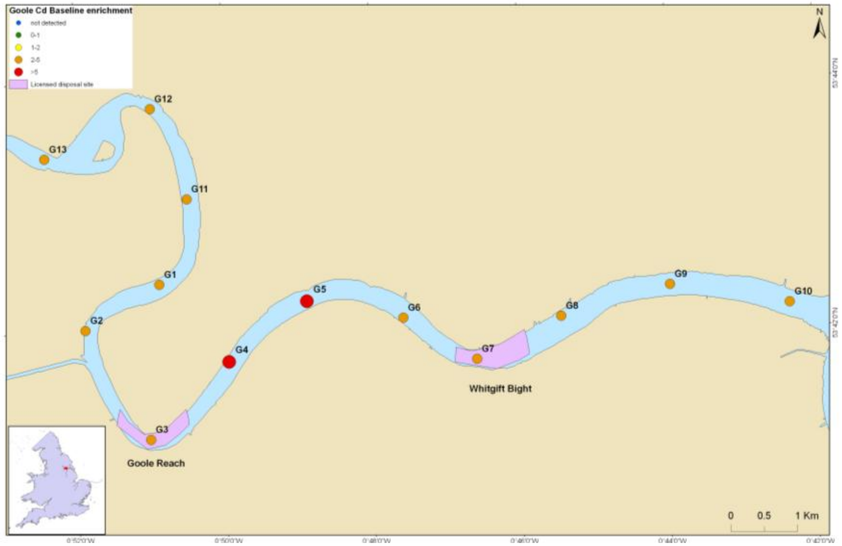
Slight enrichment was also depicted in Cu according to both assessment methods which is comparable to that in 2010. When comparing with the OSPAR BAC value for Zn, slight enrichment is observed at stations located upstream of the river, a moderate enrichment at stations downstream of the river. Zn enrichment was less pronounced according to the baseline approach, however Zn levels at G5, G6 and G7 (stations located in the middle of the river) remaining 2-5 times the regional baseline values (Figure A2.4.12).

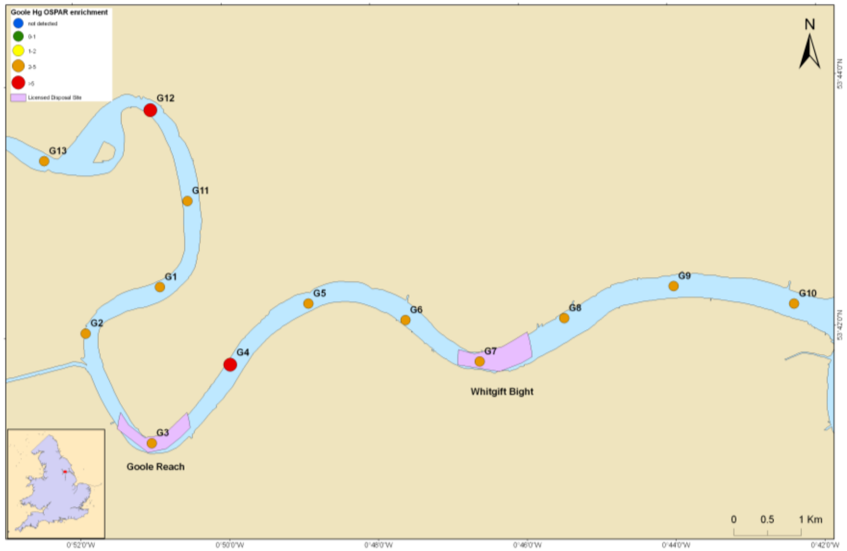
The difference in the OSPAR BAC and the regional value for Hg was also reflected in the enrichment maps from both assessment methods. For example, most stations were found to be moderately enriched with G12 and G4 showing concentrations >5 times the OSPAR BAC value, whereas Hg enrichment is attenuated when assessment was conducted using the regional baseline method (Figure A2.4.12).

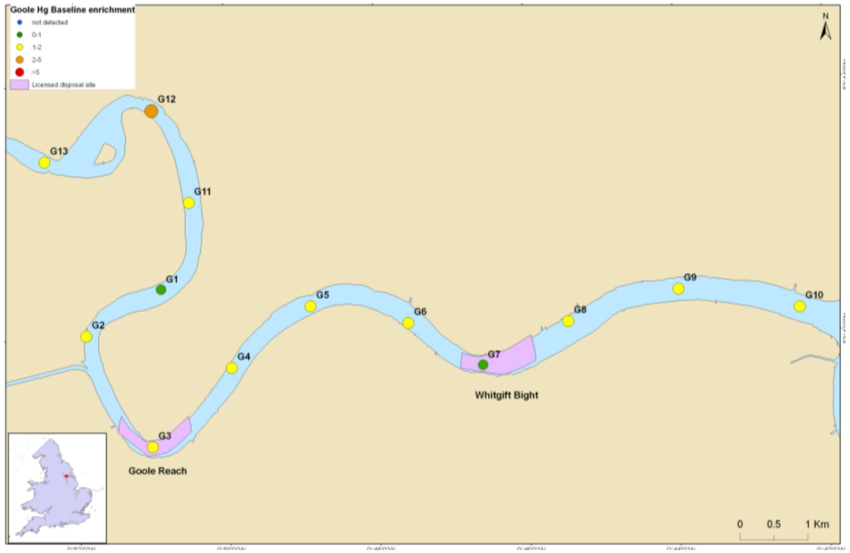
When comparing with the OSPAR BAC value for Cr, Ni and Pb, all stations are found to be either slightly enriched (Cr and Ni) or moderately enriched (Pb; Figure A2.4.12). All remained slightly enriched at those stations when comparing to the baseline values. In the 2010 survey, Cr and Ni were found not to be enriched using the same assessment method, suggesting a slight increase in Cr and Ni in 2011.

As indicated in Table A1.4.1 (see Appendix 1), the proposed baseline values for Humber region are generally higher that the current OSPAR BAC, except for Cd. This suggests that there is regional variability and that the proposed baselines values might be more suitable to use when assessing for metal enrichment. In summary, comparisons with last year’s survey data reveals that there could be a slight increase in enrichment for As, Cr and Ni whereas levels seem to remain generally stable for Cd, Cu, Hg, Pb and Zn.


Goole Cd OSPAR enrichment
● not detected
● 0-1
● 1-2
● 2-5
● >5
▨ Licensed disposal site
N
G12
G13
G11
G1
G2
G5
G6
G4
G7
G8
G9
G10
G3
Whitgift Bight
Goole Reach
53°44'0"N
53°42'0"N
0
0.5
1 Km
0°52'0"W
0°50'0"W
0°48'0"W
0°46'0"W
0°44'0"W
0°42'0"W


Goole Cd Baseline enrichment
● not detected
● 0-1
● 1-2
● 2-5
● >5
▨ Licensed disposal site
N
G12
G13
G11
G1
G2
G5
G6
G4
G7
G8
G9
G10
G3
Whitgift Bight
Goole Reach
53°44'0"N
53°42'0"N
0
0.5
1 Km
0°52'0"W
0°50'0"W
0°48'0"W
0°46'0"W
0°44'0"W
0°42'0"W


Goole Hg OSPAR enrichment
● not detected
● 0-1
● 1-2
● 2-5
● >5
▨ Licensed Disposal Site
N
G12
G13
G11
G1
G2
G5
G6
G4
G7
G8
G9
G10
G3
Whitgift Bight
Goole Reach
53°44'0"N
53°42'0"N
0
0.5
1 Km
0°52'0"W
0°50'0"W
0°48'0"W
0°46'0"W
0°44'0"W
0°42'0"W


Goole Hg Baseline enrichment
● not detected
● 0-1
● 1-2
● 2-5
● >5
▨ Licensed disposal site
N
G12
G13
G11
G1
G2
G5
G6
G4
G7
G8
G9
G10
G3
Whitgift Bight
Goole Reach
0
0.5
1 Km

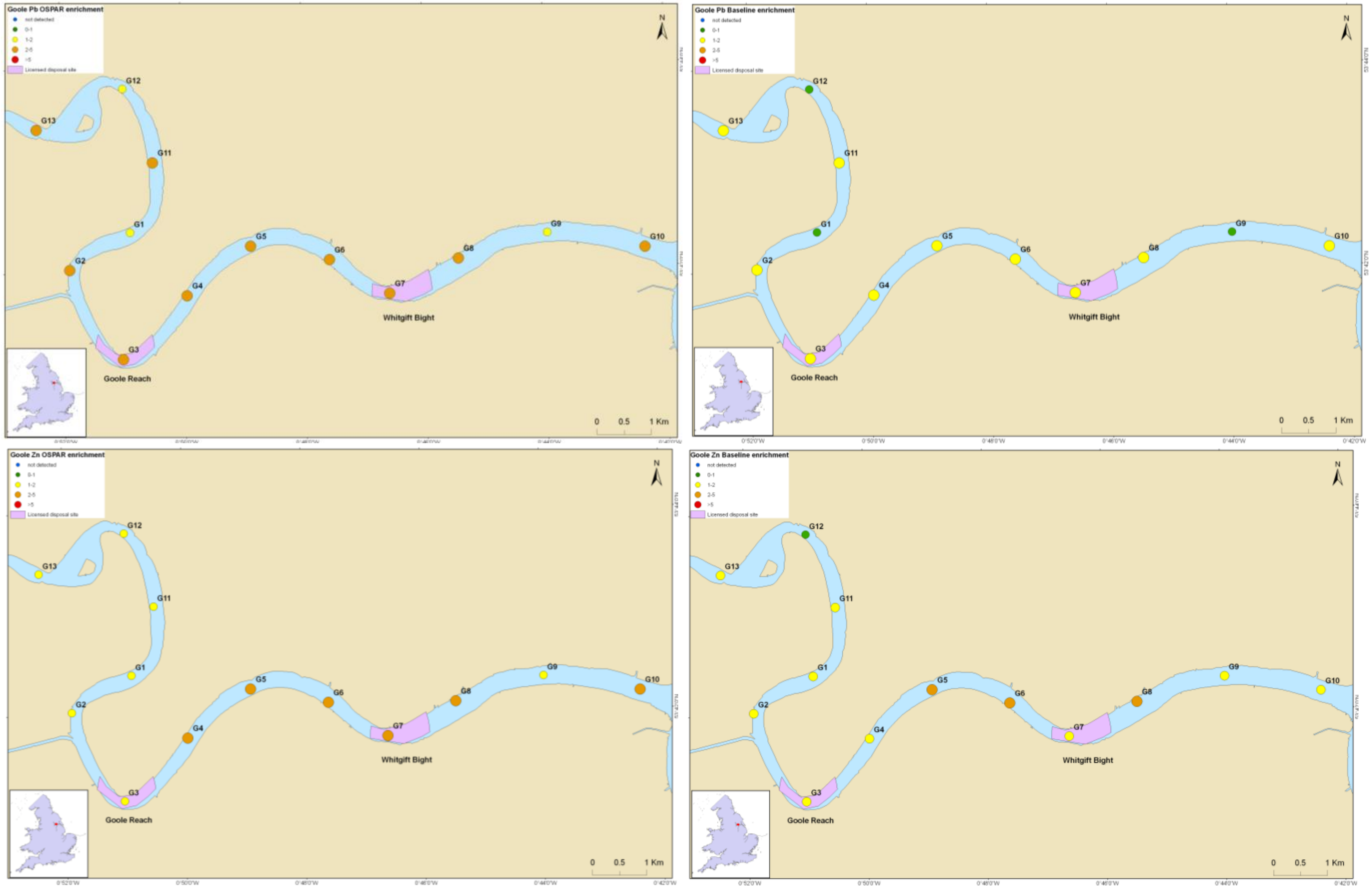


Figure A2.4.12. Enrichment to OSPAR BACs (left) and Baseline values (right) at Goole for Cd, Hg, Pb and Zn.

2.5 Humber Estuary (HU081, HU082, HU083)

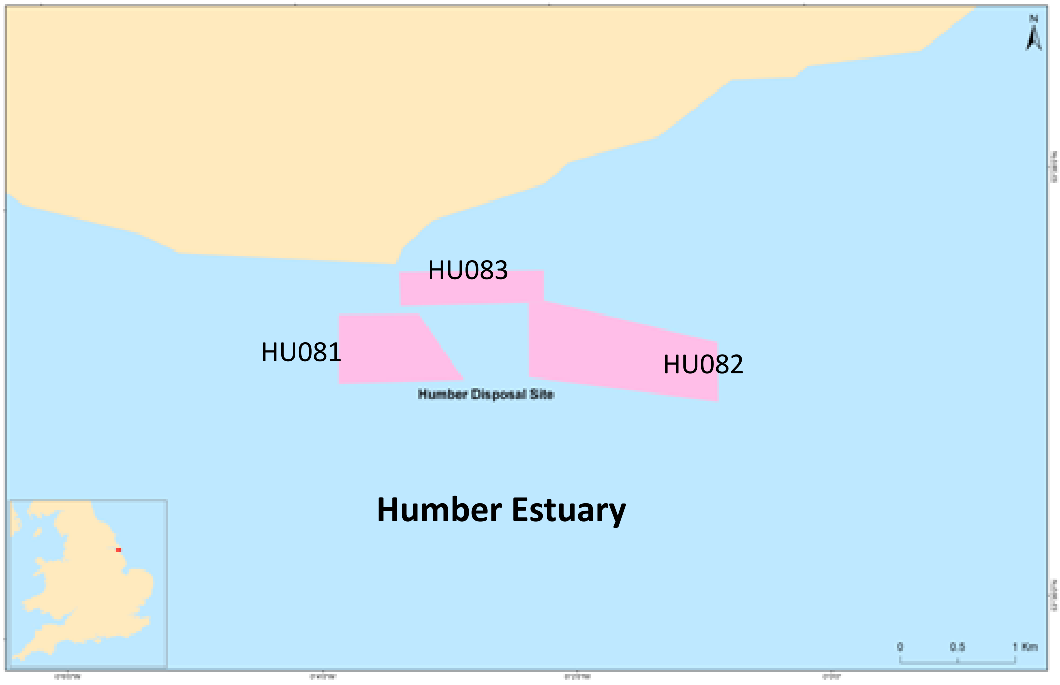


Figure A2.5.1. Location of the three dredged material disposal sites in the Humber Estuary targeted for acoustic survey under SLAB5, 2011.

2.5.1 Background

Three disposal sites (HU081, HU082, HU083) within the Humber Estuary receive dredged material of glacial origin. This material is somewhat physically stable and thus erodes very slowly following deposition. The three sites are located within an area of natural scour and until now have only sporadically been used for the disposal of small amounts of material. However, multiple licences have been granted for disposal at the sites: one of them for up to 1,000,000 tonnes. Therefore, there is current concern regarding the potential accretion of material at the sites as it is likely that the deposition rate of the material will exceed the subsequent rate of erosion. Monitoring at these three disposal sites under SLAB5 during 2011 will focus on acquiring multibeam data over the three licensed boundaries. Such data can be used as a baseline from which any future changes in seabed topography due to accumulation (or otherwise) of deposited material can be determined.

2.5.2 Impact hypothesis

- Disposed material will not accumulate sufficiently to pose a threat to aquatic navigation

2.5.3 Parameters to be assessed

Multibeam acoustics

2.5.4 Results

2.5.4.1 Acoustics

The Humber dredged material disposal sites HU081, HU082 and HU083 were surveyed in October 2011 by the Environment Agency Geomatics Division utilising a Reson Seabat 8125. The purpose of the survey was to ascertain the bathymetry and calculate the capacity of the disposal sites. All depths recorded are relative to Ordnance datum Newlyn.

The majority of the sediments within the vicinity of the disposal sites are muddy sand with approximately a third of the estuary being exposed at low water as mud or sand flats (Winn, Eurovision Case Study). There are numerous pits/depressions across the disposal sites accounting for a large depth change within a small area.

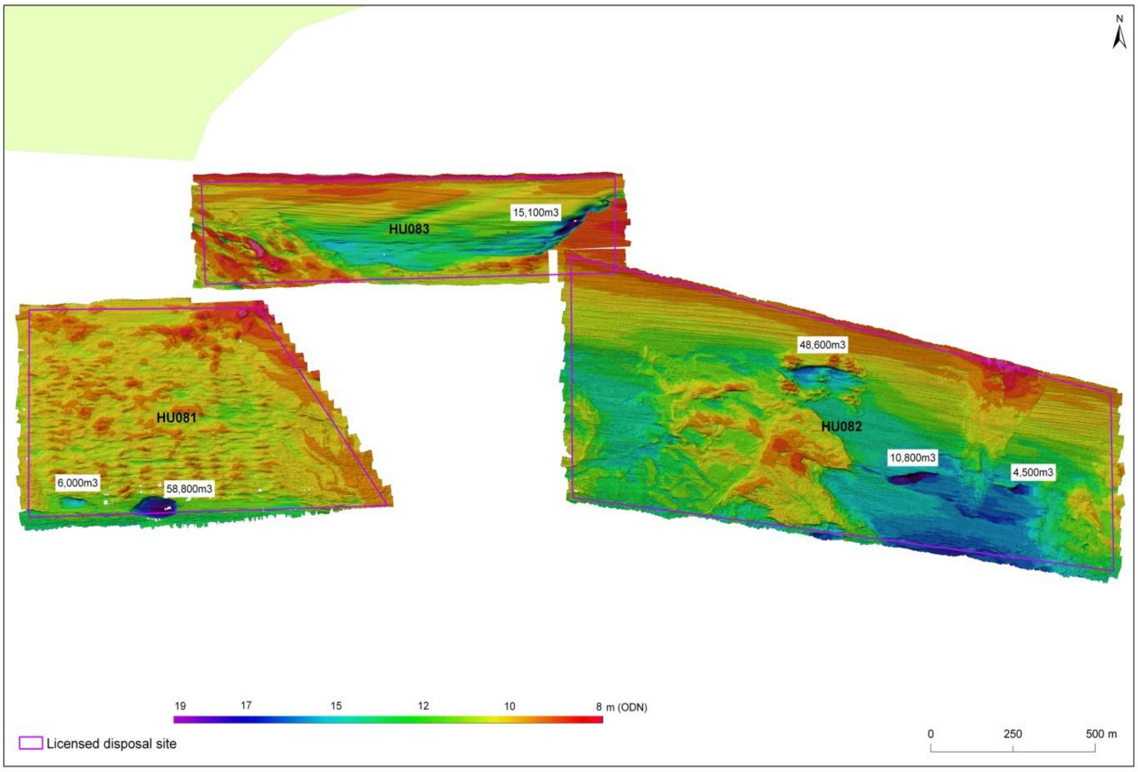
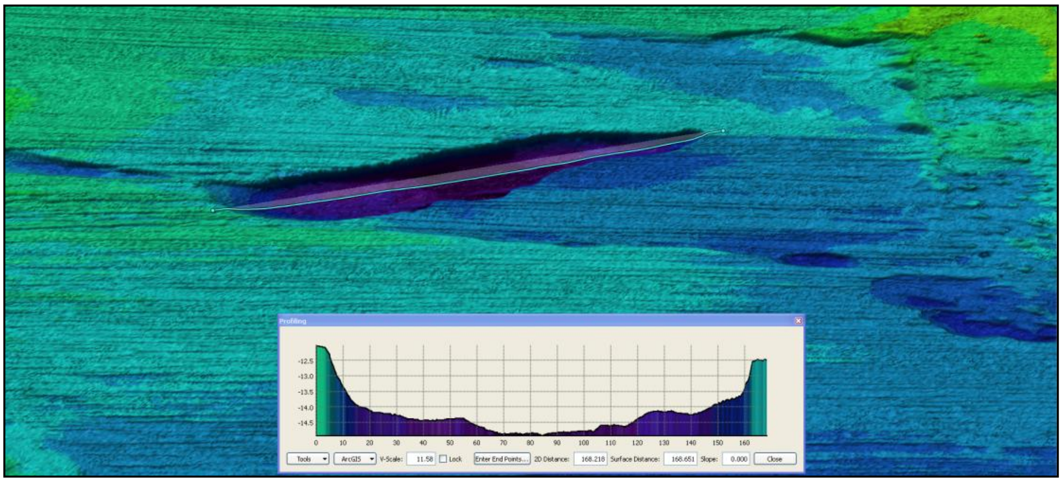


Figure A2.5.2. Overview of the multibeam bathymetry collected in October 2011 at HU081, HU082 and HU083.

Figure A2.5.2 presents the three disposal sites with the capacity of the individual depressions identified. The capacities of these depressions have been calculated in cubic meters for each disposal site by measuring the width, length and height of each depression. The images in Figures A2.5.3 to A2.5.9 show these sites in greater detail and help illustrate how QINSy-Fledermaus software was utilised to estimate these measurements.



V-Scale: 11.58

2D Distance: 168.218

Surface Distance: 168.651

Slope: 0.000

Figure A2.5.3. Image showing the length calculation of a depression at HU082.

HU081

The average water depth for disposal site HU081 is 10m below ODN, although the site is shallower to the northeastern edge with depths of 8m. There are two depressions on the southern rim of the disposal area, with one reaching 18m at the deepest (Figure A2.5.2, A2.5.4 & A2.5.5). The larger (most easterly) depression has a capacity of 58,800 m^3 and the smaller 6,000 m^3. The majority of the sediments are muddy sand with concentrations of sand in the south eastern corner.

HU083

HU083 is the smallest of the three disposal sites and closest inshore, with depths ranging from 18 m to 8 m (Figure A2.5.2). The west side of the rectangular shape disposal site has ridges of mud running in northwesterly to southeasterly direction (Figure A2.5.6). There is a central trench with an average water depth of 13 m. To the east, a series of depressions follow the tidal flow, with an approximate capacity of 15,100 m^3 (Figure A2.5.7). These depressions are surrounded by muddy sands.

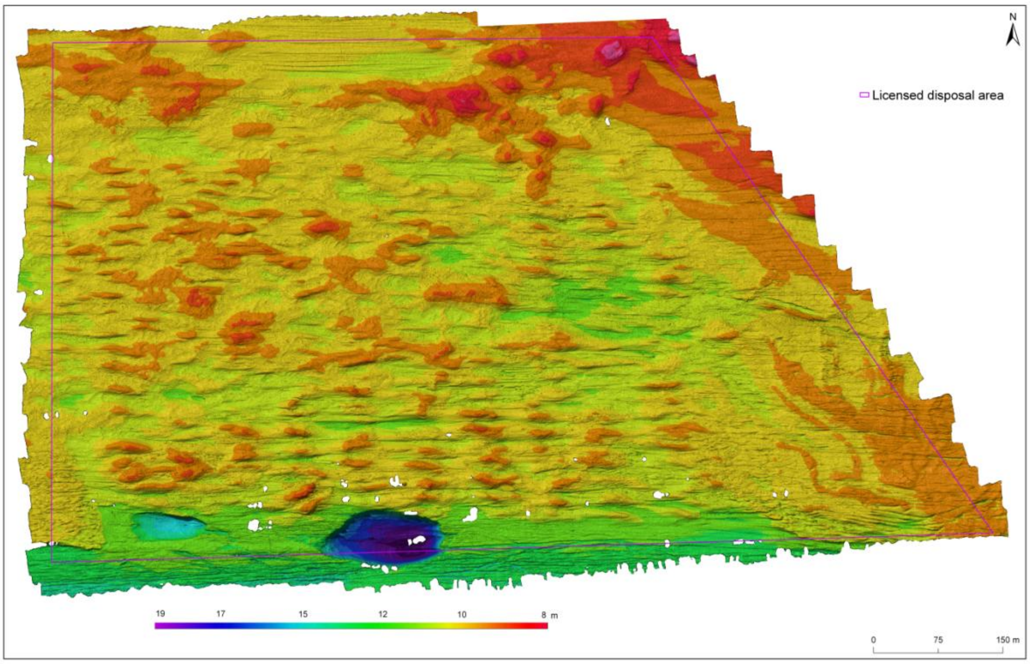


Figure A2.5.4. Bathymetry from data collected at HU081, 2011.

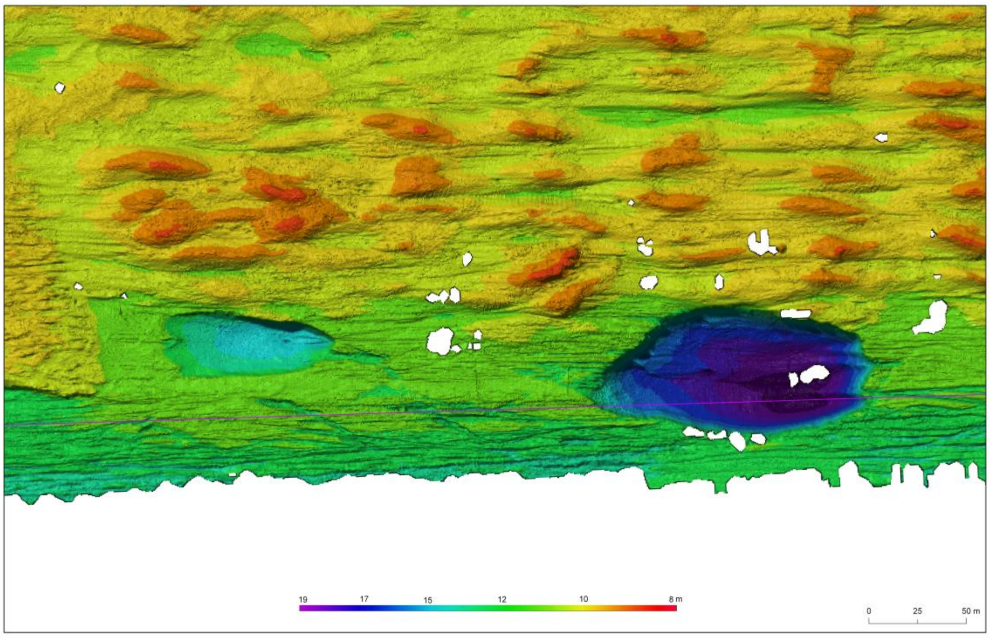


Figure A2.5.5. Close-up view of the depressions at HU081, 2011.

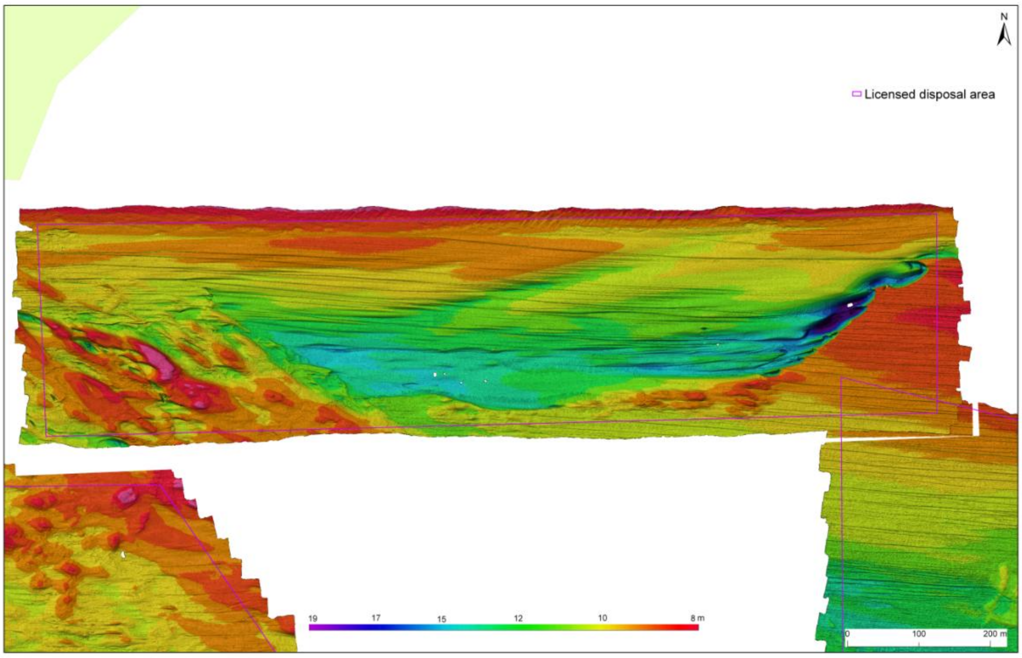


Figure A2.5.6. Multibeam bathymetry from data collected at HU083, 2011.

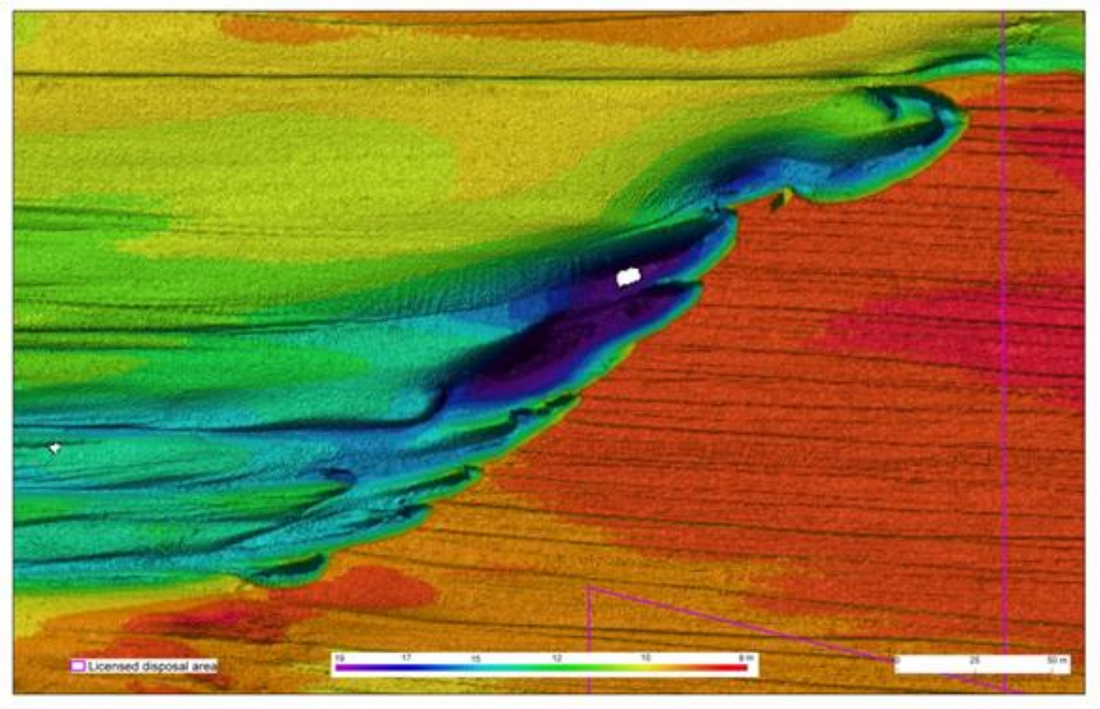


Figure A2.5.7. Close-up view of the depressions at HU083, 2011.

HU082

The largest of the three sites, HU082, is also the most complex (Figures A2.5.8 & A2.5.9). The average depth is 11 m with depths ranging from 8 m to 14 m. There is an increase in gravel content towards the south eastern corner; however the majority of sediments with the disposal site consist of sandy mud. HU082 has the largest capacity with a number of depressions located in the southern edge. The total capacity across the site is 63,900 m^3 (Figure A2.5.2).

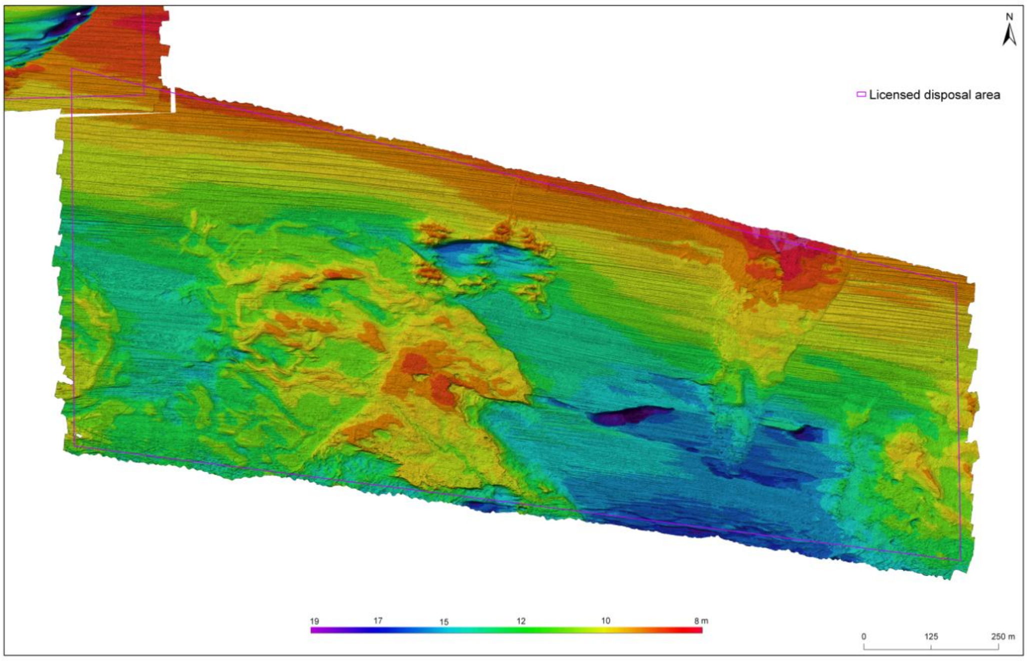


Figure A2.5.8. Multibeam bathymetry from data collected at HU082, 2011.

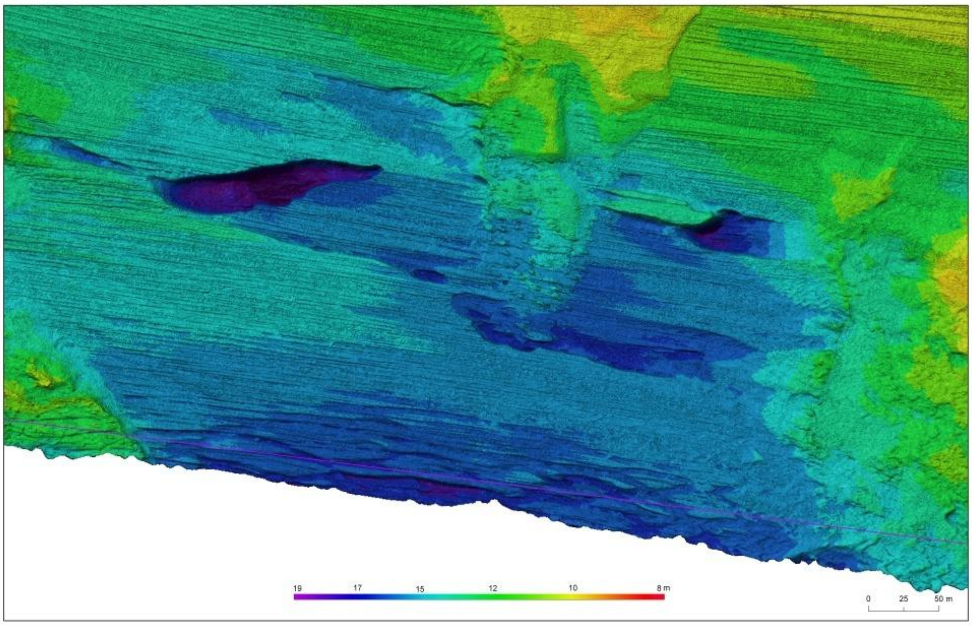


Figure A2.5.9. Close-up of the depressions at HU082, 2011.

It should be noted that when calculating the capacity of the depressions, inaccuracies might occur in their measurements. The purpose of surveying the Humber dredged disposal site has been fulfilled therefore there is no need for future surveys at the three sites. If non-erodible material were to be disposed of therein, it would be of interest to see how the sites are impacted upon in such a tidally distinct region.

2.6 Inner Gabbard East (TH056)

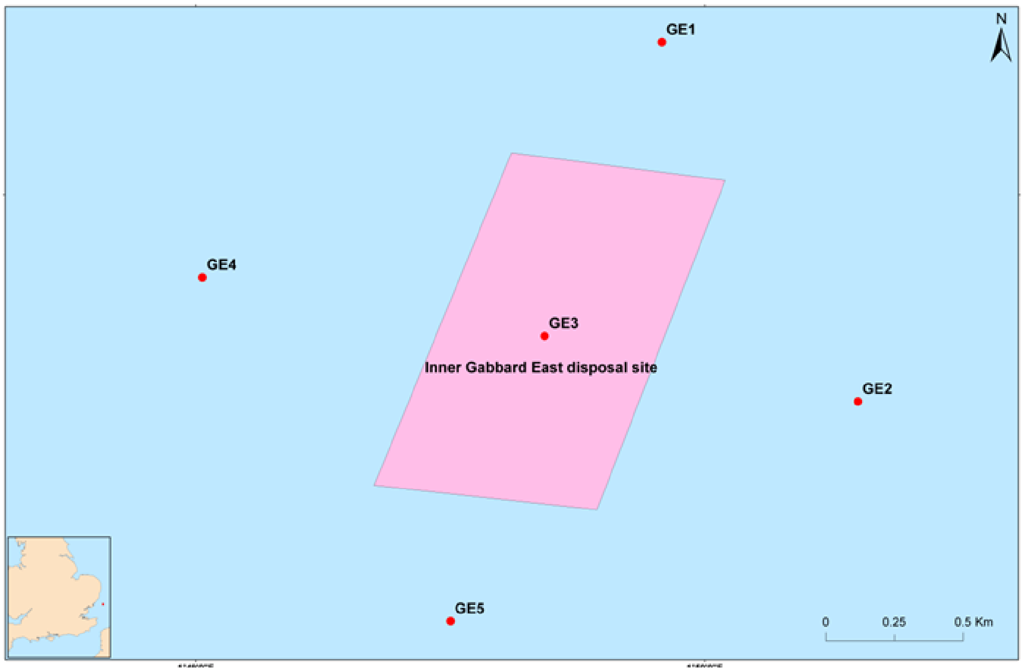


Figure A2.6.1. Map showing the position of the stations sampled for ground-truthing at Inner Gabbard East, 2011.

2.6.1 Background

Inner Gabbard East (IGE; TH056) is a relatively new dredged material disposal site characterised by Harwich Haven Authority (HHA) to take consolidated capital dredged material from the proposed container port development at Bathside Bay and, more recently, the Felixstowe South Redevelopment (FSR). The site is broadly similar in terms of wave and tidal flow climates and bed conditions to the existing Inner Gabbard (TH052) disposal site, being characterised as fairly featureless, flat sand and gravel beds. The main difference is depth: TH056 is in an elongated depression in the seabed approximately 55 m deep.

As the FSR was the first to be realised the site is now taking material from that project. Dispersion of material from the IGE site was not seen as a major issue, however, it was proposed it could be minimised by undertaking a series of placements at one location, thus creating localised mounds that effectively trap material in the lower layers. As the location of the disposal site is in an elongated depression north to south it was also proposed to form bunds to the northern and southern ends at the start of the disposal operations. These ‘bunds’ would consist of more consolidated material and would form less ‘erodable’ ends to the deposit, providing some shelter from the prevailing currents for the mixed material subsequently placed.

However, during the FSR project more of the dredged material was usable for use in reclamation than anticipated, leading to a reduced import of new material to the disposal site. In addition, as a result of changes to the dredging methodology, more of the material destined for the IGE site, and particularly most of that dredged at first, was likely to be finer material, containing a mixture of sands, clays and smaller stone pieces. Therefore, it was not possible to form the initial bunds at the ends of the site. As a result, the Marine and Fisheries Agency (MFA; the licensing agency at that time) revised the licence conditions, as detailed below:

- Material for disposal is to be placed by bottom dumping when the dredger is stationary, located initially no closer than 250 m from the northern or southern limits of the site and no closer than 50 m from the eastern or western limits of the site (the whole licensed disposal site is approximately 1,250 m by 500 m). Material is to be placed evenly over this reduced area using a system of targeted and recorded locations for each disposal
- Rock and stiff clay is to be placed in the areas at the northern and southern ends of the site, in targeted loads to produce an even distribution. Barges, when releasing their material, are to be located no closer than 50 m from the disposal site boundary.

Concerns:

As a result of these changes, the MMO requires Cefas to identify this disposal site as a priority for monitoring to ensure that the disposal operation has been carried out as agreed, and to determine if the deposited material is remaining in place or being eroded. Acoustic surveys of this site was conducted by Cefas under the auspices of SLAB5 during 2009 and 2010: the 2011 survey essentially comprises a repeat of these to improve our understanding of the fate of the deposited material.

RAT prioritisation assessment: Tier 1.

- where a significant increase in the quantity of material disposed of has occurred (*new site*)
- where specific concerns have been raised
- that have been observed or pose an increased risk to the surrounding area and receptors

2.6.2 Impact hypothesis

- to ensure deposited material is being maintained within the confines of the licensed disposal site

2.6.3 Parameters monitored:	Sidescan and multibeam Sediment particle size

2.6.4 Results

2.6.4.1 Sidescan and multibeam

Inner Gabbard East licensed disposal area was surveyed employing a Kongsberg EM3002D multibeam echosounder during June 2011. The data acquired revealed that the seabed at IGE is relatively uniform with a central channel running in an almost north to south orientation. The average water depth within the disposal site is 50 m below CD, reaching 55 m at its deepest (Figure A2.6.2). The channel gently shallows to the east whereas to the west a sudden incline occurs, increasingly steeply from 50 m to 35 m within a 50 m range.

To aid the interpretation of the acoustic data, PSA samples were collected *via* a Hamon Grab at a number of locations across the multibeam survey area. Thirty samples were collected in total, three replicates from ten locations across the site (Figure A2.6.2): this has increased from previous years to further aid the interpretation. Prior to 2011, for example, 15 samples were collected at only five locations, only one being located within the licensed disposal site itself. Descriptions of PSA samples given *in situ* during the survey have also aided substrate analysis and therefore enhanced the interpretation of the acoustic data.

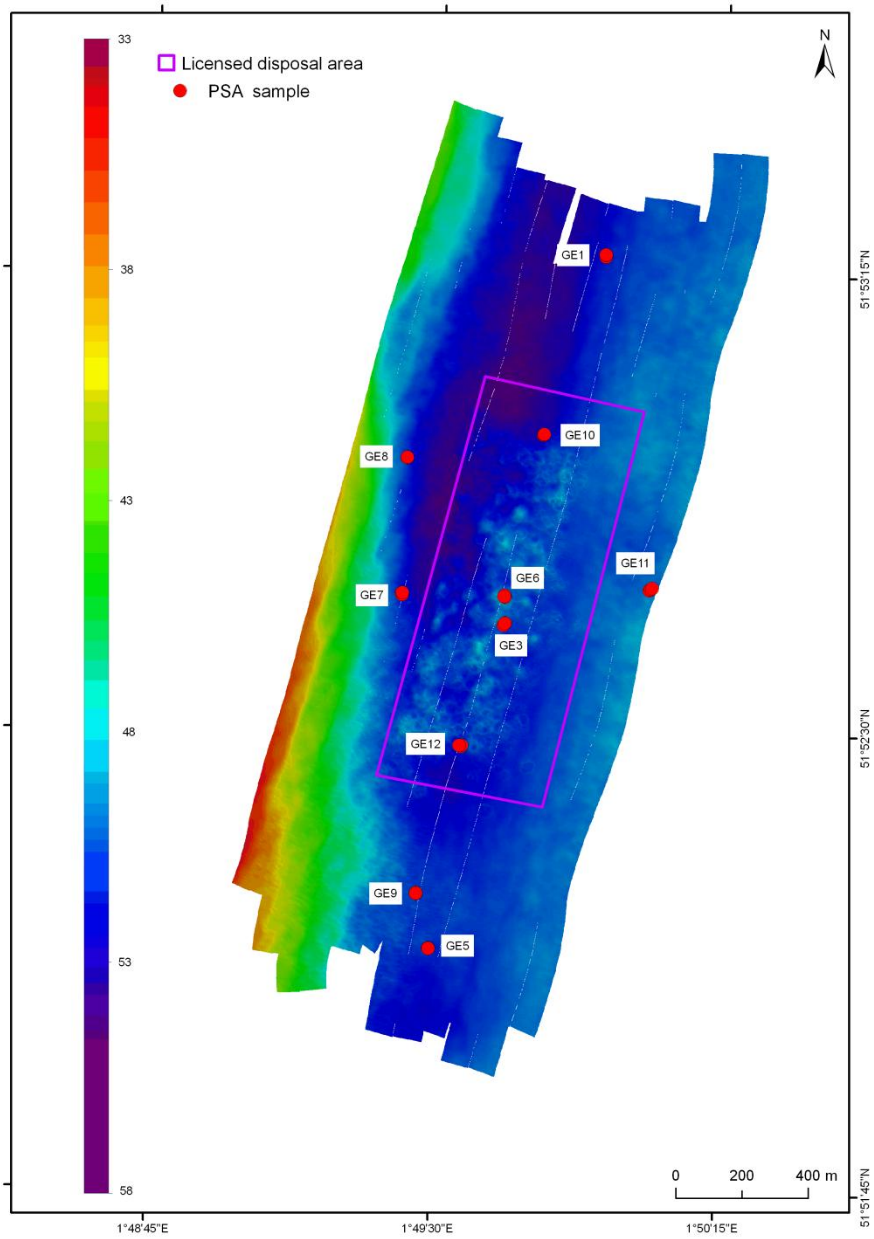


Figure A2.6.2. Inner Gabbard East seabed bathymetry from the 2011 multibeam survey.

The backscatter derived from the multibeam data collected at IGE allows an interpretation of the sediment type to be made: the intensity from the return signal can be analysed to determine sediment type and uniformity. This approach indicates that the seabed at IGE, as previously stated, has a channel running from the north to south, and that this channel displays a varied backscatter signature with a mixture of high and low returns (Figure A2.6.3). The centre of the disposal site has a lower return than that of the surrounding seabed with areas of higher backscatter strength bordering the lower returns. Circular features with weak returns can also be seen adjoining the disposal area: these features are likely to be a direct result of dredge disposal activity. The seabed outside of the licensed disposal area has a relatively consistent nature with an area to the south reflecting a lower backscatter.

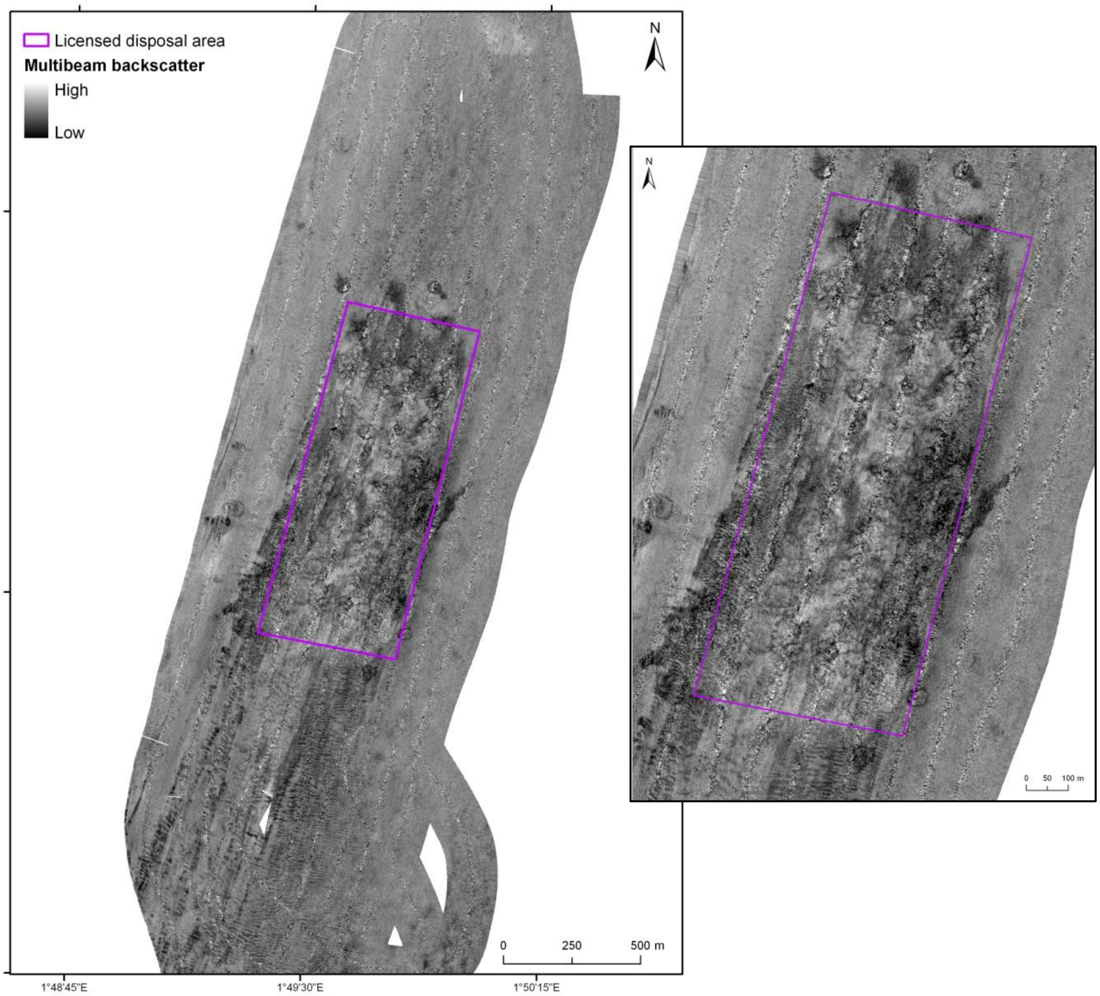


Figure A2.6.3. Multibeam backscatter collected in June 2011 at Inner Gabbard East (Figure on right presents a more detailed version of the disposal site section).

Figure A2.6.4 presents the interpretation of the acoustic data sets. The disposal activity (as depicted by the sediment types) is contained within the licensed disposal area with the main sediment type being gravelly muddy sand. Directly to the south and surrounding the gravelly muddy sand the gravel content changes to slightly gravelly muddy sand. There is a boundary running from the north east to the south west of the site dividing the muddier sediments to the east from the sandier sediments to the west.

Figure A2.6.4. Interpretation of the multibeam data from the 2011 Inner Gabbard East survey.

To the east and following the gentle slope, gravel and mud increases, with a sediment type of gravelly mud dominating the locality. The seabed to the north of the disposal area is comprised of muddy gravel and to the west the sand percentage increases, resulting in muddy sandy gravel (Figure A2.6.4). On the northern edge of the acoustic coverage an area of sandy mud can be identified. Within the muddy sandy gravel to the west there are pockets of gravelly muddy sand associated with dredge disposal activity.

The outline of the extent of disposal activity identified from both the 2010 and 2011 data is presented in Figure A2.6.5. It reveals that there has been very little change in the distribution of the disposal material, although the spatial extent in 2011 appears larger than that derived from the 2010 survey. The overall shape of the dredged material affected region has altered with larger concentrations spreading to the south: however, the data suggests that the physical impacts of dredged disposal material are still generally contained within the licensed disposal site outline. The two smaller patches of material of gravelly muddy sand 200 m to the west of the disposal site, likely to be associated with dredging spoil, have not changed in shape or extent since the 2010 survey.

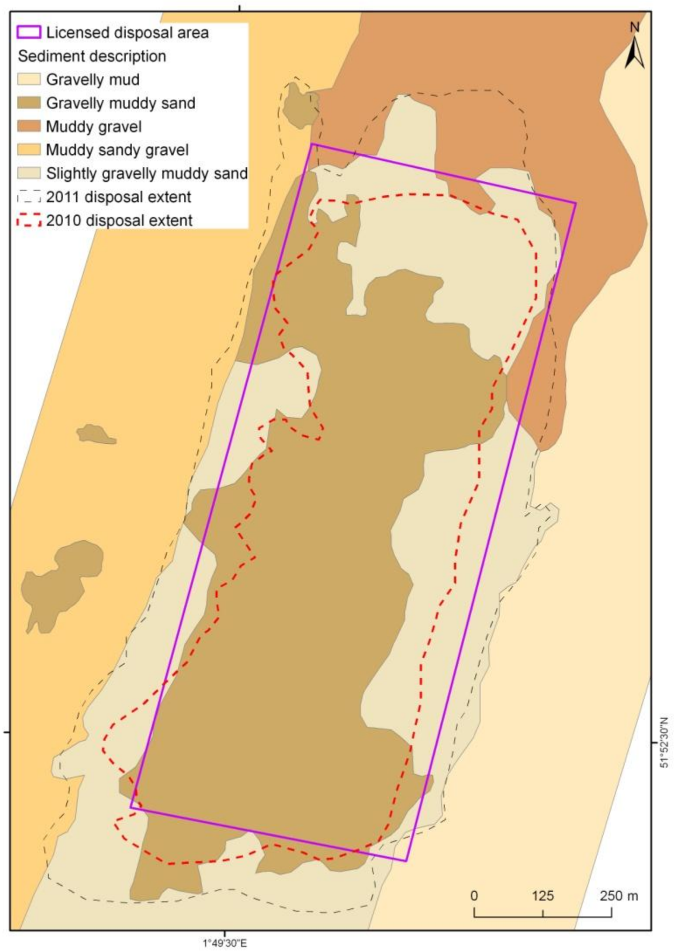


Figure A2.6.5. Interpretation of the 2011 acoustic data (as in Figure A2.6.4) with the outline of the 2010 and 2011 disposal activity superimposed.

2.6.4.2 Sediment particle size

While the primary purpose of the particle size analysis samples was to provide data to allow ground-truthing of the acoustic data, it is worth describing such data in their own right, together with making temporal comparisons.

IGE sediments are predominantly muddy gravels / gravelly muddy sands and gravelly muddy sands (Table A2.6.1). Changes in sediment group between 2009 and 2011 are shown in Table A2.6.2: temporal data is only available in 2011 from GE1, GE3 and GE5 and these all show a reduction in silt/clay content compared with 2010. Sediments are varied at many of the sampling stations indicating the importance of taking replicates for assessment. The lowest mud contents are found to the west and south of the disposal site. Pie charts of gravel, sand and silt/clay are shown in Figure A2.6.6 for 2011, and silt/clay content in Figure A2.6.7.

Table A2.6.1 Average sediment descriptions and statistics for each sediment group at Inner Gabbard East.

Sediment group	Number of samples	Sample Type	Sediment description	MODE 1 (µm):	MODE 2 (µm):	MODE 3 (µm):
GaE1a	20	Polymodal, Very Poorly Sorted	Gravelly Mud	9.4	302.5	855
GaE1b	2	Polymodal, Extremely Poorly Sorted	Gravelly Mud	9.4	302.5	855
GaE2	8	Bimodal, Very Poorly Sorted	Gravelly Muddy Sand	302.5	9.4	
GaE3a	25	Polymodal, Extremely Poorly Sorted	Muddy Sandy Gravel	302.5	855	2400
GaE3b	6	Trimodal, Very Poorly Sorted	Muddy Sandy Gravel	19200	302.5	605
GaE4	4	Unimodal, Poorly Sorted	Gravelly Muddy Sand	427.5		

Sediment group	Gravel (%)	Sand (%)	Silt/clay (%)	Very coarse sand (%)	Coarse sand (%)	Medium sand (%)	Fine sand (%)	Very fine sand (%)
GaE1a	11.28	16.15	72.57	3.01	3.93	4.99	2.25	1.98
GaE1b	17.84	24.13	58.03	4.07	5.59	6.96	4.45	3.05
GaE2	14.55	47.38	38.07	3.30	8.18	26.40	7.30	2.19
GaE3a	36.25	37.28	26.47	8.54	11.47	11.01	4.15	2.10
GaE3b	68.64	22.14	9.22	3.37	7.82	7.98	2.17	0.80
GaE4	7.22	83.31	9.48	11.89	31.46	38.96	0.71	0.29

Table A2.6.2. Sediment groups for each sample code for 2009, 2010 and 2011 at IGE. SH – Shipek grab surface sample, Replicates A,B and C (A and B in 2011) are Hamon grab subsamples – mixed sediment to ~8cm. Note in 2011 the full Shipek sample collected (not just surface was removed).

	Year		
Sample code	2009	2010	2011
GE1_A	GaE1a	GaE1b	GaE1
GE1_B	GaE1a	GaE1b	GaE1b
GE1_C	GaE1b	GaE1b	
GE1_SH		GaE1b	GaE3a
GE2_A	GaE1a	GaE1a	
GE2_B	GaE1b	GaE1a	
GE2_C	GaE3a	GaE3a	
GE2_SH		GaE3a	
GE3_A	GaE2	GaE1a	GaE1b
GE3_B	GaE3b	GaE1a	GaE2
GE3_C	GaE2	GaE1a	
GE3_SH		GaE1a	GaE4
GE4_A	GaE3b	GaE1b	
GE4_B	GaE1b	GaE1b	
GE4_C	GaE1b	GaE1b	
GE4_SH		GaE3b	
GE5_A	GaE1a	GaE1b	GaE2
GE5_B	GaE1a	GaE1b	GaE4
GE5_C	GaE3a	GaE3a	
GE5_SH		GaE2	GaE4
GE6_A			GaE2
GE6_B			GaE3a
GE6_A_SH			GaE3b
GE7_A			GaE3b
GE7_B			GaE3b
GE7_A_SH			GaE3b
GE8_A			GaE3a
GE8_B			GaE3b
GE8_A_SH			GaE3a
GE9_A			GaE4
GE9_B			GaE3a
GE9_A_SH			GaE3a
GE10_A			GaE1
GE10_B			GaE1
GE10_A_SH			GaE2
GE11_A			GaE1
GE11_B			GaE3a
GE11_A_SH			GaE3a
GE12_A			GaE1
GE12_B			GaE1
GE12_A_SH			GaE1

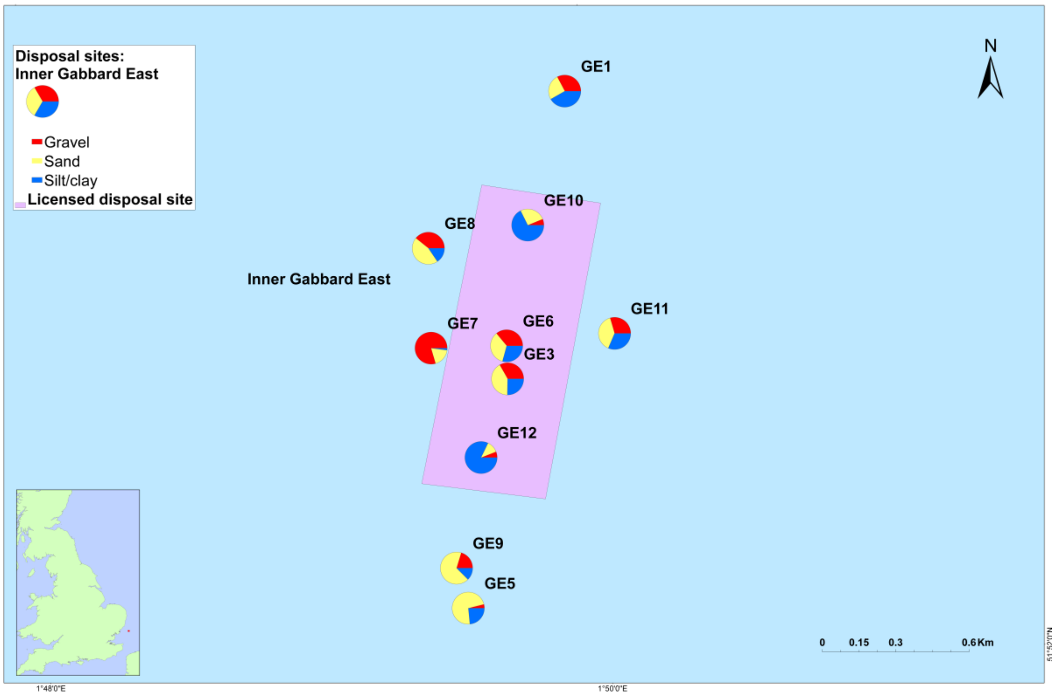


Figure A2.6.6. Pie charts of average gravel, sand and silt/clay at Inner Gabbard East in 2011.

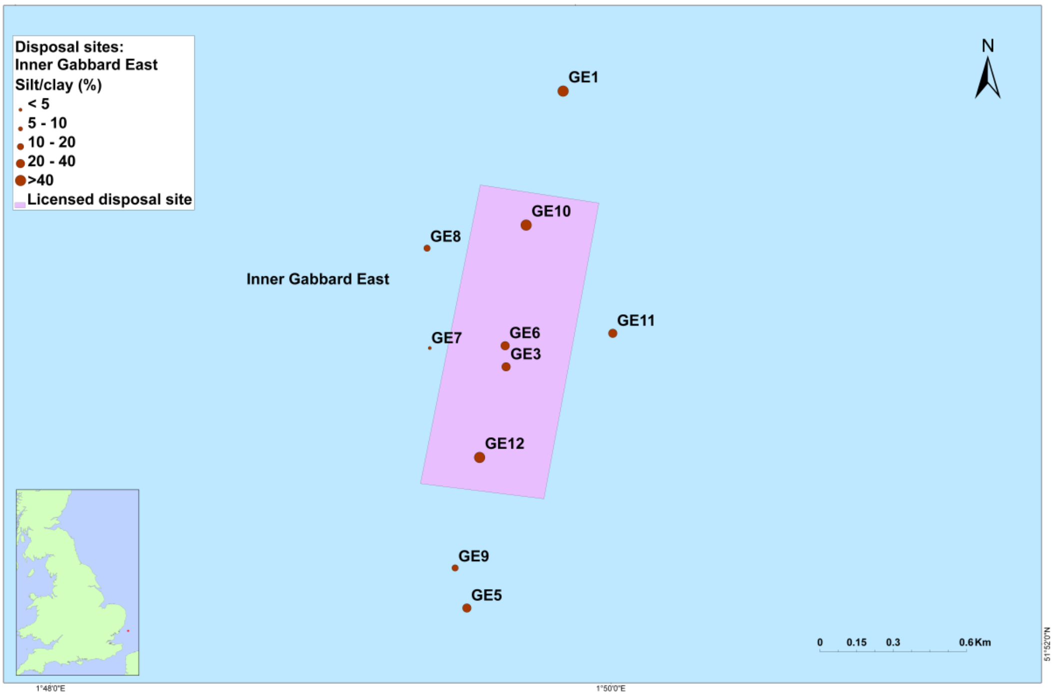


Figure A2.6.7. Average silt/clay (%) at Inner Gabbard East in 2011.

2.7 Nab Tower

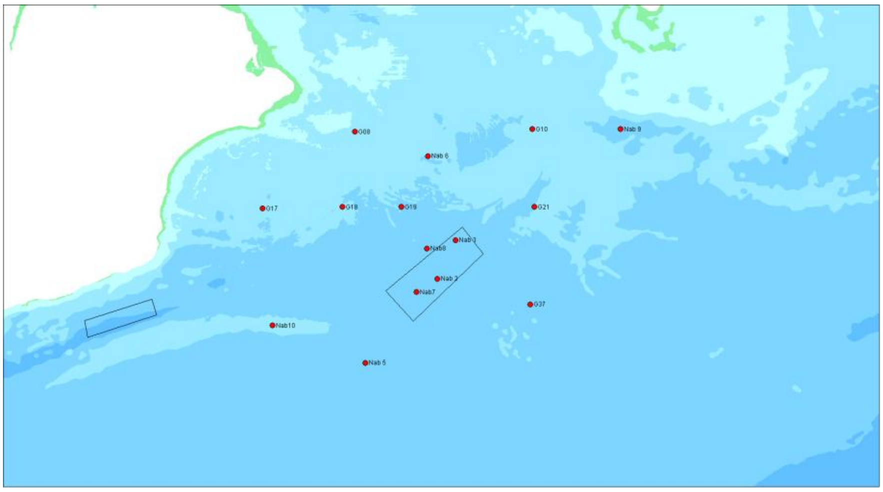


Figure A2.7.1. Location of the Nab Tower disposal site, southeast of the Isle of Wight.

2.7.1 Background

Nab Tower is an open and active disposal site approximately 13 km southwest of Bembridge, Isle of Wight (Figure A2.7.1) at 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 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 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 of.

Recently, there have been two applications for larger scale capital disposals to Nab Tower. The first from the Cowes Outer Harbour Development Project which would see 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 2011 focused on the acquisition of multibeam acoustic bathymetry and backscatter data. These data will be used as a contemporary baseline from which any bathymetric changes resulting from the proposed large deposits can be gauged. Existing data acquired through monitoring during 2003 and 2004 may be used as a suitable comparison from which any changes since then can also be measured.

2.7.2 Impact hypothesis

- Any changes to the physical habitat will be confined to within and the near vicinity of the disposal site, principally along the tidal axis

2.7.3 Parameters to be assessed

- Multibeam acoustic data

2.7.4 Results

2.7.4.1 Acoustics

Nab Tower licensed disposal area was surveyed during July 2011 to assess the nature of the seabed therein. A Kongsberg EM3002D multibeam echosounder was utilised to collect acoustic data in the area. The seabed is moderately flat with an average water depth of 40 m (Figure A2.7.2). The southwestern and southern parts of the site are generally deeper although these boundaries are flanked by much shallower regions (approximately 26 m), while the northern part is slightly shallower, reaching a depth of 37 m (Figure A2.7.2).

Sediment samples were not collected at the Nab Tower disposal site in July 2011: instead, particle size analysis (PSA) samples collected in 1997 were used as an aid to seabed interpretation. The Nab Tower disposal site has an assortment of backscatter returns with the majority of the seabed reflecting stronger returns. The northern part of the disposal site has a lower backscatter return with isolated marks of weaker returns surrounding. These low intensity mottled features are likely to be associated with dredged disposal material due to their apparent impact nature and dissimilarity to the adjacent seabed (Figure A2.7.3 & A2.7.4 (right)).

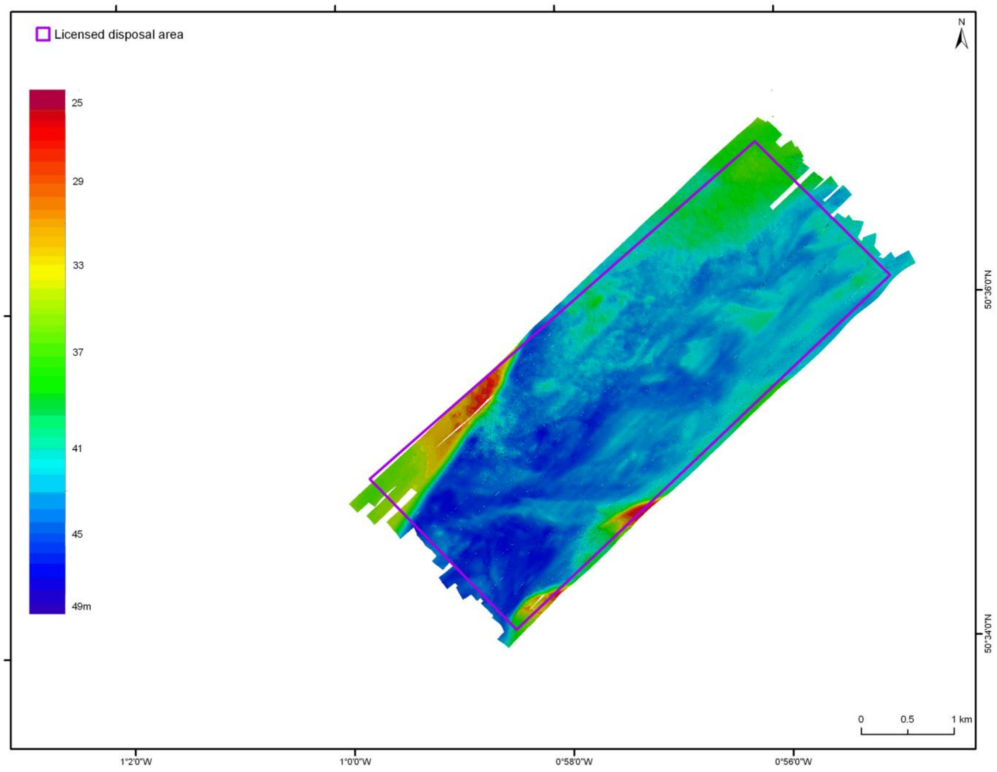


Figure A2.7.2. Nab Tower seabed bathymetry from the July 2011 multibeam survey.

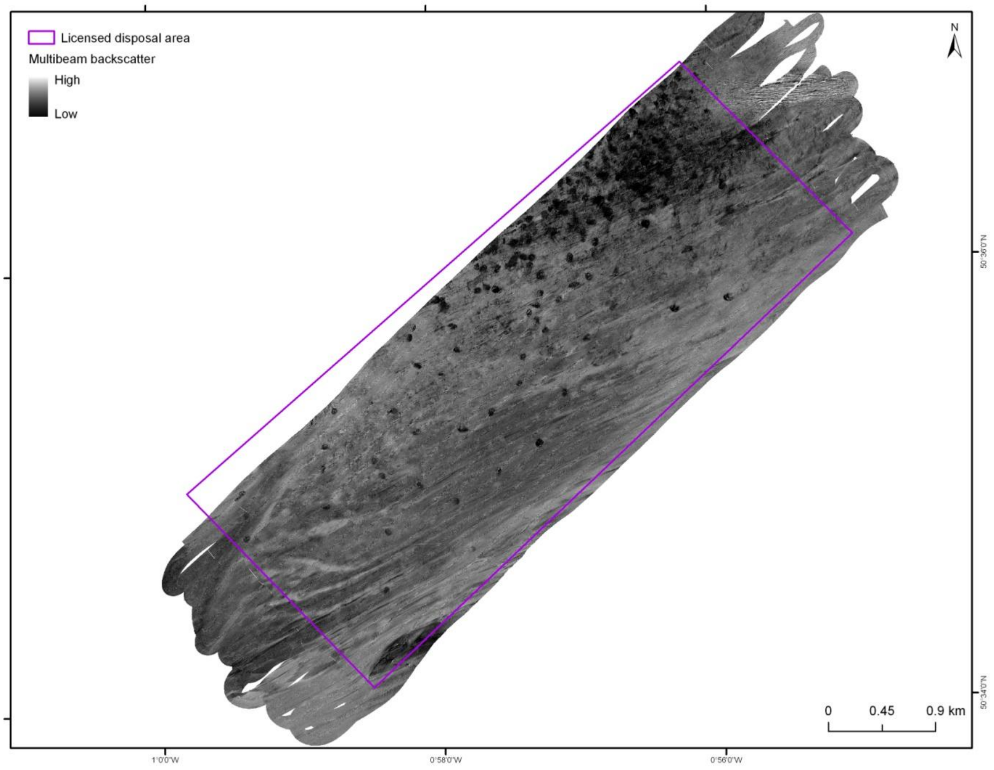


Figure A2.7.3. Multibeam backscatter collected at Nab Tower, July 2011.

Within the vicinity of the disposal site evidence of aggregate dredging is noted. Figure A2.7.4 (left) reveals that scars resulting from this activity were distinguishable at the northern edge of the disposal site. These scars have a stronger return and are therefore distinguishable from the surrounding seabed.

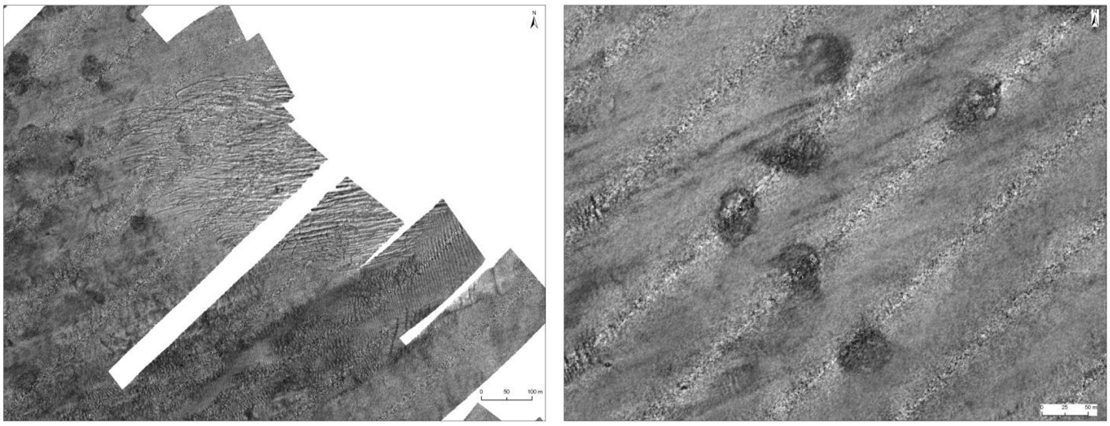


Figure A2.7.4. Detail of aggregate dredging scarring (left) and dredged disposal material (right) from the July 2011 multibeam backscatter survey at Nab Tower.

Figure A2.7.5 presents the substrates and seabed features observed over the acoustic survey area. The data suggests that the site is predominantly gravelly sand with sand occurring in swathes to the western and eastern edges of the site. The southern corner of the site is predominantly coarse sand. The northwestern and eastern edge of the acoustic survey area has discrete patches of anthropogenic activity as previous mentioned. Evidence of dredged material deposits is restricted to the northern corner of the site, however, patches of dredged material can also be seen across the site within the gravelly sandy seabed (Figure A2.7.5).

Evidence of significant disposal activity can be observed in the northern part of the site, close to the boundary of the licensed disposal site. The acoustic survey did not extend beyond the licensed area and it is therefore difficult to ascertain whether the dredged disposal activity and/or material is contained within the disposal area. The main impacted area appears to be concentrated to the northern section of the disposal site with patches of material scattered across the site. If the acoustic survey area were to be extended, it would be advisable to investigate the footprint of the current dredged material boundary and to see if the deposition goes beyond the extent of the disposal site to the north.

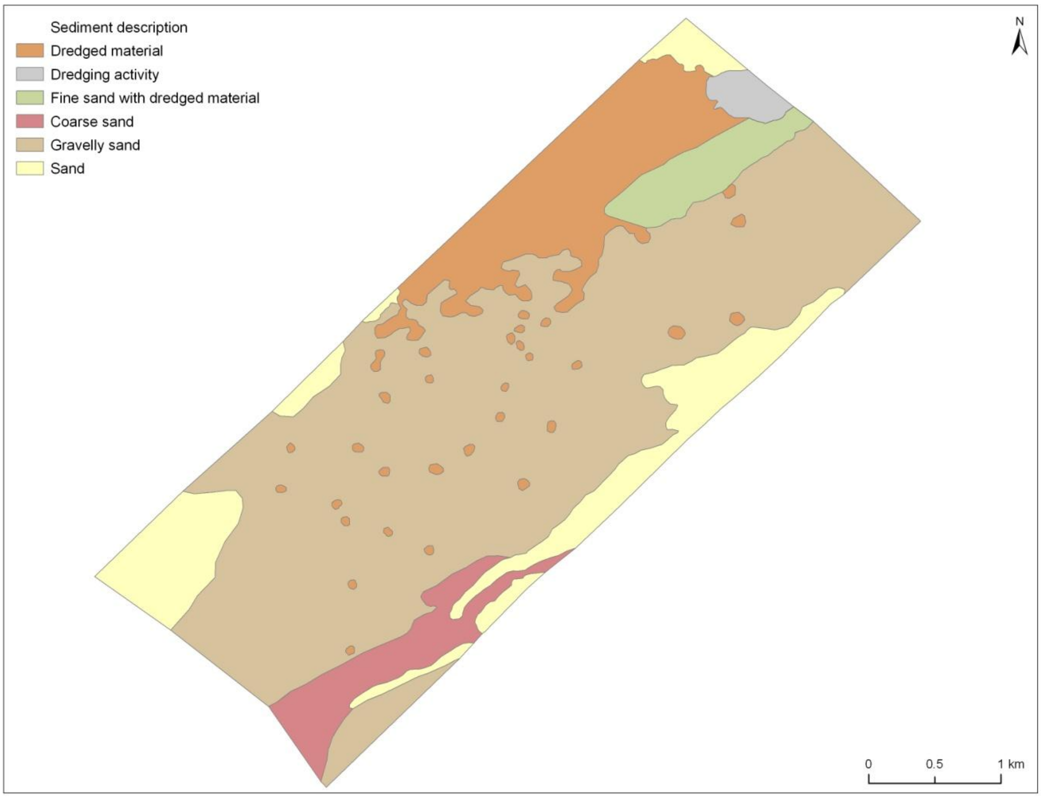


Figure A2.7.5. Interpretation of the acoustic data collected at Nab Tower, July 2011.

2.8 Rame Head (PL031)

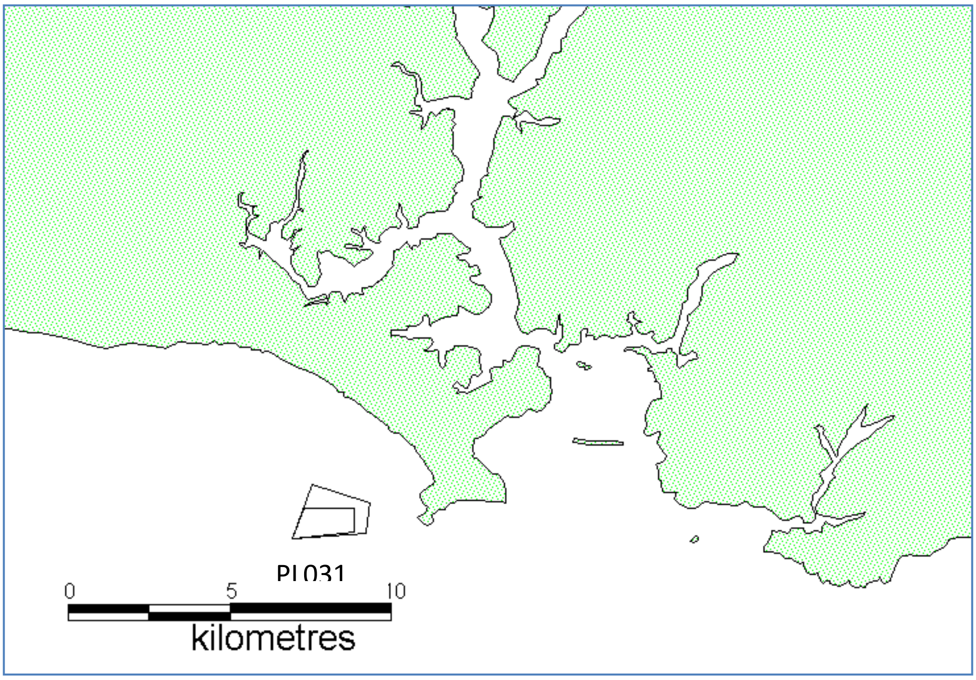


Figure A2.8.1. Location of the Rame Head dredged material disposal site.

2.8.1 Background

Rame Head 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: 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 be derived from the disposal activity. 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, including an appraisal of the monitoring work that has been undertaken at this site under SLAB5 (previously BA004). Amongst the conclusions, the report indicated there were several areas where further studies at this site may allow an improved understanding regarding the factors affecting the ecology of this region. Cefas has taken note of the conclusions and recommendations stated in the report and, in consultation with MMO, plan to undertake monitoring under SLAB5 (if required) in accordance with these recommendations. 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. As such, monitoring at this site in 2011 concentrated on acquiring acoustic data in this proposed extension area to allow an assessment of the physical characteristics of this region.

2.8.2 Parameters to be assessed

- Multibeam bathymetry and backscatter
- Sediment particle size
- Trace metals

2.8.3 Results

2.8.3.1 Acoustics

The Rame Head disposal site was surveyed utilising a Kongsberg EM3002D multibeam echosounder during July 2011. Acoustic data were collected from the bed within the disposal site and directly to the south. The seabed at Rame Head is gently sloping along a northeasterly to southwesterly direction with depths ranging from 18 – 38 m below CD (Figure A2.8.2). Exposed bedrock extends through the northern section of the site. Typically, the source dredged material deposited at Rame Head is composed of sandy mud (Bolam et al., 2005).

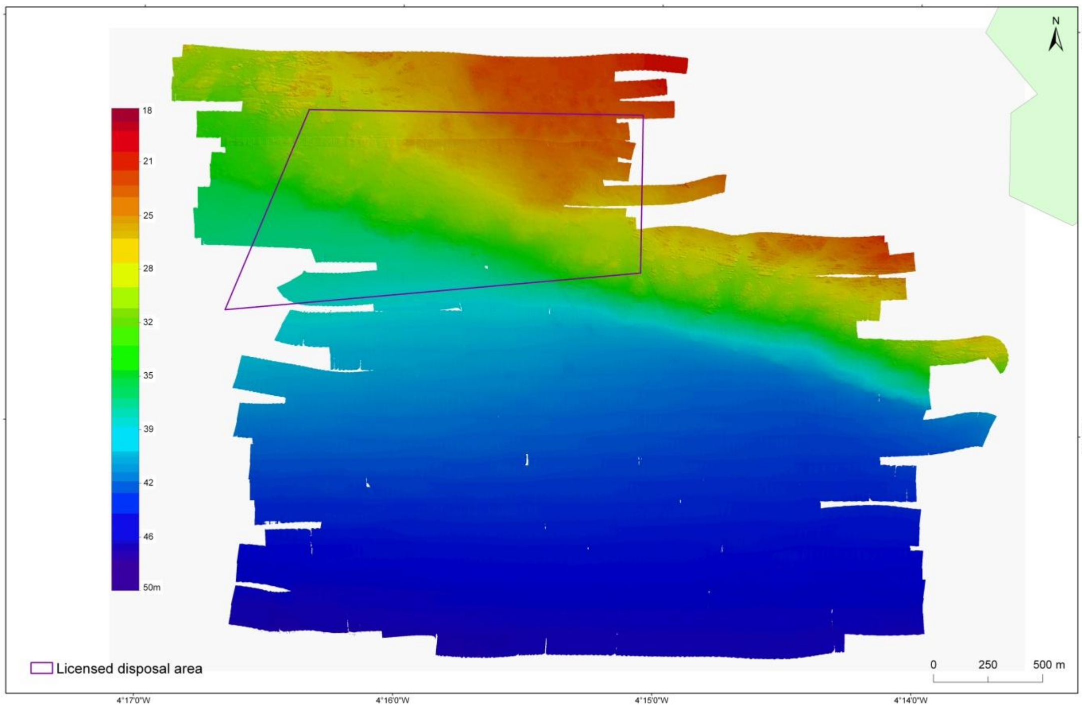


Figure A2.8.2. Rame Head seabed bathymetry from the July 2011 multibeam survey.

Full multibeam coverage was achieved across the site. The acoustic data included bathymetry and the derived multibeam backscatter to determine sediment type and distribution. Eight PSA samples (Figure A2.8.3) were collected to the south of the licensed disposal area to allow an assessment of the surrounding sediment type to be made.

The backscatter return from the multibeam has a distinct boundary running in a southeast to northwest direction. The exposed bedrock extending in an east-west direction is an outcrop of bedrock with associated boulders and cobbles. Isolated outcrops are also present in the central and northern part of the site. The exposed bedrock is characterised by a lighter backscatter return, as opposed to largely low intensity where the licensed disposal area is located.

The southwest corner of the disposal site exhibits a steep depth change from 27 m to 35 m below CD (Figure A2.8.3). The seabed to the south of the disposal site has a lighter backscatter return associated with sandy or muddy sediments. Additionally, backscatter returns from the acoustic data collected to the south and outside of the disposal area are of a lower intensity than that within the site, and indicate a depth of 40 m to 50 m. The far southeast corner of the acoustic survey region has a mixture of high intensity returns with distinct patches of low returns, indicating an assortment of sediments (Figure A2.8.3).

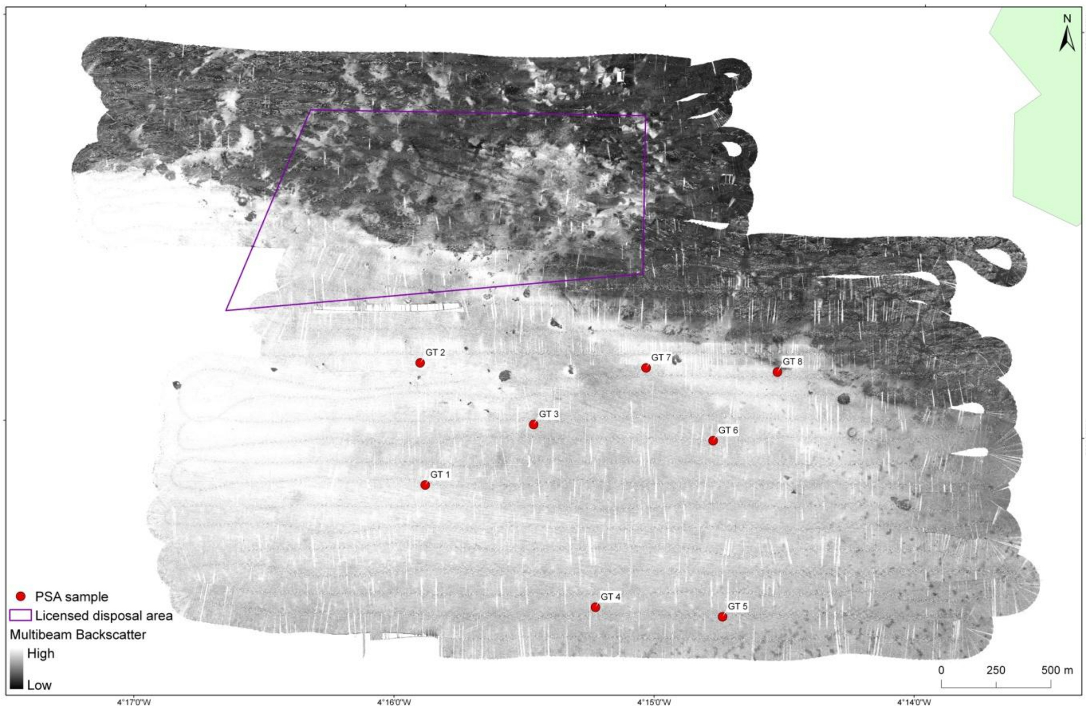


Figure A2.8.3. Location of the stations sampled for particle size analysis (red dots) with multibeam backscatter data collected at Rame Head, July 2011.

Figure A2.8.4 presents the interpretation of the 2011 Rame Head acoustic data using the PSA data collected from the Day grabs. The seabed sediments within the acoustic area are dominated by sand with gravel and mud in places. As previously mentioned, there is a boundary running from the northwest to the southeast edge of the acoustic coverage, which runs through the disposal site. As samples were not collected inside the licensed area during the 2011 survey, previous samples collected between 2002 and 2009 were used to aid the backscatter interpretation in terms of sediment analysis (these are indicated by the yellow sample points on Figure A2.8.4).

In the northern section of the disposal site, rocky outcrops occur interspersed with a mix of sediments. A corridor of mixed sediment can be seen in the area of backscatter change and to the southwest the sediment type dramatically changes to a much sandier consistency.

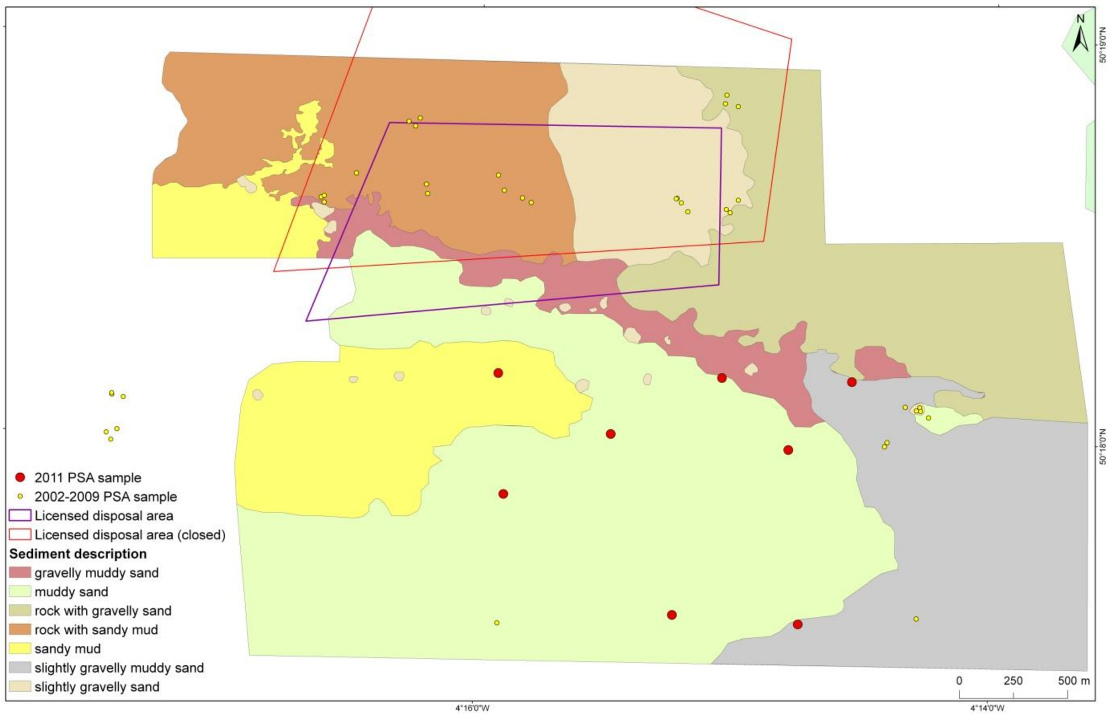


Figure A2.8.4. Interpretation of the multibeam data from the Rame Head survey, 2011.

The seabed surrounding the licensed disposal area is also varied in nature. The seabed directly south of the licensed area constitutes muddy sands with an area to the west comprising of sandy mud. The southeast of the backscatter data suggests that isolated coarser sediment patches are present within the muddy sands, identified as a mixture of high and low intensity returns.

2.8.3.2 Sediment particle size

Rame Head sediments, collected between 2001 and 2011, vary from muddy sands, gravelly muddy sands, muddy sand gravels and sands as well as muddy sandy gravels (Table A2.8.1 and A2.8.2 for 2011 sediments). Pie charts of gravel, sand and silt/clay for 2011 are shown in Figure A2.8.5. The sediments in 2011 were collected to ground-truth an area to the southeast of the disposal site to test the hypothesis that this may be a sink area on the edge of the shelf where accumulation of redispersed dredged material (from disposal site) may be occurring. These sediments predominantly fall in sediment group RaH1 (2 in sediment group RaH2) which contain the highest silt/clay content.

Table A2.8.1 Average sediment descriptions and statistics for each sediment group at Rame Head.

Sediment group	Number of samples	Sample Type	Sediment description	MODE 1 (µm):	MODE 2 (µm):	MODE 3 (µm):
RaH1	30	Bimodal, Poorly Sorted	Slightly Gravelly Muddy Sand	76.5	37.75	
RaH2	22	Bimodal, Very Poorly Sorted	Gravelly Muddy Sand	107.5	37.75	
RaH3	19	Polymodal, Very Poorly Sorted	Gravelly Muddy Sand	107.5	605	9600
RaH4	21	Unimodal, Poorly Sorted	Slightly Gravelly Sand	215		
RaH5	8	Polymodal, Very Poorly Sorted	Muddy Sandy Gravel	19200	38250	2400
RaH6a	8	Unimodal, Poorly Sorted	Slightly Gravelly Sand	605		
RaH6b	15	Unimodal, Poorly Sorted	Sandy Gravel	1200		
RaH7	30	Unimodal, Moderately Well Sorted	Slightly Gravelly Sand	152.5		

Sediment group	Gravel (%)	Sand (%)	Silt/clay (%)	Very coarse sand (%)	Coarse sand (%)	Medium sand (%)	Fine sand (%)	Very fine sand (%)
RaH1	0.26	52.20	47.54	0.54	1.30	1.99	6.31	42.08
RaH2	6.19	68.00	25.81	2.54	5.47	7.35	16.90	35.75
RaH3	23.59	52.99	23.41	9.30	11.36	8.79	8.04	15.50
RaH4	4.20	89.87	5.93	2.62	9.51	24.72	40.52	12.50
RaH5	66.23	29.46	4.31	8.89	7.92	5.07	4.44	3.15
RaH6a	4.43	91.64	3.93	12.74	37.35	29.61	10.14	1.81
RaH6b	35.86	61.35	2.79	32.60	21.37	4.72	1.56	1.09
RaH7	0.13	99.18	0.69	0.58	2.23	10.49	69.00	16.88

Table A2.8.2 Sediment groups for each station sampled between 2001 and 2011 at Rame Head.

Sample code	2011
GT1	RaH1
GT2	RaH1
GT3	RaH1
GT4	RaH1
GT5	RaH1
GT6	RaH1
GT7	RaH1
GT8	RaH2
GT9	RaH2

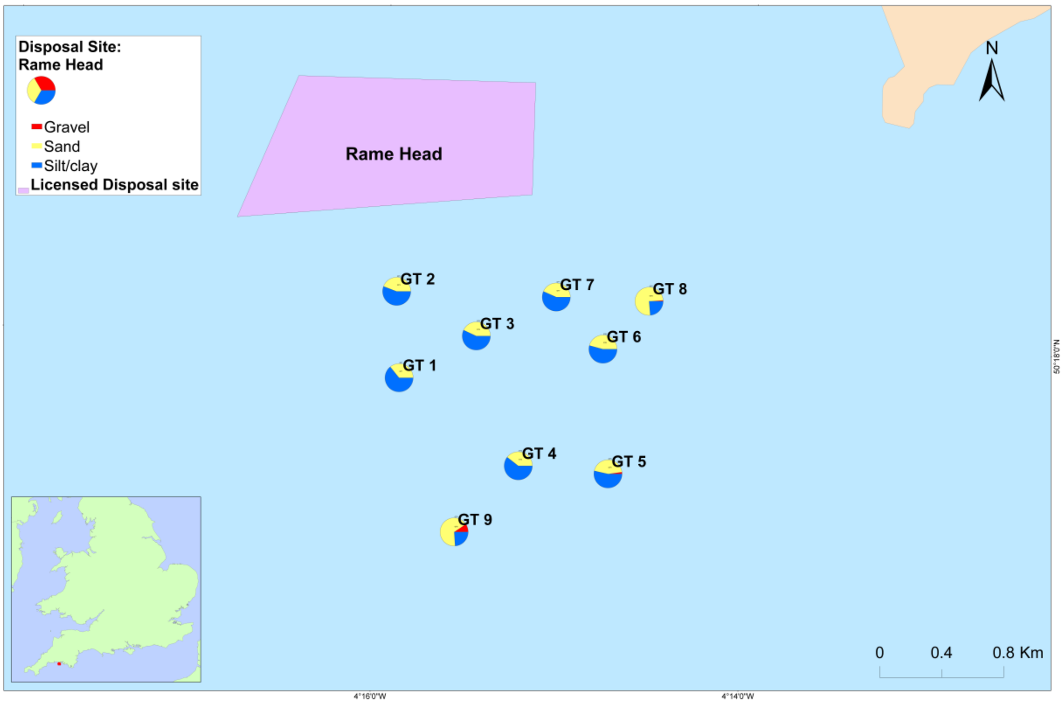


Figure A2.8.5. Pie charts of gravel, sand and silt/clay at Rame Head, 2011.

2.8.3.3 Sediment contaminants

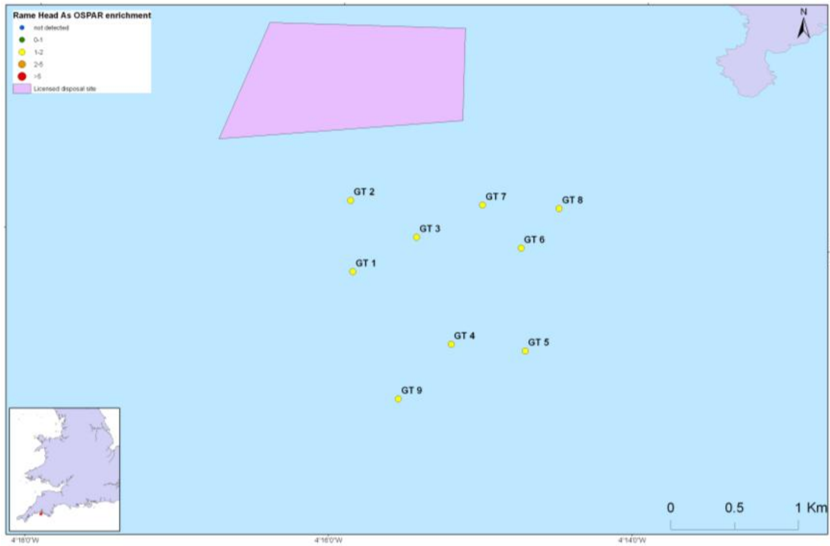
2.8.3.3.1 Trace metals

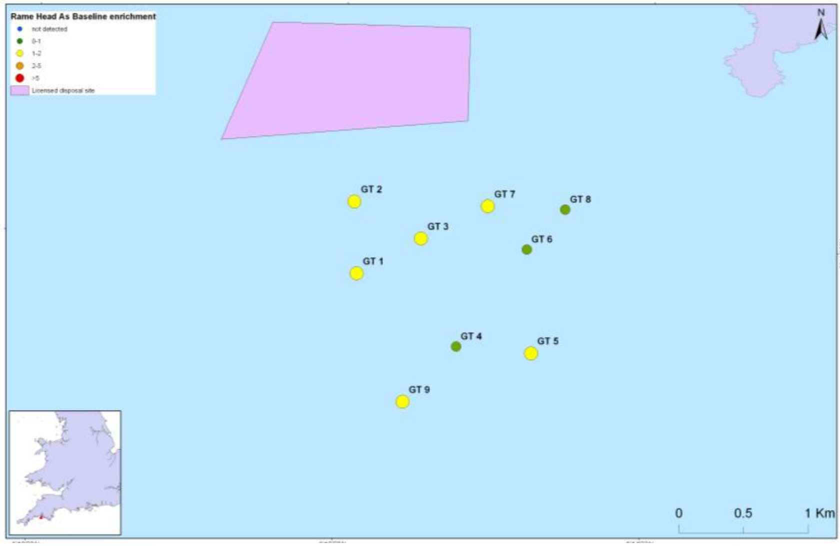
Assessment of metals enrichment using the OSPAR BAC method indicates that all stations were found to be slightly enriched with As, whereas using the baseline numerical approach 50 % of the stations show no enrichment with slight enrichment being observed across the remaining stations (Figure A2.8.6). Cd concentrations are comparable to the OSPAR BAC and baseline values with most stations being either slightly enriched or below the Cd level of detection.

No enrichment was observed for Cu or Pb at most stations when the baseline method was used for enrichment assessment, however, enrichment is more pronounced (i.e. 2-5 times the OSPAR BAC values) when assessing against the OSPAR values (Figure A2.8.6).

Regional variability is even more pronounced for Hg as the derived baseline value is 10 times that of the OSPAR BAC for the West Channel (see Appendix 1, Table A1.4.1), resulting in an important difference in enrichment factors between the two assessment approaches. For example, while all stations were found to be >5 times the OSPAR BAC value, their enrichment levels were reduced 1-2 times the proposed baseline value, with GT4 being lower than the baseline value (Figure A2.8.6).

The difference in the OSPAR and proposed baseline values, particularly for Cu, Pb and Hg shows that the OSPAR BAC values might not be suitable for direct comparison at Rame Head stations as these values do not take into account the regional and historical variability. Since the proposed baselines incorporate these factors as part of their derivation, it is more appropriate to carry out enrichment assessment using the baseline values (Table A1.4.1 in Appendix 1).


Rame Head As OSPAR enrichment
not detected
0-1
1-2
2-5
>5
Licensed disposal site
N
GT 1
GT 2
GT 3
GT 4
GT 5
GT 6
GT 7
GT 8
GT 9
0
0.5
1 Km
4°18'0"W
4°16'0"W
4°14'0"W
50°18'0"N


Rame Head As Baseline enrichment
not detected
0-1
1-2
2-5
>5
Licensed disposal site
N
GT 1
GT 2
GT 3
GT 4
GT 5
GT 6
GT 7
GT 8
GT 9
0
0.5
1 Km
50°18'0"N


Rame Head Cu OSPAR enrichment
not detected
0-1
1-2
2-5
>5
Licensed disposal site
N
GT 1
GT 2
GT 3
GT 4
GT 5
GT 6
GT 7
GT 8
GT 9
0
0.5
1 Km
4°18'0"W
4°16'0"W
4°14'0"W
50°18'0"N

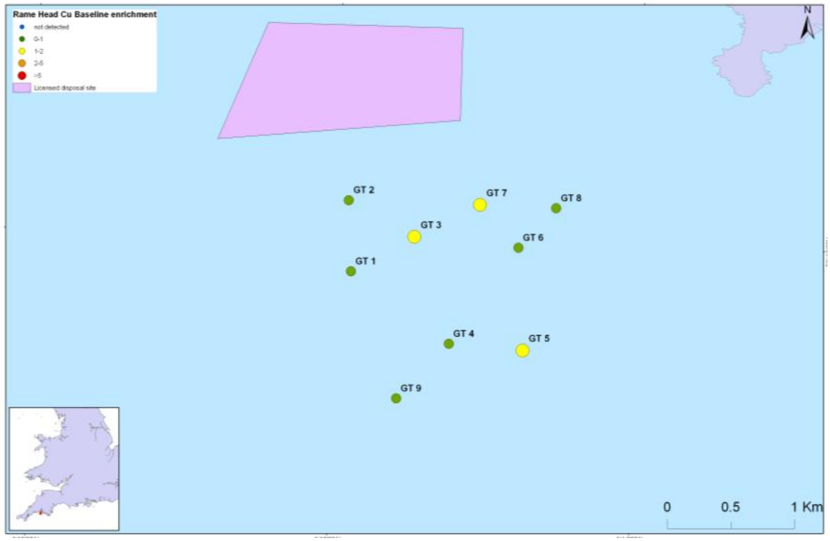

Rame Head Cu Baseline enrichment
not detected
0-1
1-2
2-5
>5
Licensed disposal site
N
GT 1
GT 2
GT 3
GT 4
GT 5
GT 6
GT 7
GT 8
GT 9
0
0.5
1 Km

Figure A2.8.6 Enrichment to OSPAR BACs (left) and regional baseline values (right) at Rame Head, 2011, for As, Cu, Hg and Pb.

About us

Cefas is a multi-disciplinary scientific research and consultancy centre providing a comprehensive range of services in fisheries management, environmental monitoring and assessment, and aquaculture to a large number of clients worldwide.

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