REPORT

# Port of Falmouth Approach Channel Dredge and Habitat Mitigation Scheme

Information for Habitats Regulations Assessment (HRA)

Client: A&P Group / Falmouth Harbour Commissioners

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## Table of Contents

## Table of Tables

## Table of Figures

# Appendices

# 1. INTRODUCTION

## 1.1 Introduction to the Port of Falmouth Development Initiative

In 2009 the Falmouth Harbour Commissioners (FHC) and the Falmouth Docks and Engineering Company (FDEC) submitted three applications to the Marine Management Organisation (MMO) which together formed a proposal to improve the port facilities and approach channel at Falmouth, Cornwall. This project is known as the Port of Falmouth Development Initiative (PFDI) and includes:

- Dredging and disposal of approximately 700,000m$^3$ of marine sediment to create a deeper and straighter approach channel from the Carrick Roads to the Queens and Northern Wharves.
- Seabed habitat mitigation works in the eastern channel (maerl re-lay).
- The construction of a longer berth, combining the Queens and Northern Wharves.

During the consultation following submission (November 2010), Natural England (NE) advised that, given the location, size and significance of the project, there may be an effect, directly and/or indirectly, on the Fal and Helford Special Area of Conservation (SAC) and the following key risks to protected features were considered to require further investigation before a conclusion of no adverse impact on integrity could be reached:

- destruction of the maerl matrix during dredging and re-lay;
- burying of live maerl present within the proposed dredge channel;
- the predicted rates of sedimentation as described in the hydrodynamic modelling output; and
- potentially over-optimistic rates of recovery associated with the re-laid dead maerl habitat.

In January 2011 the MMO confirmed that the proposed amalgamation of the Queens and Northern Wharves would not have a ‘likely significant effect’ on the SAC and, hence, these elements of the PFDI scheme are not considered further in this Habitats Regulations Assessment (HRA). This document focusses on the proposed approach capital dredge (and associated mitigation works) which are necessary at the Port of Falmouth in order to provide deeper waters and improved access for larger vessels at all states of the tide. These improvements to the approach channel are required irrespective of any proposal to construct a longer berth.

Under the Falmouth Harbour Act and Orders 1870 to 2004, the FHC have general powers to *“take steps from time to time as they consider necessary or desirable for the maintenance, operation and improvement of the harbour and the accommodation and facilities (including navigation facilities) available in or in connection with the harbour”*. Under the Falmouth Docks Act 1959, Falmouth Docks and Engineering Company (A&P) also has powers for the maintenance and the development of its facilities and the navigation of vessels within its waters.

The PFDI required Environmental Impact Assessment (EIA) and Habitats Regulations Assessment (HRA) in accordance with the Marine Works (Environmental Impact Assessment) Regulations 2007 and Regulation 61 of the Conservation of Habitats and Species Regulations 2010 (the ‘Habitats Regulations’) given its location within the Fal and Helford SAC. An Environmental Statement (ES), herein referred to as the 2009 ES, was therefore submitted to the MMO in August 2009, with further Information to inform an Appropriate Assessment submitted in July 2010.

## 1.2 Requirement for a revised Habitats Regulations Assessment

The information to inform an Appropriate Assessment (AA) provided within the 2009 ES initially summarised the potential impacts on the SAC as:

- removal of dead maerl habitat during the dredging activity, and
- removal of species/communities living within the dead maerl during the dredging activity.

As a result of the proposed works, a potential net loss of 4 hectares (ha) of dead maerl habitat was identified and therefore mitigation was recommended. The mitigation recommended by NE at that stage involved over-dredging specific areas by 1m and placing a 1m thick layer of previously dredged dead maerl habitat back onto the seabed (**Section 2.2.3** provides details of the current proposals). This was to ensure that a viable dead maerl habitat remained following completion of the dredging. Taking account of the implementation of the mitigation proposals, the information to inform an Appropriate Assessment chapter concluded that an overall increase in the area of dead maerl and mixed dead maerl habitat of around 2ha would result. Similarly the replacement of the dead maerl and mixed dead maerl habitat was concluded to offer mitigation for the removal of species/communities during the dredging activity which would support recovery of the habitat within 2 to 5 years through recolonisation (though it was acknowledged that long-lived species may take longer). The loss of live maerl was not predicted to be a potential impact as the surveys to inform the 2009 ES did not identify live maerl communities within the dredged channel.

With mitigation in place, it was concluded that whilst the dredging would result in a temporary impact on the SAC, it was not considered to be of sufficient severity to constitute an adverse effect on the integrity of the site. This is because the dead maerl habitat within the channel would become recolonised in time and the area of dead maerl affected constituted a relatively small proportion of the dead maerl habitat within the SAC. Therefore the SACs ecological structure and function would be maintained and the dead maerl habitat would continue to contribute in the same way to the favourable conservation status of the SAC. An additional benefit was that there would be an overall increase in the dead maerl habitat available for recolonisation following the completion of the scheme.

After consulting NE, the MMO received advice (summarised in **Section 1.1**) and concluded that there was a significant risk associated with the mitigation scheme, specifically in that there was no evidence within the science community that the mitigation would work (i.e. field evidence). In their decision letter of January 2011 the MMO stated:

*"The MMO is aware that there is, at present, insufficient evidence to understand how maerl will respond to a relocation exercise. We would be willing to review any further evidence available to demonstrate successful maerl relocation to inform future licensing decisions in relation to this project."*

In light of the evidence provided to support the AA, the MMO could not therefore conclude that there would be no adverse effect on the integrity of the Fal and Helford SAC.

Since the original provision of information for the Appropriate Assessment in the 2009 ES, several strands of work have been carried out in order to address the concerns raised in the MMO decision letter; see **Section 4**. Additionally, a new Special Protection Area (SPA) has been proposed, the boundary of which overlaps that of the proposed PFDI. As a result, NE has confirmed that it is possible that the dredging works could impact on the interest features of the Falmouth Bay to St Austell Bay pSPA and, as such, the updated HRA should give consideration to this additional designation. In the absence of full designation information for the pSPA, consultation has been undertaken with NE to guide this element of the HRA and more information is provided in **Section 5** of this document. In addition, Natural England is in the process of updating the feature framework information for each SAC. The draft supplementary advice on conserving and restoring site features for the Fal and Helford SAC is also now available and has been incorporated into this HRA.

It is worth noting that the 2010 MMO AA concluded no likely significant effect for a number of features and sub-features of the SAC and, as such, these were screened out of the HRA process. These are identified below and are not re-assessed in this updated HRA:

- Large shallow inlets and bays.
- Eelgrass beds.
- Mudflats and sandflats not covered by seawater at low tide.
- Atlantic salt meadows.

## 1.3 Overview of the HRA Process

The 'Habitats Directive' (Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora) protects habitats and species of European nature conservation importance. Together with Council Directive 2009/147/EC on the conservation of wild birds (the 'Birds Directive'), the Habitats Directive establishes a network of internationally important sites designated for their ecological status.

SACs and Sites of Community Importance (SCIs) are designated under the Habitats Directive and promote the protection of flora, fauna and habitats. SPAs are designated under the Birds Directive in order to protect rare, vulnerable and migratory birds. These sites combine to create a Europe-wide 'Natura 2000' network of designated sites, which are hereafter referred to as 'European sites'.

The Conservation of Habitats and Species Regulations 2010 (the Habitats Regulations) incorporate all SPAs into the definition of European sites and, consequently, the protection afforded to European sites under the Habitats Directive applies to SPAs designated under the Birds Directive. In addition to sites designated under European conservation legislation, UK Government policy (ODPM Circular 06/2005) states that internationally important wetlands designated under the Ramsar Convention 1971 (Ramsar sites) are afforded the same protection as SPAs and SACs for the purpose of considering development proposals that may affect them.

Regulation 61 of the Habitats Regulations defines the procedure for the assessment of the implications of plans or projects on European sites. Under this Regulation, if a proposed scheme is unconnected with site management (for nature conservation purposes) and is likely to significantly affect the designated site, the competent authority must undertake an 'appropriate assessment' (Regulation 61(1)).

Typically, a staged process to assessment under the Habitats Regulations is undertaken, as follows:

- **Screening/Likely Significant Effect (LSE) assessment (Stage 1)**: The process to identify the likely impacts of a project upon a European site, either alone or in combination with other plans and projects, and consider whether the impacts are likely to be significant.
- **Appropriate Assessment (Stage 2)**: A decision (by the competent authority) with regard to the effect on the integrity of the European site, either alone or in combination with other plans and projects. Where there are adverse impacts, an assessment of mitigation options is carried out to determine adverse effect on the integrity of the site. If these mitigation options cannot avoid adverse effects on site integrity, then development consent can only be given if subsequent tests (see Stages 3 and 4 below) can be satisfied.

- **Consideration of Alternative Solutions (Stage 3)**: Examining alternative ways of achieving the objectives of the project to establish whether there are solutions that would avoid an effect - or have a lesser effect - on European sites.
- **Imperative Reasons of Overriding Public Interest (IROPI) (Stage 4)**: If the above tests can not be satisfied, it is necessary to demonstrate that the project is required for IROPI. If this test is met, then the project can only proceed if sufficient compensatory measures can be identified and implemented to maintain the overall coherence of the Natura 2000 network.

All four stages of the process are referred to collectively as the HRA, to clearly distinguish the whole process from the stage within it referred to as the 'Appropriate Assessment'.

In respect of Stage 2, the integrity of a European site is defined as: "*the coherence of the site's ecological structure and function, across its whole area, which enables it to sustain the habitat, complex of habitats and/or populations of species for which the site has been designated*" (EC, 2001). An adverse effect on integrity, therefore, is likely to be one which prevents the site from making the same contribution to favourable conservation status for the relevant feature(s) as it did at the time of designation.

Natural England's Habitats Regulations Guidance Note (HRGN) 1 'The Appropriate Assessment (Regulation 48)' (English Nature, 1997) describes how an AA should be undertaken. This guidance bases the assessment on a series of nine key steps that the competent authority should follow in undertaking an AA. These steps, including consultation, data collection, impact identification and assessment, recommendation of project modification and/or restriction and reporting, are outlined in **Table 1-1** below.

***Table 1.1 Recommended key steps in the preparation of information to inform an Appropriate Assessment***

| Step | Description of requirements |
|---|---|
| 1 | Consult with Natural England |
| 2 | Consult with other organisations and the general public (e.g. Environment Agency etc.) |
| 3 | Define the site's conservation objectives |
| 4 | Gather information as may reasonably be required to undertake the assessment |
| 5 | Identify the effects of the proposal on habitats and species of international importance and how those effects are likely to affect the site's conservation objectives |
| 6 | Decide whether the plan or project, as proposed, would adversely affect the integrity of the site in light of the site's conservation objectives |
| 7 | Consider the manner in which the plan or project is proposed to be carried out, whether it could be modified, or whether conditions or restrictions could be imposed, so as to avoid adverse effects on the integrity of the site |
| 8 | Conclude whether the proposal, as modified by conditions or restrictions, would adversely affect the integrity of the site |
| 9 | Record the Assessment and notify Natural England of the conclusions |

It is the role of NE to provide advice on the potential significance of effects of the project on European designated interests (as the statutory advisor to Government on nature conservation and the implications of development on European sites). In accordance with the Habitats Directive, the MMO, as a 'competent authority' will therefore consult with NE in order to ensure that the MMO can be satisfied that the project will not cause an adverse impact on the integrity of any European site before it can grant permission for the project.

## 1.4 HRA Structure

This report provides updated information to support a revised HRA for the proposed capital dredging/disposal and mitigation strategy for the PFDI and addresses both the issues listed above (see **Section 1.2**) and the potential effects on the newly proposed SPA. As this assessment draws upon a number of existing documents (e.g. the 2009 ES) duplication has been minimised through reference to relevant reports, some of which are appended to this HRA. It should be noted that a number of key technical investigations have been carried out since the MMO's HRA was prepared in 2010, including:

- An experimental trial to assess the impact of extracting, storing and re-laying the top 30cm of maerl habitat within the planned dredge area (2013/14).
- Production of a new mitigation strategy in consultation with NE (2014/15).
- Consideration of the potential impact on the live maerl habitat in the SAC summarised in a peer-reviewed technical note (2015).
- Expert review of relevant case law, including Briels and Sweetman (2014/15).

These documents are particularly relevant to this HRA and are referenced and drawn upon as necessary throughout this report. All of these additional elements of investigation have been undertaken in consultation with NE (where relevant), with input from the Centre for Environment, Fisheries and Aquaculture Science (Cefas), the MMO and other stakeholders as appropriate.

The information in this report is presented in the following sections:

- Section 1 – Introduction.
- Section 2 – Information about the Proposed Project.
- Section 3 – European Designated Sites.
- Section 4 – Potential Impacts on the Interest Features of the SAC.
- Section 5 – Potential Impacts on the Interest Features of the pSPA.
- Section 6 – In-Combination Assessment.
- Section 7 – Implications for the Integrity of the SAC and pSPA.
- Section 8 – References.
- Appendices.

# 2. INFORMATION ABOUT THE PROPOSED PROJECT

## 2.1 Scheme Design

*New Navigation Channel*

A new navigation channel is proposed to accommodate the safe navigation of larger vessels into Falmouth Docks and the design vessel used to inform these proposals is the MS Freedom of the Seas (for more information see 2009 ES, Section 2.1). The proposed channel location is shown in **Figure 2-1**. The conceptual channel design is principally based on guidance by PIANC (1997) and Thoresen (2003). More details are provided within Channel Design and Navigation Simulations (Royal Haskoning, 2008).

The required navigable depth is 10.5m; based on the design vessel's draught (i.e. 8.8m), squat (assuming low ship speed; i.e. 0.5m), waves (allowing for some swell at the Narrows; i.e. 0.2m), dredging tolerance (i.e. 0.5m) and heel corresponding to approximately 1.5º (i.e. 0.5m). For sufficient flexibility of safe operations for the design vessel, a tidal window equivalent to 75% of a typical tide is to be provided by the proposed capital dredging (i.e. nine hours during an average tide). Therefore, the proposed new channel would have a declared depth of 8.3m below CD (Chart Datum).

The lateral channel dimensions allow for:

- A turning area for vessel manoeuvres of 540m, which is equivalent to 1.6 times the maximum design vessel length (i.e. minimum recommended diameter).
- A channel width of 155m for the eastern part of the proposed dredge channel aligned east-west from Carrick Roads / The Narrows to the Eastern Breakwater; and
- A channel width of 125m for the western part of the proposed dredge channel aligned east-west from the Eastern Breakwater to the Queens and Northern Wharves.

*Deep Water Berth*

The proposed conceptual channel design includes a deep water berthing pocket alongside the current combined length of the Queens and Northern Wharves. The berthing pocket would be deepened and lengthened along its proposed lateral dimensions (510m by 50m) to accommodate berthed cruise vessels on all states of the tide. The current declared depth of the berths along the Queens Wharf and the Northern Wharf is 6m below CD. Based on the design vessel, the new berthing pocket would have a declared depth of 9.5m below CD.

*Seabed Habitat Mitigation*

In order to offset the potential impacts on the seabed habitat associated with the capital dredging of the new navigation channel, a mitigation strategy has been developed in consultation with NE. Further detail is provided in **Section 2.2**.

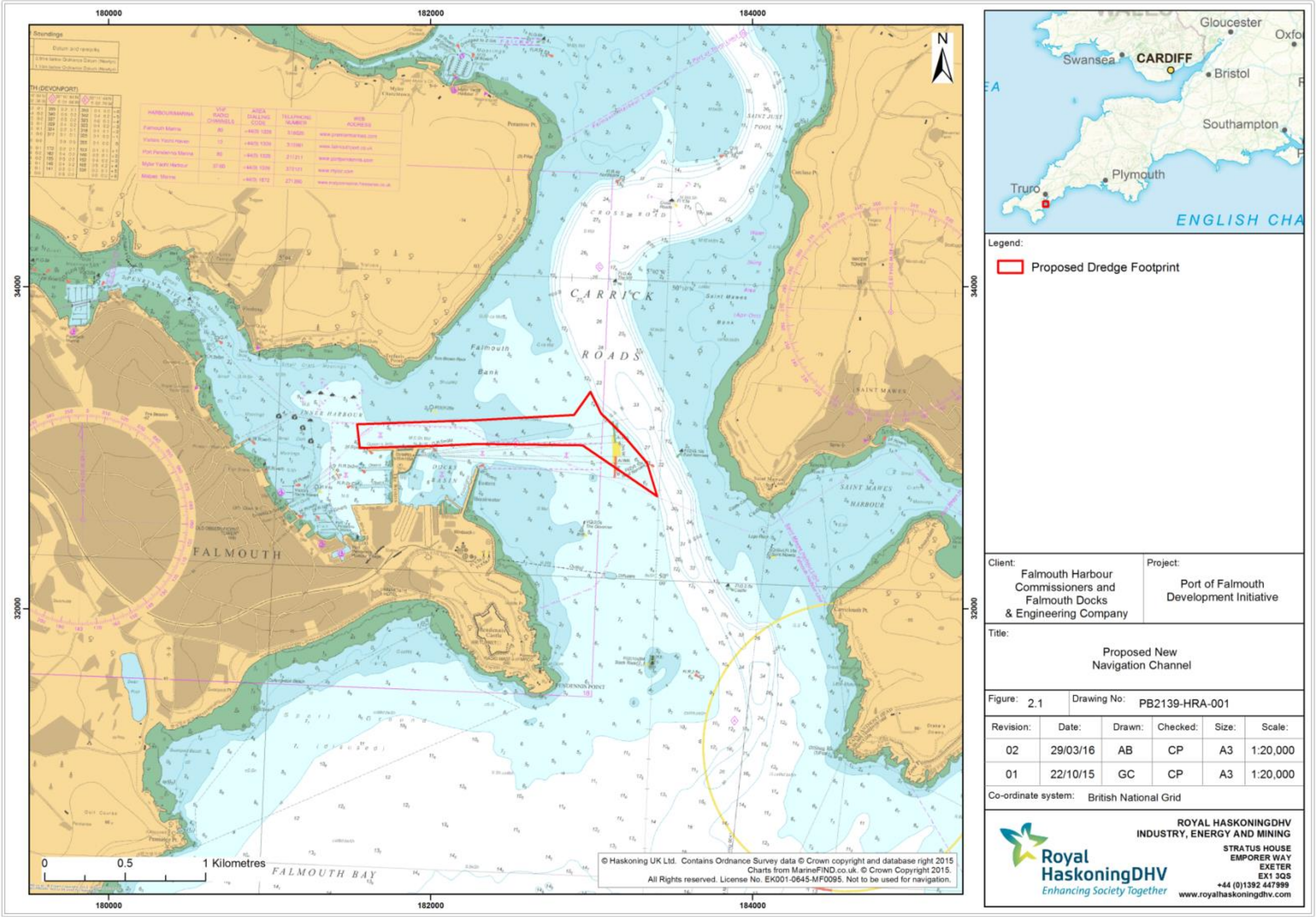


*Figure 2-1 Proposed new navigation channel*

## 2.2 Dredging Methodology

The proposed dredging method has not been finalised as new technologies are continually being developed. With the current available technologies it is likely that backhoe dredgers and barges will be used for the works and this HRA has been undertaken based on this assumption; further detail about this method is provided in the Falmouth Cruise Terminal: Preliminary Report on Dredging (Dredging Research, 2008). As FDEC and FHC continue to liaise with dredging contractors it is possible that other dredging methods may be considered, however, only those where the impact in terms of sediment transportation does not exceed that modelled for backhoe dredging would be taken forward.

Backhoe dredgers are similar to land-based excavators but are mounted on a pontoon or a vessel. They can dredge most materials including stiff materials and weak rock, and are suitable for dredging in confined areas. Backhoe dredgers use a bucket mounted to the end of the boom to remove material from the seabed and place it into a barge for transport and disposal. Bucket size depends on the nature of the material to be dredged and they can be equipped with visor grabs instead of open buckets. Visor grabs are mounted to the end of the boom and use a revolving visor flap to enclose the material in the grab prior to its removal from the seabed. The benefits of the visor grab include maximising the excavated material's density and reducing suspended sediment during dredging (John, 2000) and are particularly useful for restricting the mobilisation of the contaminated sediments. A detailed methodology for the dredging has not yet been developed but any methodology proposed will ensure that the sediment plumes created do not exceed the existing model outputs. Maximum thresholds for plumes associated with contaminated sediments will be proposed with this methodology.

The predicted volumes of material to be removed from the proposed dredge channel and cruise berth are estimated to be 594,540$m^3$ without the over-dredge and 695,110$m^3$ with the over-dredge. . These figures indicate the volume of material in situ and do not allow for any volume changes that might occur during dredging, treatment and disposal activities. The volume estimated with the over-dredge includes the additional volume of material when over-dredging by 0.3m is taken into account to achieve the declared depths in the navigation channel and cruise berth. The over dredge is to accommodate a 30cm layer of dead maerl (see section 2.2.3).

The proposed seabed habitat mitigation does not affect the dredged material volumes for disposal, because the cut and fill volumes balance each other so there is no net gain or loss therefore the disposal requirement is represented by the 'without over dredge' columns.

It is envisaged that the capital dredging would be undertaken using the methodologies outlined below.

### 2.2.1 Dredging of contaminated material

A survey of the characteristics of the proposed dredged material in 2004 was used to support the previous application for the disposal of dredged material at sea. A series of samples were taken from within the proposed dredge area and sent to Cefas for analysis (see **Section 6.2** of the 2009 ES for more detail). On the basis of the results, Cefas advised that the surface sediments in the area sampled are contaminated by metals, Polyaromatic Hydrocarbons (PAHs) and Polychlorinated biphenyls (PCBs) at concentrations that would preclude disposal at sea, for the material dredged to 1m below bed level in the western part of the proposed navigation channel, and that to be dredged to 2m in the proposed deep water cruise berth. By applying this advice to the proposed capital dredge, it is estimated that the indicative volume of contaminated dredged material would be approximately 100,000$m^3$. As previous sampling has determined that the material comprising fine sediment taken from the western part of the channel is not going to be disposed at sea further sampling is not deemed to be necessary in this area for the purposes of this HRA. The areas in the eastern part of the channel comprise coarser sediments which do not associate readily with contaminants and sampling from within this area has previously not shown any evidence of contaminants to the extent that they were considered to be unsuitable for disposal. It is possible that further sampling of surface sediments may be undertaken to support the updated ES.

Methods of reducing the spill level when dredging contaminants have been investigated. The key methods being the use of silt screens and use of a closed grab bucket or visor. The silt screens were not considered to be effective due to the area to be dredged and the currents in the area. Silt screens are generally used for protecting smaller areas from suspended sediment such as intakes or particularly sensitive resources in sheltered environments. It is proposed that a backhoe dredger with a visor or other means similarly effective in reducing sediment spill to the water is used to dredge the contaminated material present in the proposed channel (aligned east-west from the Eastern breakwater to the Queens and Northern Wharves). This would reduce the exposure of contaminated sediments to the water column and reduce the amount of sediment spill considerably, It has been estimated that a modern closed bucket backhoe could reduce the amount of sediment spillage by up to 50% (HR Wallingford, 2016) when compared to an open bucket backhoe. A maximum release rate for sediment during dredging of contaminated material will be proposed with the detailed methodology.

One option for treating the contaminated material is described in **Section 2.3.2** of the 2009 ES and, although this detail is not repeated here, is it important to note that no discharges (other than clean water) to the marine environment would occur as a result of the treatment process. FDEC are continuing to investigate the options for re-using the dredged spoil in order to minimise the quantity for disposal at landfill. However for the purposes of this HRA it is assumed that all contaminated material would be taken to an approved disposal facility on land, subject to the appropriate regulation. Detailed plans for this will continue to be developed with the Environment Agency and others, and additional consents will be sought as necessary.

### 2.2.2 Dredging of non-contaminated material in the proposed channel

'Clean material' is defined as material that does not contain contaminants at concentrations that prohibit disposal or re-use in the marine environment under the requirements of the Marine and Coastal Access Act (MCAA), 2009 i.e. sediments that are below action level 2 (using Cefas guidance on dredged material assessments).

For the purposes of this assessment, it is assumed that a backhoe dredger supported by sea-going barges (with an estimated capacity of 1,000m$^3$) fitted for bottom opening would be used in part of the proposed channel (aligned east-west from Carrick Roads/ The Narrows to the Eastern Breakwater). The production rate of backhoe dredging is lower than other dredging methods, which is beneficial in terms of reducing the potential rate of sediment release into the water column. A 12 hour working day and a 7 day working week are assumed for this phase of the dredging activity.

The edges of the dredged channel would be graded to prevent slumping taking into account the characteristics of the material and the relevant design standards. Although every effort would be made to achieve the required gradient within the existing footprint of the dredge, there may be instances where the stability of the slope requires a shallower gradient to prevent slumping which may reduce the width of the channel below that required to ensure navigational safety. This is currently unpredictable, as in all dredging projects, and it is more likely to occur in areas of finer sediment in the east of the channel. If a requirement is determined to broaden the dredged channel beyond the existing footprint in certain parts for navigational safety purposes, the minimum additional area would be used taking into account the existing depths and stability of seabed material. The dredge footprint would not need to be extended to the south in proximity to the live maerl fragments recently discovered as any channel widening in this area could be accommodated to the North

The envisaged disposal option for the clean dredged material that is not proposed for use in the mitigation strategy is to place it at the Falmouth Bay offshore disposal site, assuming that alternative beneficial uses cannot be found / agreed for the material; the option exists, for example, to re-use some of the dredge material as a soil improver.

A licensed offshore disposal site that has been in use since 1988 exists in Falmouth Bay. The disposal site is referenced as Falmouth Bay B (PL075) and defined as a segment of a circle with a radius of 0.5 nautical miles centred on a point of latitude 50° 06.400'N and longitude 04°56.500'W. It is situated some 7km south-east of the Fal Estuary's mouth, at the location shown in **Figure 2-2**. The water depth is approximately 55 to 60m below CD.

The barge would proceed to the offshore site and deposit the dredged material into the water via doors in the hull. The dredged material would fall to the seabed within the boundaries of the offshore site, as required by disposal licensing requirements under the MCAA. The barge would then return to the dredging area. It is anticipated that the barge would have a volume of c. 1,000m$^3$, which would require c.600 sailings to and from the disposal site over a six – twelve months dredging period.

Disposal plans will be drawn up to ensure an accurate and even distribution of material across the disposal site in line with advice from Cefas. The dredging of the proposed channel will be carefully planned to optimise the maerl translocation process and the efficiency of the dredge.

### 2.2.3 Maerl translocation

The maerl translocation would involve the removal of maerl from within the proposed channel and relocation of maerl habitat in a strictly controlled operation, as set out in the 2015 mitigation strategy (Appendix A, **Section 3.2**). A bathymetric multi-beam pre-survey of the dredge area would be carried out and a digital terrain model prepared that would be integrated into the dredge control software to ensure accurate excavation of the seabed in line with the requirements of the mitigation strategy.

Sites have been identified within the channel for extraction of the top 30cm of dead maerl habitat, as illustrated in **Figure 2-3**. The equipment and methodology used for extraction storing and re-laying the dead maerl habitat will be similar to that used in the trial dredge. A backhoe dredger (fitted with a flat/grading bucket with no teeth) would be used to skim the top 30cm of dead maerl at each of the sites. The use of a backhoe dredger and barges would minimise the potential for suspended sediment plumes and associated disturbance to the maerl habitat. Water quality sampling was undertaken during the trial dredge and the report confirms that generally minimal sediment transfer occurred (further discussion of potential for water quality impacts is included within **Section 4.4.2**). The dredged maerl would then be placed in suitable containers and stored until it can be re-laid (up to a maximum of 12 hours later).

The maerl for relaying would be placed onto specific areas of the seabed within the proposed channel that had been dredged to levels approximately 30cm deeper than required (over dredged), taking into account the maximum dredging requirement (i.e. 30cm deeper than the required -8.3CD). It is proposed that 30cm of maerl would be placed in the placement location, covering an area of approximately 1.5ha in total. The placement of material would be undertaken using accurate position fixing equipment on board the dredger. The effectiveness and accuracy of these techniques were established during the trial dredge and the reports produced summarising the outcomes of the trial are provided in Appendices to this HRA.

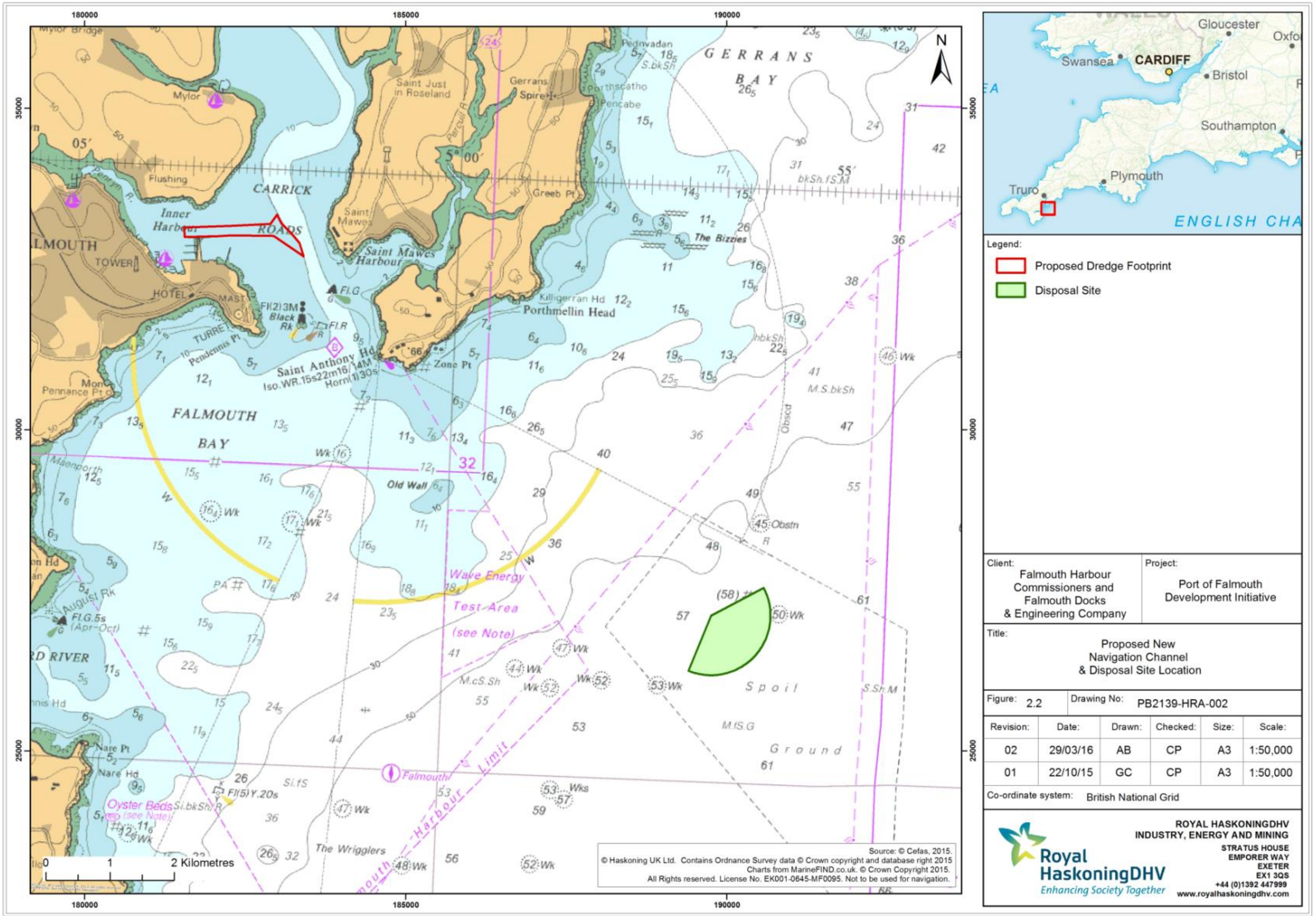


*Figure 2-2 Location of the offshore disposal site in relation to the proposed channel dredge*

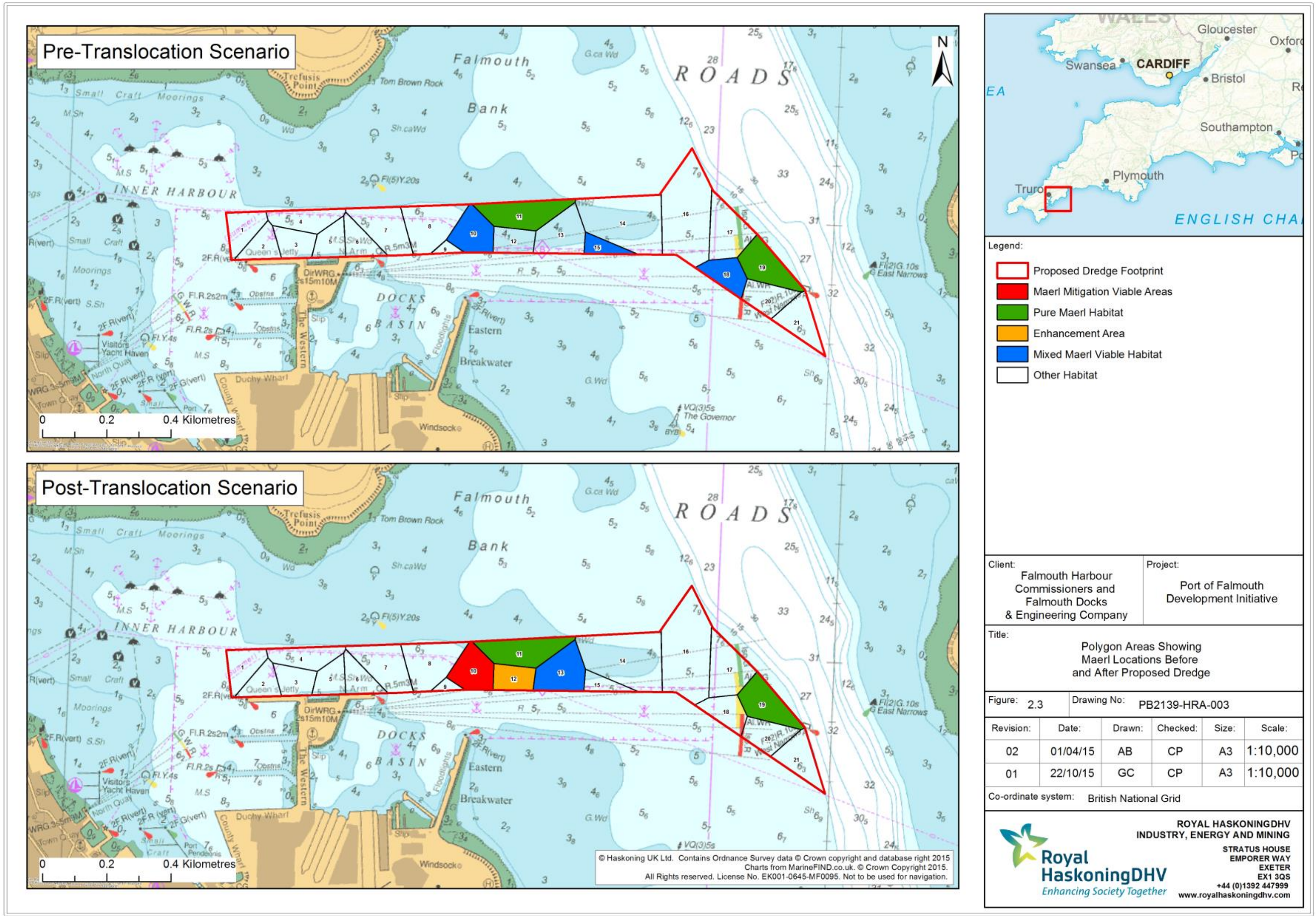


*Figure 2-3 Polygon areas showing maerl locations before and after proposed dredge*

The area proposed for the placement of maerl material as mitigation is polygon 10 (as shown on **Figure 2-3** as a red polygon). The polygons in the figure showing viable maerl habitat represent areas where maerl habitat or mixed maerl habitat with sand and maerl exists to 30cm depth of substrate (see **Figure 2-3**).

These polygons differ from those previously shown in the 2009 ES, which considered a viable maerl habitat to 1m depth of substrate (see **Section 3.2** of **Appendix A** (Mitigation Strategy Paper, September 2014)). The difference in the polygons reflect the decisions made relating to the viability of maerl habitat based on a literature review undertaken during and after the trial dredge (see **Appendix A**). The figure of 30cm reflects the agreed optimum depth to remove a suitable layer of maerl and the majority of the associated assemblage, but not to collect extensive areas of hypoxic or anoxic sediment that will have detrimental consequences for the survival of organisms at the surface and increased chance of burial when relayed. Additionally, burrowing infauna within maerl typically lives 10-30cm below the surface of a maerl bed (Bosence 1979), illustrated by **Figure 2.4** taken from Hall-Spencer (2010), the red lines indicating 30 cm depth. In these schematics of maerl faunal distribution, the only species completely below the line are thalassinid shrimps that have not been recorded in the Fal dredge area (Axellson et al. 2008) and the occasional large bivalve mollusc *Mya truncata*. *M. truncata* may well burrow below 30cm, but the large bivalve species present are commonly distributed species not specific to maerl that have no conservation designation (MarLIN database) and are likely to be found more commonly in other less-coarsely packed sediment. NE has also stated that they do not expect any deep fauna in the planned dredged area of the Fal due to its silty nature (Natural England, *pers. comm.*).

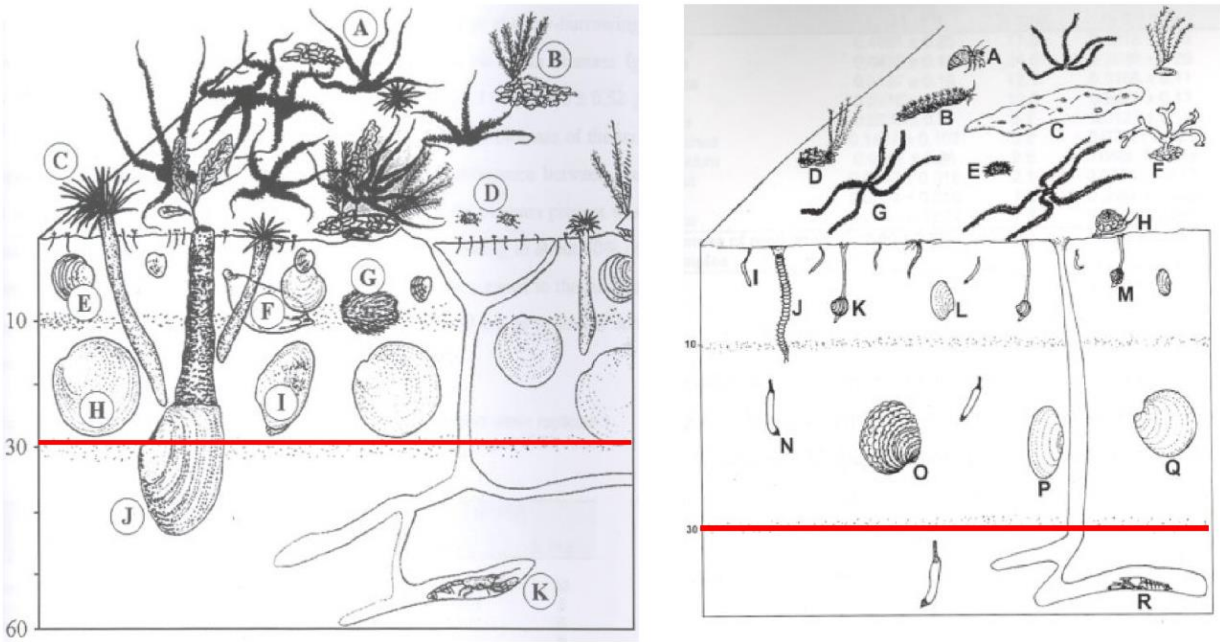


***Figure 2-4*** *Schematic diagrams showing the life positions of organisms on and in maerl at 1) -10m CD, Creag Gobhain, Loch Fyne, Scotland (Hall-Spencer, 2010)*

For the 2009 ES, the area of maerl habitat that would have been affected was 4ha. Based on current views on the viability of maerl, the area of initial loss of maerl habitat is predicted to be 7.6ha. Of this area, 4.1ha are expected to remain the same (i.e. the same habitat would be present at depth) after dredging. This area of loss would be balanced by the exposure of a new area of viable maerl, as a result of the dredging, amounting to 2ha; leaving a residual 1.5ha of loss to be mitigated (refer to **Table 3** in the Maerl Mitigation Strategy (**Appendix A**) for more information).

In addition to the mitigation proposed, polygon 12 has been identified as an enhancement area (shown on **Figure 2.3** as an orange polygon) where maerl habitat would be created following dredging activity within an area currently identified as clay with maerl. The same placement methodology as proposed for use in the mitigation polygon would be adopted for the enhancement polygon.

The digital terrain model would be updated to include the areas of extracted maerl to ensure accurate positioning of the barges adjacent to the placement sites. The maerl for relaying would then be placed via backhoe onto specific areas of the seabed within the channel that had been dredged to levels approximately 30cm deeper than required (to -8.6mCD). The placement of material would be undertaken using accurate position fixing equipment on board the dredger.

Placement of the maerl material would be guided by the dredge control software and spread in a layer as close as possible to 30cm in depth. No additional levelling would be undertaken.

### 2.2.4 Dredging of the deep water berth

The berthing pocket alongside the combined lengths of the Queens and Northern Wharves would be dredged to a depth of -9.5mCD. It is known that there is an area of weathered rock located in the area off the Northern Wharf. Although the rock strength/quality is not known it is assumed that the rock occurs as weathered laminar material (e.g. schist) which can be excavated using a dredger. This assumption is supported by existing information, which indicates that rock takes the form of weathered schist (e.g. Posford Duvivier, 1998). It is estimated that 25,500$m^3$ of rock would be required to be removed as well as the softer material that overlays it. A backhoe dredger would be used together with self-propelled barges and the proposal is for this material to be disposed of at the Falmouth Bay offshore disposal site. A more detailed methodology relating to the dredging and disposal of any rock including consideration of potential beneficial use will be put forward as part of an updated marine licence application.

### 2.2.5 Dredging Programme

The capital dredging is estimated to last between six and twelve months depending on the contractor, plant employed, potential constraints on operation and the specific methodology employed.

## 2.3 Operational Activities

Details of the baseline operational activities associated with Falmouth Docks and the anticipated changes as a result of the proposed capital dredging and mitigation are set out in the 2009 ES; a summary and updated figures are provided below, where they are available.

### 2.3.1 Ship repair activity

Currently, the turnover of the ship repair business is in the region of £38 million per annum employing 340 full-time and an average of 120 part time and 100 contracted employees. Depending on the mix of work, approximately 100 ships are docked each year with dockings ranging in duration from 2 to 200 days. A similar amount of vessels also use the alongside berths each year. There are approximately 450 tug boat movements each year. A wide range of vessels are handled including tankers, roll-on roll-off (Ro-Ro) vessels, ferries and bulkers. In recent years there has been a considerable increase in contracts with the MoD, including a long term contract with five Royal Fleet Auxiliary ships to be based in Falmouth when they require major refit and repairs and the 4 new Tide class tanker vessels.

## 2.3.2 Other vessel activity

Falmouth Docks is a busy harbour with numerous vessel movements all day throughout the year. Operating 24 hours a day, the docks have remained busy over recent years as **Figure 2.5** highlights (annual data provided by FHC).

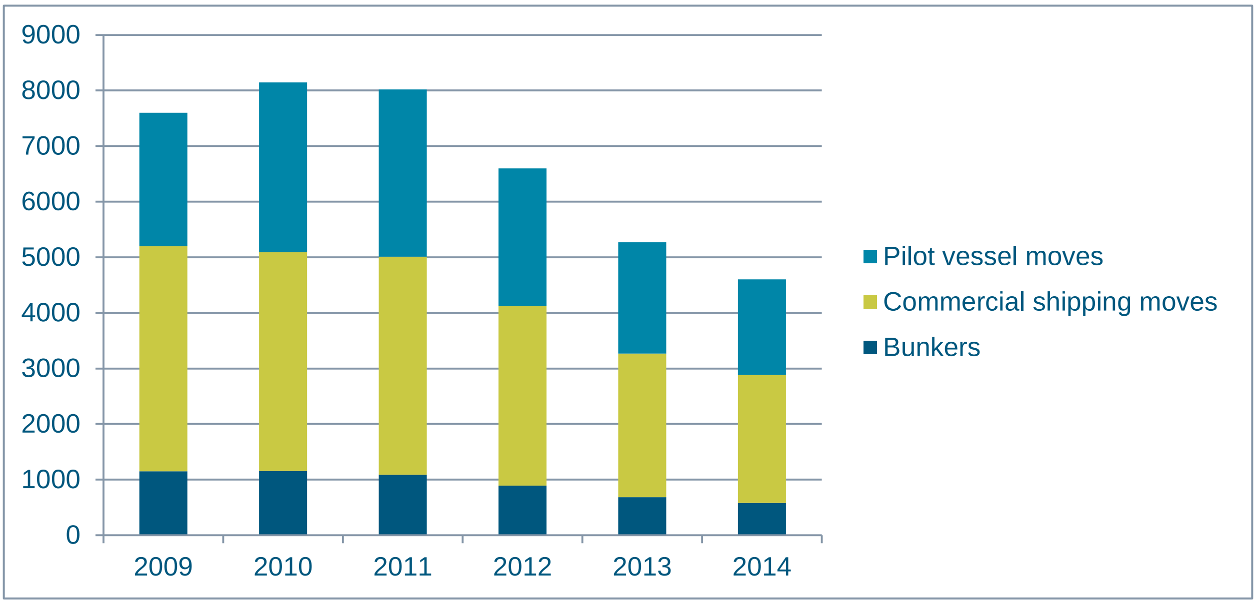


***Figure 2-5 Number of commercial shipping movements per year (FHC, 2015)***

Associated with commercial shipping movements are the pilot boats and bunkering vessels which service the commercial ships; these movements have also been included in the data illustrated on **Figure 2.5.** The increase in numbers between 2009 and 2012 is linked to the European Emission Control area of the English Channel and the North Sea that was established at the longitudinal line of 5 degrees west, making Falmouth a prime location for the supply of low sulphur fuels to shipping entering the English Channel. Commercial shipping levels have now returned to normal levels.

Focussing on the most recent three years the data suggests that commercial vessel movements are at their highest in the summer and autumn months perhaps reflecting an increase in visiting cruise traffic. Although numbers are lower for the winter months Falmouth remains a busy port with an average 380 vessel movements a month in 2014.

It is important to recognise that these figures do not capture all vessel movements in and around the harbour; only those which generate revenue for FHC. It is likely therefore that these figures are underestimating the true situation; further contributions to vessel traffic are detailed below.

### Marine Contractors/ Service Operators

A number of marine contractors use Falmouth or Penryn harbours as the base for operations. These businesses operate a number of working vessels ranging from crane barges to small work boats and carry out work in and around the harbour as well as further afield. Organisations include Seawide Services, KLM, Sub Marine Services (SMS) and Marine & Towage Services (MTS). FHC also operate a workboat year round to conduct maintenance and deploy buoys as necessary. A small enforcement vessel is also used to patrol the harbour.

Other marine organisations such as Fugro Seacore and contractors working on the Hayle Wave Hub and FabTest sites regularly use the harbour for mobilisation and demobilisation activities as well as maintenance of vessels.

Passenger craft operate from various harbours. There are passenger services linking Falmouth to Tolverne and Truro (seasonal from April to October), and to Flushing and St Mawes (year round). In addition, the demand for leisure moorings in the Fal Estuary outstrips supply. In a study published in 2012 (Latham, *et al*.) the use of the Fal Estuary was described as including '3878 full time, seasonal and visitor moorings, marking buoys, 23 marinas and pontoon systems, 69 public and private slipways, eight boat parks and storage areas, 34 small tender haul-out and beach launch areas, 36 jetties and quays and several designated anchorage areas'.

#### Recreational Boating

There are approximately 30 recreational sailing clubs in and around Falmouth Harbour. The main sailing clubs include Royal Cornwall Yacht Club, Flushing Sailing Club, St Mawes Sailing Club, Mylor Yacht Club and Restronguet Sailing Club. There are numerous sailing events throughout the year, including the Falmouth Regatta Week, which is the largest sailing regatta in the southwest. Events take place almost every day between April and October and include village regattas, championship races, special club races, club series and offshore races. Sailing races generally take place on the weekend and during some weekday evenings in the summer.

Tourist services are continued throughout the winter period with companies offering sea safaris and fishing trips that operate a number of days a week. Tall Ships also visit year round although during the winter months numbers tend to decrease.

### 2.3.3 Cruise activities

Cruise operations already occur at Falmouth Docks and so many aspects of the operational phase of the proposed project are not new activities to the site and the surrounding environment.

However, the number of cruise calls are predicted to increase if the dredging takes place. Accordingly, the numbers of cruise passengers are also predicted to increase. The EIA and therefore this HRA process is informed by the predictions of the URS Port of Falmouth and Penryn River, Economic Analysis, Supply Chain and the URS, Port of Falmouth and Penryn River, Economic Analysis, Supply Chain and Demand Assessment, August 2015.

For the purposes of this HRA, the operational phase commences on completion of the construction phase and will comprise:

- general cruise terminal activities;
- day calls;
- turnaround calls; and
- general port operation and maintenance activities.

#### Berthing

At present, cruise vessels either berth alongside a wharf within Falmouth Docks or moor at a dedicated deep water anchorage within the Carrick Roads from where passengers are transferred to land by tender. The location of mooring depends on the state of the tide relative to a vessel's size and its arrival and departure times.

With dredging achieved, cruise vessels would access the Docks via the approach channel and berth alongside in an appropriate location.

## Passenger Handling

Day calls occur when a cruise vessel visits Falmouth as part of a cruise's itinerary and tend to use Falmouth between May and September. For day calls, cruise vessels will berth alongside in an appropriate location. In the morning, passengers will disembark and be allocated a coach for their shore excursion or a shuttle bus for transfer into Falmouth. For their return in late afternoon, passengers will be brought back to the port and will embark the cruise vessel.

Turnaround calls occur when a cruise vessel uses Falmouth as its base port for the start and end of a cruise, and use Falmouth throughout the year. For turnaround calls, passengers will arrive by coach, car or be dropped off by friends and relatives. If arriving by coach, passengers will be dropped off at the wharf. If arriving by car, passengers will park in the car parking areas within the docks estate and be bussed to the wharf. All embarking passengers will be checked and pass through security as will their luggage before boarding their ship. Disembarking passengers will collect their luggage in the terminal area and pass through customs before departing.

## Day Calls

*Recent History*

In 2010, Falmouth attracted 32 day calls bringing approximately 27,040 passengers to the town and west Cornwall. This equates to an average of 845 passengers per day call. Of the day call passengers coming ashore normally approximately 50% visit Falmouth by walking or shuttle bus, while the other 50% visit other parts of west Cornwall by coach. Allowing for 45 passengers per coach, day calls generated up to 10 coach movements per day call.

*Predicted Day Call Vessels*

With the proposed PFDI in place and operational from 2020, FDEC predict the numbers of vessels visiting Falmouth for day calls to increase from 32 in 2010 to 84 in 2030 (**Table 2.1**, URS 2015 table 4.23 page 61), which equates to an increase of three per cent per annum.

***Table 2.1 Revised outlook for Falmouth cruise sector to 2030 (URS, 2015)***

| Forecast Year: | 2011 Masterplan | | | | Revised Outlook | | | |
|---|---|---|---|---|---|---|---|---|
| | 'Do Nothing' scenario | | 'Investment' scenario | | 'Do Nothing' scenario | | 'Investment' scenario | |
| | Pax | Calls | Pax | Calls | Pax | Calls | Pax | Calls |
| 2010 A | 27,040 | 32 | 27,040 | 32 | 27,040 | 32 | 27,040 | 32 |
| 2015F | 34,583 | 37 | 48,510 | 45 | 14,295 | 26 | 14,295 | 26 |
| 2020F | 42,944 | 42 | 115,275 | 75 | 11,124 | 17 | 45,289 | 41 |
| 2025F | 52,358 | 47 | 154,947 | 87 | 11,124 | 17 | 72,939 | 59 |
| 2030 F | 66,975 | 54 | 193,440 | 96 | 11,124 | 17 | 117,469 | 84 |

*Predicted Day Call Passengers*

FDEC also predicted the numbers of passengers visiting Falmouth on those vessels to increase from 27,040 in 2010 to 117,469 in 2030 (see **Table 2.1**, URS 2015 table 4.23 page 61), which equates to an increase of five per cent per annum. The rate of increase for passengers is higher than for vessels because FDEC's calculations assumed a gradual increase in the size of cruise vessels creating an increase in the average numbers of passengers per vessel.

### 2.3.3 Maintenance Dredging

The future need for maintenance dredging depends on the potential for material to settle and accumulate in the new navigation channel and berth. The following paragraphs describe the potential for fine-grained sediment (i.e. silt) and medium-grained sediment (i.e. sand) to accrete in the new navigation channel based on numerical modelling studies undertaken by HR Wallingford (2008).

SANDFLOW was used to simulate the sediment transport patterns throughout Falmouth Bay and Harbour due to tidal conditions alone, and including the effects of wave stirring. The resulting sediment transport patterns include only the **potential** for sediment transport (assuming that sediment is available), since the information on the actual availability of sediment is not incorporated. The sediment grain size varies over the study area. Therefore, for the purposes of this study the more traditional approach of specification of a representative median grain diameter was used, and a value of 0.25mm was used. By adopting this approach there is a requirement to interpret the model predictions carefully to account for areas where sediment of this grain diameter does not prevail. The sand transport modelling assumed abundant sand supply throughout the model area, therefore in areas such as Carrick Roads where gravels are more common the model predictions were worst case predictions and are likely to be significant over-predictions. The bed grab data in the area showed sand sized material was rare in the area of the channel with samples being dominated by fine sediment in Inner Falmouth Harbour or gravel size material in Carrick Roads. Furthermore the assessment of the likely material to dredge only included 3% sand, although there was also 23% sand or gravel with frequent maerl (HR Wallingford, 2016).

Calculation of the total volume of sand currently deposited annually (i.e. baseline conditions) in the area of the proposed channel provides a figure of less than 20m$^3$/year. This suggests that whilst sand is mobile in the area of the proposed new navigation channel, little deposits overall. This insignificant level of predicted deposition is consistent with the absence of a requirement to undertake maintenance dredging in the approaches to Falmouth Docks and Harbour currently, and the relatively stable nature of the seabed in the longer term. The calculation of the annual accretion predicted with the proposed new navigation channel in place (i.e. the proposed conditions) gives an accretion total of 5,500m$^3$/year. However, given the actual sediment types in the area, the HR Wallingford study considered that the likely long term rate of sand accumulation in the dredged channel would be significantly less than the 5,500 m$^3$/year predicted (HR Wallingford, 2016). The majority of this deposition is predicted to occur in the first year following dredging as the channel slope stabilises. The ongoing annual deposition is predicted as 2500m$^3$/yr, which would give a 10mm/yr average deposition over the channel area (HR Wallingford, 2016). The predicted change in accretion rate is linked to the prediction of generally unchanged sand fluxes due to the channel but with deeper depths, which provides a reduced potential for transport directly over the deeper area and, therefore, causes deposition. These volumes are also based on the assumption that sand is available for transportation and are expected to be reduced based on the reduced availability of sand on the seabed in the area. The total would also be expected to reduce as a result of vessel passage in the channel (HR Wallingford, 2016). Based on the modelling results and the seabed characteristics, HR Wallingford has predicted that regular maintenance dredging would not be required in the proposed channel.

In terms of silt, the annual deposition of silt in the proposed capital dredge area now (i.e. the baseline conditions) has been calculated as 2360m$^3$/yr. The deposition in the same area after capital dredging (i.e. the proposed conditions) has been calculated as 2970m$^3$/yr, i.e. there is very little difference before and after the capital dredging. Additionally, Falmouth Estuary is macro-tidal and has a mobile seabed with daily tidal movements. It is expected that each day, as fine sediments are deposited, that they would be re-mobilised by water movement associated with the tides (FHC, *personal communication 2015*). The total amounts of fine sediment depositing during the dredge are unlikely to change the nature of the bed in the areas studied (HR Wallingford, 2016). Currently no maintenance dredging is required within this part of Falmouth Docks and as such it is anticipated that **no additional maintenance dredging** would be required as a result of the capital dredging proposed.

The potential for additional maintenance dredging is therefore not considered any further in this document as it is unlikely that it will be required. In the event that maintenance dredging becomes a requirement in the future, this will be explored and assessed under a separate licence application.

## 2.4 Additional Work Completed Since 2009 ES

In response to the previous licence applications to carry out the proposed capital dredging and mitigation, NE and the MMO raised a number of concerns in relation to the designated feature of the European site 'Sandbanks which are slightly covered by sea water all the time'. These are summarised in **Table 2.2**.

***Table 2.2 Summary of concerns in relation to the sandbanks slightly covered by water at all times feature***

| Concern | Background to concern |
|---|---|
| Destruction of maerl matrix | NE's concern related to the potential for a maerl matrix to exist and that the sediments proposed to be moved contained specific layers of certain sized fragments in a specific order, from surface to depth, which give rise to ecological communities that contribute to the importance of the feature. If this matrix was disturbed or damaged during the works, this could adversely impact the ecological communities both now and into the future. |
| Burying of live maerl | This concern related to the presence of live maerl habitat in the southern part of the main dredge channel. Photographic evidence was supplied to the MMO by a member of the public as part of a response to the original licence applications. |
| Predicted rates of sedimentation | NE's concern related to the information presented within the ES which indicated that large amounts of sand would accrete within the proposed areas for the maerl to be re-laid. |
| Potentially overoptimistic rates of recovery associated with the re-laid maerl habitat | This concern stemmed from the fact that all of the above factors may impact on the potential for the re-laid maerl to be recolonised following storage and placement. Additionally, there was a concern that the more long lived species would not recover within the timescales suggested in the ES (i.e. four to five years). |

### 2.4.1 Further survey work to look at live maerl habitat presence

In order to understand the potential for live maerl to be present within the proposed dredge channel, The University of Plymouth were commissioned to undertake a survey in 2011 using a High Definition (HD) video mounted on a towed flying array to film the seabed. Transects of the proposed dredging area (approximately 0.5m in width and 1000m in length) were filmed and live maerl was recorded in real time. Subsequent video analysis then allowed the amount of live maerl within each transect to be defined in more detail. Full details of the survey can be found in Sheehan *et al* (2012).

The results of this survey showed that live maerl nodules do occur throughout the Fal and Helford Estuaries, however, at varying abundances. This works has provided further information in relation to the presence and more importantly the abundance of live maerl nodules within the proposed dredge location; which has allowed for a more accurate assessment of the type of live maerl habitat predicted to be impacted and the areas of nodule presence over which the impact would occur. Additionally, it allowed the proposed translocation trial (described below) to target at least one area containing live maerl nodules in order to assess their sensitivity to the translocation process. This information informed a live maerl note (see below).

Additional surveys have also been undertaken and the results have been summarised by NE to provide an overall figure of known distribution of live maerl. The figure is discussed further in **Section 4.6.2**.

The data reviewed (including the Plymouth University Surveys) were as follows:

- 2013 Fal and Helford SAC feature mapping report and associated data;
- Cornwall Inshore Fisheries Conservation Authority (CIFCA) towed video work in the Cross Road and Saint Just Pool areas between Penarrow Point and Carclase Point (2014);
- Seastar 2013 maerl condition monitoring draft maps1, and
- Plymouth University 2011-2012 maerl survey data in and around the channel.

### 2.4.2 Maerl Translocation Trial

A maerl translocation trial was designed and undertaken at the suggestion of the MMO in order to address a number of the issues raised in **Table 2-2** since the available scientific data to support the proposals was in question. As a result, The University of Plymouth were commissioned to prepare a methodology for the trial and, following acceptance of the methodology by the MMO, to undertake it. It should be noted that, at this stage, the proposed mitigation depth was revised from 1m as detailed in the 2009 ES to 30cm (with the agreement of the MMO). This is because 30cm was considered to better reflect the optimum depth to remove a suitable layer of maerl and the majority of the associated assemblage likely to be contributing to the conservation status of the feature, without collecting extensive areas of hypoxic or anoxic sediment that could have a detrimental consequence for the survival of organisms at the surface. Additionally it was considered that there would be an increased chance of burial when re-laid (Sheehan *et al*, 2014).

The trial focussed on the relocation of dead maerl beds since the proposed area is dominated by dead maerl, with a small discreet area of live maerl nodules (Sheehan *et al*, 2012). However, in order to provide further information on the predicted survival of live maerl nodules and the potential for the live maerl area to support richer species diversity, a small area with live maerl nodules was also included.

The trial also incorporated water quality data collection during the dredging activities to monitor any actual changes that occurred. The results are discussed in **Section 3.1.3**.

Details of the results of the trial are provided in Sheehan *et al*, 2014 but, in summary, the trial was considered to address the effectiveness of removing and relaying dead maerl in terms of the impact on the organisms and the habitat. It provided scientific evidence that recovery within the timeframes indicated in the 2009 ES were possible. As a result, the concern regarding overoptimistic rates of recovery was addressed and the proposed maerl mitigation strategy updated accordingly to reflect the observations and lessons from the trial.

The trial also provided evidence to confirm the theory that, although there are different sediment types that exist within the maerl, the loss of a specific component did not impact on the ability of the habitat to recover. Additionally it was concluded that the maerl structure remained relatively intact following being dredged and re-laid. Hence the concern regarding the loss of the sediment matrix was also addressed.

Further detail about the trial and the investigations regarding the results of the trial and the feasibility of scaling up the results to fit the actual dredge is provided in **Section 4.7**.

### 2.4.3 Live maerl paper

In order to address the remaining concern regarding the burial of live maerl, a technical note was prepared (provided as **Appendix B**) and peer reviewed (by Dr Nicholas Kamenos, see **Appendix C**) in order to determine the ecological significance of the predicted loss of the live maerl nodules. This paper addresses the ecological value of the live maerl nodules within the channel area, the possible mechanisms to explain the presence of the live maerl nodules in this area and the potential impact of the loss of the live maerl.

### 2.4.4 Predicted rates of sedimentation

Concern relating to predicted rates of sedimentation was addressed by providing additional explanation regarding the information provided within the 2009 ES as part of discussions with NE and the MMO since the submission of the original applications. The key issues linked to the predictions were associated with the set-up of the model and how the model reflects the natural conditions.

A question was raised in relation to the data used for the model associated with the low average suspended sediment baseline for Falmouth. Subsequent data from the Environment Agency was reviewed and provided confidence in the data used during the modelling. The MMO subsequently determined that the bathymetric data, resolution (i.e. spatial and depth resolution), extent, scale and the area of the plume model was acceptable and that the application of 1985 data was valid and robust (letter dated November 2013, **Appendix D**).

A question was also raised regarding the response of the estuary to wind generated or storm events. The modelling shows the dispersion of sediment for conditions which will occur for most of the time during the dredge operation (tides being dominant). Any effect associated with storms or high freshwater flows will be episodic and would be expected to raise the background suspended sediment concentrations, reducing the relative effect of the sediment plume. The raising of ambient suspended sediment concentrations is demonstrated in the case of both wind-waves and storm waves in the modelling of ambient fine sediment transport. Additionally, dredging will cease during large storm events and therefore the storm aspect and other event-based hydrodynamic effects are not considered representative of conditions during which dredging will be undertaken. As a result, these scenarios have not been modelled.

Additionally, the live maerl note (Royal HaskoningDHV, 2015) and **Section 4.5** provides a detailed description of the evidence available in order to provide further information on potential sedimentation to the south of the dredge channel where denser areas of live maerl nodules were noted during the live maerl tow survey.

### 2.4.5 Changes to light attenuation

A concern was also raised by a member of the public regarding the change in topography within the channel and whether this was likely to affect the potential photosynthetic yield of any live maerl within the channel. This issue was dealt with in a technical note that investigated the level of turbidity within the channel and in deeper areas where live maerl occurs (provided as **Appendix E**). This paper was also peer reviewed by Dr Nicholas Kamenos (**Appendix F**). It was concluded that the increase in depth of the channel would not prohibit live maerl fragments present in the channel from photosynthesising. This potential impact is also discussed further in **Section 4.3**.

## 2.5 Location of the works in relation to European Marine Sites

The proposed works are located within the boundary of two European Marine Sites (EMS) identified in **Section 1**. The boundaries of both the Fal and Helford SAC and the Falmouth Bay to St Austell Bay pSPA in relation to the proposed dredge channel and the offshore disposal site are illustrated in **Figure 2-6** and further details are provided in **Section 3**.

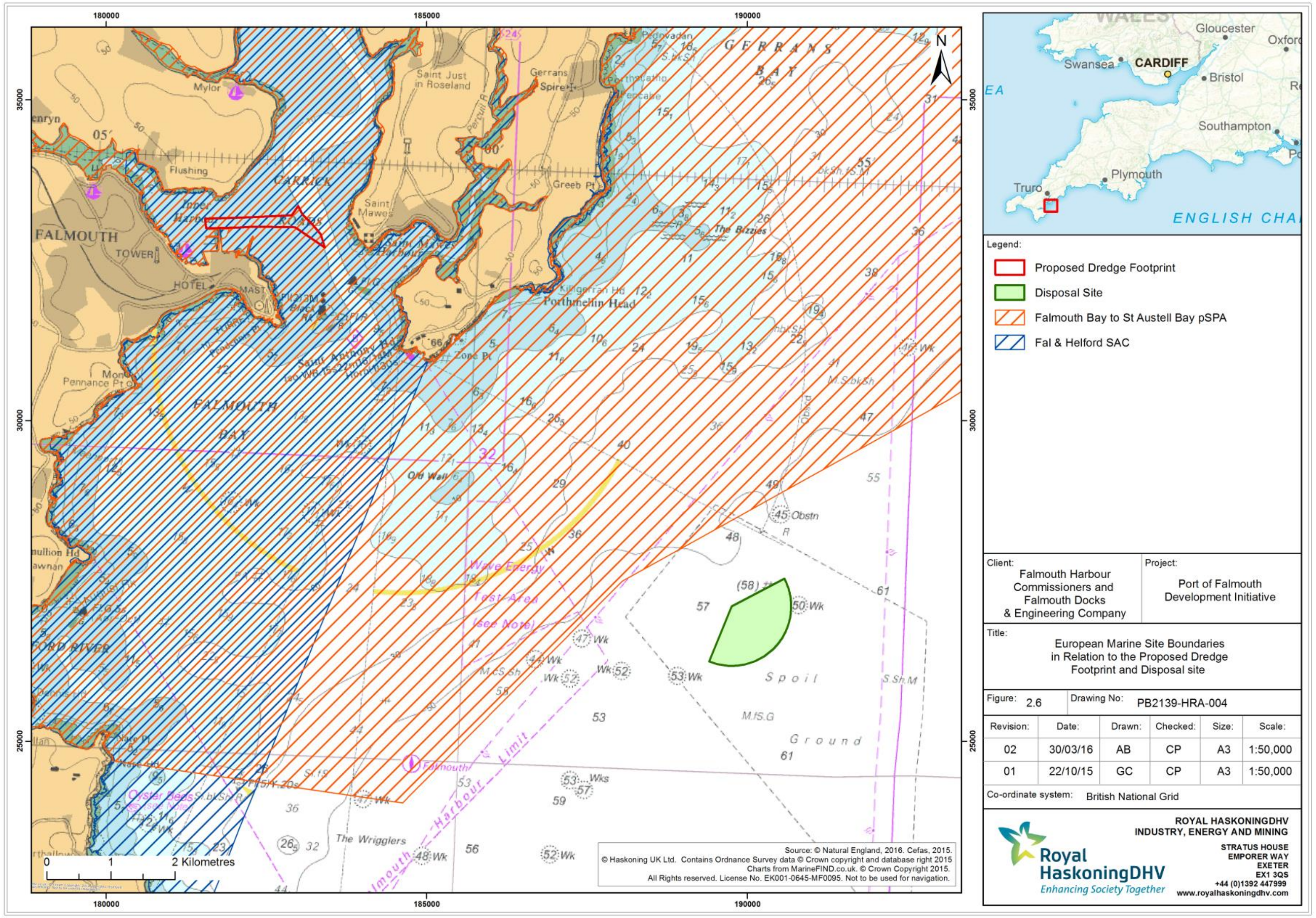


*Figure 2-6 Location of EMS in relation to the proposed dredge and offshore disposal site*

# 3. BASELINE INFORMATION FOR DESIGNATED MARINE SITES

## 3.1 The Fal and Helford SAC

### 3.1.1 Designated Features and Conservation Objectives

The Fal and Helford have been designated as a SAC for the following qualifying features (Natural England, 2014):

- **Sandbanks which are slightly covered by sea water all the time** – e.g. maerl beds in the Fal Estuary, particularly the live bed on St. Mawes Bank;
- **Estuaries** – e.g. the Fal Estuary and the Helford Estuary;
- **Mudflats and sandflats not covered by seawater at low tide** – e.g. the upper reaches of Polwheveral and Frenchman's Creeks;
- **Large shallow inlets and bays** – e.g. the whole bay from Manacle Point to Zone Point, within this are habitats such as reefs and rocky shores;
- **Reefs** – e.g. St Anthony's Head and inshore around Manacle Point;
- **Atlantic salt meadows** – e.g. top of Fal & Ruan Creeks at Ruan Lanihorne; and
- ***Rumex rupestris*; Shore dock** – Annex II species occurring above Highest Astronomical Tide.

**Figure 3-1** shows the distribution of the habitats within the Fal estuary as known at the time of designation (Natural England, 2000). Live maerl beds are shown in the key but dead maerl areas and areas with lower abundance of live maerl are included within other features. An up-to-date figure showing known areas of live maerl abundance throughout the estuaries is shown in **Section 4**.

Natural England has a statutory responsibility for developing conservation objectives to guide the management of the Fal and Helford SAC. The role of these conservation objectives is to set targets for what needs to be achieved by all the relevant authorities in order to protect the site's qualifying features. These objectives act as a starting point around which the management scheme can be developed. They also provide the basis for assessing what types of activities are likely to have a significant effect upon the interest features of the site, including new planning or license applications.

The Conservation Objectives for the site are to:

*Ensure that the integrity of the site is maintained or restored as appropriate, and ensure that the site contributes to achieving the Favourable Conservation Status of its Qualifying Features, by maintaining or restoring;*

- *The extent and distribution of qualifying natural habitats and habitats of qualifying species*
- *The structure and function (including typical species) of qualifying natural habitats*
- *The structure and function of the habitats of qualifying species*
- *The supporting processes on which qualifying natural habitats and the habitats of qualifying species rely*
- *The populations of qualifying species, and,*
- *The distribution of qualifying species within the site.*

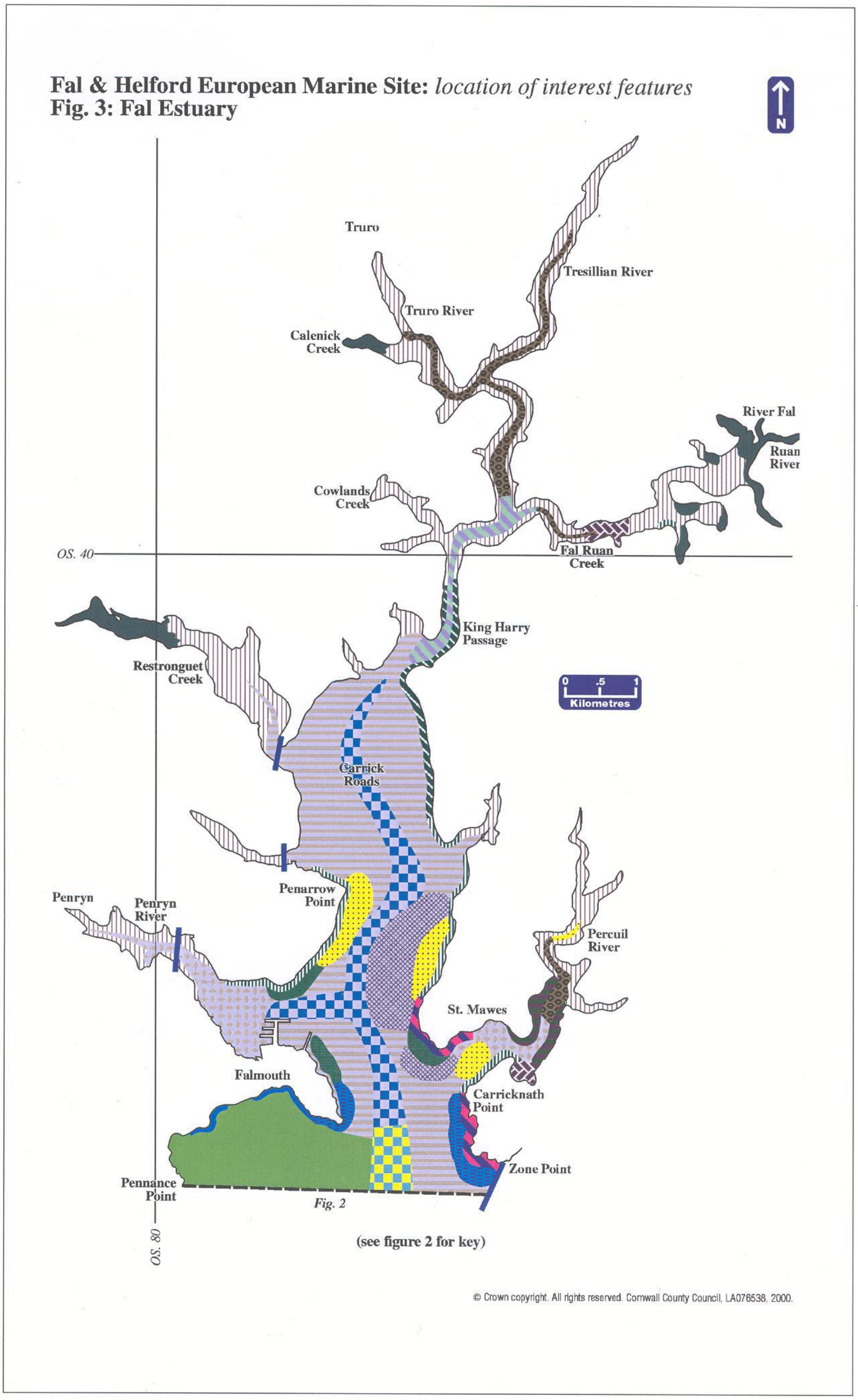


*Figure 3-1 Fal and Helford European Marine Site (sourced from English Nature report, 2000)*


Modelling undertaken for the 2009 ES (RHDHV, 2009) indicated that the potential impacts on the site (**Section 4.2**) generally would be local to the channel area. Negligible changes to the hydrodynamics and sediment dynamics within the site are predicted, such that there is not expected to be any potential for significant impacts on intertidal areas or on the functioning of the estuary itself, or the large shallow inlets and bays feature. Screening undertaken for the HRA during production of the 2009 ES outlined that for the purposes of the Appropriate Assessment information should be provided on the potential impacts due to the removal of the maerl habitats (maerl and maerl/sediment matrix). A summary table provided in **Section 4.9** outlines the potential for a Likely Significant Effect (LSE) to arise with respect to all of the features outlined above.

Of the above features, the one for which a LSE is acknowledged is the subtidal sandbanks feature. The description of this feature – summarised from the Supplementary Advice Package information (Natural England, 2015) for the site – is provided below:

- Sandbanks which are slightly covered by seawater all the time - cover a large part of the lower Carrick Roads and extend across Falmouth Bay and into the mouth of the Helford. Key sub-features in the context of the proposed dredging are listed below:
  - **Maerl beds** composed of accumulations of living and dead unattached coralline algae. Live maerl is pink and is found in the largest quantities in England and Wales on St Mawes Bank and offers shelter to a large number of other species of plants and animals. There are also extensive areas of dead maerl and these sediments are also species rich and provide an

important habitat for deep burrowing species, attached seaweed and large areas of brittle stars.
  - **Subtidal Mixed Sediments** - these contain important habitats for a range of species and may support surface dwelling animals and plants.

NE's Regulation 33 package (Natural England, 2000) provides advice on the sensitivity of the listed sub-features and states that the sub-features of the subtidal sandbanks are considered to be vulnerable to physical damage. This may be through increased siltation from dredging operations at particularly sensitive sites where maerl beds occur. The Supplementary advice package also includes sensitivity assessment for specific activities which includes capital dredging and disposal of capital dredged material.

This HRA therefore addresses the potential for impact on the areas of maerl beds or mixed sediments and their associated species that could be affected during, and as a result of, the proposed dredging activity.

Draft Supplementary Advice has been published recently (September 2015) presenting attributes which are ecological characteristics of the designated species and habitats within a site. The listed attributes for each site are considered to be those that best describe the sites ecological integrity and if safeguarded will enable achievement of the conservation objectives for the site (https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/457183/Fal_and_Helford_SAC_supplementary_advice.PDF). Each attribute is given a target which identifies the desired state for the attribute. The Draft tables identify "Maerl Beds and Maerl Beds (Maerl in Sediments)" for definition of attributes which require consideration under this HRA. The attributes listed within the draft advice have been considered within this HRA through the general assessment of potential impacts on the maerl beds and the maerl in sediments and have been included in the summary table in **Section 4.9**.

### 3.1.2 Favourable Condition Targets

When a plan or project is proposed its effects should be considered against the conservation objectives of the site. Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora ('the Habitats Directive') encourages the definition and implementation of mitigation measures (with respect to any potential impacts) to ensure that the project can proceed in line with the designated sites' 'conservation objectives'. If it can be shown that such measures will succeed, then it can be concluded that the project would not have an adverse effect on integrity of the site. The conservation objectives for the Fal and Helford SAC apply to the qualifying features of the site (one of which is the subtidal sandbanks feature). Within the subtidal sandbanks there are sub-features of interest for which favourable condition targets apply. The sub-feature for this site that has the potential to be affected is maerl bed communities.

In order to determine whether the proposed dredging works (the project) would have an adverse impact on the integrity of the SAC it is important to consider the favourable condition targets that apply to the sub-features of interest that could be affected. These are listed in **Monitoring of** the achievement of the conservation objectives (and the favourable condition targets) should occur within the NE reporting period to define the status of the site in relation to the objectives. Monitoring of the condition of the Sites of Special Scientific Interest (SSSI) that occur within the SAC provides an indication of the status of the site. The latest condition assessment for the Lower Fal and Helford Intertidal SSSI is recorded on the NE website (https://designatedsites.naturalengland.org.uk/ReportCondition Summary.aspx?SiteCode=S2000174&ReportTitle=LOWER FAL & HELFORD INTERTIDAL) as 100% favourable.

The condition assessment for the feature of Sandbanks which are slightly covered by sea water all the time is given in the draft supplementary advice package as "Not Assessed". This category is explained as applying where there is insufficient evidence to determine a feature's condition. A vulnerability assessment, incorporating sensitivity and exposure information, would then be used as a proxy for condition. 'Restore' targets have been selected for some of the attributes for maerl beds due to the past influences from maerl extraction and scallop dredging. It is acknowledged however that the management measures currently in place are sufficient and that no further measures are required for restoration of the attributes and that given the slow growth and recruitment rates, restoration may not be achievable.

***Table 3.1a Favourable condition targets for the sub-features relating to the conservation objectives for Subtidal Sandbanks (source: Natural England - Regulation 33 Package, 2000)***

| Feature | Sub-feature | Attribute | Measure | Target |
|---|---|---|---|---|
| Subtidal sandbanks | Maerl bed communities | Extent | Area (ha) of maerl (live and dead). Measure once during reporting cycle. | No decrease in extent of maerl as a whole, or of either dead or live maerl from an established baseline, subject to natural change. |
| | | Distribution of maerl bed communities | Distribution of maerl bed communities. Measure once per reporting cycle. | Distribution of maerl bed communities should not deviate significantly from an established baseline, subject to natural change. |
| | | Species composition of maerl bed communities | Presence and abundance of composite species of biotopes from maerl areas. Measured during summer, one during reporting cycle. | Presence and abundance of composite species should not deviate significantly from an established baseline, subject to natural change. |

Table 3.**.1a** for the Fal and Helford SAC where they apply to the relevant marine sub-features of interest (i.e. the maerl bed communities). **Table 3.1b** provides the attributes and targets within the Draft Supplementary Advice Package (2015).

Monitoring of the achievement of the conservation objectives (and the favourable condition targets) should occur within the NE reporting period to define the status of the site in relation to the objectives. Monitoring of the condition of the Sites of Special Scientific Interest (SSSI) that occur within the SAC provides an indication of the status of the site. The latest condition assessment for the Lower Fal and Helford Intertidal SSSI is recorded on the NE website (https://designatedsites.naturalengland.org.uk/ReportConditionSummary.aspx?SiteCode=S2000174&ReportTitle=LOWER FAL & HELFORD INTERTIDAL) as 100% favourable.

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***Table 3.1a Favourable condition targets for the sub-features relating to the conservation objectives for Subtidal Sandbanks (source: Natural England - Regulation 33 Package, 2000)***

| Feature | Sub-feature | Attribute | Measure | Target |
|---|---|---|---|---|
| Subtidal sandbanks | Maerl bed communities | Extent | Area (ha) of maerl (live and dead). Measure once during reporting cycle. | No decrease in extent of maerl as a whole, or of either dead or live maerl from an established baseline, subject to natural change. |
| | | Distribution of maerl bed communities | Distribution of maerl bed communities. Measure once per reporting cycle. | Distribution of maerl bed communities should not deviate significantly from an established baseline, subject to natural change. |
| | | Species composition of maerl bed communities | Presence and abundance of composite species of biotopes from maerl areas. Measured during summer, one during reporting cycle. | Presence and abundance of composite species should not deviate significantly from an established baseline, subject to natural change. |

*Table 3.1b Favourable condition targets for the sub-features relating to the conservation objectives for Subtidal Sandbanks (source: Natural England - Supplementary Advice Package, 2015)*

| Feature | Sub-feature | Attribute | Measure | Target |
|---|---|---|---|---|
| Subtidal sandbanks | Maerl beds | Extent and distribution | Presence and Area (ha) of maerl (live and dead). Currently estimated at 1041 ha (but accepting that may not include all current known areas not yet mapped). | Maintain the total extent and spatial distribution of maerl bed |
| | | Extent of supporting habitat | Extent is known to migrate. Area needs to be maintained to allow it it to continue to migrate. | Maintain the area of habitat which is likely to support the feature |
| | | Distribution of maerl bed communities | Detailed location and pattern of maerl habitats within the potential area of occupation. Linked to distribution of biotopes. | Restore the presence and spatial distribution of maerl bed communities. |
| | | Structure: age/size frequency | A full range of sizes of maerl pieces should be present to ensure a healthy, productive population. | Restore the size structure and composition of maerl thalli across the site |
| | | Structure: biomass | Amount of live thalli usually found at or near the surface of the bed. | Restore the biomass of maerl to natural levels within the site, to ensure a healthy, resilient habitat. |
| | | Supporting processes: energy/exposure | Wave energy and tidal flows across the site. | Maintain the natural physical energy resulting from waves, tides and other water flows, so that the exposure (high, medium, low) does not cause alteration to the biotopes, and stability, across the habitat. |
| | | Structure: non-native species and pathogens | Presence of non-native species. | Reduce the introduction of non-native species and pathogens, and their impacts. |
| | | Structure: population abundance | Total volume of live and dead maerl across the site. | Restore the abundance of maerl across the sub-feature |
| | | Structure: presence and abundance of typical species | To be determined by Natural England (typical species for the habitat feature). | [Maintain OR Recover OR Restore] the abundance of listed typical species, to enable each of them to be a viable component of the habitat. |
| | | Structure: sediment composition and | Distribution of maerl communities. | Maintain the existing distribution of sediment |

| Feature | Sub-feature | Attribute | Measure | Target |
|---|---|---|---|---|
| | | distribution | | composition types across the sub-feature. |
| | | Structure: species composition of component communities | Species overall range and relative abundance. | Restore the species composition of component communities. |
| | | Supporting processes: light levels | Depth of maerl from the surface. | Maintain the natural light availability at the maerl surface. |
| | | Supporting processes: physico-chemical properties | Salinity, pH and temperature. | Maintain the natural physico-chemical properties of the water. |
| | | Supporting processes: sedimentation rate | Sedimentation rates within the estuary | Maintain the natural rate of sediment deposition. |
| | | Supporting processes: water quality - contaminants | Contaminant levels within the estuary. | Reduce aqueous contaminants to levels equating to High / Good Status (according to Annex VIII and X of the Water Framework Directive), avoiding deterioration from existing levels. |
| | | Supporting processes: water quality - dissolved oxygen | DO concentrations within the estuary | Maintain the dissolved oxygen (DO) concentration at levels equating to High Ecological Status (specifically ≥ 5.7 mg per litre (at 35 salinity) for 95 % of the year), avoiding deterioration from existing levels. |
| | | Supporting processes: water quality - nutrients | Nutrient concentrations within the estuary | Restore the natural water quality and specifically winter dissolved inorganic nitrogen (DIN) to a concentration equating to Good Ecological Status (specifically mean winter DIN is < 12 μM for coastal waters), avoiding deterioration from existing levels. |
| | | Supporting processes: water quality - turbidity | Turbidity measurements within the estuary | Maintain natural levels of turbidity (e.g. suspended concentrations of sediment, plankton and other material) across the habitat. |
| | | Supporting processes: disturbance regime | Level of disturbance within the estuary | Maintain the natural maerl disturbance regime. |
| | | Structure: population abundance | Total volume of live and dead maerl across the site. | Restore the abundance of maerl across the subfeature. |
| | Subtidal mixed sediments | Extent and distribution | Presence and area of habitat | Maintain the total extent and spatial distribution of subtidal mixed sediment. |

| Feature | Sub-feature | Attribute | Measure | Target |
|---|---|---|---|---|
| | | Distribution: presence and spatial distribution of subtidal mixed sediment communities | Variety of communities present based on representative biotope descriptions | Maintain the presence and spatial distribution of subtidal mixed sediment communities. |
| | | Structure: presence and abundance of typical species | Abundance of typical species (further work necessary by Natural England) | [Maintain OR Recover OR Restore] the abundance of listed typical species, to enable each of them to be a viable component of the habitat. |
| | | Structure: sediment composition and distribution | Sediment character | Maintain the distribution of sediment composition types across the feature |
| | | Structure: species composition of component communities | Species composition of communities including the range of species and their relative abundance | Maintain the species composition of component communities. |

### 3.1.3 Baseline Environmental Conditions

This section sets out the baseline conditions for the parameters and features that could be changed as a result of the proposed capital dredging and mitigation. The data is based on the surveys and modelling undertaken to inform the 2009 ES (and subsequently), as well as the additional work that has been undertaken to address issues raised as part of the previous licence applications. This includes the trial of the methodology to be used for the dredge and mitigation, with associated monitoring, to provide evidence for recovery potential following the proposed dredge.

Although no additional hydrodynamic modelling has been undertaken, further turbidity analysis has been carried out which is of relevance to the HRA. These results are discussed below for water quality. The sediment quality assessment at this stage in the process is based on sampling results provided within the 2009 ES. It is not expected that there will be significant changes to the sediment quality in the study area since the sampling occurred. There are historic contamination issues affecting the seabed around the Docks Basin and berths, including heavy metals and particularly Tributyl Tin (TBT) contamination. Sediments from this area would be disposed of in a contaminated facility to contain any contaminants. Other areas that have not accumulated sediments in the past generally comprise coarser sediments or consolidated clay which does not have such an affinity for attachment to contaminants and, as such, any subsequent pollution events are unlikely to have caused any build-up of contaminants in these areas.

This section covers:

- Water and Sediment Quality.
- Coastal Processes.
- Maerl Habitats and Associated Species/Communities.

**Water and Sediment Quality**

Dredging can affect water quality through the suspension of particulates in the water column and through the release of any contaminants present in the sediment that is dredged. In order to determine the potential scale of effect, measurements of water quality are required together with an assessment of sediment quality through sampling. Modelling of potential plumes is also required to determine the distribution and extent of any changes that may occur.

***Water Quality***

When taking measurements of the suspended sediment concentration (SSC) various methods can be used and, in some cases, measurements of turbidity can provide an indication of SSC levels, based on a correlation between actual values taken concurrently, albeit with some assumptions based on the data.

Turbidity is a measure of the attenuation of light through the water column and is influenced by a number of factors, namely the amount of organic and inorganic particulate suspended matter and dissolved substances in water. These factors can change considerably dependent on activities occurring within the estuary and rivers and the time of year for natural occurrences, i.e. during spring and autumn plankton blooms occur which have a high level of influence.

Turbidity data (from the Environment Agency) has been analysed from within the Fal Estuary complex to determine ambient levels and variations throughout the year to show seasonal change.

*Environment Agency data*

The Environment Agency has provided water quality monitoring data for locations within the Fal Estuary (**Figure 3-2** shows sampling locations) during 2011 to 2013, which includes turbidity values taken at specific sampling stations at approximately monthly intervals. The closest sampling location, to the Falmouth Docks, where turbidity readings were taken was at Penryn, Falmouth Road. This location was therefore used to represent the likely conditions at the maerl locations within the dredge footprint. Turbidity monitoring is undertaken using a transmissometer at a sample depth of 0.2m (note: results of turbidity profiles taken during the trial dredge (Ecospan, undated) show that turbidity is likely to be similar throughout the water column). The results of the turbidity monitoring at all stations are shown in **Appendix G** for the different locations.

The range of values for turbidity is relatively similar for all sites (where turbidity data was taken), averaging around 3 Formazin Turbidity Units (FTU), apart from one site with much higher values (River Fal at Tolverne) where turbidity values range around 10 FTU and reached 53 FTU during a peak in Autumn 2012. To provide some indication of the clarity of water using FTU/NTU values, **Figure 3-3** shows a typical series of standards for turbidity readings.

In general, the sampling sites show good water quality with low turbidity values. The results of the turbidity monitoring show clear peaks which are expected to be due to sediment being suspended in the water column, as a result of wave action during stormy weather. Such peaks occur throughout most of the sampling sites. Some of the sites show additional peaks which are more likely to be due to localised phenomenon, as they are only apparent at specific sites.

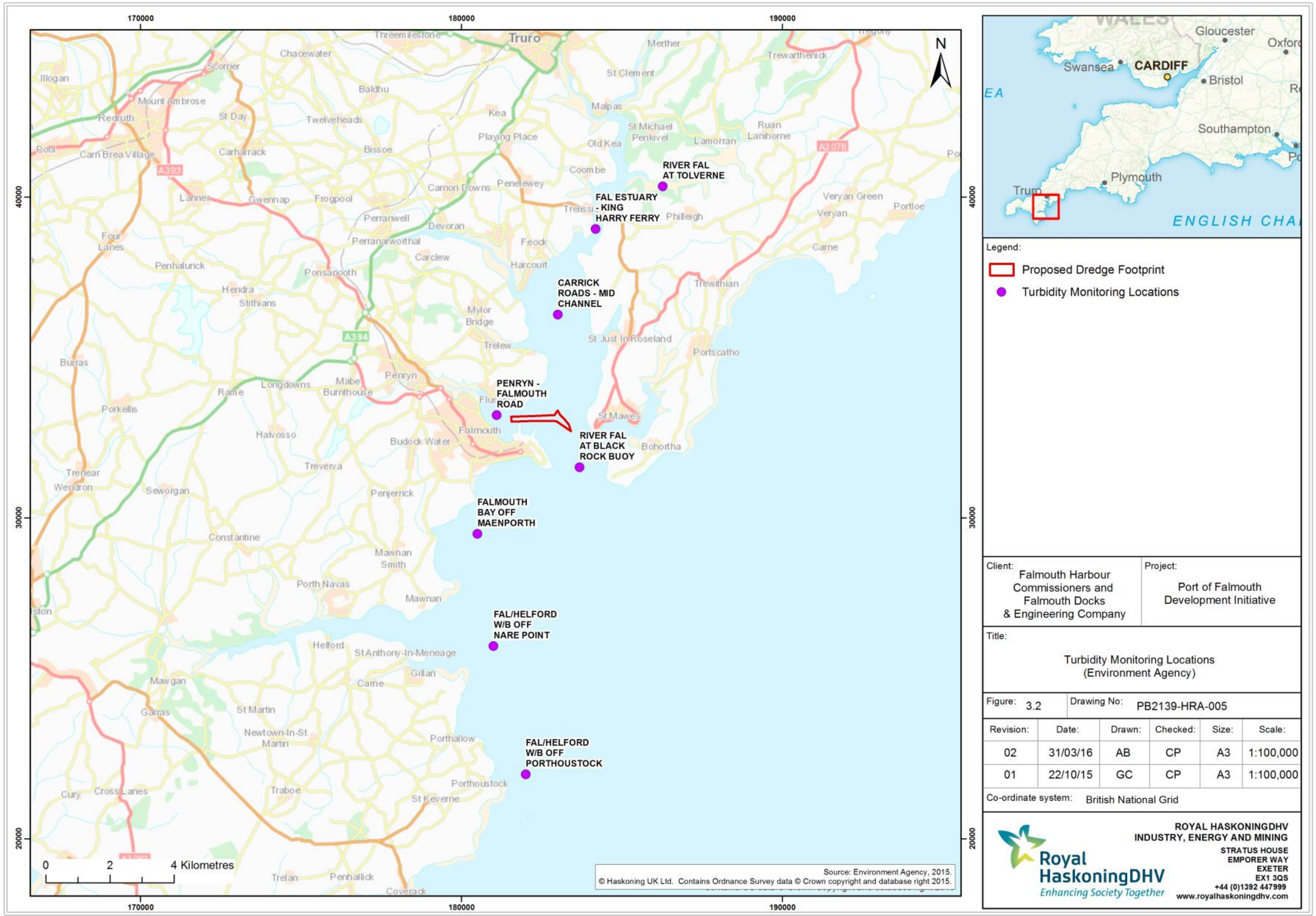



*Figure 3-2 Environment Agency sampling locations*

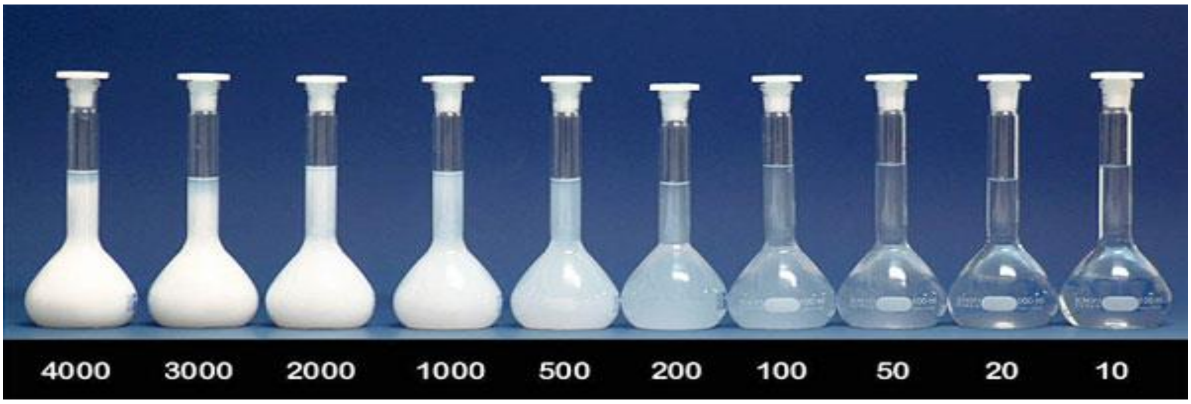



*Figure 3-3 Typical series of Formazin turbidity Standards shown in NTU/FTU (source Optek Turbidity Overview online (http://www.optek.com/Turbidity_Measurement_Units.asp))*

The peaks of turbidity generally increase the FTU values from an average of 3 FTU up to approximately 8-10 FTU throughout most of the estuary, although there are much higher FTU peaks occurring at the inner estuarine sites.

A comparison of the water quality data available for all sites (as shown in **Appendix E**) shows that the clarity of the water seems to be at similar levels in the outer estuary (including the site at Penryn – Falmouth Road (close to the docks) (see **Figure 3-4**) and the Falmouth Bay sites (example shown in **Figure 3-5**)).  These sites also show similar trends for the peak occurrences of turbidity. It can be assumed, therefore, that in terms of light availability these sites would experience similar levels of light attenuation through the water column.

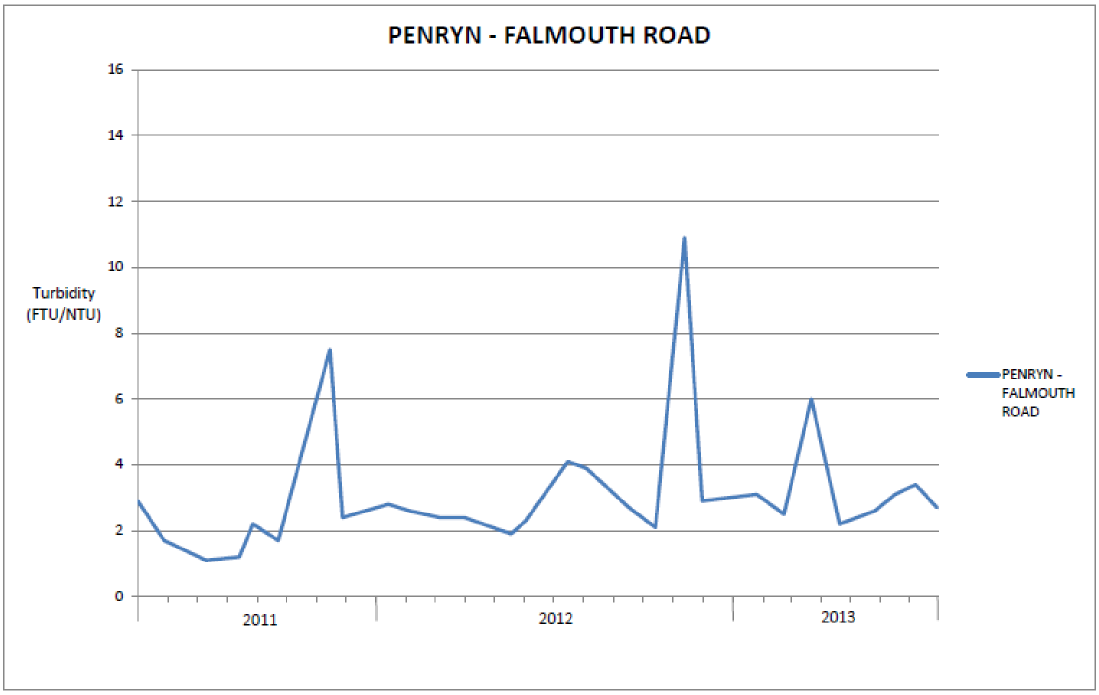



*Figure 3-4 Turbidity (FTU) data for Penryn – Falmouth Road*

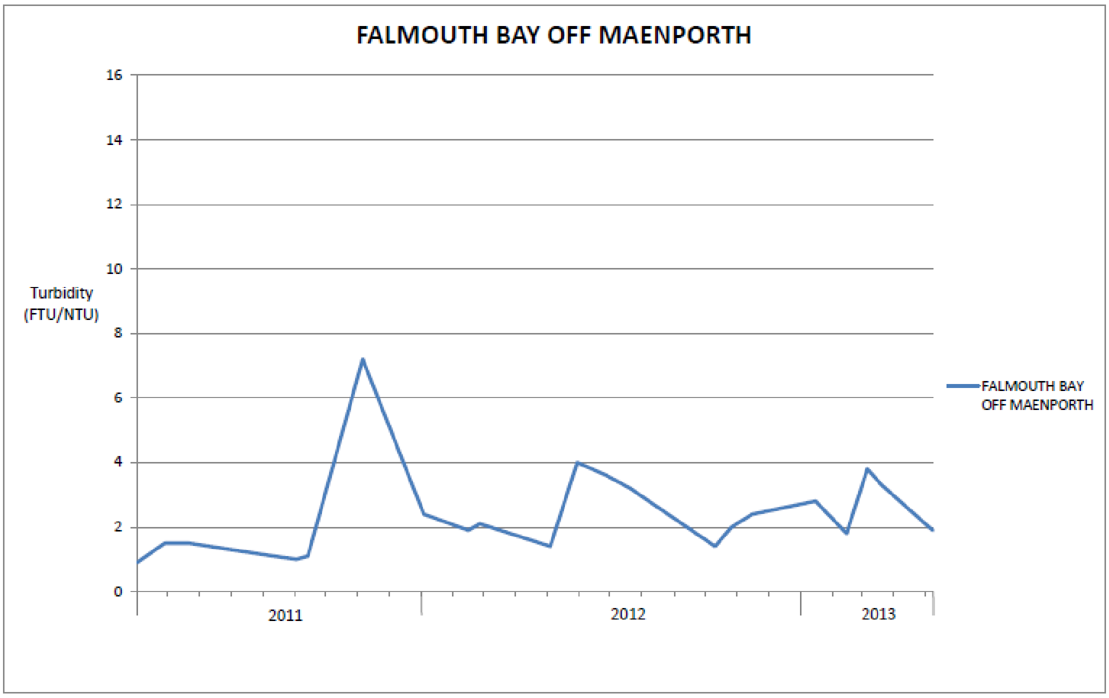



*Figure 3-5 Turbidity (FTU) data for Falmouth Bay – Maenporth*

Data from Carrick Roads – Mid Channel (further into the estuary) also show low turbidity values but show a higher variability. Sites further into the estuary (River Fal at Tolverne) show much higher values of turbidity.

*Data from Monitoring of Water Quality during Maerl Translocation Trials in Falmouth*

Water quality data was collected during dredging activity for the maerl translocation trials undertaken for the PFDI project in 2012. The results were reported (Ecospan, undated) and show profiles through the water column for areas close to the dredge and from sites situated approximately 100m from the dredge (**Appendix G** includes a copy of the report). The turbidity profiles for the sites located at a distance from the dredging activity (i.e. 'control' sites) are expected to show typical profiles through the water column for the location.

Measurements reveal that the profile through the water column for turbidity at the control sites is very linear (i.e. the turbidity values do not differ through the water column) when compared with sites affected by the dredging activity, as shown in **Figures 3-6** and **3-7**. It appears that, during normal conditions (i.e. with no activities occurring, as shown in the control sites), the water column is well mixed and that values for turbidity at the surface are similar to those at depth. The values taken for turbidity (which were converted to Suspended Solids ($mg/l^{-1}$) using a calibration curve) show very low values at all 'control' sites, indicating good water quality conditions. It is also clear that, as expected, there is a gradient of effect moving away from the dredging activity, such that the turbidity close to the seabed is higher close to the dredge. The turbidity measurements taken downstream of the dredging activity show that the turbidity returns to an ambient level between 25m and 100m from the dredge for all sites. The potential impact associated with increases in suspended sediment concentrations during dredging activity is discussed in **Section 4.4**.

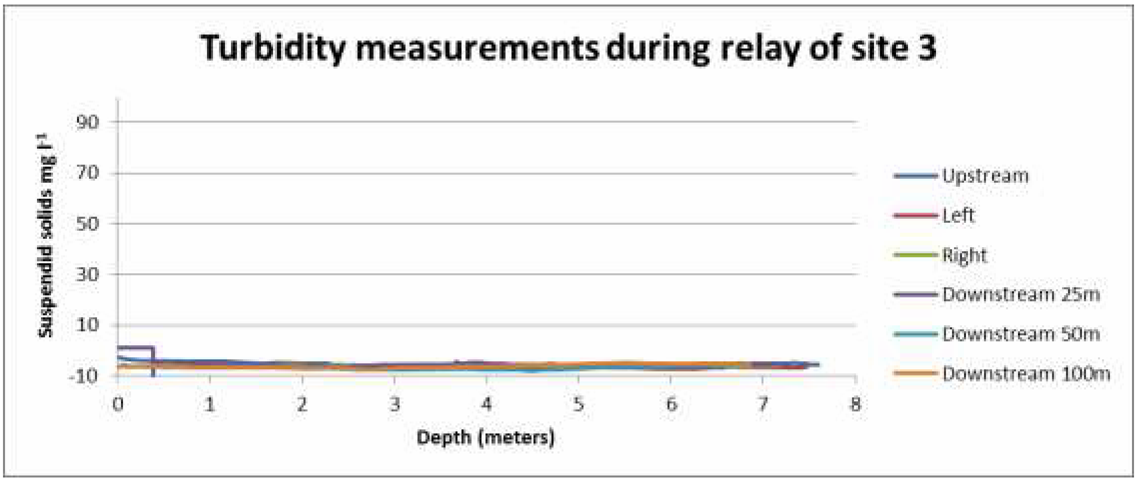



*Figure 3-6 Showing a site unaffected by dredging induced turbidity (SSC) profile*

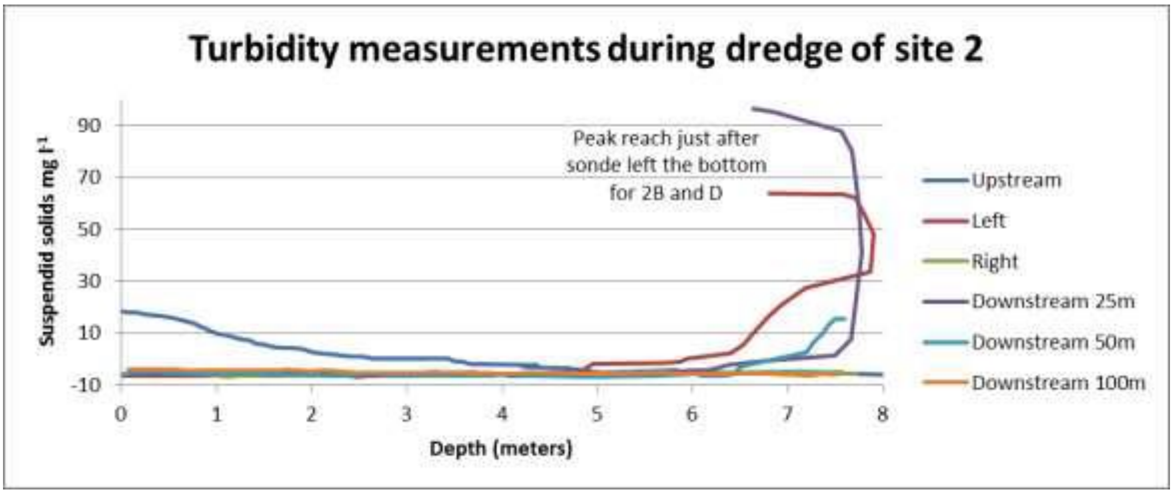



*Figure 3-7 Showing a site affected by dredging induced turbidity (SSC) profile*

### *Sediment Quality Data*

The material to be dredged comprises a variety of sediments, including fine silts in the western part of the dredged channel grading to coarser or more consolidated materials including sand, clay with maerl and maerl in the eastern part of the channel.

Water quality is regulated with regard to the Environmental Quality Standards Directive (EQSD) (2008/105/EC) which implements Article 16 of the Water Framework Directive, with the aim of achieving good surface water chemical status. The EQSD establishes the maximum acceptable concentration and / or annual average concentration for 33 priority substances and 8 other pollutants which, if met, allow the chemical status of a water body to be described as 'good'.

The presence of contaminants and, where present, contaminant concentrations within samples taken from the dredge area have been compared against Environmental Quality Standards (EQS) associated with the EQSD.

The surface sediments of the western part of the navigation channel contain elevated concentrations of TBT and metals (Cu, Hg, Pb and Zn) and, therefore, provide a source of high potential for the release of concentrations of TBT and metals into the controlled waters in the Fal Estuary and Falmouth Bay. The baseline concentrations of TBT within the Fal Estuary already exceed the EQS as quoted within the Dangerous Substances Directive. Following dredging, the concentrations of TBT would increase the level of exceedance of the EQS for this substance. By contrast, although levels of metals are high, they are not high enough to cause a breach of the respective EQS.

Within the remainder of the channel the material is suitable for sea disposal.

**Coastal Processes**

Data for the study was gleaned from a number of sources. The sources can be grouped as those linked to particular engineering studies, those from studies of maerl extraction, those reviewing the Fal and Helford in the light of their designated status and finally those collected for the present study. The data used for the various elements for the study have provided baseline for the characteristics listed below:

- Bathymetry
- Tides and water level
- Currents
- Waves
- Bed types
- Suspended sediment concentrations

The findings of the surveys and data review phases have been summarised in the Hydrodynamic and Sedimentary studies report (HR Wallingford, 2008).

In summary, the predicted effects of the completed dredge were:

- A small reduction in tidal currents local to the dredge.
- No general change to the magnitude of wave conditions. Some small increase in wave energy on the southern edge of the dredged channel and towards the west of Falmouth Inner Harbour.
- No general effect on mud transport. A small amount of accretion in the dredged area was predicted but insufficient to suggest regular maintenance dredging will be required.
- No change to sand transport fluxes in the area. A potential accretion rate of sands of 5,500m$^3$/yr was predicted, mostly on the south side of the eastern end of the dredged channel. This value is insufficient to require regular maintenance dredging but suggests monitoring of the southern side of the channel should be considered during the early stages following the completion of the dredge.

Further supplementary information is provided in **Appendix H** and is summarised below.

For the purposes of the modelling predictions all the sediment types including some fine sediment (clay and mud) were assumed as being mostly fine even in cases such as the ‘clay with frequent maerl’ which makes up 35% of the total dredge. Therefore in areas such as Carrick Roads where gravels (maerl) are more common the model predictions are likely to be significant over-predictions (HR Wallingford, 2016 (**Appendix H**)).

Two scenarios were modelled (HR Wallingford, 2008), one for the contaminated material using a 2.5m$^3$ backhoe dredger and one for uncontaminated material using a 5 m$^3$ backhoe dredger. The bucket was assumed to be open, i.e. without a visor or other means sediment release reduction. A loss rate of 17 kg/m$^3$ dredged and a dredging operation every 30-40 s, dredging continuously resulted in the release of 1 kg/s for the smaller bucket backhoe and 2 kg/s for the larger. Furthermore all the material lost from the dredging was assumed to be in the fine sediment fraction.

Sediment release was modelled at three locations to encompass the areas of proposed dredging to demonstrate the likely maximum footprint of any plume generated during the dredging. In reality the dredger will frequently relocate such that any area affected by the sediment plume will also frequently change.

The above scenarios were used to provide a worst case prediction during the modelling and therefore provide a significant over-estimate of the likely situation in reality (HR Wallingford, 2016). In addition, the sand modelling was based on the potential for sand movement assuming that sand is available in the system. Given the existing lack of maintenance dredging required, the amount of sand available for transportation in reality is likely to be much lower (further discussion of results of modelling and potential for change is provided in **Section 4.2**).

To provide a more realistic scenario for the dredging predictions, the following should be noted:

- Use of a closed bucket with a visor is considered to be likely based on the sensitivity of the site, particularly for the contaminated sediment. Measurements of a closed backhoe in the Netherlands, working in fine sediments suggested a loss rate of 11 kg/m$^3$ dredged (Waterloopkundig Laboratarium, 1990). Other literature suggests loss rates for modern closed bucket backhoes may be half those of open bucket backhoes. A reduction in the amount of sediment lost per bucket load will influence both the short term increase in suspended sediment concentration due to the dredge and the amount of material deposited both as short term temporary deposition at slack water and deposited permanently;
- The dredger working rate is unlikely to be as fast as assumed throughout the operation due to, for example, barge movements, plant maintenance, weather and other operational factors. An operation per minute is considered more likely as a long term average;
- Vibrocore data collected since the 2008 studies showed notable layering in the bed material with the surface material often being sand size material, including significant amounts of maerl with very low fine sediment content. Further down the core, layers of fine sediment are occasionally found, although these are interspersed with coarser sediments and in many of the samples mixed sediments were found. Therefore the modelled loss rate with all the losses in the fine sediment fraction is only likely to happen for a proportion of the dredge.

Based on the above assessment the likely sediment release rate is considered to be 30% - 50% of the precautionary scenario modelled during periods when fine sediment is encountered. This reduced release rate could halve the short term elevations in suspended sediment concentration, and the rate of sediment deposition as modelled. Furthermore for periods where no fine sediment is present in the dredged material (approximately 50% of the total dredged volume) negligible fine sediment release is anticipated.

It should be noted that in addition to the fine sediment release as modelled, some coarser sediments may be released during the dredge. This material will have a larger settling velocity, will fall back into the area to be dredged and will be subsequently re-dredged. No dispersion of coarser sediments is anticipated outside the proposed dredge area.

**Maerl and Maerl Bed Communities**

Maerl species can form extensive beds, mostly in coarse clean sediments of gravels and clean sands or muddy mixed sediments (OSPAR, 2010). Maerl beds have been well studied in terms of their associated species and it appears to be widely accepted that there is a distinction between the species associated with live maerl beds and areas that support dead maerl.

Live maerl beds provide an important habitat for many species which live amongst or are attached to the nodules, or which burrow in the coarse gravel or fossil maerl beneath the top layer. A dense surface layer of live maerl can provide a diverse habitat matrix with its three dimensional structure providing spaces for habitation by a wide range of invertebrates and macroalgae. Maerl beds are recorded as providing a three-dimensional habitat for benthic fauna in which food is supplied by algae and detrital debris which becomes trapped within its branches (Bosence, 1979). Pristine live maerl beds also provide valuable nursery areas for many species of fish and shellfish and are preferentially selected as a habitat for juvenile scallops over impacted dead maerl, sand and gravel (Kamenos et al. 2004 a), b) and c)). Maerl beds and dead maerl deposits also act as a long term carbon store (Burrows et al, 2014)

Dead maerl also has an ecological importance, supporting diverse communities although these have been reported to be less rich than those which live in live maerl beds (Keegan, 1974). Unimpacted, pristine maerl has a higher structural heterogeneity, and has more species and individuals, than dead maerl (Barbera et al. 2003), which resembles a gravel bottom in structure (Kamenos et al. 2003).

**Plates 1, 2** and **3** (taken from Sheehan & Attrill, 2012) show the distinct differences between the live maerl beds at St Mawes in comparison with the dead maerl beds and areas of dead maerl with live nodules in the channel.

Keegan has also noted the presence of a transitory accumulation of maerl debris within a channel subject to very strong tidal flows which render the maerl mobile. This type of habitat was considered to be formed from the erosion of material from mobile dunes of live and dead maerl and had a limited infauna. This occurrence of maerl debris including the movement of maerl from a live maerl bed forming fragmented maerl nodules on top of fossil deposits is also discussed in Foster, 2001, who developed a model for the structure and dynamics of rhodoliths and rhodolith beds (as shown below in **Figure 3.8**) showing how rhodoliths can be transported into and out of beds, sometimes forming such transitory accumulations.

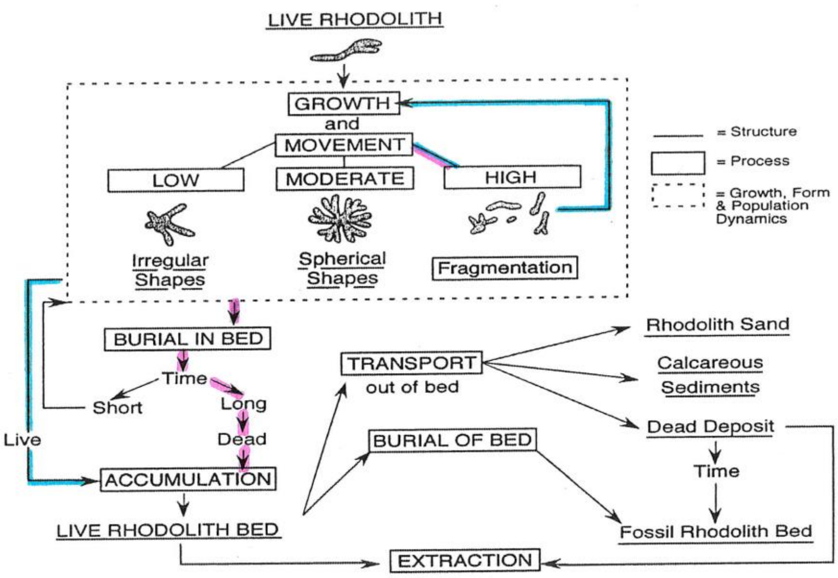



*Figure 3-8 Model developed by Foster to show movement and development of Rhodoliths*

It is accepted that dead maerl beds (sometimes referred to as fossil deposits) also provide a habitat for associated species, albeit not so diverse as a live maerl bed, such as is seen at St. Mawes Bank. The potential impact on dead maerl habitat and the proposed measures to mitigate the impact on dead maerl is discussed further within a proposed mitigation strategy whilst this note focusses on the potential for impact on the live maerl.


***Plates 1, 2 and 3 showing different status of maerl within areas of the Fal Estuary***

Due to the very slow rate of growth, maerl is considered to be a non-renewable resource and, even if the proportion of living maerl in commercially collected material is low, extraction has major effects on the wide range of species present in both live and dead maerl deposits (Hall-Spencer, 1998; Barbera et al., 2003). Although it is agreed that the loss of live maerl is a loss of a non-renewable resource, a trial dredge has shown however, that the loss of the maerl habitat (both the dead maerl and the dead maerl with live nodules) in the channel and replacement with the dredged maerl, does not have a significant effect on the taxa and abundance of species present in the particular deposits in this area following recolonisation (Sheehan et al (2014)). A change in biomass was observed but it was concluded that this was due to a disproportionately affected annelid species and was expected to recover within two years. A contributory factor to the rapid colonisation is thought to be that the habitat in this area is composed mostly of dead maerl with rarely distributed abundance of live nodules rendering the habitat closer to a coarse gravel substrate which together with the higher presence of fine material (clay) seem to reduce the species diversity when compared to a maerl bed with higher proportions of live maerl.

The trial dredge (Sheehan *et al*, 2014) investigated recolonisation potential following maerl removal and replacement within 6 trial areas located within the channel. The results showed that, of the samples taken for the baseline, there was no evidence to suggest that there were any major differences in faunal assemblages or habitat character between the purely dead maerl sites (1 to 5) and the site containing dead maerl with live maerl fragments (Site 6). The trial also showed that maerl communities recolonised the relocated maerl within the sites within 44 weeks following removal and re-lay.

From the review of the information collected during the trial and collated above, it can be concluded that the dead maerl with live fragments (found within the channel) and the dead maerl provide a similar habitat and that the presence of fragments of live maerl do not provide any unique characteristics that would enhance the ecological value of the habitat.

### 3.1.4 Baseline Activities within the SAC and pSPA

The European marine sites were designated with various commercial and recreational activities already being undertaken. There are listed recognised commercial and recreational activities within the site management report (Fal and Helford Special Area of Conservation Management Scheme), including capital and maintenance dredging. Small amounts of maintenance dredging are recorded in the Truro and Penryn Rivers, within Docks Basin and at Mylor Yacht Harbour. There is very little need for any maintenance dredging within the dredged channel, with no maintenance dredging having been necessary since the 1960s.

Capital dredging related to ‘specific projects’ is also identified as a recognised activity.

## 3.2 The Falmouth Bay to St Austell Bay pSPA

The area between Falmouth Bay and St Austell Bay has been proposed as an SPA (pSPA) under Article 4 of the Birds Directive (2009/147/EC). The pSPA includes an area from Nare Point in the west to Southground Point in the east (**Figure 3.9**), including parts of Carrick Roads and the Helford estuary. The area that is currently under consideration extends out from the mean high water mark to the 49m depth contour, including the intertidal zone.

Under Regulation 33(2) of The Conservation (Natural Habitats &c.) Regulations 1994, Natural England have a duty to advise other relevant authorities as to the conservation objectives for the European marine site.

Judgements of likely significant effect (or significant effect on integrity) need to be based upon assessment of potential effects on the features for which the pSPA is proposed for designation and taking into account their conservation objectives. The conservation objectives set out what is needed to ensure Favourable Condition of the designated feature (i.e. species). The term 'favourable condition' is used to represent the concept of Favourable Conservation Status for the interest features of a SPA. Conservation objectives are used as the basis from which management measures and monitoring programmes may be developed for the designated site. Conservation Objectives are also utilised to inform appropriate assessment under the Habitats Regulations and in this respect it is important to ensure that assessment of potential project effects is undertaken with reference to available site objectives. Conservation objectives for the Falmouth Bay to St Austell Bay pSPA were published in February 2016 and are as follows:

*With regard to the potential SPA and the individual species and/or assemblage of species for which the site may be classified (the 'Qualifying Features' listed below), and subject to natural change;*

***Ensure that the integrity of the site is maintained or restored as appropriate, and ensure that the site contributes to achieving the aims of the Wild Birds Directive, by maintaining or restoring;***

- *The extent and distribution of the habitats of the qualifying features*
- *The structure and function of the habitats of the qualifying features*
- *The supporting processes on which the habitats of the qualifying features rely;*
- *The population of each of the qualifying features, and*
- *The distribution of the qualifying features within the site.*

The qualifying features being the three diver species (i.e. black-throated diver, great northern diver, and Slavonian grebe).

### 3.2.1 Status of Designation Process

Informal consultation was held with stakeholders in 2012/2013 and the site recommendation for the pSPA was submitted for Ministerial approval in January 2014. Government approval was granted to start the formal public consultation in January 2014 which ended in April 2014. During this consultation process, all interested stakeholders and organisations were given the opportunity to provide feedback on the proposed designation.

The FHC have actively worked with Natural England throughout the consultation period and have developed a Working Agreement between the two organisations in relation to the management of port activity in the future. Key principles detailed within this agreement include the following:

- Natural England have concluded that all current port activities pose low risk effects to the bird species and therefore this low level of current risk will be reflected in any advice on conservation management measures.
- Proposed, new port activities will be subject to a collaborative and evidence- based risk assessment between Natural England and Falmouth Harbour Commissioners.
- Proposed changes to management measures from Natural England must be demonstrably necessary, based on evidence and proportionate to the risks identified from the activity.
- Both organisations will collaborate to undertake the scientific monitoring of the site in terms of the current and future port activities.

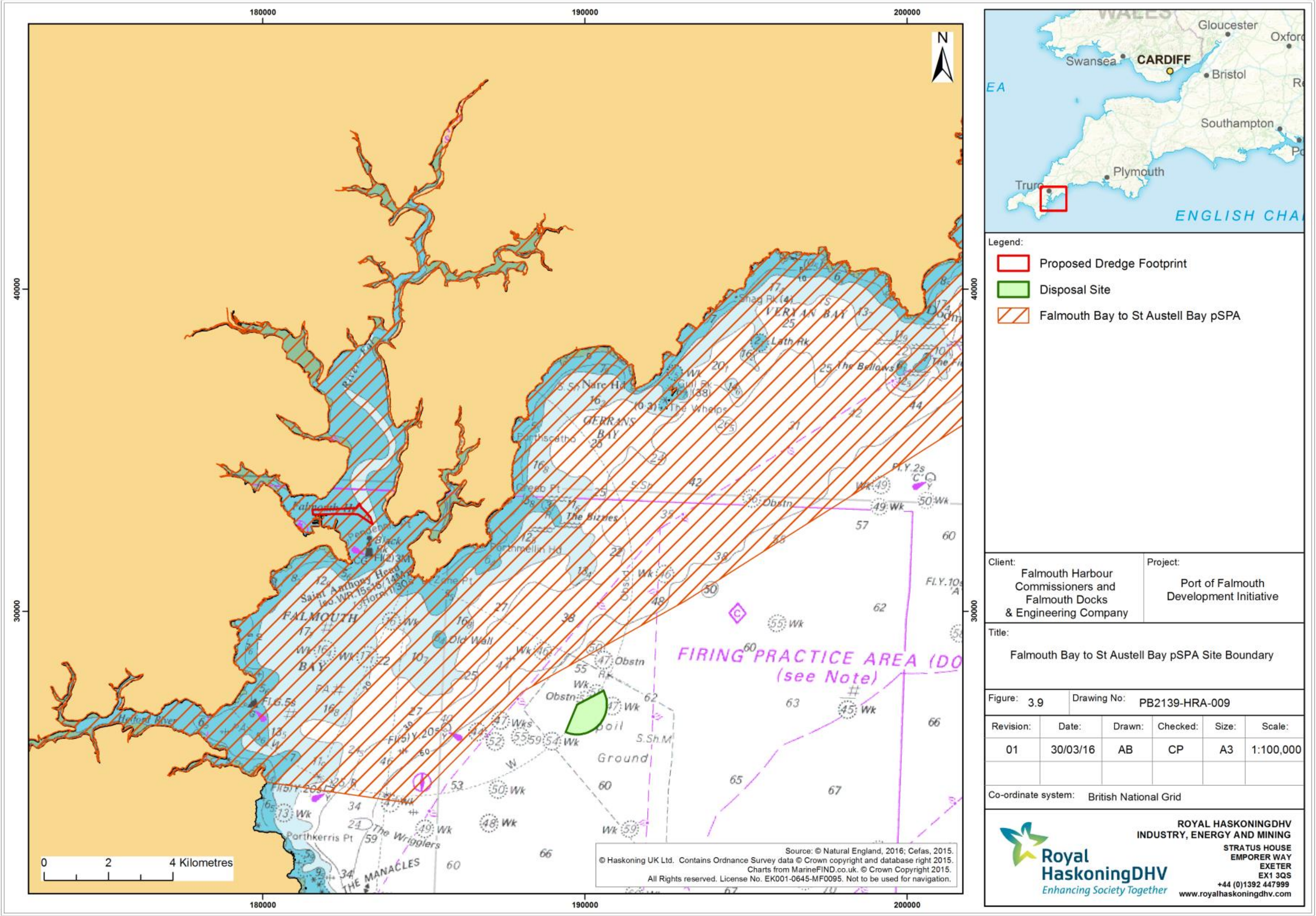



*Figure 3-9 Location of Falmouth Bay to St Austell Bay pSPA*

It is important to highlight, therefore, that the existing port activities are considered not to require any management, as they do not affect the achievement of the favourable condition status of the proposed SPA features. The potential impacts of the proposed channel dredge have been set against this baseline scenario.

### 3.2.2 Interest Features

The south Cornwall coast supports important populations of rare wintering birds, which arrive in October and spend the winter months feeding on crustaceans and small fish, before they return to their breeding ground in March.

A review of existing data on inshore water bird distribution in south west England and a series of shore based surveys along the south coast of Cornwall confirmed the significance of the pSPA as an important area for overwintering divers and grebes. It was established that the pSPA regularly supports more than 1% of the Great Britain wintering bird population estimate of three Annex I species, which have been identified as the qualifying interest features of the pSPA, these species are:

- Black throated diver, *Gavia arctica*;
- Great northern diver, *G.immer;* and
- Slavonian grebe, *Podiceps auritus*.

**Table 3.2** summarises the ornithological interest identified within Falmouth Bay to St Austell pSPA during the surveys. Presence of these birds in the numbers identified during the surveys was significant enough to trigger SPA qualification.

***Table 3.2 Summary of ornithological interest of the Falmouth Bay to St Austell Bay pSPA (Natural England, 2013)***

| Species | Peak mean count (period)[1] | UK wintering population[2] | % of GB estimate (individuals)[3] | Interest type |
|---|---|---|---|---|
| Black-throated diver *Gavia arctica* | 115 – wintering (2009/10 – 2010/11) | 560 | 20.5% | Annex I |
| Great northern diver *Gavia immer* | 74 individuals – wintering (2009/10 – 2010/11)1 | 2,600 | 3.0% | Annex I |
| Slavonian grebe *Podiceps auritus* | 15 individuals – wintering (2007/08 – 2011/12)[4] | 1,1000 | 1.4% | Annex I |

### 3.2.3 Vulnerability Assessment

The Falmouth Bay to St Austell Bay pSPA has not yet been designated; therefore data on feature condition is assessed through determining whether or not the features are currently vulnerable to damage/disturbance. This is undertaken through a vulnerability assessment (VA). A feature is vulnerable when it is exposed to a pressure (from a human activity) to which it is sensitive. The degree to which the feature is vulnerable is dependent on the degree of sensitivity and the level of exposure (Natural England, no date).

[1] *Peak mean count data from O'Brien et al., (2012b) excerpt;*
[2] *www.rspb.org.uk*
[3] *From Musgrove et al., 2011*
[4] *Wetland Bird Survey (WeBS) data from 2007/08 – 2011/12*

Royal HaskoningDHV

Natural England has undertaken a VA for the features within the Falmouth Bay to St Austell Bay pSPA which represents the current understanding of the sensitivity of the three qualifying features (black-throated diver, great northern diver and Slavonian grebe) to known activities. For the purpose of this HRA, the VA for ports and shipping has been used as a starting point to identify potential impacts; those activities identified as triggering the need for potential management actions as determined by NE are provided in **Tables 3.6**, **3.7** and **3.8**.

The sensitivity of each feature was derived from the combination of species intolerance to a pre-defined list of pressures and recoverability of features to these pressures. This was based on evidence from peer-reviewed literature or where no evidence was available, expert judgment by Natural England's ornithologists. Sensitivity was rated on a scale of 0 to 3 (see **Table 3.3**). This information was combined with evidence (including local knowledge and information obtained from local stakeholders) of current exposure to activities exerting these pressures to derive the feature's vulnerability. Exposure was rated on a scale of 0-3) see **Table 3.4**). Vulnerability was calculated by multiplying sensitivity to the activity by exposure of the feature to that activity as shown in **Table 3.5**.

If the qualifying feature was found to show high vulnerability (score ≥ 6) to a particular pressure, then the Impact Assessment describes the additional mitigation that is likely to be needed to address impacts of the associated human activity on the feature. If the qualifying feature was found to show moderate vulnerability (score 3 or 4) to a particular pressure, then some form of monitoring may be required to assess whether any impacts are occurring. If the qualifying feature was found to show low or no vulnerability (score 0 to 2) to a pressure then no additional mitigation is proposed.

***Table 3.3 Sensitivity Ratings (NE)***

| **Table A: Sensitivity Ratings** | |
|---|---|
| None | 0 |
| Low | 1 |
| Moderate | 2 |
| High | 3 |

***Table 3.4 Exposure Ratings***

| **Table B: Exposure Ratings** | |
|---|---|
| None | 0 |
| Low | 1 |
| Medium | 2 |
| High | 3 |

*Table 3.5 Vulnerability Ratings*

| Table C: Vulnerability Rating | | | | | |
|---|---|---|---|---|---|
| | | Relative sensitivity of the interest feature | | | |
| | | High (3) | Moderate (2) | Low (1) | None (0) |
| Relative exposure of the interest feature | High (3) | 9 | 6 | 3 | 0 |
| | Medium (2) | 6 | 4 | 2 | 0 |
| | Low (1) | 3 | 2 | 1 | 0 |
| | None (0) | 0 | 0 | 0 | 0 |

Full details on the methodology behind the VA, together with the full list of pressures considered for the pSPA features, are available from the NE report (http://webarchive.nationalarchives.gov.uk/20140605090108/http://www.naturalengland.org.uk/ourwork/conservation/designations/spa/falmouth-staustell-consultation.aspx). It is worth noting that those VA results highlighted in green were concluded as not requiring a management scenario; those in yellow were identified as requiring minimum monitoring; those in red were identified as requiring a management scenario to be developed.

### 3.2.4 Baseline Environmental Conditions

This section presents information on the existing environmental baseline conditions of the dredge area and the surrounding area. The information is provided so that potential impacts of the dredging works on the pSPA can be identified and assessed. Data has been collated through desk study and consultation with Natural England.

Falmouth Bay to St Austell Bay pSPA is located on the south coast of Cornwall (Figure 3-9) covering an area of approximately 295km$^2$. The seaward boundary traces the 49 m depth contour of the seabed, meaning it extends approximately between 4 and 13 km from the landward boundary into the marine environment. The entire site is approximately bounded by Nare Point in the west and Gribbin Head in the east. It covers the marine environment incorporating five shallow, sandy bays: Falmouth Bay, Gerrans Bay, Veryan Bay, Mevagissey Bay and St Austell Bay. It also includes Carrick Roads, an estuarine area which meets the sea between Falmouth and St Mawes, and part of the tidal Helford River.  The river complex areas are part of a ria system, typified by steep sides and slow tidal currents, with subtidal rocky shores and exposed intertidal mud on creeks and river branches.

#### Over Wintering Bird Species

**Black-throated diver *Gavia arctica***

The Eurasian breeding range of the black-throated diver extends eastwards from the Hebrides to northern Siberia, the bulk of the population breeds in Russia. Studies of seabird distributions off north-west Europe show that most individuals remain inshore, with concentrations around Denmark, Germany, the Netherlands and Belgium, and smaller numbers around the UK coast (Liley *et al*., 2014).

*Table 3.6 Vulnerability Assessment for Ports and Shipping – Black Throated Diver (BTD) as produced by Natural England (no date)*

| Pressure | Activity | Description of sensitivity of species to pressure | Sensitivity rating | Exposure | Exposure rating | Vulnerability rating | Management Scenarios |
|---|---|---|---|---|---|---|---|
| Non-physical damage to feature e.g. Noise, visual | Noise emanating from vessels and dredging activity displaces interest feature. Presence of vessels, port and harbour infrastructure displaces interest, anchorage vessels displace interests through visual disturbance. | BTD are shy birds that are easily displaced due to visual stimuli induced by vertical structures (vessels as well as static structures) in the offshore environment and are flushed at large distances by approaching ships/vessels. The species may suffer from effective habitat loss due to shipping traffic. | 3 | Year round anchoring of commercial vessels occurs in the Fal and Falmouth Bay not frequented by BTD. Anchoring also occurs to a lesser extent in Gerrans Bay which is frequented by BTD Port and dredging activities confined to Falmouth Docks and Fal/Helford respectively which are not frequented by BTD | 1 | 3 | Min. Monitoring Requiremen ts |
| Physical loss of habitat e.g. removal, smothering | Anchoring causes loss of benthic feeding habitat. Installation of moorings, pontoons results in loss of feeding habitat, smothering associated with dredging activity or dredge material disposal | Physical loss of feeding habitat and related reduction of available prey may reduce foraging success of BTD.<br>More time may need to be spent to satisfy energetic needs and physical condition of birds may be negatively impacted.<br><br>Small scale physical loss of habitat may be tolerable due to the species being an opportunistic feeder. Nonetheless, BTD is not flexible in habitat use due to being restricted to certain water depths and e.g. port development projects could claim considerable areas of shallow inshore waters representing potential foraging habitat. | 2 | Year round anchoring of commercial vessels occurs in the Fal and<br>Falmouth Bay not frequented by BTD. Anchoring also occurs to a lesser extent in Gerrans Bay which is frequented by BTD.<br><br>Mooring of large vessels confined to the Fal and Helford and not frequented by BTD Dredging activities occurs at numerous locations in the Fal and the Helford which are not frequented by BTD.<br><br>Dredging activities occurs at numerous locations in the Fal and the Helford which are not frequented by BTD. | 1 | 2 | No |

| Pressure | Activity | Description of sensitivity of species to pressure | Sensitivity rating | Exposure | Exposure rating | Vulnerability rating | Management Scenarios |
|---|---|---|---|---|---|---|---|
| Pollution (toxic contamination) of species, prey or habitat | Marine pollution incident associated with vessels. Marine pollution incident associated with vessel refuelling/bunkering. | The species is highly vulnerable to marine pollution, especially oil spills.<br>During the non-breeding season the species is purely marine and does not go ashore, spending the majority of time on the water surface or within the water column during foraging dives, where it is susceptible to pollution. | 3 | Year round bunkering activities occurs in the Fal Estuary and Falmouth Bay both areas are not frequented by BTD Main area of potential exposure would be Mevagissey harbour/St Austell Bay and from general spills; | 1 | 3 | Min. Monitoring Requiremen ts |
| Biological disturbance - e.g. Introduction on microbial pathogens, non-native species, selective extraction of species etc. | Introduction of non-native species through the use of vessels, ballast water and hull cleaning resulting in mortality of prey species | BTD is an opportunistic feeder that will forage on a variety of prey species. Currently there is no evidence for the spread of any non-native species introduced due to international shipping that would repress any key prey species of BTD. Nonetheless the sector incorporates a certain risk in this context. | 1 | Main areas for activities in anchoring areas and the Fal Estuary not frequented by BTD. Ballast water cleaning may occur offshore | 1 | 1 | No |
| Other direct impacts on prey | Noise emanating from vessels displaces prey species. Noise and WQ impacts from dredging displace prey species. Marine pollution incident emanating from recreational craft or refuelling berths results in prey mortality | Shipping & port related activities displacing prey species are likely to directly displace BTD too. Therefore, the indirect pathway of displaced prey species triggering impacts on BTD appears unlikely. Direct impacts on prey due to pollution events may occur and could affect food supply of BTD. | 1 | Year round anchoring of commercial vessels occurs in the Fal and Falmouth Bay. Anchoring also occurs although to a lesser extent in Gerrans Bay and Veryan Bay which are not frequented by BTD Port activities confined to the Falmouth Docks area Recreational fuelling confined to summer month | 1 | 1 | No |

| Pressure | Activity | Description of sensitivity of species to pressure | Sensitivity rating | Exposure | Exposure rating | Vulnerability rating | Management Scenarios |
|---|---|---|---|---|---|---|---|
| Other indirect impacts on prey | Impacts associated with water quality impacts associated with sector activity including contaminated sediments. Impacts to prey associated with introduction of non-native species. | Indirect, potentially long-term impacts leading to reduced recruitment of prey species e.g. due to a pollution event may be of concern and could affect food supply of BTD. Moreover, disposal of maintenance dredging materials may have indirect impacts on BTD prey species by e.g. damaging spawning areas/sediments or smothering of spawn. | 1 | Year around shipping and anchoring activities occur in the Fal Estuary and Falmouth Bay, not areas frequented by GND Dredging activities occurs at numerous locations in the Fal and the Helford with capital dredge planned in the Fal which are not areas frequented by BTD | 1 | 1 | No |

*Table 3.7 Vulnerability Assessment for Ports and Shipping - Great Northern Diver (GND) as produced by Natural England (no date)*

| Pressure | Activity | Description of sensitivity of species to pressure | Sensitivity rating | Exposure | Exposure rating | Vulnerability rating | Management Scenarios |
|---|---|---|---|---|---|---|---|
| Non-physical damage to feature e.g. Noise, visual | Noise emanating from vessels and dredging activity displaces interest feature. Presence of vessels, port and harbour infrastructure displaces interest, anchorage vessels displace interests through visual disturbance. | GND are shy birds that are easily displaced due to visual stimuli induced by vertical structures (vessels as well as static structures) in the offshore environment and are flushed at large distances by approaching ships/vessels. The species may suffer from habitat fragmentation respectively habitat loss due to shipping traffic. | 3 | Year round anchoring of commercial vessels occurs in the Fal and Falmouth Bay. Anchoring also occurs although to a lesser extent in Gerrans and Veryan bay which are key locations for GND Port activities confined to the Falmouth Docks area<br><br>Dredging activities occur at numerous locations in the Fal and the Helford with capital dredge planned in the Carrick Roads area of the Fal. | 1 | 3 | Min. Monitoring Requiremen ts |

| Pressure | Activity | Description of sensitivity of species to pressure | Sensitivity rating | Exposure | Exposure rating | Vulnerability rating | Management Scenarios |
|---|---|---|---|---|---|---|---|
| | | | | Dredging and shipping activities take place in a very localised area, and these areas are generally avoided by GND. | | | |
| Physical loss of habitat e.g. removal, smothering | Anchoring causes loss of benthic feeding habitat. Installation of moorings, pontoons results in loss of feeding habitat, smothering associated with dredging activity or dredge material disposal | Physical loss of feeding habitat and related reduction of available prey may reduce foraging success of GND. More time may need to be spent to satisfy energetic needs and physical condition of birds may be negatively impacted. Small scale physical loss of habitat may be tolerable due to the species being an opportunistic feeder. Nonetheless, GND is not very flexible in habitat use due to being restricted to certain water depths and e.g. port development projects could claim considerable areas of shallow inshore waters representing potential foraging habitat. | 2 | Year round anchoring of commercial vessels occurs in Falmouth Bay. Anchoring also occurs although to a lesser extent in Gerrans Bay and Veryan Bay which are key locations for GND Mooring of large vessels confined to the Fal and Helford, if capital dredge goes ahead then mooring installation for large ships likely to increase Dredging activities occur at numerous locations in the Fal and the Helford with capital dredge planned in the Fal | 2 | 4 | Min. Monitoring Requiremen ts |

| Pressure | Activity | Description of sensitivity of species to pressure | Sensitivity rating | Exposure | Exposure rating | Vulnerability rating | Management Scenarios |
|---|---|---|---|---|---|---|---|
| Physical damage to habitat | Anchoring causes disturbance to benthic feeding habitat. Installation of moorings results damage to the feeding habitat. Deposit made on the seabed by ports and harbour infrastructure/vessels - intentional and accidental. | Physical damage of feeding habitat and related reduction of available prey may reduce foraging success of GND. More time may need to be spent to satisfy energetic needs and physical condition of birds may be negatively impacted. | 2 | Year round anchoring of commercial vessels occurs in the Fal and Falmouth Bay. Anchoring also occurs although to a lesser extent in Gerrans Bay and Veryan Bay which are key locations for GND Mooring of large vessels confined to the Fal and Helford, if capital dredge goes ahead then mooring installation for large ships likely to increase; however this will be restricted to a very localised area (shipping channel), which is generally avoided by GND. | 2 | 4 | Min. Monitoring Requiremen ts |
| Pollution (toxic contamination) of species, prey or habitat | Marine pollution incident associated with vessels. Marine pollution incident associated with vessel refuelling/bunkering. | The species is highly vulnerable to marine pollution, especially oil spills. During the non-breeding season the species is purely marine and does not go ashore, spending the majority of time on the water surface or within the water column during foraging dives, where it is susceptible to pollution. | 3 | Year round bunkering activities occur in the Fal Estuary and Falmouth Bay, both areas are frequented by GND; but this is adequately managed through the Oil Spill Contingency Plan.<br><br>Other sources of potential oil spillage including river run-off from the numerous river tributaries above port’s jurisdiction and along the coastline; Tidal ingress from the Port of Falmouth; Storm water draining from Truro and Penryn where they run directly into the harbour; and Spill during waste oil discharge. | 1 | 3 | Min. Monitoring Requiremen ts |

| Pressure | Activity | Description of sensitivity of species to pressure | Sensitivity rating | Exposure | Exposure rating | Vulnerability rating | Management Scenarios |
|---|---|---|---|---|---|---|---|
| Biological disturbance - e.g. Introduction on microbial pathogens, non-native species, selective extraction of species etc. | Introduction of non-native species through the use of vessels, ballast water and hull cleaning resulting in mortality of prey species | GND is an opportunistic feeder that will forage on a variety of prey species. Currently there is no evidence for the spread of any non-native species introduced due to international shipping that would repress any key prey species of GND. Nonetheless the sector incorporates a certain risk in this context. | 1 | Year around shipping activities occur in the Fal Estuary and Falmouth Bay, both areas are frequented by GND | 1 | 1 | No |
| Other direct impacts on prey | Noise emanating from vessels displaces prey species. Noise and WQ impacts from dredging displace prey species. Marine pollution incident emanating from recreational craft or refuelling berths results in prey mortality | Shipping & port related activities displacing prey species are likely to directly displace GND too. Therefore, the indirect pathway of displaced prey species triggering impacts on GND appears unlikely. Direct impacts on prey due to pollution events may occur and could affect food supply of GND. | 1 | Year round anchoring of commercial vessels occurs in the Fal and Falmouth Bay. Anchoring also occurs although to a lesser extent in Gerrans Bay and Veryan Bay which are key locations for GND Port activities confined to the Falmouth Docks area Recreational fuelling confined to summer months | 1 | 1 | No |
| Other indirect impacts on prey | Impacts associated with water quality impacts associated with sector activity including contaminated sediments. Impacts to prey associated with introduction of non-native species. | Indirect, potentially long-term impacts leading to reduced recruitment of prey species e.g. due to a pollution event may be of concern and could affect food supply of GND. Moreover, disposal of maintenance dredging materials may have indirect impacts on GND prey species by e.g. damaging spawning areas/sediments or smothering of spawn. | 1 | Year around shipping and anchoring activities occur in the Fal Estuary and Falmouth Bay , both areas are frequented by GND Dredging activities occurs at numerous locations in the Fal and the Helford with capital dredge planned in the Fal | 2 | 2 | No |

*Table 3.8 Vulnerability Assessment for Slavonian grebe as produced by Natural England (no date)*

| Pressure | Activity | Description of sensitivity of species to pressure | Sensitivity rating | Exposure | Exposure rating | Vulnerability rating | Management Scenarios |
|---|---|---|---|---|---|---|---|
| Non-physical damage to feature e.g. Noise, visual | Noise emanating from vessels and dredging activity displaces interest feature. Presence of vessels, port and harbour infrastructure displaces interest, anchorage vessels displace interests through visual disturbance. | Slavonian grebe is sensitive to shipping traffic and reported to be flushed by approaching vessels. The species may suffer from habitat fragmentation respectively habitat loss due to shipping traffic. | 2 | Year round anchoring of commercial vessels occurs in Falmouth Bay. Anchoring also occurs, although to a lesser extent, in Gerrans Bay and Veryan Bay which are key locations for SG Port activities confined to the Falmouth Docks area Carrick Roads is relatively rarely used and there is unlikely to be interaction between this proposed SPA feature and activities associated with the dredge. | 1 | 2 | No |
| Physical loss of habitat e.g. removal, smothering | Anchoring causes loss of benthic feeding habitat. Installation of moorings, pontoons results in loss of feeding habitat, smothering associated with dredging activity or dredge material disposal | Physical loss of feeding habitat and related reduction of available prey may reduce foraging success of Slavonian grebe. More time may need to be spent to satisfy energetic needs and physical condition of birds may be negatively impacted. Small scale physical loss of habitat (see column C) may be tolerable due to the species feeding on a variety of small prey species. Nonetheless, Slavonian grebe is not very flexible in habitat use due to being restricted to certain water depths and e.g. port development projects could claim considerable areas of shallow inshore waters representing potential foraging | 2 | Year round anchoring of commercial vessels occurs in the Fal and Falmouth Bay. Anchoring also occurs although to a lesser extent in Gerrans Bay and Veryan Bay which are key locations for SG<br><br>Mooring of large vessels confined to the Fal and Helford.<br><br>Carrick Roads is relatively rarely used (unless there are strong easterly winds) and there is unlikely to be interaction between this proposed SPA feature and activities associated with the dredge | 2 | 4 | Min. Monitoring Requiremen ts |

| Pressure | Activity | Description of sensitivity of species to pressure | Sensitivity rating | Exposure | Exposure rating | Vulnerability rating | Management Scenarios |
|---|---|---|---|---|---|---|---|
| | | habitat. | | | | | |
| Physical damage to habitat | Anchoring causes disturbance to benthic feeding habitat. Installation of moorings results damage to the feeding habitat.<br><br>Deposit of made on the bed by ports and harbour infrastructure/vessels - intentional and accidental. | Physical damage of feeding habitat and related reduction of available prey may reduce foraging success of Slavonian grebe. More time may need to be spent to satisfy energetic needs and physical condition of birds may be negatively impacted. | 2 | Year round anchoring of commercial vessels occurs in the Fal and Falmouth Bay. Anchoring also occurs, although to a lesser extent, in Gerrans Bay and Veryan Bay which are key locations for SG Exposure for SG (2) considered to be reduced when compared with GND (3) as SG distribution does not include inside the Helford. Therefore, exposure to anchoring (disturbance to benthic feeding habitat) and installation of moorings (damaging feeding habitat) is slightly lessened. Mooring of large vessels confined to the Fal and Helford. | 2 | 4 | Min. Monitoring Requiremen ts |
| Pollution (toxic contamination) of species, prey or habitat | Marine pollution incident associated with vessels. Marine pollution incident associated with vessel refuelling/bunkering | The species is highly vulnerable to marine pollution, especially oil pills. A large portion of the population will spend the non-breeding season in the marine environment, where the majority of time is spend on the water surface or within the water column during foraging dives, where it is susceptible to pollution. | 3 | Year round bunkering activities occurs in the Fal Estuary and Falmouth Bay, both areas are frequented by SG; but this is adequately managed through the Oil Spill Contingency Plan.<br><br>Other sources of potential oil spillage including river run-off from the numerous river tributaries above port's jurisdiction and along the coastline; Tidal ingress from the Port of Falmouth; Storm water draining from Truro and Penryn | 1 | 3 | Min. Monitoring Requiremen ts |

| Pressure | Activity | Description of sensitivity of species to pressure | Sensitivity rating | Exposure | Exposure rating | Vulnerability rating | Management Scenarios |
|---|---|---|---|---|---|---|---|
| | | | | where they run directly into the harbour; and Spill during waste oil discharge | | | |
| Biological disturbance - e.g. Introduction on microbial pathogens, non-native species, selective extraction of species etc. | Introduction of non-native species through the use of vessels, ballast water and hull cleaning resulting in mortality of prey species | Slavonian grebe will forage on a variety of prey species. Currently there is no evidence for the spread of any non-native species that would repress any key prey species. Nonetheless, selective extraction of prey species may affect Slavonian grebe. Nonetheless the sector incorporates a certain risk in this context. | 1 | Year around shipping activities occur in the Fal Estuary and Falmouth Bay, both areas are frequented by SG | 1 | 1 | No |
| Other direct impacts on prey. | Noise emanating from vessels displaces prey species. Noise and WQ impacts from dredging displace prey species. Marine pollution incident emanating from recreational craft or refuelling berths results in prey mortality | Shipping & port related activities displacing prey species are likely to directly displace Slavonian grebe too. Therefore, the indirect pathway of displaced prey species triggering impacts on Slavonian grebe appears unlikely. Direct impacts on prey due to pollution events may occur and could affect food supply of Slavonian grebe. | 1 | Year round anchoring of commercial vessels occurs in the Fal and Falmouth Bay. Anchoring also occurs although to a lesser extent in Gerrans Bay and Veryan Bay which are key locations for SG Port activities confined to the Falmouth Docks area Recreational fuelling confined to summer months | 1 | 1 | No |

| Pressure | Activity | Description of sensitivity of species to pressure | Sensitivity rating | Exposure | Exposure rating | Vulnerability rating | Management Scenarios |
|---|---|---|---|---|---|---|---|
| Other indirect impacts on prey | Impacts associated with water quality impacts associated with sector activity including contaminated sediments. Impacts to prey associated with introduction of non-native species. | Indirect, potentially long-term impacts leading to reduced recruitment of prey species e.g. due to a pollution event may be of concern and could affect food supply of Slavonian grebe. Moreover, disposal of maintenance dredging materials may have indirect impacts on Slavonian grebe prey species by e.g. damaging spawning areas/sediments or smothering of spawn. | 1 | Year around shipping and anchoring activities occur in the Fal Estuary and Falmouth Bay, both areas are frequented by SG Dredging activities occurs at numerous locations in the Fal and the Helford with capital dredge planned in the Fal, both areas are frequented by SG | 2 | 2 | No |

The wintering population of black-throated divers in Great Britain is estimated to be 560 individuals (Musgrove *et al*., 2011). Within the UK, Cornwall and North West Scotland contain the bulk of the known distribution of the species, with a small concentration also in Orkney (Brown and Grice 2004; Holt *et al*., 2012). In winter, the UK as a whole contains a small fraction of the estimated European breeding population, approximately 153,000 – 276,000 individuals (Delaney and Scott 2006), with most of the population wintering in the eastern North Sea, Baltic Sea, Black Sea, Caspian Sea and Adriatic Sea (BirdLife International, 2004).

The pSPA is the most important wintering site in the UK for this species (O"Brien *et al*., 2012). The two year peak mean (2009/10 – 2010/11) of 115 individuals (**Table 3.14**) represents almost twice as many as Wester Ross, which is the site with the next highest estimates (peak mean of 65). The site has regularly supported such important aggregations, with peaks of 135 in 1994/95 (Slade, 1996) and 160 in 1999/00 (Geary and Lock, 2001) from exactly the same geographical survey area.

### Great northern diver *Gavia immer*

Great northern divers breed almost exclusively in the Nearctic, from the Aleutians across Canada, Northern America and Greenland.

The breeding population of great northern divers in Europe is dwarfed by the separate population of North America, with 700 – 2,300 pairs in Greenland and Iceland comparing to at least 607,000 pairs in the USA and Canada (BirdLife International, 2004; Delaney and Scott 2006). In the winter, an estimated 5,400 individuals are found around European coasts; of these, 46% – 56% (2,500 – 3,000) are within the UK, with a further 26% (1,400) in the Republic of Ireland (BirdLife International, 2004).

The pSPA is at the southern extremity of the species range within the UK, with the bulk of the wintering population in Scotland (Musgrove *et al.,* 2011). Data from systematic shore-based counts, with a two year peak mean (2009/10 – 2010/11) of 74 individuals (**Table 3.9**) represents almost 3% of the wintering population (2,500) (Musgrove *et al*., 2011) in Great Britain. This value is similar to peak estimates from previous surveys: 84 in 1994/95 (Slade 1996); 109 in 1999/00 (Geary & Lock, 2001).

***Table 3.9 Sum of total of divers recorded in 35 count sectors within the South Cornwall Area of Search (AoS) 2009/10 – 2010/11 (the mean of peaks (MoP) is the mean of the highest counts (bold) from each winter)***

| JNCC shore based counts | Winter 2009/10 | | Winter 2010/11 | | MoP |
|---|---|---|---|---|---|
| | Dec 2009 | Feb 2010 | Dec 2010 | Feb 2011 | |
| Great northern diver | 45 | **72** | 27 | **75** | 74 |
| Black-throated diver | 16 | **127** | 53 | **102** | 115 |

It has been noted that Great northern divers can lose their flight feathers during the wintering season and potentially become flightless for some of the period. There is therefore some risk that they become less mobile and potentially more vulnerable for some of the winter (Byrkjedal, 2011).

### Slavonian grebe *Podiceps auritus*

There is a small breeding population of Slavonian grebes in the UK, currently estimated at 30 (Musgrove *et al*., 2013), all of which are in Scotland. This is a small proportion of the 4,600-6,800 individuals estimated to breed in coastal north-west Europe (Delaney and Scott, 2006). However, in winter, numbers in inshore areas of the UK increase; Musgrove *et al*., (2011) estimates 1,100 individuals in Britain, compared with a wider north west Europe wintering population of between 3,000 and 4,100 (BirdLife International, 2004; Brown and Grice, 2005). ). Outside Scotland, Gerrans Bay is the most important area for Slavonian grebe (Holt *et al* 2011).

Initial outputs of the latest SPA review indicate that the Great Britain non-breeding SPA suite for Slavonian grebe is currently 'insufficient'.

This necessitates addition to the network of the best remaining unclassified sites for the species, of which Falmouth Bay to St Austell Bay qualifies. Because of this requirement, the SPA and Ramsar (Avian) Scientific Working Group (SPAR SWG) considered it appropriate to relax the generally applied ‘minimum 50’ rule; this rule, which applies a minimum threshold of 50 where 1% of the relevant threshold is below this value, is designed to avoid classifying sites for small numbers of species which may be better protected at other sites. Data from the WeBS counts 2007/08 – 2011/12, and the five year peak mean value of 15 is sufficient to meet the Stage 1.1 SPA selection guideline (>1% of the GB estimated population; Stroud *et al*., 2001). The five year peak mean of 15 (**Table 3.10**) represents 1.4% of the wintering population currently estimated at 1,100 (Musgrove *et al*., 2011). Apparent declines over time in Slavonian grebe abundance at the pSPA may indicate declines in breeding birds in Finland and Sweden (BirdLife International 2004). Geary and Lock (2001) reported a peak of 57 Slavonian grebes for the same geographic area, whereas Slade (1996) recorded a peak of 36.

***Table 3.10 Peak counts of Slavonian grebes in relevant WeBS count sectors 2007/08 – 2011/12. No count in 2010/11***

| | 2007/08 | 2008/09 | 2009/10 | 2010/11 | 2011/12 | Mean of Peaks |
|---|---|---|---|---|---|---|
| Carrick Roads | 2 | 2 | 1 | No data | 0 | 1.25 |
| Gerrans Bay | 4 | 13 | 20 | No data | 18 | 13.75 |
| **Site sum** | **6** | **15** | **21** | | **18** | **15** |

## Recent Research

To inform the designation process for the pSPA, the JNCC commissioned three aerial surveys were carried out in the South Cornwall Coast Area of Search (AoS, as defined by JNCC), in January 2007, March 2007 and February 2009. Additionally, four systematic shore-based counts of the AoS were conducted in 2009-2011. Distance sampling methods and the mean of peak counts (MoP, the mean of the highest counts from each winter) were used to estimate the numbers of each waterbird species within the AoS.

There are three WeBS count areas within the South Cornwall AoS: the Fal Complex, Gerrans Bay and the Helford Estuary (http://blx1.bto.org/websonline). The Helford Estuary supported only very low numbers of divers (one or two records each winter) and out of five species of grebes only little grebes occurred more regularly but also in very low numbers (MoP = 4). The Fal Complex comprises seven individual count areas but only two areas regularly supported divers and grebes: Carrick Roads and the Percuil River. Gerrans Bay supported the greatest number of divers with black-throated and great northern divers present in higher numbers than other count areas. In comparison with black-throated divers, great northern divers appear to be under recorded by WeBS counts, probably due to most of them occurring outside the WeBS counts areas.

In shore based bird surveys, Black-throated divers were most frequently recorded in the central part of the South Cornwall AoS, in Veryan Bay, with lower numbers in Gerrans Bay and St Austell Bay, in the east of the AoS. None were recorded in the west of the AoS, in Falmouth Bay, on any of the four surveys. Black-throated divers were seen to move between bays, depending on state of tide and wind direction. Great northern divers were recorded throughout the AoS, from almost every count point. Generally, they tended to be recorded less frequently and in lower numbers in the west of the AoS, in Falmouth Bay, and more commonly in the central part and east of the AoS, in Gerrans Bay, Veryan Bay, Mevagissey Bay and St Austell Bay. Slavonian grebes were recorded regularly in Gerrans Bay, and at times in most other areas of the AoS always in small numbers. **Figures 3.10** and **3.11** (taken from O'Brien *et al*.,2014) illustrate the distribution of the highest counts of both diver species across the South Cornwall AoS to provide an example of distribution recordings through this survey. The results from the Slavonian grebe counts are not reproduced here as the maximum number recorded did not exceed two individuals in any of the shore-based counts conducted on behalf of JNCC.

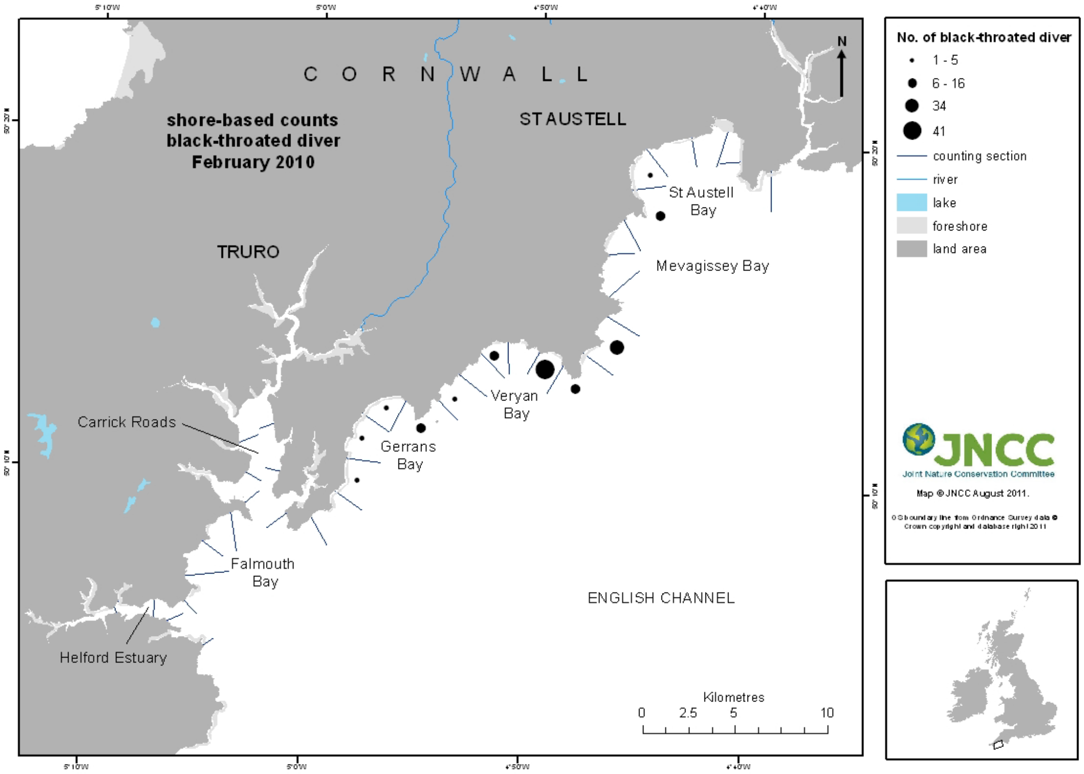



*Figure 3-10 Distribution of black-throated divers in February 2010 during shore-based counts (O'Brien et al, 2014)*

Footprint Ecology have also carried out some recent research (published in 2015) which provides information on the distribution, abundance and ecology of the three bird species in the pSPA. This involved bird surveys over the winter of 2014 (mid-January to mid-March) and the results of these were then analysed alongside physical parameters such as water depth and tidal state. Vantage point counts were undertaken in two day windows, with all survey points (12 in total) being visited in each survey window. The survey area was focussed in locations already identified as important for target bird species and is characterised as being sheltered from prevailing weather systems (south-westerlies) by the Lizard, with a series of bays with a particular aspect and cliffs that provide shelter. The water is relatively clear and free of silt (many of the bays lack a strong freshwater input) and some of the bays are relatively undisturbed.

The survey windows were spread between mid-January and mid-March, and selected to coincide with better weather conditions. While it is possible that birds may have been double counted (for example moving between points as the surveyor moved), the total number of individuals counted across all survey points in a two-day window gives a rough indication of the total number of birds using the area. **Figure 3-12** illustrates the locations of the vantage points in relation to the proposed dredge footprint.

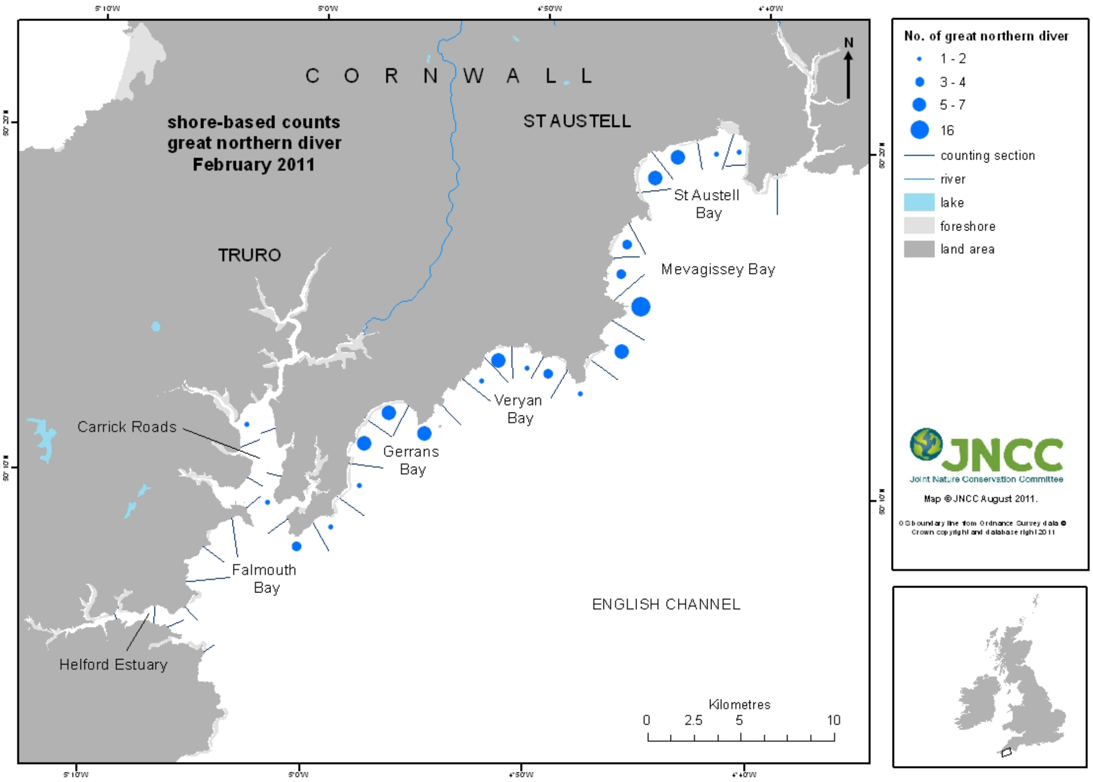



*Figure 3-11 Distribution of great northern divers in February 2011 during shore-based counts (O'Brien et al, 2014)*

*Numbers of Birds Observed*

The results indicate that the area holds high numbers of wintering Black-throated and Great Northern Divers. Over the course of the survey there were 252 sightings of Black-throated Divers (535 individuals) were observed, 263 sightings of Great Northern Divers (332 individuals) and 24 sightings of Slavonian Grebe (27 individuals). Records were to some extent concentrated in Falmouth Bay (off Mawnan Smith and Pendennis Point), at Gerrans Bay (observed from Portscatho car park) and Veryan Bay (located at the northern end of the pSPA), with these locations holding significantly higher numbers of Divers than other locations. The highest numbers of both types of Diver were observed from Pendennis Point (53 Great Northern Divers and 135 Black-throated Divers); observations from Pendower Beach also yielded high sightings of Great Northern Divers (54 individuals). The lowest numbers meanwhile were observed at West Bay (Great Northern Diver) and Gorran Haven (Black-throated Diver). Slavonian Grebe sightings were clustered around Portscatho car park and Pendower Beach with 6 individuals observed from each point. **Figure 3.12** illustrates the position of these locations in relation to the proposed dredge footprint and the offshore disposal site.

Black-throated Divers and Slavonian Grebes were observed in higher numbers in late January (82 individual Black-throated Divers and 10 Slavonian Grebes peak) and in lower numbers in March (17 Black-throated Divers, 0 Slavonian Grebes). Great Northern Divers however were observed in highest numbers in early March while the lowest count was in late January.

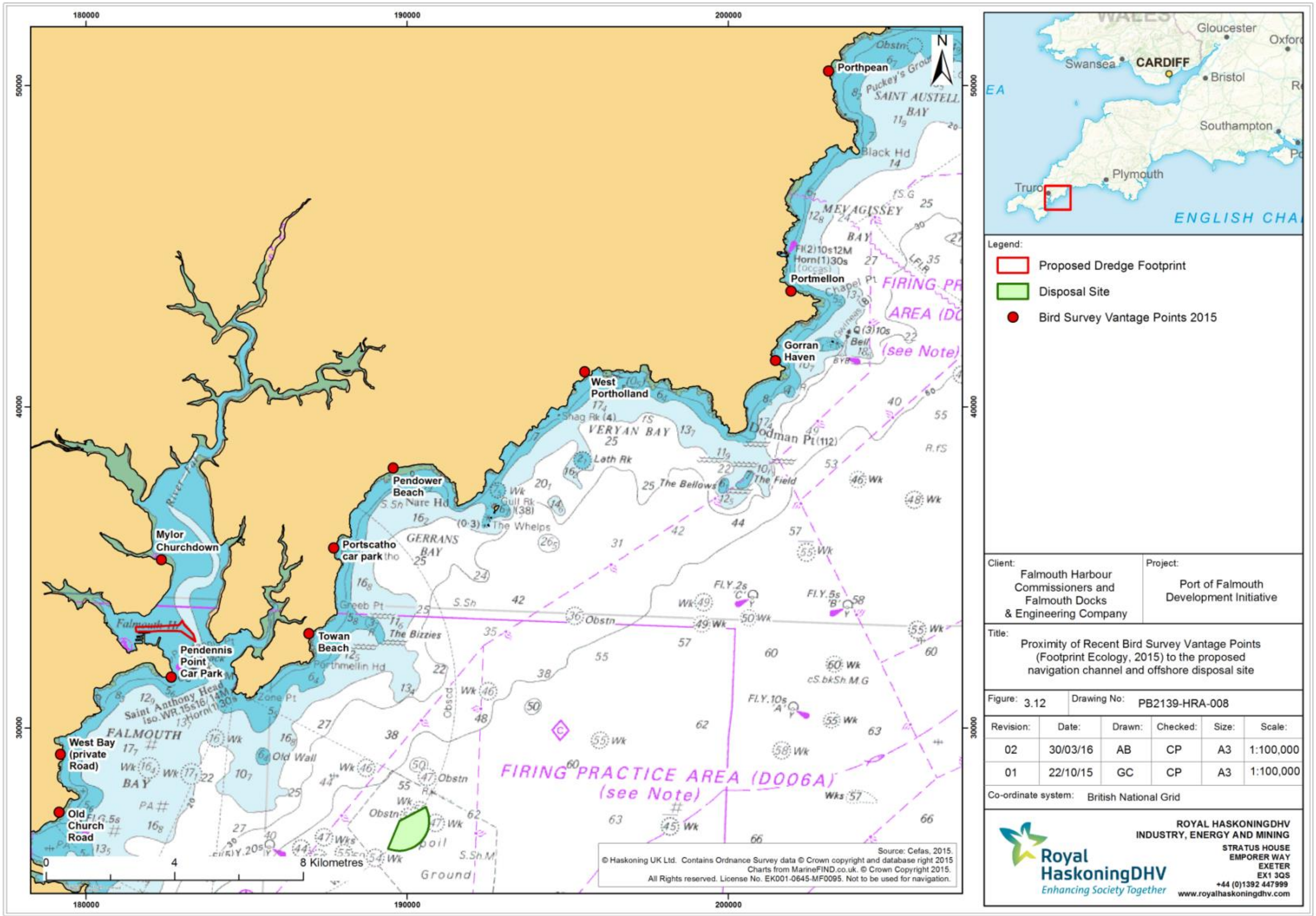



***Figure 3-12 Vantage points for pSPA bird observations (Liley* et al.*, 2014)***

Black-throated Divers appeared to flock more with 38% of those sighted appearing in groups of 5 or more (with nine sightings involved groups of 10 individuals or more) though there was no clear pattern in the behaviour of larger flocks and no suggestion that the larger flocks were linked to particular tidal states. By contrast 41% of observed Great Northern Divers appeared as lone individuals and only 2% were seen in groups of 5 individuals or more.

Flocks appeared to be erratic in both time and space; the overall counts of Black-throated Divers however were reasonably consistent across the 12 counts suggesting that birds are moving in response to prey abundance and coming together to exploit marked aggregations of prey. The flocking behaviour of Black-throated Divers may have conservation implications, as a high proportion of the wintering population could be affected by a single isolated incident.

*Behaviours Observed*

Over the course of the study the majority of Black-throated Diver sightings (58%) involved birds diving repeatedly; around one quarter of the sightings (26%) were of birds loafing/asleep and a further 35 sightings (14%) were birds preening. No statistically significant pattern could be identified between the behaviours observed and the distance offshore or the tidal state. The vantage points with the highest numbers of Black-throated Divers however are all in bays with a southerly aspect.

For Great Northern Divers, two thirds of the sightings (67%) involved birds diving repeatedly; 22% involved birds loafing/inactive and a further 9% were preening. Although the Great Northern Divers that were loafing/inactive tended to be slightly further from the vantage points than those recorded undertaking other behaviours these differences were not found to be statistically significant.

No specific roosts were identified for either species of Diver over the course of the survey with birds appearing to roost close to where they were feeding and not in large rafts or in consistent locations. This is in contrast to the Isle of Mull, where Shackleton's (2012) descriptions and photographs show Great Northern Divers swimming purposefully towards regular roost sites, which appear to be relatively constant locations where birds coalesce into rafts. It is possible that sheltered bays and sea lochs are more attractive and important roost sites in northern locations and that in an open coast environment like the Falmouth-St Austell area, set roost sites are less important to birds.

*Observations of Diet*

Ten observations of Great Northern Divers with prey were made during the Footprint Ecology survey; seven of these involved crabs and the other three were flat fish. When diving the birds seemed to be resurfacing more or less close to where they dived. This suggests that these Divers are regularly feeding on the bottom, potentially supported by the results showing Great Northern Divers occurring in shallower water, closer inshore. Modelling to investigate the relevance of habitat parameters (e.g. water depth and tidal state) indicated that distribution was more closely linked to maximum water depth and it perhaps make sense that the birds would select areas where they can get to the bottom to feed. Specifically the modelling results indicated that Great Northern Diver sightings tended to be in water below 20m depth and especially in areas where the water depth is below 10m, and in areas surrounded by more shoreline, suggested water depth and shelter are important variables for this species.

There was only one observation of a Black-throated Diver with any prey, a possible flat fish. Black-throated Divers appeared to be actively pursuing prey, often in flocks; some observation of them feeding actively with large groups of shags in shallow water of bays suggests fish being trapped. The lack of observations of birds with fish at the surface would suggest that prey are potentially eaten underwater or as the bird surfaces. Black-throated Divers also appeared a long way from where they dived down suggesting that they were travelling considerable distances underwater; one bird was estimated to have resurfaced 200m from the point where it dived. It can be inferred from this that Black-throated Divers are pursuit fishing and capturing small fish that are consumed while underwater or as the bird surfaces. Modelling indicated that minimum water depth was a strong indicator of distribution which could be linked to the inferred feeding preferences.

### 3.2.5 Supporting Habitats and Prey Species

The differences in feeding ecology between the two species of Divers suggest the seabed habitats may be important for Great Northern Divers, and for Black-throated Divers, stocks and shoaling behaviour of small fish will be important (Liley *et al*, 2014). The winter diet of Great Northern Divers is known to consist largely of small fish and benthic dwelling crustaceans and molluscs. They catch their prey by diving underwater to depths of 60 m (200ft) and they seize or sometimes spear fish with their strong bill (O'Brien *et al*., 2014).

The feeding ecology of the Slavonian Grebe differs from the Divers in that they require a sufficiently large extent of shallow coastal water for feeding and roosting. They are streamlined with feet set far back on the body, enabling them to pursuit dive from the sea surface using feet for propulsion. They can dabble for food items and can dive for prey in marine waters up to 20 m depth.

Slavonian Grebes winter mainly in sheltered inlets, bays and estuaries, feeding on small fish, especially sculpins and custaceans (mysids, amphopods and decapods), insects and molluscs (Liley *et al*., 2015). Seagrass beds provide an important nursery area for these prey species.

Slavonian Grebes primarily catch fish, insects (such as mayflies or damselflies) crustaceans, molluscs and marine worms, with fish and crustaceans being more important components of the diet during winter when the species is at sea.

#### Fish and Shellfish Resource in Falmouth Bay

Falmouth Bay (including the area of the dredged material disposal site) supports a number of fish species, including some of commercial importance. Local vessels are known to target shellfish, sole and monkfish as well as a variety of mixed demersal species in the area. Beam trawl surveys carried out by Cefas in 2007 as part of the Fisheries Science Partnership Western Channel Sole and Plaice survey included a station in the vicinity of Falmouth Bay. Out of ten selected retained species and in order of abundance, records show catches of red gurnard *Aspitrigla cuculus*, sole, plaice, monkfish *Lophius piscatorius* and hake *Merluccius merluccius* (more detail is available in **Section 11** of the 2009 ES).

Juvenile fish are an important food source for the pSPA species and much of the waters surrounding the area of the proposed PFDI are a designated bass nursery area. This designation prohibits the fishing for bass from a boat between 30th April and 1st January or fishing with live sandeel. As well as being a designated bass nursery area, it is likely that the estuary is a good nursery ground for a number of other fish species such as flounder, mackerel and whiting, gilthead bream and grey mullet (more details in the 2009 ES). The Western Approaches is particularly important as a nursery area for mackerel, and the 'Mackerel Box' was introduced in 1986 in order to reduce pressure on the juvenile stock. Falmouth Bay falls within this area which is also used as a nursery ground by whiting. Spawning maps also indicate that sprat also use the area for as a spawning ground.

The Fal Estuary also supports a wide range of shellfish which are equally important as prey sources for wintering Great Northern Divers and Slavonian Grebes. Prawn *Palaemon serratus*, green crab *Carcinus maenas,* edible crab *Cancer pagurus* and crawfish *Palinurus elephas* are all notable examples known to be prevalent and support the potting industry in this area.

#### Marine Habitats and Benthic Infauna

The key habitats around the PFDI area are described in **Section 3** and **4** and in more detail in **Section 8** of the 2009 ES. As well as being recognised as valuable habitats through the SAC designation, these habitats are also important in supporting the pSPA species. There are particularly rich sublittoral sand invertebrate communities with eelgrass (*Zostera marina)* beds near the mouth of both the Fal and Helford and in some channels of the rias, such as the Percuil River and Passage Cove. The SAC also supports examples of sheltered intertidal mudflats and sandflats representative of south-west England that support rich and diverse invertebrate communities including amphipods, polychaete worms, the sea cucumber *Leptopentacta elongata* and bivalve molluscs. These sediment and seagrass communities provide important foraging opportunities for the overwintering birds of the pSPA, in particular the Slavonian Grebe. The nearest seagrass bed to the proposed navigation channel is approximately 1km away to the South of Penarrow Point.

### 3.2.6 Baseline conditions potentially affecting bird numbers

#### Vessel Activity

As described in **Section 2**, Falmouth Docks is a busy harbour with numerous vessel movements all day throughout the year. Operating 24 hours a day, the docks have remained busy over recent years as **Figure 2.5** highlights. Information has been provided by FHC on commercial shipping movements. Associated with commercial shipping movements are the pilot boats and bunkering vessels which service the commercial ships; these movements have also been included in the data illustrated on **Figure 2.5** (see **Section 2**). The increase in numbers between 2009 and 2012 is linked to the European Emission Control area of the English Channel and the North Sea that was established at the longitudinal line of 5 degrees west, making Falmouth a prime location for the supply of low sulphur fuels to shipping entering the English Channel. Commercial shipping levels have now returned to normal levels.

Focussing on the most recent three years the data suggests that commercial vessel movements are at their highest in the summer and autumn months perhaps reflecting an increase in visiting cruise traffic. As detailed in **Section 2**, Falmouth Harbour is also a hub for recreational boating activity and this is particularly focussed in the summer months with sailing regattas and other events such as Falmouth Week in August. Although numbers are lower for the winter months Falmouth remains a busy port with an average 380 vessel movements a month in 2014.

It is important to recognise that these figures do not capture all vessel movements in and around the harbour; only those which generate revenue for FHC. It is likely therefore that these figures are underestimating the true situation; further contributions to vessel traffic are detailed below.

### Marine Contractors/ Service Operators

A number of marine contractors use Falmouth or Penryn harbours as the base for operations. These businesses operate a number of working vessels ranging from crane barges to small work boats and carry out work in and around the harbour as well as further afield. Organisations include Seawide Services, KLM, Sub Marine Services (SMS) and Marine & Towage Services (MTS). FHC also operate a workboat year round to conduct maintenance and deploy buoys as necessary. A small enforcement vessel is also used to patrol the harbour.

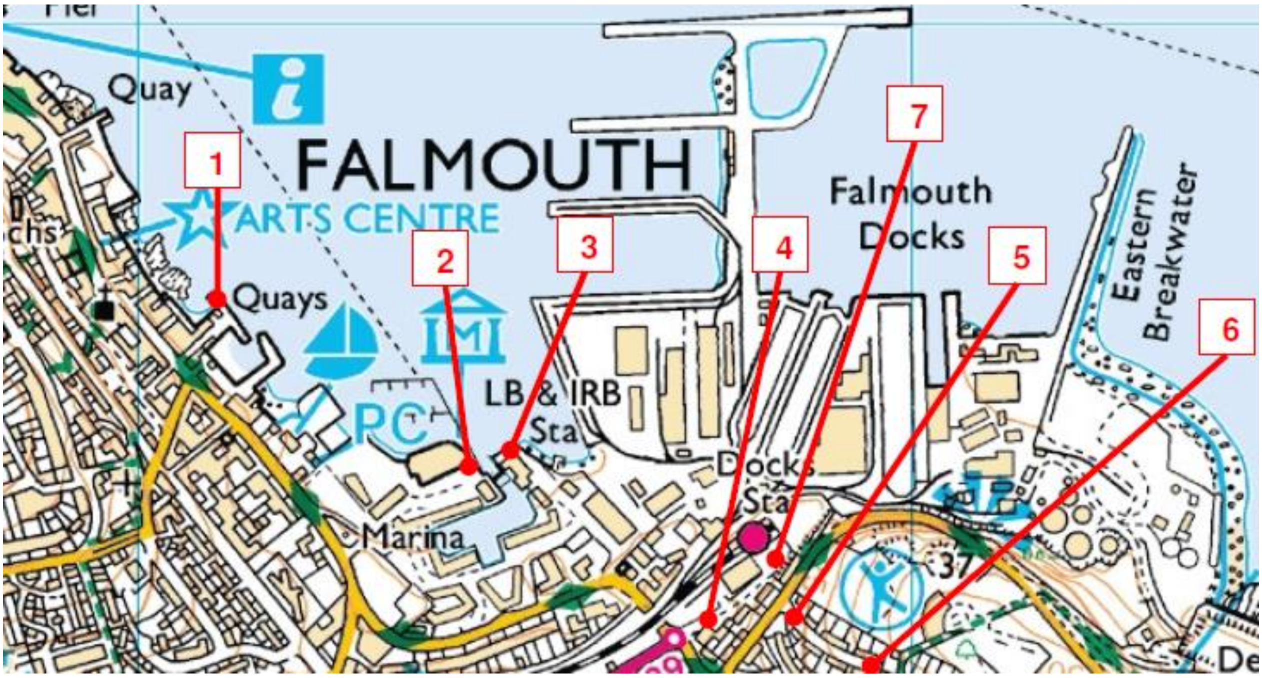
Other marine organisations such as Fugro Seacore and contractors working on the Hayle Wave Hub and FabTest sites regularly use the harbour for mobilisation and demobilisation activities as well as maintenance of vessels.

### Noise levels in Falmouth Docks

The noise assessment (see Section 17 of the 2009 ES) included within the 2009 ES focused on terrestrial receptors as showed in **Figure 3-13**; principally residential properties. The assessment also considered the potential receptors directly across the water at Trefusis Beach.

The 2009 assessment concluded for dredging activities that (for the receptors illustrated in **Figure 3.11**) an impact of negligible significance would occur. For Trefusis Beach (over the water), the impact was predicted to be of minor significance, without mitigation, although at significantly lower levels than, for example, piling.

In terms of understanding where the designated species are likely to be found within the estuary, the report by Footprint Ecology (2015) (as detailed in **Section 3.2.4**), is the most accurate source of information to date. In terms of the study area for this effect, this section focusses on the information gained at the vantage point Pendennis Point (see **Figure 3-12**) which, although located around the point from the docks (approximately 500m from the proposed dredge location), recorded some activity directly in line with the docks. Here the most commonly recorded species were Black Throated and Great Northern Divers, which were predominantly noted to be diving for prey. In February, the divers off Pendennis Point accounted for 40% of all birds counted; in March, the counts represented 20% of all Great Northern Divers and 55% of all Black Throated Divers. A tendency for the Black Throated Diver to gather in flocks was also noted during these months. Some were located close to the point and some were located across the estuary. The birds closest to the potential area of effect were mostly diving. Birds located across the estuary tended to be loafing/inactive. No major concentrations or rafts of roosting divers were, however, recorded. In all other months that counts took place only one or two divers were counted from Pendennis Point with the birds instead appearing in higher numbers off Perbargas Point and Maenease Head which are both more than 10km away from Falmouth Docks. Across the survey sites, Slavonian Grebe numbers were too low to allow detailed analysis of distribution.




Key

1. King Charles Quay;
2. Custom House Quay;
3. Port Pendennis (Tinners Walk near Lifeboat Station);
4. Pendennis Rise;
5. Junction of Tredynas Road and Castle Drive;
6. Top (south-east) of Tredynas Road; and
7. Train station car park.

***Figure 3-13 Noise receptors assessed within the 2009 ES***

# 4. POTENTIAL IMPACTS ON THE INTEREST FEATURES OF THE FAL AND HELFORD SAC

## 4.1 Introduction

The potential changes in the SAC that could arise from the proposed works and may affect features of interest (qualifying features and sub-features), in the context of the Habitats Regulations, are listed below:

- Hydrodynamic changes with the potential to affect habitats.
- Changes to bathymetry with the potential to affect maerl bed communities.
- Changes to water quality that could impact on maerl bed communities.
- The deposition of sediment on maerl bed communities.
- Removal of maerl during the dredging activity.
- Removal of associated species/communities during the dredging activity.

This list of potential changes has been agreed with the MMO and NE through an HRA Framework Document (RHDHV, 2014) that outlined the approach to be taken and the changes to be assessed in the updated HRA. This Framework Document was submitted to the MMO and agreement to the overall approach received on the 17th February 2015.

It is important to note that the proposed dredging activities are not expected to have any effect on the known live maerl beds within the Fal or Helford Estuaries, namely around St. Mawes Bank and within the mouth of the Helford Estuary where live maerl occurs in superabundant (>80%) and abundant (40-79%) quantities, respectively (as recorded from GIS data provided by Natural England (2014)).

The area to be dredged is dominated by fine sediment to the west and clay or sand with dead maerl habitat, to the east.  There is a low abundance of live maerl (<10% cover in the majority of sites with any live maerl) on dead maerl deposits in certain places within the proposed channel area, generally on the south-eastern edges of the channel with increasing amounts of live maerl occurring to the south of the channel.  Other areas comprise dead maerl with no live nodules or mixed maerl with sand, gravel, clay or shell.

## 4.2 Hydrodynamic changes potentially affecting the functioning of the estuary or the maerl bed communities

The predicted changes to hydro and sediment dynamics as a result of the channel deepening were modelled to enable an assessment of impacts to be undertaken (further details in **Section 3.1.3; Coastal Processes**). The predicted effects were reported (HR Wallingford, 2008 and 2016) and are summarised below:

- A small reduction in tidal currents local to the dredge.
- No general change to the magnitude of wave conditions. Some small increase in wave energy is predicted on the southern edge of the dredged channel and towards the west of Falmouth Inner Harbour.
- No general effect on mud transport. A small amount of accretion in the dredged area was predicted, but insufficient to suggest regular maintenance dredging will be required; and

- No change to sand transport fluxes in the area. A potential accretion rate of sands of 5,500$m^3$ for the first year during slope stabilisation and 2500$m^3$/yr was predicted for the longer term, mostly on the south side of the eastern end of the dredged channel. This value was considered to be an over-prediction based on the sediment types in the area and it was concluded that the deposition volumes would be insufficient to require regular maintenance dredging.

A series of locations were investigated with regard to potential change in hydrodynamics in the operational phase and the overall conclusion reached was that the dredging activity would cause negligible change at Falmouth Docks, Kiln Quay and Trefusis and no change at Gyllyngvase and Castle Beaches, Castle Headland, Port Pendennis Marina, the National Maritime Museum, Discovery Quay, Custom House Quay, Visitors Yacht Haven, Fish Strand Quay, Prince of Wales Pier, Admirals Quay, Greenbank Quay and Flushing.

There would be a change in the bathymetry at the disposal site following the deposition of sediment. The predicted change was up to 0.5m within the disposal site.

In light of the findings resulting from the modelling predictions it is concluded that the proposed dredging is unlikely to have any significant effects on the hydrodynamic characteristics of the estuary such as they would affect the habitats within the SAC.

## 4.3 Changes to bathymetry affecting maerl bed communities

Living maerl requires enough light to photosynthesise otherwise it dies and then becomes bleached, losing its pink colour. Greater depths of water cause greater levels of light attenuation which can affect the photosynthetic activity of live maerl nodules within the deepened areas.

Turbidity data (from the Environment Agency) has been analysed from within the Fal Estuary complex to determine whether there are similarities in turbidity levels between deeper areas supporting live maerl in Falmouth Bay and areas further inshore within the estuarine complex (**Section 3.1.3**). If turbidity levels are similar and the maerl in the deeper areas is considered to be viable then it would provide a good indication of the potential viability of live nodules of maerl within the channel following the proposed deepening of the channel area.

The maximum depth in the proposed area for deepening is approximately 6m below CD. With a 6m tidal range in the Falmouth area this would make the greatest depth in the channel at spring high tide approximately 12m. The dredged depth in the new channel will be a maximum of 8.3m which would give a maximum depth of water in the channel of 14.3m. Any live maerl fragments that are placed back into the channel or subsequently roll back into the channel, therefore, would be at this deeper depth for short periods of time.

Water quality data and research papers were reviewed, as summarised in **Section 3.1.3** and reported in **Appendix E**, and it was concluded that:

- Turbidity levels within the Inner Harbour area and Falmouth Bay are good (low values) and show similar values between sites in both locations.
- Live maerl is found throughout the study area in waters of varying depth and down to depths of -17m CD (maximum high water depth of -23m) in Falmouth Bay.

- Research has found that maerl is known to occur typically down to depths of 20m and deeper where conditions allow.

Given the above findings it is not expected that the proposed increase in depth from 6m below CD to 8.3m below CD within the channel area would be a restrictive measure for any photosynthetic activity that may occur.

## 4.4 Changes to water quality impacting on maerl bed communities

### 4.4.1 Release of contaminants

The fate of sediment released during the capital dredge and disposal operations was modelled with special reference to the portion of the sediment to be dredged that is known to contain contaminants. The extent of the sediment plume from the dredging was predicted to be dominated by the exchange of flow between Inner Falmouth Harbour and Fal Bay, with the plume remaining to the western side of Carrick Roads (see **Section 4.1** for modelling results). Baseline water quality condition for TBT already exceeds the EQS and is an existing water quality concern in the Fal Estuary, while other indicator parameters (Cu, Hg, Pb and Zn) are generally below their respective EQSs. Some excess concentrations larger than those experienced in the area typically were predicted in the area of the dredger. However, the dispersion of contaminants released by the dredging showed exceedence of the EQS values in the immediate area of the dredger only.

Specific methods of dredging aimed at minimising sediment release (e.g. using a backhoe dredger with a closed bucket) are being considered for dredging the sediments that are associated with contaminants as such methods retain the structure of the sediment matrix which will, in turn, reduce the amount of contaminant release. The sediment that is unfit for sea disposal will be landed for treatment and disposal ashore.

The 2009 ES concluded that, overall, the capital dredging is predicted to:

- increase concentrations of TBT to the extent that water quality requirements would be breached for the EQSs required under the Dangerous Substances Directive (DSD); but
- not increase concentrations of the other indicator contaminants to the extent that water quality requirements would be breached for the EQSs required under the DSD.

The scale of the impact on TBT concentrations would be limited in space (i.e. largely around Falmouth Docks and the harbour area with exceedance of the EQSs only occurring immediately around the dredger) and time (i.e. over the duration of the capital dredge for contaminated sediment). Capital dredging is predicted to cause a temporary moderate adverse impact on water quality with regard to TBT concentrations. Normally, a high impact magnitude and high impact sensitivity would lead to a major adverse impact, but in this case the impact is put into the context of the baseline conditions where TBT is already present at concentrations exceeding the EQS and, accordingly, capital dredging would make a bad situation worse (rather than making a good situation bad).

It should be noted that the dredging would also have a long-term beneficial impact on the SAC through removal of contaminated sediments. Capital dredging would remove large quantities of chemical contaminants from the seabed. Approximately 100,000m$^3$ of sediment would be dredged which is not suitable for disposal at sea due to elevated levels of contaminants. Removal of the contaminated sediment would lead to an improvement in sediment quality, particularly for organo-tins (TBT and DBT), some metals (As, Cu, Hg, Pb and Zn), PAHs and total PCBs. Within the 2009 ES (RH, 2009) this change to chemical status was predicted to cause a beneficial impact of moderate to major significance. Similarly, there would be an improvement in the sediment toxicity characteristics; a beneficial impact of moderate to major significance.

There also exists a possible route for an impact on the SAC through the discharge of effluent from the treatment of contaminated dredged material onshore. At the time of writing, the treatment method for contaminated material has yet to be defined, but it is likely that some form of dewatering would take place. The treatment process would most likely be carried out by a mobile treatment plant, which will require a permit from the Environment Agency. Any effluent would therefore be treated to an appropriate standard such that it is not likely to have a significant effect on the SAC. This would be reviewed in consultation with the Environment Agency, once the treatment method for the material has been defined. For the purposes of this assessment, it is assumed that the treatment process would not have a significant effect on the SAC and therefore it has not been considered further within this HRA.

### 4.4.2 Increase in Suspended Sediment Concentrations

To provide detail for the potential for changes to suspended sediment concentrations (SSC) that could result in impacts on areas of maerl, the results of the modelling undertaken for the 2009 ES were reviewed. During the dredging activity the movement of the sediment plume was calculated for a range of locations covering the proposed dredged area and predictions made as to the plume distribution and concentration in different areas. It is apparent from the dredge outputs that any changes resulting from the dredging and the subsequent deposition are restricted to the Western side of the deeper water channel (for example results see **Figures 4-1** to **4-2**) and, therefore, there is no risk of affecting the live maerl bed on St Mawes Bank.

The increase in suspended sediment and subsequent deposition also declines to very low levels within a distance such that it would not affect the live maerl beds in the Helford River. Modelling of the sediment plume associated with dredging disposal also confirmed no route for fine sediment from the disposal site to the Helford River.

**Figure 4-1** shows the result of the simulation of sediment release at a site at the eastern end of the proposed dredged area for spring tides. This simulation provides the largest spatial extent of the plume and shows that the concentrations of suspended sediment are very low (<5mg/l) within a few kilometres.

**Figure 4-2** shows equivalent results for release centrally in the dredged area for neap tides. Release during neap tides would be anticipated to provide the highest increases in sediment concentration near to the dredging site due to the reduced dispersion associated with reduced currents during neap tides.

**Figures 4-1** and **4-2** show the maximum excess suspended sediment concentration predicted during the simulation for the two dredging locations at different states of the tide. These types of figure are useful for quickly identifying the maximum concentration increases caused by dredging/disposal plumes at any time within the study area but it should be noted that this form of presentation greatly over-emphasises the extent of the plumes at any given time. A minimum threshold for plotting the increase in suspended sediment concentration above background levels of 3 mg/l has been used to account for the generally low suspended sediment concentrations found in the area.

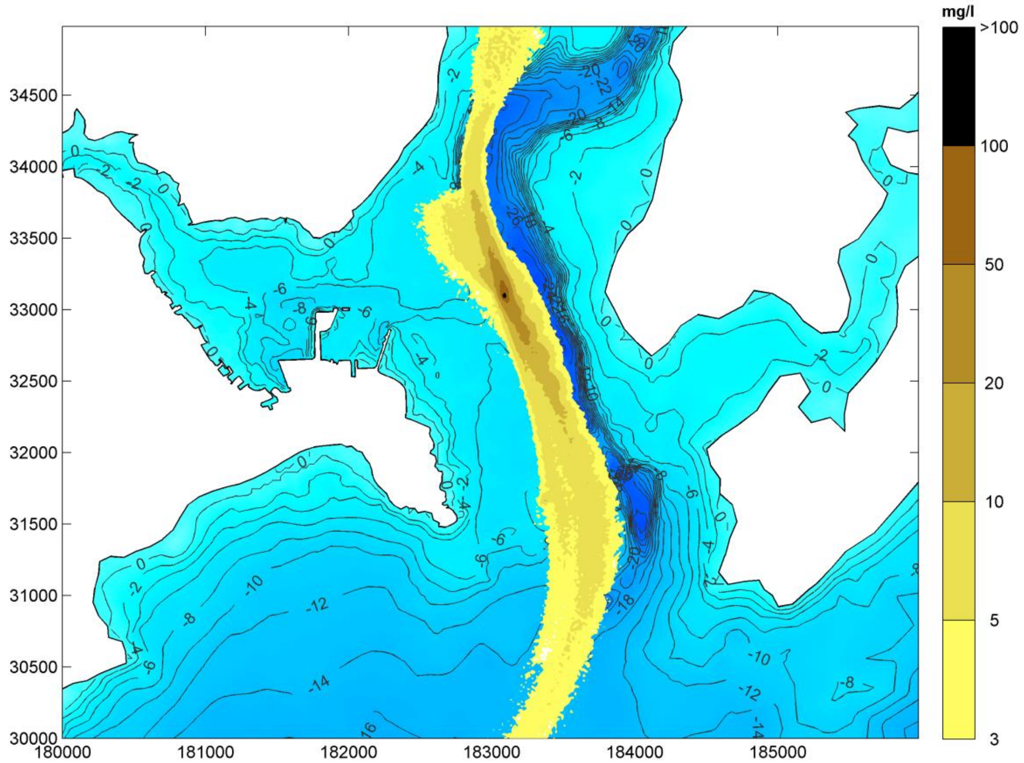



***Figure 4-1 Maximum suspended solids concentration for backhoe dredging at Site C, spring tide (this scenario showed the largest extent of the plume for all dredge scenarios)***

Dredging activity cannot avoid causing a plume of sediment from the dredge but this is minimised through design by using appropriate dredging techniques such as a backhoe dredger which retains the sediment structure as much as possible, thereby minimising the release of fines. The figures included in **Appendix H** show the suspended sediment concentrations for the same area as the figures above for different tidal conditions. The figures show that there is a larger plume during spring tides, as would be expected, but the area covered by the higher concentration plumes are more localised during neap tides as the plume is moving more slowly.

Additional data on increases in the SSC during dredging was collated during the trial dredge to support the modelling data (**Appendix G** for survey report Ecospan). Although this data used a smaller grab than in the modelled predictions (this could be expected to balance against the lower number of grabs required during the actual dredge), the observations confirm the prediction of a low rate of dispersion of SSC from this type of dredging operation, leading to small and localised increases of SSC. This data is discussed in **Section 3.1.3** and shows, as expected, a clear gradient of effect moving away from the dredging activity, such that the turbidity close to the seabed is higher close to the dredge. The turbidity measurements taken downstream of the dredging activity (see **Figure 3-7** in **Section 3.1.3**) show that a turbidity increase occurs close to the dredge of up to approximately 25mg/l and that the turbidity returns to an ambient level between 25m and 100m from the dredge.

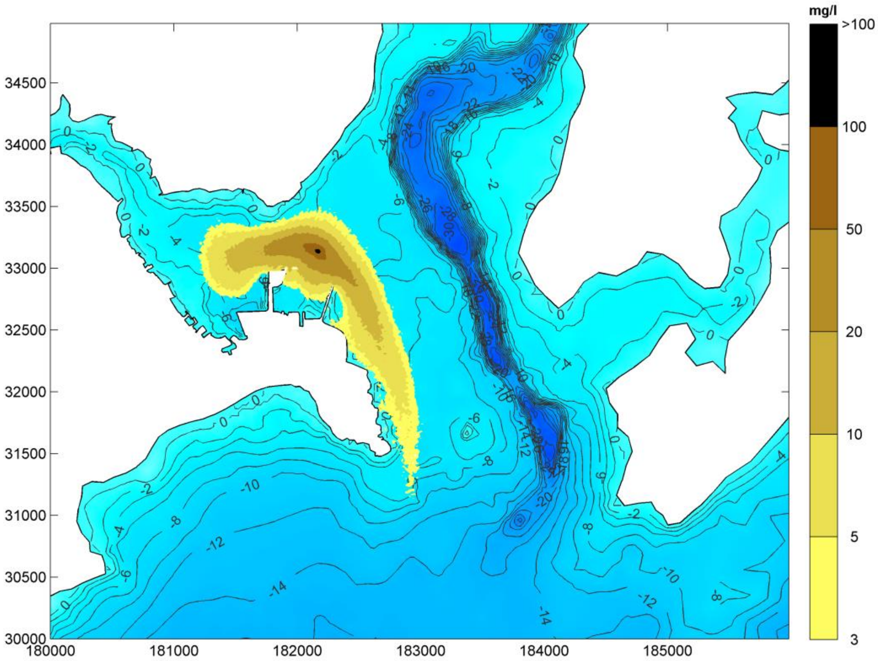



*Figure 4-2 Maximum suspended solids concentration for backhoe dredging at Site B, neap tide*

HR Wallingford reported on the findings of the modelling against the findings of the water quality monitoring undertaken during the trial dredge (HR Wallingford, 2016). The results showed considerable variation in the increase in suspended sediment concentrations associated with the dredging with 2 out of the 6 sets of dredging operations monitored showing no detectable plume. Of the other 4 some of the highest suspended sediment concentrations (up to 96 mg/l) are shown after the instrument reached the bed and therefore may be due to disturbance of the bed by the instrument; however even during the instrument descent suspended sediment concentrations of 50-70 mg/l are shown by the measurements. An example of the results is shown in **Figure 4.3** which shows the vertical profile of suspended sediment concentration for dredging operations at Location 2.  The maximum suspended sediment concentration is shown at 25 m distant from the dredging operation. The observed peak values then reduce to slightly over 10 mg/l at 50 m from the dredger and no plume is detectable at 100 m downstream from the dredger.

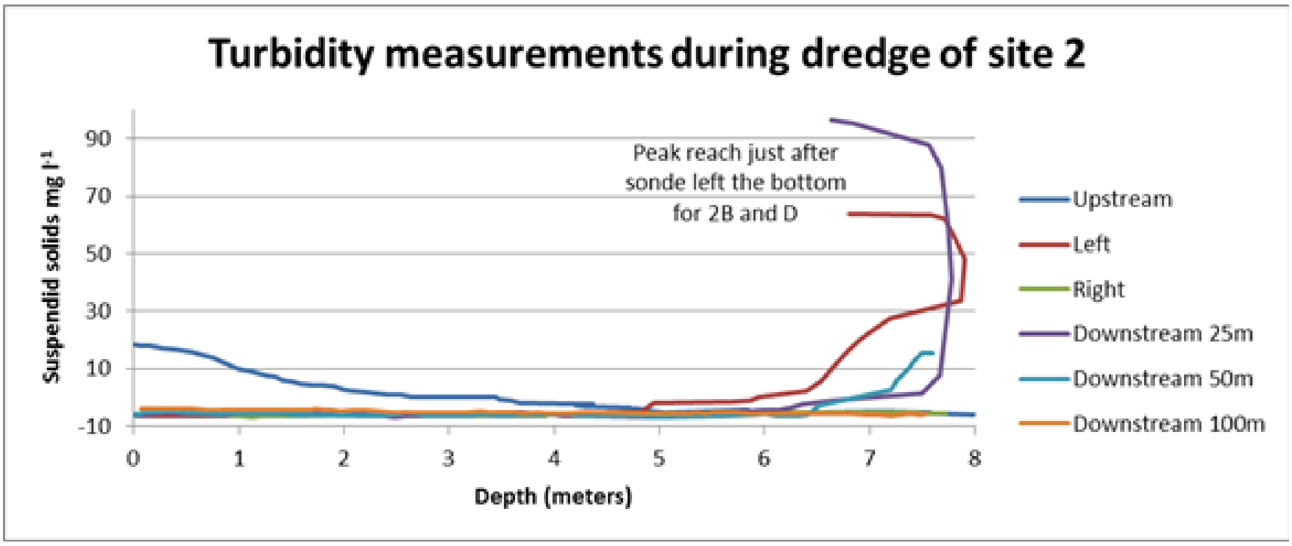



*Figure 4-3 Trial site 2 Cruciform station during dredge Turbidity measurements*

*Source: Ecospan (2012)*

The monitoring results confirm the view presented by the modelling of limited spatial extent of the sediment plume. For comparison **Figure 4.4** shows the model results for sediment release at a site nearby Queens Quay. Circles indicating 25 m, 50 m and 100 m from the sediment release point are overlaid for reference. As might be expected the results, for a 5 m dredger bucket, show larger increases in suspended sediment concentration than those monitored with peak values of up to 150 mg/l occurring within 25 m of the dredger. The suspended sediment concentration falls to approximately 80 mg/l at 50 m distant from the dredger and 60 mg/l at 100 m from the dredger.

Overall, given the low levels of concentration of sediment in the outer areas of the plume, the state of the tide does not appear to be influential enough to make a difference to the level of impact. **Figures 4-1** and **4-2** show that the plume modelling predicts that excess suspended sediment levels reach peak concentrations at the dredge location of up to150mg/l and in the area surrounding the dredger of between 20-100mg/$l^{-1}$, reducing within a short distance to 10mg/$l^{-1}$.

Based on the assumptions made during the modelling (**Section 3.1.3: Coastal Processes**) the likely sediment release rate is considered to be 30% - 50% of the precautionary scenario modelled during periods when fine sediment is encountered. This reduced release rate could halve the short term elevations in suspended sediment concentration, and the rate of sediment deposition as modelled. Furthermore for periods where no fine sediment is present in the dredged material (approximately 50% of the total dredged volume) negligible fine sediment release is anticipated.

Based on the above, the likely results for dredging at Sites B and C, adjacent to the maerl areas are presented below (**Figures 4.5** and **4.6**). As the effect is directly proportional to the amount of sediment introduced, the consequential effects are also scaled down by 50%. It should be noted that in addition to the fine sediment release as modelled, some coarser sediments may be released during the dredge. This material will have a larger settling velocity, will fall back into the area to be dredged and will be subsequently re-dredged. No dispersion of coarser sediments is anticipated outside the proposed dredge area.

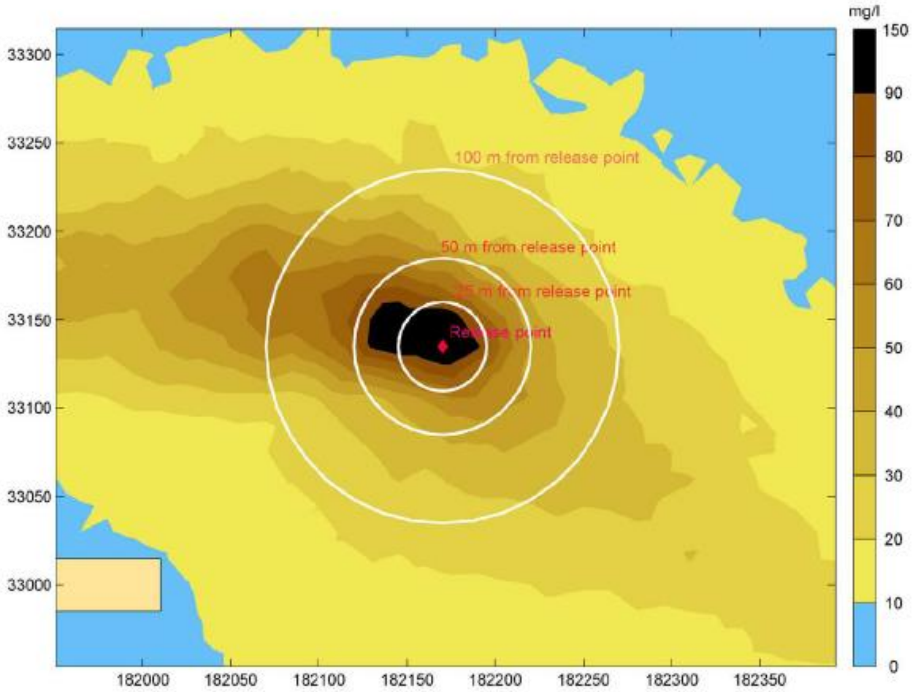



*Figure 4-4 Maximum increase in suspended sediment concentration due to dredging at Site B*

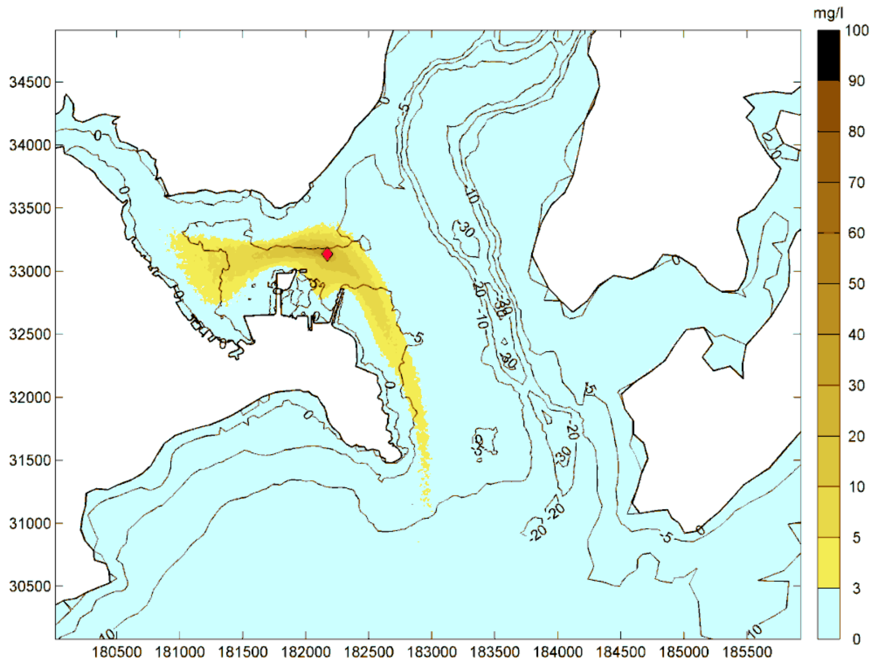



*Figure 4-5 Maximum increase in suspended sediment concentration for backhoe dredging at Site B, spring tide (realistic scenario)*

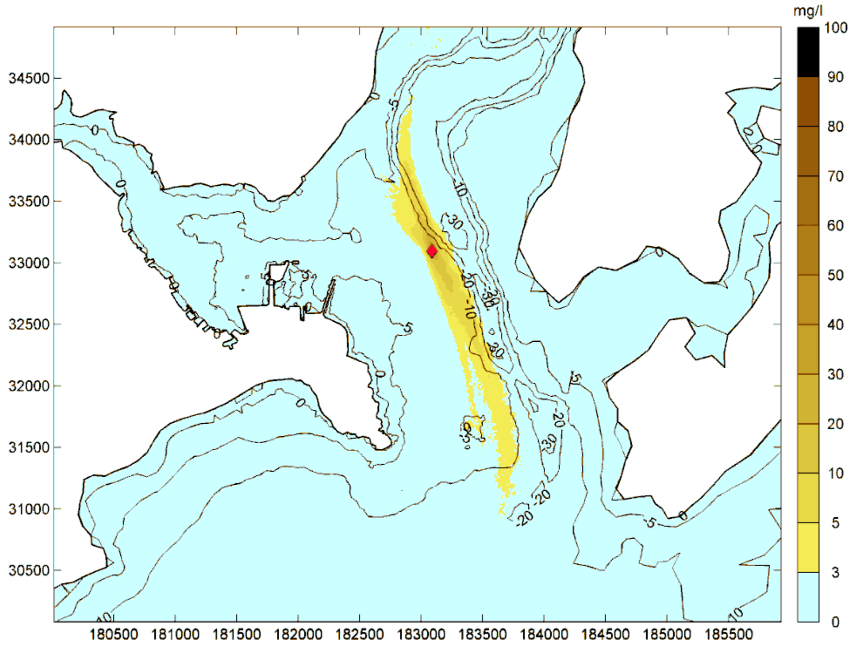



***Figure 4-6 Maximum increase in suspended sediment concentration for backhoe dredging at Site C, spring tide (realistic scenario)***

Such levels, on a temporary basis during the dredging activity, are not expected to result in an impact on the maerl beds or associated species due to siltation as the level is low enough to be expected to be moved from the area by tidal movements. Falmouth harbour is macro tidal which is a term applied to areas where the tidal range is in excess of 4m and therefore tidal currents dominate the processes within the area. These tidal currents combined with the fact that the majority of the sediments escaping from the dredging process are fine and therefore easily transported means that any sediments falling out of suspension are unlikely to stay in place for long due to the regular tidal currents. The results for water quality monitoring during the trial dredge (**Figure 3.7**) showed that levels of turbidity reached a maximum of 36.8NTU which correlated with a suspended sediment concentration of 97mg/l-1 (Ecospan). This corresponds with the predicted levels from the modelling results.

Sediment release was modelled at three locations to encompass the areas of proposed dredging to demonstrate the likely maximum footprint of any plume generated during the dredging. In reality the dredger will frequently relocate such that any area affected by the sediment plume will also frequently change. The model results were presented as the maximum increase in suspended sediment concentration and maximum depth of deposition predicted for each modelled scenario. The maximum increase in suspended sediment concentration figures for spring tides show the maximum spread from the sediment release locations during any spring tides for the entire dredge duration (6-12 months).

The regular movement of the dredger (causing the plume to affect different areas) as the dredging progresses along the channel will not cause a continuous reduction in light levels in any one location and it is recognised that maerl can survive with reduced light levels for a number of weeks (Wilson *et al*, 2004). Wilson also concludes that, although they investigated a relatively short dark period, it is very likely that maerl can survive several months of darkness with no deleterious effect. It is therefore highly unlikely that there would be a significant impact on maerl and maerl communities caused by a decrease in light attenuation through increased turbidity.

## 4.5 Deposition of sediment on maerl bed communities

### 4.5.1 During Dredging

Deposition of sediment onto live maerl thalli can impact on the photosynthetic ability of the maerl. Wilson *et al* (2004) found that smothering of live maerl thalli with muddy sand after one week caused the thalli buried under 2cm of sediment to turn a very pale pink while the thalli on the sediment surface and those buried under 0.25cm were a stronger pink. All thalli had become white by the end of the second week, when they were deemed to be dead. When covered by coarser sediment (sand), after four weeks of smothering there was no significant difference between the thalli at depths of 4 and 8 cm, but thalli on the surface of the substratum had significantly higher photosynthetic yield. All thalli that were smothered using gravel or sand remained alive after the 4 week experiment. Burial with sediments containing hydrogen sulphide was quickly detrimental, even for maerl thalli on the surface of the fine sediment.

The experiments referenced above (Wilson *et al,* 2004) indicated that, in the fine sediments, reduction of water movement around the thalli probably limits gaseous exchange with detrimental effects on the algae.

The material to be dredged from the channel as part of the PFDI comprises a variety of sediment types ranging from fine sediments predominantly in the western end of the channel and mixed coarser sediments dominating in the eastern end of the channel. The dredging in the middle of the channel is indicated by the modelling results to be the area that may cause some deposition onto the live maerl beds and this area comprises maerl, sand, mixed sand and maerl and clay/silt with maerl. The method put forward for dredging minimises the release of sediment in suspension. In addition, any sediment that is released into the water column comes into contact with higher levels of dissolved oxygen in the water (than were available in the seabed sediments) and therefore oxidation will occur as discussed in Cappuyns and Swennen (date unknown). Any anoxic sediment that is dredged and subsequently released from the dredger as part of the sediment plume will therefore be oxidised as it moves through the water column. Levels of dissolved oxygen (DO) were recorded throughout the water column during the dredge trial and the results show an expected decline in DO levels with depth of water for control and potential effect sites but the lowest values seen were above 87% at any depth. There was no indication that there was any effect related to dredging activities. Even where increased turbidity was detected no associated reduction in DO was observed (Ecospan).

Modelling was undertaken to determine the likelihood of deposition of the fine component and therefore the potential for smothering of live maerl nodules (see **Section 3.1.3** for modelling summary). The modelling predicted a small amount of deposition around the channel area. During each modelling run for the three locations, the deposition has been predicted and there is localised deposition immediately around the dredger of greater than 3mm which drops down to 1-3mm very quickly (**Figure 4-3**). The larger areas of deposition are below 0.1mm per tide. The majority of the deposition within these areas would remobilise with subsequent tides.

Overall, the modelling predicted an average depth of total deposition for the duration of the capital dredge of between 0.5 to 1.7mm with the higher levels occurring to the north of the channel. The area of live maerl to the south of the channel was predicted to receive between 1.1 and 1.3mm of deposition in total during the dredge activity (expected to last approximately 6 - 12 months).

The modelling predictions were considered likely to be over-precautionary for a number of reasons (as discussed in Section 3.1.3) and as such the predicted rates and total deposition for the dredge activity is considered to be 30-50% of the predicted scenario.  This will reduce the level of change and any impact. The reduced sediment release described above would also significantly reduce the total fine sediment depositing, reducing the average depth of deposition to less than 1mm over the 6-12 months of the dredge (HR Wallingford, 2016). **Figures 4.7** and **4.8** show the deposition totals for the whole dredge, during spring tides, under the realistic scenario.

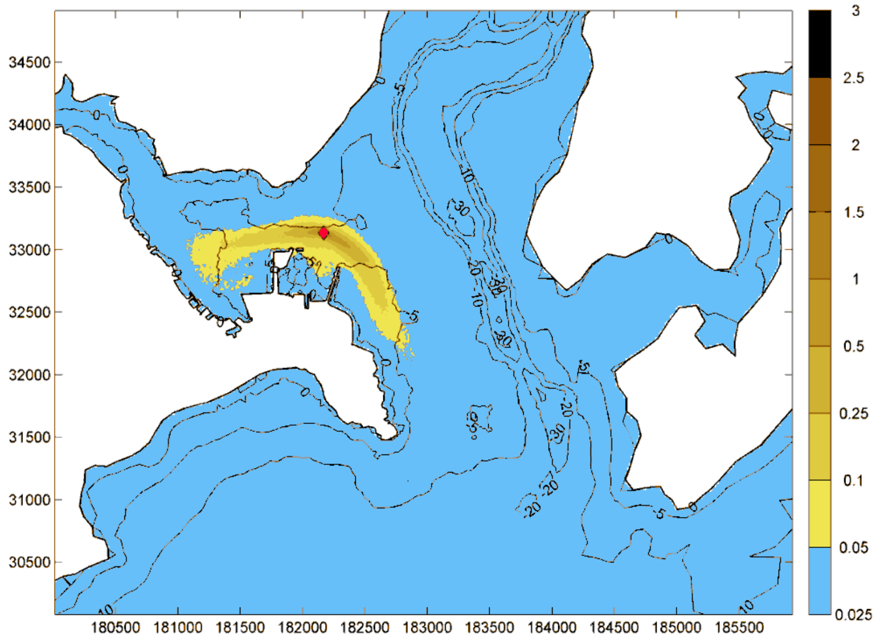



***Figure 4-7 Maximum fine sediment deposition depth during backhoe dredging at Site B, spring tide (realistic scenario)***

The levels of deposition predicted are not expected to impact on live maerl nodules, particularly as the rate of deposition is so low with the total predicted deposition for the duration of the dredge (six - twelve months) between a maximum of 1.1 and 1.3mm (precautionary scenario).  The live maerl that occurs to the south of the channel with an abundance of rare to abundant would be subject to deposition during dredging within and around Site B.  The maximum level of deposition at any one time resulting from dredging in these locations at the areas of live maerl outside of the channel are shown to be between 0.025 and 0.1mm (modelled over a duration of four tides (**Figure 4-7** above (for realistic scenario) and Figures in **Appendix E** for precautionary scenario)). Some of the material deposited would also remobilise on subsequent tides. There is no expectation that there would be enough sediment accumulation to cause the burial of the live maerl in sediment. Fine sediment may remain on some of the maerl nodules if water movement is not sufficient to remove it. This could potentially cause some localised smothering of smaller nodules of maerl; however, the total amount of deposition of fine material calculated over a six month period is not enough to cover the live maerl nodules which are expected to be in the region of 4-6mm diameter. The HR Wallingford report states that the deposition rates are unlikely to change the nature of the bed in the areas studied (HR Wallingford, 2008).

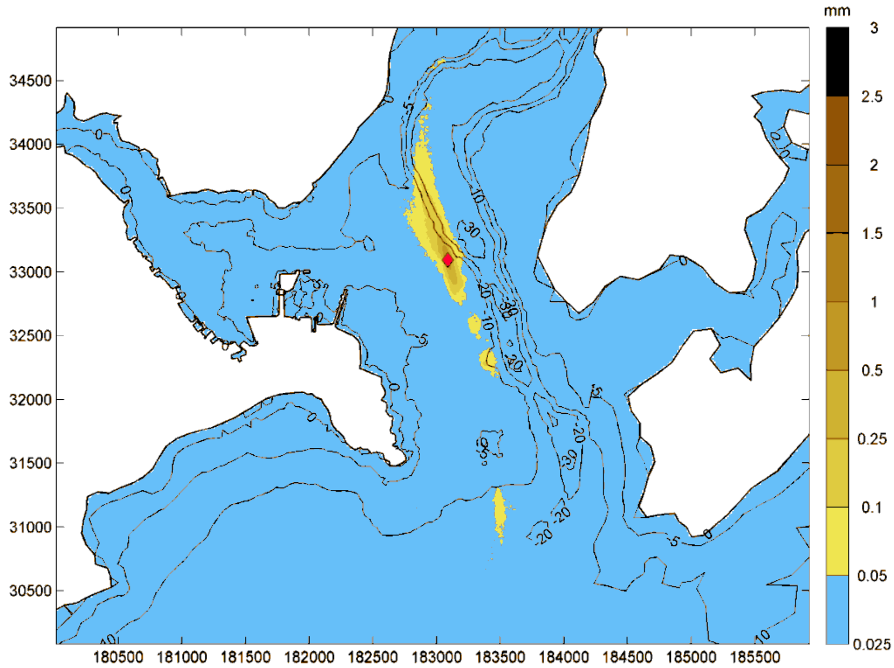


*Figure 4.8 Maximum fine sediment deposition depth during backhoe dredging at Site C, spring tide (realistic scenario)*

## 4.5.2 During operation

A calculation of the total volume of sand deposited annually (the difference between potential erosion and deposition) in the area of the proposed channel gives a figure of less than 20 $m^3$/yr. This simulation suggests that whilst sand is mobile in the area of the proposed channel, the bed levels are generally stable with little net deposition or erosion overall. This insignificant amount of predicted bed change is consistent with the present lack of need to undertake maintenance dredging in the approaches to Falmouth and the relatively stable nature of the sea bed in the longer term.

The worst case scenario calculation of the annual accretion with the proposed dredging in place gives an accretion total of 5500 $m^3$/yr. As outlined in **Section 3.1.3**, this is not a realistic scenario and the likely effects should be scaled down by 50% (HR Wallingford, 2016). This accretion rate is linked to the prediction of generally unchanged sand fluxes due to the channel but with deeper depths – resulting in less potential for transport directly over the deeper area and, therefore, deposition. The bulk of the deposition is predicted on the south-eastern corner end of the dredged area with a maximum depth of deposition in the range 0.2 -0.3 m/yr. Values of less than 0.1 m/yr are predicted on the southern side of the channel and less than 0.02 m/yr on the northern side. Further consideration of these predictions (personal communication, HR Wallingford, 2015) suggests that this level of accumulation is due to the southern slope of the channel readjusting and therefore is only anticipated to occur until a stable channel slope is established by localised accumulation at the bottom of the slope (potentially within the first year depending on storm and wave conditions). Following the establishment of the channel slope these levels would reduce such that minimal levels of accumulation would then occur (averaging less than 5mm per year (based on the realistic scenario)). It should be noted that the modelling assumed an abundant availability of mobile sand. Bed surface grabs show a transition between sandy areas half way along the proposed channel to a gravelly bed in Carrick Roads, therefore the sand transport predictions provide a precautionary estimate of sandy infill in the channel. This is confirmed by the sedimentation plot predicting the situation before the dredge (existing situation (shown in Figure 2 in **Appendix A**)) which would indicate that there are currently annual deposits of the same magnitude within areas of the channel. The lack of maintenance dredging requirement in the channel proves that this theoretical annual accretion is not occurring and this is considered to be due to the lack of sand in the system that could have resulted in such levels of accretion.

There was a small increase in deposition of fine sediment (mud) predicted in the channel area (610 $m^3$/yr taking the value from 2360 $m^3$/yr to 2970 $m^3$/yr) but it was recognised in the modelling report that currently there is no requirement for maintenance dredging and, therefore, it was assumed that other processes are acting in the area to reduce deposition, for example ship passage could keep the channel generally clear of sediment accretion reducing the simulated baseline rate of 2360 $m^3$/yr to zero (or negligible). This total is very low, suggesting the accretion rate for fine sediment in the dredged area may not be sufficient to require regular maintenance dredging of the channel. The report concluded that the small increase in fine sediment infill predicted to be associated with the dredging suggests that the dredge would not significantly change the fine sediment regime in Falmouth Harbour.

These levels of deposition over the durations predicted are not expected to change the habitat type. In addition, given that this level of deposition is over a year and would be depositing at a very slow rate there should not be an impact on live maerl nodules. Maerl mitigation areas have been planned to avoid the areas of highest deposition as predicted by the modelling.

Outside of the channel area (beyond the top of the slope of the channel) there is not expected to be a change in deposition during the operational phase of the project, as the bed level would not have changed in these areas and any changes to current flows and waves are predicted to be minimal. There is not therefore expected to be any impacts on the maerl to the south of the channel in relation to changes as a result of the channel deepening.

## 4.6 Removal of Maerl during the Capital Dredging

One of the favourable condition targets for the sub-feature of maerl beds within the SAC is no decrease in the extent of maerl (either dead or live) from an established baseline subject to natural change. The presence of a dredged channel within this area makes this a difficult aim to achieve within this particular area as the majority of navigation channels require maintenance at some stage. However, with the implementation of the proposed mitigation strategy, the same extent of the viable maerl bed habitat as exists now would remain in the navigation channel following the proposed dredging. The live nodules have been shown to have no influence on the infaunal species associated with the beds. In terms of the number of epifauna taxa there may be some benefit from the presence of live maerl but it would require a relatively high % of live maerl to show any benefit. The low levels of cover of live maerl in the proposed channel area are not likely to provide a significant benefit. The sampling undertaken for the trial only showed very low abundance and number of taxa of epifauna within the proposed channel area (as discussed in Section 4.7 below). In this respect, the maerl bed habitat and the communities associated with the bed would not decrease significantly due to the works.

There are therefore two potential issues with respect to aiming to meet the favourable condition targets relating specifically to the removal of maerl during dredging. These are the removal of dead maerl and removal of live maerl.

### 4.6.1 Removal of dead maerl

The dredging activity proposed necessitates the removal of dead maerl. However this has been addressed through the proposed mitigation strategy (outlined in **Section 2.2.3**, with a detailed approach to the strategy set out in **Appendix A**). The certainty of recovery has been established during the pilot dredge trial where dead maerl was successfully relayed following dredging. The potential impact on associated communities is covered below.

The proposed mitigation strategy provides a means to fully mitigate the loss of dead maerl habitat currently present in the proposed navigation channel. Following discussion with NE and the MMO over the initial mitigation proposals presented in the 2009 ES, the area of maerl habitat predicted to be affected has been re-calculated using a depth of viable maerl habitat of 30cm and using sand and maerl or pure maerl as a viable maerl habitat. Based on this information it was determined that approximately 7.6 ha of viable maerl habitat had the potential to be impacted overall. Of this amount, 4.1ha would remain as the same habitat type following dredging. The remaining 3.5ha would be changed to a non-viable maerl habitat following dredging. The dredging activity also exposes 2ha of viable maerl habitat that was previously not viable maerl habitat. This left 1.5ha to be mitigated by habitat replacement.

Consequently, a mitigation package has been proposed which involves a 30cm over-dredge of 1.5ha of the seabed within the dredged channel and replacing this with 30cm of dredged maerl. This technique was tested during a trial project (as set out above) and has reported successful re-colonisation of the maerl habitat to provide similar communities as those present under pre-dredge conditions.

Other maerl habitat includes clay with maerl, of which there is 10.8ha before dredging and would be 9.6ha exposed after dredging. The 1.2ha of clay with maerl that would be lost is within polygon 12 where enhancement is proposed by relaying pure maerl onto the remaining clay habitat. In this respect there would be no net loss of dead maerl habitat with an area (1.2ha) of mixed sediment maerl habitat being enhanced by replacing it with pure maerl.

With the above mitigation and enhancement in place, the project would enhance the extent of dead maerl habitat within the footprint of the channel.

### 4.6.2 Burial of live maerl

During the removal and relay of maerl habitat, the live maerl nodules are likely to be buried during the relay. This would cause some loss of live maerl resource from the dredge footprint.

Live maerl as a species is listed under Annex V of the Habitats Directive, which does not require strict protection but includes ‘animal and plant species of community interest whose taking in the wild and exploitation may be subject to management measures’.

The areas identified as ‘live maerl bed’ within the estuaries exist on St Mawes Bank and in an area in the mouth of the Helford River. Live maerl beds do not appear to occur elsewhere in the Fal and Helford Estuaries and there do not appear to be any other areas where live maerl occurs in high abundance (see **Figure 4-9**).

Live maerl nodules do occur throughout the Fal and Helford Estuaries however at varying abundances. **Figures 4-10** and **4-11** below provide a good indication of the distribution of live maerl nodules within the proposed channel and surrounding area, established from video tows (Sheehan *et al,* 2012). It appears that the abundance of maerl decreases to the north in the area sampled.

There is no record of regular maintenance dredging having been undertaken in the channel since the1960s. The lack of maintenance dredging requirement indicates that the accumulation of material is very low within this area, which is confirmed by the modelling report (between 0 and 0.02m/year in the most sheltered area and between 0 and 0.016m/year in the main channel area). This indicates that ship movements in the channel, or current speeds, are enough to prevent settlement of sediment and/or that sediment in suspension is at low concentrations within this area.

The figures above confirm that live maerl does occur within the proposed channel but generally at levels below 10% cover (measured for each dot over an area of $1m^2$). There are a few locations which record percent cover at above 10% but less than 20% and one location that shows cover of live maerl to be between 20 and 30%. To the south of the proposed channel and within the existing channel there are areas that record live maerl at higher levels of cover with abundance of live maerl appearing to increase within and to the south of the existing channel. These nodules of live maerl would have accumulated in the channel since the cessation of maintenance dredging in the 1960s.

The question remains as to where the live maerl is coming from. There is a marked reduction in abundance of living nodules of maerl moving northwards in the proposed channel area (as shown in **Figure 4-10**) which indicates that living maerl is on the edge of its boundary of distribution in this area and is limited by external factors, most likely physical conditions. Given the low levels of cover of live maerl it is not considered to be accumulating as a live maerl bed in this area. It is expected that the most likely scenario is that the nodules of live maerl within the existing channel have been moved from areas surrounding the channel, most likely to the south where abundance is slightly higher, tumbling along the seabed with the currents into the channel area. **Figure 4-11** also indicates that once live maerl rolls into the channel, the live maerl nodules concentrate at the base of the channel (higher abundance directly at the base of the channel where the channel slope meets the seabed) but still remains at very low levels of abundance.

There are a number of options to explain what potentially could be happening in the channel area. One of these is that maerl is surviving in the channel areas at low levels of abundance but not enough to form a live maerl bed. The live nodules that are present within the existing channel would have arrived in the channel at any point since the last dredging activity (which occurred in the 1960s) and are likely to be moved around by currents in this area. It is also therefore possible that the currents within the channel, which provide sufficient movement to reduce any settlement of sediment, also increase the mobility of the maerl in this area, such that its survival is limited. This would limit the survival of live maerl in the channel areas in the long term and over time maerl would die off in these more mobile areas.

It is recognised that the loss of living maerl from a live maerl bed (such as that found in St Mawes Bank) would be a significant loss to the overall living maerl habitat within the Fal and Helford SAC, given the slow growth rates of the maerl and the contribution that the live rhodoliths make to the habitat structure and hence species diversity of the habitats. However, the impact in this case relates to a dead maerl deposit existing with a low abundance of live nodules; which do not constitute a live maerl bed.

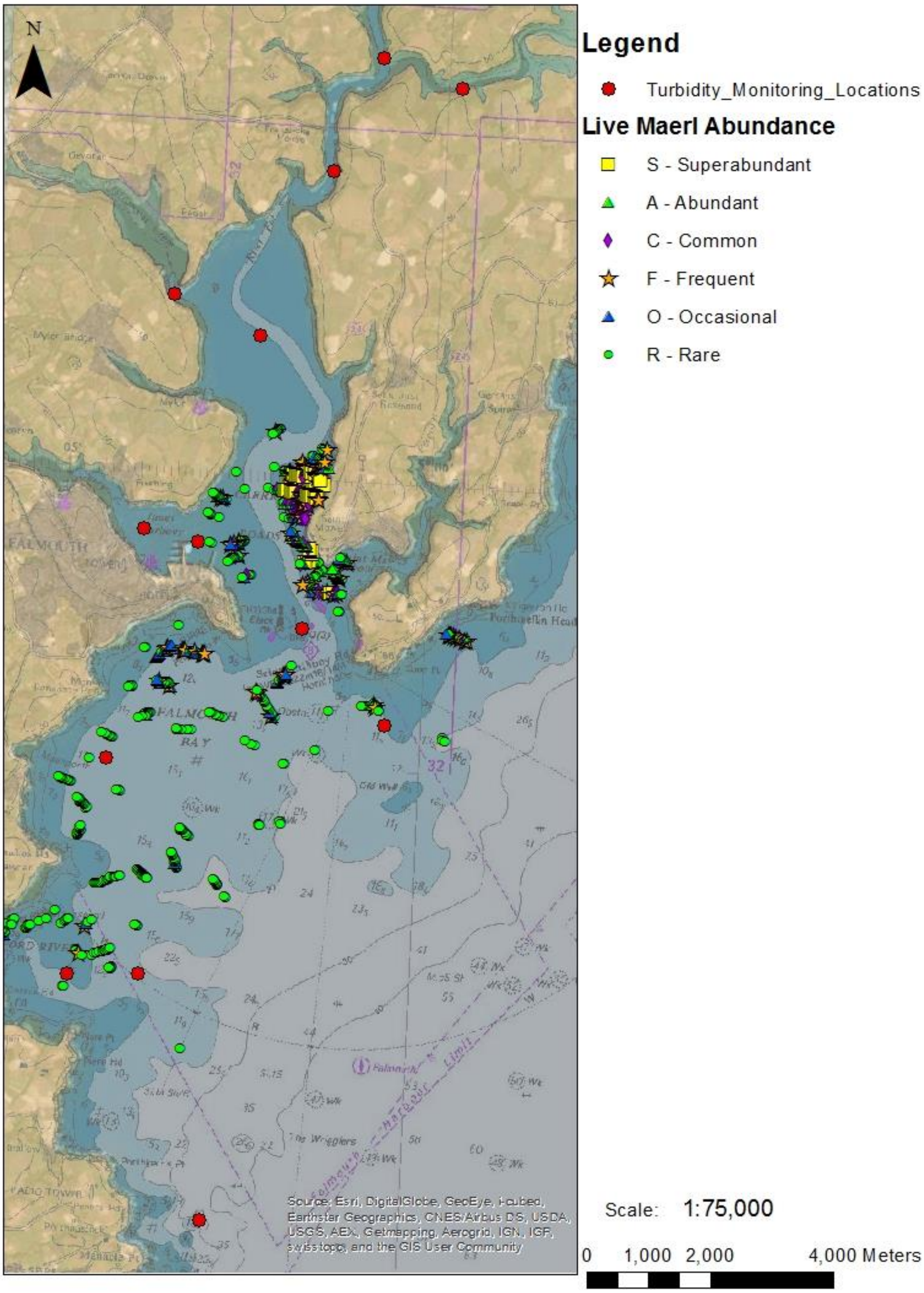



*Figure 4-9 Live Maerl Abundance throughout the Estuaries (Sourced from data supplied by Natural England)*

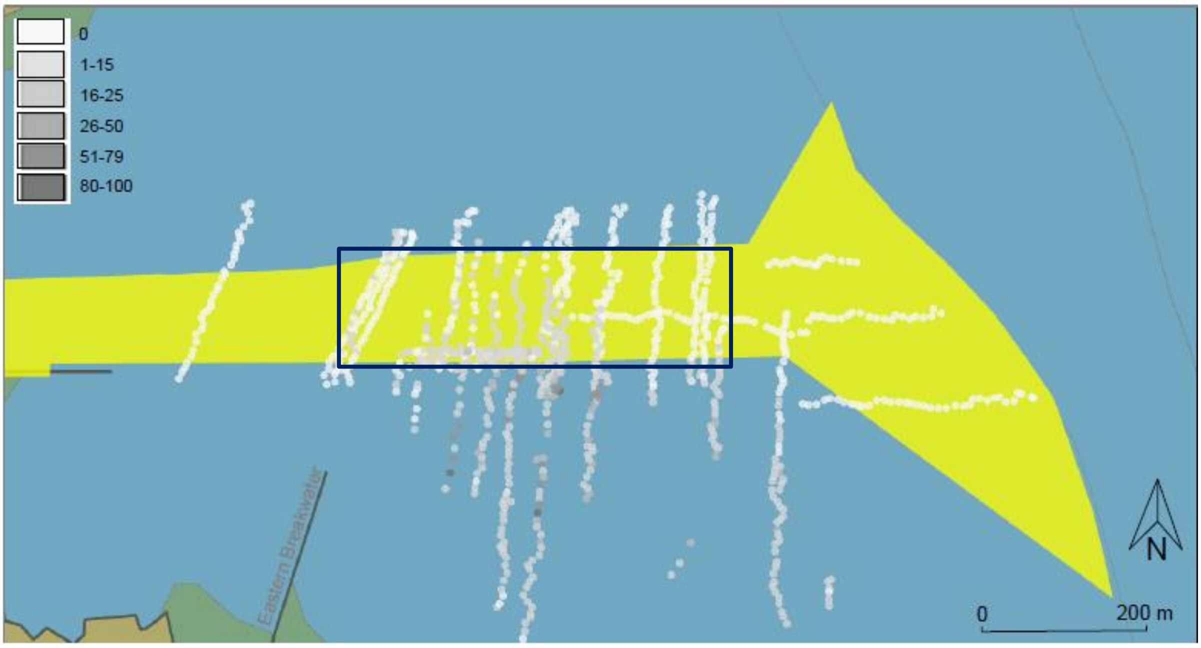



*Figure 4-10 Adjusted percentage cover live maerl within the proposed channel and surrounding area (adjusted to include presence of live maerl if not occurring under one of the points for recording % cover) (Black box shows approximate location of zoomed in figure below)*

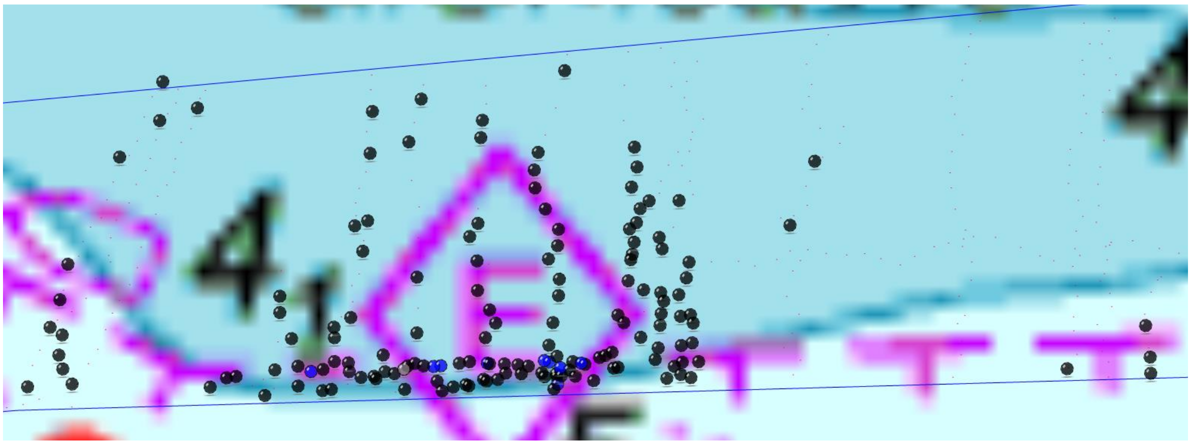


*Figure 4-11 An enhanced area of the southern area of the proposed channel within Figure 2. Image shows all points in The Channel where live maerl was recorded. Black circles show live maerl cover at <10%, blue at <20% and grey at <30%.*

The maerl fragments in the channel are likely to have originated from a nearby living maerl bed, where fragments are broken off by tidal movements and transported along the seabed by the underwater currents to other areas. Where environmental conditions are favourable, the live maerl fragments could accumulate as a live bed similar to that at St Mawes (a process shown in the model developed by Foster). Where conditions are unfavourable, these fragments will die and accumulate as a bed of dead calcified seaweed deposits, much like leaves falling from a tree and decaying on the ground.

One of the favourable condition targets for the Fal and Helford SAC requires no decrease in the extent of maerl as a whole, or of either dead or live maerl, from an established baseline, subject to natural change. One of the approaches to this would be to assume that as there is currently no update on the condition status of the extent of maerl, the established baseline is taken as the baseline established at the time of the designation of the site. The Regulation 33 package (January, 2000) outlines the live maerl areas within the Fal and Helford Estuaries as the live bed at St Mawes Bank and another live maerl bed recorded in the mouth of the Helford. There is also reference to extensive areas of dead and crushed maerl, found south of Penarrow Point out into Falmouth Bay. There are no other references to areas of live maerl. However, it is recognised that the baseline that was established at the time of designation is likely to have missed areas of live maerl that were present but not recorded. More recent research has shown there to be additional areas of live maerl within the estuaries but not at such high levels of abundance. The live maerl within the channel and in the area adjacent to the south of the channel is not considered to be at a high enough abundance to constitute a live maerl bed.

The favourable condition table for the Fal and Helford SAC does refer to the distribution of the maerl bed communities. The relative distribution of the biotopes listed is referred to as an important structural aspect of the Sandbank feature (within which the maerl beds form a sub-feature). The communities listed include the biotopes for maerl which are shown as occurring on St Mawes Bank and in the mouth of the Helford. Maerl biotopes are not recorded within the channel, which is described as sublittoral mud with bedrock outcrops.

In relation to the loss of extent of live maerl from the established baseline, the dredging activity is not predicted to cause the loss of any of the live maerl from the living maerl bed areas on St Mawes Bank and the live maerl in the mouth of the Helford Estuary. In this respect, it would not cause a decrease in extent of live maerl, from the baseline of distributed maerl bed communities established at the time of designation.

In relation to the existing baseline for live maerl (recent surveys have found more live maerl resources throughout the estuaries) the removal of the live nodules from the channel area is not expected to have a long term significant effect on the extent or distribution of live maerl. It also would not affect the quantity of live maerl from any ‘live maerl beds’. The removal of the live nodules would remove a live resource from the system from an area characterised by dead maerl habitat. However, the most likely scenario is that the live resource in these particular areas is not a long term feature of the site. The low abundance of live maerl implies that they are nodules that have been moved to this location radiating away from an area of higher abundance.

Natural England has estimated that there is 1041 hectares (ha) of known maerl habitat in the SAC comprising of maerl beds and maerl in sediments (draft supplementary advice package, 2015). Natural England have also estimated the extent of live maerl resource within the SAC at approximately 92 hectares (Natural England, *pers. comm*. 2014).

In terms of the extent of loss of the live nodules from the proposed dredging area, estimates have been made in order to provide a value to show the area that would be affected in relation to the known area of live maerl currently estimated within the Fal and Helford SAC. It is recognised that the estimates are based on surveys undertaken to date and that there is likely to be additional areas within the estuaries that support live maerl nodules and so the values used are considered to underestimate the amount of live maerl in the SAC and are therefore likely to overestimate the % of live maerl that could be removed from the site. Natural England has undertaken estimates of live maerl cover within the SAC and the channel area. Using the suggested estimates for live maerl cover within the SAC and the data for live maerl cover within the channel assigned to a polygon derived using the Plymouth Marine Institute mapping (including a 20m buffer as recommended by Natural England), this estimates that 0.17% of the known area of live maerl within the SAC would be removed from the channel during the dredging. The use of the Plymouth Marine Institute live maerl channel area is thought to represent the best estimate for live maerl occurrence as other areas of the channel are composed of finer material (silt and clay) which is unlikely to support live maerl habitats. Only one instance of live maerl was discovered in the wider channel area and this is most likely an anomaly. The % calculation is expected to be an overestimate (as identified above) as the total amount of live maerl within the SAC is not actually known, given the difficulties of surveying in the marine environment and it is likely that there are additional areas that have not been surveyed which support live maerl. The actual total area is therefore likely to be higher than the estimated total area used for the calculation which would reduce the value for the % removed.

In terms of the overall distribution of the live maerl, following dredging, live maerl nodules are expected to continue to roll into the channel from adjacent areas. Evidence for this is supplied from the survey showing live maerl fragments in previously dredged areas. In this way the long term distribution of live maerl will be maintained. It is recognised that there will be initial slope stabilisation in some localised areas which may cause some smothering of maerl that initially falls into the channel, following the dredging activity. However, given the nature of the sea bed (coarse maerl substrate and/or clay), the side slopes within this area are considered to be relatively stable (compared with finer and/or less cohesive sediment) and it is only expected that there would be localised stabilisation during the first year following dredging. Therefore, this is only expected to cause a localised temporary effect following which recovery of the live maerl cover will continue with nodules moving into the channel.

To enable an assessment to be made on the potential significance of the loss of this area of live maerl, the following points from the above discussions are summarised:

- Extent – the removal and translocation of the dead maerl habitat with live nodules in the dredged channel would not result in a decrease in the extent of live maerl from the baseline established at the time of designation within the Fal and Helford SAC. The site is designated for an Annex 1 habitat of sandbanks which are slightly covered by seawater at all times. Within this category there are four main sub-types, one of which is maerl beds. The abundance of live maerl present in the channel is not considered to fall within the category of a maerl bed. The loss of the live maerl nodules in the proposed channel area would be a loss of extent when compared to the existing area of live maerl coverage known to occur within the SAC. This loss would be of approximately 0.17% of the known live maerl resource in the SAC. This removal would not affect areas of live maerl beds. Maerl as a species in itself is listed within Annex V of the Habitats Directive and as such its exploitation is feasible but may be subject to management measures.

- Distribution – the live maerl resource currently within the proposed channel area is considered to be fragments that have left areas comprising of higher abundance live maerl and been transported by water currents to this area. It is not considered that the maerl would grow or accumulate within this area to become a live maerl bed, such as exists at St Mawes Bank, due to the conditions within this area. Immediately post dredge there would be a reduction in the distribution of live maerl in the channel area, as the live nodules removed with the relocated habitat are likely to be buried during re-placement and subsequent stabilisation of the side slopes. However, this is expected to be a short to medium term temporary change to the overall distribution and it is not expected that the distribution of live maerl would change in the long term as, once the dredge is completed and the side slopes have stabilised, nodules of live maerl would again be rolled into the channel area. Sedimentation is not considered to be an issue for live maerl within the estuaries based on the low levels of change predicted in the area surrounding the channel both during and following the dredge.

- Species composition – the live maerl nodules in this area do not contribute significantly to the habitat diversity of the maerl habitat in the proposed channel area.

### 4.6.3 Overall finding

Overall, in terms of the loss of maerl habitat, the proposed works are not considered to be likely to have a significant effect on the overall habitat extent and distribution within the channel area. Following mitigation, there would be no loss of dead maerl habitat after dredging activity has occurred (indeed the enhancement measure proposed would increase the area of pure dead maerl habitat). It is concluded that the dredging, with associated mitigation, would not affect the overall structural and functional importance of the Annex I sandbank feature or the sub-feature of 'maerl bed communities'.

The live maerl nodules do not constitute a 'live maerl bed' and are considered to be most likely to be dying off naturally in the channel following their movement into the channel from the south of the site. The loss of the live nodules from this area due to the proposed works is not predicted to affect the functioning or long term integrity of the system.

## 4.7 Removal of Associated Species/Communities during the Capital Dredging

The removal of species associated with the maerl proposed to be removed during the capital dredging has been addressed through the proposed mitigation strategy and the recovery potential of the re-placed habitat has been tested during a trial dredge and re-lay of maerl habitat. The key requirements for ensuring recovery of associated species is to ensure that the same, or similar, habitat is available following any disturbance to existing habitat and that the same species occur outside of the dredged area to enable recolonisation. The mitigation strategy has been designed to ensure that similar habitat would remain in the area and the benthic sampling undertaken before and after the trial dredge has shown that there was no significant difference between the species present prior to dredging and those that recolonised the site 44 weeks after dredging.

As described elsewhere, the trial dredge (further details in **Appendix G** and Sheehan *et al*, 2015) involved skimming the top 30cm of sediment from the seabed within two plots at six sample locations using a long reach excavator (**Plate 4**). The seabed material was then stored in a barge under seawater (**Plate 5**) before using the excavator to re-lay the material in the original location.


**Plate 4 Multi-purpose dredging pontoon and Tug**

**Plate 5 Barge used to store the maerl for 12 hours**

The benthic survey involved sampling within the maerl areas prior to the trial dredge and resampling 5 weeks and 44 weeks after the removal and re-lay of maerl habitat (Sheehan *et al* 2015). The six sample locations were identified within the channel area using data from a towed video survey (Sheehan et al 2015b) to locate maerl habitat. Each sample location had a control site (similar area of habitat not affected by the translocation) to enable a comparison with any natural changes in species assemblages that may occur during the survey period.

The method for survey was agreed in advance with the MMO and an Independent Scientific Advisory Panel in order to meet a number of objectives, namely:

- Does translocation of maerl affect the animal communities living within it (in terms of number of species, total abundance, species composition, biomass) and the nature of the habitat itself (proportion of live maerl within the dead maerl habitat, maerl structure, mean particle size, % organic content)?
- Are animal communities different between live and dead maerl and, if so, does translocation of dead maerl affect animal communities differently than translocation of live maerl?
- Are observed effects consistent across the different sites sampled along the proposed channel?
- Are effects detectable after 6 months?

Following the dredge and re-lay activity the habitat showed a loss of fine sediment resulting in an increase in mean particle size within the treatment samples. This change was only significant for the lower half of the core. There was no such significant interaction for organic content. The maerl structure seemed to remain relatively intact following the activity.

The results for community structure showed that there was a significant decrease in number of taxa and abundance in the treatment sites (sites with maerl extraction) at week 5, then an increase by week 44 such that no significant difference between treatment and control was evident. The only notable significant difference in faunal assemblage was the change in annelid biomass between the treatment and control sites that was evident in week 5 and maintained through to week 44. This was found to be due to the decline of one species of worm in the samples taken from before and after the dredge, and was thought to be due to the loss of fine material following habitat translocation.

In conclusion, the trial demonstrated that removing and replacing the top 30cm of the maerl habitat is technically feasible and whilst some differences in the habitat structure following re-laying were evident, associated with loss of fine sediment, this did not affect the habitat quality enough to prevent recolonisation of infauna. By 44 weeks after re-laying the dead maerl habitat, the diversity, abundance and species composition of infauna was not significantly different between the treatment and control conditions.

The habitat structure and associated invertebrate assemblage within the site containing live maerl were not notably more distinct than the dead maerl sites and the assemblage did not respond any differently from the other sites (Sheehan, et al, 2014).

The trial did not consider effects on species that could have occurred in deeper depths of sediment. Burrowing infauna within maerl typically lives 10-30 cm below the surface of a maerl bed (Bosence, 1979). Natural England has also stated that they do not expect any deep fauna in the planned dredged area of the Fal due to its silty nature (Marine Institute, 2012).

Scaling up of the trial for the actual mitigation proposal is not considered to be an issue due to the design of the trial itself and how this relates recolonisation following the capital dredge.

The trial methodology reflected as far as possible the likely conditions that will be experienced by the maerl during the main dredge i.e. the proposed storage time and monitoring of the maerl directly reflected comments from the potential dredging contractors in terms of what is realistic on a larger scale. The trial was designed to replicate conditions as would be experienced by the organisms living within the maerl (termed 'habitat perception windows') and after a certain threshold increasing the size of the area dredged was considered to have no influence. Each of the trial dredge areas was just smaller than a badminton court, from which two sets of five 10cm cores were taken from the central region (at least 2m from any edge) so the decision on plot size related to whether doubling or trebling the distance from sample to edge would make any difference. For small organisms of around a cm or less, there were not any edge effects (i.e. impact from the surrounding habitats and conditions) 2m into the trial dredge area, thus the conditions experienced by these organisms sampled are anticipated to be equivalent to those they would experience during the full dredge.

Additionally, many species within the maerl habitat disperse through larval movement. Species that reproduce through larval mechanisms are likely to have a high recolonisation potential as larval forms will drift in the currents and settle widely throughout the estuaries following spawning activity each year. Most benthic macrofaunal populations, except those in the high arctic and deep sea, have high fecundities and a planktonic larval phase to maximise dispersal (Kennish, 2000). In general, the microscopic size of the majority of the species found during the trial was such that recruitment to the newly dredged areas must have occurred through larval recruitment via passive transport in the water column rather than through recolonisation from the edge of the trial sites (i.e. laterally from un-dredged maerl habitat adjacent to the trial sites) given the size of the trial sites in comparison to the small species size. It is thus expected that recolonisation would occur through larval recruitment from the same species occurring within other areas of the estuary, as happened during the trial dredge. A comparison of estuary wide data from grab sampling undertaken for the Water Framework Directive (APEM, 2010) showed that the majority of species found within the trial dredge areas were also found within other areas of the estuary. Ecological survey work reported in the 2009 ES also shows that the macrofaunal community is relatively consistent across the study area, and this included samples taken from within the channel and outside of the channel. This provides additional evidence to support the viability of larval recruitment from surrounding areas.

Research carried out for aggregate extraction sites also supports the recovery potential of the site, showing that substantial recovery of community composition can occur in mobile sandy deposits in the Southern North Sea over a period of months (Newell and Woodcock (2013). This also supports the results of other studies carried out in sandy deposits elsewhere.

Slower growing species, generally found in more stable, coarser deposits can take longer to recover but given the method to be used, many of the slower growing species may either evade the dredge altogether or remain in the maerl during translocation and recolonise the site following relay. The trial found that there was no significant change to the overall biomass of mollusca, crustacea and echinodermata across the study area and suggested that this could be due to the larger individuals of these groups remaining present at 5 and 44 weeks after dredging (Sheehan *et a,* 2014).

The study did include photographic recording of quadrats to assess changes in the surface organisms. However it was concluded that due to the few observations of epifauna within the photoquadrats, no analyses were undertaken (Sheehan *et al,* 2014). Results were presented in a table however and showed that there were only 11 taxa from six phyla observed (4 arthropoda, 3 mollusca and one from each of Cnidaria, Annelida and Chordata).

Further analysis of towed video footage from Falmouth was carried out by the Plymouth University Marine Institute (Sheehan *et al*. 2015). The resulting data, together with data collated from Jersey, was analysed to determine whether the presence of live maerl fragments increased the ecosystem service 'habitat provision'. The paper showed that the number of epifauna taxa increased significantly in the Falmouth sites with increasing % occurrence of live maerl nodules but there was not a statistically significant relationship between the abundance of epifauna and % occurrence of live maerl. The area to be affected by dredging within Falmouth Harbour has very low levels of live maerl (the majority of sites with <10% cover) which could offer an explanation as to the very low numbers of epifauna taxa and abundance present during both surveys. The analysis of towed video data again showed that the density of epifaunal taxa within the Falmouth sites was very low (with 2.9 taxa per $m^2$ for mixed maerl habitat (which includes some sites with only 4% occurrence of live maerl nodules and 40% of maerl habitat) and 2.55 per $m^2$ for dead maerl habitat), which may explain some of the findings from the paper. The greatest difference observed in the findings of the paper is between the numbers of tube worms present in the sample sites with a higher number in the sites associated with live maerl (which also show a higher number of taxa). These worms are found in fine sediment habitats with stones and sand and build tubes out of shell fragments and small stones. However it is also recognised in the paper that the tube worms themselves increase the structural complexity of the habitat. This is not discussed further within the paper but it could offer a potential explanation as to why these sites also have a higher number of taxa. The results were not consistent for the two areas and showed that for the sites surveyed in Jersey, beds with live maerl supported less individuals than dead maerl and a similar number of taxa. It is possible that the differences observed in Falmouth could be due to other response variables that were not assessed.

Given the findings above, it is predicted that there would not be a significant impact on infauna or epifauna species in the medium and long term. The trial dredge has shown that recovery of the community is likely to occur rapidly. Depending on the exact time of year of the dredging, recovery should initiate during the following spring and summer and a similar community is expected within the short term (i.e. one to two years).

## 4.8 Operational Phase

The objective for providing a deeper channel is to allow larger vessels into the Docks and to improve the operating tidal window for vessels with deep drafts.

In terms of operational impacts on the features of interest within the SAC there are not likely to be any significant impacts during this phase. Any changes linked to vessel usage would be unlikely to affect any of the features of interest. There is also unlikely to be a requirement for maintenance dredging according to the modelling undertaken and based on the current lack of maintenance dredging required.

## 4.9 Summary of Predicted Effects

The main way in which the SAC features could be affected by the proposed works is through the removal of habitats and communities within the footprint of the dredge, during the capital dredging. The predicted effects of this on the SAC favourable condition targets (taken from the Regulation 33 Package (2000) are set out in **Table 4-1** below. **Table 4-2** provides a summary for predicted effects for all of the relevant attributes from the more recent draft supplementary advice package (2015).

## 4.10 Potential for Adverse Effect on Integrity

Guidance on what constitutes the integrity of a European site has been provided by the European Commission (EC, 2000). In this guidance, integrity is defined as: *"the coherence of the site's ecological structure and function, across its whole area, which enables it to sustain the habitat, complex of habitats and/or populations of species for which the site has been designated"*.

There are a number of factors that require consideration when determining the potential for an adverse effect on integrity, including the scale of the effect, the longevity of that effect, and the certainty of the impacts on the Annex I habitat.

### 4.10.1 Scale of effect

Although dead maerl habitat is not mapped quantitatively it is known to occur widely throughout the estuaries and within Falmouth Bay. As a result of the proposed dredging and mitigation strategy, there is not expected to be a loss of dead maerl habitat, indeed an overall enhancement of the ratio of mixed maerl habitat to pure maerl habitat is predicted through the replacement of an area of maerl with sediment to an area of pure maerl.

There is no predicted effect on the live maerl beds in the estuaries. There is only expected to be a minimal effect on the mixed dead maerl habitat which has a scattering of live nodules on the surface within the dredge footprint, with an estimated loss of live maerl of up to 0.17% of the overall live maerl resource in the SAC. This loss is not from a live maerl bed but from an area with very low cover (averaging <10% cover) of live maerl. **Figures 4-9**, **4-10** and **4-11** in **Section 4.6** show the areas of live maerl within the estuaries and illustrate the low abundance live maerl within the channel area that would be affected. The MMO have previously determined that the worst case scenario loss of 0.0015% of overall maerl habitat (dead and/or alive) due to the effects of the Trial would not constitute an adverse effect on the integrity of the sandbank feature (MMO, 2012).

Any change to communities associated with the maerl is expected to be a temporary localised effect within the dredge footprint. The species associated with the maerl are typically found throughout the estuary.

*Table 4.1 Impacts on favourable conditions (based on Regulation 33 package)*

| Sub-feature | Attribute | Target | Potential construction impact | Preventative measures | Significance of residual impact | Effect on designated site |
|---|---|---|---|---|---|---|
| Large shallow inlet and bay | | | | | | |
| | Extent | No decrease in extent from an established baseline. | No impact on extent of shallow inlet and bay | N/A | N/A | No change from existing situation |
| | Water clarity | Average light attenuation should not deviate significantly from the established baseline, subject to natural change. | Small increase in SSC during works.<br>Deeper depth of channel would change light attenuation but not considered to affect photosynthetic yield as change is minimal. | Type of material and the selection of a backhoe dredge would reduce the potential for a significant sediment plume | N/A | Temporary change of minor significance during construction |
| | Nutrient status – phytoplankton concentration | No significant increase in phytoplankton concentration from the established baseline, subject to natural change. | No impact on phytoplankton concentration | N/A | N/A | No change from existing situation |
| Rocky shore communities | Distribution of characteristic rocky shore communities | No decrease in littoral extent of range of rocky shore communities from an established baseline value (intertidal biotope mapping survey 1998), subject to natural change. | No route for impact on extent of rocky shores. | N/A | N/A | No change from existing situation |
| | Species composition of low- shore boulder communities | Presence and abundance of composite species (biotope MLR.Fse.Bo.) should not deviate significantly from established baseline, subject to natural change | No route for impact on extent of rocky shores. | N/A | N/A | No change from existing situation |
| | Species composition of | Presence and abundance of composite species should not | No route for impact on extent on rockpool communities. | N/A | N/A | No change from existing situation |

| Sub-feature | Attribute | Target | Potential construction impact | Preventative measures | Significance of residual impact | Effect on designated site |
|---|---|---|---|---|---|---|
| | rockpool communities | deviate significantly from established baseline, subject to natural change. Average percentage cover of *Sargassum muticum* (Japweed) should not increase from the established baseline. | | | | |
| Kelp forest communities | Algal species composition | Presence and abundance of composite algal species should not deviate significantly from established baseline, subject to natural change. | No impact likely on kelp beds – the proposed works would only affect the area around the dredge zone. There were no kelp beds found within the direct dredge zone and surrounding area. Any increases in SSC would be temporary and settlement of material would be minimal and close to the dredge zone. | N/A | N/A | No change from existing situation |
| | Characteristic species – *Laminaria hyperborea & L. ochroleuca* population size | Average ratio *of Laminaria hyperborea: L. ochroleuca* should not deviate significantly from an established baseline, subject to natural change. Average density of each species should not deviate significantly from an established baseline, subject to natural change. | No impact likely on kelp beds – the proposed works would only affect the area around the dredge zone. There are no indications of kelp communities within the direct dredge zone and surrounding area. Any increases in SSC would be temporary and settlement of material would be minimal and close to the dredge zone. | N/A | N/A | No change from existing situation |
| | Characteristic species – *Distomus* | Average percentage cover should not deviate significantly from an established baseline, | No impact likely on kelp beds – the proposed works would only affect the area around | N/A | N/A | No change from existing situation |

| Sub-feature | Attribute | Target | Potential construction impact | Preventative measures | Significance of residual impact | Effect on designated site |
|---|---|---|---|---|---|---|
| | *variolosus* population size | subject to natural change. | the dredge zone. There are no indications of kelp communities within the direct dredge zone and any increases in SSC would be temporary and settlement of material would be minimal and close to the dredge zone. | | | |
| Subtidal rock and boulder communities | Species composition of characteristic biotopes MCR.ErSEun and ECR.AlcMas | Presence and abundance of composite species should not deviate significantly from an established baseline, subject to natural change. | No impact – the proposed works would not impact on these community types. | N/A | N/A | No change from existing situation |
| Subtidal mud communities | Species composition of characteristic biotopes | Presence and abundance of composite species should not deviate significantly from an established baseline, subject to natural change. | The capital dredge would remove communities associated with the clay habitats in the inner harbour area. The habitat remaining after the dredge would be the same as that which is there prior to the dredge and it is anticipated that the same communities would recolonise the clay habitats. | N/A | Negligible | No significant effect |
| Subtidal sandbanks | | | | | | |
| | Extent | No decrease in extent from an established baseline, subject to natural change. | No change in extent of subtidal sandbanks | N/A | N/A | No change from existing situation |
| | Sediment character | Average PSA parameters should not deviate significantly from an established baseline, | Removal of mixed maerl habitat through capital dredge. | Replacement of viable habitat to ensure no net loss of maerl habitat within | Negligible Minimal change due to reduction in fine sediment | No significant net loss of extent of sediment character within the maerl habitat |

| Sub-feature | Attribute | Target | Potential construction impact | Preventative measures | Significance of residual impact | Effect on designated site |
|---|---|---|---|---|---|---|
| | | subject to natural change. | | the SAC | content at a lower depth profile as fines are removed during the removal and re-laying process (not considered to be a significant change). | existing extent given mitigation measure |
| | Topography | Depth distribution should not deviate significantly from an established baseline, subject to natural change. | Capital dredge would increase the depth within the navigation channel to accommodate vessels. Depth would not be such that photosynthetic ability would be affected. | N/A | N/A | Navigation channel would be deeper than the existing channel |
| | Water density | Average temperature/salinity should not deviate significantly from an established baseline, subject to natural change. | No impact anticipated | N/A | N/A | No change from existing situation |

| Sub-feature | Attribute | Target | Potential construction impact | Preventative measures | Significance of residual impact | Effect on designated site |
|---|---|---|---|---|---|---|
| Eelgrass bed communities | Extent | No decrease in extent from an established baseline, subject to natural change. | No impact – the proposed works would only affect the immediate area around the dredge zone and jetty and, therefore, no eelgrass habitats would be impacted. | N/A | N/A | No change from existing situation |
| | Characteristic epiphytic species – *Zostera marina* | Average density should not deviate significantly from an established baseline, subject to natural change. | No impact – the proposed works would only affect the immediate area around the dredge zone and jetty and, therefore, no eelgrass habitats would be impacted. | N/A | N/A | No change from existing situation |
| | Characteristic species – Epiphytic community | Presence and abundance of epiphytic species should not deviate significantly from an established baseline, subject to natural change. | No impact – the proposed works would only affect the immediate area around the dredge zone and jetty and, therefore, no eelgrass habitats would be impacted. | N/A | N/A | No change from existing situation |
| | Nutrient status – green algal mats | No increase in extent of green algal mats from an established baseline, subject to natural change. | No impact – the proposed works would only affect the immediate area around the dredge zone and jetty and, therefore, no eelgrass habitats would be impacted. | N/A | N/A | No change from existing situation |
| Maerl bed communities | Extent | No decrease in extent of maerl as a whole, or of either dead or live maerl, from an established baseline, subject to natural change. | Capital dredging would remove maerl and mixed maerl habitat (small fragments of live maerl) from the navigation channel | Replace lost habitat by overdredging and replacing with mixed and pure maerl substrate dredged during same campaign. | There would be no decrease in extent of maerl habitats. Temporary loss of habitat only whilst re-lay process occurs (i.e. approximately 12 hours). Loss of minimal cover of live maerl in an area of dead maerl communities in | No decrease in live maerl bed communities. No decrease in extent of maerl bed communities or maerl bed habitat as a whole. Temporary loss of dead maerl communities and loss of low cover of live maerl from area of dead maerl communities in |

| Sub-feature | Attribute | Target | Potential construction impact | Preventative measures | Significance of residual impact | Effect on designated site |
|---|---|---|---|---|---|---|
| | | | | | the channel not considered to be of significance. | the channel. Such changes are considered not to have a significant effect on the designated site. |
| | Distribution of maerl bed communities | Distribution of maerl bed communities should not deviate significantly from an established baseline, subject to natural change. | Capital dredge will remove mixed maerl communities from the navigation channel | Replace lost habitat by overdredging and replacing with mixed maerl substrate dredged during same campaign to promote recolonisation with similar community | Temporary localised impact as the distribution of maerl bed communities would not change overall in the medium to long term but there would be a temporary disturbance to the habitat followed by subsequent short term recovery of similar communities. | No significant changes in distribution over the medium to long term. |
| | Species composition of maerl bed communities | Presence and abundance of composite species should not deviate significantly from an established baseline, subject to natural change. | Capital dredge will remove species associated with mixed maerl habitats | Habitat replacement and presence of the same species/communities close to the dredge area would promote recolonisation with same or similar species composition | Temporary localised impact with recovery predicted within approximately one to two years. | Temporary effect on designated site until area recolonises. |
| | Nutrient status – green algal mats | No increase in extent from an established baseline, subject to natural change. | No anticipated impact | N/A | N/A | No change from existing situation |

| Sub-feature | Attribute | Target | Potential construction impact | Preventative measures | Significance of residual impact | Effect on designated site |
|---|---|---|---|---|---|---|
| Gravel and sand communities | Species composition of characteristic biotopes | Presence and abundance of composite species should not deviate significantly from an established baseline, subject to natural change. | Capital dredge would remove communities associated with gravel and sand habitats | Habitat replacement and presence of the same communities close to the dredge area would ensure that recolonisation occurs | Temporary, localised impact | Temporary effect on designated site until area recolonises. |
| Mixed sediment communities | Species composition of characteristic biotopes | Presence and abundance of composite species should not deviate significantly from an established baseline, subject to natural change. | Capital dredge would remove communities associated with mixed sediment habitats | Habitat replacement and presence of the same communities close to the dredge area would ensure that recolonisation occurs | Temporary, localised impact | Temporary effect on designated site until area recolonises. |
| Intertidal mudflats and sandflats | | | | | | |
| | Extent | No decrease in extent from an established baseline, subject to natural change. | No impact – the proposed works would only affect the immediate area around the dredge zone and jetty and, therefore, no intertidal habitats would be impacted. | N/A | N/A | No change from existing situation |
| | Sediment character | Particle size parameters and sediment penetrability should not deviate significantly from an established baseline, subject to natural change. | No impact – the proposed works would only affect the immediate area around the dredge zone and jetty and, therefore, no intertidal habitats would be impacted. | N/A | N/A | No change from existing situation |
| Mud communities | Extent and distribution of characteristic biotopes | Extent and distribution of the biotopes should not deviate significantly from an established baseline, subject to natural change. | No impact – the proposed works would only affect the immediate area around the dredge zone and jetty and, therefore, no intertidal habitats would be impacted. | N/A | N/A | No change from existing situation |
| | Topography | Shore profile measurements should not deviate significantly from an established baseline, | No impact – the proposed works would only affect the immediate area around the | N/A | N/A | No change from existing situation |

| Sub-feature | Attribute | Target | Potential construction impact | Preventative measures | Significance of residual impact | Effect on designated site |
|---|---|---|---|---|---|---|
| | | subject to natural change. | dredge zone and jetty and, therefore, no intertidal habitats would be impacted. | | | |
| | Nutrient status – green algal mats | Extent of green algal mats should not increase from an established baseline, subject to natural change. | No impact – the proposed works would only affect the immediate area around the dredge zone and jetty and, therefore, no intertidal habitats would be impacted. | N/A | N/A | No change from existing situation |
| Sand and gravel communities | Extent and distribution of characteristic biotopes | Extent and distribution of the biotopes should not deviate significantly from an established baseline, subject to natural change. | No impact – the proposed works would only affect the immediate area around the dredge zone and jetty and, therefore, no intertidal habitats would be impacted.. | N/A | N/A | No change from existing situation |
| Muddy sand communities | Extent and distribution of characteristic biotopes | Extent and distribution of the biotopes should not deviate significantly from an established baseline, subject to natural change. | No impact – the proposed works would only affect the immediate area around the dredge zone and jetty and, therefore, no intertidal habitats would be impacted. | N/A | N/A | No change from existing situation |
| Atlantic salt meadows | | | | | | |
| | Extent | No decrease in extent of Atlantic salt meadows from an established baseline, subject to natural change. | No impact – the proposed works would only affect the immediate area around the dredge zone and jetty and, therefore, no salt marsh habitats would be impacted. | N/A | N/A | No change from existing situation |
| | Creek patterns | No significant alteration of creek patterns from an established baseline, subject to natural change. | No impact – the proposed works would only affect the immediate area around the dredge zone and jetty and, | N/A | N/A | No change from existing situation |

| Sub-feature | Attribute | Target | Potential construction impact | Preventative measures | Significance of residual impact | Effect on designated site |
|---|---|---|---|---|---|---|
| | | | therefore, no salt marsh habitats would be impacted. | | | |
| | Range and distribution of characteristic NVC communities | Range and distribution of characteristic saltmarsh communities should not deviate significantly from an established baseline, subject to natural change. | No impact – the proposed works would only affect the immediate area around the dredge zone and jetty and, therefore, no salt marsh habitats would be impacted. | N/A | N/A | No change from existing situation |
| | Vegetation structure | Vegetation structure should not deviate significantly from an established baseline, subject to natural change. | No impact – the proposed works would only affect the immediate area around the dredge zone and jetty and, therefore, no salt marsh habitats would be impacted. | N/A | N/A | No change from existing situation |

***Table 4.2*** *Impacts on sub-features within the sandbank feature of the Fal and Helford SAC (based on draft supplementary advice package, 2015)*

| Sub-feature | Attribute | Measure | Target | Potential Impact | Preventative Measures | Significance of residual impact | Effect on designated site |
|---|---|---|---|---|---|---|---|
| Maerl beds | Extent and distribution | Presence and Area (ha) of maerl (live and dead). Currently estimated at 1041 ha (but accepting that may not include all current known areas not yet mapped). | Maintain the total extent and spatial distribution of maerl bed | Removal of dead maerl (with minimal live nodules) habitat during the dredging activity. No impact on live maerl beds. | Mitigation strategy in place to replace dead maerl habitat. | No significant impact on extent of distribution of dead maerl habitat following mitigation. Overall enhancement of 1.2 ha of dead maerl habitat from mixed maerl to pure maerl. No significant effect on live maerl given the very low extent of live maerl to be removed during the dredging (0.17% of total within SAC). Distribution of live maerl is expected to recover over time when live nodules are moved into the channel by water | Loss of minimal area of live maerl is not considered to be a significant effect on the overall function of the site. Only 0.17% loss of overall live maerl from the SAC which occurs from an area that is not a live maerl bed but low % cover of nodules moved into the site from an area of higher abundance through water movements. A temporary effect on the distribution of live maerl in the designated site until live maerl is transported back into the |

| Sub-feature | Attribute | Measure | Target | Potential Impact | Preventative Measures | Significance of residual impact | Effect on designated site |
|---|---|---|---|---|---|---|---|
| | | | | | | movements. | channel through water movements. |
| | Extent of supporting habitat | Extent is known to migrate. Area needs to be maintained to allow it to continue to migrate. | Maintain the area of habitat which is likely to support the feature | Removal of habitat during dredging | Mitigation strategy proposed | No significant impact | Temporary localised effect during dredging activity but supporting habitat to be replaced immediately post dredging. No overall change to supporting habitats within the designated site. |
| | Distribution of maerl bed communities | Detailed location and pattern of maerl habitats within the potential area of occupation. Linked to distribution of biotopes. | Restore the presence and spatial distribution of maerl bed communities. | Removal of associated species/communities during the capital dredging | Mitigation strategy will replace habitat removed with similar habitat | Mitigation strategy has shown that a similar infaunal community recolonised the translocated maerl habitat within 44 weeks. Mobile epifauna are of very low abundance and would be expected to either evade removal from the site or recolonise from surrounding areas rapidly. | Temporary localised effect on designated site until area recolonises. No change in the medium to long term. Expect to see recovery within 1-2 years. |
| | Structure: age/size frequency | A full range of sizes of maerl pieces should be present to ensure a healthy, productive population. | Restore the size structure and composition of maerl thalli across the site | Removal of maerl during dredging | Mitigation strategy will translocate the maerl habitat which will replace the same age/size frequency as that removed. | No significant impact predicted | No change predicted |
| | Structure: biomass | Amount of live thalli usually found at or near the surface of the bed. | Restore the biomass of maerl to natural levels within the site, to ensure a healthy, resilient habitat. | Removal of maerl during dredging | Live maerl will be removed during the dredge which will reduce the overall biomass | The removal of live maerl is so minimal that it is not expected to be significant in terms of overall biomass. | Not considered to be a significant effect on the designated site. Only 0.17% loss of overall live maerl cover from the SAC. |
| | Supporting | Wave energy and tidal | Maintain the | Hydrodynamic | Not required | No significant change to coastal | No change |

| Sub-feature | Attribute | Measure | Target | Potential Impact | Preventative Measures | Significance of residual impact | Effect on designated site |
|---|---|---|---|---|---|---|---|
| | processes: energy/ exposure | flows across the site. | natural physical energy resulting from waves, tides and other water flows, so that the exposure (high, medium, low) does not cause alteration to the biotopes, and stability, across the habitat. | changes potentially affecting the functioning of the estuary or the maerl bed communities | | processes predicted. | |
| | Structure: non-native species and pathogens | Presence of non-native species. | Reduce the introduction of non-native species and pathogens, and their impacts. | No change to risk of invasive species expected. | Not required over and above actions taken by the port during normal operations | No significant change | No change |
| | Structure: population abundance | Total volume of live and dead maerl across the site. | Restore the abundance of maerl across the sub-feature | Removal of maerl during dredging will remove some volume of maerl and maerl mixed with sediment. Removal of habitat depth would remove potential for burrowing species. | Mitigation strategy will reduce loss of volume in the site. It has also been designed to ensure that sufficient depth of habitat remains on site to enable burrowing species to recolonise. | Although there will be a loss of volume this will not affect the surface area or volume available for associated communities. Sufficient depth of habitat will remain following mitigation measures. | Not expected to be a significant change to the designated site as enough depth of maerl will remain to provide a viable habitat. |
| | Structure: presence and abundance of typical species | To be determined by Natural England (typical species for the habitat feature). | [Maintain OR Recover OR Restore] the abundance of listed typical species, to enable | Typical species to be advised by Natural England once further work is undertaken. In the interim reference should be | Mitigation strategy in place to ensure similar habitat remains for recolonisation of similar species. | Similar communities expected to recolonise the site in the medium to long term so not expected to affect any typical species significantly. | Temporary localised effect on designated site until recolonisation occurs. No change in the medium to long term. |

| Sub-feature | Attribute | Measure | Target | Potential Impact | Preventative Measures | Significance of residual impact | Effect on designated site |
|---|---|---|---|---|---|---|---|
| | | | each of them to be a viable component of the habitat. | made to the distribution of maerl bed communities above | | | |
| | Structure: sediment composition and distribution | Distribution of maerl communities. | Maintain the existing distribution of sediment composition types across the sub-feature. | Removal of dead maerl will change the sediment composition in some areas by reducing the finer sediment component of the habitat. It is expected that this will built up over time gradually. The reduction in fine sediment did not significantly affect the recovery potential of the community apart from the biomass of polychaetes which was thought to be due to the decline of one species. | Mitigation strategy will translocate the habitat following dredging. May be some minor localised change to fine sediment component in the short term. | Not considered to be significant | Temporary localised effect on sediment composition following dredging until fine sediment component resettles within the affected area. Change is minimal and not considered to influence the status of the designated site. |
| | Structure: species composition of component communities | Species overall range and relative abundance. | Restore the species composition of component communities. | Removal of associated species/ communities during dredging. | Mitigation strategy proposed to provide similar habitat for recolonisation | Not significant in the medium or long term. | Temporary localised effect on designated site until recolonisation occurs. No significant effect on overall SAC in the medium to long term. |
| | Supporting processes: light levels | Depth of maerl from the surface. | Maintain the natural light availability at the maerl surface. | Changes to bathymetry affecting maerl bed communities could affect photosynthetic | Not required | Maerl is known to photosynthesise at greater depths within the Fal Estuary with similar conditions as the dredged area. It is therefore not | No change to functioning of maerl within designated site |

| Sub-feature | Attribute | Measure | Target | Potential Impact | Preventative Measures | Significance of residual impact | Effect on designated site |
|---|---|---|---|---|---|---|---|
| | | | | ability of live maerl nodules | | expected to be an impact. | |
| | Supporting processes: physico-chemical properties | Salinity, pH and temperature. | Maintain the natural physico-chemical properties of the water. | No change due to proposed dredge | Not required | No impact | No change |
| | Supporting processes: sedimentation rate | Sedimentation rates within the estuary | Maintain the natural rate of sediment deposition. | Deposition of sediment during dredging and operation. Localised change in sedimentation rate during dredging and in the short-term following dredging whilst channel profile stabilises. | Slope of channel edge is profiled to minimise slumping. Additional measures not required | Not expected to have a significant effect on areas of maerl habitat. | No significant change overall to the designated site |
| | Supporting processes: water quality - contaminants | Contaminant levels within the estuary. | Reduce aqueous contaminants to levels equating to High / Good Status (according to Annex VIII and X of the Water Framework Directive), avoiding deterioration from existing levels. | Release of contaminants caused by dredging mobilising contaminated sediment. | Mechanical dredging method selected for works and additional measures proposed for dredging fine sediment where contamination is high to include use of a closed bucket. Contaminated sediment will be removed and treated onshore. | May be some temporary increase in mobilisation of contaminants that will increase the concentration of certain contaminants. Outstanding issue for TBT within the estuary already. Dredging will remove some areas of contamination which could improve the status locally. | Temporary localised effect from remobilisation which should be balanced against localised benefit of removal of contaminants from the site. Not considered to be a significant effect overall on the status of the designated site. |
| | Supporting | DO concentrations | Maintain the | Trial showed slight | Not required | No significant impact | No significant change |

| Sub-feature | Attribute | Measure | Target | Potential Impact | Preventative Measures | Significance of residual impact | Effect on designated site |
|---|---|---|---|---|---|---|---|
| | processes: water quality - dissolved oxygen | within the estuary | dissolved oxygen (DO) concentration at levels equating to High Ecological Status (specifically ≥ 5.7 mg per litre (at 35 salinity) for 95 % of the year), avoiding deterioration from existing levels. | localised decline in dissolved oxygen levels during dredging but still remains very high level of DO. | | | |
| | Supporting processes: water quality - nutrients | Nutrient concentrations within the estuary | Restore the natural water quality and specifically winter dissolved inorganic nitrogen (DIN) to a concentration equating to Good Ecological Status (specifically mean winter DIN is < 12 μM for coastal waters), avoiding deterioration from existing levels. | Not expected to change significantly. | Not required | No significant impact | No significant change |
| | Supporting processes: water quality - turbidity | Turbidity measurements within the estuary | Maintain natural levels of turbidity (e.g. suspended concentrations of sediment, | Increase in sediment suspension concentrations occurs in a localised area around the dredger at | Mechanical dredging will reduce the amount of breakdown of the sediment structure | Not expected to be significant in the medium or long term or beyond a localised zone around the dredger. | No significant change to the overall functioning of the SAC. |

| Sub-feature | Attribute | Measure | Target | Potential Impact | Preventative Measures | Significance of residual impact | Effect on designated site |
|---|---|---|---|---|---|---|---|
| | | | plankton and other material) across the habitat. | any one time. The increases predicted are only temporary and as such not expected to have an impact on habitats or species in the SAC. | and release less sediment into suspension. Dredging in fine sediment to be undertaken with a closed bucket to minimise turbidity. | | |
| | Supporting processes: disturbance regime | Level of disturbance within the estuary | Maintain the natural maerl disturbance regime. | Removal of maerl during dredging and removal of associated species. Dredging will cause the disturbance of maerl habitat in the dredge area. This is only a temporary effect and it is not expected that there will be a need for maintenance dredging so unlikely to be regular levels of disturbance. | Not required | Not expected to be significant given a low frequency of disturbance and temporary effect. | No significant change to overall function of SAC |
| Subtidal mixed sediment s | Extent and distribution | Presence and area of habitat | Maintain the total extent and spatial distribution of subtidal mixed sediment. | Dredging will remove sediment from the dredge footprint and cause some localised deposition in the surrounding area. | A mechanical dredger is proposed which will reduce the overall losses of sediment into suspension. | The habitat that will remain post dredging will be very similar to that which existed prior to dredging. There should not be a significant change to the subtidal mixed sediments other than a temporary localised reduction of fine material in some areas. | There is not expected to be a significant effect on the designated site. A temporary localised effect on the designated site will occur until the minimal % of fine sediments gradually resettle within the area. |
| | Distribution: presence and spatial | Variety of communities present based on | Maintain the presence and spatial distribution | Removal of associated species/ communities during | Mitigation strategy will replace habitat removed with | Mitigation strategy has shown that a similar infaunal community recolonised the translocated | Temporary localised effect on designated site until area recolonises. No change in the |

| Sub-feature | Attribute | Measure | Target | Potential Impact | Preventative Measures | Significance of residual impact | Effect on designated site |
|---|---|---|---|---|---|---|---|
| | distribution of subtidal mixed sediment communities | representative biotope descriptions | of subtidal mixed sediment communities. | the capital dredging | similar habitat | maerl habitat within 44 weeks. Mobile epifauna are of very low abundance and would be expected to either evade removal from the site or recolonise from surrounding areas rapidly. | medium to long term. Expect to see recovery within 1-2 years. |
| | Structure: presence and abundance of typical species | Abundance of typical species (further work necessary by Natural England) | [Maintain OR Recover OR Restore] the abundance of listed typical species, to enable each of them to be a viable component of the habitat. | Further work necessary to define typical species but removal of species/ Communities has been assessed and would include typical species present. | Mitigation strategy will replace habitat removed with similar habitat | Mitigation strategy has shown that a similar infaunal community recolonised the translocated maerl habitat within 44 weeks. Mobile epifauna are of very low abundance and would be expected to either evade removal from the site or recolonise from surrounding areas rapidly. | Temporary localised effect on designated site until area recolonises. No change in the medium to long term. Expect to see recovery within 1-2 years. |
| | Structure: sediment composition and distribution | Sediment character | Maintain the distribution of sediment composition types across the feature | Dredging will remove sediment from the dredge footprint and cause some localised deposition in the surrounding area. | A mechanical dredger is proposed which will reduce the overall losses of sediment into suspension. | The habitat that will remain post dredging will be very similar to that which existed prior to dredging. There should not be a significant change to the subtidal mixed sediments other than a temporary localised reduction of fine material in some areas. | There is not expected to be a significant effect on the designated site. A temporary localised effect on the designated site will occur until the minimal % of fine sediments gradually resettle within the area. |
| | Structure: species composition of component communities | Species composition of communities including the range of species and their relative abundance | Maintain the species composition of component communities. | Removal of associated species/ communities during the capital dredging | Mitigation strategy will replace habitat removed with similar habitat | Mitigation strategy has shown that a similar infaunal community recolonised the translocated maerl habitat within 44 weeks. Mobile epifauna are of very low abundance and would be expected to either evade removal from the site or recolonise from surrounding areas rapidly. | Temporary localised effect on designated site until area recolonises. No change in the medium to long term. Expect to see recovery within 1-2 years. |

### 4.10.2 Longevity of effect

There is only expected to be a short term impact on maerl habitat and its associated communities whilst the recovery process occurs following removal, re-lay and, in some localised areas, slope stabilisation. Recovery of the dead maerl habitat and associated species is expected to occur within one to two years.

The living maerl nodules that occur on the dead maerl habitat would be lost through burial during relay and some of the live maerl that rolls into the new channel during the first year could be smothered during any slope stabilisation but would be expected to be replaced in terms of overall distribution over the short to medium term as water movements transport live maerl from areas of higher abundance back into the dredged area following slope stabilisation. The timing of this recovery process is highly dependent on water movements within the estuaries. It is expected that nodules of live maerl would start to move back into the estuary within the same period of recovery for the associated communities. There is some uncertainty over the time period for the cover of live maerl to reach similar levels to at present given that this is dependent on natural processes. However, given the low levels of cover currently present in this area it is expected that it would be within the medium term (5-10 years).

### 4.10.3 Level of certainty

The HRA previously submitted for this project outlined the recovery potential for the communities associated with the maerl habitat as being between 2 and 5 years. There was some scientific doubt about this conclusion and further work was commissioned in the form of a trial dredge and monitoring. The results of the monitoring for the trial dredge have been reported in the sections above and show that substantial recovery occurred within 44 weeks. Recovery of the communities associated with the maerl habitat is, therefore, expected to occur within one to two years, depending on the time of the year of the dredging activity.

As outlined above there is some uncertainty over the timescale of full recovery of the percentage cover of live maerl nodules, as this is dependent on natural processes which can be variable. However, the loss of this minimal area (up to 0.17% of overall live SAC resource currently known to occur in the SAC) of low abundance live maerl is not expected to have a significant effect on the overall maerl habitat and associated communities. The effect on live maerl has been assessed based on a review of available scientific knowledge. A live maerl technical note has been produced which outlines the findings from this review in relation to the potential for impact on live maerl (**Appendix B**). This technical note has been peer reviewed by a maerl expert (**Appendix C**) and is, therefore, expected to reflect up-to-date scientific expertise.

### 4.10.4 Relevant Information from Previous Case Studies

Legal precedent is often referred to during Appropriate Assessment decisions. However, it is recognised that every situation has to be considered with reference to its own specific circumstances so, whilst similarities can be considered, the outcome will be dependent on the individual case.

#### Loss of extent

A small scale loss can be significant in some circumstances and has been judged to be so in the case of the Sweetman Ruling [C258/11] where, even though the predicted loss was small, because it was permanent it was determined to represent an adverse effect on the integrity (AEOI) of the European site in question. In the Sweetman case the habitat in question was 'priority' Annex I habitat, whereas maerl bed is a sub-feature of a non-priority Annex I habitat (subtidal sandbanks), with the species itself being listed in

Annex V of the Habitats Directive; which is for animal and plant species of community interest whose taking in the wild and exploitation may be the subject of management measures. Priority habitats are defined as those that are considered to be particularly vulnerable; it is therefore expected that Priority habitats are likely to have a greater degree of protection than non-priority habitats and sub-features of Annex I habitats.

When the significance of the effect predicted in this case is considered, the above needs to be taken into account, along with the extent of the loss and other factors relating to the location of the live maerl within a navigation channel (an area expected to be subject to periodic disturbance and already present at the time of designation), the expected life span of live maerl in this area, the potential for impact on the functioning of the site and the ecological niche that the live nodules provide. Hence, in the context of the Sweetman Ruling, an AEOI is not predicted in the case of the proposed channel dredging.

In the more recent CJEU Briels case (C-521/12), the concern was the potential loss of non-priority Annex I habitat and involved clarification regarding the application of mitigation and compensation. However this case involved a likely significant 'residual' effect on account of increasing levels of pollutants that would be generated as a result of the project. This, together with the effect of drying out and acidification of the earth affecting 6.7ha of *Molinia* meadows, was considered in the assessment process. In addition to this, there was uncertainty over the created *Molinia* meadows being able to provide such a valuable habitat as existing areas that would be degraded. It was determined that the habitat creation works proposed would compensate for a residual impact that could not be mitigated and there was no guarantee that the project would not adversely affect the overall integrity of the site.

In the case of the proposed channel dredging, the removal of the sediment underneath the dead maerl habitat, which could have had a likely significant effect on dead maerl habitat, can be mitigated to ensure that no residual adverse effect on the habitat in question arises, through the contiguous replacement of the dead maerl habitat and subsequent (rapid) recolonisation of the habitat from species in the surrounding areas.

### In conclusion

It is not predicted that the proposed works would affect the overall ecological function, and hence the integrity, of the features or sub-features located within the Fal and Helford SAC.

There would be no permanent loss of habitat function within the SAC as a result of the proposed dredging works, either directly or indirectly. The short term loss would only be for the twelve hours during which the deepening occurs. Habitat re-lay would occur within twelve hours of removal.

It is expected, based on the positive results of a trial survey, that the communities associated with the dead maerl bed would recover within one to two years.

There would be a minimal loss of live maerl from the proposed navigation channel. The live maerl nodules do not play a significant role in the function of the site and maerl is listed in Annex V of the Habitats Directive and, as such, its exploitation is possible without significant effect on the national resource.

There would be no loss of live maerl from the sub-feature of 'live maerl bed' within the sandbanks Annex I habitat.

Hence there are not predicted to be any impacts of significance on the habitats or species within the SAC.

### 4.10.5 Recommended Monitoring

As outlined in NE's letter in response to the HRA Framework Document (RHDHV, 2015), it is proposed that an appropriate monitoring strategy will be discussed and agreed with NE and the MMO taking into account the Natural England/Falmouth Harbour Commissioners Joint Working Agreement (currently linked to the pSPA designation). Dependent on the outcome of the HRA process, this activity will occur.

# 5. POTENTIAL IMPACTS ON THE INTEREST FEATURES OF THE FALMOUTH BAY TO ST AUSTELL BAY PSPA

## 5.1 Assessment Approach

Conservation objectives for the features of the Falmouth Bay to St Austell Bay pSPA were published in February 2016 and the assessment of likely significant effect has been based on these, together with the baseline information presented in **Section 3.2**, including the recent bird survey data from O'Brien *et al.* (2014) and Liley *et al.* (2014). It is important to note that the winter of 2014 was subject to an unusually high level of storm events and it is therefore possible that the activity and behaviours observed may have been influenced by this. In the absence of specific favourable condition targets inferences have been drawn from existing SPA condition targets (e.g. the Liverpool Bay SPA) in light of the recently published attributes.

## 5.2 Dredging Phase

The details of the dredging activity proposed are provided in **Section 2** and the dredging programme is anticipated to be completed over the course of 6 to 12 months. The exact timing of the dredging would be influenced by a number of external factors including the weather, the appointed dredging contractor and the availability of suitable plant.

### 5.2.1 Physical disturbance (noise and visual) during dredging and dredge disposal

During the course of the dredge and disposal activity there would be additional vessel movements in and around the Falmouth Docks area, and out toward the offshore disposal site. The number of vessel movements would be influenced by the plant utilised by the dredging contractor and it is anticipated that the appointed contractor will seek to maximise the loading barge size in the interests of minimising the number of trips out to the disposal site (and therefore costs). However, if a barge with a capacity of c. $1000m^3$ is assumed then that would equate to approximately 2-8 movements per day (over the course of 6 to 12 months). Against a baseline of an average 380 vessel movements a day in 2014 (see **Figure 2.5**), this represents a 2% increase in vessel movements.

Many studies have looked into the effects of disturbance on estuarine waterbirds, although few have been able to demonstrate that disturbance can actually have an impact upon a population (Burton *et al.,* 2002). Disturbance usually interrupts bird activity patterns or displaces the birds for short distances away from the disturbing activity and only a small proportion of disturbance events may actually cause birds to leave a site (Burton, 1996 in Burton *et al.,* 2002). Whilst the estuarine environment is important for the pSPA features they also spend much of their time further offshore and observations of Great northern and Black-throated divers in and around offshore windfarms have highlighted their sensitivity to vessel and aerial activity (e.g. Garthe & Huppop, 2004; Mendel *et al*., 2008; Furness *et al.*, 2013); and this is identified in the VA for the Falmouth Bay to St Austell Bay pSPA.

The Footprint Ecology survey of 2014 observed the highest numbers of Divers off Mawnan Smith and Pendennis Point, Gerrans Bay and Veryan Bay, with these locations holding significantly higher numbers of Divers than other locations. Pendennis Point is the closest vantage point to the proposed dredge and disposal activities being 1.3km from the proposed navigation channel and 8.3km from the disposal site. Although Pendennis Point is located around the corner from the docks some bird activity was observed in line with the docks during the 2014 survey (Liley *et al*., 2015). The most commonly recorded species were

Black-throated and Great Northern Divers which were predominantly noted to be diving for prey. In February, the divers off Pendennis Point accounted for 40% of all birds counted; in March, the counts represented 20% of all Great Northern Divers and 55% of all Black-throated Divers. There was also noted a tendency for the Black-throated Diver to gather in flocks during these months. Some were located close to the point and some were located across the estuary; larger groups of Black-throated Diver were observed to be slightly closer in shore, with some flocks appearing to be significantly closer to the vantage points (e.g. for flocks of more than 14 birds, the median observed distance was 632.4m from the mean high water mark (MHWM), compared to groups of between 5 and 14 birds being around 1236m from MHWM). A clear pattern was observed for both diving species with the density of birds declining with distance from the vantage points suggesting that birds have a preference for feeding at a particular distance from shore (Liley *et al*., 2014). The birds closest to the potential area of effect were mostly diving. Birds located across the estuary tended to be loafing/inactive. No major concentrations or rafts of roosting divers were, however, recorded.

Estimates can be made of the noise levels likely to be generated by different construction techniques and **Table 5.1** provides an indication of the noise levels associated with backhoe dredging and how these levels might change with increasing distance from the dredger.

***Table 5.1 Noise levels associated with backhoe dredging***

| Source Noise Level (dB LAeq) | Distance to receptor (m) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 10 | 20 | 50 | 100 | 200 | 500 | 1000 | 2000 | 5000 |
| Backhoe dredger | 74 | 68 | 60 | 54 | 48 | 40 | 34 | 28 | 20 |

It is possible that the presence of the dredger could result in some disturbance to the Divers overwintering in the pSPA (between October and March), particularly those around Pendennis Point. This could be particularly relevant for Great northern divers if dredging activity coincides with a loss of flight feathers. The largest amount of material to be removed from within the dredge footprint is expected to be at the western end of the channel, closest to the docks themselves. By contrast, the eastern end of the channel (closest to Pendennis Point) requires less dredging (as it is deeper already) and as such the dredger and loading barges are likely to spend less time operating in this area. Data collected by Liley *et al.* (2014) also indicate the presence of birds within the proposed dredge footprint and closer to the Docks suggesting there is some use of this area by the divers albeit to a lesser extent than other locations (see **Figure 5.1**). It is however recognised that the pSPA birds do not tend to make as much use of the areas close to the docks (NE VA, no date) and therefore it is likely that only the dredging activity to the eastern end of the proposed channel will have the potential to cause disturbance.

The noise levels generated by the backhoe dredger have been calculated together with attenuated levels at the distances from the proposed approach channel to the waters off Pendennis Point. At a distance of 500m from the dredge channel (which is calculated to be the closest part of the proposed approach channel to Pendennis Point) the noise from the dredger would be approximately 40dB LAeq. (in order to provide some context to the level of noise, this is equivalent to the noise level from a refrigerator). It is anticipated that this level of noise would have a negligible effect on the birds making use of the waters off Pendennis Point. The results of the Footprint Ecology survey (winter 2014/15) indicates that the birds prefer to be located relatively close to shore, especially when in larger groups, thus it is possible that the birds would be more than 500m away from the dredging activity. It is anticipated, therefore, that relatively few birds are likely to be disturbed by the presence of the dredger and loading barges. Any birds that are temporarily disturbed may relocate closer to Pendennis Point, or elsewhere in Falmouth Bay; it is not considered likely that any birds would be displaced beyond the boundaries of the pSPA.

Although sensitive to vessel movements birds are known to be more affected by fast moving, high-sided vessels with larger noise and visual effects. Dredging vessels and loading barges are slow moving vessels (i.e. don't tend to make fast and sudden changes in direction) and tend to be relatively low profile. It is likely therefore that within the context of other vessel movements in the docks and the navigation channels, the addition of a dredger and loading barges would not represent a significant increase in disturbance to the birds in this location.

The proposed dredge channel generally follows the route of the existing approach channel to the docks (see **Figure 5-1**) and as such is regularly utilised by a range of vessels and has been for many years. It is therefore considered unlikely that this area represents a key 'space' for the pSPA species and indeed the VA for the pSPA highlights that Falmouth Docks itself does not tend to be frequented by the Divers. The species present within the site are likely to be acclimatised to the noise levels and vessel movements associated with day-to-day port operations. In addition, potential noise effects associated with dredging would not be significant in relation to bird disturbance outside of the localised area associated with the docks (i.e. would not affect any overwintering birds using the coastal areas to the south of the docks, outside of the estuary) because buildings and land use would likely buffer any travelling noise.

The potential route to the disposal site crosses a more open area of the pSPA and it is possible that the presence of the loading barges could give rise to disturbance for birds making use of these areas. However, the route between the dredge channel and the disposal site follows established transit routes (i.e. the Carrick Roads) for vessels entering and leaving Falmouth Docks and as such is frequented by other vessels year round.

It is important to recognise that Falmouth Docks is a working port, operating 24 hours a day, 360 days a year. Whilst it is possible that some birds may be disturbed by the presence of the dredger/loading barges, the increase from existing noise and activity levels is not considered to be sufficient to result in a likely significant effect on the pSPA species.

### 5.2.2 Reduction in prey species during construction

The 2009 ES identified potential for impacts on benthos, shellfish and fish resources within the footprint of the proposed capital dredge and also in and around the disposal site. This has the potential to result in a reduction in available prey species for the pSPA birds. It is important to recognise that the majority of these impacts are focussed within and in close proximity to the dredge footprint which follows an established shipping route that is regularly utilised. It is not, therefore, considered likely to represent a key foraging area for any of the pSPA species and although recent survey data indicates some usage of this area by divers, other locations appear to be more frequently utilised for feeding (Liley *et al*., 2014; O'Brien *et al*., 2014).

Similarly, the offshore disposal site has been licensed to receive dredge arisings for many years now and as such is not considered to support the rich benthic communities found elsewhere in the estuary. It is not therefore likely to represent a key foraging area for the birds of the pSPA. Furthermore, the feeding ecology of the Great Northern Diver is such that it would focus its energy on areas closer to shore with shallower water. While the Black-throated Diver would make use of deeper water to feed, there are likely to be more valuable foraging areas elsewhere in the pSPA.

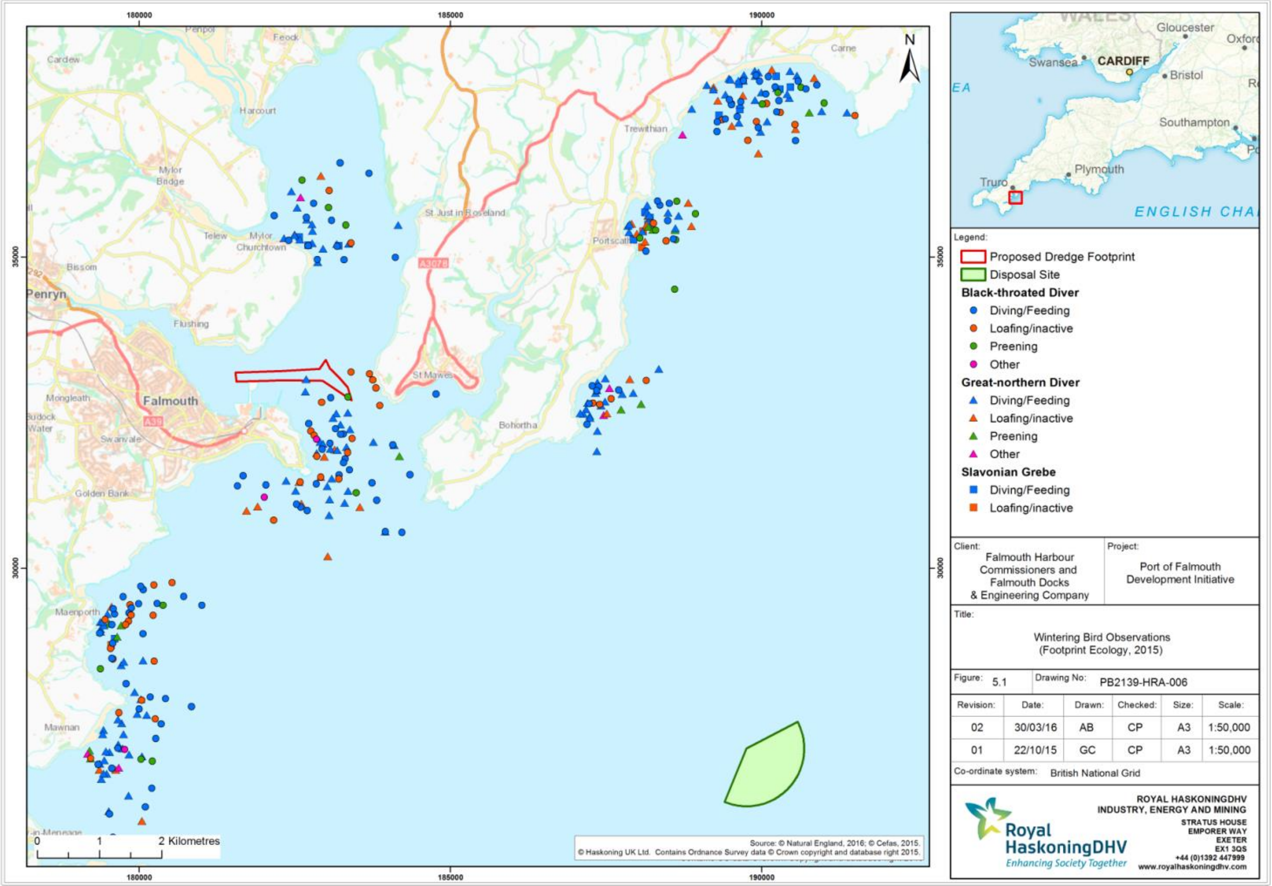



*Figure 5-1 Wintering bird observations (2014/15) from Liley et al., 2014*

The 2009 ES describes the background suspended sediment concentrations in the Fal Estuary as quite low and the increases predicted to occur (especially within the vicinity of the dredger) during the dredging operation will be higher than finfish typically experience under natural conditions (NE, 2014). Small fish and flatfish form integral elements of the diet of both pSPA Divers and it is possible that this increase could impact on the available prey. Fish are able to exhibit avoidance reactions, and the hydrodynamic modelling undertaken for the 2009 ES indicated that the sediment plume will not extend across the whole estuary. Therefore not all available feeding grounds could be expected to be impacted and as such the effect on pSPA birds from this impact is considered to be negligible. The potential changes to water quality that could impact on prey species are predicted to be localised around the dredger and, as such, the area affected would be limited. The direct impact is on benthic species and would be localised within the channel area and recovery is expected to occur in this area within approximately one year.

Shellfish are also an important part of the Great Northern Diver and Slavonian Grebe diet. Shellfish may be sensitive to changes in suspended sediment concentrations and suspended sediments however, in the EIA process, it was identified that any increases in suspended sediment are likely to be minor or temporary and reversible. As such, the shellfish resource in the estuary is not predicted to be heavily impacted. It is unlikely therefore that any impacts on the shellfish resource would result in a likely significant effect on the pSPA features.

The modelling undertaken for the 2009 ES concluded that there is predicted to be a minor (1.7mm) to negligible (0.5mm) change to sediment deposition due to capital dredging. This change would be temporary (i.e. it would only occur during the dredge) and would be reversible (i.e. the seabed would generally return to baseline conditions after the dredge).

Impacts on benthic infauna outside of the dredge footprint and the disposal area were considered to be negligible and the prey availability for the pSPA birds is unlikely to be impacted. It is therefore concluded that the minor reductions in prey species during the proposed dredge and disposal would not result in a likely significant effect on the features of the pSPA.

### 5.2.3 Reduction in foraging success due to increased turbidity

It is possible that as a result of increased turbidity in the water during the course of the dredge and disposal activities there may be an impact on the ability of the pSPA species to locate their prey. Research has indicated that divers may avoid more turbid water however impacts on foraging success are not well understood.

Modelling from the 2009 ES and subsequent monitoring of turbidity during the trial dredge showed that overall there is predicted to be temporary change of up to 100mg/l immediately around the dredger. This reduces rapidly to within 3-5mg/l a short distance from the dredger (**Section 3.1.3**). Whilst higher than background these increases are comparable to turbidity observations made by the Environment Agency elsewhere in the system (more information is provided on this in **Section 3.1.3**). In addition, these impacts are anticipated to be temporary and whilst birds may be displaced from these localised areas whilst turbidity is elevated not all foraging areas within the estuary would be impacted and resource is available elsewhere.

It is proposed that turbidity levels would be monitored during the dredge as was the case during the trial to understand the nature of this potential impact.

Levels could also be expected to increase at the disposal site. Hydrodynamic modelling carried out for the 2009 ES indicated suspended sediment concentrations of up to 10mg/l with some spots greater of up to

20mg/l in the immediate area of the disposal site. Larger values >10mg/l are confined to the disposal site (Section 5.4.3 of the ES). The disposal site is not considered to be a key foraging site for the pSPA features and as such these temporary increases in turbidity in these locations are unlikely to result in a reduction in foraging success. Given that the disposal site is approximately 1km outside of the pSPA boundary, these increases in turbidity are expected to be considerably less inside the pSPA.

## 5.3 Summary of Predicted Effects

The main way in which the pSPA features could be affected by the proposed dredging and mitigation is through disturbance due to the presence of the dredger and loading barges close to Pendennis Point, during the dredging of the eastern end of the proposed new approach channel.

The predicted effects associated with this on the pSPA favourable condition targets are presented in **Table 5.2**, based on the conservation objectives drafted for the pSPA as published in February 2016. Although no specific new favourable condition targets have been identified for each it is considered reasonable to assume that the targets will be similar to those for existing SPAs (such as the Liverpool Bay SPA) and extended to account for the additional attributes. The table is therefore structured to capture both elements in a succinct form.

## 5.4 Potential for Adverse Effect on Integrity

Guidance on what constitutes the integrity of a European site has been provided by the European Commission (EC, 2000). In this guidance, integrity is defined as: “the coherence of the site’s ecological structure and function, across its whole area, which enables it to sustain the habitat, complex of habitats and/or populations of species for which the site has been designated”.

There are a number of factors that require consideration when determining the potential for an adverse effect on integrity including the scale of the effect, the longevity of that effect, and the certainty of the impacts on the protected features.

### 5.4.1 Scale of effect

There is no predicted effect on the three bird species protected under the pSPA, nor is any effect predicted on the supporting habitats for these features. The only minor effect could be as a result of the noise disturbance from the dredging activity for those birds frequenting the waters in and around the dredge area and off of Pendennis Point (approximately 1km away from the proposed dredge footprint). However the water around the docks and close to Pendennis Point are a small area within the pSPA and many other suitable foraging and loafing areas exist within the site boundary. As both diver species are highly mobile it is considered likely that they will access various parts of the pSPA over the 6-7 month overwintering period. Although the recent survey indicates use of the proposed dredge footprint by diver species, it also confirms that birds are likely to use other areas of the pSPA in higher numbers and the VA by NE undertaken to inform the designation of the pSPA (together with anecdotal evidence from CIFCA) highlights the habituation of the birds in and around Falmouth Docks.

### 5.4.2 Longevity of effect

As the area of the proposed new approach channel closest to Pendennis Point is also the section requiring the least dredging, the dredging plant is likely to be present in this location for a relatively short period of time.

*Table 5.2 Impacts on Favourable Conditions*

| Attribute | Measure | Target | Potential construction impact | Preventative measures | Significance of residual impact | Effect on designated site |
|---|---|---|---|---|---|---|
| **Great Northern Diver** | | | | | | |
| Population | Size and distribution within the site | Maintain or enhance populations on the site subject to natural fluctuations. There should be no permanent decline, only non-significant fluctuation around the mean to account for natural change. | Disturbance to birds diving off Pendennis Point during the course of the dredging of the eastern end of the proposed new approach channel (approximately 500-1000m away). | Observations from 2014/15 overwintering survey indicate a preference for Divers to feed closer to shore when in groups. Relatively few birds therefore considered likely to be disturbed by dredging activity. | Any birds disturbed by the dredging activity could relocate closer to Pendennis Point or be displaced into Falmouth Bay. It is not considered likely that any birds will be displaced outside of the pSPA boundary. | Possible temporary minor to negligible effect on birds close to Pendennis Point. |
| Supporting Habitats | Extent and distribution; Structure and function; Supporting processes | No significant decrease in the extent of supporting habitat available for Great Northern Diver. | Capital dredge will remove communities associated with mixed sediment habitats as well as gravel and sand habitats in the sub-tidal. | Habitat replacement and presence of the same communities close to the dredge area will ensure recolonisation occurs | Although these habitats contain prey species of interest to the Great Northern Diver the proposed approach channel is not a key foraging area for the pSPA species. The impact is anticipated to be local and temporary. | No change from existing situation |
| **Black Throated Diver** | | | | | | |
| Population | Size and distribution within the site | Maintain or enhance populations on the site subject to natural fluctuations. There should be no permanent decline, only non-significant fluctuation around the mean to account for natural change. | Disturbance to birds diving off Pendennis Point during the course of the dredging of the eastern end of the proposed new approach channel (approximately 500-1000m away). | Observations from 2014/15 overwintering survey indicate a preference for Divers to feed closer to shore when in groups. Relatively few birds therefore considered likely to be disturbed by dredging activity. | Any birds disturbed by the dredging activity could relocate closer to Pendennis Point or be displaced into Falmouth Bay. It is not considered likely that any birds will be displaced outside of the pSPA boundary. | Possible temporary minor to negligible effect on birds close to Pendennis Point. |
| Supporting Habitats | Extent and distribution; | No significant decrease | Capital dredge will | Habitat replacement and | The proposed approach | No change from existing |

| Attribute | Measure | Target | Potential construction impact | Preventative measures | Significance of residual impact | Effect on designated site |
|---|---|---|---|---|---|---|
| | Structure and function; Supporting processes | in the extent of supporting habitat available for Black-throated Diver. | remove communities associated with mixed sediment habitats as well as gravel and sand habitats in the sub-tidal which support the small fish prey resource that may be shoaling in the estuary. | presence of the same communities close to the dredge area will ensure recolonisation occurs. | channel is not a key foraging area for the pSPA species. The impact is anticipated to be local and temporary. | situation |
| **Slavonian Grebe** | | | | | | |
| Population | Size and distribution within the site | Maintain or enhance populations on the site subject to natural fluctuations. There should be no permanent decline, only non-significant fluctuation around the mean to account for natural change. | Falmouth Docks and the Carrick Roads are relatively rarely used by Slavonian Grebe and there is unlikely to be interaction between this proposed SPA feature and activities associated with the dredge (NE VA). | N/A | N/A | No change from existing situation |
| Supporting Habitats | Extent and distribution; Structure and function; Supporting processes | No significant decrease in the extent of supporting habitat available for Slavonian Grebe. | Capital dredge will remove communities associated with mixed sediment habitats as well as gravel and sand habitats in the sub-tidal; no route for impact on seagrass beds. | Habitat replacement and presence of the same communities close to the dredge area will ensure recolonisation occurs. | Impact on subtidal habitats will be temporary and localised. Dredge channel is not thought to be a key foraging area for this species. | No change from existing situation |

### 5.4.3 Level of certainty

Based on the anticipated noise levels from the backhoe dredger and the distance between Pendennis Point and the eastern end of the approach channel, the impact on the birds is expected to be negligible.

### In conclusion

Maintaining the integrity of the pSPA is based on maintenance of the population levels and extent of supporting habitats. It is not expected that the proposed works would affect the population levels of any of the pSPA species nor is it expected to affect the supporting habitats (which are also features within the Fal and Helford SAC, see **Section 4**).

It is expected that the temporary impacts from noise and visual disturbance from the dredging activity would cease following completion of the works. During the relatively short period that dredging would be occurring close to Pendennis Point it is anticipated that those birds affected by the disturbance would make use of resources elsewhere in the pSPA. There are not, therefore, predicted to be any impacts of significance to the species of the pSPA or their supporting habitats.

### 5.4.4 Recommended Monitoring

As described in **Section 5.2.1**, the significance of the potential effect on the birds close to Pendennis Point is considered to be minor, as the dredger would be operating more than 500m away from the areas identified during the Footprint Ecology survey. Should it be necessary to dredge within 500m of Pendennis Point during the overwintering period it is recommended that the birds be monitored for signs of disturbance.

As outlined in NE's letter in response to the HRA Framework Document (RHDHV, 2015), it is proposed that the detail of any monitoring would be discussed and agreed with NE and the MMO in line with the Natural England/Falmouth Harbour Commissioners Joint Working Agreement.

## 5.5 Operation Phase

### 5.5.1 Disturbance (noise and visual) during operation (increased commercial shipping)

Once the new navigation channel is operational it is anticipated that vessel day calls will increase from 32 in 2010 to 84 in 2030 (URS, 2015). Whilst this represents an economic benefit for FDEC in terms of physical numbers this represents only a 3% increase in port activity. As described in earlier sections Falmouth is a busy operational port with an average 30 vessel movements a day presently. The anticipated increase in vessel activity is not considered to be significant against the baseline and the pSPA bird species are habituated to the disturbance created by the docks.

The VA undertaken to inform the pSPA designation concluded that the protected species are unlikely to be impacted by the current port operations and their continued presence in the estuary despite increased vessel movements in recent years is evidence of this. The new channel generally follows an existing approach route to the harbour and NE has confirmed that the docks themselves are not a key resource area for the pSPA birds. As such the operation of the new channel is not anticipated to introduce increased disturbance levels at a significant level above the baseline.

There is not, therefore, anticipated to be a likely significant effect on the features of the pSPA as a result of increased vessel movements during operation.

### 5.5.2 Reduction in foraging success due to increased turbidity

As described in **Section 4.2** there is expected to be very little difference between the hydrodynamic and sedimentary regime before and after the capital dredge. It is expected that, as currently happens, each day, as fine sediments are deposited, they would be re-mobilised with water movement associated with the tides (FHC, *pers. comm*. 2015). As a result of this, as well as the regular shipping movements in the channel, no maintenance dredging is anticipated to be required during the operational phase.

Given that no operational changes are anticipated with respect to turbidity in the estuary there would be no associated impact on foraging success for pSPA birds. Therefore no likely significant effect is anticipated for these protected features.

# 6. IN-COMBINATION EFFECTS ON DESIGNATED SITES

## 6.1 Introduction

When assessing the implications of a plan or project in light of the conservation objectives for the European sites in question (i.e. assessing the potential for LSE and ascertaining the potential for effect on site integrity), it is necessary to consider the potential for in combination effects, as well as effects due to the project in isolation.

Natural England's Habitats Regulations Guidance Note 4 (English Nature, 2001) provides guidance on in combination effects and, at paragraph 2.3, states that other plans or projects should include:

- Approved but as yet uncompleted plans or projects;
- Permitted on-going activities such as discharge consents or abstraction licenses; and,
- Plans and projects for which an application has been made and which are currently under consideration but not yet approved by competent authorities.

It is also noted that in some circumstances it may be appropriate to include plans and projects not yet submitted to a competent authority for consideration but for which sufficient detail exists on which to make judgements on their impact on the European site.

In undertaking an in-combination assessment it is important to consider the potential for each plan or project to influence the site. In order for an in combination effect to arise, the nature of two effects does not necessarily have to be the same. The in-combination effects assessment, therefore, focuses on the overall implications for the site's conservation objectives, regardless of the type of effect.

In addition, this in-combination assessment has adopted the following principle: in order for the proposed scheme to have the potential to contribute to in-combination effects, there must be sufficient cause to consider that a relevant habitat or species is sensitive to effects due to the project itself (e.g. as a result of a particular influence or sensitivity, or the presence of a species in notable numbers on at least one survey occasion, rather than being simply recorded within the site). Therefore, only where the project alone was determined to have the potential for LSE on Natura 2000 sites and features have these sites and features been included in the in-combination assessment. If a LSE was not therefore determined due to the proposed new navigation channel, there is no real prospect of it suffering from an in-combination effect with another plan or project.

### 6.1.1 Other plans and projects screened into the HRA process

Through consultation with NE and interrogation of the Local Authority planning portal (Cornwall Council) over the course of this HRA update, a list of plans and projects that have the potential to give rise to an in combination effect with the proposed scheme has been compiled.

Details of each in terms of project type, intended construction dates (where data are available), duration of the works (where data are available) and other relevant data are provided, along with the distance from the proposed scheme. From this a decision has been taken as to whether or not it is likely to have a combined impact with the proposed scheme. The plans and projects have, therefore, been screened in or out of further assessment on this basis.

**Table 6.1** provides a summary of the plans and projects that have been considered for this in-combination assessment.

*Table 6.1 Summary of the plans and projects that have been considered for this in-combination assessment*

| Applicant | Description | Potential impacts on SAC or pSPA | Potential for In-combination effects |
|---|---|---|---|
| University of Exeter (Penryn Campus) | Construction of a Wave Energy Converter (WEC) mooring test facility. | None identified | None identified |
| Falmouth Harbour Commissioners | Establishment of a marine energy converter (MEC). Test site to facilitate the short or medium term testing of MEC devices. | None identified | None identified |
| Royal Cornwall Yacht Club | Repositioning of a seasonal pontoon. | None | None |
| Greenbank Hotel | Construction of mooring pontoons on existing swinging mooring blocks. | None identified | None identified |
| Cornwall Council | Movement of sand from the foreshore at Swanpool when large quantities accumulate. Sediment will be removed by mechanical means to below Spring High Water, allowing the waves and tides to redistribute naturally. | None identified | None identified |
| Private Individual | Construction of a reinforced concrete wall. | None identified | None identified |
| Premier Marinas | Installation of a holding pontoon. | None identified | None identified |
| Private Individual | Repair works to retaining dry stone wall. | None | None |
| FDEC | Construction of extended berth between northern and queens wharves to include some piling. | Noise disturbance to waterbirds due to construction (potential impact for pSPA).<br>Light disturbance to waterbirds during construction (potential impact for pSPA). | None |
| Tidal Lagoon Swansea Bay PLC | Proposed Loading Causeways and Breakwater at Dean Quarry, Lizard, Cornwall | Noise disturbance from construction activity (piling); however as avoiding overwintering period no LSE identified | None identified |
| Fishing Activities within the Fal Estuary | Commercial fishing activity within the boundary of the SAC and pSPA (monitored by the CIFCA) | Direct mortality of pSPA features as a result of entanglement in set nets while foraging within the water column or potentially when trying to feed on fish entangled in those nets. | None identified |

### 6.1.2 Construction Works Associated with the PFDI

In the 2009 ES the PFDI scheme included landside as well as marine elements with associated impacts. Although the terrestrial elements of the original scheme are not being considered as part of this HRA it is important to review the potential impacts of the landside activities from an in-combination perspective. During the EIA process in 2008/9 the following relevant impacts were identified for the landside elements of the PDFI:

- **Noise disturbance to waterbirds due to construction** – Each of the elements of construction was considered to result in noise which has the potential to disturb wildfowl and waterbirds in the Fal Estuary. It was noted that there is no intertidal habitat adjacent to the docks and that the optimal feeding habitat is located many kilometres distant, near Truro. Noise associated with construction will include piling to construct the new cruise quay between the Queens and Northern Wharves. Although piling noise was assessed as likely to affect receptors within Falmouth and Trefussis Beach, these locations do not provide suitable intertidal foraging areas for wildfowl and waterbirds, and therefore the impact to ornithology was considered to be negligible.

- **Light disturbance to waterbirds during construction** – any night time construction will require lighting and this has the potential to disturb wildfowl and waterbirds in the Fal Estuary. However, the existing dock operations are currently 24 hours and lighting is common overnight, particularly when vessels are being repaired in the dry dock. Given the existing level of lighting within the docks estate the lighting for construction was considered to have a negligible impact on birds.

However, these impacts need to be reviewed in light of the information available as a result of the pSPA submission since the features of interest will have been assessed without the information available on the three species of interest.

In order to undertake this assessment, it is important to understand the elements of the landside activities that could give rise to potential impacts on the designated species. A short summary is therefore provided here.

The main landside works require a dedicated cruise quay of approximately 430m in length to be constructed by combining the lengths of the Queens and Northern Wharves. The majority of the Queens Wharf already comprises an open piled structure that is in good condition but in order to provide a continuous quay, the gap will need to be bridged between the Queens Wharf and Northern Quay. The condition of the Northern Quay will also need to be improved.

The preferred improvement option to bridge the gap is construction of an open piled structure of c.750mm vertical tubular piles with a concrete deck. It is likely that impact piling will be required in order to install both the tubular piles and sheet piling. Impact piling will also be required in order to replace the disused area of the Northern Wharf in the same manner to which the gap will be bridged. There are other works such as concrete pouring and breaking out that are required as part of these and the general improvement works however these are deemed less likely to cause noise at risk of disturbing overwintering birds and therefore this assessment will focus on the requirement for impact piling and the potential in-combination with noise associated with the dredging and disposal activities. This assumption was also confirmed in the noise assessment provided in **Section 17** of the 2009 ES which highlighted consistently higher noise levels at all receptors considered associated with piling (see **Table 17-5**, 2009 ES).

In terms of timeframe, the landside works could potentially last for up to 18 months if the phases of construction are undertaken consecutively. This could be a lot shorter if undertaken in parallel, in the region of six months. It should be noted that the timeframe over which piling will occur is much shorter, up to approximately 13 weeks and it is unlikely that impact piling will be continuous for this period.

However as the Falmouth Bay to St Austell Bay pSPA was not designated at the time of the 2008/9 EIA the potential impacts on the three species of interest for the pSPA were not assessed with the focus instead being on the intertidal feeding and roosting areas within the estuary. As the impact of the landside works as a separate project has not been assessed for the pSPA alone it is not possible for an in-combination assessment to be made between this and the proposed capital dredge and disposal.

The landside works are not expected to have a significant effect on the SAC features.

### 6.1.3 Proposed development at Dean Quarry, Lizard, Cornwall (Tidal Lagoon Power PLC)

This project requires the creation of a marine loading area, a breakwater and associated works at the Lizard in Cornwall (see **Figure 6-1** for location plan) in order to provide stone to support the building of the tidal lagoon at Swansea Bay. The proposed development would include the construction of two new loading points comprising causeways, floating linkspan bridges and dolphin piles to allow safe berthing, together with a breakwater to allow loading of material at all states of the tide. The works also include improvements and an extension to the existing quarry access to the loading area, including footbridges over the public right of way. During the operational phase, the main effects are considered likely to be associated with any vessel movement carrying stone from the quarry to Swansea Bay around the coast.

Details of the exact nature of the proposals have not yet been released and therefore a detailed assessment of the potential effects of these proposals has not yet been made in the form of an EIA. However, an EIA Screening and Scoping Report (Wardell Armstrong, 2014) is available and therefore this assessment is based on the outline information provided in this report.

Outline construction information indicates that the loading facilities will be constructed using stone from the quarry. There will also be a requirement for piling in order to secure the mooring facilities, blasting of rock within the quarry and the installation of footbridges. The report also states that the construction of the loading facility and breakwater will not be carried out during the peak overwintering bird periods. The proposed works are also not located within the boundary of the pSPA (see **Figure 6-1**) nor located nearby to the areas identified as particularly important to the pSPA features such as Gerrans Bay and St Austell Bay. During the operational period, due to restrictions associated with shallow water, large barges (towed by tugs) transporting the stone will not pass by or within the pSPA boundary.

Based on this information, it is therefore not anticipated that the proposals will not have any effect on the overwintering bird species identified within the pSPA designation. This is further confirmed by Natural England's response to the EIA Screening and Scoping Report (Wardell Armstrong, 2014) which concludes that "*the timing of the construction works outside of the overwintering bird period (i.e. avoiding October – April), would avoid any potential construction impacts on the pSPA birds features*" (see MMO letter dated 13th October, 2015). As a result, an in-combination effect with PFDI dredging and disposal activities is not anticipated.

As these impacts were both considered to be negligible within the context of existing dock activities it is unlikely that there is the potential for in-combination effects with the marine elements of the PFDI which are the subject of this HRA.

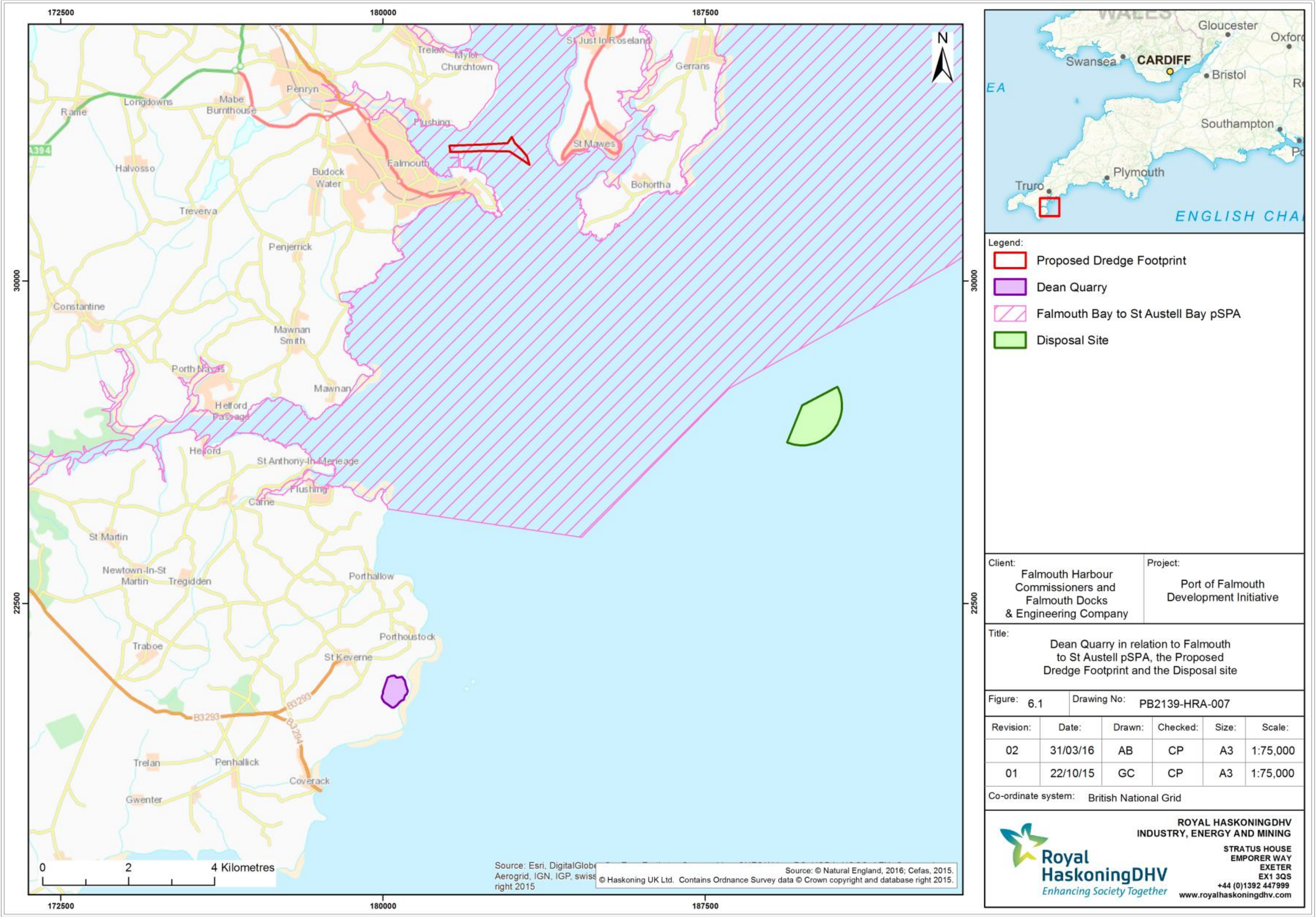



*Figure 6-1 Dean Quarry in relation to the Falmouth to St Austell pSPA, the proposed dredge footprint and the disposal site*

### 6.1.4 Fishing activities within the SAC and pSPA boundary

Small boats work lines of pots close inshore around the coast of Cornwall, catching crab and lobster. A fleet of 150 small boats, most <10m in length, catch primarily mackerel *Scomber scombrus* but also bass *Dicentrarchus labrax*, pollock *Theragra chalcogramma* and squid. Most fish are caught within six miles of land by handline, a low intensity fishing method that appears sustainable and results in little bycatch (Marine Stewardship Council, 2009). During winter, the fleet works along the more sheltered south Cornwall coast, within the South Cornwall AoS. Crab and lobster boats will also work the inshore areas of the South Cornwall AoS in winter (O'Brien *et al*., 2014).

In general fishing activity in the area is considered to be sporadic in terms of effort and widely dispersed within the boundary of the pSPA. Some set netting activities also take place (surface netting including ring netting for small pelagics and demersal set-netting) year round in Gerrans Bay; Veryan Bay including Dodman Point round to Goran Haven and St Austell Bay. Coastal surface gill netting intensity increases in the summer months (Natural England, no date) and ring netting of small pelagics is considered to be an increasing activity. Set netting is however banned in the Fal and Helford. Oyster farming activities are localised to the Carrick Roads and Helford Estuary whilst mussel farming takes place in the Fal Estuary and St Austell Bay.

The potential impacts of fishing were considered within the VA for the pSPA by Natural England and the only identified risk that was considered to require management was the potential for direct mortality to the pSPA features as a result of entanglement in static fishing gear (especially set/gill nets) while foraging within the water column or potentially when trying to feed on fish entangled in those nets. Direct mortality is not anticipated to be a risk arising from the proposed dredge and disposal activity and there is no potential geographic overlap in activities as the Docks are more than 6km from the nearest area where this type of fishing takes place.

Some potential for damage/loss of feeding resource was also highlighted through the VA, linked to a reduction in foraging success, however due to the low levels and sporadic nature of fishing activity and its dispersion over a wide area, the exposure risk of the pSPA features to this pressure was considered to be low. Temporary effects on benthic infauna are predicted as a result of the proposed dredge within the footprint of the new channel; however these are expected to result in a negligible effect on prey availability for pSPA birds. Similarly temporary increases in turbidity are anticipated during the dredge however these are predicted to be within background levels and temporary in nature and, therefore, unlikely to impact on the foraging success of the pSPA birds.

## 6.2 Conclusion

Based on the available information relating to the plans/projects with the potential to impact on the Falmouth Bay to St Austell Bay pSPA or the Fal and Helford SAC, it is concluded that no in-combination effects are anticipated to arise as a result of the capital dredge and disposal proposed for the PFDI scheme.

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# Appendix A – Maerl Mitigation Strategy

HASKONINGDHV UK LIMITED
INDUSTRY, ENERGY & MINING

# Port of Falmouth Development Initiative

Maerl Mitigation Strategy

27 April 2016
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PB2139

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|---|---|
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| | | |
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**SUMMARY**

The Falmouth Harbour Commissioners (FHC) and Falmouth Docks and Engineering Company Ltd (FDEC) have put forward a proposal to improve the port facilities and approach channel at Falmouth, Cornwall. This project is known as the Port of Falmouth Development Initiative (PFDI) and lies within the Fal and Helford Special Area of Conservation (SAC). The proposed PFDI comprises dredging works, seabed mitigation and berth construction.

The PFDI requires Environmental Impact Assessment (EIA) and Habitats Regulation Assessment (HRA) in accordance with the Marine Works (Environmental Impact Assessment) Regulations 2007 and regulation 61 of the Conservation of Habitats and Species Regulations 2010 ('the 2010 Habitat Regulations').

The EIA and HRA identified that the proposed works within the Fal and Helford SAC related to the PFDI have the potential to have a significant effect associated with the dredging works to deepen the channel. The potential impact relates to removal of part of the maerl habitat (predominantly dead maerl) and its associated species within the estuary. This strategy is put forward to mitigate this potential impact.

Following discussion over the initial mitigation proposals presented in the Environmental Statement (ES), the area of maerl predicted to be affected has been re-calculated using a depth of maerl habitat of 30cm and using sand and maerl or pure maerl as a viable maerl habitat and it is concluded that approximately 7.6 ha of viable maerl habitat would be impacted overall. Of this amount, 4.1ha would remain as the same habitat type following dredging. The remaining 3.5ha would be changed to a non-viable maerl habitat following dredging. The dredging activity exposes 2ha of viable maerl habitat which leaves 1.5ha to be mitigated by habitat replacement.

Consequently, a mitigation package is being proposed which involves a 30cm over-dredge of 1.5ha of the seabed within the dredged channel and replacing this with a viable depth of dredged maerl. This technique has been tested during a trial project and has reported successful colonisation of the maerl habitat to provide similar communities as to the pre-dredge conditions.

Other maerl habitat includes clay with maerl of which there is 10.8ha before dredging and 9.6ha exposed after dredging. The 1.2ha of clay with maerl that is lost is within polygon 12 where enhancement is proposed by relaying pure maerl onto the remaining clay habitat.

With mitigation and enhancement in place, it is predicted that the project would not decrease the extent of maerl habitat within the footprint of the channel, with the objective of ensuring no residual impact on the conservation objectives for the Fal and Helford SAC.

**CONTENTS**

# 1 INTRODUCTION

## 1.1 Background

The Falmouth Harbour Commissioners (FHC) and Falmouth Docks and Engineering Company Ltd (FDEC) have previously submitted three applications to the Marine Management Organisation (MMO) which together form a proposal to improve the port facilities and approach channel at Falmouth, Cornwall. This project is known as the Port of Falmouth Development Initiative (PFDI) and lies within the Fal and Helford Special Area of Conservation (SAC).

The proposed PFDI comprises:

- dredging approximately 700,000$m^3$ of marine sediment to create a deeper and straighter approach channel from the Carrick Roads to the Queens and Northern Wharves;
- seabed habitat mitigation works in the eastern channel; and
- the construction of a longer berth, combining the Queens and Northern Wharves.

The PFDI requires Environmental Impact Assessment (EIA) and Habitats Regulation Assessment (HRA) in accordance with the Marine Works (Environmental Impact Assessment) Regulations 2007 and regulation 61 of the Conservation of Habitats and Species Regulations 2010 ('the 2010 Habitat Regulations'). An Environmental Statement and Information for Appropriate Assessment were submitted to the MMO in August 2009 and July 2010 respectively.

The EIA and HRA identified that the proposed works within the Fal and Helford SAC related to the PFDI have the potential to have a significant effect associated with the dredging works to deepen the channel. The potential impact relates to removal of part of the maerl habitat (predominantly dead maerl) and its associated species within the estuary. It was concluded that approximately 4 hectares (ha) of dead maerl (2% of total dead maerl in the SAC) would be impacted overall. Since then, there has been discussion on the depth of maerl habitat required for colonisation by burrowing species. Following investigation by The Marine Institute at Plymouth University it was concluded that typically species burrow into maerl to a depth of 30cm (Marine Institute, 2012). Further investigation into maerl habitat requirements and biotopes (an area of uniform environmental conditions providing a living place for a specific assemblage of plants and animals) through review of published literature has also questioned the maerl fragments mixed with clay or mud as a viable habitat (**Appendix A**). The area has therefore been recalculated using a viable depth of maerl habitat of 30cm and using sand and/or gravel with maerl or pure maerl as a viable habitat and it is concluded that approximately 7.6 ha of viable dead maerl habitat would be impacted overall. Of this amount, 4.1ha would remain as the same habitat type following dredging. The remaining 3.5ha would be changed to a non-viable habitat following dredging. The dredging activity exposes 2ha of viable dead maerl habitat which leaves 1.5ha to be mitigated by habitat replacement.

Consequently, a mitigation package is proposed which involves a 30cm over-dredge of approximately 1.5ha of the seabed within the dredged channel and replacement with a viable depth of dredged maerl. This mitigation package has been developed in liaison with Natural England.

The remaining maerl habitat is defined as clay with maerl, of which there is 10.8ha before dredging and 9.6ha exposed after dredging. The 1.2ha of clay with maerl that is lost is within polygon 12 where enhancement of the habitat is proposed by relaying 30cm depth of pure maerl onto the remaining clay habitat.

With mitigation and enhancement in place, it was predicted that the project would not decrease the extent of maerl habitat within the footprint of the channel, with the objective of ensuring no residual impact on the conservation objectives for the Fal and Helford SAC.

This document sets out the approach proposed for the mitigation strategy in light of on-going research and consultation.

## 1.2 Favourable condition targets for maerl bed communities

Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora (‘the Habitats Directive’) encourages the definition and implementation of mitigation measures (with respect to any potential impacts) to ensure that the project can proceed in line with the designated sites’ ‘conservation objectives’. If it can be shown that such measures will succeed, then it can be concluded that the project would not have an adverse effect on integrity of the site.

The conservation objectives for the Fal and Helford SAC apply to the subtidal sandbanks feature and within the subtidal sandbanks there are sub-features of interest for which favourable condition targets apply. One such sub-feature for this site is maerl bed communities.

In order to determine whether the proposed dredging works (the project) would have an adverse impact it is important to consider the favourable condition targets that apply to the sub-features of interest that could be affected. These are listed below in **Table 1** for the Fal and Helford SAC where they apply to the relevant marine sub-features of interest (i.e. the maerl bed communities).

**Table 1 Favourable condition targets for the sub-features relating to the conservation objectives for Subtidal Sandbanks (source: Natural England - Regulation 33 Package, 2000)**

| Feature | Sub-feature | Attribute | Measure | Target |
|---|---|---|---|---|
| Subtidal sandbanks | Maerl bed communities | Extent | Area (ha) of maerl (live and dead). Measure once during reporting cycle. | No decrease in extent of maerl as a whole, or of either dead or live maerl from an established baseline, subject to natural change. |
| | | Distribution of maerl bed communities | Distribution of maerl bed communities. Measure once per reporting cycle. | Distribution of maerl bed communities should not deviate significantly from an established baseline, subject to natural change. |
| | | Species composition of maerl bed communities | Presence and abundance of composite species of biotopes from maerl areas. Measured during summer, one during reporting cycle. | Presence and abundance of composite species should not deviate significantly from an established baseline, subject to natural change. |

## 2 DEVELOPMENT OF THE MAERL MITIGATION STRATEGY

In response to the licence applications to carry out the proposed works, concerns were raised by Natural England regarding the impact of the proposed dredge and proposed replacement of the maerl. Natural England highlighted that the assessment criteria for maintaining the favourable condition of the maerl bed communities states that *"the extent, distribution and species composition of the maerl beds should not deviate significantly from the established baseline"* (in order to maintain the conservation objectives of the site).

Specifically Natural England's residual concerns in September 2009 were:

- destruction of the maerl matrix;
- burial of live maerl;
- the predicted rates of sedimentation; and
- over-optimistic rates of recovery.

As a consequence, further investigative work has been undertaken and a mitigation strategy has been proposed that aims to ensure that the favourable condition targets for the maerl communities outlined in **Section 1.2** can be maintained. The mitigation strategy set out herein has developed through discussions with relevant regulators, and in particular with Natural England, to address the specific concerns raised above.

In relation to Natural England's concerns regarding the destruction of the maerl matrix and over-optimistic rates of recovery, these have been addressed through the monitoring of recovery following a trial dredge and replacement of maerl (as discussed below in **Section 4.3**). In relation to predicted rates of sedimentation this issue has been addressed through selection of specific areas for relaying of maerl to avoid areas of higher sedimentation, see **Section 3.2**. The concern raised relating to the burial of live maerl will be addressed within a separate technical note for inclusion in the updated HRA.

The following objectives are therefore proposed with respect to the mitigation strategy:

- The relaying of areas of maerl within the Fal Estuary, that offer the potential for recolonisation by species that are representative of the communities that currently occur – and that would contribute to the favorable condition target regarding maerl communities;
- In total, the provision should be to replace the dead maerl viable habitat that would be lost and is not replaced through natural exposure of viable dead maerl habitat and the placement areas should be located where the potential for sedimentation is minimised; and
- To maintain, as far as possible, the distribution of maerl habitat.

## 3 MAERL MITIGATION STRATEGY

### 3.1 Mitigation methodology

It is proposed that dredging of the seabed would occur in the channel (see **Figure 1**) using a backhoe dredger and barges. This method would reduce the potential for suspended sediment plumes and minimise disturbance to the maerl habitat as much as possible. In addition, measures have been considered that aim to reduce the loss of live species and recovery time, including overtopping of the barges with water during storage of the maerl and relaying onto the areas selected for mitigation with storage times for the maerl not exceeding those used in the trial (i.e. twelve hours).

The maerl for relaying would be placed onto specific areas of the seabed within the channel that had been dredged to levels approximately 30cm deeper than required (over dredged), taking into account the maximum dredging requirement (i.e. 30cm deeper than the required -8.3CD). It is proposed that 30cm of maerl would be placed in the placement location, covering an area of approximately 1.5ha in total. The placement of material would be undertaken using accurate position fixing equipment on board the dredger. Placement of maerl, using the same methodology, would also occur in an area of 1.2ha as an enhancement measure.

It is proposed that beneficial uses, including infill options, would be sought for any clean dredged material remaining and that any dredged material for disposal would be either deposited on land, if material is contaminated, or taken to the Falmouth Bay offshore disposal site.

### 3.2 Placement locations

The area proposed for the placement of maerl as mitigation is polygon 10 (as shown on **Figure 1** below as a red polygon). The area for enhancement using the same methodology as for the mitigation is polygon 12. The polygons in the figure showing maerl habitat represent areas where maerl habitat or mixed maerl habitat with sand and maerl exists to 30cm depth of substrate (see **Figure 1**).

These polygons differ from those previously shown in the 2009 Environmental Statement which considered a viable maerl habitat to 1m depth of substrate (see **Section 1.1**). The difference in polygons reflect the decisions made relating to the viability of maerl habitat that have been based on a literature review undertaken during and after the trial dredge (See **Section 1.1** and **Appendix A**). For the 2009 ES, the area of maerl habitat that would have been affected was 4ha. With the current decisions on viability of maerl the area of initial loss of maerl habitat is predicted to be 7.6ha. Of this area, 4.1 ha are expected to remain as the same habitat after dredging. This area of loss is also balanced by exposure of a new area of viable maerl, as a result of the dredging, of 2ha, leaving 1.5ha to be mitigated.

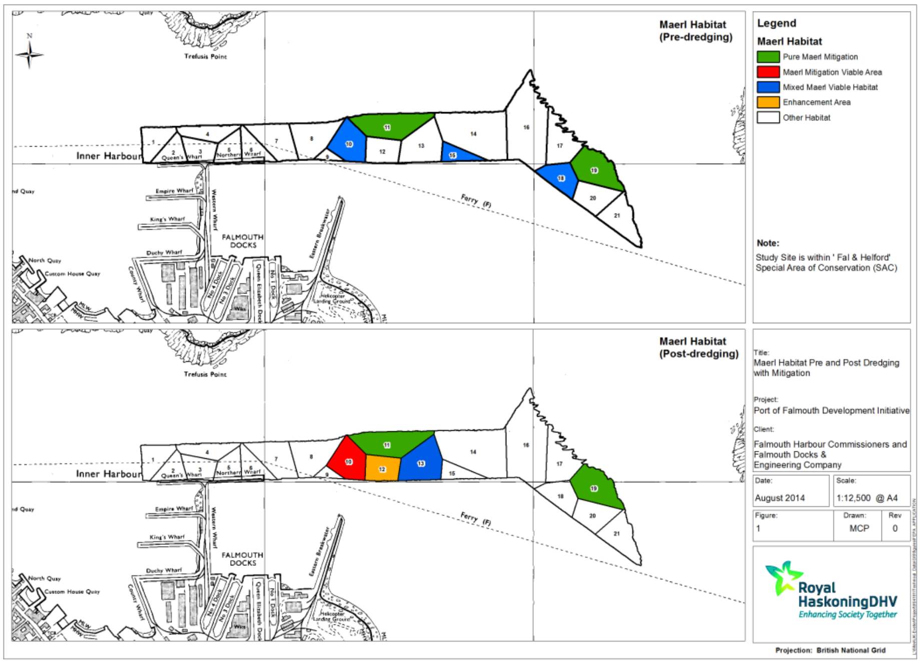
Clay with maerl is the other defined habitat type and this habitat (outside of the area of higher sedimentation not considered to be suitable for maerl habitat) is estimated to cover an area of 10.8ha before the dredge and 9.6ha after the dredge. Polygon 12 is the area that is clay with maerl before the dredge and becomes clay after the dredge. In addition to the mitigation proposed, polygon 12 has been identified as an enhancement area (shown on **Figure 1** below as an orange polygon) where viable maerl habitat will be created following dredging activity. This polygon will therefore change from clay with maerl to a pure maerl habitat. The same placement methodology as used for the mitigation polygon will be undertaken for the enhancement polygon.

The aim of the enhancement site is to provide a positive benefit to the viable maerl area following works with the aim of increasing the area of pure maerl habitat within the site.

The locations for placement of maerl have been selected based on a number of criteria as follows:

- The maerl should be placed in areas which have the characteristics to support maerl communities. The western half of the channel (polygons 1-9) does not currently contain viable maerl habitat and is dominated by more silty sediments (see **Figure 1** below) and, hence, is not preferred.
- The maerl should not be placed in areas where at least 30cm depth of maerl would remain anyway after the dredge (polygons 11, 13 and 19); as there would already be maerl habitat in these areas following dredging activity (**Figure 1**).
- The maerl should be placed in locations which are subject to the least effects of sedimentation following placement. Suspended material is currently more likely to settle out in the south eastern corner of the dredged channel whereas, after the dredge, material is more likely to settle in the south western corner of the dredge channel (see **Figure 2** and **Figure 3** below showing annual deposition of sand before and after the dredge). It should be noted that maerl habitats currently exist in areas of sedimentation, so the maerl and associated species must be able to tolerate some sedimentation. Areas 15, 18 and 20 (some of which were originally proposed for maerl relocation) are, therefore, not considered to be suitable for the relocation of maerl due to predicted increased rates of sedimentation following the dredge.

**Figure 1 Polygon areas showing maerl locations before and after the proposed dredge**



### Table 2 Summary of findings for viable maerl habitat

| Polygon Number | Area of Vibrocore (ha) | Suitability as an area for maerl placement | Bed Level 0m | Bed Level 0.3m | Bed Level After Dredge | 30cm below Bed Level After Dredge | Notes |
|---|---|---|---|---|---|---|---|
| 1 | 1.1 | No – fine sediment area | Clay Freq Maerl | Clay Freq Maerl | Clay | Clay | |
| 2 | 0.9 | No – fine sediment area | Clay | Clay | Clay | Clay | |
| 3 | 1.0 | No – fine sediment area | Clay | Clay | Clay[a] | Clay[a] | |
| 4 | 1.1 | No – fine sediment area | Clay | Clay | Clay Freq Maerl | Clay Freq Maerl | Strong H2s smell in vibrocore |
| 5 | 1.0 | No – fine sediment area | Mud with Maerl | Mud with Maerl | Mud with Maerl | Mud/Clay | Black sandy silty mud with shells and pieces of calcified weed |
| 6 | 1.0 | No – fine sediment area | Clay | Clay | Rock | Rock | |
| 7 | 1.7 | No – fine sediment area | Clay | Clay | Clay[b] | Clay[b] | |
| 8 | 1.9 | No – fine sediment area | Clay | Clay | Rock | Rock | |
| 9 | 0.3 | No – fine sediment area | Maerl | Clay | Clay | Clay | |
| 10 | 1.6 | Yes | Sand Freq Maerl | Sand Freq Maerl | Clay | Clay | Black sediment in vibrocore |
| 11 | 2.2 | No – maerl will remain anyway | Maerl | Maerl | Maerl[c] | Maerl[c] | |
| 12 | 1.2 | Yes | Clay/Silt Freq Maerl | Clay/silt Freq Maerl | Clay | Clay | |

| Polygon Number | Area of Vibrocore (ha) | Suitability as an area for maerl placement | Bed Level 0m | Bed Level 0.3m | Bed Level After Dredge | 30cm below Bed Level After Dredge | Notes |
|---|---|---|---|---|---|---|---|
| 13 | 2.0 | No – maerl will be present anyway | Sand | Sand Freq Maerl | Sand Freq Maerl | Sand Freq Maerl | |
| 14 | 3.9 | No – maerl will remain anyway | Clay Freq Maerl | Clay Freq Maerl | Clay Freq Maerl | Clay Freq Maerl | Very clayey Maerl Strong H2S smell |
| 15 | 0.7 | No – will be subject to increased deposition | Sand/Gravel & Maerl | Sand/Gravel & Maerl | Clay | Clay | |
| 16 | 4.1 | No – maerl will remain anyway | Clay Freq Maerl | Clay Freq Maerl | Clay Freq Maerl | Clay Freq Maerl | Strong H2S smell |
| 17 | 1.7 | Yes | Shell with maerl | Shell with maerl | Clay | Clay | Strong H2S smell throughout vibrocore |
| 18 | 1.2 | No – will be subject to increased deposition | Sand Freq Maerl | Sand Freq Maerl | Sand[d] | Sand[d] | |
| 19 | 1.9 | No – maerl will remain anyway | Maerl | Maerl | Maerl | Maerl | |
| 20 | 1.4 | No – will be subject to increased deposition | Sand | Clay Freq Maerl | Clay[e] | Clay[e] | |
| 21 | 1.6 | Yes | Maerl | Clay Freq Maerl | Clay Freq Maerl | Clay Freq Maerl | |

a – assumed as clay as vibrocore penetration stopped at 1.4m
b – assumed as clay as vibrocore penetration stopped at 1.8m

c – assumed as vibrocore penetration continued until 5m but analysis stopped at 2.5m recorded as maerl all the way down

d – assumed as vibrocore penetration stopped at sand at 1.8m

Figure 2 Sedimentation plot - before dredge

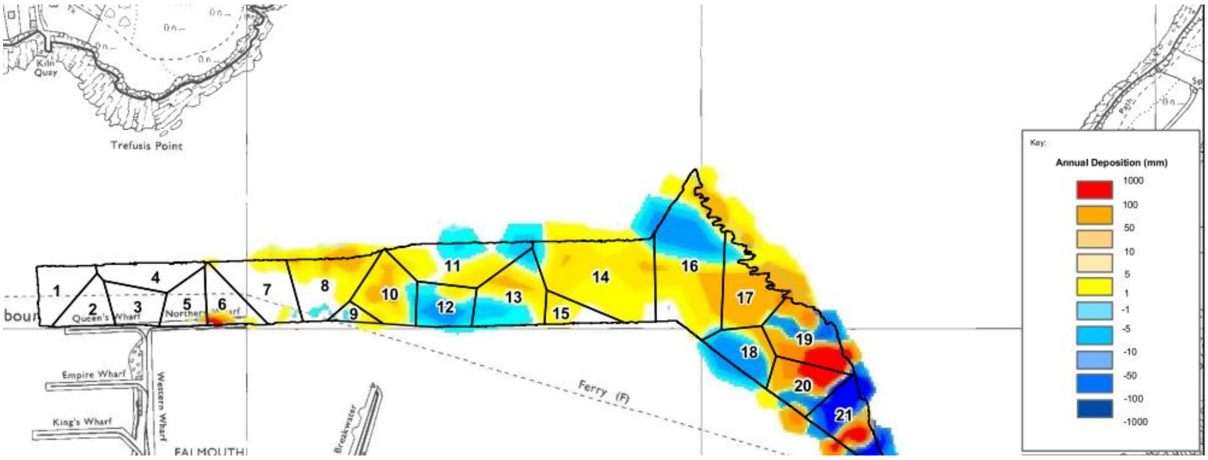
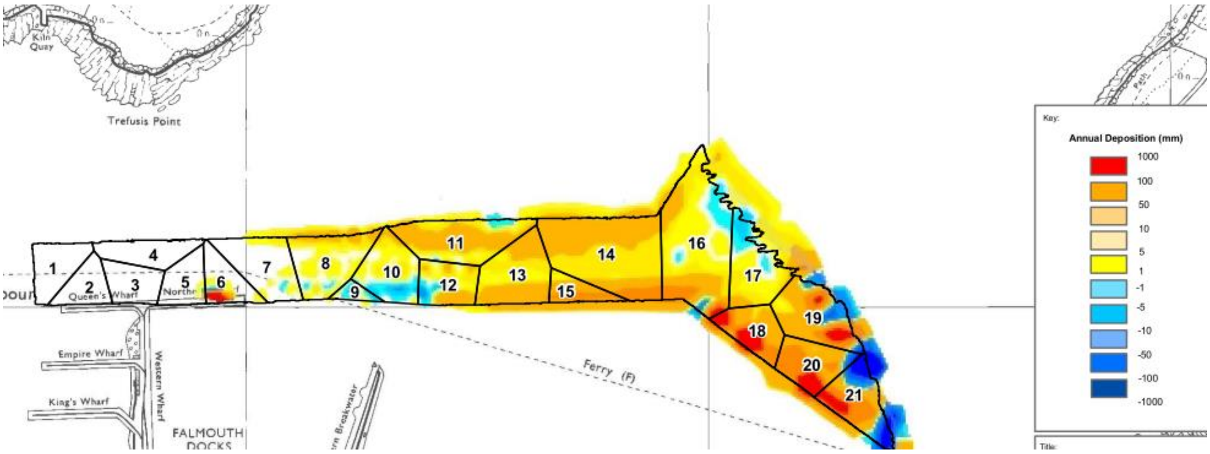



Figure 3 Sedimentation plot - after dredge




**Source: HR Wallingford, Falmouth Cruise Terminal Hydrodynamic and Sedimentary Studies, 2008.**

# 4 ACHIEVING THE FAVOURABLE CONDITION TARGETS

## 4.1 Extent of maerl

One of the favourable condition targets for the maerl bed communities is to ensure no decrease in the extent of maerl as a whole, or of either dead or live maerl from an established baseline, subject to natural change.

As discussed previously in **Section 1.1** the viable habitat for maerl is a depth of maerl or sand with maerl habitat of at least 30cm. Vibrocore surveys have been undertaken to determine the profile of material throughout the proposed dredge depth (Gardline and Mojo Maritime Surveys, 2007). **Table 2** above (based on the 2009 ES and the methodology summarised in **Appendix B**) details the sediments that were found to be present in each vibrocore at the respective depths. The study area was then divided into polygons around each vibrocore assuming that the habitat within the vibrocore was representative of the area within the polygon to the mid-way point between each vibrocore. This assumption was necessary to enable estimates of areas of habitat to be derived. The polygons were then used to estimate the area in hectares of the various substrates present at differing depths (these values are predictions as the boundaries are indicative based on available data).

In order to calculate the predicted changes in the area of viable maerl habitat (i.e. enabling a full range of species to colonise both mixed and maerl only habitat), data from the Gardline and Mojo Maritime Surveys (2007) were used to estimate pre- and post-dredge areas of maerl communities to a viable depth (i.e. a depth of substrate of 30cm calculated using areas of maerl or sand and maerl at bed level (and post-dredge bed level) that continued to a depth of at least 30cm in the vibrocore ). Viable maerl habitats were taken as maerl or mixed maerl with sand habitat. One of the polygons (polygon 17) was recorded as shell with maerl with a strong smell of hydrogen sulphide throughout the vibrocore and was not considered to be a viable habitat given the anoxic conditions present. The predicted results for the changes in viable habitat are shown in **Table 3**.

The areas of clay with maerl (outside of the areas of higher siltation) are detailed in **Table 2** showing the habitat before and after the dredge. The one polygon that is lost from the clay with maerl habitat is polygon 12 which is proposed for enhancement with pure maerl being relayed onto the remaining clay habitat.

Following the mitigation and enhancement proposed in **Section 2**, the area of maerl remaining can be estimated based on the approximate area of each polygon that would be included within the mitigation locations.

The mitigation and enhancement measures proposed would ensure that there is no “decrease in overall extent” of maerl habitat. It is not expected that the live maerl bed at St. Mawes Bank would be affected by the proposed works.

**Table 3 Estimated viable maerl habitat pre- and post-dredge within the proposed new navigation channel with mitigation areas proposed**

| Polygon Number | Polygon Area (ha) | Sand and Maerl or pure maerl habitat | Remains as sand and maerl or pure maerl habitat | Loss of maerl habitat | Naturally Gained maerl habitat (through exposure via dredge) | Net change | Mitigation – gained maerl habitat | Enhancement |
|---|---|---|---|---|---|---|---|---|
| 1 | 1.1 | | | | | | | |
| 2 | 0.9 | | | | | | | |
| 3 | 1.0 | | | | | | | |
| 4 | 1.1 | | | | | | | |
| 5 | 1.0 | | | | | | | |
| 6 | 1.0 | | | | | | | |
| 7 | 1.7 | | | | | | | |
| 8 | 1.9 | | | | | | | |
| 9 | 0.3 | | | | | | | |
| 10 | 1.6 | | | | | | | |
| 11 | 2.2 | | | | | | | |
| 12 | 1.2 | | | | | | | |
| 13 | 2.0 | | | | | | | |
| 14 | 3.9 | | | | | | | |
| 15 | 0.7 | | | | | | | |
| 16 | 4.1 | | | | | | | |
| 17 | 1.7 | | | | | | | |
| 18 | 1.2 | | | | | | | |
| 19 | 1.9 | | | | | | | |
| 20 | 1.4 | | | | | | | |
| 21 | 1.6 | | | | | | | |
| Total (ha) | | 7.6 | 4.1 | 3.5 | 2 | 1.5 | 1.6 | 1.2 |

## 4.2 Distribution of maerl bed communities

The target for the distribution of maerl bed communities is that the works should not cause a significant deviation from an established baseline.

The maerl relocation would occur within a polygon (polygon 10) that was recorded as viable maerl habitat prior to the dredge and of the areas lost (polygons 15 and 18) polygon 15 is adjacent to polygon 13 which has a natural gain in viable maerl habitat. There is, therefore, only one polygon (polygon 18) that has a loss that is not either mitigated or adjacent to an area gaining habitat. It is therefore considered that the distribution of maerl bed communities following mitigation would not deviate significantly from the baseline distribution. **Table 4** shows the overall change in viable habitat for each of the polygons following mitigation.

**Table 4 Overall change in viable maerl habitat after mitigation for each polygon**

| Polygon | Overall change in viable maerl habitat |
|---|---|
| 1 | No change |
| 2 | No change |
| 3 | No Change |
| 4 | No change |
| 5 | No change |
| 6 | No change |
| 7 | No change |
| 8 | No change |
| 9 | No change |
| 10 | No change with mitigation |
| 11 | No change |
| 12 | No change[1] |
| 13 | Gain |
| 14 | No change |
| 15 | Loss |
| 16 | No change |
| 17 | No change |
| 18 | Loss |
| 19 | No change |
| 20 | No change |
| 21 | No change |

1 – Polygon 12 would be enhanced with maerl habitat

## 4.3 Species composition of maerl bed communities

The proposed works should not cause the presence and abundance of composite species to deviate significantly from an established baseline, subject to natural change.

To ensure the maintenance of the species composition of maerl bed communities it is necessary to ascertain some of the characteristics that are essential to support particular species. Two critical characteristics are sediment distribution and depth of habitat. Both of these can be determined through core sampling within a given habitat to investigate both the habitat and associated species. Assessment of the differences between species associated with different habitat types can then be determined to see whether this is a critical factor. In this context, in order to distinguish between a surface covering of maerl and a viable maerl habitat that supports specific infaunal communities it was necessary to determine the depth of maerl habitat that was considered to be viable. This was discussed in a report produced by the Marine Institute (2012) regarding the agreed methodology for the maerl relocation trial (see below). It was concluded that burrowing infauna within maerl typically lives 10-30cm below the surface. Thirty centimetres was the depth of maerl that was, therefore, considered to provide a viable habitat for re-colonisation and is considered to be viable habitat in the context of the mitigation proposals.

In order to ensure that there was no reasonable doubt as to the maintenance of the maerl habitat and likelihood of re-colonisation of the maerl by similar communities, a trial dredge and placement was undertaken by the Plymouth University Marine Institute within the Fal Estuary. The main aim of the trial was to determine the impact of extracting and re-laying the top 30cm of dead maerl habitat on the sediment structure and associated faunal assemblage (Marine Institute, 2014).

The trial involved sampling the trial areas (as well as control areas) to assess sediment and community composition prior to the extraction and re-laying, 5 weeks after re-laying and 44 weeks after re-laying. The trial found that *"removing and replacing the top 30cm of the maerl habitat is technically feasible and, whilst some differences in the habitat structure following re-laying were evident, associated with loss of fine sediment, this did not seem to affect the habitat quality enough to prevent re-colonisation of infauna. By 44 weeks after re-laying the dead maerl matrix, the diversity, abundance and species composition of infauna was not significantly different between treatment and control conditions"* (Marine Institute, 2014).

The results plotted as an nMDS plot (**Figure 4** showing the degree of similarity between samples at different times) show that the Control samples are similar to each other across all weeks. On the other hand the Treatment samples were more dissimilar to each other, especially in Week 5.

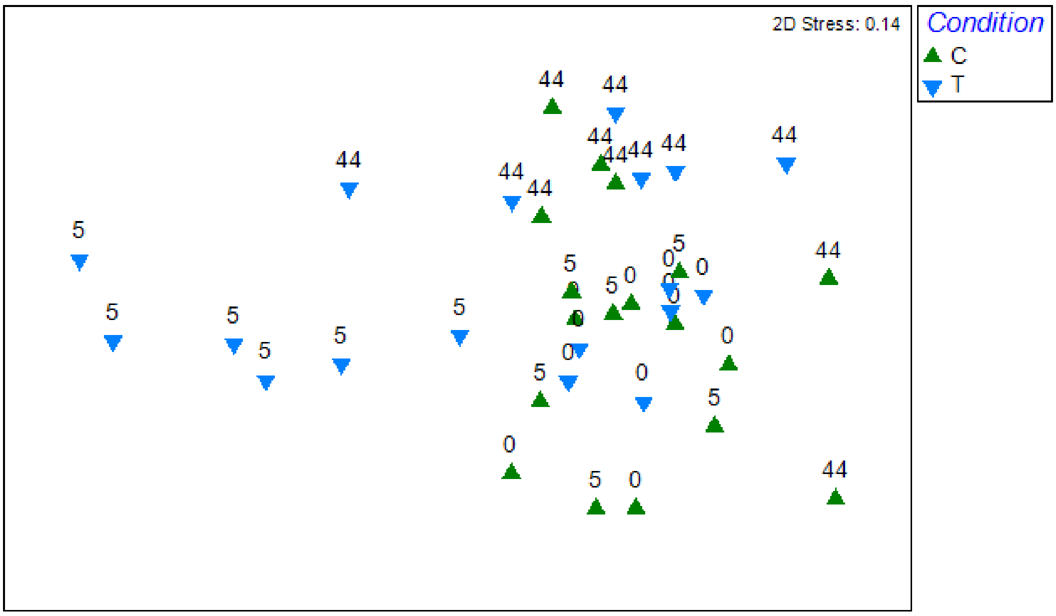



**Figure 4** ***nMDS plot showing the degree of similarity in assemblage composition between the Treatment (T) and Control (C) over time (Week 0, Week 5 and Week 44)(Source: IMS 2013)***

Investigation of community composition showed that five weeks after the trial there was a significant decrease in treatment sites for both taxa and abundance compared with control sites, with a loss of around 45% of taxa.  This suggests that >50% of organisms survived the relocation process or recolonized very quickly.  However, by week 44 there was no significant difference in taxa and abundance between control and treatment sites.

There were no significant changes to the biomass of molluscs, crustaceans and echinoderms throughout the trial.  The only notable difference in faunal assemblage at weeks 5 and 44 was for the annelid biomass which showed a significant difference from the baseline and against control sites.  This indicates that the annelids are more sensitive to disturbance which is likely given their soft body structure compared to the other taxa.  However the taxon richness for annelids showed no major difference between baseline and week 44 in control and treatment sites.

Further review of annelid data by the Marine Institute has revealed that overall there were no major losses of common or high biomass species from the annelid assemblage, the single disproportionately affected species being the deposit feeding annelid *Mediomastus fragilis* which is recognised as having a medium-fast recovery. It is likely that the loss of fines has been a factor in annelid patterns, but sedimentation onto the maerl habitat is likely to build this up over time. An estimate of recovery time based on the data collected (two sampling dates in time) indicates that conditions at treatment sites and recovery sites are likely to be the same within two years (Additional notes from the Marine Institute, following the trial report).

The trial has shown that the recolonisation of the maerl habitat can be expected to occur and that the species composition that results would not deviate significantly from the baseline condition.

## 4.4 Achievement of Favourable Condition Targets

Given the discussions regarding the extent and distribution of the maerl habitat and the likelihood of recovery of the species composition of maerl bed communities, it is possible to conclude with reasonable certainty that the favourable condition targets for maerl bed communities would not be compromised following the proposed works.  Based on this, it is not therefore expected that there would be a residual impact on the site.

# Appendix A

## Maerl Habitat Characteristics

**Viable Maerl Habitat Information**

Numerous references were sourced to provide a summary of the habitat characteristics necessary for viable maerl habitat in order to develop this mitigation strategy. A summary of the key information found is provided below. The findings indicate that viable maerl habitat would be found where maerl is present with coarse sediment and adequate water movement to prevent smothering by finer sediment. Anoxic sediments were not considered to provide a viable maerl habitat, as shown by experiments undertaken by Wilson *et al*.

- Maerl forming species require some protection from wave action to prevent burial and dispersal into deeper water and adequate water movement to prevent siltation. *J. Hall Spencer, 1998. Conservation issues relating to Maerl beds as habitats for Molluscs. Journal of Conchology Special Publication No. 2.*

- Smothering by fine sediment, lowered oxygen concentrations and the presence of hydrogen sulphide are particularly damaging to maerl forming algae (Wilson et al, 2004). Experiments to investigate the tolerance levels of maerl showed that thalli subjected to periods of darkness as well as to burial in coarse, fine and organic rich muddy sediment. Darkness alone or burial in coarse sediment had less severe effects on the algae than periods of burial in fine sediment. In the fine sediments, reduction of water movement around the thalli probably limits gaseous exchange with detrimental effects on the algae. Burial by a shallow layer of muddy sand containing hydrogen sulphide was quickly detrimental and even maerl on the surface of the sediment was dead within two weeks (Wilson et al, 2004). *Sian Wilson, Charmaine Blake, John Berges and Christine Maggs. 2004. Environmental tolerances of free-living coralline algae (maerl): implications for European marine conservation. Biological Conservation 120, 283-293.*

- Maerl species can form extensive beds, mostly in coarse clean sediments of gravels and clean sands or muddy mixed sediments. *OSPAR Commission, Background Document for Maerl Beds, Biodiversity Series, 2010*.

- Maerl can form large beds, when the conditions are right – a fast tidal flow or sufficient wave action to remove fine sediments, but not strong enough to break the brittle maerl branches. *Natural England website* http://www.naturalengland.org.uk/ourwork/marine/mpa/mcz/features/habitats/maerl.aspx

- Maerl beds are an important habitat for a wide variety of marine animals and plants which live amongst or are attached to its branches, or burrow in the coarse gravel of dead maerl beneath the top living layer. *UK Biodiversity Action Plan Priority Habitat Descriptions, Maerl Beds, BRIG, 2008*.

- Biotope Classification for Maerl beds (Source: http://www.jncc.gov.uk/marine/biotopes/biotope.aspx?biotope=JNCCMNCR00001554) and The Marine Habitat Classification for Britain and Ireland

**SS.SMp.Mrl**
**Maerl beds**

Full Hierarchy >> SS >> SS.SMp >> SS.SMp.Mrl

**Habitat (physical) description** **Distribution**

| | |
|---|---|
| **Salinity:** | Full (30-35 ppt) |
| **Wave exposure:** | Moderately exposed, Sheltered, Very sheltered, Extremely sheltered |
| **Tidal streams:** | Moderately strong (1-3 kn), Weak (>1 kn), Very weak (negligible) |
| **Substratum:** | Gravels, clean sands |
| **Zone:** | Infralittoral |
| **Depth Band:** | 0-5 m, 5-10 m, 10-20 m |
| **Other Features:** | |

**Biotope description**
Beds of maerl in coarse clean sediments of gravels and clean sands, which occur either on the open coast or in tide-swept channels of marine inlets (the latter often stony). In fully marine conditions the dominant maerl is typically *Phymatolithon calcareum* (SMP.Pcal), whilst under variable salinity conditions in some sealochs beds of *Lithothamnion glaciale* (SMP.Lgla) may develop.

(There is one biotope code within this wider code that is described as *Lithothamnion corallioides* maerl beds on infralittoral muddy gravel which widens the substratum type to muddy gravel). In addition, one rarely recorded species, *L. fasciculatum* can occur in mud substrate.

**Previous code**

This biotope occurred in previous versions of the classification as:
**IGS.Mrl** - Version: 97.06
**IMX.MrlMx** - Version: 97.06

- Habitat requirements (Source: UK Marine SAC habitats review http://www.ukmarinesac.org.uk/communities/habitats-review/hr21_1.htm)

| ***Habitat factor*** | ***Range of conditions*** |
|---|---|
| **Salinity** | Full, Variable (IGS.Mrl). The salinity tolerance of maerl is species specific with *Phymatolithon calcareum, Lithothamnion corallioides* and *Lithophyllum* sp. usually associated with full salinity areas and *Lithothamnion glaciale* with variable salinities such as in Scottish sealochs. Maerl beds in Galway Bay, Ireland are subject to fully |

| | |
|---|---|
| | saline water for most of the year, bottom salinity being measured as between 34.4 ‰ and 34.8 ‰. However, in February and April the salinity was reduced to about 30 ‰ (Birkett *et al* 1998) |
| **Wave exposure** | Exposed (IGS.Mrl), Moderately exposed (IGS.Mrl), Sheltered, Very sheltered (IMX.MrlMx) |
| **Tidal streams** | Strong (IGS.Mrl), Moderately strong (IGS.Mrl), Weak, Very weak |
| **Substratum** | Gravels (IGS.Mrl), Clean gravels (IGS.Mrl), Muddy gravels (IMX.MrlMx) *(Note: Since replaced by SS.SMp.Mrl with substratum description of gravels and clean sands as shown above)* |
| **Zone** | Infralittoral |
| **Depth range** | 0-20 m (IGS.Mrl), 0-10 m (IMX.MrlMx) |
| **Temperature** | Maerl biotopes occur in a wide range of temperature regimes, from the tropics to northern Norway, but the species composition and distribution of the maerl beds is greatly influenced by temperature. The most obvious temperature-related phenomenon in the UK is the absence of *Lithothamnion corallioides* from Scotland, either because winter temperatures occasionally drop below the minimum survival temperature of this species (between 2-5$^{o}$C) or because temperatures do not remain high enough for long enough to support sufficient annual growth. Laboratory studies on Spanish maerl (Adey & Mckibben 1970) showed that *Phymatolithon calcareum* survived down to 2$^{o}$C, dying at 0.4$^{o}$C, and that the optimum growth was at 15$^{o}$C. *Lithothamnion corallioides* had a higher minimum survival temperature, dying at 2$^{o}$C, and surviving without growth at 5$^{o}$C. |
| **Water quality** | The light levels under which maerl can grow are suggested by the depth ranges in which it grows. Maerl found in tropical waters is usually found at depths below the range of the reef -binding coralline algae associated with coral reefs. At the other extreme of the habitat range, at a few sites in western Ireland (e.g. Mannin Bay, part of Killary Harbour and Muckinish) and Brittany, France maerl occurs intertidally, generally only near the extreme low-water mark. |
| **Nutrients** | Cabioch (1969) has suggested tolerance of elevated nutrient levels on the basis of field observations of maerl distribution in Brittany, France; however experimental studies are lacking. |
| **Calcium** | King & Scramm (1982) reported that the salient factor affecting growth of maerl in culture experiments using various salinity growth media was the calcium ionic concentration, rather than salinity *per se*. They found an optimum uptake of calcium carbonate at 30 ‰. |

## Appendix B

## Methodology for estimating seabed habitat types

SEABED HABITAT INFORMATION

*Information was collated from three sources:*

1. Submarine services (2004).
2. Falmouth docks dredging study (1998).
3. Gardline/Mojo Maritime (2007).

Co-ordinates for each core were plotted in Mapinfo. A large number of varying descriptions of the cores are provided in the various reports, so these were simplified into nine sediment types. For the purposes of the calculation, the sediment type was classified as being the dominant type recorded in each section of the core. For example, where clay with frequent shell was recorded, this was classified as clay. The exception to this was where maerl was recorded. A more detailed analysis was carried out and maerl is recorded even where the dominant sediment is mud for example.

*Summary of assumptions:*

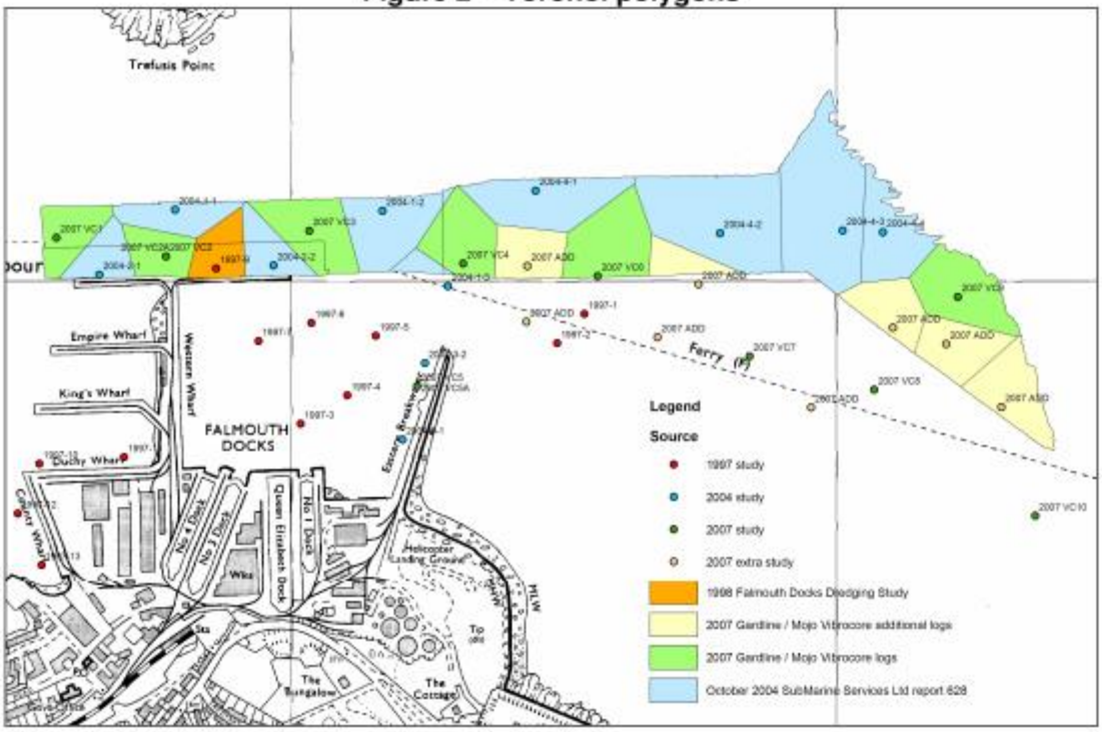
1. Each grid point is represented by the nearest vibrocore. The middle line between two cores is the boundary of the polygon. The assumption is that each vibrocores is representative of the area surrounding it and that there is a distinct line between areas. When the core analysis does not extend as deep as the proposed dredge depth but the core penetration continued it was assumed that the sediment recorded at the bottom of the core continues to the dredge depth.
2. An average was taken of the seabed level in each polygon (because of undulation).
3. Where a sample was taken for testing, it was assumed to be the adjacent spoil type. If the sample was taken in between two spoil types, then the depth of the sample was split between the two types.
4. Sediment type descriptions varied between surveys, so some inference has been made.

*Summary of methodology:*

1. All cores plotted in GIS.
2. Mapinfo created voronoi polygons around each core within the channel and labelled with core number.
3. Bathymetry grids were used to calculate the seabed level (mean average) for each polygon.
4. The vibrocore information was analysed. Types of soil plus depth, where there were changes, were recorded in a table for each polygon.
5. Using mean surface elevated for each polygon, depths of change were converted into elevations in Chart Datum (CD).
6. This information was overlaid with a trench grid at the surface elevation and then at subsequent depths where sediment change was recorded. This allowed the calculation of the volume of material at each spoil type change (note that this work was done to calculate how much spoil of each sediment type was present for dredging purposes, not to calculate the amount of maerl at depths).
7. All resulting volumes were tabulated and total volumes of each spoil type were calculated for each polygon.

8. 21 polygons are shown on the figure (but actually the figure is made up of more; hence the difference in numbers in the excel spreadsheet.

**Figure 2 – Voronoi polygons**



# Appendix B – Live Maerl Technical Note

2/04/16

# Note

HASKONINGDHV UK LIMITED
INDUSTRY, ENERGY & MINING

| | | |
|---|---|---|
| To | : | Falmouth Harbour Commissioners, A & P Falmouth Ltd. |
| From | : | Chris Adnitt |
| Date | : | 27th April 2016 |
| Copy | : | Sian John and Caroline Price |
| Our reference | : | PB2139/N/304382/PBor (version 4 Peer reviewed by Dr Nick Kamenos) |
| **Subject** | **:** | **Technical Note – Live Maerl** |

## Aims of the Note

This technical note aims to put forward information to assist in making an informed decision relating to the potential for impact on loss of 'live' maerl during the dredging activity for the Port of Falmouth Dredging Initiative (PFDI). This information includes the ecological value of live maerl nodules within the channel area, the possible mechanisms to explain the presence of the live maerl nodules in this area and the potential impact of the loss of the live maerl.

## Issue of Concern

Concern was raised by Natural England in relation to the removal and smothering of 'live' maerl nodules in the dredge channel and surrounding area.

## Background to the project and potential impacts

This technical note deals with the potential impacts on the habitats comprising dead maerl with low abundance of live nodules of maerl associated with it. The potential impacts relate to the removal of live nodules of maerl from within the channel as a direct result of deepening activities and the potential for smothering in areas immediately adjacent to the channel.

It is important to note that the proposed dredging activities are not expected to have any effect on the known live maerl beds within the Fal or Helford Estuaries, namely around St. Mawes Bank and within the mouth of the Helford Estuary where live maerl occurs in superabundant (>80%) and abundant (40-79%) quantities respectively (as recorded from GIS data provided by Natural England (2014)).

The area to be dredged is dominated by fine sediment to the west and clay with dead maerl habitat, to the east. There is a low abundance of live maerl (<10% cover in the majority of sites with any live maerl) on dead maerl deposits in certain places within the proposed channel, generally on the south-eastern edges of the channel with increasing amounts of live maerl moving south. Other areas comprise dead maerl with no live nodules or mixed maerl with sand, gravel, clay or shell.

A company of Royal HaskoningDHV

**Differences between live and dead maerl communities**

Maerl species can form extensive beds, mostly in coarse clean sediments of gravels and clean sands or muddy mixed sediments (OSPAR, 2010). Maerl beds have been well studied in terms of their associated species and it appears to be widely accepted that there is a distinction between the species associated with live maerl beds and areas that support dead maerl.

Live maerl beds provide an important habitat for many species which live amongst or are attached to the nodules, or which burrow in the coarse gravel or fossil maerl beneath the top layer. A dense surface layer of live maerl can provide a diverse habitat matrix with its three dimensional structure providing spaces for habitation by a wide range of invertebrates and macroalgae. Maerl beds are recorded as providing a three-dimensional habitat for benthic fauna in which food is supplied by algae and detrital debris which becomes trapped within its branches (Bosence, 1979). Pristine live maerl beds also provide valuable nursery areas for many species of fish and shellfish and are preferentially selected as a habitat for juvenile scallops over impacted dead maerl, sand and gravel (Kamenos *et al*. 2004 a), b) and c)). Maerl beds and dead maerl deposits also act as a long term carbon store (Burrows *et al*, 2014)

Dead maerl also has an ecological importance, supporting diverse communities although these have been reported to be less rich than those which live in live maerl beds (Keegan, 1974). Unimpacted, pristine maerl has a higher structural heterogeneity, and has more species and individuals, than dead maerl (Barbera et al. 2003), which resembles a gravel bottom in structure (Kamenos et al. 2003).

Plates 1, 2 and 3 (taken from Sheehan & Attrill, 2012) show the distinct differences between the live maerl beds at St Mawes in comparison with the dead maerl beds and areas of dead maerl with live nodules in the channel.

Keegan has also noted the presence of a transitory accumulation of maerl debris within a channel subject to very strong tidal flows which render the maerl mobile. This type of habitat was considered to be formed from the erosion of material from mobile dunes of live and dead maerl and had a limited infauna. This occurrence of maerl debris including the movement of maerl from a live maerl bed forming fragmented maerl nodules on top of fossil deposits is also discussed in Foster, 2001, who developed a model for the structure and dynamics of rhodoliths and rhodolith beds (as shown below in *Figure 1*) showing how rhodoliths can be transported into and out of beds, sometimes forming such transitory accumulations.

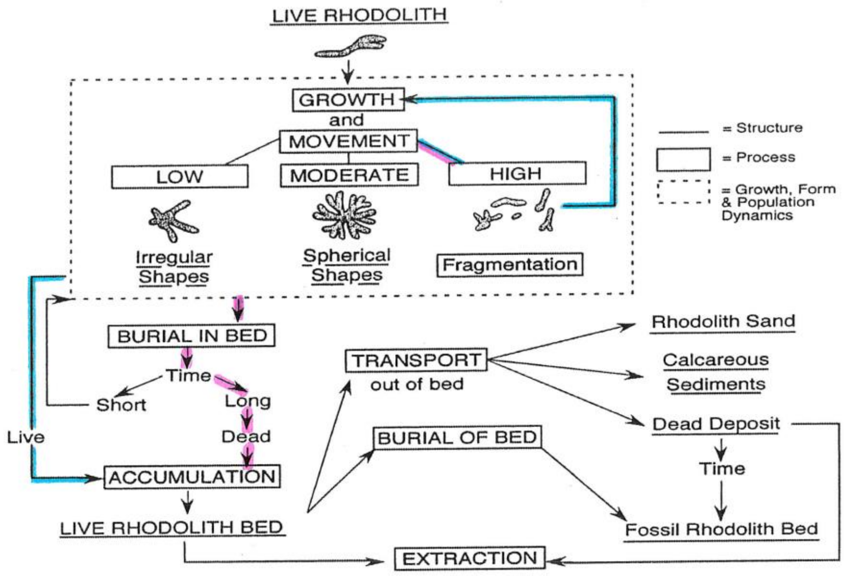



*Figure 1 Model developed by Foster to show movement and development of Rhodoliths*


*Plates 1, 2 and 3 showing different status of maerl within areas of the Fal Estuary*

It is accepted that dead maerl beds (sometimes referred to as fossil deposits) also provide a habitat for associated species, albeit not so diverse as a live maerl bed, such as is seen at St. Mawes Bank. The potential impact on dead maerl habitat and the proposed measures to mitigate the impact on dead maerl is discussed further within a proposed mitigation strategy whilst this note focusses on the potential for impact on the live maerl.

Due to the very slow rate of growth, maerl is considered to be a non-renewable resource and, even if the proportion of living maerl in commercially collected material is low, extraction has major effects on the wide range of species present in both live and dead maerl deposits (Hall-Spencer, 1998; Barbera et al., 2003). Although it is agreed that the loss of live maerl is a loss of a non-renewable resource, a trial dredge has shown however, that the loss of the maerl habitat (both the dead maerl and the dead maerl with live nodules) in the channel and replacement with the dredged maerl, does not have a significant effect on the taxa and abundance of species present in the particular deposits in this area following recolonisation (Sheehan *et al* (2014)). A change in biomass was observed but it was concluded that this was due to a disproportionately affected annelid species and was expected to recover within two years. A contributory factor to the rapid colonisation is thought to be that the habitat in this area is composed mostly of dead maerl with rarely distributed abundance of live nodules rendering the habitat closer to a coarse gravel substrate which together with the higher presence of fine material (clay) seem to reduce the species diversity when compared to a maerl bed with higher proportions of live maerl.

The results of the trial dredge (Sheehan *et al*, 2014) that investigated recolonisation potential following maerl removal and replacement within 6 trial areas located within the channel, showed that, of the samples taken, there was no evidence to suggest that there were any major differences in faunal assemblages or habitat character between the purely dead maerl sites (1 to 5) and the site containing dead maerl with live maerl fragments (Site 6). The trial also showed that maerl communities recolonised the relocated maerl within the sites within 44 weeks following removal and replacement.

The study did include photographic recording of quadrats to assess changes in the surface organisms. However it was concluded that due to the few observations of epifauna within the photoquadrats, no analyses were undertaken (Sheehan *et al,* 2014). Results were presented in a table however and showed that there were only 11 taxa from six phyla observed (4 arthropoda, 3 mollusca and one from each of Cnidaria, Annelida and Chordata).

Further analysis of towed video footage from Falmouth was carried out by the Plymouth University Marine Institute (Sheehan *et al*. 2015). The resulting data, together with data collated from Jersey, was analysed to determine whether the presence of live maerl fragments increased the ecosystem service ‘habitat provision’. The paper showed that the number of epifauna taxa increased significantly in the Falmouth sites with increasing % occurrence of live maerl nodules but there was not a statistically significant relationship between the abundance of epifauna and % occurrence of live maerl. The area to be affected by dredging within Falmouth Harbour has very low levels of live maerl (the majority of sites with <10% cover) which could offer an explanation as to the very low numbers of epifauna taxa and abundance present during both surveys. The analysis of towed video data again showed that the density of epifaunal taxa within the Falmouth sites was very low (with 2.9 taxa per $m^2$ for mixed maerl habitat (which includes some sites with only 4% occurrence of live maerl nodules and 40% of maerl habitat) and 2.55 per $m^2$ for dead maerl habitat), which may explain some of the findings from the paper. The greatest difference observed in the findings of the paper is between the numbers of tube worms present in the sample sites with a higher number in the sites associated with live maerl (which also show a higher number of taxa). These worms are found in fine sediment habitats with stones and sand and build tubes out of shell fragments and small stones. However it is also recognised in the paper that the tube worms themselves increase the structural complexity of the habitat. This is not discussed further within the paper but it could offer a potential explanation as to why these sites also have a higher number of taxa. The results were not consistent for the two areas and showed that for the sites surveyed in Jersey, beds with live maerl supported less individuals than dead maerl and a similar number of taxa. It is possible that the differences observed in Falmouth could be due to other response variables that were not assessed.

From the above information collected during the trial, and following review of the information collated above, it can be concluded that the dead maerl with live fragments (found within the channel) and the dead maerl, provide a similar habitat and that the presence of such a low abundance of fragments of live maerl do not provide any unique characteristics that would enhance the ecological value of the habitat in this area.

It is recognised that there is the potential for transient species to use the maerl habitats, for example as a nursery area, and that the amount of live maerl present within a habitat may affect the use by such species. However, given the low levels of cover of live maerl within the proposed channel it is not expected that the live maerl would make a difference to the utilisation of the habitat in this area.

**Requirements for maerl establishment and growth**

There are several characteristics that are required for the successful establishment of a maerl bed comprising living maerl. These are summarised below.

Maerl is found in waters up to 32-40m deep, depending on water turbidity, as a result of its requirement for light to photosynthesise (OSPAR Commission, 2010). Typically however, maerl is found in waters down to 20m depth (UK Biodiversity Action Plan). Living maerl requires enough light to photosynthesise, otherwise it becomes bleached losing its pink colour and subsequently dies.

Maerl forming species require some protection from wave action to prevent burial and dispersal into deeper water and adequate water movement to prevent siltation (Hall-Spencer, 1998). Smothering by fine sediment, lowered oxygen concentrations and the presence of hydrogen sulphide are particularly damaging to maerl forming algae (Wilson et al, 2004). Experiments to investigate the tolerance levels of maerl subjected the thalli to periods of darkness as well as to burial in coarse, fine and organic rich muddy sediment. Darkness alone or burial in coarse sediment had less severe effects on the algae than periods of burial in fine sediment. In the fine sediments, reduction of water movement around the thalli probably limits gaseous exchange with detrimental effects on the algae (S. Wilson et al, 2004). Burial by a shallow layer of muddy sand containing hydrogen sulphide was quickly detrimental and even maerl on the surface of the sediment was dead within two weeks.

Fragmentation of maerl is considered to be detrimental as it causes compaction of the sediment which reduces water movement. Fragmentation can be caused by trawling or extraction activities but also from high levels of water movement.

**Conservation Value**

Two maerl species, *Lithothamnion corallioides* and *Phymatolithon calcareum,* are listed in Annex V of the Habitats Directive and in some locations, including in the Fal and Helford Estuaries SAC, maerl beds are also a sub-type habitat within some of the Annex I habitats of the Directive and therefore given protection through the designation of Special Areas of Conservation. The EU Habitats Directive requires Member States to take appropriate management measures to ensure that any exploitation is compatible with maerl beds being maintained at a favourable conservation status. The live maerl bed at St Mawes Bank is also specifically identified within the Fal and Helford Estuaries which is a recommended Marine Conservation Zone on account of its maerl and seagrass beds.

The UK Marine SAC website (http://www.ukmarinesac.org.uk/communities/maerl/m1_1.htm) reports that "Maerl beds have considerable conservation value because although maerl is confined to a very small proportion of European shallow sublittoral waters, each of the beds studied to date has been found to harbour a disproportionately high diversity and abundance of associated organisms in comparison with surrounding biotopes; some of these species are confined to the maerl habitat or rarely found elsewhere".

The value of maerl beds as a unique assemblage of biotopes is currently threatened by several types of human activity, e.g. large-scale commercial extraction, reduction of water quality by discharges, and the use of heavy demersal fishing gear (UK Marine SAC website).

The unique assemblage of biotopes linked to maerl beds occur within the broad description of "beds of maerl in coarse clean sediments of gravels and clean sands, which occur either on the open coast or in tide-swept channels of marine inlets (the latter often stony)", for which there are four biotopes (1-4) and two sub-biotopes (1a and 1b), as listed below in *Table 1.*

| **Habitat type** | **Biotope Classification/*Sub-biotope*** |
|---|---|
| 1 - Maërl beds characterised by *Phymatolithon calcareum* in gravels and sands. | SS.SMp.Mrl.Pcal |
| 1a - Upper infralittoral maërl beds characterised by *Phymatolithon calcareum* in gravels and sand with a wide variety of associated red seaweeds. | *SS.SMp.Mrl.Pcal.R* |
| 1b - Lower infralittoral maërl beds characterised by *Phymatolithon calcareum* in gravels and sand with a variety of associated echinoderms. | *SS.SMp.Mrl.Pcal.Nmix* |
| 2 - Live maërl beds in sheltered, silty conditions which are dominated by *Lithothamnion corallioides* with a variety of foliose and filamentous seaweeds. | SS.SMp.Mrl.Lcor |
| 3 - Shallow, sheltered infralittoral muddy plains with *Lithophyllum fasciculatum* maërl. | SS.SMp.Mrl.Lfas |
| 4 - Upper infralittoral tide-swept channels of coarse sediment in full or variable salinity conditions with *Lithothamnion glaciale* maërl 'rhodoliths' | SS.SMp.Mrl.Lgla |

*Table 1 Habitat type and Biotopes associated with Maerl beds*

The maerl species noted for the Fal and Helford Estuaries are *Lithothamnion coralliodes* and *Phymatolithon calcareum* which would be found associated with biotopes 1 and 2.

Latham *et al* (2012) mapped the biotopes within the Fal and Helford Estuaries, based on previous mapping studies, which showed the channel area as sub-littoral marine mixed sediments with sponges and ascidians (MarMu;FaMs; AlcMas; Aasp; SubSoAS). Specific maerl biotopes were mapped within the Fal and Helford Estuaries associated with the live maerl beds on St Mawes Bank and in the mouth of the Helford.

Samples from the Seastar survey (Axelsson et al, 2008) from the dead maerl beds within the Fal Estuary, revealed that of the 194 taxa recorded from core samples within the channel area, 74 species were annelids, 50 crustaceans, 48 molluscs and seven echinoderms. The dominant species were amphipods and isopods. Other dominant species were polychaetes, brittle stars and a gastropod snail. These species are mostly species of coarse substrata exploiting the interstices of gravels, shell debris and maerl.

**Summary of information collated relating to ecological value of live maerl nodules**

It is concluded, based on the above information, that the presence of fragments of live maerl occurring rarely or occasionally within an area of dead maerl is not thought to contribute significantly to the habitat diversity for associated species or to provide any benefit to the habitat. Given the low level of % cover of maerl in the proposed channel area, the importance of the live maerl nodules in this situation is therefore due to the presence of the live maerl as a species in its own right. The following sections discuss the potential impact relating to the loss of the live maerl.

**Distribution of Live Maerl within the Fal and Helford Estuaries and specifically within the navigation channel**

There are extensive deposits of dead maerl within the Fal Estuary and Falmouth Bay, which indicate that it is likely that live maerl beds may historically have existed within the Fal and Helford Estuaries to a much greater extent than has been observed since within this area. The decline of these beds could possibly have been due to historic changes in sea level or water quality. Dead maerl beds in some parts of the UK appear to be relicts and may indicate the effects of past climate change (http://www.ukmarinesac.org.uk/pdfs/maerl.pdf).

The areas remaining as live maerl bed within the estuaries exist on St Mawes Bank and in an area in the mouth of the Helford River. Live maerl beds do not appear to occur elsewhere in the Fal and Helford Estuaries and there do not appear to be any other areas where live maerl occurs in high proportions.

Live maerl nodules do occur throughout the Fal and Helford Estuaries however at varying abundances. Figures 2 and 3 below provide a good indication of the distribution of live maerl nodules within the proposed channel and surrounding area, established from video tows (Sheehan *et al,* 2012). It appears that the abundance of maerl decreases as you move north in the area sampled. This could be due to the more exposed nature of this area away from the coast or due to its use as a navigation channel. This area is used for shipping and is not dredged for maintenance. The last time the existing channel was maintenance dredged was thought to be in the 1960’s. The lack of maintenance dredging indicates that the amount of settlement of material is very low within this area, which is confirmed by the modelling report (between 0 and 0.02m/year (in the most sheltered area) and between 0 and 0.016m/year in the main channel area). This indicates that ship movements in the channel or currents are fast enough to prevent settlement of sediment and/or that sediment in suspension is at low concentrations within this area.

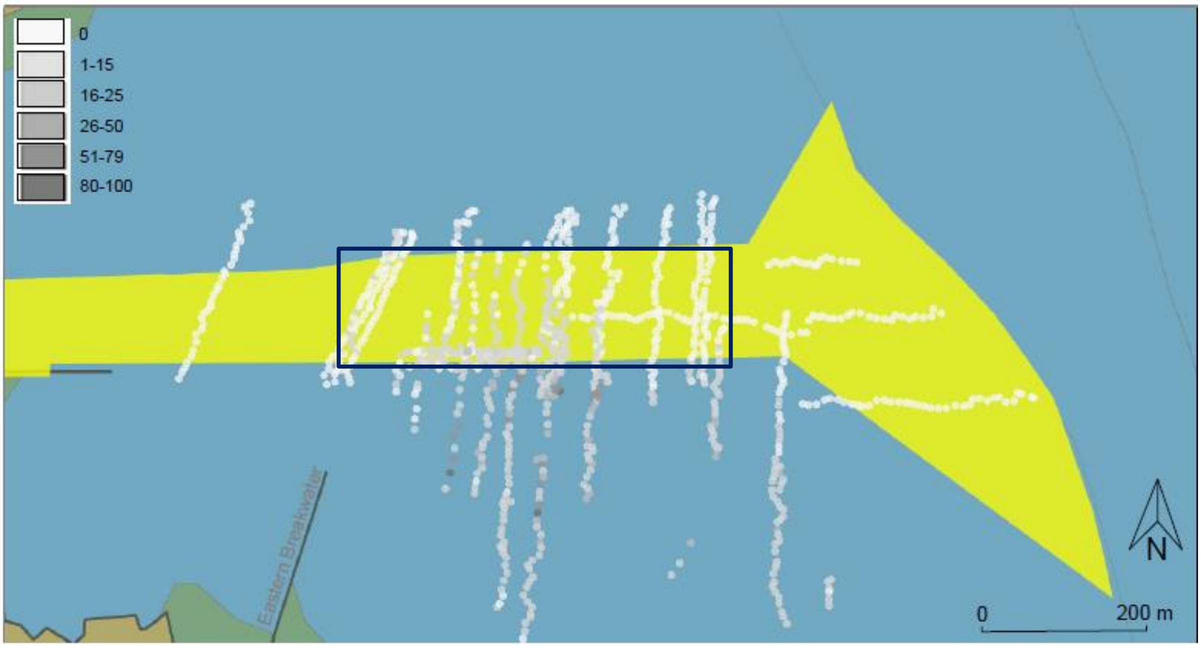



*Figure 2 Adjusted percentage cover live maerl within the channel and surrounding area (adjusted to include presence of live maerl if not occurring under one of the points for recording % cover) (Blue box shows approximate location of zoomed in figure below)*

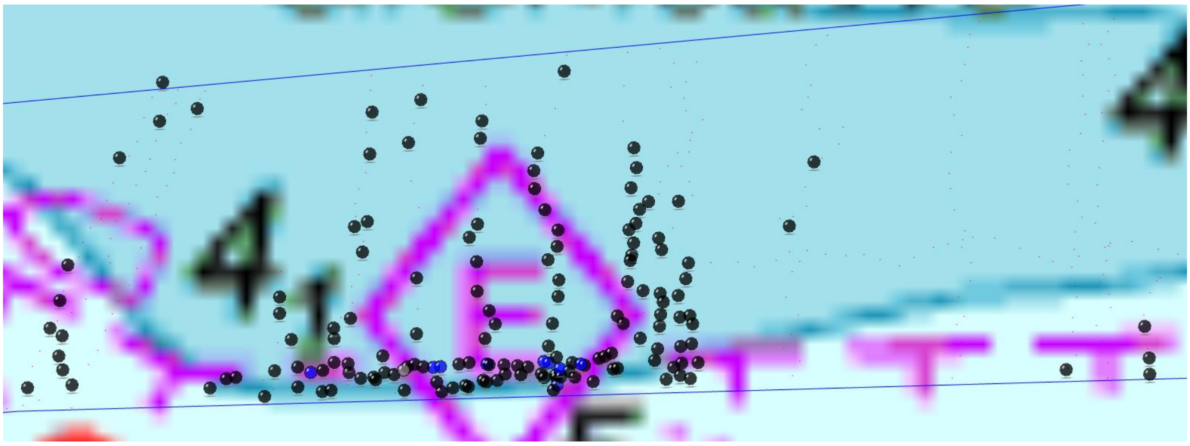


*Figure 3  An enhanced area of the southern area of the proposed channel within Figure 2. Image shows all points in The Channel where live maerl was recorded. Black circles show live maerl cover at <10%, blue at <20% and grey at <30%.*

The figures above confirm that live maerl does occur within the proposed dredge area but generally at levels below 10% cover (measured for each dot over an area of $1m^2$). There are a few locations which record percent cover at above 10% but less than 20% and one location that shows cover of live maerl to be between 20 and 30%. To the south of the proposed channel (and within the existing channel) there are areas that record live maerl at higher levels of cover with abundance of live maerl appearing to increase in abundance the further south records were taken. This data could indicate that characteristics that occur within the channel (i.e. depth, mobility of substrate caused by tidal currents and/or vessel movements) could play a part in influencing the presence and distribution of live maerl.

The question remains as to where the live maerl is coming from. Given the low levels of cover of live maerl it is not considered to be accumulating as a live bed in this area. It is therefore expected that the most likely scenario is that the nodules of live maerl within the existing channel have been moved from an area to the south, tumbling along the seabed with the currents into the channel area. The marked reduction in abundance of living nodules of maerl moving northwards into the proposed channel area (as shown in Figure 2 above) indicates that the live maerl in the existing channel is likely to be accumulating at the base of the channel slope but still remaining at low levels of abundance. Figure 3 also indicates that once live maerl rolls into the channel the live maerl nodules concentrate at the base of the channel (higher abundance directly at the base of the channel where the channel slope meets the seabed).

There are a number of options to explain what could potentially be happening in the channel area. One of these is that maerl is surviving in the channel areas at low levels of abundance but not enough to form a live maerl bed. The low abundance of live nodules in the proposed channel area, compared to the area within the existing channel, indicates that live maerl may be tumbling into the existing channel and accumulating at the base of the channel slope before tumbling away and radiating out or remaining in this location and dying off. The live nodules that are present within the channel would have arrived there at any point since the last dredging activity which occurred in the 1960's. It is possible that the movement of vessels within the channel, which provides sufficient movement to reduce any settlement of sediment, also increases the mobility of the maerl in this area such that its survival is limited.

**Suspended sediment and sedimentation effects on live maerl**

The predicted change to hydro and sediment dynamics as a result of the channel deepening was modelled to enable an assessment of impacts. The predicted effects were reported (HR Wallingford, 2008 and 2016) and summarised as:

- A small reduction in tidal currents local to the dredge;
- No general change to the magnitude of wave conditions. Some small increase in wave energy is predicted on the southern edge of the dredged channel and towards the west of Falmouth Inner Harbour;
- No general effect on mud transport. A small amount of accretion in the dredged area was predicted, but insufficient to suggest regular maintenance dredging will be required; and
- No change to sand transport fluxes in the area. A potential initial accretion rate of sands of 5500 $m^3$/yr was predicted, mostly on the south side of the eastern end of the dredged channel. This value would drop to 2500$m^3$/yr in the longer term. This value was considered to be an over-prediction and would be insufficient to require regular maintenance dredging but suggests monitoring of the southern side of the channel should be considered during the early stages following the completion of the dredge.

The potential impact of these findings on live maerl is discussed below:

*During the dredging activity*

To provide more detail for the potential for impacts on areas of live maerl an appraisal of the modelling results was undertaken. During the dredging activity the movement of the sediment plume and the rate of deposition were calculated for a range of locations covering the proposed dredged area and predictions made as to the average deposition in different areas. It is apparent from the dredge outputs that any changes resulting from the dredging and the subsequent deposition are restricted to the Western side of the deeper water channel (for example results see **Figures 4** to **5**) and therefore there is no risk of affecting the live maerl bed on St Mawes Bank.

Figure 4 shows the result of the simulation of sediment release at a site at the eastern end of the proposed dredged area for spring tides. This simulation provides the largest spatial extent of the plume. Figure 5 shows equivalent results for release centrally in the dredged area for neap tides. Release during neap tides would be anticipated to provide the highest increases in sediment concentration near to the dredging site due to the reduced dispersion associated with reduced currents during neap tides.

Figures 4 and 5 show the maximum excess suspended sediment concentration predicted during the simulation for the two dredging locations at different states of the tide. These types of figure are useful for quickly identifying the maximum concentration increases caused by dredging/disposal plumes at any time within the study area but it should be noted that this form of presentation greatly over-emphasises the extent of the plumes at any given time. A minimum threshold for plotting the increase in suspended sediment concentration above background levels of 3 mg/l has been used to account for the generally low suspended sediment concentrations found in the area.

The increase in suspended sediment and subsequent deposition also declines within a distance such that it would not affect the live maerl beds in the Helford River. Modelling of the sediment plume associated with dredging disposal also confirmed no route for fine sediment from the disposal site to the Helford River.

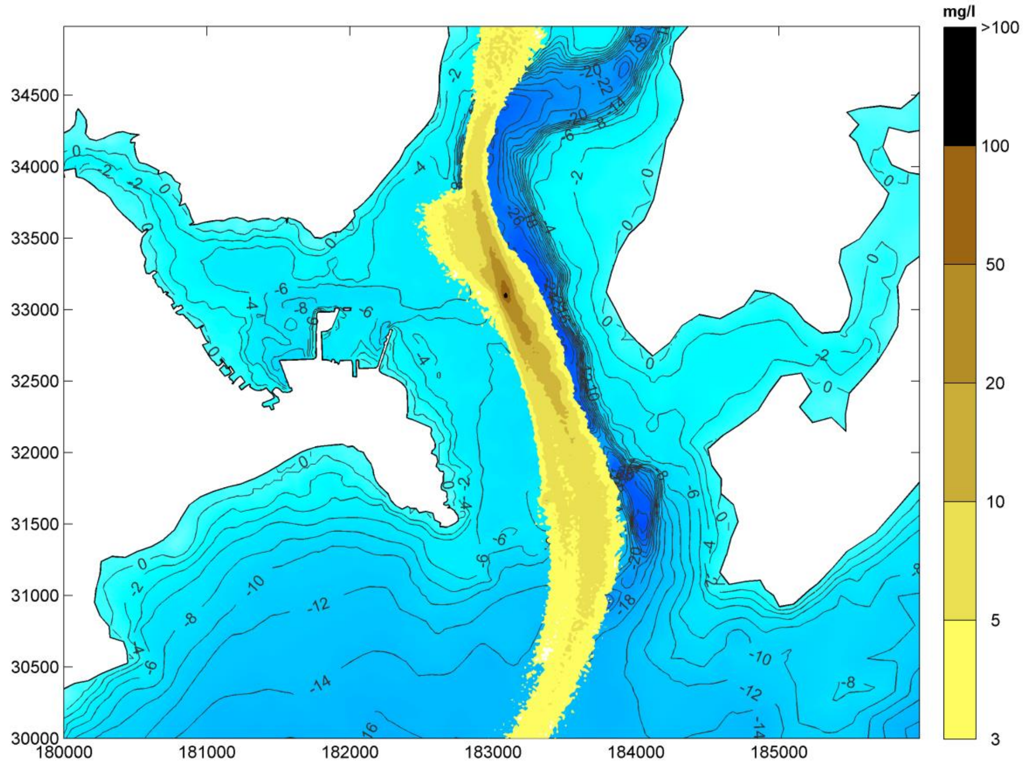



*Figure 4 Maximum suspended solids concentration for backhoe dredging at Site C, spring tide (this scenario showed the largest extent of the plume for all dredge scenarios)*

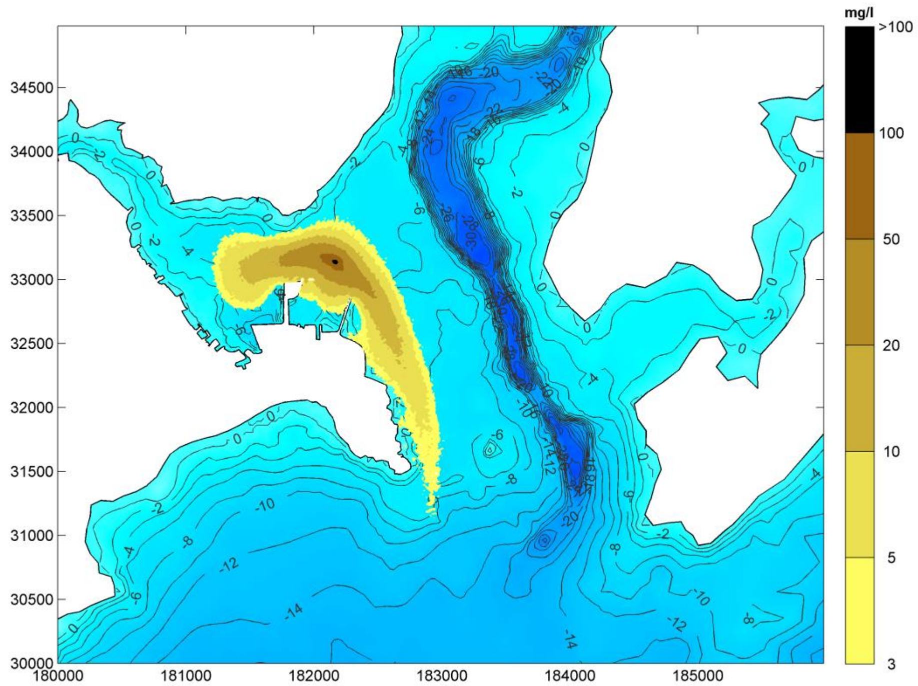



*Figure5 Maximum suspended solids concentration for backhoe dredging at Site B, neap tide*

There would be a plume of sediment from the dredge but this is minimised through design by using a backhoe dredger which retains the sediment structure as much as possible, thereby minimising the release of fines. The figures shown in Appendix A show the suspended sediment concentrations for the same area for different tidal conditions. The figures show that there is a larger plume during spring tides, as would be expected, but the area covered by the higher concentration plumes are more localised during neap tides as the plume is moving more slowly. Overall, given the low levels of concentration of sediment in the outer areas of the plume, the state of the tide does not appear to be influential enough to make a difference to the level of impact. **Figures 4** to **5** (above) show that the plume reaches peak concentrations around the dredger of between 20-100mg/l$^{-1}$ reducing within a short distance to 10mg/l$^{-1}$. Such levels, on a temporary basis during the dredging activity are not expected to result in an impact on the live maerl. The intermittent nature of the dredging (twelve hour days and lasting for a duration of approximately 6 months) and the continuous movement of the dredger within the channel (causing the plume to affect different areas) would not cause a continuous reduction in light levels in any one location and it is recognised that maerl can survive with reduced light levels for a number of weeks (Wilson *et al*, 2004).

Deposition of sediment onto live maerl thalli can impact on the photosynthetic ability of the maerl. Wilson *et al* (2004) found that smothering of live maerl thalli with muddy sand after one week caused the thalli buried under 2cm of sediment to turn a very pale pink while the thalli on the sediment surface and those buried under 0.25cm were a stronger pink. All thalli had become white by the end of the second week, when they were deemed to be dead. When covered by coarser sediment (sand), after four weeks of smothering there was no significant difference between the thalli at depths of 4 and 8 cm, but thalli on the surface of the substratum had significantly higher photosynthetic yield. All thalli that were smothered using gravel or sand remained alive after the 4 week experiment. Burial with sediments containing hydrogen sulphide was quickly detrimental, even for maerl thalli on the surface of the fine sediment.

The experiments referenced above (Wilson et al 2004) indicated that, in the fine sediments, reduction of water movement around the thalli probably limits gaseous exchange with detrimental effects on the algae.

The material to be dredged from the channel as part of the PFDI comprises a variety of sediment types ranging from fine sediments predominantly in the western end of the channel and mixed coarser sediments dominating in the eastern end of the channel. The dredging in the middle of the channel is indicated by the modelling results to be the area that may cause some deposition onto the live maerl beds and this area comprises maerl, sand, mixed sand and maerl and clay/silt with maerl. Any anoxic sediment that is dredged and subsequently released from the dredger as part of the sediment plume will be oxidised as it moves through the water column. The method put forward for dredging minimises the release of sediment in suspension. In addition, any sediment that is released into the water column comes into contact with higher levels of dissolved oxygen in the water (than were available in the seabed sediments) and therefore oxidation will occur as discussed in Cappuyns and Swennen (date unknown). Any anoxic sediment that is dredged and subsequently released from the dredger as part of the sediment plume will therefore be oxidised as it moves through the water column.

Modelling was undertaken to determine the likelihood of deposition of the fine component and therefore the potential for smothering of live maerl nodules. The modelling predicted a small amount of deposition around the channel area. During each modelling run for the three locations, the deposition has been predicted and there is localised deposition immediately around the dredger of greater than 3mm which drops down to 1-3mm very quickly (**Figure 6**). The larger areas of deposition are below 0.1mm per tide. The majority of the deposition within these areas would remobilise with subsequent tides.

Overall, the modelling predicted an average depth of total deposition for the duration of the capital dredge of between 0.5 to 1.7mm with the higher levels occurring to the north of the channel. The area of live maerl to the south of the channel was predicted to receive between 1.1 and 1.3mm of deposition in total during the dredge activity (expected to last approximately 6 months).

The levels of deposition predicted are not expected to impact on live maerl nodules, particularly as the rate of deposition is so low and the total predicted deposition for the duration of the dredge is between 1.1 and 1.3mm. The live maerl that occurs to the south of the channel with an abundance of rare or occasional would be subject to deposition during dredging within and around Site B. The maximum level of deposition at any one time resulting from dredging in these locations at the areas of live maerl outside of the channel are shown to be between 0.025 and 0.25mm (modelled over a duration of four tides (Figure 6 below and Figures in Appendix B)). Some of the material deposited would also remobilise on subsequent tides. There is no expectation that there would be enough sediment accumulation to cause the burial of the live maerl in sediment. Fine sediment may remain on some of the maerl nodules if water movement is not sufficient to remove it. This could potentially cause some localised smothering of smaller nodules of maerl. However, the total amount of deposition of fine material for the duration of the dredge (approximately 6 months) is not enough to cover the live maerl nodules which are expected to be in the region of 4-6mm diameter. There may be some minor settlement on to some nodules of live maerl which may cause some localised stress but the majority of the settlement is expected to either roll off the maerl nodules and fall to the bed or be remobilised through water movements. The HR Wallingford report states that the deposition rates are unlikely to change the nature of the bed in the areas studied (HR Wallingford, 2008).

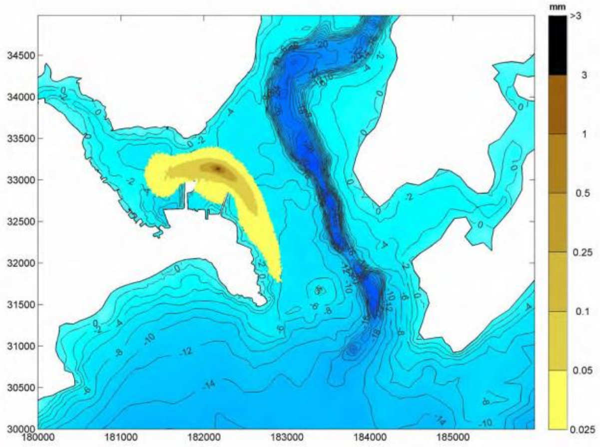



*Figure 6 Maximum deposition for backhoe dredging at Site B, neap tide*

*During operation*

A calculation of the total volume of sand deposited annually (the difference between potential erosion and deposition) in the area of the proposed channel gives a figure of less than 20 $m^3$/yr. This simulation suggests that whilst sand is mobile in the area of the proposed channel, the bed levels are generally stable with little net deposition or erosion overall. This insignificant amount of predicted bed change is consistent with the present lack of need to undertake maintenance dredging in the approaches to Falmouth and the relatively stable nature of the sea bed in the longer term.

The calculation of the annual accretion within the dredged channel with the proposed dredging in place gives an accretion total of 5500 $m^3$/yr for the first year due to slope stabilisation. This accretion rate is linked to the prediction of generally unchanged sand fluxes due to the channel but with deeper depths – resulting in less potential for transport directly over the deeper area and, therefore, deposition. The bulk of the deposition is predicted on the south-eastern corner of the dredged area with a maximum depth of deposition in the range 0.2 -0.3 m/yr. Values of less than 0.1 m/yr are predicted on the southern side of the channel and less than 0.02 m/s on the northern side. The area that will experience this deposition will be the area that has already been dredged so it is not expected that there will be any significant amounts of live maerl in this area. Any live maerl that is within this area will have rolled into the channel since the dredging occurred. Further consideration of these predictions (personal communication, HR Wallingford, 2015) suggests that this level of accumulation is due to the southern slope of the channel readjusting and therefore is only anticipated to occur until a stable channel slope is established by localised accumulation at the bottom of the slope (potentially within the first year depending on storm and wave conditions). Following the establishment of the channel slope these levels would reduce such that minimal levels of accumulation would then occur predicted to average 0.1m/yr. It should be noted that the modelling assumed an abundant availability of mobile sand. Bed surface grabs show a transition between sandy areas half way along the proposed channel to a gravelly bed in Carrick Roads, therefore the sand transport predictions provide a precautionary estimate of sandy infill in the channel. This is confirmed by the sedimentation plot predicting the situation before the dredge (existing situation (shown in Appendix C)) which would indicate that there are currently annual deposits of the same magnitude within areas of the channel. The lack of maintenance dredging requirement in the channel proves that this theoretical annual accretion is not occurring and this is considered to be due to the lack of sand in the system that could have resulted in such levels of accretion.

There was a small increase in deposition of fine sediment (mud) predicted in the channel area (610$m^3$/yr taking the value from 2360$m^3$/yr to 2970$m^3$/yr) but it was recognised in the modelling report that currently there is no requirement for maintenance dredging and therefore it was assumed that other processes are acting in the area to reduce deposition, for example ship passage could keep the channel generally clear of sediment accretion reducing the simulated baseline rate of 2360 $m^3$/yr to zero (or negligible). This total is very low suggesting the accretion rate for fine sediment in the dredged area may not be sufficient to require regular maintenance dredging of the channel. The report concluded that the small increase in fine sediment infill associated with the development suggests that the dredge will not significantly change the fine sediment regime in Falmouth Harbour.

These levels of deposition over the durations predicted may change the habitat slightly in localised areas but given that this level of deposition is over a year and would be depositing at a very slow rate there should not be an impact on live maerl nodules. In addition, maerl mitigation areas have been planned to avoid the areas of highest deposition as predicted by the modelling. It is also apparent from the figures showing before and after dredging that relatively high levels of existing deposition are shown occurring in areas where maerl habitat occurs.

Outside of the channel area (beyond the top of the slope of the channel) there is not expected to be a change in deposition during the operational phase of the project as the bed level will not have changed in these areas and any changes to current flows and waves are minimal. There is not therefore expected to be any impacts on the maerl to the south of the channel in relation to changes as a result of the channel deepening.

**Loss of live maerl**

Although it is recognised that the loss of living maerl from a live maerl bed such as that found in St Mawes Bank, would be a significant loss to the overall living maerl habitat within the Fal and Helford Estuaries SAC, given the slow growth rates of the maerl and the contribution that the live rhodoliths make to the habitat structure and hence species diversity of the habitats. However, this impact is only concerned with a dead maerl deposit existing with low abundance of live nodules which do not constitute a live maerl bed.

In areas of dead maerl deposits, such as occur in the channel area the loss of live maerl nodules are not expected to affect the habitat structure as is shown from the trial dredge where the presence of live maerl nodules on the surface of the dead maerl deposit made no significant difference to the associated communities present. The live maerl nodules are not expected to accumulate into a live maerl bed over time in this area. The nodules are predicted to have been present in this area since the 1960s and have not formed a live maerl bed.

The maerl fragments in the channel are likely to have originated from a nearby living maerl bed, where fragments are broken off by tidal movements and transported along the seabed by the underwater currents to other areas. Where environmental conditions are favourable, the live maerl fragments could accumulate as a live bed similar to that at St Mawes (a process shown above in the model developed by Foster). Where conditions are unfavourable, these fragments will die and accumulate as a bed of dead calcified seaweed deposits (Foster), much like leaves falling from a tree and decaying on the ground.

One of the favourable condition targets for the Fal and Helford Estuaries SAC requires no decrease in extent of maerl as a whole, or of either dead or live maerl, from an established baseline, subject to natural change. The established baseline would have been the baseline established at time of designation of the site. The Regulation 33 package (January 2000) outlines the live maerl areas within the Fal and Helford Estuaries as the live bed at St Mawes Bank and another live maerl bed recorded in the mouth of the Helford. There is also reference to extensive areas of dead and crushed maerl, found south of Penarrow Point out into Falmouth Bay. There are no other references to areas of live maerl. However, the baseline that was established at the time of designation is likely to have missed areas of live maerl that were present but not recorded. More recent research has shown there to be additional areas of live maerl within the estuaries but not at such high levels of abundance. The live maerl within the channel and in the area adjacent to the south of the channel is not considered to be at a high enough abundance to constitute a live maerl bed.

The favourable condition table for the Fal and Helford Estuaries does refer to the distribution of the maerl bed communities (listed in appendix III). The relative distribution of the biotopes listed in the appendix is referred to as an important structural aspect of the Sandbank feature (within which the maerl beds form a sub-feature). The communities listed in this referenced appendix include the biotopes for maerl which are shown as occurring on St Mawes Bank and in the mouth of the Helford. Maerl biotopes are not recorded within the channel which is described as sublittoral mud with bedrock outcrops.

The dredging activity is not predicted to cause the loss of any of the live maerl from the living maerl bed areas on St Mawes Bank and the live maerl in the mouth of the Helford Estuary. In this respect, it would not cause a decrease in extent of live maerl, from the baseline of maerl bed communities.

In relation to the existing (recent surveys have found more live maerl resources throughout the estuaries although not at the same level of abundance as the maerl bed at St Mawes and in the Helford) total baseline for live maerl (including live maerl associated with predominantly dead beds) the removal of the live nodules from the channel area is not expected to have a long term effect on the extent or distribution of live maerl. The removal of the live nodules will remove a live resource from the system, some of which may be re-laid on the surface of the seabed during the replacement of the maerl habitat. The loss of the remaining amount of live maerl is a loss of extent of live maerl. However, the most likely scenario is that this live resource is not a long term feature of the site. It is considered that when the live maerl nodules naturally roll into the channel they are then subject to greater levels of mobility, most probably due to the movement of vessels. This is then likely to cause these nodules to fragment and die off, which explains why the abundance of maerl in the channel is low relative to the abundance in areas to the south of the channel.

Natural England has estimated that there is 1041 hectares (ha) of known maerl habitat in the SAC comprising of maerl beds and maerl in sediments (draft supplementary advice package, 2015). Natural England have also estimated the extent of live maerl resource within the SAC at approximately 92 hectares (Personal Communication, Natural England 2014).

In terms of the extent of loss of the live nodules from the proposed dredging area, estimates have been made in order to provide a value to show the area that would be affected in relation to the known area of live maerl currently estimated within the Fal and Helford SAC. It is recognised that the estimates are based on surveys undertaken to date and that there is likely to be additional areas within the estuaries that support live maerl nodules and so the values used are considered to underestimate the amount of live maerl in the SAC and are therefore likely to overestimate the % of live maerl that could be removed from the site. Natural England has undertaken estimates of live maerl cover within the SAC and the channel area. Using the suggested estimates for live maerl cover within the SAC and the data for live maerl cover within the channel assigned to a polygon derived using the Plymouth Marine Institute mapping (including a 20m buffer as recommended by Natural England), this estimates that 0.17% of the known area of live maerl within the SAC would be removed from the channel during the dredging. The use of the Plymouth Marine Institute live maerl channel area is thought to represent the best estimate for live maerl occurrence as other areas of the channel are composed of finer material (silt and clay) which is unlikely to support live maerl habitats. Only one instance of live maerl was discovered in the wider channel area and this is most likely an anomaly. The % calculation is expected to be an overestimate (as identified above) as the total amount of live maerl within the SAC is not actually known, given the difficulties of surveying in the marine environment and it is likely that there are additional areas that have not been surveyed which support live maerl. The actual total area is therefore likely to be higher than the estimated total area used for the calculation which would reduce the value for the % removed.

Following dredging, more live maerl nodules are expected to continue to roll into the channel from adjacent areas. Evidence for this is supplied from the survey showing live maerl fragments in previously dredged areas. In this way the long term distribution of live maerl will be maintained.

To enable a decision on the potential significance of the loss of this area of living maerl the following points are summarised:

- Extent – the removal and translocation of the dead maerl habitat with live nodules in the dredged channel would not result in a decrease of extent of live maerl from the baseline established at the time of designation within the Fal and Helford SAC. The site is designated for an Annex 1 habitat of sandbanks which are slightly covered by seawater at all times. Within this category there are four main sub-types, one of which is maerl beds. The abundance of live maerl present in the channel is not considered to fall within the category of a maerl bed. The loss of the live maerl nodules in the proposed channel area would be a loss of extent when compared to the existing area of live maerl coverage known to occur within the SAC. This loss would be of approximately 0.17% of the known live maerl resource in the SAC. This removal does not affect areas of live maerl beds. Maerl as a species in itself is listed within Annex V of the Habitats Directive and as such its exploitation is feasible but may be subject to management measures. ;
- Distribution - The Maerl resource within the channel is considered to be fragments that have left the areas of higher abundance live maerl and been transported by water currents to the channel area. It is not considered that the maerl would grow or accumulate within this area to become a live maerl bed, such as is known at St Mawes Bank, due to the conditions within this area. Sedimentation is not considered to be an issue for live maerl based on the low levels of change predicted in the area surrounding the channel both during and following the dredge. Immediately post dredge there is likely to be a reduction in the distribution of live maerl in the channel area as some of the live nodules replaced with the relocated habitat would be buried. However, this is expected to be a short to medium term temporary change to the overall distribution and it is not expected that the distribution of live maerl will change in the long term as once the dredge is completed, nodules of live maerl will again be rolled into the channel area; and
- Species composition – the live maerl nodules in this area do not contribute significantly to the habitat diversity of the maerl habitat in the channel area.

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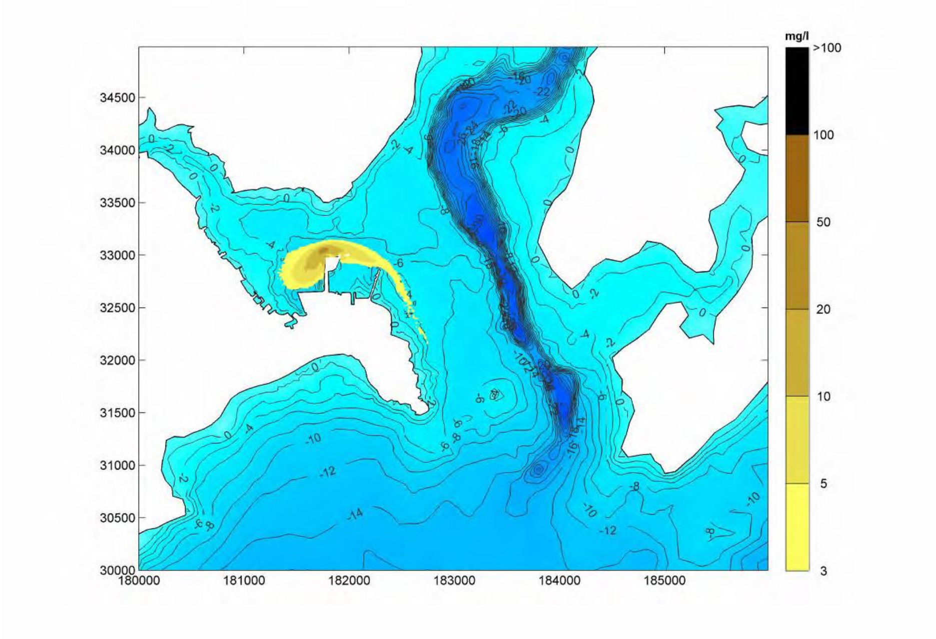
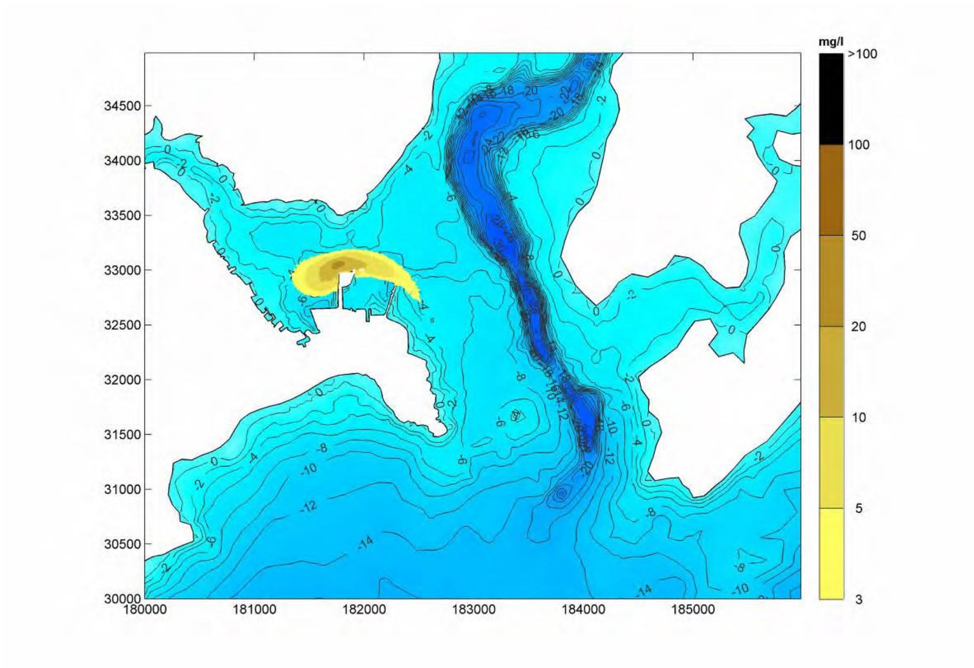
Appendix A

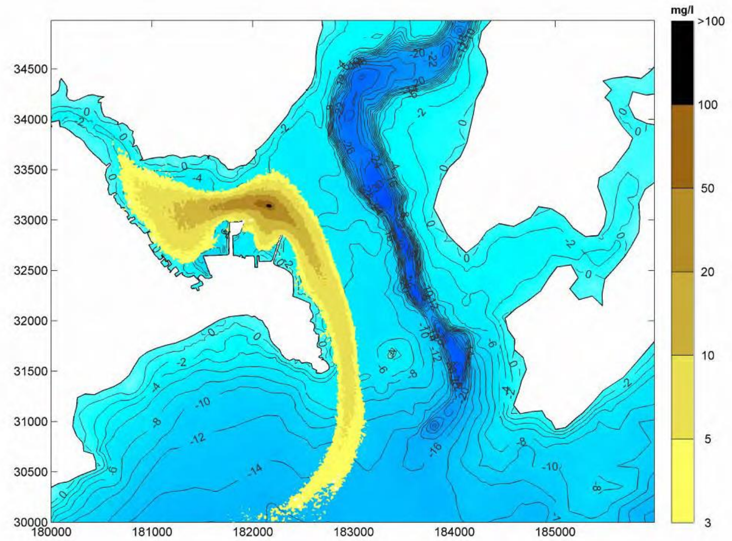
Suspended Sediment Concentrations for Dredging at three different locations



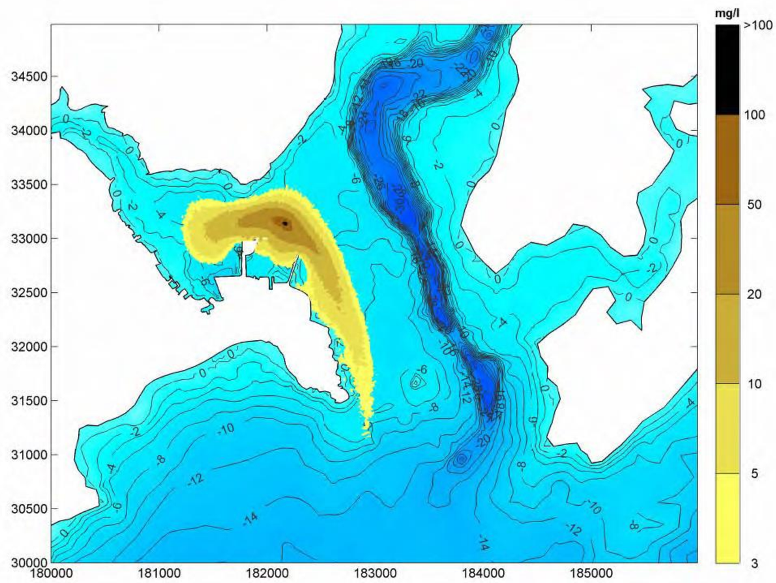

**Maximum suspended solids concentration for backhoe dredging at Site A, spring tide**



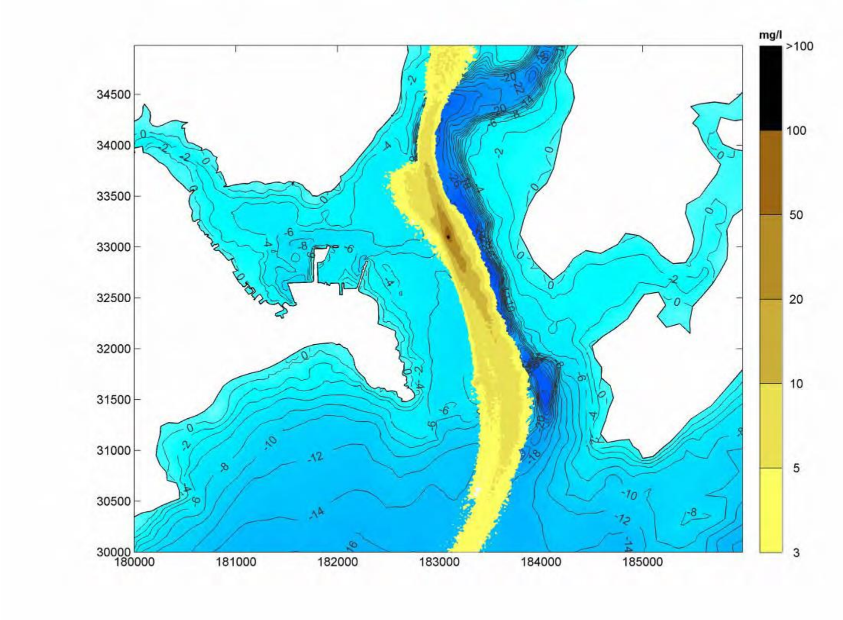

**Maximum suspended solids concentration for backhoe dredging at Site A, neap tide**



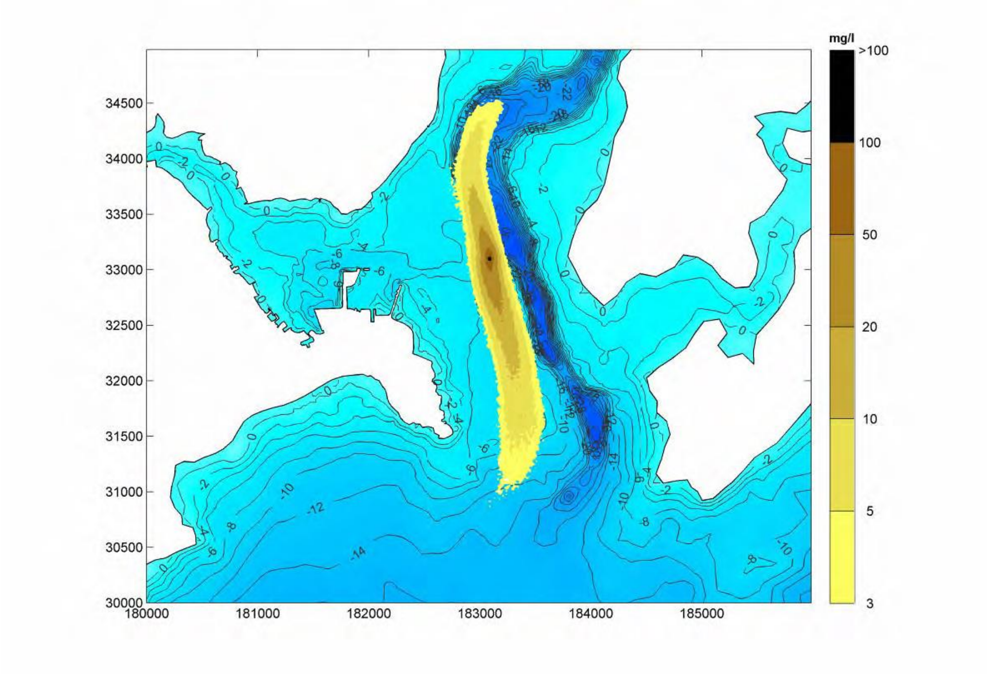

**Maximum suspended solids concentration for backhoe dredging at Site B, spring tide**




**Maximum suspended solids concentration for backhoe dredging at Site B, neap tide**



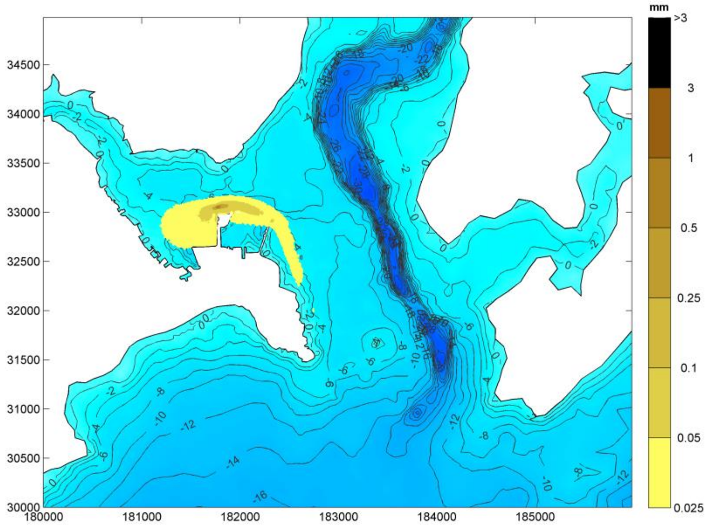

**Maximum suspended solids concentration for backhoe dredging at Site C, spring tide**



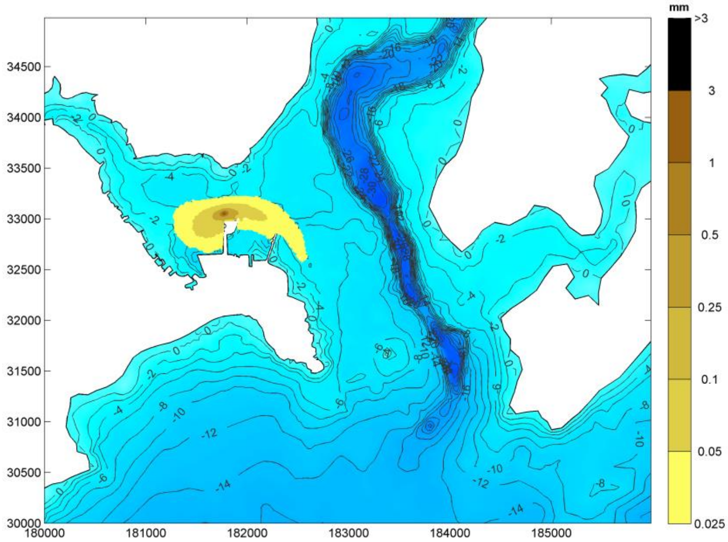

**Maximum suspended solids concentration for backhoe dredging at Site C, neap tide**

Appendix B

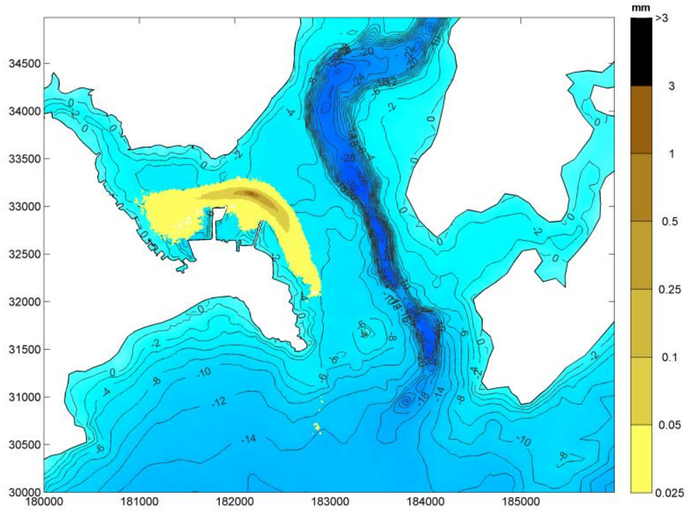
Results of sediment deposition modelling for dredging activity at the three Dredge locations



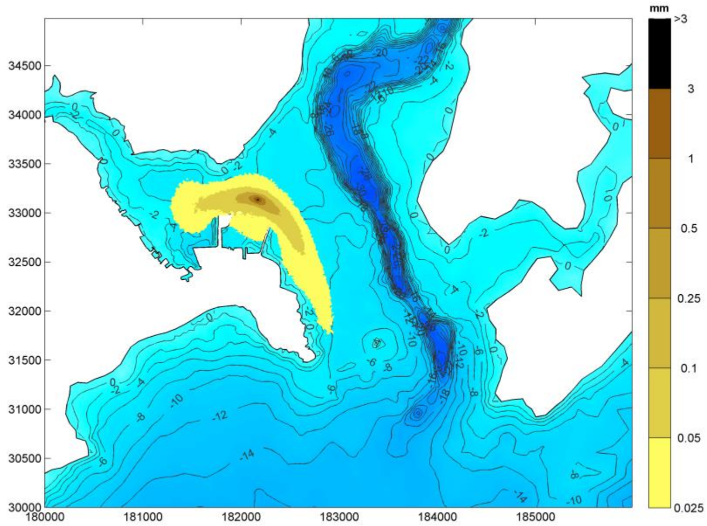

**Maximum deposition for backhoe dredging at Site A, spring tide**



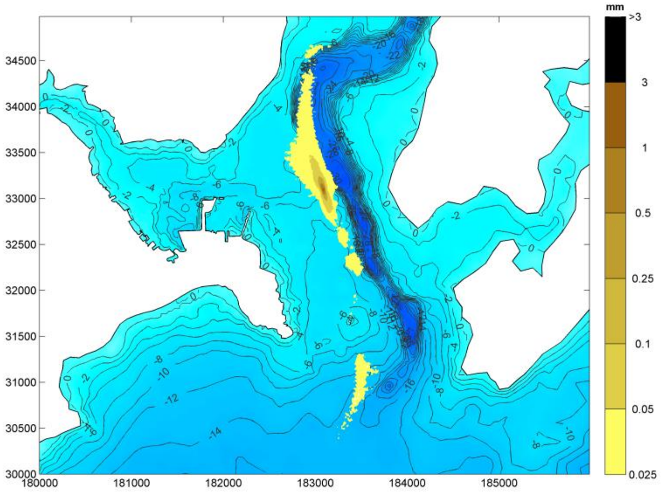

**Maximum deposition for backhoe dredging at Site A, neap tide**



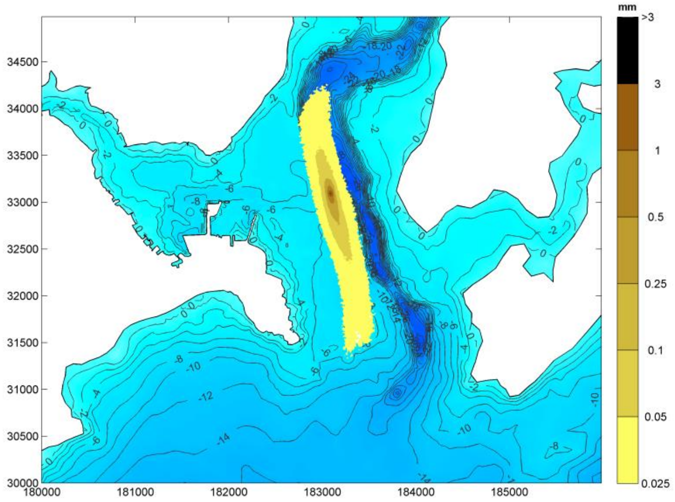

**Maximum deposition for backhoe dredging at Site B, spring tide**




**Maximum deposition for backhoe dredging at Site B, neap tide**




**Maximum deposition for backhoe dredging at Site C, spring tide**

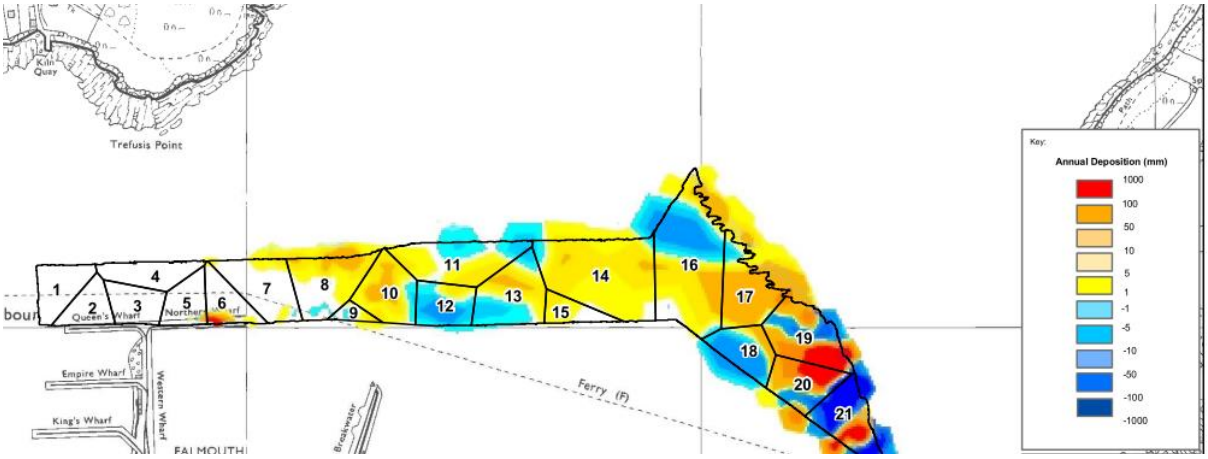



**Maximum deposition for backhoe dredging at Site C, neap tide**

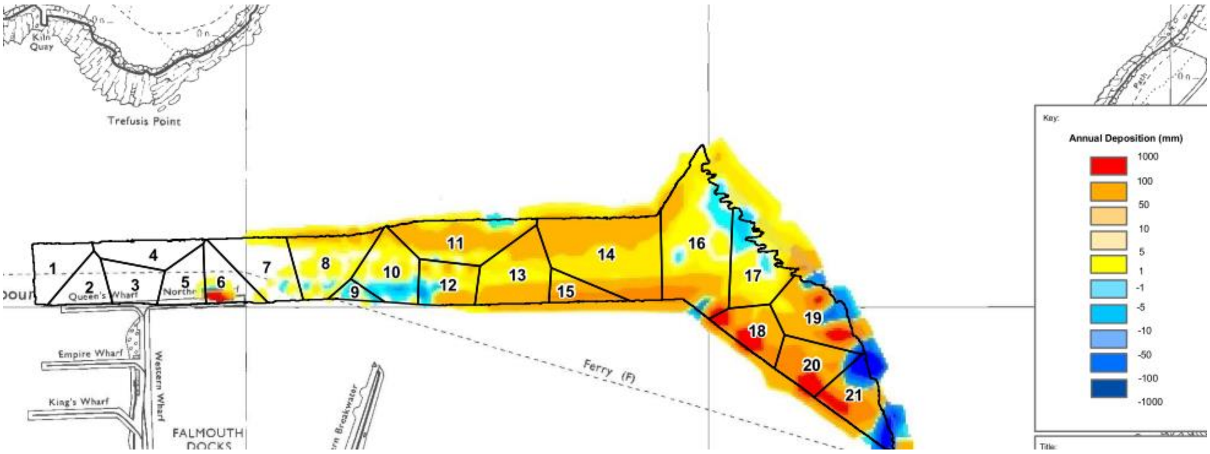
Appendix C

Sedimentation Plots (modelling results for sand deposition before and after dredge)

### Sedimentation plot - before dredge




### Sedimentation plot - after dredge




**Source: HR Wallingford, Falmouth Cruise Terminal Hydrodynamic and Sedimentary Studies, 2008.**

## Appendix C – Live Maerl Technical Note Review Paper (to follow) and Dr Nick Kamenos CV

# Dr Nicholas A. Kamenos

Kamenos research website: http://www.gla.ac.uk/schools/ges/staff/nicholaskamenos/
Google Scholar: http://goo.gl/OPBMtr
Researcher ID: http://www.researcherid.com/rid/F-2421-2010

**CURRENT POSTIONS:**

2014 Senior Lecturer in Organism-Climate Dynamics, School of Geographical and Earth Sciences, University of Glasgow, Scotland

2005 to date Honorary Lecturer in Marine Science, School of Life Sciences, University of Glasgow, Scotland

**PAST POSITIONS & EDUCATION:**

2014 to 2014 Lecturer in Organism-Climate Dynamics, School of Geographical and Earth Sciences, University of Glasgow, Scotland

2009 to 2014 Scottish Government / Royal Society of Edinburgh Personal Research Fellow, School of Geographical and Earth Sciences, University of Glasgow, Scotland

2007 Visiting Research Scientist, Dalhousie University, Halifax, Nova Scotia, Canada

2006 to 2009 NERC Independent Postdoctoral Research Fellow, University of Glasgow, Scotland

2004 to 2006 Postdoctoral Research Scientist, University Marine Biological Station Millport, UK

2001 to 2004 PhD, Marine Biology, University of London, UK

2000 Research and editorial assistant, University of Windsor, Ontario, Canada

1997 to 2000 BSc Marine Biology, University of Wales, Bangor, Wales (1st Class with Honours)

1995 to 1997 Ministry of Defence, Republic of Cyprus: Served 26 months compulsory military service

**GRANT INCOME >£1K: (total to date £2M)**

**Kamenos, N.A.**, Burdett, H.B., Hennige, S. Couto, J., Exton, D. 2015. **NERC DTP studentship.** Understanding coral survival in a warmer world; the role of historic coral bleaching (£70,000)**.**

Mair, D. **Kamenos, N.A.**, Rea, B. and Schofield, E. 2014. **Leverhulme.** Calving Glaciers: Long term validation and evidence (£263,331).

Mao, J., **Kamenos, N.A.** and Burdett, H.L. 2014. Quantifying blue carbon sequestration in temperate coastal waters. **Aandaraa**. SeaGuard Award Programme (£20,000)

**Kamenos, N.A.** and Hennige, S.J. 2014. **MASTS**. Understanding 400 years of Pacific coral reef bleaching; will corals adapt to future climate change? (£1100)

**Kamenos, N.A.** 2014. **The Carnegie Trust.** Mediterranean biodiversity responses to ocean acidification: using $CO_2$ vents as analogues (£2,400)

Burdett, H.L., **Kamenos, N.A**. and Hennige, S.J. 2014. **Gilchrist Educational Trust / Royal Geographical Society (with IBG**). Past, present, future: determining the climate tolerance thresholds of Maldivian corals, and the impact this has on the nation’s natural capital (£15,000)

Burdett, H.L., Hennige, S. and **Kamenos, N.A.** 2014. **Carnegie Research Incentive Grant.** Past, present, future: environmental tolerance of Maldivian corals, and impact on the nation’s natural capital (£7250).

**Kamenos, N.A.,** Buttar, C. and Cusack, M. 2013. **EPSRC**. Rapid detection of changes in marine carbonate chemistry (£73,000)

**Kamenos, N.A.** and Burchmore, R. 2013. **BBSRC**. Biomineralisation under global change (£65,000)

Cusack, M., **Kamenos, N.A**. and Chung, P. 2013. **Diamond Synchrotron**. Amorphous calcium carbonate in biominerals (~£60,000 in kind support)

Foster, G. and **Kamenos, N.A.** 2013. **NERC**. Historic pH change in the North Atlantic; insights from the boron isotopic composition of coralline algae (£60,806, grant num: NE/H010025)

Burrows, M., Black, K., Heymans, S., Howe, J., **Kamenos, N.A.**, Stahl, H., Stewart, A. and Tett, S. **Scottish Natural Heritage**. Assessment of carbon budgets and potential blue carbon stores in Scotland's coastal and marine environment (£25,000)

**Kamenos, N.A.**, Lucey, N. 2013. **FP7-ASSEMBLE Marine.** Reconstructing the impacts of historic ocean acidification on marine biodiversity (~£27,000)

Padget, M. *et al* (including **Kamenos, N.A.**) 2012. **EPSRC**. Upgrading the small scale equipment base for early career researchers in the engineering and physical sciences (£550,000, grant num: EP/K031732/1)

**Kamenos, N.A.** 2012. **NERC Field Spectroscopy Facility grant.** How does photosynthesis respond to environmental stress (£7500 in kind support)

**Kamenos, N.A.** and Burdett, H.L. 2012. **FP7-ASSEMBLE Marine.** Holocene changes in Mediterranean marine biodiversity revealed by coralline algae (~£35,000)

Burchmore, R., **Kamenos, N.A.** and Burgess, K. 2012. **The Wellcome Trust.** Can marine calcifying organisms use proteomic responses to adapt to anthropogenically induced global change? (£16,980)

**Kamenos, N.A.** 2012. **NERC UKOA**. The impacts of ocean acidification on marine biogenic carbonates (£1000 added value award)

**Kamenos, N.A.** and Burdett, H.L. 2012. **FP7-ASSEMBLE Marine**. The potential impact of coralline algal habitats on local climate (£15,000)

**Kamenos, N.A.** 2011. **The Carnegie Trust**. How do marine calcifiers and the biogenic carbonates they deposit adapt to ocean acidification? (£2080)

**Kamenos, N.A.**, Cusack, M. and Wimperis, S. 2011. **EPSRC NMR facility grant**. Determination of boron speciation in red coralline algae using $^{11}$B MAS NMR (£6000 in kind support)

**Kamenos, N.A.** 2011. **NERC Field Spectroscopy Facility grant.** The impacts of ocean acidification on marine biogenic carbonates (£6500 in kind support)

Cusack, M.R., **Kamenos, N.A.** and Phoenix, V. 2011. **Leverhulme.** Biomineralisation: protein and mineral response to ocean acidification (RPG-042 £255,234)

**Kamenos, N.A.** and Burdett, H.L. 2010. **FP7-ASSEMBLE Marine**. The impact of Pacific upwelling on planktonic dynamics over the last two centuries (£22,000)

**Kamenos, N.A.**, Cusack, M.R. and Roberts, M. 2010. **MASTS**. Organism responses to ocean acidification at the molecular level (As a prize studentship for Donohue, P. £40,000)

Widdicombe, S. *et al* (including **Kamenos, N.A.**) 2010. **NERC**. Impacts and implications of ocean acidification on key benthic ecosystems, communities, habitats, species and life cycles (£2M, grant num: NE/H010025/1)

**Kamenos, N.A.** 2009. **The Royal Society of Edinburgh.** Assessing the age of coralline algal deposits in the western Atlantic (£11,505)

**Kamenos, N.A.** and Hoey, T. 2009. **The Carnegie Trust.** Reconstructing runoff from the Greenland Ice Sheet using calcifying algae (£3,600)

**Kamenos, N.A.** 2008. **Scottish Government / The Royal Society of Edinburgh Personal Research Fellowship:** Impacts of climatic variability on shallow water marine ecosystems and resources (~£515,000, grant num: 48704/1)

**Kamenos, N.A.** 2008. **The Royal Society of Edinburgh / British Petroleum Personal Research Fellowship:** High-resolution climatic impacts on shallow-water marine environments during the Holocene (£265,640, this fellowship was turned down to accept the Scottish Government / RSE Fellowship above)

**Kamenos, N.A.** and Cusack, M. 2007. **Swiss Light Source:** Magnesium in coralline algae (£25,000 in-kind, grant num: 20070967)

**Kamenos, N.A.** 2007. **NERC**: Ion Microprobe Facility. Using $\delta^{18}O$ in coralline algae as both a salinity and temperature proxy (£22,550 in-kind, grant num: IMF 323/1007)

**Kamenos, N.A.** 2006. **NERC Postdoctoral Fellowship**: High resolution impacts of climatic variability on shallow-water marine ecosystems during the Holocene (£397,423, grant num: NE/D008727/1)

**ESTEEM INDICATORS, AWARDS AND PANEL INVITATIONS:**

- Editorial board member for *Nature Scientific Reports* (2012 to date)
- Peter Jones Memorial Award from the Estuarine and Coastal Sciences (2013)
- Marine Alliance for Science and Technology Scotland (MASTS): Elected Convenor of the Marine Biogeochemistry Forum (MASTS is an £80M pooling initiative) (2014 to date)
- MASTS: Member of Executive Committee (alternate) (2011 to date)
- MASTS: Invited member of Biodiversity and Ecosystem Function steering group (2009 to 2011)
- University of Toronto: Grant pre-filtering review panel as international expert (2011 to date)
- Invited chair for 2 sessions: AGU Ocean Sciences 2012 in Utah (4k-5k attendees)
- Invited chair at the World Conference on Marine Biodiversity 2011
- Invited panel member: Brazilian Commission on Subtidal Conservation (2009)
- Royal Society of Edinburgh / Scottish Government Personal Research Fellowship (2008)
- NERC Independent Postdoctoral Research Fellowship (2006)
- Sheina Marshall Scholarship to follow a PhD in marine biology (2001)

**INTERNATIONAL GRANT REVIEWER FOR:**

National Science Foundation USA, Netherlands Organisation for Scientific Research, Canadian Foundation for Climate and Atmospheric Sciences, American Association of Underwater Sciences, Marine Science and Technology Foundation (a Google charity), University of Toronto.

**MANUSCRIPT REVEIWER FOR:**

Nature, Science, Nature Geoscience, Nature Climate Change, Nature Scientific Reports, Global Change Biology, PLoS ONE, Journal of Phycology, Geochimica Cosmochimica Acta, Journal of Geophysical Research - Oceans, Palaeoceanography – Palaeoclimatology – Palaeoecology, Geology, Geochemistry - Geophysics - Geosystems, Journal of Sea Research, Marine Biology, ICES Journal of Marine Science, Marine Biology Research, Animal Behaviour, Journal of the Marine Biological Association of the UK, Cahiers De Biologie Marine, Ciencias Marinas, Scientia Marina.

**PROFESSIONAL SOCIETY MEMBERSHIP:**

Association for Scientists in Limnology and Oceanography, Marine Alliance for Science and Technology Scotland, Scottish Alliance for Geoscience, Environment and Society, European Geophysical Union, American Geophysical Union.

**CURRENT RESERCH GROUP:**

**PDRAs:** Fitzer, S**.,** Schoenrock, K. **PhDs:** Donohue, P., Smiley, C., Hill, K., Mao, J., Recknagel, H., Baxter, H. **MScs:** Pauly, M., Gillet, K. **RAs:** Perna, G., Stachnik, L.

**INDUSTRIAL COLLABORATORS:**

Gas Sensing Solutions (Glasgow) and Twin Celts Engineering (Oban): Development of novel marine $p\mathrm{CO_2}$ sensors.

**TEACHING RESPONSIBILITIES:**

MScs in Water Science, Impacts of Climate Change, MSc/L4 Coral Reefs, MSc/L4 Coral Reef field trip (2 weeks), Nearshore Ecology field trip (1 week).
L4/L3 Micropalaeontology, L4 project seminars, L4 project posters presentation
L2 Arran field trip (1 week)
L1 Geography: Changing World
International courses: Lecturer on the FP7-funded MARES course in Italy: *Effects of global warming and ocean acidification* (www.mares-eu.org)
Module Organiser: MSc Impacts of Climate Change module, MSc/L4 Coral Reefs, L4/L3 Micropalaeontology, L4 project seminars and L4 project poster presentations.

**CURRENT ADMINISTRATIVE DUTIES AND COMMITTEE MEMBERSHIP:**

| | |
|---|---|
| 2013 to date | Athena SWAN Self-Assessment Team |
| 2012 to date | Leading Geographical and Earth Sciences website development team (5 people) |
| 2010 to date | MSc Development Team: development of new taught and research MSc courses |
| 2010 to date | Manage Marine Mesocosm Facility |
| 2009 to date | Manage Carbon and Sulphur Gas Analytical Instrumentation |
| 2009 to date | Manage BioEarth Laboratory |
| 2009 to date | University of Glasgow Scientific Diving Advisory Panel |
| 2009 to date | Diving Project Manager and water-based Health and Safety advisor |

**RELEVANT QUALIFICATIONS:**

PADI Divemaster, CMAS One Star Diver, BSAC Advanced Diver, BSAC Boat Handler, RYA Boat Handler, HSE Oxygen Administrator, HSE First Aid at Work, MCA Sea Survival, Bronze Medallion Life Saving Award, VHF Licence, Full Driving Licence.

**PHD EXAMINER**

External: Webb, A. (Univ. of East Anglia, 2014), Williamson, C. (Univ of Cardiff, 2015).
Internal: Moossen, H. (2012), Dunlop, K. (2013), Skuce, R. (2014).

**STUDENT SUPERVISION:**

**PhD** (* indicates primary supervisor)

**Mao, J.*** 2014-ongoing. *The role of coralline algal deposits in blue carbon sequestration* (Co-supervisors Henrik Stahl (SAMS) & Heidi Burdett (St. Andrews).

**Recknagel, H.** 2014-ongoing. *Evolutionary genetics of vivparity* (Co-supervisor Kathryn Elmer)

**Hill, K.*** 2013-ongoing. *Detecting natural carbonate chemistry variability in marine systems.* (Co-supervisor: M. Cusack)

**Smiley, C.*** 2012-ongoing. *High resolution changes in the North Atlantic climate system* (Co-supervisor: T. Hoey)

**Donohue, P.*** 2010-2014. *Organism responses to ocean acidification at the molecular level* (Co-supervisors: M. Cusack & M. Roberts (Heriot-Watt University))

**Burdett, H.L.*** 2009-2013. *DMSP dynamics in marine coralline algal habitats* (Co-Supervisor: A. Hatton, Scottish Association for Marine Science)

**MRes / MSc** (as primary supervisor)

**Gillett, K.** 2014. (MSc) *The role of ocean acidification on abiotic calcium carbonate breakdown.*

**Pauly, M.** 2014. (MSc) *A novel proxy for palaeo-ocean acidification*

**Mao, J.** 2014 (MSc) *How marine calcifying habitats alter marine carbonate chemistry.*

**Sililo, N.** 2013 (MSc) *Acid vision: synergistic effects of ocean acidification and hypoxia on chiton eyes* (Co-supervisor S. Hennige).

**Tiffoney, M.** 2012 (MRes) *Can Mediterranean biomineralisers affect regional climate*

**Fawcett, D.** 2012 (MSc) *Antifouling potential of algal metabolites* (Co-supervisor V. Phoenix)

**Carruthers, M.** 2011 (MRes) *The response of corals to ocean acidification* (Co-supervisor, H. Burdett).

**Rix, L.** 2010 (MRes) *Do coralline algae affect local cloud cover or simply respond to it?*

**Guo, D-J.** 2008-2010 (MRes) *Biomineralisation in abalone* (Co-supervisor M. Cusack)

**Hall, A.** 2008 (MRes)*The effect of stress on growth in coralline algae*

**Chiebao, F.** 2008 (MRes) *Can marine algae record climate change*?

**Burden, V.** 2006 (MSc) *Bivalve community structure in coralline algal assemblage*

**Strong, S.** 2006 (MSci Hons) *The role of coralline algae in the global dimethylsulphide budget*

**Bush, V.** 2004 (MRes) *Maerl deposits in Lamlash Bay, Arran: A proposed marine reserve and regeneration area*

**Jackson, C.** 2004 (MSc) *Meiofaunal bivalves in maerl deposits*

**BSc** > 20 BSc Hons project students on biological and climate science

# Appendix D – Marine Management Organisation Correspondence

Marine
Management
Organisation

# Environmental Statement Review

## The Marine Works (Environmental Impact Assessment) Regulations 2007, as amended ("the Regulations"):

**Title:** Port of Falmouth Development Initiative

**Location:** Falmouth Harbour, Cornwall

**Operator:** Falmouth Harbour Commissioners and Falmouth Docks and Engineering Company

**Address of applicant/operator:** The Docks, Falmouth Docks, Falmouth, Cornwall, TR11 4NR

**Application reference no:** 34538/090805
34539/090805
34540/090805

**November 2013**

# 1 Contents

## 2 Background

Three applications were submitted to the Marine Management Organisation (MMO) (formally the Marine and Fisheries Agency (MFA) in 2009 relating to the Port of Falmouth Development Initiative (PFDI). The applications were as follows:

- Disposal of approximately 700,000 cubic metres of material to create a deeper and straighter navigation channel and deep water berthing pocket
- Construction works consisting of the amalgamation of the Queens and Northern wharves to create a 430 metre berthing area
- The relocation of dredged maerl substrate to the eastern part of the navigation channel.

The applications relating to the disposal of dredged material and the maerl habitat mitigation scheme were unable to proceed in their current form, as the MMO in its Appropriate Assessment (AA) of the proposals was unable to conclude ‘no adverse effect’ on the integrity of the Fal and Helford Estuaries Special Area of Conservation (SAC).

A separate application to undertake a maerl relocation trial was subsequently submitted to the MMO and approved in August 2012. The aim of the trial is to determine the initial impact to the maerl, sediment structure and the associated benthic assemblages of removal and replacement, and assess the potential for recovery by re-sampling the translocated maerl after the translocation.

An Independent Scientific Advisory Panel (ISAP) was established to advise the MMO on the scientific methodology for the trial and review its conclusions to ensure that they are scientifically robust. The independently-verified results from the trial will provide information on the extent to which maerl and its associated communities survive and can recover from relocation.

The results of the maerl relocation trial will form part of the evidence required to inform any future determination the MMO makes with regards to the PFDI applications.

## 3 Legislative Overview: Marine Licensing

The Marine and Coastal Access Act (MCAA) 2009 came into force in April 2011 with the overarching aim of achieving clean, healthy, safe, productive and biologically diverse oceans and seas. The MCAA has a broad scope covering construction, removals from the seabed and dredging, as well as deposits in the marine environment.

Part 4 of the Act simplified the consenting system by drawing previous licences and consents together into a single consenting process. It largely replaced a number of regulatory regimes including those under Part 2 of the Coast Protection Act (CPA) 1949 and Part 2 of the Food and Environment Protection Act (FEPA) 1985.

The PFDI applications were submitted to the MFA in 2009 under the requirements of both FEPA and CPA. A licence under Part II of FEPA was required to deposit substances or articles within UK waters or UK controlled waters. Consent under Part II, section 34 of the CPA was required where an operation (construction, deposit or removal) was likely to result in obstruction or danger to navigation.

Several activities proposed as part of the PFDI, specifically the harbour construction works, disposal of dredged material and habitat mitigation scheme fell under the requirements of FEPA. In addition, Board of Trade consent was required to undertake the dredging activity within Falmouth Harbour Commissioner's (FHC) jurisdiction, pursuant to section 10 of the Falmouth Harbour Act 1870. Similarly ministerial approval was required for Falmouth Docks and Engineering Company FDEC to deposit dredged material below mean high water springs (MHWS), pursuant to section 26 of the Falmouth Docks Act 1959.

The proposed capital dredge was exempt from requiring CPA consent providing works were carried out within the jurisdiction of the Harbour, as defined by the Falmouth Harbour Act 1958 and extended by the Falmouth Harbour Revision Order 1991.

Following the adoption of the MCAA, future submissions made by FHC in relation to the PFDI will be considered in accordance with requirements of the MCAA. This may have particular significance for the capital dredging programme proposed as part of the PFDI, as dredging now constitutes a licensable activity under MCAA. Maintenance dredging activities not covered by an exemption will also require a marine licence from April 2014, unless the proponent is a Statutory Harbour Authority with its own powers to dredge. It will be for the Harbour Authority to determine whether this exemption applies. The disposal of maintenance dredgings to sea will however still require a marine licence, as was the situation under FEPA.

All licensable activities associated with the PFDI, as defined under Part 4, Section 66 of the MCAA, will be considered as one marine licence application, should the proponent wish to advance their applications.

# 3 Need for Environmental Impact Assessment

The requirement for an Environmental Impact Assessment (EIA) to be undertaken pursuant to the Marine Works (EIA) Regulations 2007 was determined voluntarily by Falmouth Harbour Commissioners. A screening opinion was not sought from a competent authority.

FHC's screening process considered the proposal to fall within Annex I, Part 8b of the EIA Directive which identifies the following type of development: *'Trading ports, piers for loading and unloading connected to land and outside ports (excluding ferry piers) which can take vessels of over 1350 tonnes'*.

FHC prepared an ES (the '2009 ES') in support of their applications under FEPA and CPA. The purpose of this Environmental Statement (ES) review is to ensure that the relevant information has been included in the 2009 ES for the purposes of the Marine Works (EIA) Regulations 2007 (as amended) along with any recommendations for consideration prior to any future or updated applications to be considered under Part 4 of the MCAA.

## 3.1 ES Review

This review outlines the current understanding of the MMO and our scientific advisors the Centre for Environment, Fisheries and Aquaculture Science (CEFAS) of the PFDI proposals, taking into account advice received from statutory consultees Natural England, the Environment Agency and Cornwall County Council and representations made to the MMO by other parties.

The advice provided in this review is non-binding. Any consideration of advice presented here, and subsequent adoption in documents supporting a marine licence application is a matter for the applicant. It should also be noted that all pre-application work by the MMO is undertaken without prejudice to any future decision made by the MMO.

# 4 ES Structure

The 2009 ES in full is presented in three documents, which are:

- Non-Technical Summary;
- Environmental Statement; and
- Appendices.

Those chapters of the 2009 ES which require to be updated are listed below; however it is the applicant's responsibility to ensure that the updated ES reads coherently as a single document. This includes corrections to any cross-referencing or conclusions presented.

- Chapter 3: Consideration of Alternative Options
- Chapter 4: Planning ad Policy Context
- Chapter 5: Hydrodynamic and Sediment Regime
- Chapter 6: Sediment Quality
- Chapter 7: Water Quality
- Chapter 8: Marine and Coastal Ecology
- Chapter 9: Ornithology
- Chapter 12: Commercial fisheries and Shellfisheries
- Chapter 16: Traffic and Transportation
- Chapter 22: Summary of Potential Impacts and Mitigation Measures
- Chapter 23: Cumulative Impacts
- Chapter 24: Implications for the Designated Status of the Fal and Helford Estuaries SAC
- Chapter 25: Proposals for Monitoring
- Chapter 26: References

# 5 ES Review comments

The following sections of this document provide the MMO's comments on the 2009 ES and suggested amendments where necessary.

## 5.1 Chapter 3 - Consideration of Alternative Options

The MMO notes that alternatives for disposal were previously addressed within Chapter 3 of the 2009 ES. This should be revisited by the applicant and addressed in an updated ES submitted in support of any future marine licence application, particularly in light of any newly available information and/or technologies.

In addition, the MMO advises the applicant to consider credible worst case scenarios within this section of the updated ES, with particular reference to the possibility that not all material may be suitable for disposal at sea.

The principles of the Waste Hierarchy (Council Directive 2008/98/EC, ‘the Waste Framework Directive’) must be followed, where disposal to sea is considered to be the final option only once all other feasible alternatives have been investigated.

Should any alternative options include land-based recovery of dredged sediment, it should be noted that the applicant will be required to obtain any relevant consents and permissions from the Environment Agency.

## 5.2 Chapter 4 - Planning and Policy Context

The MMO has been advised by Cornwall Council (as Local Planning Authority) that no formal approach has been made to the Council regarding the delivery of any future landward projects at the docks, in particular by exercising any specific rights under either Part 11 and/or Part 17 of Schedule 2 of the General Permitted Development Order (GPDO) 1995 (as amended).

The Council have further advised the MMO that in such instances, the GPDO requires the submission of a prior approval notification to the Council, to determine if any such development proposed would satisfy the requirements to qualify as permitted development under Parts 11 or 17 of Schedule 2 of the Order. Cornwall Council has confirmed that they have not yet received such a submission.

The Council have also advised that in addition to the above, Article 3(1) of the GPDO 1995 (as amended) sets out that permitted development only applies subject to The Conservation of Habitats and Species Regulations 2010 (as amended) (‘the Habitats Regulations’). Article 3(1) also requires the Council to have consideration of the requirement or otherwise for EIA as a result of any particular project(s) that might arise in the future and where appropriate, require those to be considered through a planning application which would include appropriate consultation, including with the MMO.

## 5.3 Chapter 5 - Hydrodynamic and Sediment Regime

### 5.3.1 Sedimentation Model

The MMO are of the opinion that the extent of the area of the plume model is acceptable, with sufficient bathymetric data and an appropriate level of resolution and scale. It is considered that the use of 1985 data in the sedimentation model is valid and robust, however written evidence to support this conclusion must be presented within the updated ES.

Details of the data or information used to inform the values in section 5.5.4 of the 2009 ES (Change to Sand Transport Conditions) should also be presented as they do not directly correspond to Figure 5.28. They also do not appear to be present in Appendix A.

Further work is required to the sedimentation model to capture near seabed sediment concentrations and the impact of weather induced factors such as high fluvial flows and significant river run-off. The underlying impact in question is the amount of light reaching the seabed. Modelling presented within the 2009 ES has been undertaken on a neap/spring cycle with no accounting of storm flows or tidal forcing. It is recommended that the applicant undertakes further modelling and assessment of suspended sediment concentrations (SSC) near the seabed during high fluvial flows and storm events.

CEFAS have previously suggested the use of long-term current data which should include storm events. The MMO would advise the applicant to contact the Environment Agency as they may hold additional current data over a significant time frame, collected during the assessment of Asset Management Programme (AMP) improvements.

The MMO notes that a basic approximation of site settling velocities has been made in the “absence of any site specific data”. It is important to understand the particle size analysis (PSA) fractions of the sediments directly underneath the maerl habitat, therefore the MMO suggest that a more robust approach should be incorporated into the updated ES, using PSA curves from the surveys carried out in 2004 and 2007.

The MMO previously advised on the requirement for salinity profiling to check mixing and demonstrate that the use of the 2D model used is appropriate. The report submitted to the MMO by Royal Haskoning DHV (Ref 9V1059/303311/Exet, March 2013) clearly demonstrates that there is no strong vertical stratification. The MMO are therefore content that the use of the 2D model is appropriate.

**5.3.2 Disposal of dredged material**

The MMO will require an agreed dredged material disposal plan submitted in support of any future marine licence application. A programme of monitoring and potential corrective actions should also be provided for the MMO’s consideration. The MMO recommends that the plan should consider dredging and disposal operations in a range of operational weather conditions. This should include whether alternative disposal options or mitigation measures may be required in poor weather.

The MMO recommends that the applicant investigates the adoption of a zonal approach to the proposed disposal operations to mitigate the potential for negative impacts on fishing grounds and sensitive habitats within or adjacent to the existing Falmouth Bay certified disposal site. For example, a gridding method of disposal may be required to ensure materials are equally distributed within the disposal area to minimise consolidation within a particular area, or timed and placed to be disposed away from sensitive receptors (e.g. fishing grounds). This would also have the effect of ensuring that elevated levels of suspended sediment are distributed over as large an area as possible and/or minimising impacts on sensitive receptors. Any future application should also present a breakdown of the amounts of material to be disposed of with respect to the recommended zonal approach.

### 5.3.3 Maintenance dredging

The 2009 ES refers to the potential requirement for maintenance dredging on the southern side of the navigation channel in the ‘medium term’. The implications of future maintenance dredging for maerl habitats (including locations proposed for maerl translocation) and associated species both within the channel and surrounding area must also be considered over the longer term and presented within the updated ES.

The applicant should review previous hydrodynamic survey data which should provide a useful indication of the locations and levels of deposition within and surrounding existing dredged areas. This data may be a useful tool to inform any modelling of the impact of maintenance dredging. Furthermore this information will also complement ES modelling data to further assess the likely increased accretion as a result of the dredge, particularly in those areas proposed for maerl translocation.

The applicant is advised to provide as detailed information as possible within the updated ES regarding future maintenance dredging requirements as there remains some degree of uncertainty as to this requirement within the 2009 ES. Should there be a requirement for maintenance dredging the updated ES should consider the potential impacts on marine communities, including potential impacts of sediment suspension and smothering on maerl, translocated maerl and other sensitive habitats and species present. In addition the updated ES should consider whether maintenance dredging activities will result in the direct or indirect loss of maerl habitat, including translocated maerl. This should be fully documented in any revised documents submitted in support of any future application for a marine licence.

## 5.4 Chapter 6 - Sediment Quality

It is noted that the last sampling and analysis campaign of material from Falmouth Harbour and the approach channel was undertaken in 2009. Whilst contaminant levels would not be expected to change significantly in the intervening period, the applicant will be required to provide further sediment samples to support any application to dispose of dredged materials to sea.

## 5.5 Chapter 7 - Water Quality

The Water Framework Directive (WFD) (Council Directive 2000/60/EC) aims to protect and enhance water bodies within Europe. In England and Wales this includes all estuarine and coastal waters out to one nautical mile. The requirements of the WFD must be considered in the updated ES and details provided of how compliance with the WFD will be achieved. The Environment Agency are lead competent authority in England for implementing the WFD, and further information and guidance is provided at the following link:
http://www.environment-agency.gov.uk/research/planning/40191.aspx

## 5.6 Chapter 8 - Marine and Coastal Ecology

The size and timescale of the proposed capital dredge, the resultant shift in sediment regime (as outlined in sections 5.5.3 and 5.5.4 of the 2009 ES), and any maintenance dredging activities have the potential to exert pressures upon several sensitive habitats and species found within the Fal Estuary area, including elevated levels of suspended sediments and associated physical smothering. Sensitive habitats and species include, but are not limited to, seagrass beds at Trefusis Point, maerl habitats and their associated communities, native oyster (*Ostrea. edulis*) beds and filter-feeding organisms such as polychaetes. Maerl demonstrates low tolerance to and low rates of recovery from smothering, though this is dependent upon the type of sediment. Maerl has the potential to survive burial in gravel sediments but is unlikely to survive in fine sediments.

A larger scale capital dredge (e.g. to the depth stated in the 2009 ES) may experience ‘slumping’ as a result of tidal movements.  This risks burying the maerl and smothering associated infaunal communities. It is noted that Figure 2.13 from the 2009 ES does not indicate the slope of the channel following the dredging activity and therefore it is unclear whether the footprint of the proposed channel reflects the total area of impact. Therefore to fully assess the risk of slumping and the footprint of the dredge, the MMO would recommend that the applicant provides additional bathymetric cross sections for ‘North-South’ and ‘East-West’ profiles.

Whilst the model outputs depth average suspended sediment concentrations (SSC), the applicant is reminded that it is the near seabed SSC that are important to the majority of the benthos. The applicant should provide estimations of these concentrations for inclusion in the updated ES.

Post-dredge settlement of sediment should also be considered. If there is a large degree of sediment movement across the proposed channel as predicted, this is likely to impact habitats and their associated species communities. The MMO therefore advises the applicant to undertake further assessment of sedimentation as a result of the dredging activity on maerl habitats (including translocated maerl habitats if applicable), oyster beds and seagrass beds over several tidal cycles (including Spring and Neap Tides). The same consideration of sedimentation on sensitive habitats and species should be given to the predicted change in sediment regime over longer timescales (2009 ES figures 5.27 and 5.28) and the potential for maintenance dredging.

Should the maerl trial be used as mitigation to support any future application for the PFDI, additional work on sedimentation rates, e.g. increased sedimentation in the immediate area of maerl removal and replacement, will be required.

The updated ES should assess the worst case scenario for the impacts of sedimentation, namely the impacts at maximum potential increase and minimum potential decrease. Furthermore, whilst model outputs presented in the 2009 ES show the potential for relative increases/decreases in sedimentation, it would be very useful if these were accompanied by some figures relating to the amount of available material for deposition and therefore realised potential for deposition. A review of previous hydrodynamic surveys over time might provide such information.

Monitoring and mitigation proposals are outlined in the 2009 ES. Locations with species and habitats sensitive to sedimentation require monitoring prior to, during and after the proposed capital dredge. Ideally, levels of sedimentation should be seen to return to background levels following the cessation of operations. It may be however that localised re-suspensions of sediment could occur following completion of the dredge.

Further mitigation measures for the prevention of sedimentation should be considered within the updated ES. If applicable, mitigation will be required to ensure re-laid and live maerl to the south is not smothered by dredged material. When determining appropriate mitigation measures the applicant should have regard to requirements of the Shellfish Waters Directive regulations

## 5.7 Chapter 9 - Ornithology

The area of sea between Falmouth Bay and St Austell Bay is being proposed as a Special Protection Area (SPA) under the European Commission Conservation of Wild Birds Directive (‘the Birds Directive’). This location is known to support important numbers of wintering divers and grebes.

The proposed SPA would include an area from Nare Point in the west to Southground Point in the east and include the Fal and Helford estuaries. The area under consideration extends out from the mean high water mark out to the 49 metre depth contour, including the intertidal zone. The location of the PFDI falls within the proposed SPA.

The site is recommended for Black-throated Diver (*Gavia arctica*), Great Northern Diver (*Gavia immer*) and Black-necked Grebe (*Podiceps auritus*) with formal consultation planned for January 2014. The region is of great importance for these species during the over wintering period of October to March, although the season of some species extends into April/May. Outside of these months the local marine area is utilised by shags which breed in small numbers in parts of south west England. The species recommended for inclusion are pursuit predators which feed on prey in the water column and/or on the seabed by sub-surface diving.

The identification of potential impacts resulting from the proposed PFDI will depend on:

a) the features recommended for proposed SPA designation;
b) boundaries of any resulting SPA;
c) the specifics of the activity proposed and resulting changes in use of the marine environment; and
d) the precise extent of the overlap between the zone of influence of the proposed activity and the distribution of birds.

Taking into account the findings of a Vulnerability Assessment undertaken by Natural England as part of the process for the proposed SPA designation, it is apparent there are currently no existing Port (or related) activities which may prevent the site from being managed as a successful SPA. However, there are several new activities related to the PFDI application which may require monitoring requirements as outlined below. Further details for the VA process are contained within Annex I.

As highlighted in the VA potential short term impacts on bird populations as a result of the proposed PFDI include avoidance of the area due to disturbance caused by construction activity and shipping movements. Issues may arise relating to prey availability resulting from smothering of prey habitats due to an increase in suspended sediments and changes in turbidity and visibility.

Potential longer term impacts may include displacement caused by the presence of larger vessels and overall increase in shipping activity and associated activities, e.g. anchoring in the proposed SPA. Dredging will enable access to the port throughout the tidal cycle, extending periods of disturbance. The dredge may also lead to changes in important supporting habitats (e.g. seagrass beds) depending on the location(s) of sediment disposal and dynamics of sediment redistribution post-deposition.

The MMO would advise the applicant, in discussion with NE, to consider the following mitigation measures within the updated ES:

- The seasonality of the SPA features could allow for activities to be restricted to months when birds are likely to be on breeding grounds elsewhere and therefore absent. This would remove the short term effects of the dredge and impacts would be restricted to longer term effects associated with increase in intensity of shipping.
- Restricting the work to existing shipping channels would minimise the spatial effect assuming these areas are already avoided or used at low densities by birds in response to existing traffic.
- If vessel routes between the dredge and disposal sites are likely to overlap with areas of distribution of SPA features then it is advisable to put measures into place to monitor bird distribution en route.
- If dredging methods used can minimise the release of suspended sediment then the risk of smothering supporting habitats and affecting water clarity may be reduced.
- Disposal should ideally occur outside any proposed SPA boundary, taking into account the possibility of sediment transport into the proposed SPA.

## 5.8 Chapter 12 - Commercial Fisheries and Shellfisheries

The MMO are aware of a number of concerns raised by the local fishing community in relation to the proposed capital dredge and the frequency of disposal operations and their potential to have adverse impacts on fishing grounds. For example, particular concerns have been raised by local oyster and shell-fishermen with regards to smothering, pollution risk, and the potential for the destruction of habitats supporting commercially viable species.

The Falmouth Bay certified disposal site and surrounding areas are used by commercial fishermen. Whilst highly-mobile biota such as fish species may avoid smothering, others such as edible crab (*Cancer pagurus*) may be vulnerable. The Cornwall Inshore Fishing and Conservation Authority (IFCA) have questioned conclusions reached on residual impacts of the scheme as outlined in the 2009 ES. In addition, concerns have been raised to the MMO regarding the potential for displacement of the fishing community should FHC (using their statutory powers) advise cessation of fishing activity within certain areas, including the new navigational channel, the sailing route to the dredged material disposal site and the disposal site itself.

Cornwall IFCA have recommended that a site monitoring and mitigation package is developed which includes a baseline survey of the disposal site and sampling for cadmium in edible crabs. In addition, the ongoing concerns from the local fishing industry warrants further engagement with them by the applicant in order to explain how their concerns are being taken into account.

The MMO advise the applicant to reconsider these impacts in the light of the concerns raised and in conjunction with the local IFCA and representatives of the local fishing industry.

The oyster fishery is considered to be vulnerable to impacts from the dredging operations and could result in financial implications for affected fishermen. Chapter 11 of the 2009 ES suggests minimal impact on the oyster fishery from the total SSC increase caused by the dredging activity. This observation is based on a single tidal cycle within the model and the MMO questions whether a greater impact would be produced if a longer tidal cycle was used. There is potential to address this through monitoring.

The MMO notes that the applicant has committed to using a visor grab for contaminated areas and backhoe dredging for other areas as mitigation for SSCs.

## 5.9 Chapter 16 -Traffic and Transportation

Cornwall Council have advised the MMO that work undertaken to inform the adopted 'Port of Falmouth Masterplan', published in June 2011, gave further consideration at that time to the assessment of transport matters in relation to the potential future landward proposals.

The MMO understands that those analyses and assessments have resulted in opportunities for appropriate travel plan measures and infrastructure improvements being identified to support and inform any potential future land based proposals arising from the Masterplan, including the development of the proposed cruise terminal and associated infrastructure.

Such impacts and any improvements that may be required as a consequence of any future land based proposals would be assessed by the relevant competent authority (ies) as part of the consideration of any updated or future applications received.

## 5.10 Chapter 22 - Summary of Potential Impacts and Mitigation Measures

The MMO has no further comment to make on this chapter at this time. However, the applicant should review and update this chapter in the light of any new information or evidence and the recommendations contained in previous sections of this ES Review.

## 5.11 Chapter 23 - Cumulative Impacts

The MMO requests the applicant to undertake a review of this section of the ES, to ensure that an up to date list of projects and proposals has been considered. This should include developments such as, but not limited to, dredging at Truro and the Pendennis Shipyard development. The cumulative impact assessment should be applied to both the proposed PFDI and any future maintenance dredging requirement.

## 5.12 Chapter 24 - Implications for the Designated Status of the Fal and Helford Estuaries SAC

The MMO has no further comment to make on this chapter at this time. However, the applicant should review and update this chapter in the light of any new information or evidence and the recommendations contained in previous sections of this ES Review. In particular, in light of the new proposed SPA discussed within section 5.7 of this review.

## 5.13 Chapter 25 - Proposals for Monitoring

The MMO has no further comment to make on this chapter at this time. However, the applicant should review and update this chapter in the light of any new information or evidence and the recommendations contained in previous sections of this ES Review.

## 5.14 Chapter 26 – References

The MMO has no further comment to make on this chapter at this time. However, the applicant should review and update this chapter in the light of any new information or evidence and the recommendations contained in previous sections of this ES Review.

# 6 Consultation

## 6.1 Organisations consulted by the MMO for the ES review

| **Consulted organisations** |
|---|
| Centre for Fisheries Environment and Aquaculture Science (CEFAS) |
| Natural England |
| Environment Agency |
| Cornwall County Council |

# 7 Annexes

## 7.1 Vulnerability Assessment process for proposed SPA designation

Natural England performed a Vulnerability Assessment (VA) as part of the process for the proposed SPA designation. As agreed by Defra, if recent survey data are not available to provide information on the current condition of a feature, Natural England must use the next best available evidence to determine the feature’s conditions.

Where data on feature condition is lacking it is assessed by determining whether or not the feature is currently vulnerable to damage and or disturbance. A feature is vulnerable when it is exposed to a pressure (from human activity) to which it is sensitive. The degree to which the feature is vulnerable is dependent on the degree of sensitivity and the level of exposure. A VA provides a proxy indication of the likely condition of features and therefore is limited in its ability to provide confidence in actual condition.

The VA for the features within the Falmouth Bay to St Austell Bay proposed SPA represents Natural England’s current understanding of the sensitivity of the features to known activities. The evidence base currently used to inform the VA will continue to be used as a basis for developing future conservation objectives and will, in the absence of any new evidence, effectively mirror that of the advice contained in the current vulnerability assessment. NE’s conservation advice for the site would only be modified if:

1) New evidence becomes available that confirms that the condition of the feature and/or supporting habitats differed from that indicated through the VA
2) New evidence confirmed that designated features and supporting habitats have a difference level of sensitivity to anthropogenic activities than represented in the current VA
3) New activities that negatively impact on the designated features and supporting habitats not previously accounted for in the VA have to be considered.

It should be noted that Natural England are not responsible for drawing up appropriate management measures. It is the responsibility of the relevant regulatory authorities for securing the conservation status of the site following formal classifications.

# Appendix E – Turbidity Technical Note

# Technical Note

| | | |
|---|---|---|
| To | : | Mark Sansom, Harriet Knowles, Drystan Jones |
| From | : | Chris Adnitt |
| Date | : | 24 February 2015 |
| Copy | : | Caroline Price |
| Our reference | : | PB2139/N/304382/PBor Version 4 (peer reviewed) |
| **Subject** | **:** | **Turbidity Data Analysis - Technical Note** |

## 1. Objective

This note is intended to provide a summary of the data analysis undertaken for turbidity measurements made within the Fal Estuary complex and locations of live maerl. The objective is to determine any similarities in water quality between different areas and whether photosynthesis by live maerl would be possible within the depths proposed following the dredging undertaken for the Port of Falmouth Development Initiative (PFDI).

## 2. Background

Turbidity is a measure of the attenuation of light through the water column and is influenced by a number of factors, namely the amount of organic and inorganic particulate suspended matter and dissolved substances in water. These factors can change considerably dependent on activities occurring within the estuary and rivers and the time of year for natural occurrences i.e. during spring and autumn, plankton blooms occur which have a high level of influence.

Turbidity data (from the Environment Agency) has been analysed from within the Fal Estuary complex to determine whether there are similarities in turbidity levels between deeper areas supporting live maerl in Falmouth Bay and areas further inshore within the estuarine complex. This paper investigates the potential viability of live nodules of maerl within the channel following the proposed deepening of the channel area and thereby causing greater attenuation of light. If the maerl in this area is considered to be viable and able to survive in the long-term then it is important that the light levels are sufficient to ensure photosynthesis. By comparing the turbidity levels between the channel location and a deeper location in the area (that supports live maerl), it can be estimated whether the light levels at the greater depth are likely to support live maerl.

The maximum depth in the channel is currently -5.7mCD. With a 6m tidal range in Falmouth tide this would make the deepest depth in the channel at spring high tide currently 11.7m. The dredging would remove up to 3m of sediment and following this the maximum depth of water in the channel would be -14.7m. Any maerl that subsequently rolls back into the channel will therefore be at this deeper depth.

## 3. Available Turbidity Data

*Data from Monitoring of water quality during maerl translocation trials in Falmouth*

Water quality data was collected during dredging activity for the maerl translocation trials undertaken for the PFDI project in 2012. The results are reported (Ecospan) and show profiles through the water column for areas close to the dredge and from sites situated approximately 300m from the dredge (**Appendix A** provides the report). The turbidity profiles for the sites located at a distance from the dredging activity (i.e. 'control' sites) are expected to show typical profiles through the water column for the location.

Measurements reveal that the profile through the water column for turbidity at the control sites is very linear (i.e. the turbidity values do not differ through the water column) when compared with sites affected by the dredging activity as shown in **Figures 1** and **2.** It appears that, during normal conditions (i.e. with no activities occurring, as shown in the control sites), the water column is well mixed and that values for turbidity at the surface are similar to those at depth. The values taken for turbidity (which were converted to Suspended Solids (mg/l$^{-1}$) using a calibration curve) show very low values at all 'control' sites indicating good water quality conditions. It is also clear that there is a gradient of effect moving away from the dredging activity, such that the turbidity close to the seabed is higher close to the dredge. The turbidity measurements taken downstream of the dredging activity show that the turbidity returns to an ambient level between 25m and 50m from the dredge.

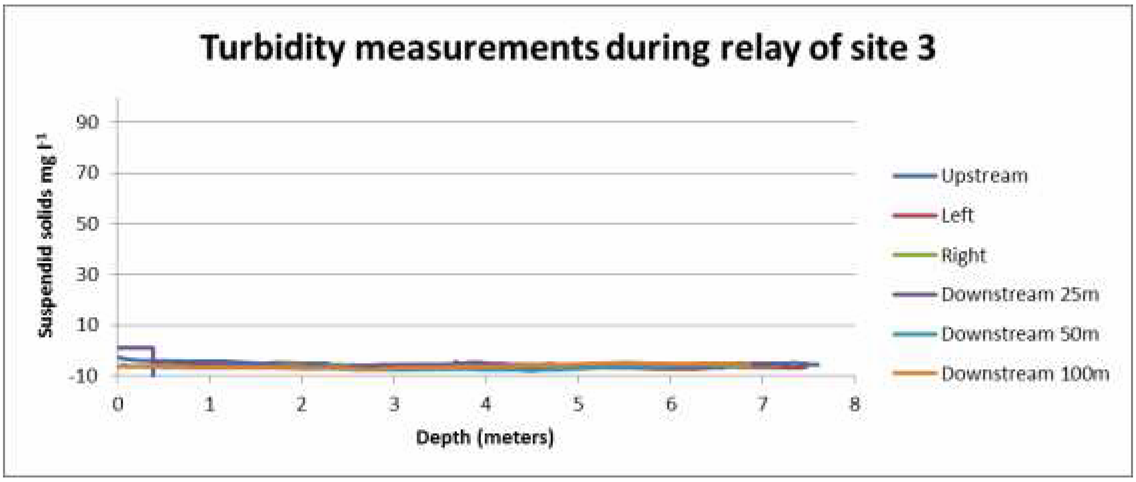



**Figure 1 showing a site unaffected by dredging induced turbidity (SSC) profile**

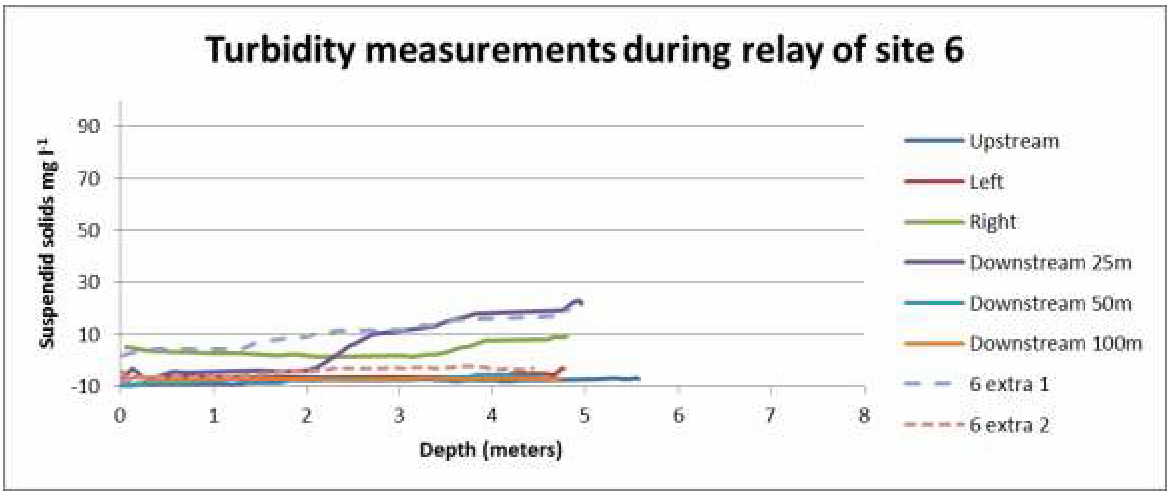



**Figure 2 showing a site affected by dredging induced turbidity (SSC) profile**

*Environment Agency data*

The Environment Agency has provided water quality monitoring data throughout the Fal Estuary (**Figure 3** shows sampling location) during 2011 to 2013 which includes turbidity values taken at specific sampling stations at approximately monthly intervals. Turbidity monitoring is undertaken using a transmissometer at a sample depth of 0.2m (results of turbidity profiles as reported above

(Ecospan) show that turbidity is likely to be similar throughout the water column). The results of the turbidity monitoring at all stations are shown in **Appendix B** for the different locations.

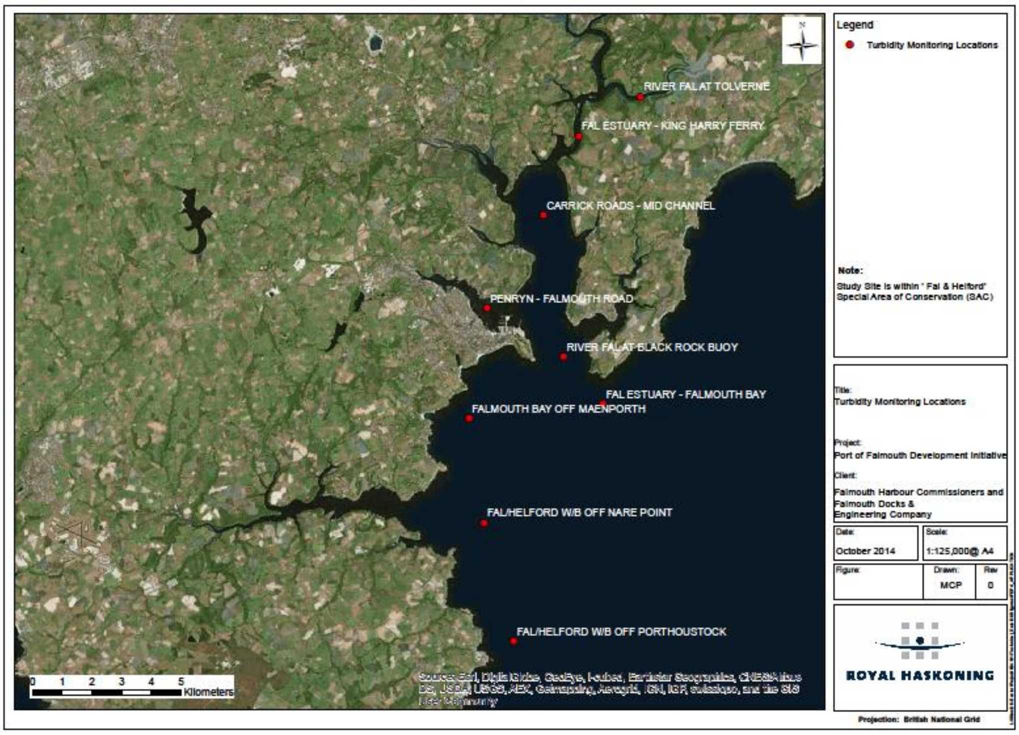



**Figure 3 Environment Agency Sampling locations (note that not all sites have data for turbidity)**

The range of values for turbidity is relatively similar for all sites (where turbidity data was taken) averaging around 3 Formazin Turbidity Units (FTU), apart from one site with much higher values (River Fal at Tolverne) where turbidity values range around 10 FTU and reach 53 FTU during a peak in Autumn 2012.

To provide some indication of the clarity of water using FTU/NTU values **Figure 4** shows a typical series of standards for turbidity readings.

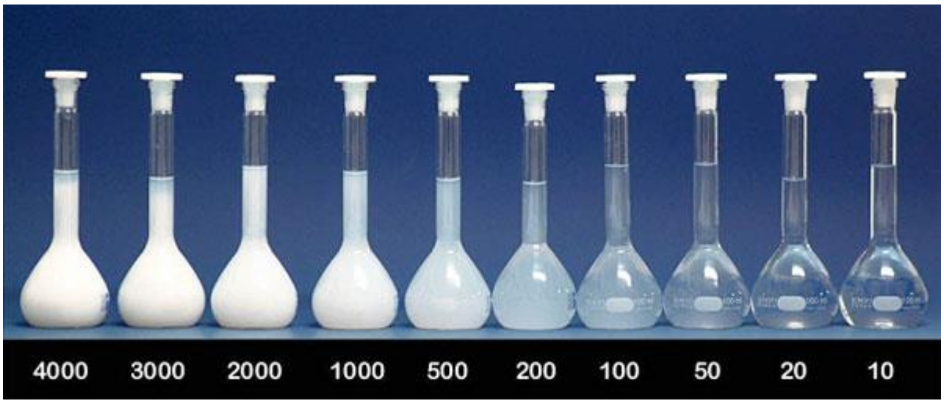



**Figure 4 Typical series of Formazin turbidity Standards shown in NTU/FTU (source Optek Turbidity Overview online (http://www.optek.com/Turbidity_Measurement_Units.asp))**

In general, the sites show good water quality with low turbidity values. The results of the turbidity monitoring show clear peaks which are expected to be due to sediment being suspended in the water column, as a result of wave action during stormy weather. Such peaks occur throughout most of the sampling sites. Some of the sites show additional peaks which are more likely to be due to localised phenomenon as they are only apparent at specific sites.

The peaks of turbidity generally increase the FTU values from an average of 3 FTU up to approximately 8-10 FTU throughout most of the estuary, although there are much higher FTU peaks occurring at the inner estuarine sites.

A comparison of the water quality data available for all sites (as shown in **Appendix B**) shows that the clarity of the water seems to be at similar levels in the outer estuary (including the site at Penryn – Falmouth Road (close to the docks) (**Figure 5**) and the Falmouth Bay sites (Example shown in **Figure 6**).  These sites also show similar trends for the peak occurrences of turbidity. It could be assumed therefore that in terms of light availability these sites would experience similar levels of light attenuation through the water column.

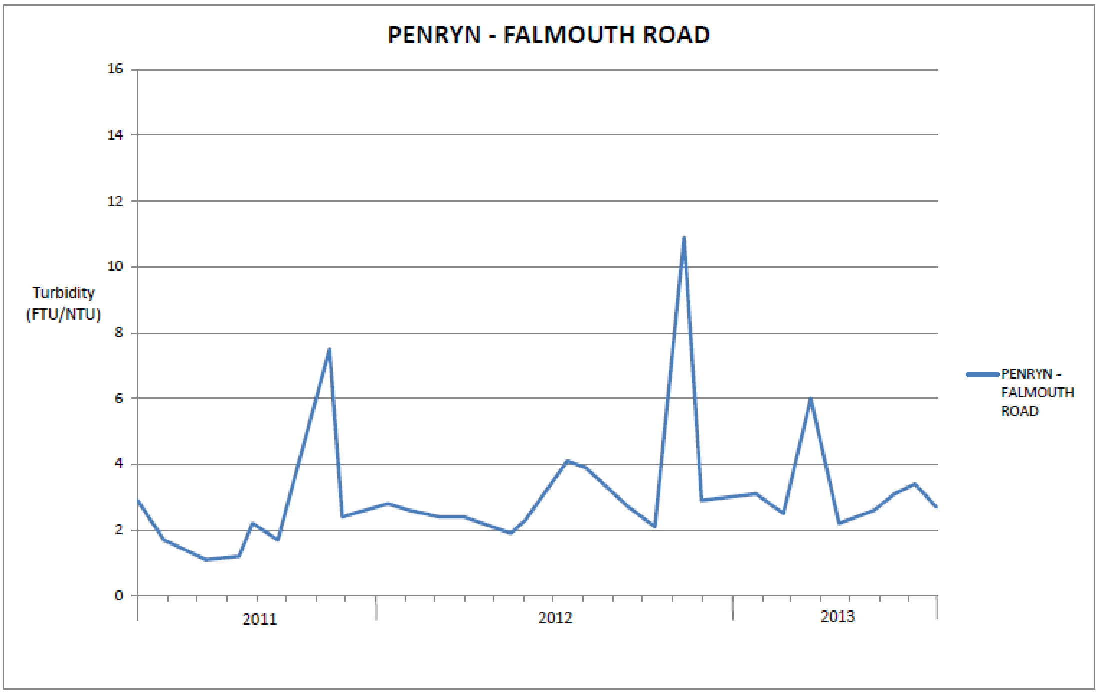



**Figure 5 Turbidity (FTU) data for Penryn – Falmouth Road**

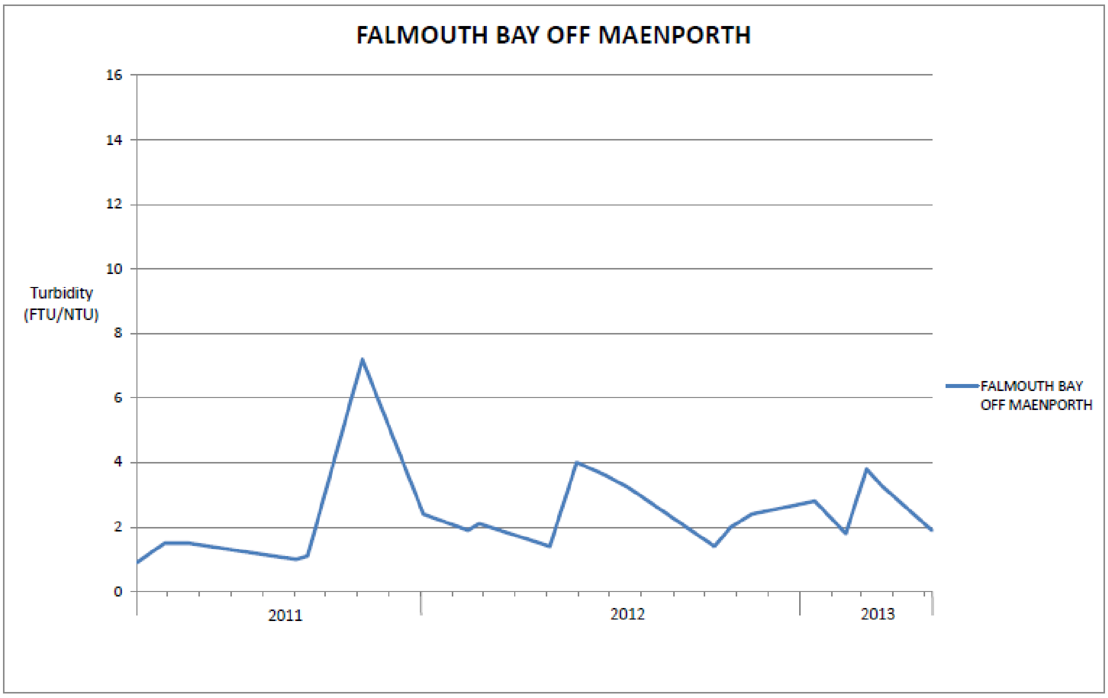



**Figure 6 Turbidity (FTU) data for Falmouth Bay – Maenporth**

Data from Carrick Roads – Mid Channel (further into the estuary) also show low turbidity values but show a higher variability. Sites further into the estuary (River Fal at Tolverne) show much higher values of turbidity.

## 4. Available Live Maerl Data

Data collated by Natural England (provided as live maerl point data) has been plotted onto the admiralty chart for Falmouth (**Figure 7**) and this shows that in the Fal and Helford Estuaries, live maerl is found within the channel area (at approximately -6 mCD) and in Falmouth Bay (down to approximately -17mCD).

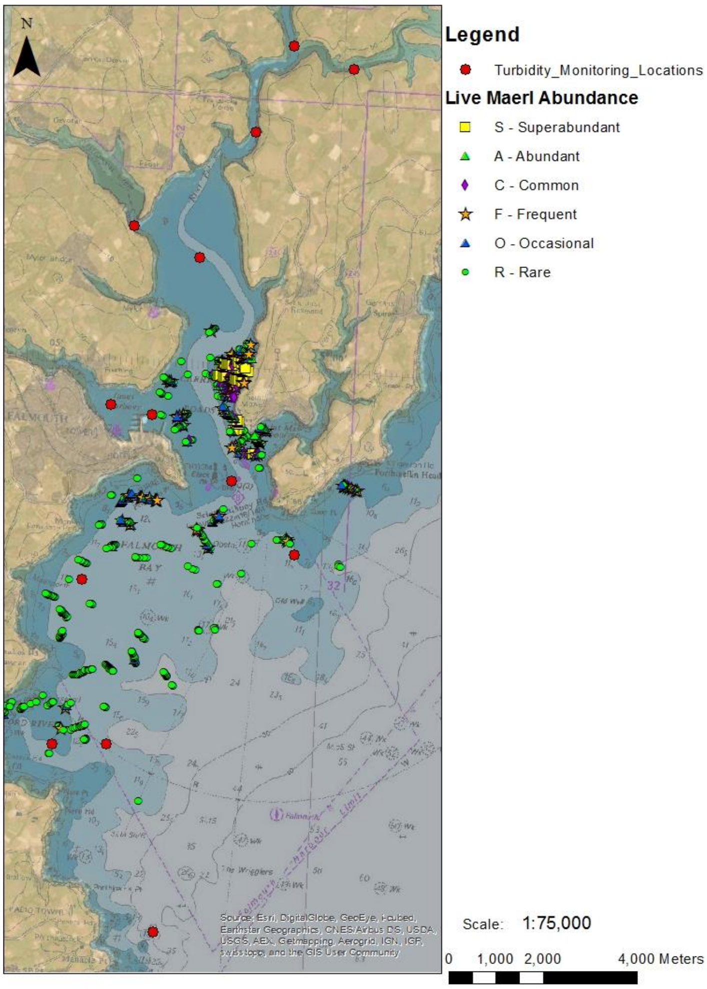



**Figure 7 Chart showing location of live maerl (from data collated by Natural England, 2014)**

This provides evidence to support the fact that the water quality within the channel and deeper areas out in Falmouth Bay is sufficient to allow photosynthesis to occur.

## 5. Other evidence from research papers

Living maerl requires enough light to photosynthesise, otherwise it dies and then becomes bleached losing its pink colour. Maerl has been reported as occurring at between 0-20m depth (Source: UK Marine Special Areas of Conservation (SAC) habitats review http://www.ukmarinesac.org.uk/communities/habitats-review/hr21_1.htm). The SAC table of habitat requirements also discusses the necessary requirements for light levels "The light levels under which maerl can grow are suggested by the depth ranges in which it grows. Maerl found in tropical waters is usually found at depths below the range of the reef -binding coralline algae associated with coral reefs. At the other extreme of the habitat range, at a few sites in western Ireland (e.g. Mannin Bay, part of Killary Harbour and Muckinish) and Brittany, France maerl occurs intertidally, generally only near the extreme low-water mark".

Other papers agree that the depth range is between 0-20m but can be deeper depending on the turbidity levels. Maerl is found in waters up to 32-40m deep, depending on water turbidity, as a result of its requirement for light to photosynthesise (OSPAR Commission, 2010). Typically however, maerl is found in waters down to 20m depth (UK Biodiversity Action Plan).

## 6. Findings of the review

In summary the key findings linked to this review have shown that:

- The turbidity throughout the water column in the channel shows little variability under normal conditions (i.e. as shown in the control sites with no dredging activity);
- Turbidity levels within the Inner Harbour area and Falmouth Bay are good (low values) and show similar values between sites in both locations;
- Peaks in turbidity occur which are thought to be related to increased wave activity during storm conditions. Such peaks generally show similar results at most sites (upstream sites in the inner estuary show greater variability);
- Live maerl is found throughout the study area in waters of varying depth and down to depths of -17m CD (maximum high water depth of -23m) in Falmouth Bay; and
- Research has found that maerl is known to occur typically down to depths of 20m and deeper where conditions allow.

Given the above findings it is not expected that the increase in depth from -5.7mCD to -8.3mCD within the channel area (as a result of the proposed dredging activity associated with the PFDI) will be a restrictive measure for any photosynthetic activity that may occur.

# Appendix A

## Report from Monitoring of water quality during maerl translocation trials in Falmouth

# MONITORING OF WATER QUALITY DURING MAERL TRANSLOCATION TRIALS IN FALMOUTH

Report Number: ER1227

**Performing Company:**

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ISO 9001

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Date of Approval: Draft

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# 7. Contents

# 1 BACKGROUND

As part of a proposal to develop the Port of Falmouth, dredging works need to be carried out which will require the removal of some areas of dead and living maerl. Since maerl beds are highly protected, the original application was refused. To mitigate for the potential damage to the maerl beds, it is proposed that the maerl is translocated from the dredge areas. To determine how effective this may be, a trial translocation project has been instigated. In order to determine the effect of such operations on the water column (particularly turbidity and dissolved oxygen), Falmouth Harbour Commissioners have stipulated that water quality monitoring must be undertaken during the trial period.

This report details the water quality monitoring undertaken at each of six trial sites dredged and relayed between the 24th and 27th of September 2012. The trial removed two areas of 5m by 5m and up to 30cm in depth at each site. This was undertaken by a barge mounted backhoe dredger fitted with a $2m^3$ toothless grading bucket. Following a 12 hour period of storage above the surface, the material was then re-laid in the same 5m by 5m area again to a depth of 30cm.

# 2 METHODS

During each translocation trial, water quality profiling and water sampling were undertaken from one of Falmouth Harbour commissioner's vessels. Ecospan Environmental provided a Trimble DSM132 survey quality positioning system typically accurate to within 1 metre. This was used along with positioning software to establish target positions around the dredge location and to accurately record the positions of the profiling points.

## 2.1 Water profiling

Once on station, a YSI 6-Series multi-parameter single optic sonde, with fitted PH, Con- temp, depth, DO and turbidity sensors were used to record the required parameters. This meter logged the data parameters required and also had the resolution required by the revised tender document. The sonde was lowered slowly from the water surface to the sea bed and then back up again whilst all parameters were logged and visually monitored where possible. The sonde was connected to a NIO water sampler which was used to take discrete samples when required. The sonde was calibrated before use and at the end of the survey period in line with the manufacturer's recommendations.

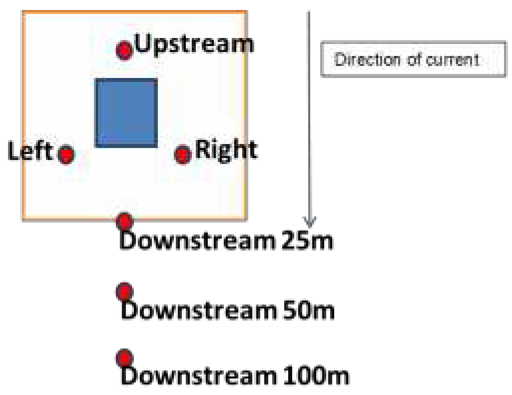
### 2.1.1 Cardinal stations

It was requested that through water column profiles of: turbidity; dissolved oxygen; salinity; and temperature were collected at 4 positions 300 meters from each dredge site to determine baseline levels. These cardinal stations were located to the North, East, South and West. Profiles were taken before any dredging operations were completed. For trial sites 1, 2 and 3 these points were reassessed on completion of the dredge at each site. After discussions with Falmouth Harbour commissioners representatives, Ecospan Environmental were asked to only monitor the cardinal sites pre dredge as per the original protocol.

### 2.1.2 Cruciform stations

Water column profiles of: turbidity; dissolved oxygen; salinity; and temperature were also assessed during dredging and relay at a series of stations positioned in a cruciform arrangement (see Fig 1.) around each dredge site. The position of the cruciform was determined based on tidal flow data from the buoy provided by Falmouth Harbour Commissioners. The primary axis of the cruciform was aligned with the tidal flow at each site. The exact positions for the profiles were dictated by both the position of the dredging barge (which due to its size was often over the theoretical sampling point) and conditions for boat handling. The weather conditions and need for night working also influenced the crew's ability to get to theoretical stations.

**Fig.1. Position of monitoring stations around the trial sites**




Where possible the distances from the dredging/relaying operations were 25 m, 50 m, 100 m in the direction of the flow with the remaining stations being within 25 m of the dredge area. Where a plume was visible additional profiles were taken and the positions of where these were recorded.

## 2.2 Water sampling and analysis

Water samples were collected during the monitoring period around the translocation operations as well as at the background stations. The samples were taken at discrete depths identified during the water profiling using NIO bottles. These bottles enabled a discrete sample to be taken, as they are triggered using a line which fires the spring mechanism completely sealing the bottle. When in the open position, the water is completely free to enter and leave the bottle (in this position the bottle is essentially an open cylinder see Fig 2).

**Fig.2. Photograph of an NIO water sampling bottle being deployed**

To enable a robust calibration of the turbidity data readings from the multi-parameter sonde, samples were collected spanning the range of turbidities encountered and analysed for suspended solids in mg $l^{-1}$. To increase the accuracy of the calibration (turbidity to suspended solids in mg $l^{-1}$) the turbidity of each actual sample was recorded in Ecospan's laboratory prior to the sample being sent to an accredited laboratory (ESG Ltd) for suspended solids analysis. This negates the requirement for the sample to be taken at exactly the same time as the turbidity reading is taken in the field. This provides more accurate calibration data, as the sediment plumes are often highly variable both spatially and temporally within very short distances and times.

Ecospan Environmental undertook particle size analysis on each water sample using a Malvern laser particle size analyser to enable the proportions of sand and silt to be determined in each sample. Although particle size analysis was completed on all samples, only data for samples containing >5 mg $l^{-1}$ are considered meaningful. For samples of <5 mg $l^{-1}$ insufficient particles were present to reduce the variability of the method and hence the data was considered to be misleading.

## 2.3 Sample handling and documentation

Documentation on this survey followed Ecospan Environmental Ltd SOP ES-07 *Documentation of methods and field data when undertaking ecological surveys.* This is consistent with ISO guidelines. This requires that all projects have a project plan, a project notebook (boat book) and a chain of custody form for sample tracking. Each sample was uniquely labelled and the details required by the guideline and the SOP entered into the project notebook. The following details were recorded:

- Survey team
- Project Number
- Date(s) and time(s) of sampling
- Weather conditions (particularly wind strength)
- Station location coordinates and datum

- Station identifier (usually a number)
- Number of replicates taken
- Details of samples taken and the sample numbers if applicable
- Any other measurements taken
- Depth of sample retrieved
- Sample description
- Water depth
- Other comments and observations

The samples were stored chilled prior to return to the laboratory where they were frozen before being sent off for analysis. All sample details were recorded on a chain of custody form.

### 2.4 Additional information

Wind speed and direction was collected at a minimum of half hourly intervals over the survey period along with parameters such as an estimate of visibility and sea state including wave height, period and direction for both wind waves and swell.

## 3 QUALITY ASSURANCE

Ecospan has an ISO 9001 accredited quality management system to ensure that we work to the high standards expected by our customers. We undertake all work in accordance with standard operating procedures and recognised national/international guidelines. For ecological work we also participate in the National Marine Biological Analytical Quality Control Scheme (NMBAQCS).

Ecospan Environmental undertakes internal auditing of processes and service provision at appropriate intervals. Systems audits are undertaken on an annual basis encompassing the full scope of the QMS. Facility audits are also completed annually. As a minimum, 5 % of projects per year are selected at random and audited by an Ecospan Environmental director. Internal audits are also conducted on projects where services provided fail to meet the needs of our customers.

## 4 RESULTS

### 4.1 Water profile positions

All positions for this project are reported in OSGB 1936 as required by the tender. All values are in degrees and decimal minutes.

#### 4.1.1 Cardinal stations

The positions for all cardinal stations for each of the 6 trial sites are provided in table 1. All profiles were taken within 10 m of the target positions.

**Table 1. Cardinal station locations for the 6 Trial sites (OSGB 1936)**

| Cardinal station | Site 1 | | Site 2 | | Site 3 | |
|---|---|---|---|---|---|---|
| North | 50 09.61498' | -05 02.75289' | 50 09.62320' | -05 02.62676' | 50 09.59985' | -05 02.53345' |
| East | 50 09.45518' | -05 02.50225' | 50 09.46136' | -05 02.37312' | 50 09.43801' | -05 02.27831' |
| South | 50 09.29202' | -05 02.75518' | 50 09.29820' | -05 02.62904' | 50 09.27480' | -05 02.53124' |
| West | 50 09.45704' | -05 03.00732' | 50 09.46298' | -05 02.88046' | 50 09.43760' | -05 02.78560' |
| **Cardinal station** | **Site 4** | | **Site 5** | | **Site 6** | |
| North | 50 09.65320' | -05 02.45514' | 50 09.59277' | -05 02.34755' | 50 09.56829' | -05 02.68178' |
| East | 50 09.49136' | -05 02.20072' | 50 09.42955' | -05 02.09313' | 50 09.40555' | -05 02.42736' |
| South | 50 09.32905' | -05 02.45293' | 50 09.26772' | -05 02.34756' | 50 09.24504' | -05 02.68095' |
| West | 50 09.49226' | -05 02.70657' | 50 09.43046' | -05 02.59964' | 50 09.40736' | -05 02.93393' |

### 4.1.2 Cruciform stations

The position of the cruciform stations determined for each trial site for monitoring during the dredge and relay are presented in Tables 2 to 7. The tidal flow direction which was obtained from the data buoy and used to determine the cruciform position is also included. On a number of occasions a plume was visually identified away from the cruciform stations and hence an extra profile was taken. The location of these additional profiles was also recorded.

**Table 2. Trial site 1 Cruciform station positions for dredge and relay (OSGB 1936)**

| Dredge | Cruciform positions (Tidal flow 244$^{0}$ at 0.2 Knots) | | Actual profile position | |
|---|---|---|---|---|
| Dredger | 50 09.44650' | -05 02.76363' | 50 09.45525' | -05 02.76362' |
| 1A | 50 09.45431' | -05 02.75030' | 50 09.45433' | -05 02.74759' |
| 1B | 50 09.44673' | -05 02.78145' | 50 09.44674' | -05 02.78014' |
| 1C | 50 09.43564' | -05 02.76619' | Under dredger | |
| 1D | 50 09.43672' | -05 02.78058' | 50 09.43841' | -05 02.78276' |
| 1E | 50 09.42764' | -05 02.79710' | 50 09.43015' | -05 02.79546' |
| 1F | 50 09.40920' | -05 02.82880' | 50 09.43500' | -05 02.79980' |
| 1 Extra | | | 50 09.44738' | -05 02.80902' |
| **Relay** | **Cruciform position (Tidal flow 216$^{0}$ at 0.2 Knots)** | | **Actual profile position** | |
| Dredger | 50 09.44650' | -05 02.76363' | 50 09.45051' | -05 02.76712' |
| 1RA | 50 09.45543' | -05 02.74905' | 50 09.46179' | -05 02.73238' |
| 1RB | 50 09.44673' | -05 02.78145' | 50 09.44318' | -05 02.79176' |
| 1RC | 50 09.43346' | -05 02.76487' | 50 09.43364' | -05 02.76796' |
| 1RD | 50 09.43758' | -05 02.78172' | 50 09.43396' | -05 02.77847' |
| 1RE | 50 09.42592' | -05 02.79977' | 50 09.42357' | -05 02.79438' |
| 1RF | 50 09.40439' | -05 02.83600' | 50 09.40567' | -05 02.84170' |
| 1R extra | | | 50 09.18575' | -05 03.85252' |

**Table 3. Trial site 2 Cruciform station positions for dredge and relay (OSGB 1936)**

| Dredge | Cruciform position (Tidal flow $289^0$ at 0.6 Knots) | | Actual profile position | |
|---|---|---|---|---|
| Dredger | 50 09.45528' | -05 02.63447' | 50 09.45528' | -05 02.63447' |
| 2A | 50 09.45063' | -05 02.61909' | 50 09.46032' | -05 02.61179' |
| 2B | 50 09.46711' | -05 02.64186' | 50 09.46522' | -05 02.63597' |
| 2C | 50 09.45131' | -05 02.64973' | 50 09.44211' | -05 02.66652' |
| 2D | 50 09.46093' | -05 02.65474' | 50 09.45757' | -05 02.66034' |
| 2E | 50 09.46573' | -05 02.67382' | 50 09.46409' | -05 02.66663' |
| 2F | 50 09.47763' | -05 02.71400' | 50 09.47596' | -05 02.70578' |
| Relay | Cruciform position (Tidal flow $289^0$ at 0.5 Knots) | | Actual profile position | |
| Dredger | 50 09.45528' | -05 02.63447' | 50 09.46314' | -05 02.63902' |
| 2RA | 50 09.45864' | -05 02.62332' | 50 09.44458' | -05 02.61914' |
| 2RB | 50 09.47466' | -05 02.64687' | 50 09.47080' | -05 02.66160' |
| 2RC | 50 09.45909' | -05 02.65585' | 50 09.44275' | -05 02.66709' |
| 2RD | 50 09.46825' | -05 02.65986' | 50 09.46920' | -05 02.65562' |
| 2RE | 50 09.47351' | -05 02.67966' | 50 09.47349' | -05 02.67816' |
| 2RF | 50 09.48427' | -05 02.72032' | 50 09.48310' | -05 02.71923' |

**Table 4. Trial site 3 Cruciform station positions for dredge and relay (OSGB 1936)**

| Dredge | Cruciform position (Tidal flow $293^0$ at 1.0 Knots) | | Actual profile position | |
|---|---|---|---|---|
| Dredger | 50 09.42856' | -05 02.54339' | 50 09.43570' | -05 02.54118' |
| 3A | 50 09.43369' | -05 02.52613' | 50 09.43990' | -05 02.52378' |
| 3B | 50 09.44742' | -05 02.54841' | 50 09.44451' | -05 02.54947' |
| 3C | 50 09.43163' | -05 02.55442' | 50 09.41087' | -05 02.55507' |
| 3D | 50 09.44170' | -05 02.56100' | 50 09.44222' | -05 02.56003' |
| 3E | 50 09.44628' | -05 02.57926' | 50 09.45071' | -05 02.57462' |
| 3F | 50 09.45635' | -05 02.61726' | 50 09.45682' | -05 02.62363' |
| Relay | Cruciform position (Tidal flow $298^0$ at 0.7 Knots) | | Actual profile position | |
| Dredger | 50 09.42856' | -05 02.54339' | 50 09.43752' | -05 02.53359' |
| 3RA | 50 09.43094' | -05 02.51637' | 50 09.43595' | -05 02.50850' |
| 3RB | 50 09.45246' | -05 02.54060' | 50 09.45373' | -05 02.53991' |
| 3RC | 50 09.43277' | -05 02.55960' | 50 09.41449' | -05 02.58680' |
| 3RD | 50 09.44101' | -05 02.54315' | 50 09.44018' | -05 02.54291' |
| 3RE | 50 09.45429' | -05 02.57826' | 50 09.44907' | -05 02.58682' |
| 3RF | 50 09.46688' | -05 02.61503' | 50 09.46885' | -05 02.61346' |

**Table 5. Trial site 4 Cruciform station positions for dredge and relay (OSGB 1936)**

| Dredge | Cruciform position (Tidal flow $002^0$ at 0.7Knots) | | Actual profile position | |
|---|---|---|---|---|
| Dredger | 50 09.49028' | -05 02.45484' | 50 09.48564' | -05 02.46060' |
| 4A | 50 09.47306' | -05 02.45965' | 50 09.46453' | -05 02.46426' |
| 4B | 50 09.49549' | -05 02.47476' | 50 09.49368' | -05 02.47272' |
| 4C | 50 09.49343' | -05 02.44852' | 50 09.48727' | -05 02.43727' |
| 4D | 50 09.49984' | -05 02.46048' | 50 09.50137' | -05 02.45831' |
| 4E | 50 09.51586' | -05 02.46063' | 50 09.51019' | -05 02.46000' |
| 4F | 50 09.53761' | -05 02.46054' | 50 09.53670' | -05 02.45981' |
| Relay | Cruciform position (Tidal flow $007^0$ at 0.8 Knots) | | Actual profile position | |
| Dredger | 50 09.49028' | -05 02.45484' | 50 09.48629' | -05 02.45934' |
| 4RA | 50 09.47306' | -05 02.45965' | 50 09.46538' | -05 02.45087' |
| 4RB | 50 09.49549' | -05 02.47476' | 50 09.49387' | -05 02.47758' |
| 4RC | 50 09.49343' | -05 02.44852' | 50 09.49233' | -05 02.44909' |
| 4RD | 50 09.49984' | -05 02.46048' | 50 09.49498' | -05 02.45910' |
| 4RE | 50 09.51586' | -05 02.46063' | 50 09.51505' | -05 02.46056' |
| 4RF | 50 09.53761' | -05 02.46054' | 50 09.53546' | -05 02.46019' |

**Table 6. Trial site 5 Cruciform station positions for dredge and relay (OSGB 1936)**

| Dredge | Cruciform position (Tidal flow $014^0$ at 0.8 Knots) | | Actual profile position | |
|---|---|---|---|---|
| Dredge | 50 09.42194' | -05 02.35683' | 50 09.43058' | -05 02.35333' |
| 5A | 50 09.41857' | -05 02.35800' | 50 09.41333' | -05 02.35431' |
| 5B | 50 09.43757' | -05 02.33894' | 50 09.43739' | -05 02.33960' |
| 5C | 50 09.44147' | -05 02.36375' | 50 09.44016' | -05 02.36246' |
| 5D | 50 09.44467' | -05 02.34887' | 50 09.44602' | -05 02.34960' |
| 5E | 50 09.45978' | -05 02.34360' | 50 09.45894' | -05 02.34771' |
| 5F | 50 09.48015' | -05 02.33725' | 50 09.47977' | -05 02.33700' |
| Relay | Cruciform position (Tidal flow $009^0$ at 0.9 Knots) | | Actual profile position | |
| Dredge | 50 09.42194' | -05 02.35683' | 50 09.42799' | -05 02.36111' |
| 5RA | 50 09.42063' | -05 02.36278' | 50 09.40743' | -05 02.35807' |
| 5RB | 50 09.43414' | -05 02.34952' | 50 09.43558' | -05 02.35094' |
| 5RC | 50 09.43574' | -05 02.37033' | 50 09.43039' | -05 02.37914' |
| 5RD | 50 09.43848' | -05 02.35860' | 50 09.43273' | -05 02.36408' |
| 5RE | 50 09.44902' | -05 02.35613' | 50 09.44681' | -05 02.35667' |
| 5RF | 50 09.46917' | -05 02.35101' | 50 09.46808' | -05 02.34352' |

**Table 7. Trial site 6 Cruciform station positions for dredge and relay (OSGB 1936)**

| Dredge | Cruciform position (Tidal flow 032⁰ at 0.6Knots) | | Actual profile position | |
|---|---|---|---|---|
| Dredge | 50 09.40168' | -05 02.68941' | 50 09.40831' | -05 02.69046' |
| 6A | 50 09.39889' | -05 02.70084' | 50 09.37989' | -05 02.70952' |
| 6B | 50 09.42476' | -05 02.69663' | 50 09.42331' | -05 02.69846' |
| 6C | 50 09.41194' | -05 02.66873' | 50 09.40995' | -05 02.66941' |
| 6D | 50 09.42064' | -05 02.67907' | 50 09.41755' | -05 02.68369' |
| 6E | 50 09.43437' | -05 02.66615' | 50 09.43368' | -05 02.66414' |
| 6F | 50 09.46047' | -05 02.64155' | 50 09.45666' | -05 02.64514' |
| Relay | Cruciform position (Tidal flow 350⁰ at 0.3 Knots) | | Actual profile position | |
| Dredge | 50 09.40168' | -05 02.68941' | 50 09.40831' | -05 02.69046' |
| 6RA | 50 09.39546' | -05 02.68708' | 50 09.39456' | -05 02.68640' |
| 6RB | 50 09.42224' | -05 02.67692' | 50 09.41927' | -05 02.67340' |
| 6RC | 50 09.41858' | -05 02.71094' | 50 09.41749' | -05 02.71282' |
| 6RD | 50 09.42133' | -05 02.69432' | 50 09.41197' | -05 02.69280' |
| 6RE | 50 09.43872' | -05 02.69961' | 50 09.44090' | -05 02.69920' |
| 6RF | 50 09.46962' | -05 02.70802' | 50 09.46770' | -05 02.70422' |
| 6 Extra 1 | | | 50 09.42453' | -05 02.71636' |
| 6 Extra 2 | | | 50 09.47250' | -05 02.78555' |

## 4.2 Cardinal stations Water quality monitoring data

The data for cardinal water monitoring at all of the sites, both before and after dredge and relay operations, is summarised in Table 8. The data for all parameters shows some variability, but this is within that would be expected for estuarine seawater.

**Table 8. Summary of maximum and minimal water quality parameters for each Cardinal station**

| Site | Temperature (°C) | | Salinity (‰) | | pH | | Turbidity (NTU) | | Dissolved Oxygen % | | Dissolved Oxygen mg $l^{-1}$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Min | Max | Min | Max | Min | Max | Max | Min | Max | Min | Max | Min |
| 1 | 13.19 | 14.87 | 34.19 | 35.63 | 7.92 | 8.05 | -0.1 | -5.9 | 87.8 | 98.2 | 7.18 | 8.09 |
| 2 | 13.19 | 14.93 | 33.47 | 36.35 | 7.98 | 8.08 | 0 | -5.3 | 88.3 | 99.3 | 7.23 | 8.2 |
| 3 | 14.53 | 14.91 | 34.49 | 35.05 | 8.03 | 8.07 | -0.4 | -4.1 | 88.6 | 96.8 | 7.23 | 7.95 |
| 4 | 14.35 | 14.88 | 34.38 | 34.99 | 7.91 | 8.07 | -2.6 | -5.4 | 89.1 | 97.9 | 7.29 | 8.04 |
| 5 | 13.32 | 14.87 | 33.8 | 35.55 | 7.95 | 8.11 | -0.5 | -5.1 | 89.1 | 98.0 | 7.29 | 8.16 |
| 6 | 12.72 | 14.84 | 34.29 | 36.14 | 7.86 | 8.09 | -1 | -5.6 | 90.6 | 98.3 | 7.45 | 8.32 |
| All | 12.72 | 14.93 | 33.47 | 36.35 | 7.86 | 8.11 | 0 | -5.9 | 87.8 | 99.3 | 7.18 | 8.32 |

## 4.3 Cruciform stations Water quality monitoring data

The data for cruciform water monitoring stations at all of the sites during the dredge and relay operations is summarised in Table 9. It can be seen that, for all parameters with the exception of turbidity the parameters were found to be in the same ranges as those seen at the cardinal stations. The data for all parameters shows some variability, but this is within that would be expected for estuarine seawater.

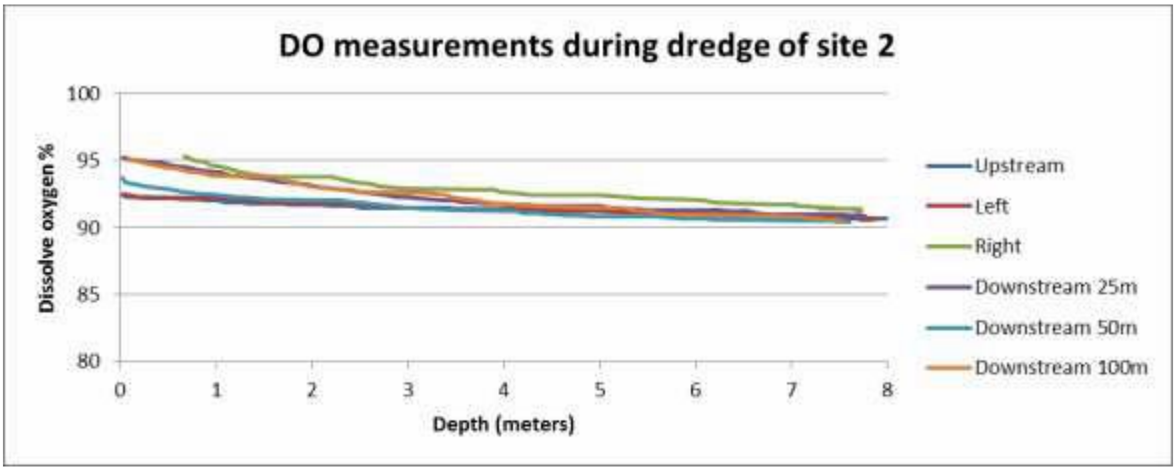
**Table 9. Summary of maximum and minimal water quality parameters for each Cruciform station**

| Station | Temperature (°C) | | Salinity (‰) | | pH | | Turbidity (NTU) | | Dissolved Oxygen % | | Dissolved Oxygen mg $l^{-1}$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max |
| 1 | 13.6 | 14.84 | 34.38 | 35.11 | 8.00 | 8.05 | -5.1 | 23.8 | 87.1 | 99.0 | 7.15 | 8.14 |
| 2 | 13.92 | 14.86 | 34.45 | 35.33 | 8.01 | 8.07 | -5.0 | 33.4 | 89.5 | 97.9 | 7.32 | 8.08 |
| 3 | 14.33 | 14.89 | 34.41 | 35.03 | 7.99 | 8.07 | -5.4 | 28.6 | 89.1 | 98.4 | 7.28 | 8.14 |
| 4 | 13.64 | 14.87 | 33.95 | 35.48 | 7.92 | 8.07 | -5.1 | 0.5 | 90.7 | 98.1 | 7.47 | 8.13 |
| 5 | 13.67 | 14.86 | 33.96 | 35.3 | 8.01 | 8.1 | -6.1 | 12.6 | 90.3 | 98.6 | 7.42 | 8.19 |
| 6 | 13.08 | 14.81 | 34.29 | 35.8 | 7.94 | 8.14 | -5.6 | 8.7 | 91.4 | 98.3 | 7.51 | 8.26 |
| All | 13.08 | 14.89 | 33.95 | 35.8 | 7.92 | 8.14 | -6.1 | 36.8 | 87.1 | 99.0 | 7.15 | 8.26 |

## 4.4 Dissolved oxygen results for cruciform stations

The results for all dissolved oxygen profiles are provided in appendix 1. Figure 3 shows a typical example of one of these from site 2. This shows some reductions in dissolved oxygen with depth, but the lowest values seen are all above 90%. For all stations all dissolved oxygen values were 87% or above and there is no indication this is related to the dredging activities. Even where increased turbidity was detected no associated reduction in dissolve oxygen was observed.

Figure 3. Trial site 2 Cruciform station dissolved oxygen measurements

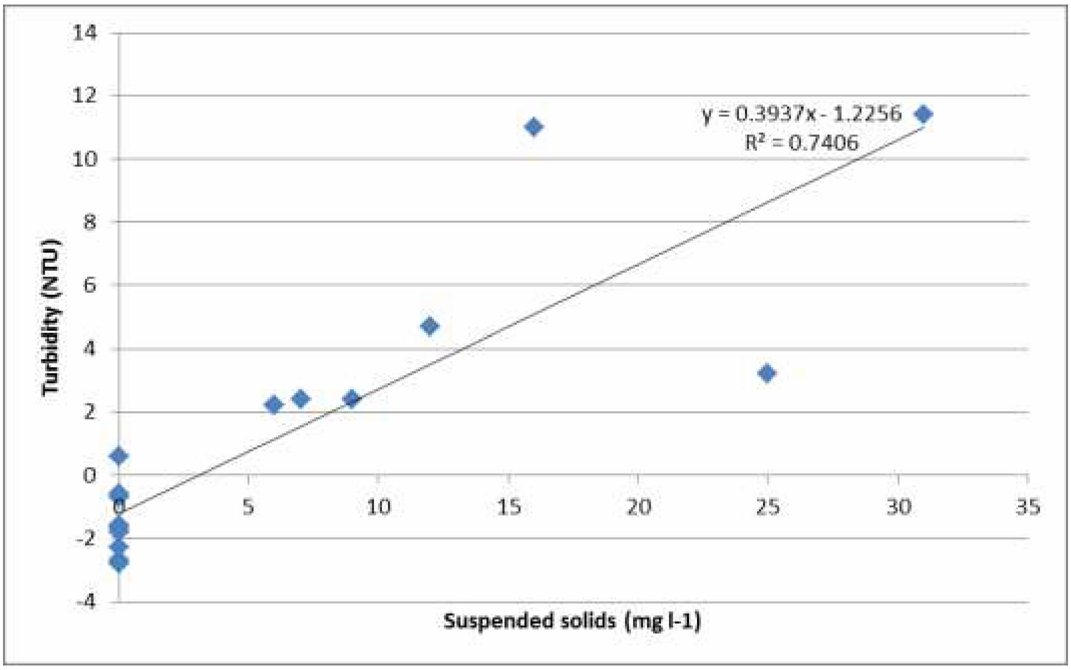



## 4.5 Turbidity calibration and results

The turbidity data from the profile monitoring was measured and logged in NTU. These can be directly related to suspended solids levels and can be converted by producing a calibration curve between the two.

As no significant turbidity was measured at the cardinal stations, the values for the cruciform stations were used to establish the relationship between turbidity and suspended solids. These have been plotted in Figure 4. During this exercise, the low levels of turbidity and suspended solids have resulted in a lower correlation coefficient than is normally seen when a greater range of turbidity is measured. However, with the correlation coefficient of 0.74 there is still a good relationship between the two. Using this, we can calculate that the highest turbidity levels measured in the field (36.8 NTU) equates to a suspended solids level of approximately 97 mg $l^{-1}$.

**Figure 4. Correlation of suspended solids and turbidity measurements**




### 4.5.1 Suspended solids analysis

The results of suspended solids analysis are shown in table 10 and 11 alongside the turbidity values measured in the field and back at Ecospan Laboratory before being sent for analysis.

**Table 10. Suspended solids analysis results for water samples taken at the cardinal stations**

| Site | position | Suspended solids mg/l | turbidity lab | turbidity Field |
|---|---|---|---|---|
| 1 | 1 S Pre | <5 | -2.7 | -3.1 |
| 1 | 1 E Pre | <5 | -2.6 | -3.9 |
| 2 | 2 E pre | <5 | -3.7 | -3.6 |
| 2 | 2 N post | <5 | -2.7 | -2.8 |
| 2 | 2 N pre | <5 | -2.6 | -3.7 |
| 3 | 3 W pre | <5 | -2.9 | -4 |
| 3 | 3 W relay | <5 | -2.2 | -4.2 |
| 4 | 4 S pre | <5 | -1 | -3.5 |
| 5 | 5 E pre | <5 | -3.2 | -3.7 |
| 5 | 5 N relay | <5 | -2.4 | -4.1 |
| 6 | 6 W pre | <5 | -3 | -3.8 |

**Table 11. Suspended solids analysis results for water samples taken at the cruciform stations during dredge and relay operations**

| Site | position | Suspended solids mg $l^{-1}$ | Turbidity lab | Turbidity Field |
|---|---|---|---|---|
| 1 | 1B | <5 | -2.7 | -4 |
| 1 | 1E | <5 | -2.3 | -3.3 |
| 1 | 1D relay | <5 | -2.8 | -3.8 |
| 1 | 1F relay | <5 | 0.6 | 10.2 |
| 2 | 2A | <5 | -1.7 | -0.4 |
| 2 | 2D | 31 | 11.4 | 23 |
| 2 | 2E | 25 | 3.2 | 4.9 |
| 2 | 2D relay | <5 | -0.7 | 1.9 |
| 3 | 3C | 16 | 11 | 23.1 |
| 5 | 5A | 12 | 4.7 | 6.2 |
| 5 | 5E | <5 | -2.8 | -4.1 |
| 6 | 6B | <5 | -0.6 | 6.8 |
| 6 | 6D | <5 | -1.6 | -2.7 |
| 6 | 6C relay | 6 | 2.2 | 6.8 |
| 6 | 6D relay | 7 | 2.4 | 7 |
| 6 | 6 extra 1 relay | 9 | 2.4 | 6.4 |
| 6 | 6 extra 2 relay | <5 | -1.8 | -2.4 |

### 4.5.2 Turbidity results for cruciform stations

All the results for turbidity presented in this section have been converted in to suspended solids mg $l^{-1}$. The results show increased turbidity levels at sites 1, 2, 3, 5 and 6 during the dredging and/or relay operations. Table 12 shows the maximum turbidity levels at each site in both NTU and suspended solids. From this it can be seen that the highest value was seen at site 2 and this was recorded at the downstream station nearest to the dredge (25m).

**Table 12. Maximum turbidity levels observed**

| Site | Turbidity NTU) | Suspended solids (mg $l^{-1}$) |
|---|---|---|
| | Max | Max |
| 1 | 23.8 | 63.57 |
| 2 | 36.8 | 96.59 |
| 3 | 28.6 | 75.76 |
| 4 | 0.5 | 4.38 |
| 5 | 12.6 | 35.12 |
| 6 | 8.7 | 25.21 |
| All | 36.8 | 96.59 |

The profiles where an increased turbidity was measured are shown below (all others are provided in appendix 2). The highest turbidity values were seen within 2 metres of the sea bed where it was expected that a plume might be detected. The data for sites 1 and 2 during the dredge showed a continual increase in the turbidity value after the sonde left the bottom before dropping back to zero after approximately 2 m. These have been included on the profile to show the maximum turbidity levels measured. There is some risk that these elevated values were a result of the sonde hitting the seabed. However, as this effect was not seen at any of the cardinal stations (or the other cruciform stations), it is considered that they probably reflect a real turbidity increase caused by the plume. On the relay of site 1 turbidity was seen near the surface and this was measured at the 1extra station added. This was also seen at sites 2 and 6, where turbidity was recorded near to the surface at some of the stations close to the dredge. This surface turbidity was not thought to be a result of the dredging activity on the seabed, but was associated with the overflow from the maerl holding tanks on the barge.

**Figure 5. Trial site 1 Cruciform station during dredge Turbidity measurements**

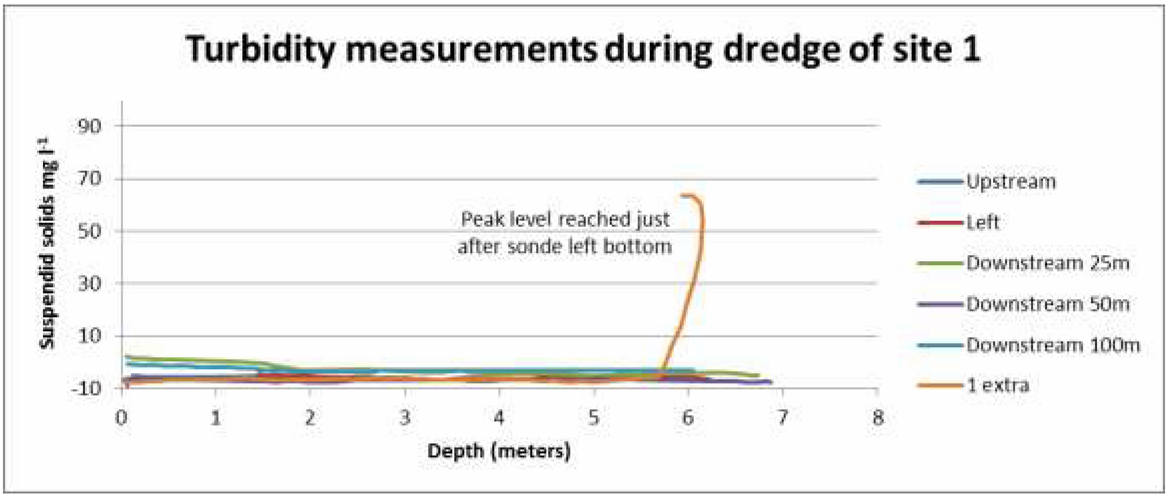



**Figure 6. Trial site 1 Cruciform station during dredge Turbidity measurements**

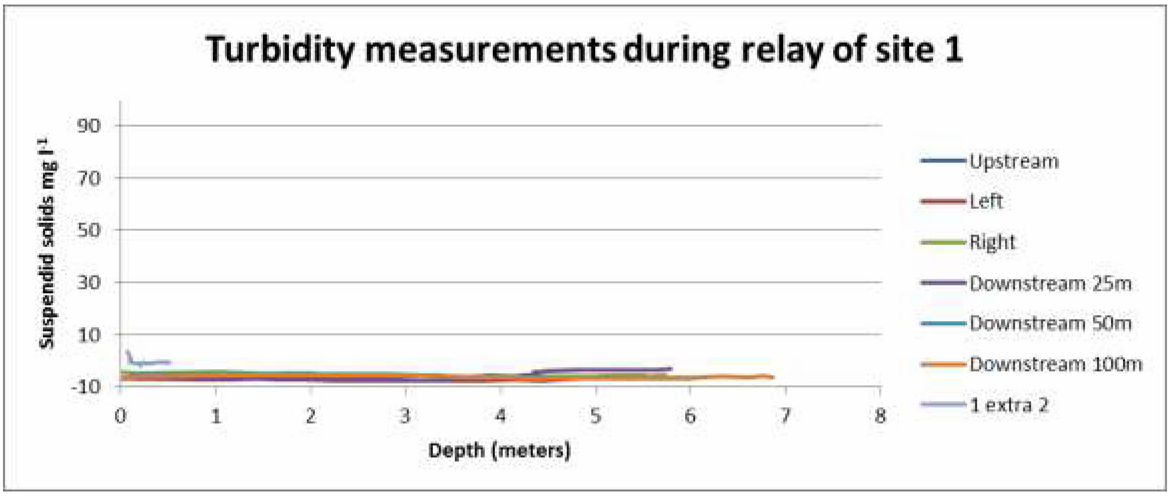


**Figure 7. Trial site 2 Cruciform station during dredge Turbidity measurements**

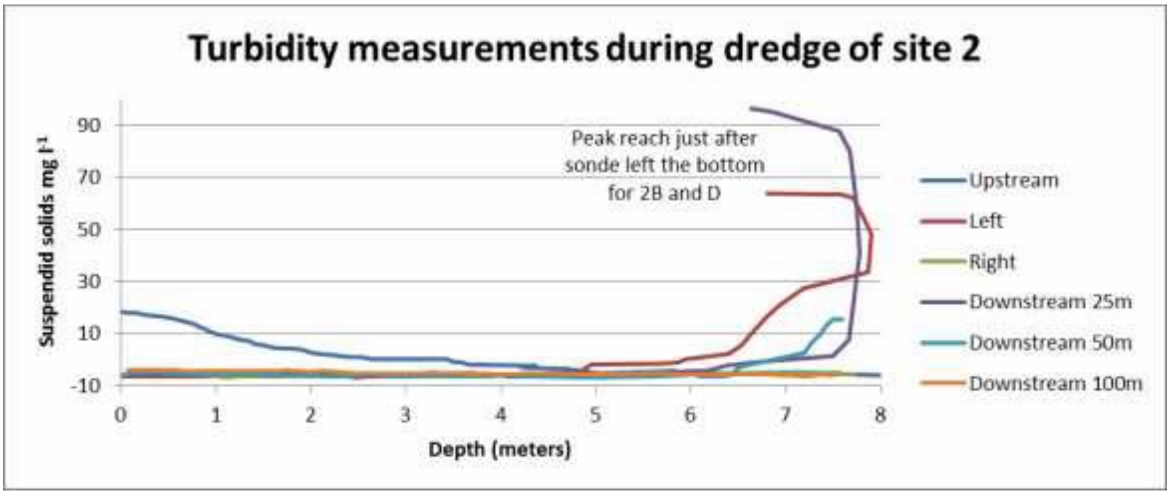



**Figure 8. Trial site 3 Cruciform stations during dredge Turbidity measurements**

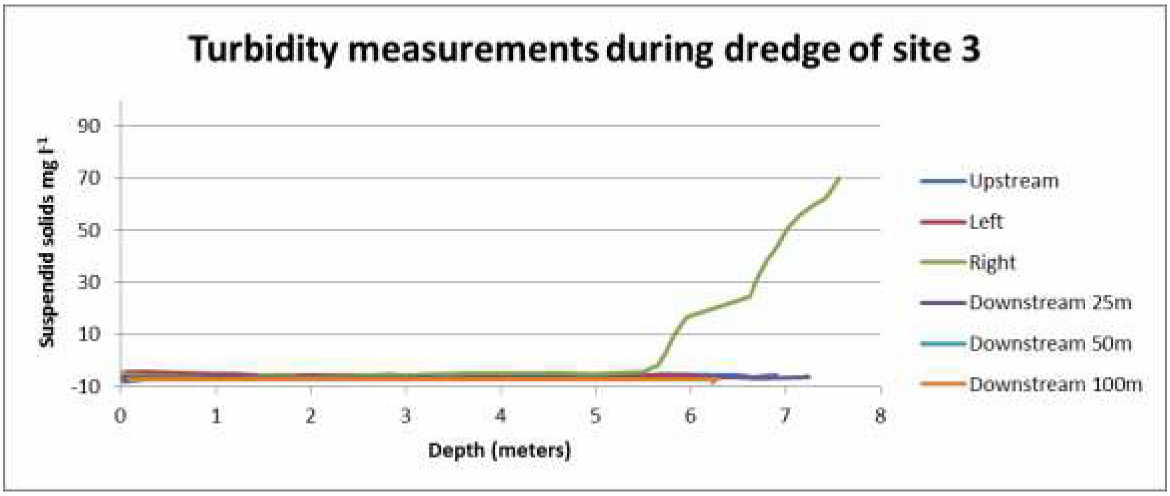



**Figure 9. Trial site 5 Cruciform stations during dredge Turbidity measurements**

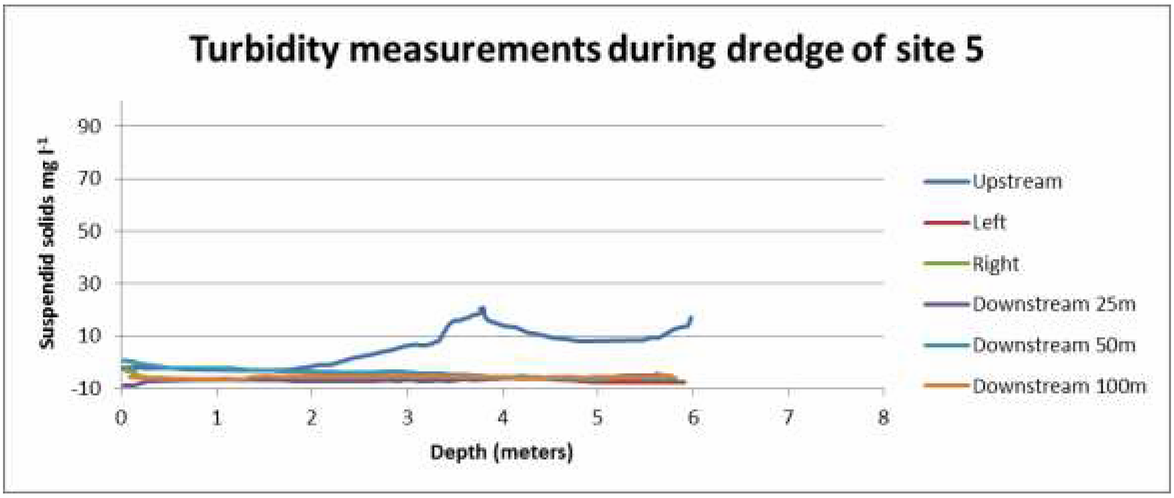
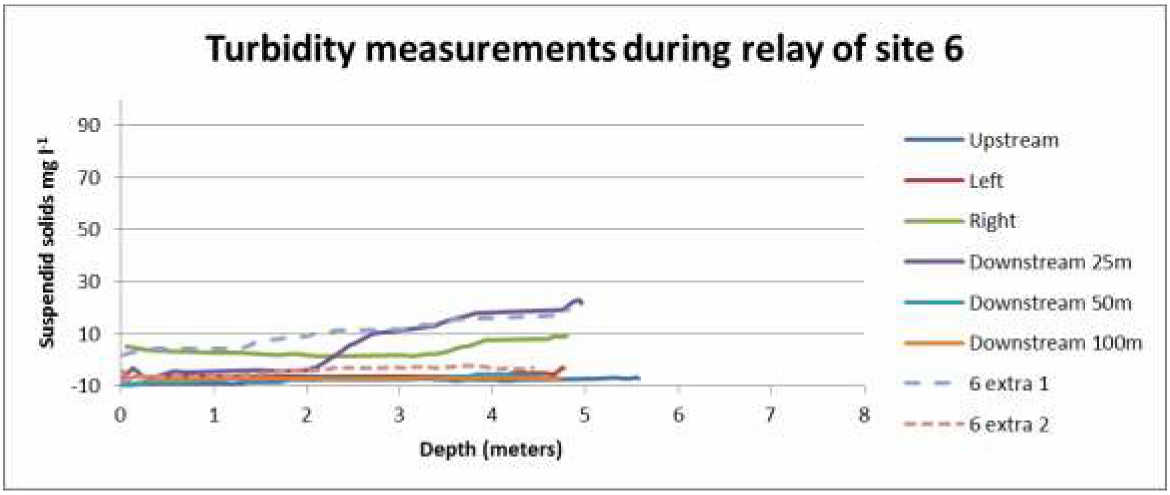


**Figure 10. Trial site 6 Cruciform stations during relay Turbidity measurements**




## 4.6 Wind and wave observations

As required by the protocol, wind and wave observations were recorded at approximately 30 minute intervals throughout the monitoring operation. The field notes taken during the monitoring are included in Appendix 3. These show that during the dredging and relay operations, the wind was consistently blowing from the south west. Wind speed varied from 1.1 to 6.9 (gusting 9.3) m $s^{-1}$ which is Force 1 to 4 on the Beaufort scale. Wave height varied from 0.1 to 0.6 m with little discernible swell.

## 4.7 Particle size analysis

Table 13 presents the particle size analysis data for all the cruciform station water samples taken. The cardinal station water samples have not been included as the very low levels of particulates present were below that required to give a robust size distribution. Similarly, only those samples from the cruciform stations where turbidity was measured are considered to give valid results and these are highlighted in yellow. In these samples it can be seen that the particulates present are mainly silt and clay mostly less than 31 µm in size. This is what might be expected as the fine particulates are more likely to become suspended and hence cause turbidity during the dredging and relay.

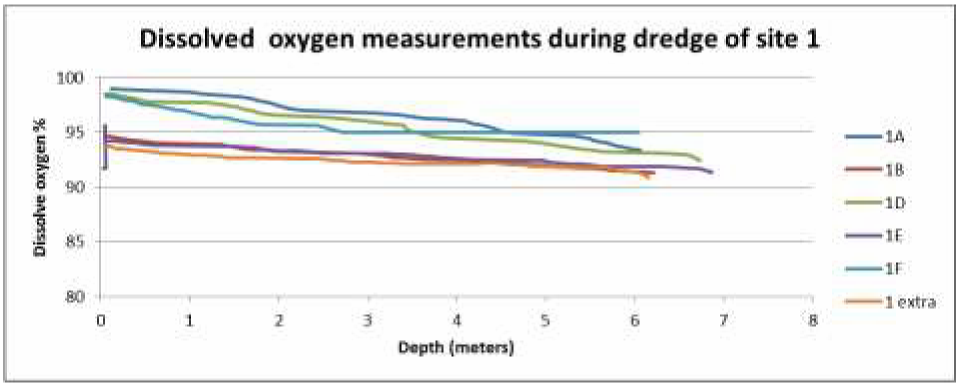
**Table 13. Particle size analysis results for water samples taken at the cruciform stations during dredge and relay operations**

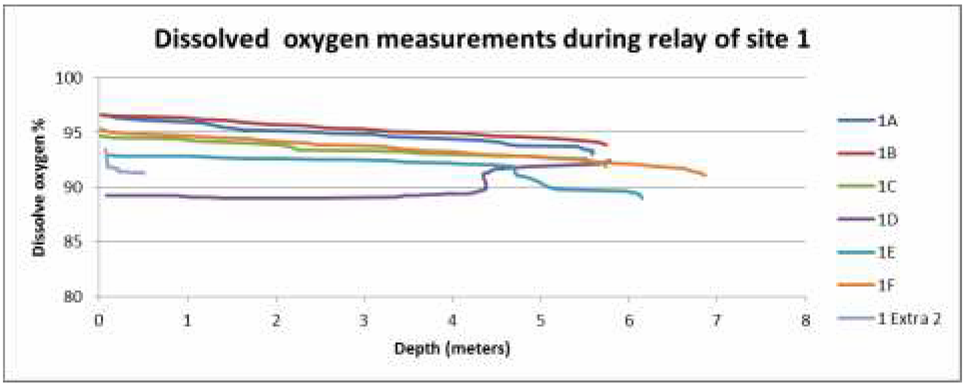
| Station | Pebbles >4 mm | Granules >2 <4 mm | Very coarse sand >1 <2 mm | Coarse sand >0.5 <1 mm | Medium sand >250 <500 µm | fine sand >125 <250 µm | Very fine sand >63 <125 µm | Silt >31 <63 µm | Silt >16 <31 µm | Silt >8 <16 µm | Silt >4 <8 µm | Clay <4 µm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1B | 0.00 | 0.00 | 0.00 | 0.00 | 1.76 | 5.64 | 2.25 | 7.78 | 15.79 | 21.25 | 19.71 | 25.84 |
| 2A | 0.00 | 0.00 | 0.00 | 0.00 | 31.18 | 13.32 | 4.69 | 12.08 | 11.20 | 7.87 | 9.28 | 10.37 |
| 2D | 0.00 | 0.00 | 0.00 | 0.00 | 0.37 | 2.78 | 1.37 | 5.73 | 13.22 | 25.40 | 25.39 | 25.70 |
| 2E | 0.00 | 0.00 | 0.00 | 0.00 | 2.48 | 0.00 | 0.00 | 1.88 | 12.44 | 26.09 | 28.46 | 28.65 |
| 2D relay | 0.00 | 0.00 | 0.00 | 0.00 | 3.44 | 3.73 | 4.83 | 13.94 | 21.71 | 21.12 | 15.61 | 15.62 |
| 3C | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 1.80 | 4.11 | 7.99 | 14.09 | 23.16 | 24.47 | 24.31 |
| 1E | 0.00 | 0.00 | 0.00 | 0.00 | 57.98 | 1.06 | 4.26 | 10.36 | 10.46 | 10.71 | 4.77 | 0.40 |
| 5A | 0.00 | 0.00 | 0.00 | 0.00 | 7.21 | 1.15 | 6.61 | 9.89 | 19.14 | 24.53 | 17.87 | 13.59 |
| 5E | 0.00 | 0.00 | 0.00 | 0.00 | 33.95 | 5.66 | 0.56 | 0.00 | 0.00 | 1.78 | 20.29 | 37.77 |
| 1D relay | 0.00 | 0.00 | 0.00 | 0.00 | 42.62 | 1.83 | 0.00 | 0.00 | 0.00 | 2.00 | 18.06 | 35.49 |
| 1F relay | 0.00 | 0.00 | 0.00 | 0.00 | 1.46 | 4.30 | 2.18 | 5.92 | 16.26 | 24.38 | 21.33 | 24.17 |
| 6B | 0.00 | 0.00 | 0.00 | 0.00 | 10.55 | 1.37 | 5.43 | 6.68 | 14.54 | 19.37 | 20.65 | 21.37 |
| 6D | 0.00 | 0.00 | 0.00 | 0.00 | 44.59 | 18.94 | 8.53 | 10.05 | 7.60 | 5.54 | 4.18 | 0.59 |
| 6 EXTRA 1 relay | 0.00 | 0.00 | 0.00 | 0.00 | 1.60 | 4.83 | 5.19 | 12.12 | 14.95 | 19.97 | 20.38 | 20.96 |
| 6C relay | 0.00 | 0.00 | 0.00 | 0.00 | 32.87 | 2.88 | 5.28 | 9.95 | 10.08 | 13.34 | 13.00 | 12.60 |
| 6D relay | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 9.39 | 26.69 | 15.25 | 15.96 | 15.91 | 16.79 |
| 6 EXTRA 2 relay | 0.00 | 0.00 | 0.00 | 0.00 | 28.00 | 2.19 | 5.12 | 6.59 | 11.79 | 13.63 | 15.65 | 17.06 |

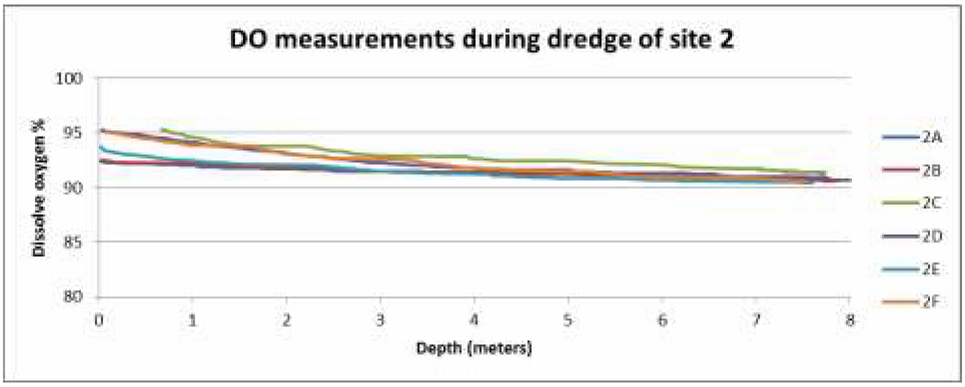
## 4.8 Calibration of YSI sonde used for water quality measurements

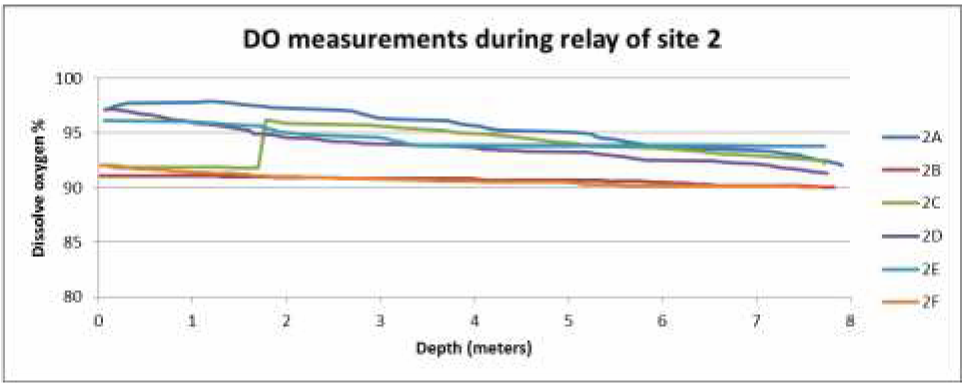
The YSI was calibrated before, during and after the monitoring survey in line with the manufactures instructions. The calibration conducted before and after is included in Appendix 4.

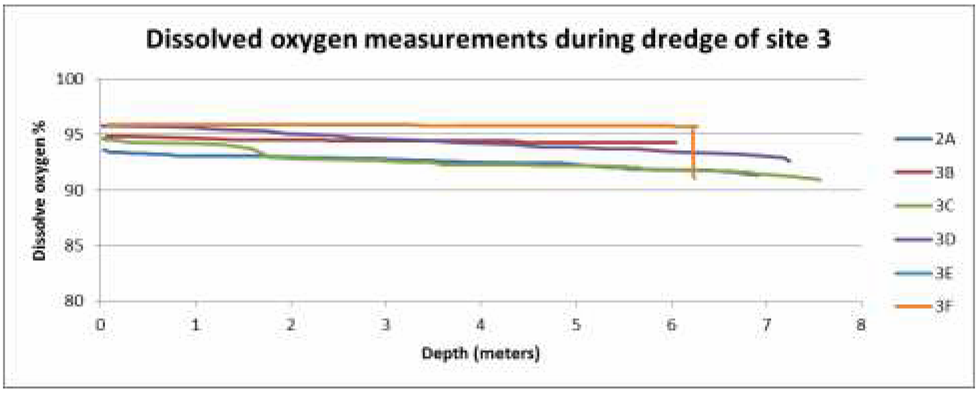
APPENDIX 1 DISSOLVED OXYGEN PROFILES FOR EACH SITE DURING DREDGE AND RELAY

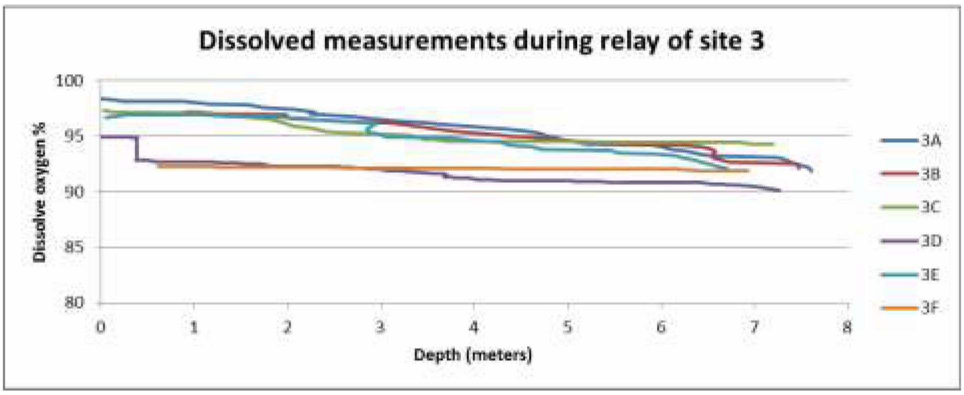


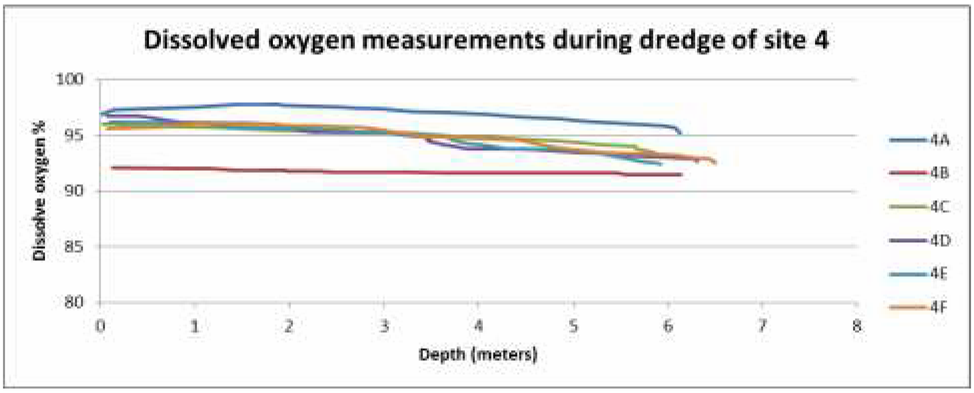



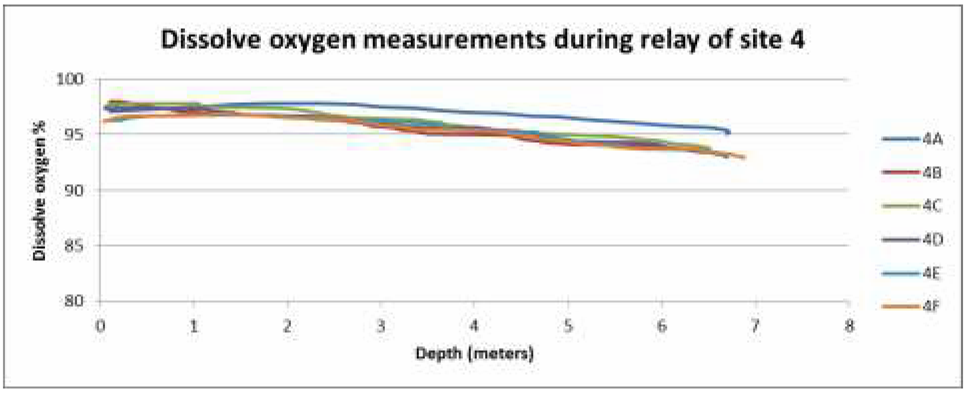



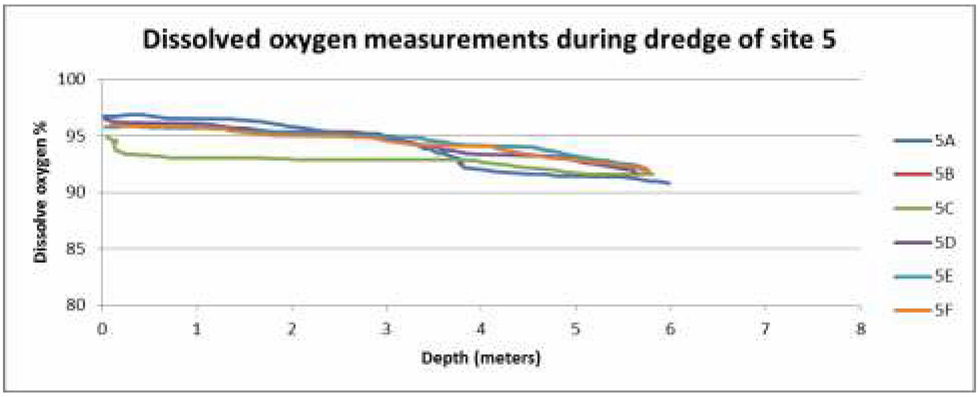



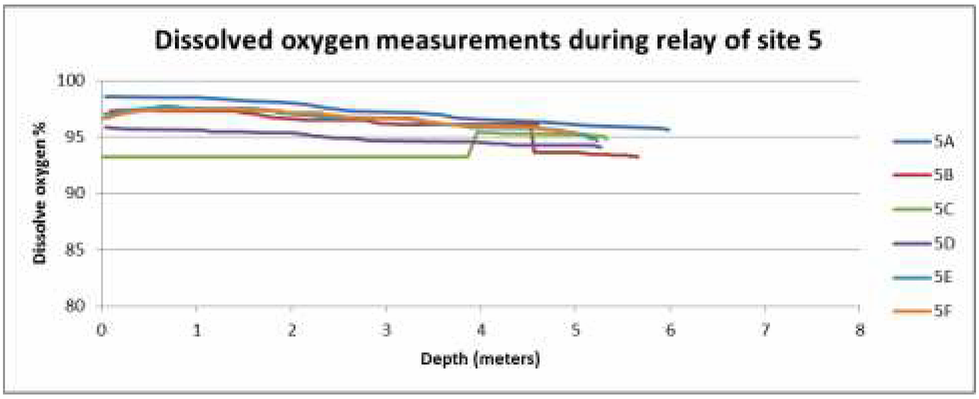

Dissolved oxygen measurements during dredge of site 3
Dissolve oxygen %
Depth (meters)
100
95
90
85
80
0
1
2
3
4
5
6
7
8
2A
3B
3C
3D
3E
3F

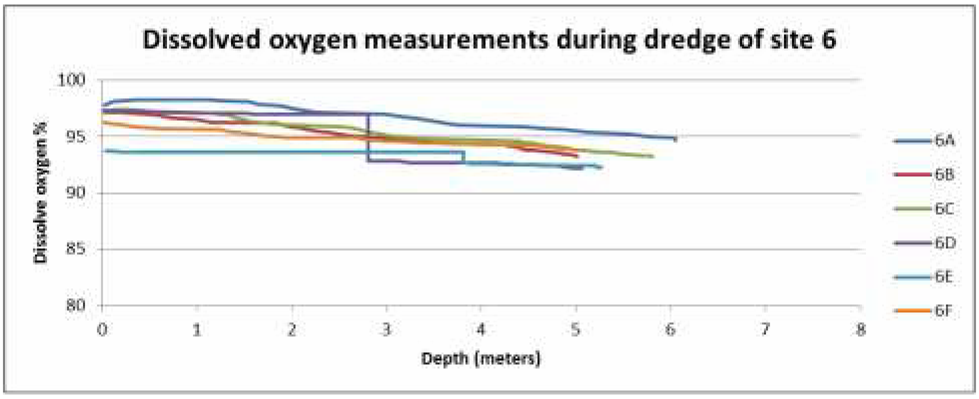

Dissolved measurements during relay of site 3
Dissolve oxygen %
Depth (meters)
100
95
90
85
80
0
1
2
3
4
5
6
7
8
3A
3B
3C
3D
3E
3F

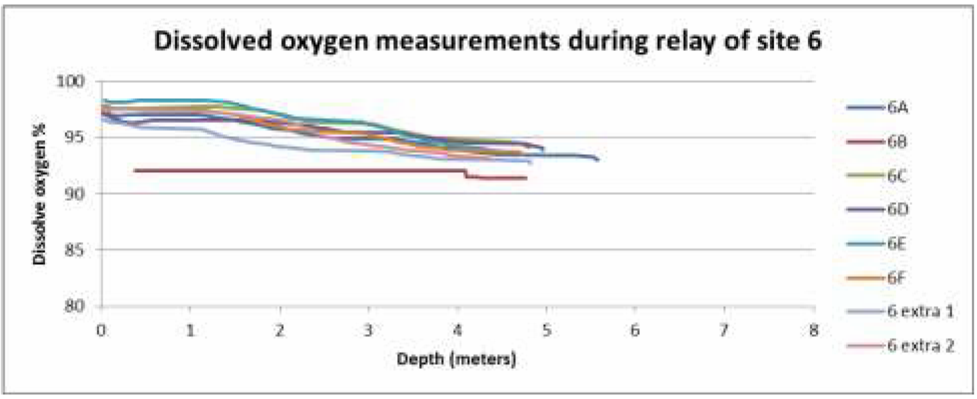

Dissolved oxygen measurements during dredge of site 4
Dissolve oxygen %
Depth (meters)
100
95
90
85
80
0
1
2
3
4
5
6
7
8
4A
4B
4C
4D
4E
4F


Dissolve oxygen measurements during relay of site 4
Dissolve oxygen %
Depth (meters)
100
95
90
85
80
0
1
2
3
4
5
6
7
8
4A
4B
4C
4D
4E
4F

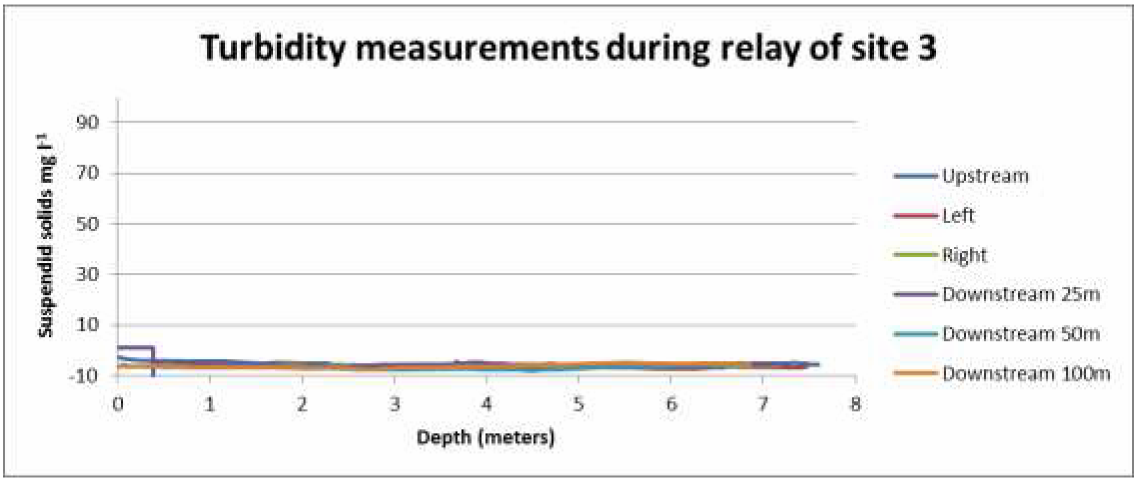

Dissolved oxygen measurements during dredge of site 5
Dissolve oxygen %
100
95
90
85
80
0
1
2
3
4
5
6
7
8
Depth (meters)
5A
5B
5C
5D
5E
5F

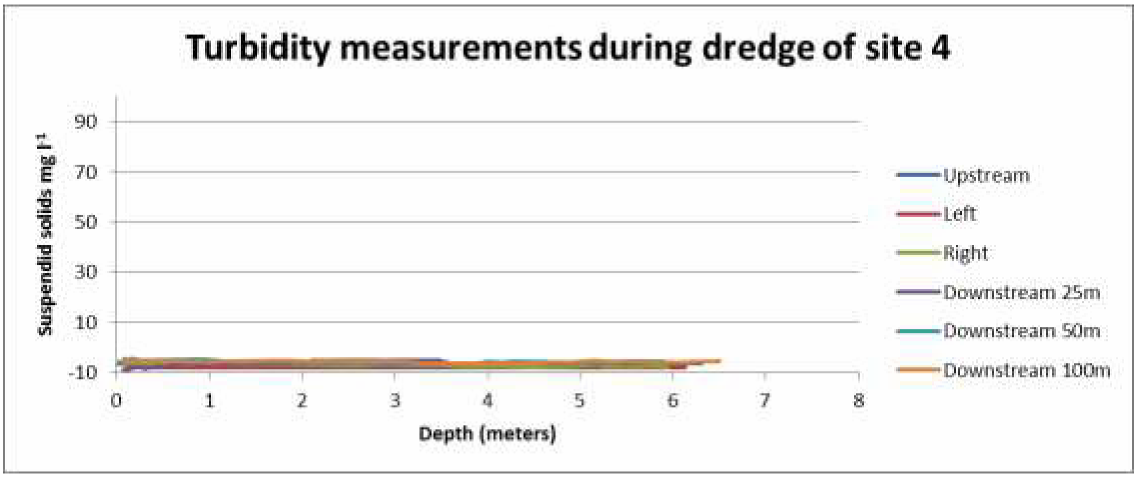

Dissolved oxygen measurements during relay of site 5
Dissolve oxygen %
100
95
90
85
80
0
1
2
3
4
5
6
7
8
Depth (meters)
5A
5B
5C
5D
5E
5F

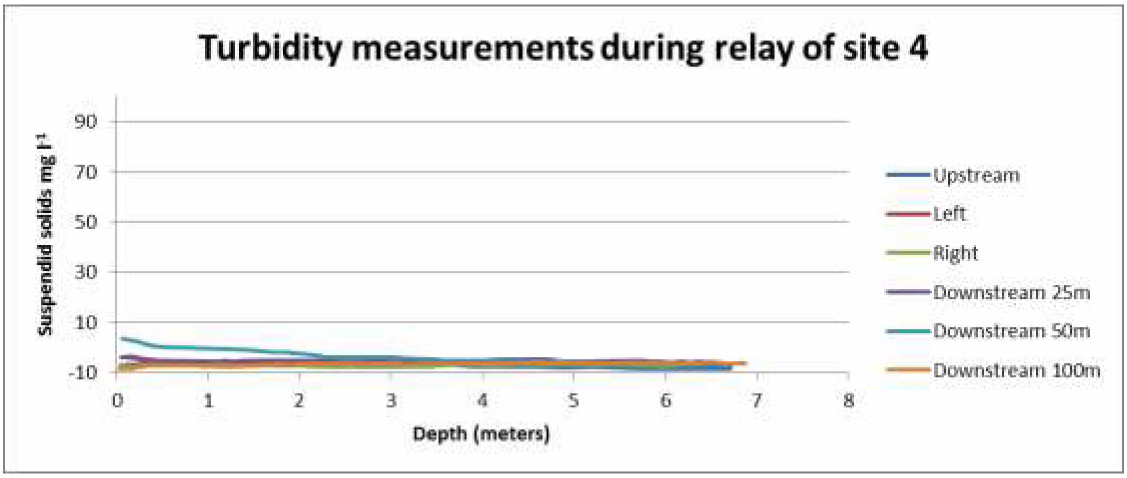

Dissolved oxygen measurements during dredge of site 6
Dissolve oxygen %
100
95
90
85
80
0
1
2
3
4
5
6
7
8
Depth (meters)
6A
6B
6C
6D
6E
6F


Dissolved oxygen measurements during relay of site 6
Dissolve oxygen %
100
95
90
85
80
0
1
2
3
4
5
6
7
8
Depth (meters)
6A
6B
6C
6D
6E
6F
6 extra 1
6 extra 2

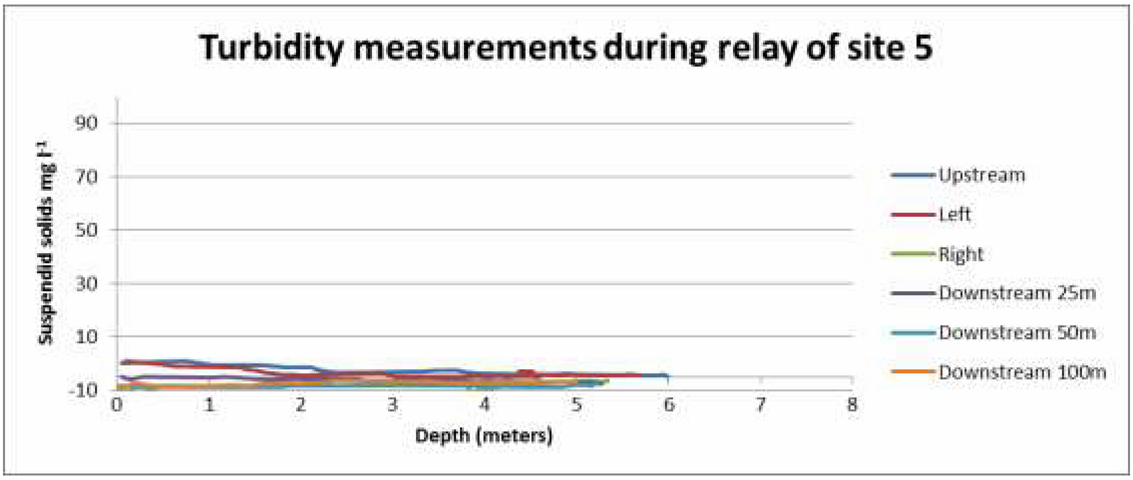
APPENDIX 2 TURBIDITY MEASUREMENTS FOR SITE DURING DREDGE AND RELAY WHERE NO INCREASED TURBIDITY WAS OBSERVED

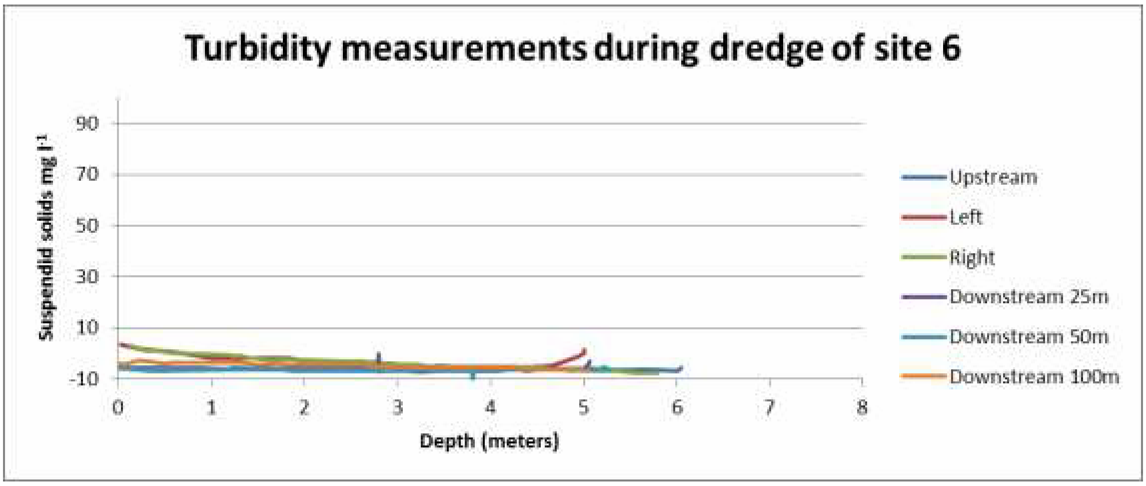


# Appendix 2 (continued) Turbidity measurements for site during dredge and relay where no turbidity was observed increased



APPENDIX 3 WIND AND WAVE OBSERVATIONS DURING MONITORING

Falmouth Water and Turbidity Monitoring Project No. 12-227

ECOSPAN

| | Time (~~GMT~~) BST | Wind Speed (m/s) | Wind Direction (Deg) | Wave Height (m) | Wave Period (Sec) | Wave Direction | Swell Direction | |
|---|---|---|---|---|---|---|---|---|
| 24.09.12 | 16:22 | 5.9 | 269 | 0.25 | 2/sec | W | (N/A | |
| | 16:54 | 3.9 | 235 | 0.1 | N/A | W | N/A | |
| | 18:25 | 5.4 | 275 | 0.25 | 2/sec | W | N/A | |
| | 18:56 | 4.3 | 290 | 0.1 | N/A | W | N/A | |
| | 19:24 | 4.2 | 265 | 0.1 | N/A | N/A | N/A | |
| | 19:55 | 3.3 | 225 | 0.1 | " | " | " | Ripple |
| | 20:25 | 4.1 | 265 | 0.1 | " | " | " | |
| | 20:56 | 2.8 | 290 | 0.1 | " | " | " | |
| | 21:23 | 4.8 | 280 | 0.1 | " | " | " | |
| | 21:55 | 4.1 | 320 | 0.1 | " | " | " | |
| | 22:20 | 3.7 | 295 | 0.1 | " | " | " | |
| | 22:48 | 3.8 | 280 | 0.1 | " | " | " | |
| | 23:20 | 3.1 | 250 | " | " | " | " | |
| | 23:50 | 4.0 | 235 | " | " | " | " | |
| | 00:29 | 3.2 | 240 | " | " | " | " | |
| | 00:59 | 3.9 | 230 | " | " | " | " | |
| 25.09.12 | 09:00 | 2.4 | 210 | 0.25 | N/A | N/A | N/A | Ripple |
| | 09:36 | 1.7 | 240 | 0.2 | " | " | " | |
| | 10:08 | 3.9 | 235 | 0.1 | " | " | " | |
| | 10:43 | 4.6 | 245 | 0.2 | " | " | " | |
| | 11:30 | 4.2 | 266 | 0.2 | " | " | " | |
| | 11:42 | 6.5 | 255 | 0.25 | 2/Sec | W | W | |
| | 12:13 | 4.1 | 280 | 0.15 | N/A | N/A | N/A | |
| | 13:08 | 3.2 | 280 | 0.3 | 2/sec | SW | SW | |
| | 13:38 | 6.9 | 270 | 0.45 | 2/sec | W/SW | W/SW | |
| | 14:13 | 5.2 | 250 | 0.2 | Irregular | Irregular | Irregular | |
| | 14:32 | 6.2 (Gusts 9.3) | 280 | 0.25 | " | NW | N/A | |
| | 15:03 | 4.3 | 240 | 0.30 | " | W | N/A | |
| | 15:34 | 5.7 | 245 | 0.30 | " | W | N/A | |
| | 16:04 | 4.4 | 220 | 0.20 | 3/Sec | W | N/A | |
| | 16:32 | 4.5 | 270 | 0.25 | 3 | WSW | N/A | |
| | 16:58 | 3.6 | 260 | 0.15 | Irregular | SW | N/A | |
| | 17:20 | 5.5 | 270 | 0.15 | " | W | N/A | |
| | 17:49 | 1.0 | 225 | 0.10 | " | irregular | N/A | |
| 26.09.12 | 18:10 | 3.6 | 220 | " | " | " | " | |
| | 01:33 | 5.2 | 240 | | | | | |

## APPENDIX 3 (CONTINUED) WIND AND WAVE OBSERVATIONS DURING MONITORING

Falmouth Water and Turbidity Monitoring Project No. 12-227

ECOSPAN

26/09/12

| Time ~~(GMT)~~ BST | Wind Speed (m/s) | Wind Direction (Deg) | Wave Height (m) | Wave Period (Sec) | Wave Direction | Swell Direction |
|---|---|---|---|---|---|---|
| 02:07 | 5.4 | 240 | 0.3 | Irregular | W | N/A |
| 02:32 | 4.6 | 240 | 0.3 | " | " | " |
| 03:08 | 2.4 | 210 | 0.25 | " | N/A | N/A |
| 03:39 | 3.3 | 40 | 0.25 | " | Irregular | N/A |
| 04:11 | 1.1 | 120 | 0.1 | " | N/A | N/A |
| 04:40 | 1.[illegible] | 240 | 0.1 | " | N/A | N/A |
| 05:19 | 3.0 | 285 | 0.1 | " | N/A | N/A |
| 05:50 | 4.4 | 330 | 0.2 | " | N/A | N/A |
| 06:21 | 3.9 | 280 | 0.2 | " | N/A | N/A |
| 06:55 | 3.6 | 310 | 0.1 | " | N/A | N/A |
| 07:35 | 2.5 | 280 | 0.5 (0.[illegible]) | 3 secs | N | N |
| 08:10 | 2.9 | 330 | 0.5 (0.1) | 3 secs | 120 | N |
| 08:45 | 2.7 | 270 | 0.5 (0.3) | 3 secs | 40 | N |
| 09:15 | 5.8 | 260 | 0.75 (0.7) | 3 secs | E | N |
| | | | | | | |
| 18:11 | 6.9 | 310 | 0.5 | irregular | N/A | N/A |
| 18:41 | 4.8 | 340 | 0.5 | " | " | " |
| 19:11 | 2.9 | 350 | 0.3 | " | " | " |
| 19:42 | 3.2 | 340 | 0.3 | " | " | " |
| 20:12 | 4.7 | 315 | 0.2 | " | " | " |
| 20:43 | 4.1 | 340 | 0.5 | " | " | " |
| 21:14 | 3.2 | 320 | 0.6 | " | " | " |
| 21:48 | 4.1 | 300 | 0.3 | " | " | " |
| 22:18 | 4.1 | 340 | 0.3 | " | " | " |
| ~~18~~ 22:49 | 4.6 | 330 | 0.4 | 0.5 | SW | " |
| 23:25 | 5.8 | 350 | 0.3 | irregular | " | " |

## APPENDIX 3 (CONTINUED) WIND AND WAVE OBSERVATIONS DURING MONITORING

Falmouth Water and Turbidity Monitoring Project No. 12-227

ECOSPAN

27/09/2012 Left shore 10·05 BST

| Time (GMT) | Wind Speed (m/s) | Wind Direction (Deg) | Wave Height (m) | Wave Period (Sec) | Wave Direction | Swell Direction |
|---|---|---|---|---|---|---|
| 09:23 | 3·3 | 310 | 0·2 | 1sec | N/A | N/A |
| 09:53 | 1·3 | 280 | 0·2 | " | N/A | N/A |
| 10:24 | 3·8 | 320 | 0·2 | " | N/A | N/A |
| 10:54 | 3·6 | 320 | 0·3 | " | N/A | N/A |

APPENDIX 4: YSI CALIBRATION PRE AND POST MONITORING

## YSI SONDE CALIBRATION CERTIFICATE

**SONDE S/N: 121274 – 6920V2 – 04H14124AA**
Date: 13/09/2012
Customer: Ecospan Environmental Limited.
Contact : Matt Hutchings

### CALIBRATION STANDARDS

Calibrated by Ecospan for SW 50,000 µS/cm

| | | | | | | |
|---|---|---|---|---|---|---|
| CONDUCTIVITY | 10000µS/CM | N/A | 1413µS/CM | N/A | 12880µS/CM | 12880 |
| DISSOLVED OXYGEN | 100% | 100 | mmHg | 760 | +vePolarisation | + |
| pH | 4.00 | 4.00 | 7.00 | 7.00 | 10.00 | 10.00 |
| pH mV | 4.00 | -16.5 | 7.00 | 155.7 | 10.00 | -193.8 |
| SLOPE CHECK | +162 TO +180→ | 172.2 | ↔ | 177.3 | ←162 TO 180 | Pass |
| ORP mV CHECK | Temp | N/A | mV | N/A | Within YSI spec | N/A |
| DEPTH | 0.0M | 0.00 | Press Offset | -14.681 | Within YSI spec | Y |
| TURBIDITY | 0.0 NTU | 0.0 | 100 NTU | - | 126 NTU | 126.0 |
| TURBIDITY OFFSET | Offset | 7.483767 | - | - | Within YSI spec | Y |
| CHLOROPHYLL | RFU Zero | N/A | OFFSET | N/A | Within YSI spec | N/A |
| BGA-PC/PA | ZERO | N/A | OFFSET | N/A | Within YSI spec | N/A |

### CALIBRATION CONSTANTS - DIAGNOSTICS

| | | | |
|---|---|---|---|
| CONDUCTIVITY | (0.92 TO 1.08) | 0.998095 | Pass |
| DO GAIN | (0.7 TO 1.7) | 1.027066 | Pass |
| DO CHARGE | (25 TO 75) | N/A | N/A |

ALL SENSORS ARE CALIBRATED TO YSI ACCURACY SPECIFICATIONS.

**Calibration Technician: Ben Johnson** **Date: 13/09/2012.**

YSI calibration at end

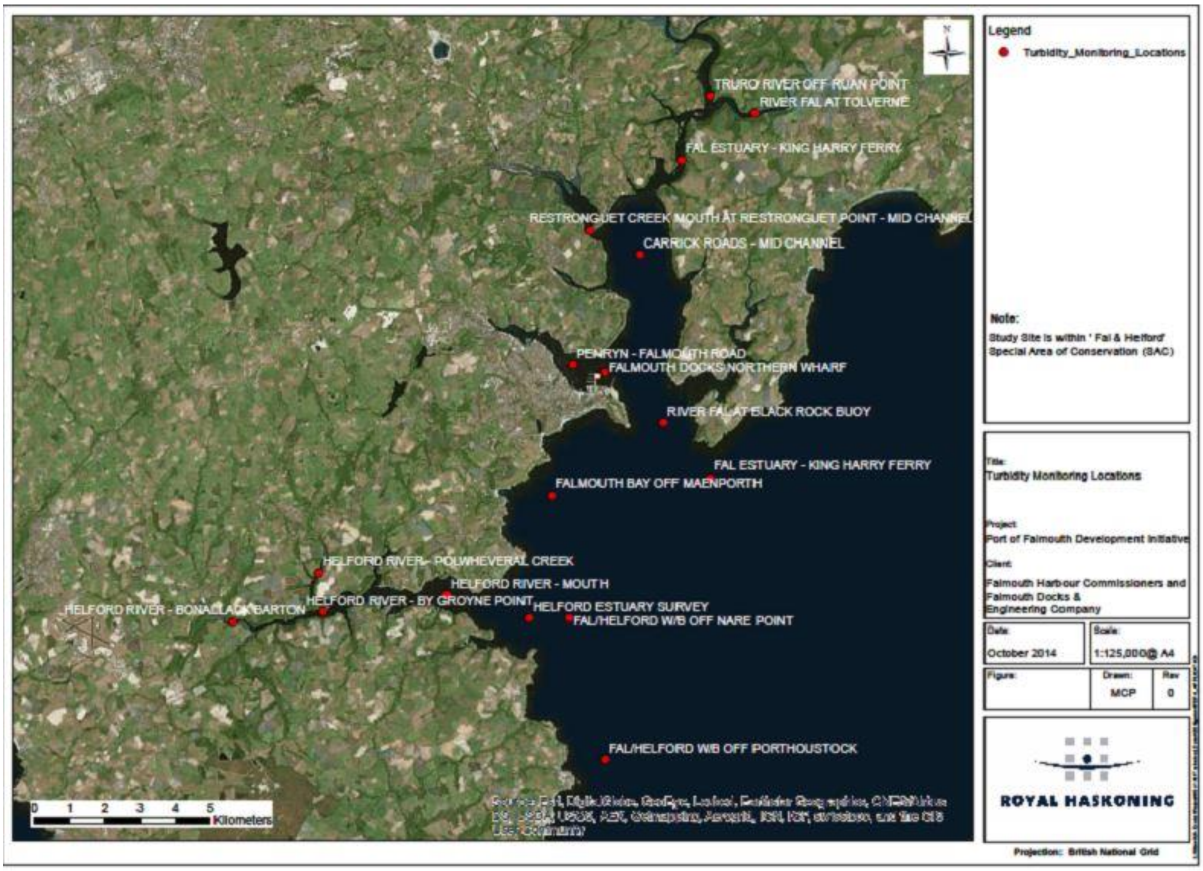
100 NTU standard reading: 107.1
DO measurement 100% reading: 99.7
Temperature against calibrate thermometer: 15.6 °C
YSI meter reading: 15.45°C
conductivity 50000 µs cm reading: 49569

MJH 27/09/2012

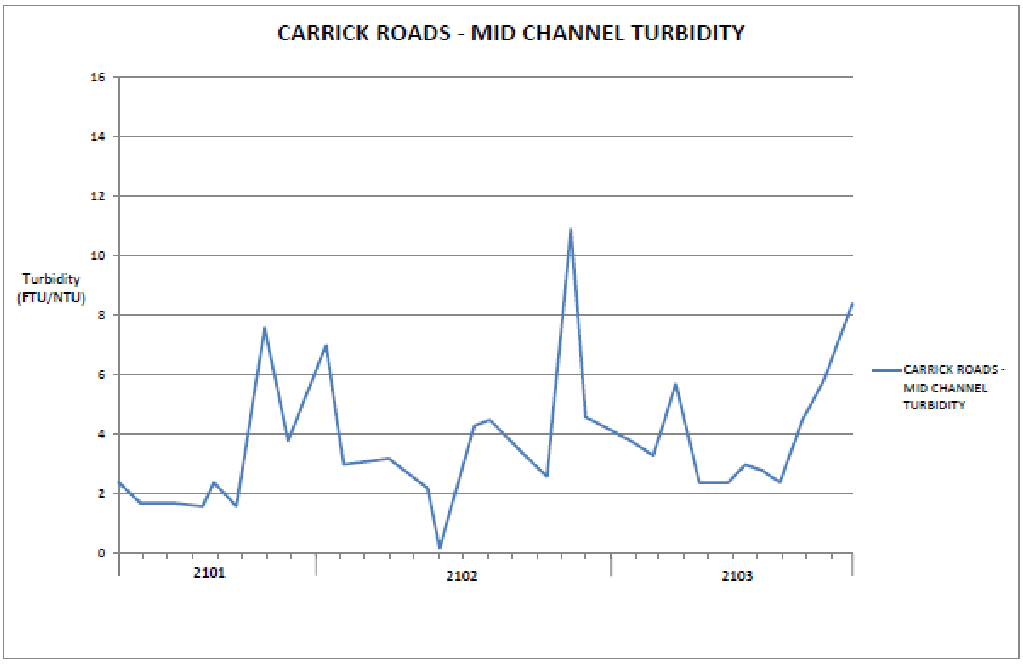
## Appendix B

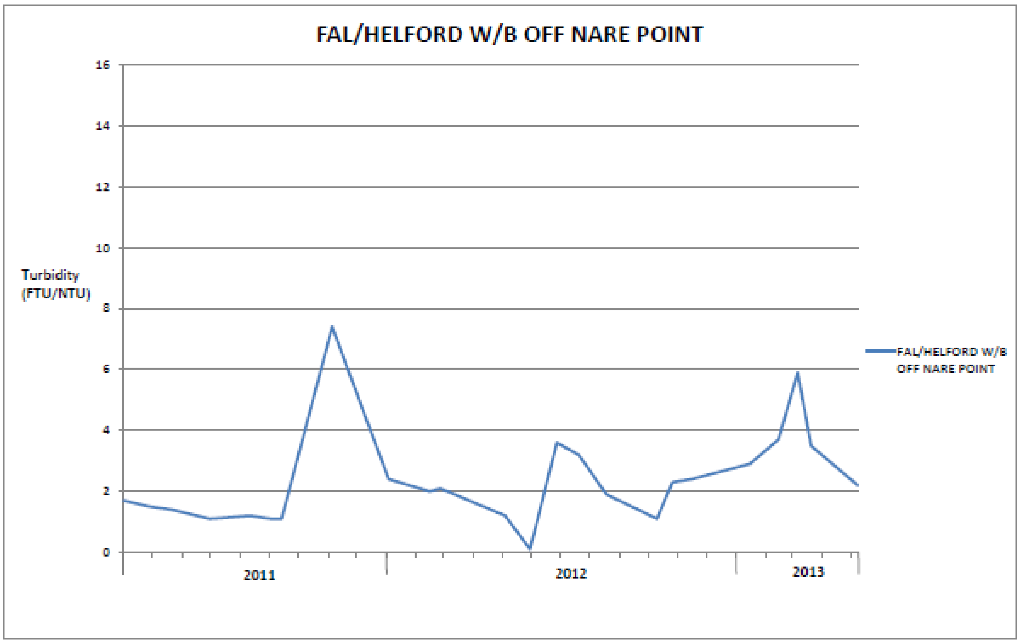
## Water quality figures derived from the Environment Agency data

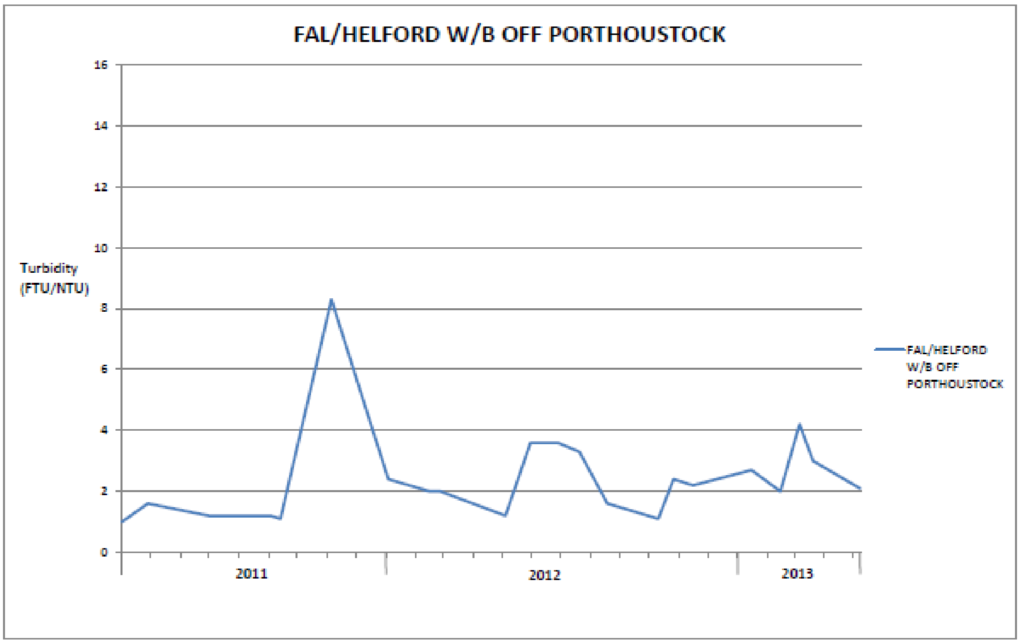
Site Locations

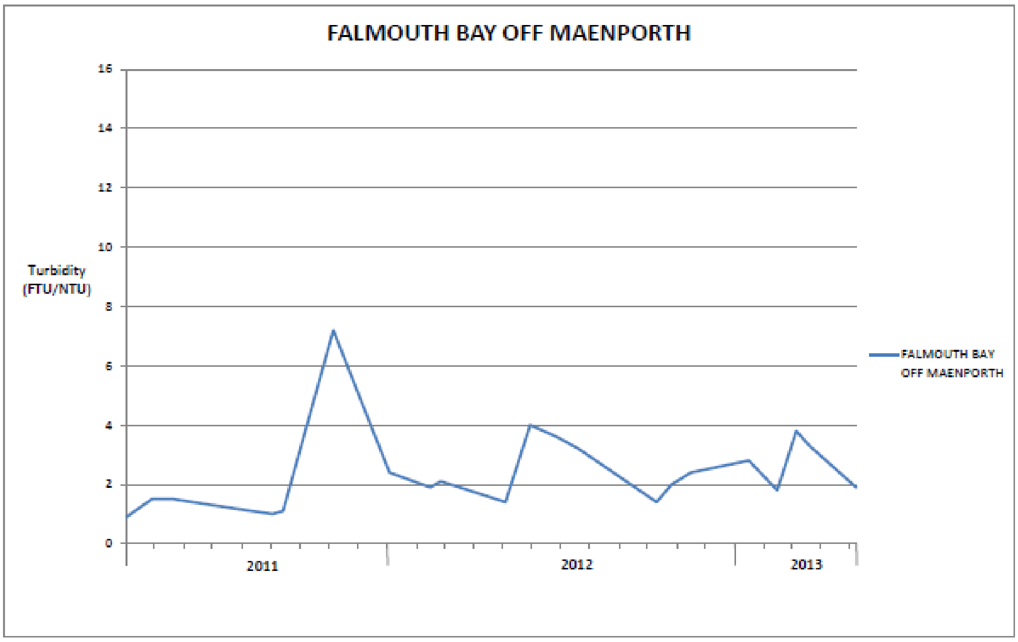


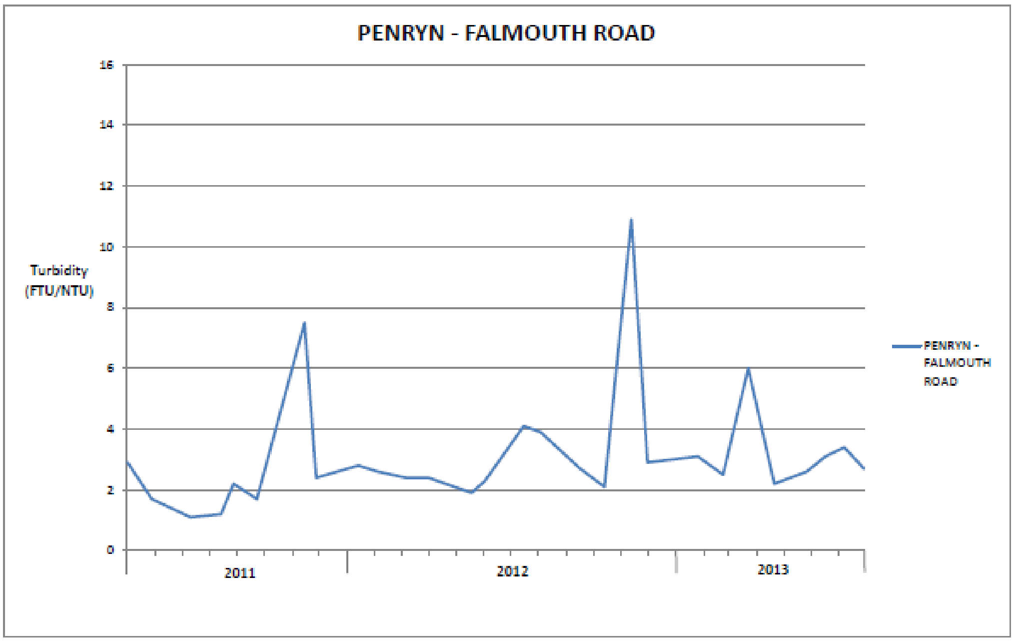
The following tables show the turbidity data for the sites where data exists:



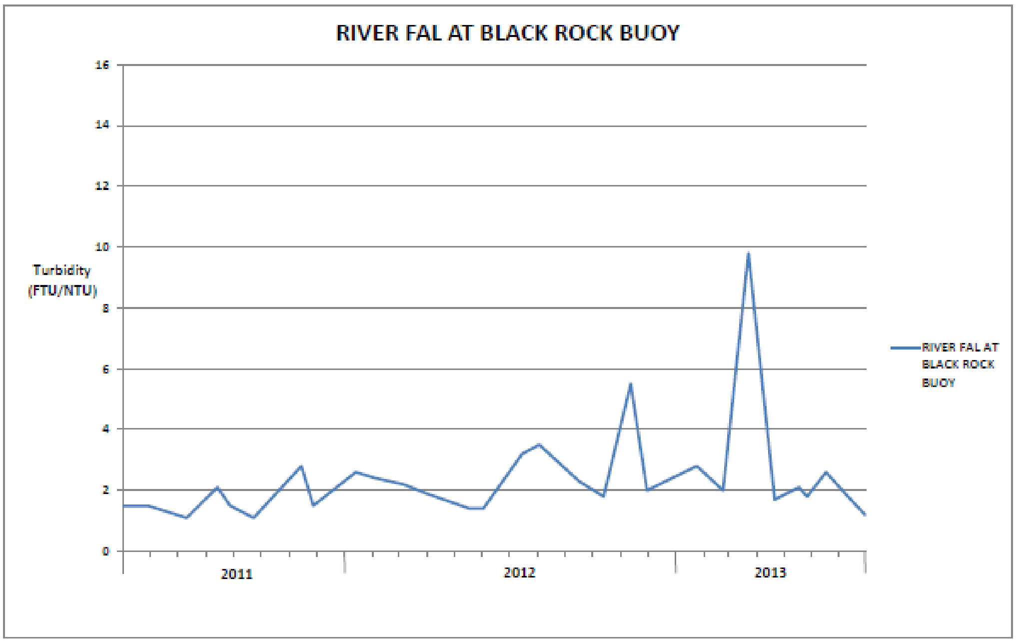

FAL/HELFORD W/B OFF NARE POINT
16
14
12
10
8
6
4
2
0
Turbidity (FTU/NTU)
FAL/HELFORD W/B OFF NARE POINT
2011
2012
2013

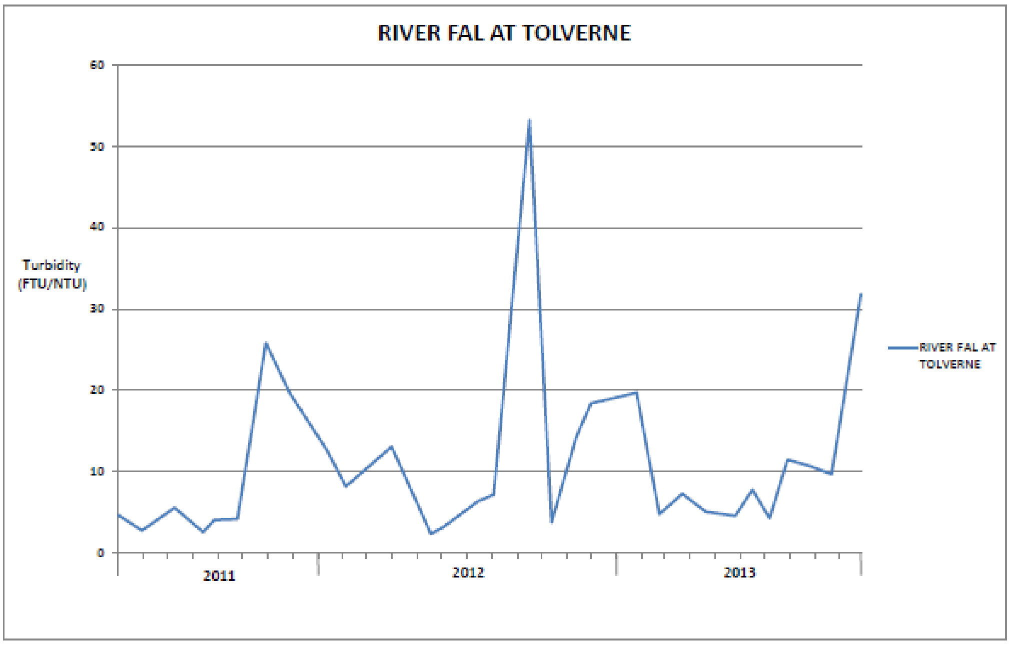

FAL/HELFORD W/B OFF PORTHOUSTOCK
16
14
12
10
8
6
4
2
0
Turbidity (FTU/NTU)
FAL/HELFORD W/B OFF PORTHOUSTOCK
2011
2012
2013


FALMOUTH BAY OFF MAENPORTH
Turbidity (FTU/NTU)
0
2
4
6
8
10
12
14
16
2011
2012
2013
FALMOUTH BAY OFF MAENPORTH


PENRYN - FALMOUTH ROAD
Turbidity (FTU/NTU)
0
2
4
6
8
10
12
14
16
2011
2012
2013
PENRYN - FALMOUTH ROAD

Royal HaskoningDHV
Enhancing Society Together



## Appendix F – Dr Nick Kamenos Technical Review of Turbidity Technical Note

University of Glasgow

**17/03/2015**

## Review of technical notes by Dr N Kamenos.

### Technical note 1: Live maerl

The note gives background information on the (ecological) importance of live / dead maerl and any projected impacts of dredging on the maerl. The technical note meets its aims and explains the possible consequences of dredging / operational activity on both live maerl nodules within a preliminarily dead bed, but also on adjacent “feeder” live beds. The latter describes the process of live nodules appearing in the dead bed. I agree with the findings of the note and I have noted within the document itself where changes / additions could be made. In addition, some more general clarifications as indicated below could be made:

1. I think there needs to be some more clarity at the start of the note about the roles of live vs dead maerl both in ecosystem service provision as well as biogeochemically (e.g. Blue carbon report by SNH). At present most of that information is there, but is sometimes spread out between a few sections.
2. In relation to (1), mention should be made of the temporal context of those roles in relation to the temporal context of the dredging (e.g. annual vs decadal impacts). For example, at decadal timescales dead maerl is less likely to persist than live maerl as it is not regenerating, but if the dredged area will continue to be fed by live nodules from and undisturbed bed, does this matter?
3. In the “Sedimentation effects on live maerl” section clarify the importance of sediment removal post deposition on live maerl. I.E. maerl beds generally occur in areas of high current / moderate wave activity as this keeps the maerl free of any sediment. Thus any sediment that settles on live maerl and has no capacity to be swept off will likely be detrimental. For the adjacent live maerl beds, as long as no major sedimentation will occur, and any minor sedimentation that does, is swept off by currents there should be no lasting effect.
4. Spring vs neap tides. From Figures 4/5 there is a large diff in potential sedimentation between spring and neap tides. It would appear that there is much less scope for sedimentation onto adjacent live maerl beds if dredging is conducted at spring tides. This should be confirmed with the modellers and clarified in the end of note summary

**Technical note 2: Turbidity data analysis:**

This note considers the role of changing turbidity / depth on the ability of maerl to continue photosynthesising. I agree with the findings of the report that long term changes in depth will not prevent the maerl photosynthesising, so any live maerl in the bottom of the deepend channel will continue to photosynthesise. I make some comments in the document itself, but in particular think the interpretation of figure 2 should be revisited. There is a distance effect away from the dredging area when considering the turbidity profile. Near the dredging site, the turbidity profiles are not the same as the control site; there is more turbidity at depth. At large distances from the dredging area turbidity profiles are similar to the control. It is likely that those differences are short lived and relate only to the dredging process.

Sincerely,

Dr Nick Kamenos

School of Geographical & Earth Sciences

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Head of School: Professor Maggie Cusack

# Appendix G – Ecospan Trial Report

# MONITORING OF WATER QUALITY DURING MAERL TRANSLOCATION TRIALS IN FALMOUTH

Report Number: ER12-227

**Performing Company:**

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52 Oreston Road
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Devon
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Tel: 01752 402238
Email: info@ecospan.co.uk
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**Sponsor:** GPS Marine Contractors Ltd

Ecospan Project No: 12-227

Ecospan Environmental Ltd. is registered in England No. 5831900

NMBAQC

mCERTS

ISO 9001

Author(s): M J Hutchings

Approved By: M D R Field

Date of Approval: Draft

**Circulation**

| | |
|---|---|
| 1. Glenn Haylor | GPS Marine Contractors Ltd |
| 2. Christa Page | Royal Haskoning |
| 3. Matt Hutchings | Ecospan Environmental Ltd |

# Contents

# 1 BACKGROUND

As part of a proposal to develop the Port of Falmouth, dredging works need to be carried out which will require the removal of some areas of dead and living maerl. Since maerl beds are highly protected, the original application was refused. To mitigate for the potential damage to the maerl beds, it is proposed that the maerl is translocated from the dredge areas. To determine how effective this may be, a trial translocation project has been instigated. In order to determine the effect of such operations on the water column (particularly turbidity and dissolved oxygen), Falmouth Harbour Commissioners have stipulated that water quality monitoring must be undertaken during the trial period.

This report details the water quality monitoring undertaken at each of six trial sites dredged and relayed between the 24th and 27th of September 2012. The trial removed two areas of 5m by 5m and up to 30cm in depth at each site. This was undertaken by a barge mounted backhoe dredger fitted with a $2m^3$ toothless grading bucket. Following a 12 hour period of storage above the surface, the material was then re-laid in the same 5m by 5m area again to a depth of 30cm.

# 2 METHODS

During each translocation trial, water quality profiling and water sampling were undertaken from one of Falmouth Harbour commissioner's vessels. Ecospan Environmental provided a Trimble DSM132 survey quality positioning system typically accurate to within 1 metre. This was used along with positioning software to establish target positions around the dredge location and to accurately record the positions of the profiling points.

## 2.1 Water profiling

Once on station, a YSI 6-Series multi-parameter single optic sonde, with fitted PH, Con-temp, depth, DO and turbidity sensors were used to record the required parameters. This meter logged the data parameters required and also had the resolution required by the revised tender document. The sonde was lowered slowly from the water surface to the sea bed and then back up again whilst all parameters were logged and visually monitored where possible. The sonde was connected to a NIO water sampler which was used to take discrete samples when required. The sonde was calibrated before use and at the end of the survey period in line with the manufacturer's recommendations.

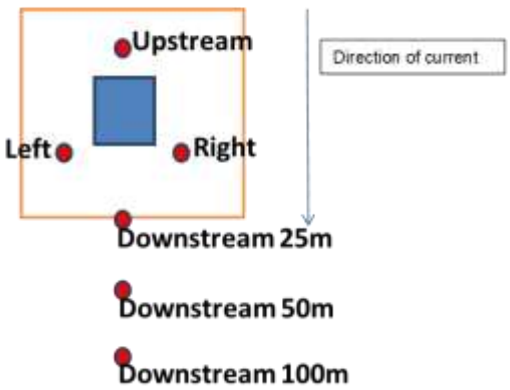
### 2.1.1 Cardinal stations

It was requested that through water column profiles of: turbidity; dissolved oxygen; salinity; and temperature were collected at 4 positions 300 meters from each dredge site to determine baseline levels. These cardinal stations were located to the North, East, South and West. Profiles were taken before any dredging operations were completed. For trial sites 1, 2 and 3 these points were reassessed on completion of the dredge at each site. After discussions with Falmouth Harbour commissioners representatives, Ecospan Environmental were asked to only monitor the cardinal sites pre dredge as per the original protocol.

### 2.1.2 Cruciform stations

Water column profiles of: turbidity; dissolved oxygen; salinity; and temperature were also assessed during dredging and relay at a series of stations positioned in a cruciform arrangement (see Fig 1.) around each dredge site. The position of the cruciform was determined based on tidal flow data from the buoy provided by Falmouth Harbour Commissioners. The primary axis of the cruciform was aligned with the tidal flow at each site. The exact positions for the profiles were dictated by both the position of the dredging barge (which due to its size was often over the theoretical sampling point) and conditions for boat handling. The weather conditions and need for night working also influenced the crew's ability to get to theoretical stations.

**Fig.1. Position of monitoring stations around the trial sites**




Where possible the distances from the dredging/relaying operations were 25 m, 50 m, 100 m in the direction of the flow with the remaining stations being within 25 m of the dredge area. Where a plume was visible additional profiles were taken and the positions of where these were recorded.

## 2.2 Water sampling and analysis

Water samples were collected during the monitoring period around the translocation operations as well as at the background stations. The samples were taken at discrete depths identified during the water profiling using NIO bottles. These bottles enabled a discrete sample to be taken, as they are triggered using a line which fires the spring mechanism completely sealing the bottle. When in the open position, the water is completely free to enter and leave the bottle (in this position the bottle is essentially an open cylinder see Fig 2).

**Fig.2. Photograph of an NIO water sampling bottle being deployed**

To enable a robust calibration of the turbidity data readings from the multi-parameter sonde, samples were collected spanning the range of turbidities encountered and analysed for suspended solids in mg $l^{-1}$. To increase the accuracy of the calibration (turbidity to suspended solids in mg $l^{-1}$) the turbidity of each actual sample was recorded in Ecospan's laboratory prior to the sample being sent to an accredited laboratory (ESG Ltd) for suspended solids analysis. This negates the requirement for the sample to be taken at exactly the same time as the turbidity reading is taken in the field. This provides more accurate calibration data, as the sediment plumes are often highly variable both spatially and temporally within very short distances and times.

Ecospan Environmental undertook particle size analysis on each water sample using a Malvern laser particle size analyser to enable the proportions of sand and silt to be determined in each sample. Although particle size analysis was completed on all samples, only data for samples containing >5 mg $l^{-1}$ are considered meaningful. For samples of <5 mg $l^{-1}$ insufficient particles were present to reduce the variability of the method and hence the data was considered to be misleading.

### 2.3 Sample handling and documentation

Documentation on this survey followed Ecospan Environmental Ltd SOP ES-07 *Documentation of methods and field data when undertaking ecological surveys.* This is consistent with ISO guidelines. This requires that all projects have a project plan, a project notebook (boat book) and a chain of custody form for sample tracking. Each sample was uniquely labelled and the details required by the guideline and the SOP entered into the project notebook. The following details were recorded:

- Survey team
- Project Number
- Date(s) and time(s) of sampling
- Weather conditions (particularly wind strength)
- Station location coordinates and datum

- Station identifier (usually a number)
- Number of replicates taken
- Details of samples taken and the sample numbers if applicable
- Any other measurements taken
- Depth of sample retrieved
- Sample description
- Water depth
- Other comments and observations

The samples were stored chilled prior to return to the laboratory where they were frozen before being sent off for analysis. All sample details were recorded on a chain of custody form.

### 2.4 Additional information

Wind speed and direction was collected at a minimum of half hourly intervals over the survey period along with parameters such as an estimate of visibility and sea state including wave height, period and direction for both wind waves and swell.

## 3 QUALITY ASSURANCE

Ecospan has an ISO 9001 accredited quality management system to ensure that we work to the high standards expected by our customers. We undertake all work in accordance with standard operating procedures and recognised national/international guidelines. For ecological work we also participate in the National Marine Biological Analytical Quality Control Scheme (NMBAQCS).

Ecospan Environmental undertakes internal auditing of processes and service provision at appropriate intervals. Systems audits are undertaken on an annual basis encompassing the full scope of the QMS. Facility audits are also completed annually. As a minimum, 5 % of projects per year are selected at random and audited by an Ecospan Environmental director. Internal audits are also conducted on projects where services provided fail to meet the needs of our customers.

# 4 RESULTS

### 4.1 Water profile positions

All positions for this project are reported in OSGB 1936 as required by the tender. All values are in degrees and decimal minutes.

#### 4.1.1 Cardinal stations

The positions for all cardinal stations for each of the 6 trial sites are provided in table 1. All profiles were taken within 10 m of the target positions.

**Table 1. Cardinal station locations for the 6 Trial sites (OSGB 1936)**

| Cardinal station | Site 1 | | Site 2 | | Site 3 | |
|---|---|---|---|---|---|---|
| North | 50 09.61498' | -05 02.75289' | 50 09.62320' | -05 02.62676' | 50 09.59985' | -05 02.53345' |
| East | 50 09.45518' | -05 02.50225' | 50 09.46136' | -05 02.37312' | 50 09.43801' | -05 02.27831' |
| South | 50 09.29202' | -05 02.75518' | 50 09.29820' | -05 02.62904' | 50 09.27480' | -05 02.53124' |
| West | 50 09.45704' | -05 03.00732' | 50 09.46298' | -05 02.88046' | 50 09.43760' | -05 02.78560' |
| Cardinal station | Site 4 | | Site 5 | | Site 6 | |
| North | 50 09.65320' | -05 02.45514' | 50 09.59277' | -05 02.34755' | 50 09.56829' | -05 02.68178' |
| East | 50 09.49136' | -05 02.20072' | 50 09.42955' | -05 02.09313' | 50 09.40555' | -05 02.42736' |
| South | 50 09.32905' | -05 02.45293' | 50 09.26772' | -05 02.34756' | 50 09.24504' | -05 02.68095' |
| West | 50 09.49226' | -05 02.70657' | 50 09.43046' | -05 02.59964' | 50 09.40736' | -05 02.93393' |

### 4.1.2 Cruciform stations

The position of the cruciform stations determined for each trial site for monitoring during the dredge and relay are presented in Tables 2 to 7. The tidal flow direction which was obtained from the data buoy and used to determine the cruciform position is also included. On a number of occasions a plume was visually identified away from the cruciform stations and hence an extra profile was taken. The location of these additional profiles was also recorded.

**Table 2. Trial site 1 Cruciform station positions for dredge and relay (OSGB 1936)**

| Dredge | Cruciform positions (Tidal flow 244$^{0}$ at 0.2 Knots) | | Actual profile position | |
|---|---|---|---|---|
| Dredger | 50 09.44650' | -05 02.76363' | 50 09.45525' | -05 02.76362' |
| 1A | 50 09.45431' | -05 02.75030' | 50 09.45433' | -05 02.74759' |
| 1B | 50 09.44673' | -05 02.78145' | 50 09.44674' | -05 02.78014' |
| 1C | 50 09.43564' | -05 02.76619' | Under dredger | |
| 1D | 50 09.43672' | -05 02.78058' | 50 09.43841' | -05 02.78276' |
| 1E | 50 09.42764' | -05 02.79710' | 50 09.43015' | -05 02.79546' |
| 1F | 50 09.40920' | -05 02.82880' | 50 09.43500' | -05 02.79980' |
| 1 Extra | | | 50 09.44738' | -05 02.80902' |
| Relay | Cruciform position (Tidal flow 216$^{0}$ at 0.2 Knots) | | Actual profile position | |
| Dredger | 50 09.44650' | -05 02.76363' | 50 09.45051' | -05 02.76712' |
| 1RA | 50 09.45543' | -05 02.74905' | 50 09.46179' | -05 02.73238' |
| 1RB | 50 09.44673' | -05 02.78145' | 50 09.44318' | -05 02.79176' |
| 1RC | 50 09.43346' | -05 02.76487' | 50 09.43364' | -05 02.76796' |
| 1RD | 50 09.43758' | -05 02.78172' | 50 09.43396' | -05 02.77847' |
| 1RE | 50 09.42592' | -05 02.79977' | 50 09.42357' | -05 02.79438' |
| 1RF | 50 09.40439' | -05 02.83600' | 50 09.40567' | -05 02.84170' |
| 1R extra | | | 50 09.18575' | -05 03.85252' |

**Table 3. Trial site 2 Cruciform station positions for dredge and relay (OSGB 1936)**

| Dredge | Cruciform position (Tidal flow 289$^0$ at 0.6 Knots) | | Actual profile position | |
|---|---|---|---|---|
| Dredger | 50 09.45528' | -05 02.63447' | 50 09.45528' | -05 02.63447' |
| 2A | 50 09.45063' | -05 02.61909' | 50 09.46032' | -05 02.61179' |
| 2B | 50 09.46711' | -05 02.64186' | 50 09.46522' | -05 02.63597' |
| 2C | 50 09.45131' | -05 02.64973' | 50 09.44211' | -05 02.66652' |
| 2D | 50 09.46093' | -05 02.65474' | 50 09.45757' | -05 02.66034' |
| 2E | 50 09.46573' | -05 02.67382' | 50 09.46409' | -05 02.66663' |
| 2F | 50 09.47763' | -05 02.71400' | 50 09.47596' | -05 02.70578' |
| Relay | Cruciform position (Tidal flow 289$^0$ at 0.5 Knots) | | Actual profile position | |
| Dredger | 50 09.45528' | -05 02.63447' | 50 09.46314' | -05 02.63902' |
| 2RA | 50 09.45864' | -05 02.62332' | 50 09.44458' | -05 02.61914' |
| 2RB | 50 09.47466' | -05 02.64687' | 50 09.47080' | -05 02.66160' |
| 2RC | 50 09.45909' | -05 02.65585' | 50 09.44275' | -05 02.66709' |
| 2RD | 50 09.46825' | -05 02.65986' | 50 09.46920' | -05 02.65562' |
| 2RE | 50 09.47351' | -05 02.67966' | 50 09.47349' | -05 02.67816' |
| 2RF | 50 09.48427' | -05 02.72032' | 50 09.48310' | -05 02.71923' |

**Table 4. Trial site 3 Cruciform station positions for dredge and relay (OSGB 1936)**

| Dredge | Cruciform position (Tidal flow 293$^0$ at 1.0 Knots) | | Actual profile position | |
|---|---|---|---|---|
| Dredger | 50 09.42856' | -05 02.54339' | 50 09.43570' | -05 02.54118' |
| 3A | 50 09.43369' | -05 02.52613' | 50 09.43990' | -05 02.52378' |
| 3B | 50 09.44742' | -05 02.54841' | 50 09.44451' | -05 02.54947' |
| 3C | 50 09.43163' | -05 02.55442' | 50 09.41087' | -05 02.55507' |
| 3D | 50 09.44170' | -05 02.56100' | 50 09.44222' | -05 02.56003' |
| 3E | 50 09.44628' | -05 02.57926' | 50 09.45071' | -05 02.57462' |
| 3F | 50 09.45635' | -05 02.61726' | 50 09.45682' | -05 02.62363' |
| Relay | Cruciform position (Tidal flow 298$^0$ at 0.7 Knots) | | Actual profile position | |
| Dredger | 50 09.42856' | -05 02.54339' | 50 09.43752' | -05 02.53359' |
| 3RA | 50 09.43094' | -05 02.51637' | 50 09.43595' | -05 02.50850' |
| 3RB | 50 09.45246' | -05 02.54060' | 50 09.45373' | -05 02.53991' |
| 3RC | 50 09.43277' | -05 02.55960' | 50 09.41449' | -05 02.58680' |
| 3RD | 50 09.44101' | -05 02.54315' | 50 09.44018' | -05 02.54291' |
| 3RE | 50 09.45429' | -05 02.57826' | 50 09.44907' | -05 02.58682' |
| 3RF | 50 09.46688' | -05 02.61503' | 50 09.46885' | -05 02.61346' |

**Table 5. Trial site 4 Cruciform station positions for dredge and relay (OSGB 1936)**

| Dredge | Cruciform position (Tidal flow 002⁰ at 0.7Knots) | | Actual profile position | |
|---|---|---|---|---|
| Dredger | 50 09.49028' | -05 02.45484' | 50 09.48564' | -05 02.46060' |
| 4A | 50 09.47306' | -05 02.45965' | 50 09.46453' | -05 02.46426' |
| 4B | 50 09.49549' | -05 02.47476' | 50 09.49368' | -05 02.47272' |
| 4C | 50 09.49343' | -05 02.44852' | 50 09.48727' | -05 02.43727' |
| 4D | 50 09.49984' | -05 02.46048' | 50 09.50137' | -05 02.45831' |
| 4E | 50 09.51586' | -05 02.46063' | 50 09.51019' | -05 02.46000' |
| 4F | 50 09.53761' | -05 02.46054' | 50 09.53670' | -05 02.45981' |
| Relay | Cruciform position (Tidal flow 007⁰ at 0.8 Knots) | | Actual profile position | |
| Dredger | 50 09.49028' | -05 02.45484' | 50 09.48629' | -05 02.45934' |
| 4RA | 50 09.47306' | -05 02.45965' | 50 09.46538' | -05 02.45087' |
| 4RB | 50 09.49549' | -05 02.47476' | 50 09.49387' | -05 02.47758' |
| 4RC | 50 09.49343' | -05 02.44852' | 50 09.49233' | -05 02.44909' |
| 4RD | 50 09.49984' | -05 02.46048' | 50 09.49498' | -05 02.45910' |
| 4RE | 50 09.51586' | -05 02.46063' | 50 09.51505' | -05 02.46056' |
| 4RF | 50 09.53761' | -05 02.46054' | 50 09.53546' | -05 02.46019' |

**Table 6. Trial site 5 Cruciform station positions for dredge and relay (OSGB 1936)**

| Dredge | Cruciform position (Tidal flow 014⁰ at 0.8 Knots) | | Actual profile position | |
|---|---|---|---|---|
| Dredge | 50 09.42194' | -05 02.35683' | 50 09.43058' | -05 02.35333' |
| 5A | 50 09.41857' | -05 02.35800' | 50 09.41333' | -05 02.35431' |
| 5B | 50 09.43757' | -05 02.33894' | 50 09.43739' | -05 02.33960' |
| 5C | 50 09.44147' | -05 02.36375' | 50 09.44016' | -05 02.36246' |
| 5D | 50 09.44467' | -05 02.34887' | 50 09.44602' | -05 02.34960' |
| 5E | 50 09.45978' | -05 02.34360' | 50 09.45894' | -05 02.34771' |
| 5F | 50 09.48015' | -05 02.33725' | 50 09.47977' | -05 02.33700' |
| Relay | Cruciform position (Tidal flow 009⁰ at 0.9 Knots) | | Actual profile position | |
| Dredge | 50 09.42194' | -05 02.35683' | 50 09.42799' | -05 02.36111' |
| 5RA | 50 09.42063' | -05 02.36278' | 50 09.40743' | -05 02.35807' |
| 5RB | 50 09.43414' | -05 02.34952' | 50 09.43558' | -05 02.35094' |
| 5RC | 50 09.43574' | -05 02.37033' | 50 09.43039' | -05 02.37914' |
| 5RD | 50 09.43848' | -05 02.35860' | 50 09.43273' | -05 02.36408' |
| 5RE | 50 09.44902' | -05 02.35613' | 50 09.44681' | -05 02.35667' |
| 5RF | 50 09.46917' | -05 02.35101' | 50 09.46808' | -05 02.34352' |

**Table 7. Trial site 6 Cruciform station positions for dredge and relay (OSGB 1936)**

| Dredge | Cruciform position (Tidal flow 032⁰ at 0.6Knots) | | Actual profile position | |
|---|---|---|---|---|
| Dredge | 50 09.40168' | -05 02.68941' | 50 09.40831' | -05 02.69046' |
| 6A | 50 09.39889' | -05 02.70084' | 50 09.37989' | -05 02.70952' |
| 6B | 50 09.42476' | -05 02.69663' | 50 09.42331' | -05 02.69846' |
| 6C | 50 09.41194' | -05 02.66873' | 50 09.40995' | -05 02.66941' |
| 6D | 50 09.42064' | -05 02.67907' | 50 09.41755' | -05 02.68369' |
| 6E | 50 09.43437' | -05 02.66615' | 50 09.43368' | -05 02.66414' |
| 6F | 50 09.46047' | -05 02.64155' | 50 09.45666' | -05 02.64514' |
| Relay | Cruciform position (Tidal flow 350⁰ at 0.3 Knots) | | Actual profile position | |
| Dredge | 50 09.40168' | -05 02.68941' | 50 09.40831' | -05 02.69046' |
| 6RA | 50 09.39546' | -05 02.68708' | 50 09.39456' | -05 02.68640' |
| 6RB | 50 09.42224' | -05 02.67692' | 50 09.41927' | -05 02.67340' |
| 6RC | 50 09.41858' | -05 02.71094' | 50 09.41749' | -05 02.71282' |
| 6RD | 50 09.42133' | -05 02.69432' | 50 09.41197' | -05 02.69280' |
| 6RE | 50 09.43872' | -05 02.69961' | 50 09.44090' | -05 02.69920' |
| 6RF | 50 09.46962' | -05 02.70802' | 50 09.46770' | -05 02.70422' |
| 6 Extra 1 | | | 50 09.42453' | -05 02.71636' |
| 6 Extra 2 | | | 50 09.47250' | -05 02.78555' |

## 4.2 Cardinal stations Water quality monitoring data

The data for cardinal water monitoring at all of the sites, both before and after dredge and relay operations, is summarised in Table 8. The data for all parameters shows some variability, but this is within that would be expected for estuarine seawater.

**Table 8. Summary of maximum and minimal water quality parameters for each Cardinal station**

| Site | Temperature (°C) | | Salinity (‰) | | pH | | Turbidity (NTU) | | Dissolved Oxygen % | | Dissolved Oxygen mg $l^{-1}$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Min | Max | Min | Max | Min | Max | Max | Min | Max | Min | Max | Min |
| 1 | 13.19 | 14.87 | 34.19 | 35.63 | 7.92 | 8.05 | -0.1 | -5.9 | 87.8 | 98.2 | 7.18 | 8.09 |
| 2 | 13.19 | 14.93 | 33.47 | 36.35 | 7.98 | 8.08 | 0 | -5.3 | 88.3 | 99.3 | 7.23 | 8.2 |
| 3 | 14.53 | 14.91 | 34.49 | 35.05 | 8.03 | 8.07 | -0.4 | -4.1 | 88.6 | 96.8 | 7.23 | 7.95 |
| 4 | 14.35 | 14.88 | 34.38 | 34.99 | 7.91 | 8.07 | -2.6 | -5.4 | 89.1 | 97.9 | 7.29 | 8.04 |
| 5 | 13.32 | 14.87 | 33.8 | 35.55 | 7.95 | 8.11 | -0.5 | -5.1 | 89.1 | 98.0 | 7.29 | 8.16 |
| 6 | 12.72 | 14.84 | 34.29 | 36.14 | 7.86 | 8.09 | -1 | -5.6 | 90.6 | 98.3 | 7.45 | 8.32 |
| All | 12.72 | 14.93 | 33.47 | 36.35 | 7.86 | 8.11 | 0 | -5.9 | 87.8 | 99.3 | 7.18 | 8.32 |

## 4.3 Cruciform stations Water quality monitoring data

The data for cruciform water monitoring stations at all of the sites during the dredge and relay operations is summarised in Table 9. It can be seen that, for all parameters with the exception of turbidity the parameters were found to be in the same ranges as those seen at the cardinal stations. The data for all parameters shows some variability, but this is within that would be expected for estuarine seawater.

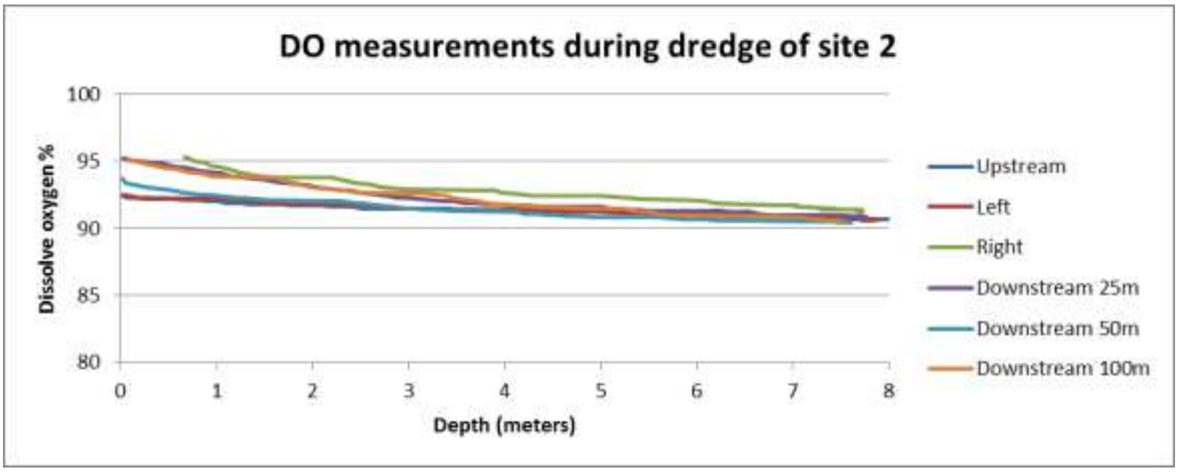
**Table 9. Summary of maximum and minimal water quality parameters for each Cruciform station**

| Station | Temperature (°C) | | Salinity (‰) | | pH | | Turbidity (NTU) | | Dissolved Oxygen % | | Dissolved Oxygen mg $l^{-1}$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max |
| 1 | 13.6 | 14.84 | 34.38 | 35.11 | 8.00 | 8.05 | -5.1 | 23.8 | 87.1 | 99.0 | 7.15 | 8.14 |
| 2 | 13.92 | 14.86 | 34.45 | 35.33 | 8.01 | 8.07 | -5.0 | 33.4 | 89.5 | 97.9 | 7.32 | 8.08 |
| 3 | 14.33 | 14.89 | 34.41 | 35.03 | 7.99 | 8.07 | -5.4 | 28.6 | 89.1 | 98.4 | 7.28 | 8.14 |
| 4 | 13.64 | 14.87 | 33.95 | 35.48 | 7.92 | 8.07 | -5.1 | 0.5 | 90.7 | 98.1 | 7.47 | 8.13 |
| 5 | 13.67 | 14.86 | 33.96 | 35.3 | 8.01 | 8.1 | -6.1 | 12.6 | 90.3 | 98.6 | 7.42 | 8.19 |
| 6 | 13.08 | 14.81 | 34.29 | 35.8 | 7.94 | 8.14 | -5.6 | 8.7 | 91.4 | 98.3 | 7.51 | 8.26 |
| All | 13.08 | 14.89 | 33.95 | 35.8 | 7.92 | 8.14 | -6.1 | 36.8 | 87.1 | 99.0 | 7.15 | 8.26 |

## 4.4 Dissolved oxygen results for cruciform stations

The results for all dissolved oxygen profiles are provided in appendix 1. Figure 3 shows a typical example of one of these from site 2. This shows some reductions in dissolved oxygen with depth, but the lowest values seen are all above 90%. For all stations all dissolved oxygen values were 87% or above and there is no indication this is related to the dredging activities. Even where increased turbidity was detected no associated reduction in dissolve oxygen was observed.

**Figure 3. Trial site 2 Cruciform station dissolved oxygen measurements**

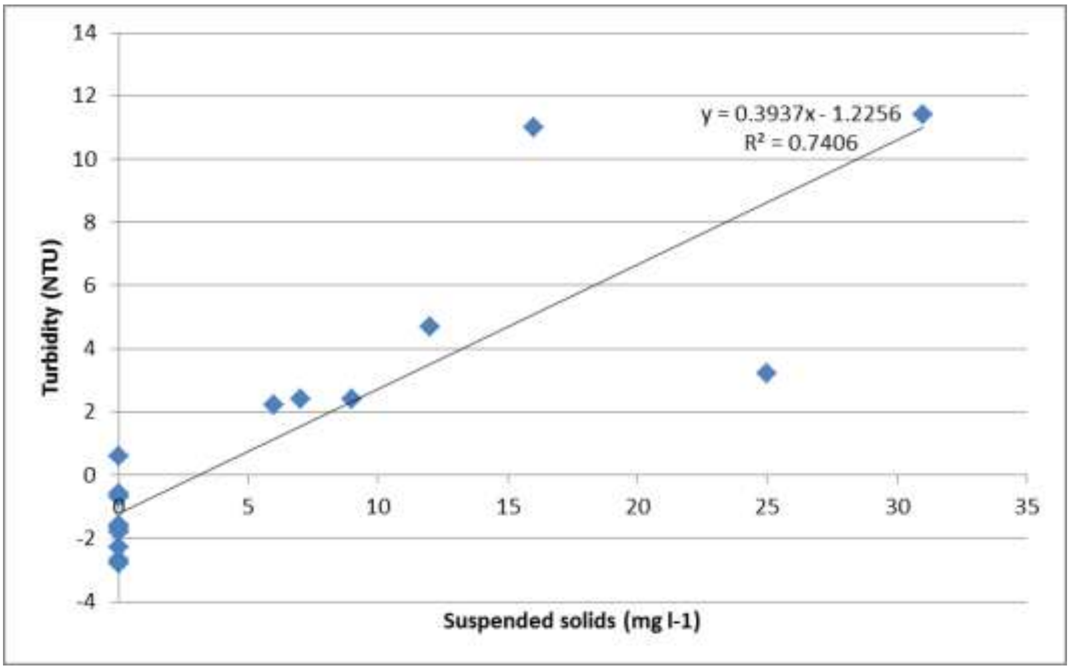



## 4.5 Turbidity calibration and results

The turbidity data from the profile monitoring was measured and logged in NTU. These can be directly related to suspended solids levels and can be converted by producing a calibration curve between the two.

As no significant turbidity was measured at the cardinal stations, the values for the cruciform stations were used to establish the relationship between turbidity and suspended solids. These have been plotted in Figure 4. During this exercise, the low levels of turbidity and suspended solids have resulted in a lower correlation coefficient than is normally seen when a greater range of turbidity is measured. However, with the correlation coefficient of 0.74 there is still a good relationship between the two. Using this, we can calculate that the highest turbidity levels measured in the field (36.8 NTU) equates to a suspended solids level of approximately 97 mg $l^{-1}$.

**Figure 4. Correlation of suspended solids and turbidity measurements**




### 4.5.1 Suspended solids analysis

The results of suspended solids analysis are shown in table 10 and 11 alongside the turbidity values measured in the field and back at Ecospan Laboratory before being sent for analysis.

**Table 10. Suspended solids analysis results for water samples taken at the cardinal stations**

| Site | position | Suspended solids mg/l | turbidity lab | turbidity Field |
|---|---|---|---|---|
| 1 | 1 S Pre | <5 | -2.7 | -3.1 |
| 1 | 1 E Pre | <5 | -2.6 | -3.9 |
| 2 | 2 E pre | <5 | -3.7 | -3.6 |
| 2 | 2 N post | <5 | -2.7 | -2.8 |
| 2 | 2 N pre | <5 | -2.6 | -3.7 |
| 3 | 3 W pre | <5 | -2.9 | -4 |
| 3 | 3 W relay | <5 | -2.2 | -4.2 |
| 4 | 4 S pre | <5 | -1 | -3.5 |
| 5 | 5 E pre | <5 | -3.2 | -3.7 |
| 5 | 5 N relay | <5 | -2.4 | -4.1 |
| 6 | 6 W pre | <5 | -3 | -3.8 |

**Table 11. Suspended solids analysis results for water samples taken at the cruciform stations during dredge and relay operations**

| Site | position | Suspended solids mg $l^{-1}$ | Turbidity lab | Turbidity Field |
|---|---|---|---|---|
| 1 | 1B | <5 | -2.7 | -4 |
| 1 | 1E | <5 | -2.3 | -3.3 |
| 1 | 1D relay | <5 | -2.8 | -3.8 |
| 1 | 1F relay | <5 | 0.6 | 10.2 |
| 2 | 2A | <5 | -1.7 | -0.4 |
| 2 | 2D | 31 | 11.4 | 23 |
| 2 | 2E | 25 | 3.2 | 4.9 |
| 2 | 2D relay | <5 | -0.7 | 1.9 |
| 3 | 3C | 16 | 11 | 23.1 |
| 5 | 5A | 12 | 4.7 | 6.2 |
| 5 | 5E | <5 | -2.8 | -4.1 |
| 6 | 6B | <5 | -0.6 | 6.8 |
| 6 | 6D | <5 | -1.6 | -2.7 |
| 6 | 6C relay | 6 | 2.2 | 6.8 |
| 6 | 6D relay | 7 | 2.4 | 7 |
| 6 | 6 extra 1 relay | 9 | 2.4 | 6.4 |
| 6 | 6 extra 2 relay | <5 | -1.8 | -2.4 |

### 4.5.2 Turbidity results for cruciform stations

All the results for turbidity presented in this section have been converted in to suspended solids mg $l^{-1}$. The results show increased turbidity levels at sites 1, 2, 3, 5 and 6 during the dredging and/or relay operations. Table 12 shows the maximum turbidity levels at each site in both NTU and suspended solids. From this it can be seen that the highest value was seen at site 2 and this was recorded at the downstream station nearest to the dredge (25m).

**Table 12. Maximum turbidity levels observed**

| Site | Turbidity NTU) | Suspended solids (mg $l^{-1}$) |
|---|---|---|
| | Max | Max |
| 1 | 23.8 | 63.57 |
| 2 | 36.8 | 96.59 |
| 3 | 28.6 | 75.76 |
| 4 | 0.5 | 4.38 |
| 5 | 12.6 | 35.12 |
| 6 | 8.7 | 25.21 |
| All | 36.8 | 96.59 |

The profiles where an increased turbidity was measured are shown below (all others are provided in appendix 2). The highest turbidity values were seen within 2 metres of the sea bed where it was expected that a plume might be detected. The data for sites 1 and 2 during the dredge showed a continual increase in the turbidity value after the sonde left the bottom before dropping back to zero after approximately 2 m. These have been included on the profile to show the maximum turbidity levels measured. There is some risk that these elevated values were a result of the sonde hitting the seabed. However, as this effect was not seen at any of the cardinal stations (or the other cruciform stations), it is considered that they probably reflect a real turbidity increase caused by the plume. On the relay of site 1 turbidity was seen near the surface and this was measured at the 1extra station added. This was also seen at sites 2 and 6, where turbidity was recorded near to the surface at some of the stations close to the dredge. This surface turbidity was not thought to be a result of the dredging activity on the seabed, but was associated with the overflow from the maerl holding tanks on the barge.

**Figure 5. Trial site 1 Cruciform station during dredge Turbidity measurements**

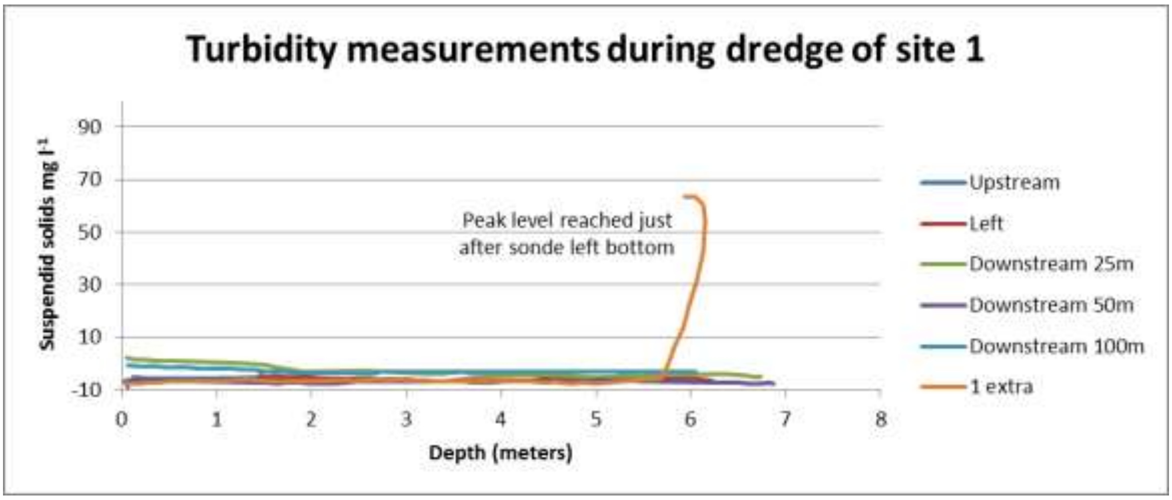



**Figure 6. Trial site 1 Cruciform station during dredge Turbidity measurements**

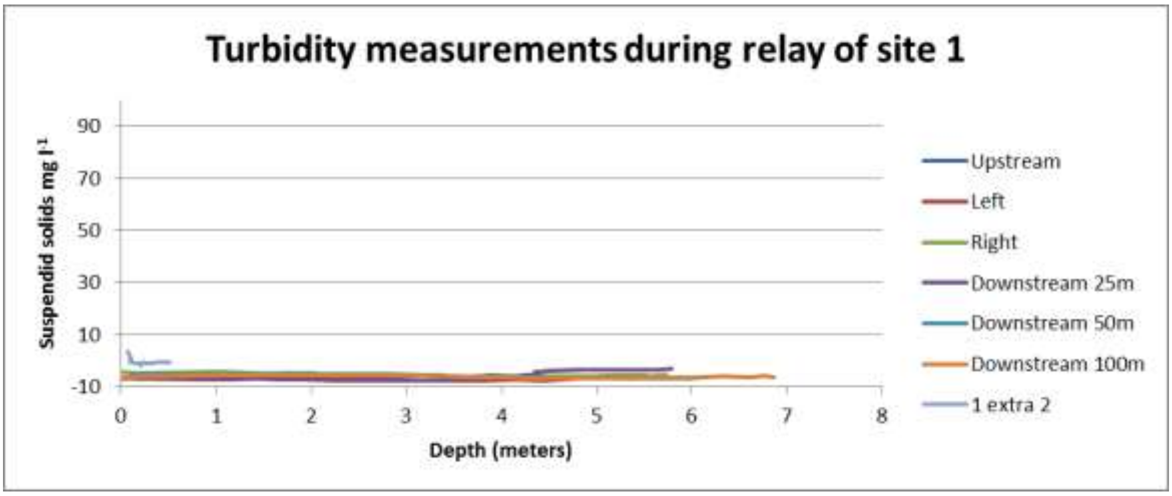


**Figure 7. Trial site 2 Cruciform station during dredge Turbidity measurements**

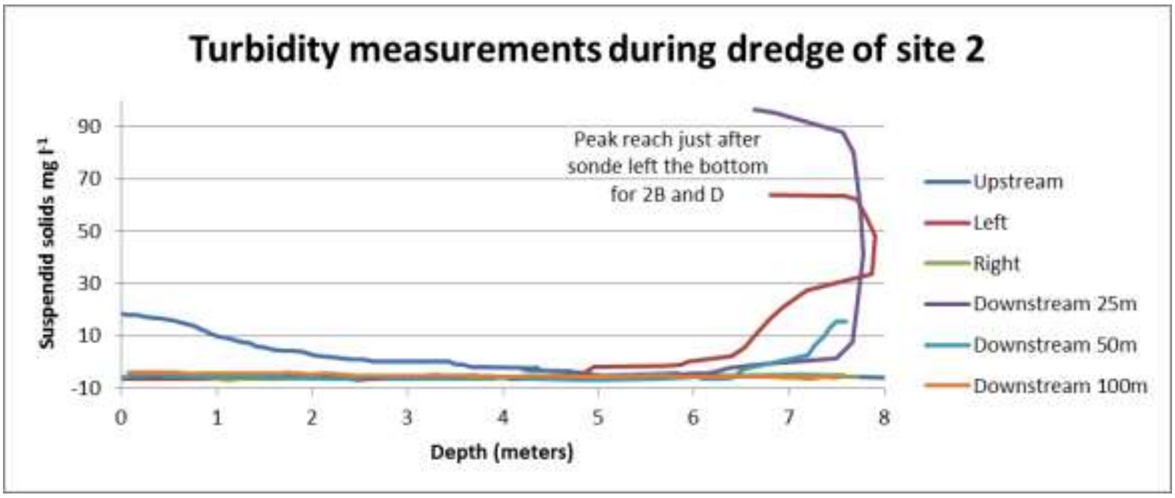



**Figure 8. Trial site 3 Cruciform stations during dredge Turbidity measurements**

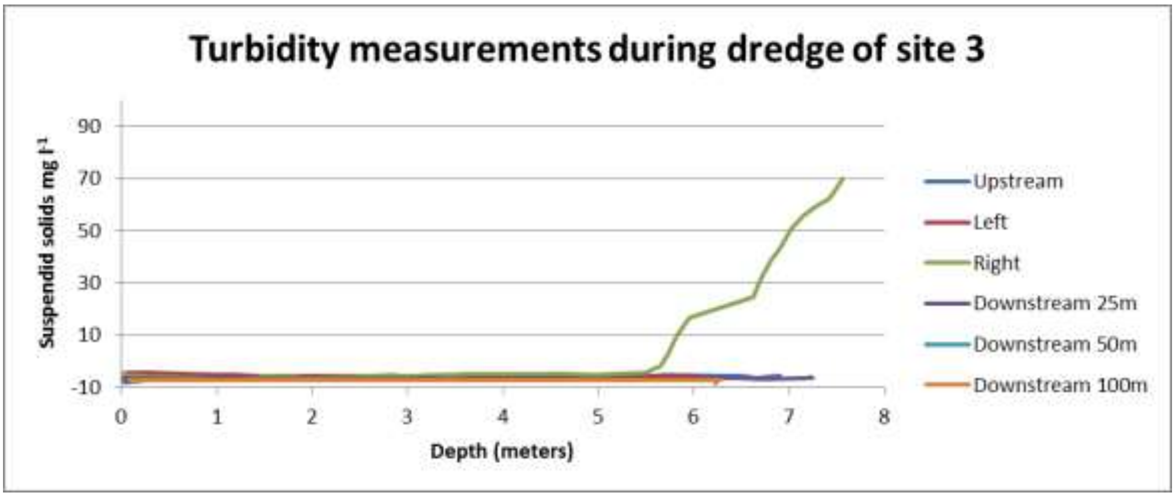



**Figure 9. Trial site 5 Cruciform stations during dredge Turbidity measurements**

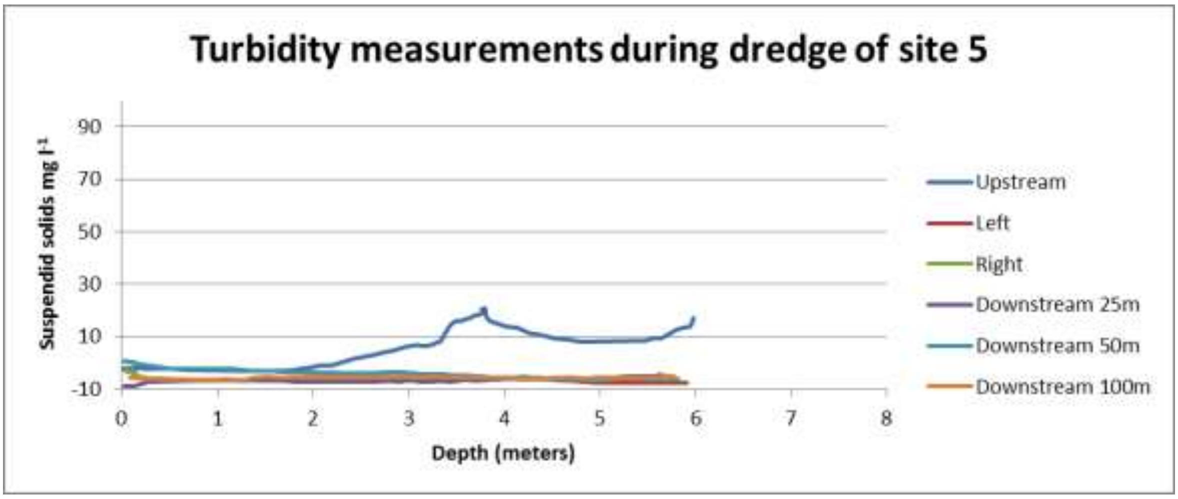
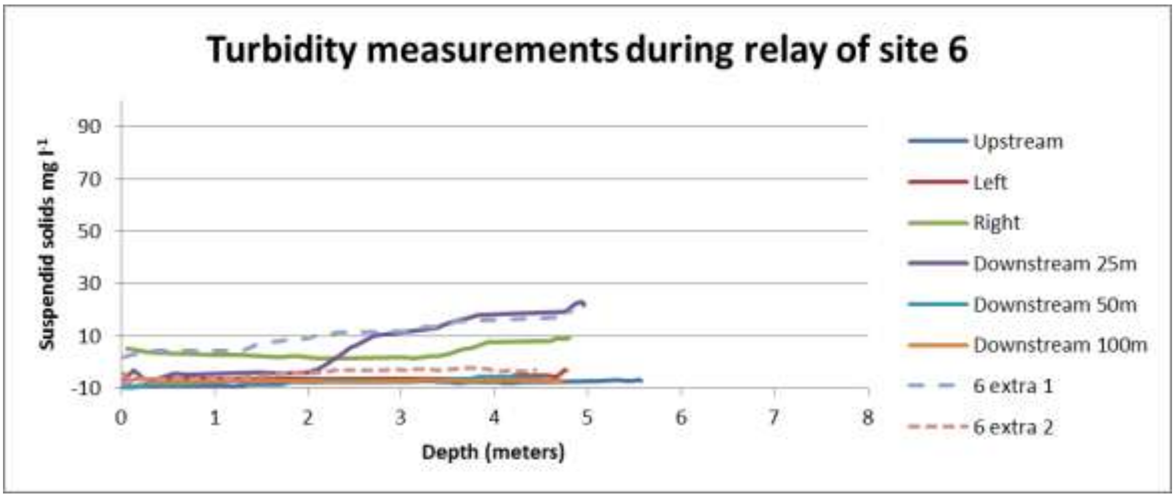


**Figure 10. Trial site 6 Cruciform stations during relay Turbidity measurements**




### 4.6 Wind and wave observations

As required by the protocol, wind and wave observations were recorded at approximately 30 minute intervals throughout the monitoring operation. The field notes taken during the monitoring are included in Appendix 3. These show that during the dredging and relay operations, the wind was consistently blowing from the south west. Wind speed varied from 1.1 to 6.9 (gusting 9.3) m $s^{-1}$ which is Force 1 to 4 on the Beaufort scale. Wave height varied from 0.1 to 0.6 m with little discernible swell.

### 4.7 Particle size analysis

Table 13 presents the particle size analysis data for all the cruciform station water samples taken. The cardinal station water samples have not been included as the very low levels of particulates present were below that required to give a robust size distribution. Similarly, only those samples from the cruciform stations where turbidity was measured are considered to give valid results and these are highlighted in yellow. In these samples it can be seen that the particulates present are mainly silt and clay mostly less than 31 µm in size. This is what might be expected as the fine particulates are more likely to become suspended and hence cause turbidity during the dredging and relay.

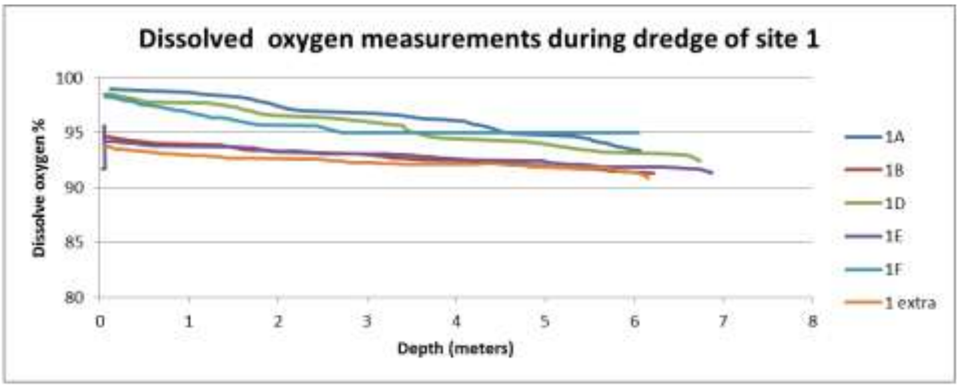
**Table 13. Particle size analysis results for water samples taken at the cruciform stations during dredge and relay operations**

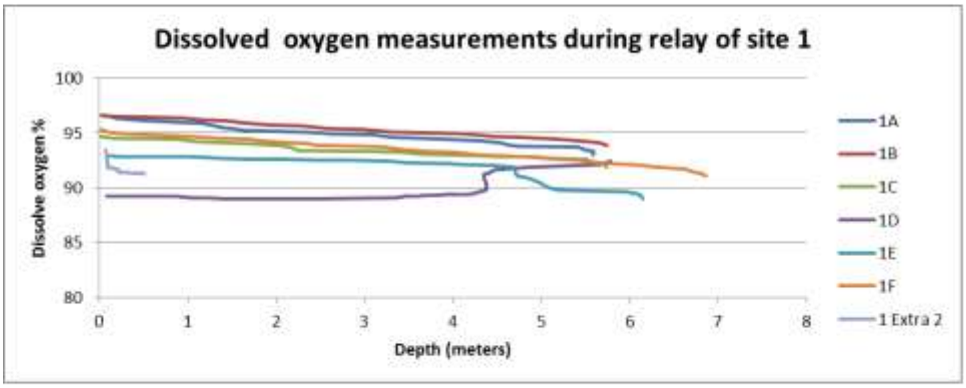
| Station | Pebbles >4 mm | Granules >2 <4 mm | Very coarse sand >1 <2 mm | Coarse sand >0.5 <1 mm | Medium sand >250 <500 µm | fine sand >125 <250 µm | Very fine sand >63 <125 µm | Silt >31 <63 µm | Silt >16 <31 µm | Silt >8 <16 µm | Silt >4 <8 µm | Clay <4 µm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1B | 0.00 | 0.00 | 0.00 | 0.00 | 1.76 | 5.64 | 2.25 | 7.78 | 15.79 | 21.25 | 19.71 | 25.84 |
| 2A | 0.00 | 0.00 | 0.00 | 0.00 | 31.18 | 13.32 | 4.69 | 12.08 | 11.20 | 7.87 | 9.28 | 10.37 |
| 2D | 0.00 | 0.00 | 0.00 | 0.00 | 0.37 | 2.78 | 1.37 | 5.73 | 13.22 | 25.40 | 25.39 | 25.70 |
| 2E | 0.00 | 0.00 | 0.00 | 0.00 | 2.48 | 0.00 | 0.00 | 1.88 | 12.44 | 26.09 | 28.46 | 28.65 |
| 2D relay | 0.00 | 0.00 | 0.00 | 0.00 | 3.44 | 3.73 | 4.83 | 13.94 | 21.71 | 21.12 | 15.61 | 15.62 |
| 3C | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 1.80 | 4.11 | 7.99 | 14.09 | 23.16 | 24.47 | 24.31 |
| 1E | 0.00 | 0.00 | 0.00 | 0.00 | 57.98 | 1.06 | 4.26 | 10.36 | 10.46 | 10.71 | 4.77 | 0.40 |
| 5A | 0.00 | 0.00 | 0.00 | 0.00 | 7.21 | 1.15 | 6.61 | 9.89 | 19.14 | 24.53 | 17.87 | 13.59 |
| 5E | 0.00 | 0.00 | 0.00 | 0.00 | 33.95 | 5.66 | 0.56 | 0.00 | 0.00 | 1.78 | 20.29 | 37.77 |
| 1D relay | 0.00 | 0.00 | 0.00 | 0.00 | 42.62 | 1.83 | 0.00 | 0.00 | 0.00 | 2.00 | 18.06 | 35.49 |
| 1F relay | 0.00 | 0.00 | 0.00 | 0.00 | 1.46 | 4.30 | 2.18 | 5.92 | 16.26 | 24.38 | 21.33 | 24.17 |
| 6B | 0.00 | 0.00 | 0.00 | 0.00 | 10.55 | 1.37 | 5.43 | 6.68 | 14.54 | 19.37 | 20.65 | 21.37 |
| 6D | 0.00 | 0.00 | 0.00 | 0.00 | 44.59 | 18.94 | 8.53 | 10.05 | 7.60 | 5.54 | 4.18 | 0.59 |
| 6 EXTRA 1 relay | 0.00 | 0.00 | 0.00 | 0.00 | 1.60 | 4.83 | 5.19 | 12.12 | 14.95 | 19.97 | 20.38 | 20.96 |
| 6C relay | 0.00 | 0.00 | 0.00 | 0.00 | 32.87 | 2.88 | 5.28 | 9.95 | 10.08 | 13.34 | 13.00 | 12.60 |
| 6D relay | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 9.39 | 26.69 | 15.25 | 15.96 | 15.91 | 16.79 |
| 6 EXTRA 2 relay | 0.00 | 0.00 | 0.00 | 0.00 | 28.00 | 2.19 | 5.12 | 6.59 | 11.79 | 13.63 | 15.65 | 17.06 |

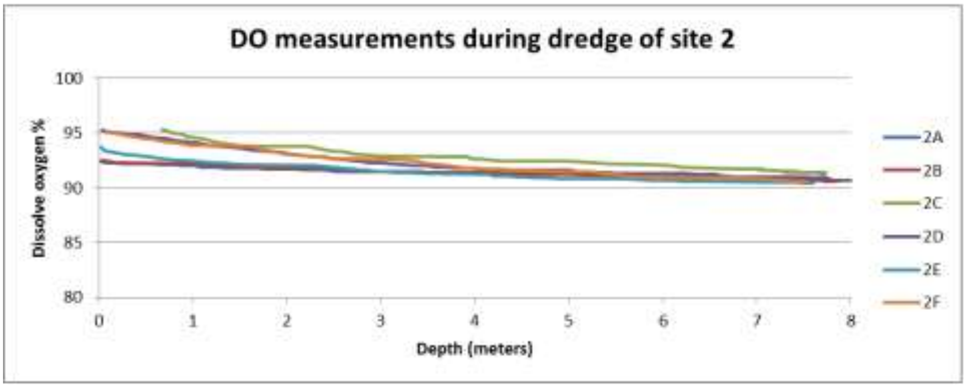
## 4.8 Calibration of YSI sonde used for water quality measurements

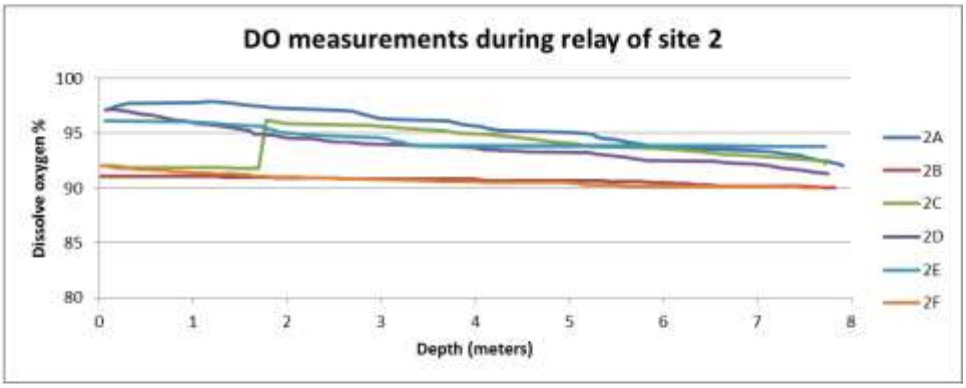
The YSI was calibrated before, during and after the monitoring survey in line with the manufactures instructions. The calibration conducted before and after is included in Appendix 4.

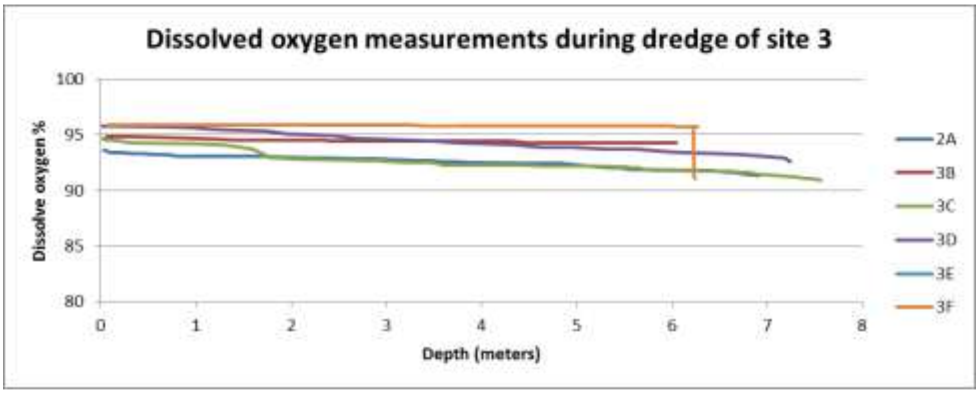
## APPENDIX 1 DISSOLVED OXYGEN PROFILES FOR EACH SITE DURING DREDGE AND RELAY

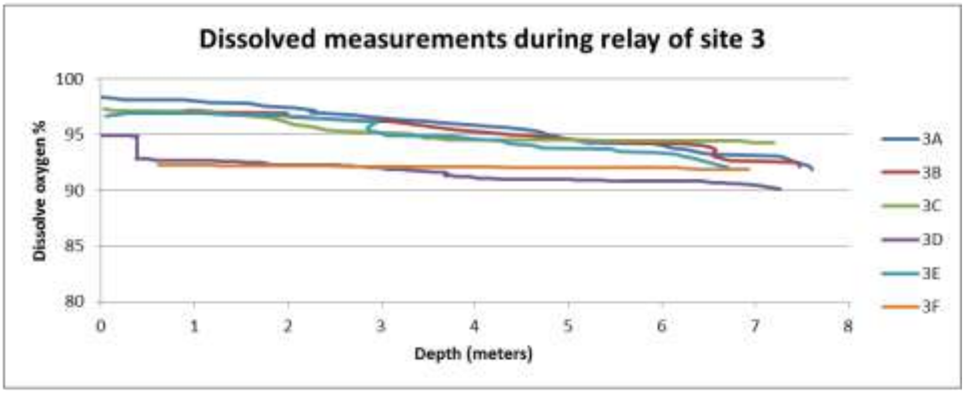


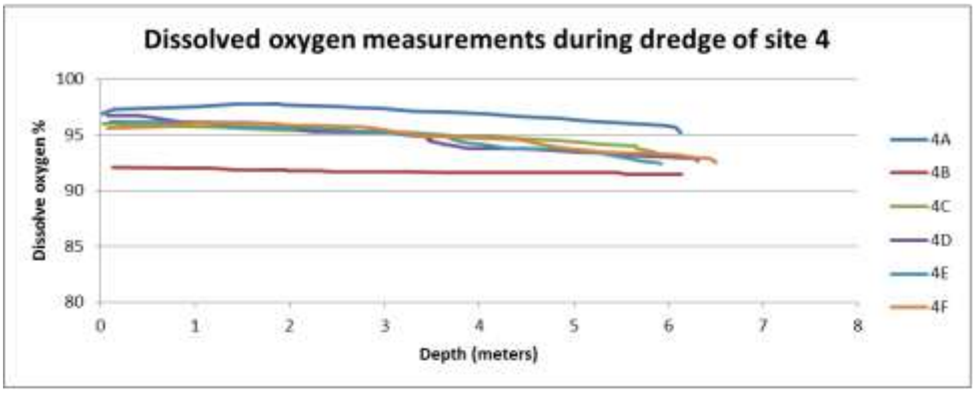



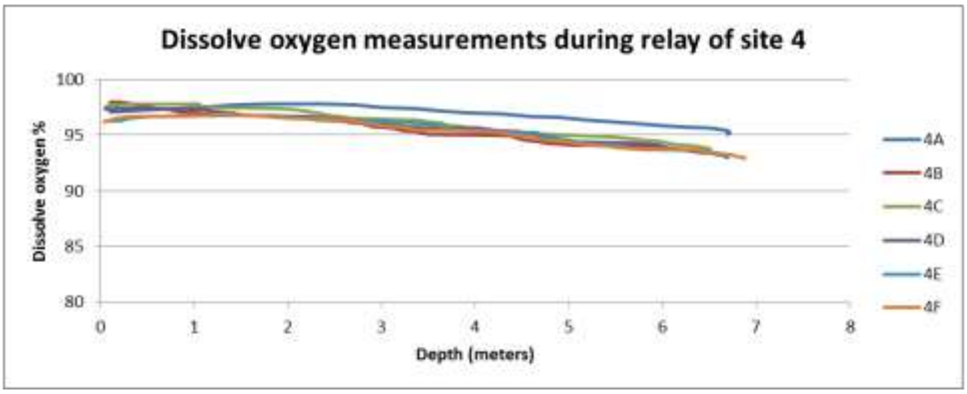



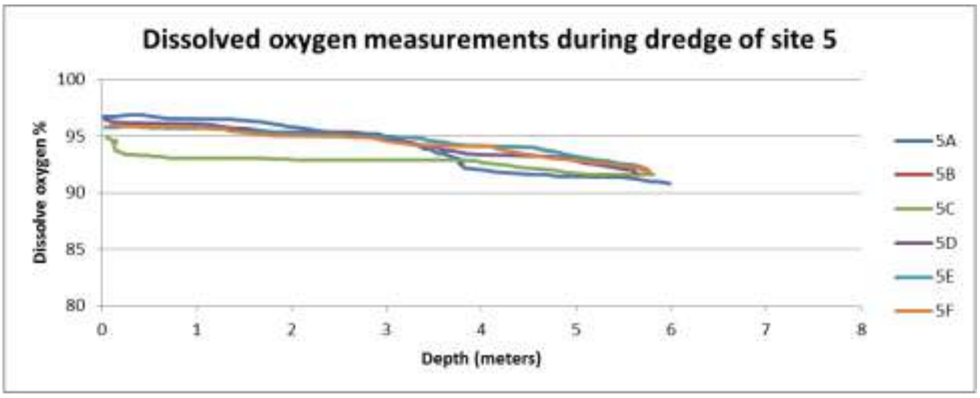



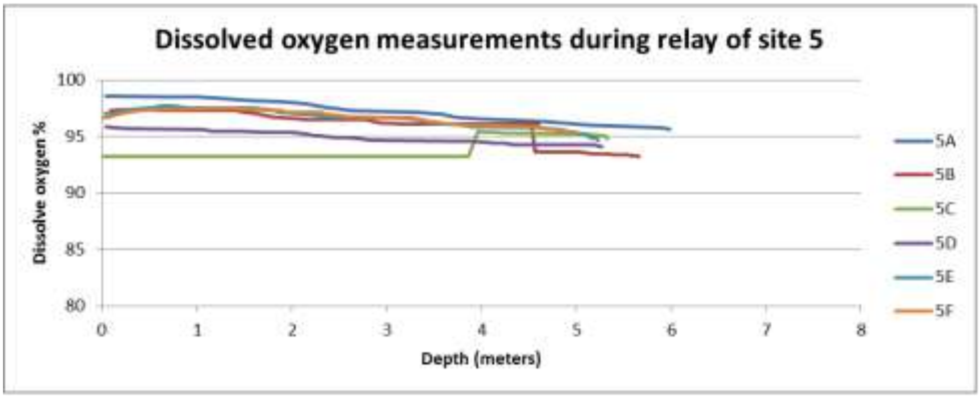

Dissolved oxygen measurements during dredge of site 3
Dissolve oxygen %
Depth (meters)
2A
3B
3C
3D
3E
3F

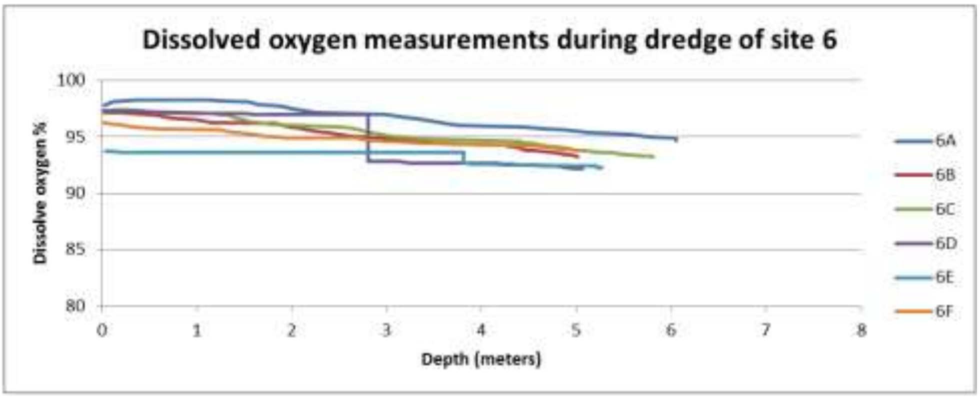

Dissolved measurements during relay of site 3
Dissolve oxygen %
Depth (meters)
3A
3B
3C
3D
3E
3F

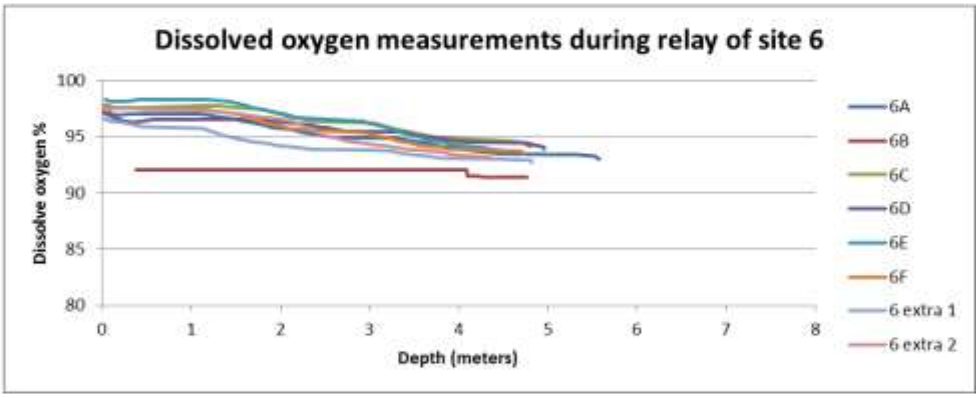

Dissolved oxygen measurements during dredge of site 4
Dissolve oxygen %
Depth (meters)
4A
4B
4C
4D
4E
4F


Dissolve oxygen measurements during relay of site 4
Dissolve oxygen %
Depth (meters)
4A
4B
4C
4D
4E
4F

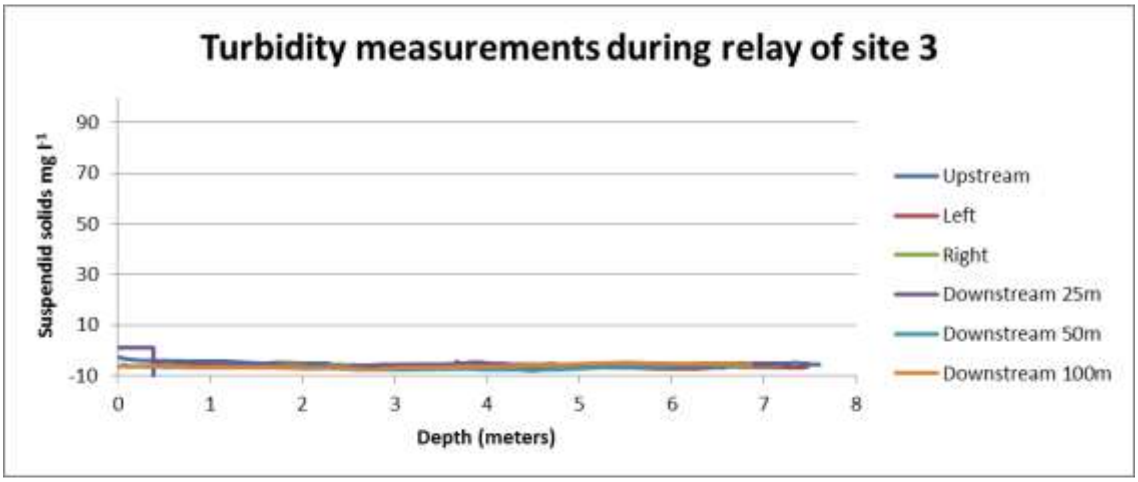

Dissolved oxygen measurements during dredge of site 5
Dissolve oxygen %
Depth (meters)
100
95
90
85
80
0
1
2
3
4
5
6
7
8
5A
5B
5C
5D
5E
5F

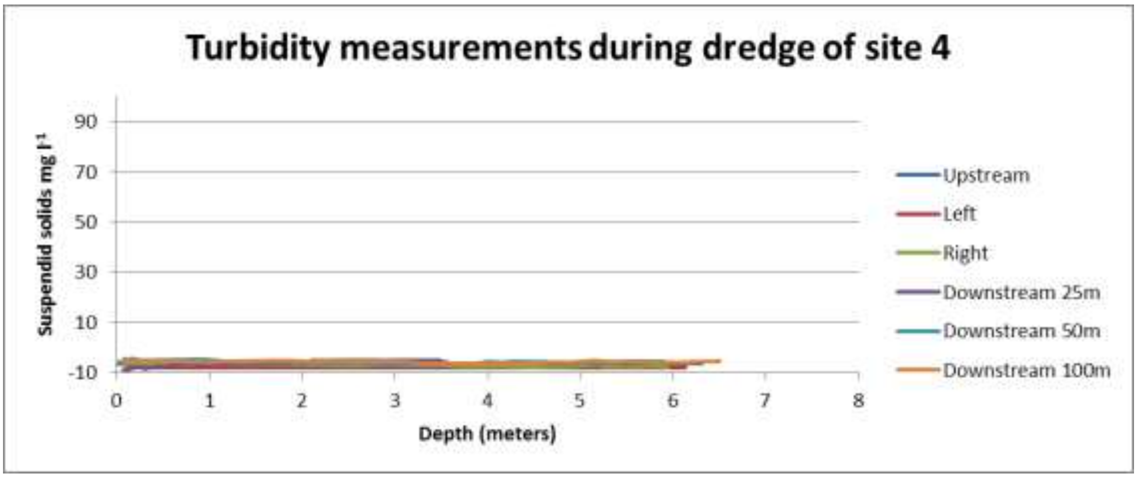

Dissolved oxygen measurements during relay of site 5
Dissolve oxygen %
Depth (meters)
100
95
90
85
80
0
1
2
3
4
5
6
7
8
5A
5B
5C
5D
5E
5F

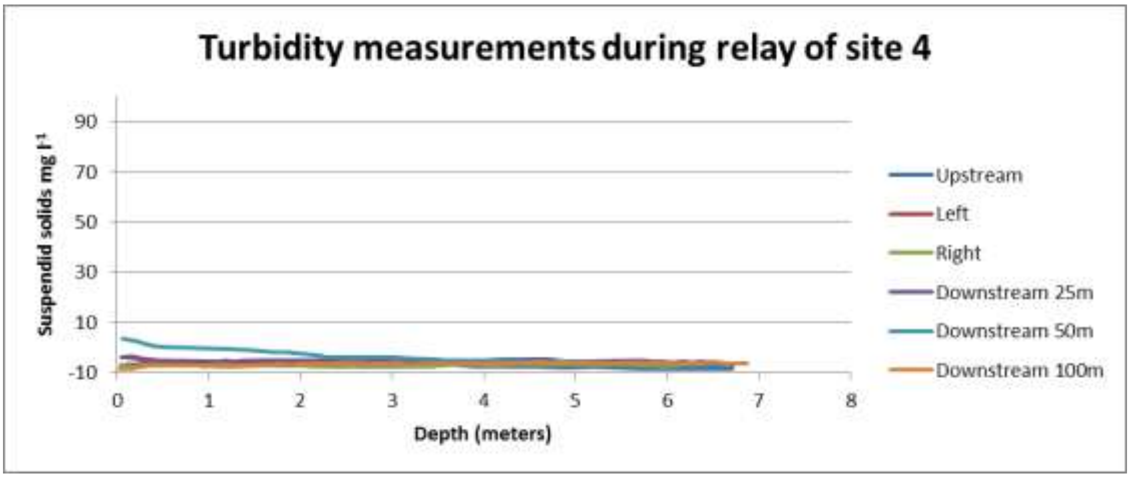

Dissolved oxygen measurements during dredge of site 6
Dissolve oxygen %
Depth (meters)
100
95
90
85
80
0
1
2
3
4
5
6
7
8
6A
6B
6C
6D
6E
6F


Dissolved oxygen measurements during relay of site 6
Dissolve oxygen %
Depth (meters)
100
95
90
85
80
0
1
2
3
4
5
6
7
8
6A
6B
6C
6D
6E
6F
6 extra 1
6 extra 2

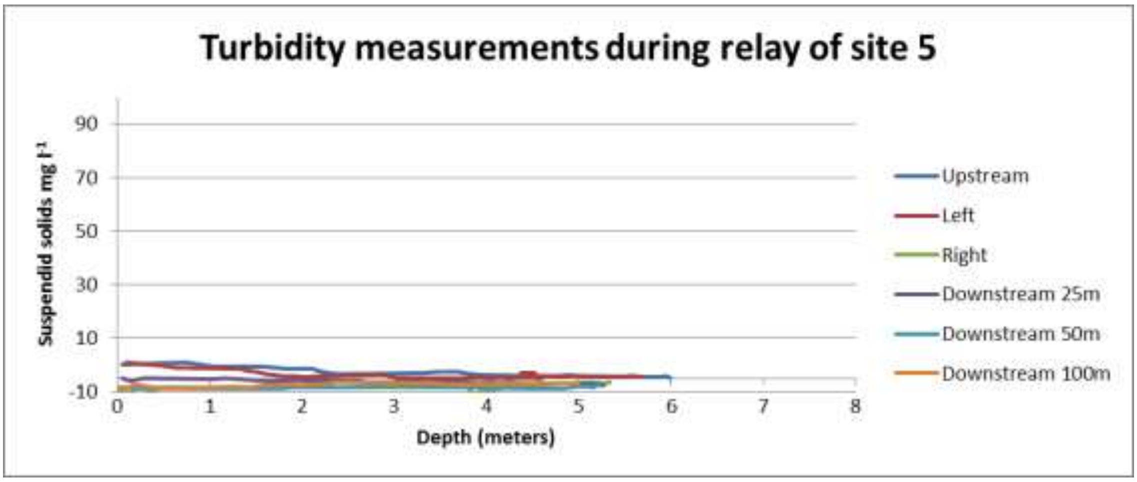
# APPENDIX 2 TURBIDITY MEASUREMENTS FOR SITE DURING DREDGE AND RELAY WHERE NO INCREASED TURBIDITY WAS OBSERVED

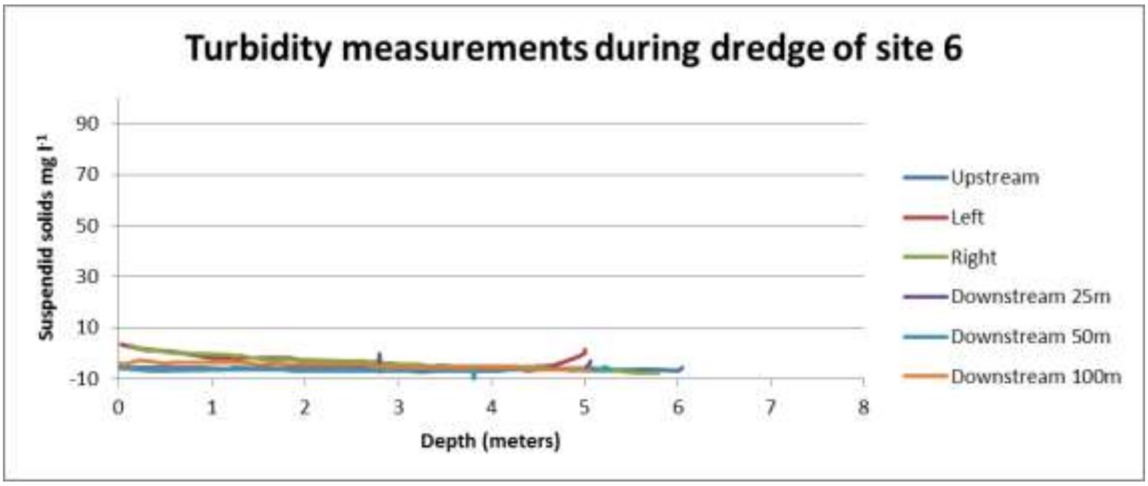


## Appendix 2 (continued) Turbidity measurements for site during dredge and relay where no turbidity was observed increased



# APPENDIX 3 WIND AND WAVE OBSERVATIONS DURING MONITORING

Falmouth Water and Turbidity Monitoring Project No. 12-227 ECOSPAN

| Date | Time (~~GMT~~) BST | Wind Speed (m/s) | Wind Direction (Deg) | Wave Height (m) | Wave Period (Sec) | Wave Direction | Swell Direction | |
|---|---|---|---|---|---|---|---|---|
| 24.09.12 | 16:22 | 5.9 | 269 | 0.25 | 2/sec | W | (N/A | |
| | 16:54 | 3.9 | 235 | 0.1 | N/A | W | N/A | |
| | 18:25 | 5.4 | 275 | 0.25 | 2/sec | W | N/A | |
| | 18:56 | 4.3 | 290 | 0.1 | N/A | W | N/A | |
| | 19:24 | 4.2 | 265 | 0.1 | N/A | N/A | N/A | |
| | 19:55 | 3.3 | 225 | 0.1 | " | " | " | Ripples |
| | 20:25 | 4.1 | 265 | 0.1 | " | " | " | |
| | 20:56 | 2.8 | 290 | 0.1 | " | " | " | |
| | 21:23 | 4.8 | 280 | 0.1 | " | " | " | |
| | 21:53 | 4.1 | 320 | 0.1 | " | " | " | |
| | 22:20 | 3.7 | 295 | 0.1 | " | " | " | |
| | 22:48 | 3.8 | 280 | 0.1 | " | " | " | |
| | 23:20 | 3.1 | 250 | " | " | " | " | |
| | 23:50 | 4.0 | 235 | " | " | " | " | |
| | 00:29 | 3.2 | 270 | " | " | " | " | |
| | 00:59 | 3.9 | 230 | " | " | " | " | |
| 25.09.12 | 09:00 | 2.4 | 210 | 0.25 | N/A | N/A | N/A | Ripple |
| | 09:36 | 1.7 | 240 | 0.2 | " | " | " | |
| | 10:08 | 3.9 | 235 | 0.1 | " | " | " | |
| | 10:43 | 4.6 | 245 | 0.2 | " | " | " | |
| | 11:30 | 4.2 | 266 | 0.2 | " | " | " | |
| | 11:42 | 6.5 | 255 | 0.25 | 2/Sec | W | W | |
| | 12:12 | 4.1 | 280 | 0.15 | N/A | N/A | N/A | |
| | 13:08 | 3.2 | 280 | 0.3 | 2/sec | SW | SW | |
| | 13:38 | 6.9 | 270 | 0.45 | 2/sec | W/SW | W/SW | |
| | 14:13 | 5.2 | 250 | 0.2 | Irregular | Irregular | Irregular | |
| | 14:32 | 6.2 (Gusts 9.3) | 280 | 0.25 | " | NW | N/A | |
| | 15:03 | 4.3 | 210 | 0.30 | " | W | N/A | |
| | 15:34 | 5.7 | 245 | 0.30 | " | W | N/A | |
| | 16:04 | 4.4 | 220 | 0.20 | 3/Sec | W | N/A | |
| | 16:32 | 4.5 | 270 | 0.25 | 3 | WSW | N/A | |
| | 16:58 | 3.6 | 260 | 0.15 | Irregular | SW | N/A | |
| | 17:20 | 5.5 | 270 | 0.15 | " | W | N/A | |
| | 17:49 | 1.0 | 225 | 0.10 | " | irregular | N/A | |
| 26.09.12 | 18:10 | 3.6 | 220 | " | " | " | " | |
| | 01:33 | 5.2 | 240 | | | | | |

## APPENDIX 3 (CONTINUED) WIND AND WAVE OBSERVATIONS DURING MONITORING

Falmouth Water and Turbidity Monitoring Project No. 12-227 ECOSPAN

26/09/12

| Time ~~(GMT)~~ BST | Wind Speed (m/s) | Wind Direction (Deg) | Wave Height (m) | Wave Period (Sec) | Wave Direction | Swell Direction |
|---|---|---|---|---|---|---|
| 02:07 | 5.4 | 240 | 0.3 | Irregular | W | N/A |
| 02:32 | 4.6 | 240 | 0.3 | " | " | " |
| 03:08 | 2.4 | 210 | 0.25 | " | N/A | N/A |
| 03:39 | 3.3 | 40 | 0.25 | " | Irregular | N/A |
| 04:11 | 1.1 | 120 | 0.1 | " | N/A | N/A |
| 04:40 | 1.0 | 240 | 0.1 | " | N/A | N/A |
| 05.19 | 3.0 | 285 | 0.1 | " | N/A | N/A |
| 05:50 | 4.4 | 330 | 0.2 | " | N/A | N/A |
| 06:21 | 3.9 | 280 | 0.2 | " | N/A | N/A |
| 06:55 | 3.6 | 310 | 0.1 | " | N/A | N/A |
| 07:35 | 2.5 | 280 | 0.5 (0.1) | 3 secs | N | N |
| 08:10 | 2.9 | 330 | 0.5 (0.1) | 3 secs | 120 | N |
| 08.45 | 2.7 | 270 | 0.5 (0.3) | 3 Secs | 40 | N |
| 09:15 | 5.8 | 260 | 0.75 (0.7) | 3 secs | E | N |
| | | | | | | |
| 18:11 | 6.9 | 310 | 0.5 | irregular | N/A | N/A |
| 18:41 | 4.8 | 340 | 0.5 | " | " | " |
| 19:11 | 2.9 | 350 | 0.3 | " | " | " |
| 19:42 | 3.2 | 340 | 0.3 | " | " | " |
| 20.12 | 4.7 | 315 | 0.2 | " | " | " |
| 20:43 | 4.1 | 340 | 0.5 | " | " | " |
| 21:14 | 3.2 | 320 | 0.6 | " | " | " |
| 21:48 | 4.1 | 300 | 0.3 | " | " | " |
| 22:18 | 4.1 | 340 | 0.3 | " | " | " |
| ~~10~~22:49 | 4.6 | 330 | 0.4 | 0.5 | SW | " |
| 23:25 | 5.8 | 350 | 0.3 | irregular | " | " |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
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| | | | | | | |
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| | | | | | | |
| | | | | | | |

# APPENDIX 3 (CONTINUED) WIND AND WAVE OBSERVATIONS DURING MONITORING

Falmouth Water and Turbidity Monitoring Project No. 12-227

ECOSPAN

27/09/2012 Left shore 10.05 BST

| Time (GMT) | Wind Speed (m/s) | Wind Direction (Deg) | Wave Height (m) | Wave Period (Sec) | Wave Direction | Swell Direction |
|---|---|---|---|---|---|---|
| 09:23 | 3.3 | 310 | 0.2 | 1 sec | N/A | N/A |
| 09:53 | 1.3 | 280 | 0.2 | " | N/A | N/A |
| 10:24 | 3.8 | 320 | 0.2 | " | N/A | N/A |
| 10:54 | 3.6 | 320 | 0.3 | " | N/A | N/A |

# APPENDIX 4: YSI CALIBRATION PRE AND POST MONITORING

## YSI SONDE CALIBRATION CERTIFICATE

**SONDE S/N: 121274 – 6920V2 – 04H14124AA**
Date: 13/09/2012
Customer: Ecospan Environmental Limited.
Contact : Matt Hutchings

### CALIBRATION STANDARDS

Calibrated by Ecospan for SW 50,000 µS/cm

| | | | | | | |
|---|---|---|---|---|---|---|
| CONDUCTIVITY | 10000µS/CM | N/A | 1413µS/CM | N/A | 12880µS/CM | 12880 |
| DISSOLVED OXYGEN | 100% | 100 | mmHg | 760 | +vePolarisation | + |
| pH | 4.00 | 4.00 | 7.00 | 7.00 | 10.00 | 10.00 |
| pH mV | 4.00 | -16.5 | 7.00 | 155.7 | 10.00 | -193.8 |
| SLOPE CHECK | +162 TO +180→ | 172.2 | ↔ | 177.3 | ←162 TO 180 | Pass |
| ORP mV CHECK | Temp | N/A | mV | N/A | Within YSI spec | N/A |
| DEPTH | 0.0M | 0.00 | Press Offset | -14.681 | Within YSI spec | Y |
| TURBIDITY | 0.0 NTU | 0.0 | 100 NTU | - | 126 NTU | 126.0 |
| TURBIDITY OFFSET | Offset | 7.483767 | - | - | Within YSI spec | Y |
| CHLOROPHYLL | RFU Zero | N/A | OFFSET | N/A | Within YSI spec | N/A |
| BGA-PC/PA | ZERO | N/A | OFFSET | N/A | Within YSI spec | N/A |

### CALIBRATION CONSTANTS - DIAGNOSTICS

| | | | |
|---|---|---|---|
| CONDUCTIVITY | (0.92 TO 1.08) | 0.998095 | Pass |
| DO GAIN | (0.7 TO 1.7) | 1.027066 | Pass |
| DO CHARGE | (25 TO 75) | N/A | N/A |

ALL SENSORS ARE CALIBRATED TO YSI ACCURACY SPECIFICATIONS.

**Calibration Technician: Ben Johnson** **Date: 13/09/2012.**

YSI calibration at end

100 NTU standard reading: 107.1
DO measurement 100%. reading: 99.7
Temperature against calibrate thermometer: 15.5 °C
YSI meter reading: 15.45 °C
Conductivity 50000 µS/cm reading: 49569

MJH 27/09/2012

# Appendix H – HR Wallingford Report

# Port of Falmouth Development Initiative

## Review of dredging effects


DDM7706-RT001-R02-00

April 2016

# Document information

| | |
|---|---|
| Document permissions | Confidential - client |
| Project number | DDM7706 |
| Project name | Port of Falmouth Development Initiative |
| Report title | Review of dredging effects |
| Report number | RT001 |
| Release number | R02-00 |
| Report date | April 2016 |
| Client | Royal Haskoning DHV |
| Client representative | Caroline Price |
| Project manager | John Baugh |
| Project director | Tim Chesher |

# Document history

| Date | Release | Prepared | Approved | Authorised | Notes |
|---|---|---|---|---|---|
| 29 Apr 2016 | 02-00 | JVB | TJM | TJM | |
| 12 Apr 2016 | 01-00 | JVB | TJM | TJM | |
| 30 Mar 2016 | 00-01 | JVB | TJC | TJC | |

# Document authorisation

| Prepared | Approved | Authorised |
|---|---|---|
| | Tom Matthewson | Tom Matthewson |

# Summary

The Falmouth Harbour Commissioners (FHC) and Falmouth Docks and Engineering Company Ltd (FDEC) have previously submitted three applications to the Marine Management Organisation (MMO) which together form a proposal to improve the port facilities and approach channel at Falmouth, Cornwall. This project is known as the Port of Falmouth Development Initiative (PFDI).

The applications were made in 2009 and included a package of hydrodynamic modelling and sedimentation assessments. The 2008 hydraulic studies were undertaken to provide a suitable worst case scenario for the assessment of environmental effects as is usually done for EIA, Since then there have been a number of discussions regarding the hydrodynamic modelling and resulting sedimentation predictions. As this has been ongoing over a period of several years, this short technical note has been developed in order to address the outstanding matters regarding the modelling applied and support the production of the Habitats Regulation Assessment (HRA).

# Contents

# 1. Introduction

The Falmouth Harbour Commissioners (FHC) and Falmouth Docks and Engineering Company Ltd (FDEC) have previously submitted three applications to the Marine Management Organisation (MMO) which together form a proposal to improve the port facilities and approach channel at Falmouth, Cornwall. This project is known as the Port of Falmouth Development Initiative (PFDI).

The applications were made in 2009 and since then there have been a number of discussions regarding the hydrodynamic modelling and resulting sedimentation predictions. Since this has been ongoing over a period of several years, this short technical note has been developed in order to address the outstanding concerns regarding the modelling applied and support the production of the Habitats Regulation Assessment (HRA).

The information available for the assessment is the hydraulic studies undertaken to support the Environmental Impact Assessment (EIA), reported in HR Wallingford (2008), and the suspended sediment concentration monitoring undertaken during a trail dredge and relaying of maerl (Ecospan, 2012). It should be noted that the 2008 hydraulic studies were undertaken to provide a reasonable worst case scenario for the assessment of environmental effects as is usually done for EIA.

The main issues are associated with the presence of live maerl to the south of the proposed dredge area and the proposed translocation of maerl to the channel following the dredge.

The outstanding points can be summarised as follows:

**Confirmation of the risk of smothering maerl due to fine sediment release during the dredging operation.**

1. Comparison of the modelled and likely fine sediment release rates.
2. Assess the total deposition likely due to the dredging operation.
3. Make reference to the results of the sediment monitoring undertaken during the dredging trial.

**Confirmation of the risk of smothering maerl due to sedimentation in, and adjacent to, the completed dredged channel**

1. Assess short and medium term sedimentation rates in, and adjacent to, the channel – for sand and fine sediments.
2. Assess the likely area affected by side slope adjustment, particularly on the southern side of the channel.

These questions are addressed in turn below.

# 2. Fine sediment release rate during the dredge

## 2.1. Modelled scenario

The material types anticipated being dredged are summarised in Table 2.1 below. For the purposes of the assessment, all the sediment types including some fine sediment (clay and mud) were assumed as being mostly fine even in cases such as the 'clay with frequent maerl' which makes up 35% of the total dredge.

Table 2.1: Summary of dredged spoil types used for sediment plume assessment

| Material | Volume ($m^3$) | Volume (%) |
|---|---:|---:|
| Mud | 866 | 0.12 |
| Clay | 115,171 | 16.54 |
| Sand | 22,416 | 3.22 |
| Rock (slate/shale) | 25,500 | 3.66 |
| Maerl | 119,649 | 17.19 |
| Clay with frequent maerl | 244,004 | 35.05 |
| Sand or sand and gravel with frequent maerl | 162,933 | 23.4 |
| Mud with maerl | 5,573 | 0.80 |
| **Total** | **695,112** | **100** |

Two scenarios were modelled (HR Wallingford, 2008), one for the contaminated material using a 2.5 $m^3$ backhoe dredger, and one for uncontaminated material using a 5 $m^3$ backhoe dredger. The bucket was assumed to be open, i.e. without a visor or other means sediment release reduction. A loss rate of 17 kg/$m^3$ dredged and a dredging operation every 30-40 s, dredging continuously resulted in the release of 1 kg/s for the smaller bucket backhoe and 2 kg/s for the larger. Furthermore all the material lost from the dredging was assumed to be in the fine sediment fraction.

Sediment release was modelled at three locations to encompass the areas of proposed dredging to demonstrate the likely maximum footprint of any plume generated during the dredging. In reality the dredger will frequently relocate such that any area affected by the sediment plume will also frequently change. The above scenario was designed to provide a reasonable worst case for assessing the impacts of the dredging operation. This was precautionary, in line with the overall approach taken to the EIA at the time.

The model results were presented as the maximum increase in suspended sediment concentration and maximum depth of deposition predicted for each modelled scenario. The maximum increase in suspended sediment concentration figures for spring tides show the maximum spread from the sediment release locations during any spring tides for the entire dredge duration. The neap tide results show the maximum increase in suspended sediment concentration near to the dredger and the maximum depths of deposition likely for dredging at the modelled dredger locations.

## 2.2. Likely scenario

Use of a closed bucket with a visor is considered to be very likely based on the sensitivity of the site, particularly for the contaminated sediment. Measurements of a closed backhoe in the Netherlands, working

in fine sediments suggested a loss rate of 11 kg/$m^3$ dredged (Waterloopkundig Laboratarium, 1990). Other literature suggests loss rates for modern closed bucket backhoes may be half those of open bucket backhoes. A reduction in the amount of sediment lost per bucket load will influence both the short term increase in suspended sediment concentration due to the dredge and the amount of material deposited both as short term temporary deposition at slack water and deposited permanently.
The dredger working rate is also unlikely to be as fast as assumed throughout the operation due to, for example, barge movements, plant maintenance, weather and other operational factors. An operation per minute is considered more likely as a long term average.

Vibrocore data collected since the 2008 studies showed notable layering in the bed material with the surface material often being sand size material, including significant amounts of maerl with very low fine sediment content. Further down layers of fine sediment are occasionally found, although these are interspersed with coarser sediments and in many of the samples mixed sediments were found. Therefore the modelled loss rate, with all the losses in the fine sediment fraction, is only likely to happen for a proportion of the dredge.

Based on the above assessment, the more likely sediment release rate is considered to be 30% - 50% of the precautionary scenario modelled during periods when fine sediment is encountered. This reduced release rate could halve the short term elevations in suspended sediment concentration, and the rate of sediment deposition as modelled. Furthermore for periods where no fine sediment is present in the dredged material (approximately 50% of the total dredged volume) negligible fine sediment release is anticipated.

Based on the above the likely results for dredging at Sites B and C, adjacent to the maerl areas are presented in Figure 2.1 to Figure 2.4, below. As the effect is directly proportional to the amount of sediment introduced, the consequential effects, as plotted, are also scaled down by 50%.

It should be noted that in addition to the fine sediment release as modelled, some coarser sediments may be released during the dredge. This material will have a larger settling velocity, and will therefore fall into the area to be dredged and will be subsequently re-dredged. No dispersion of coarser sediments is anticipated outside the proposed dredge area.

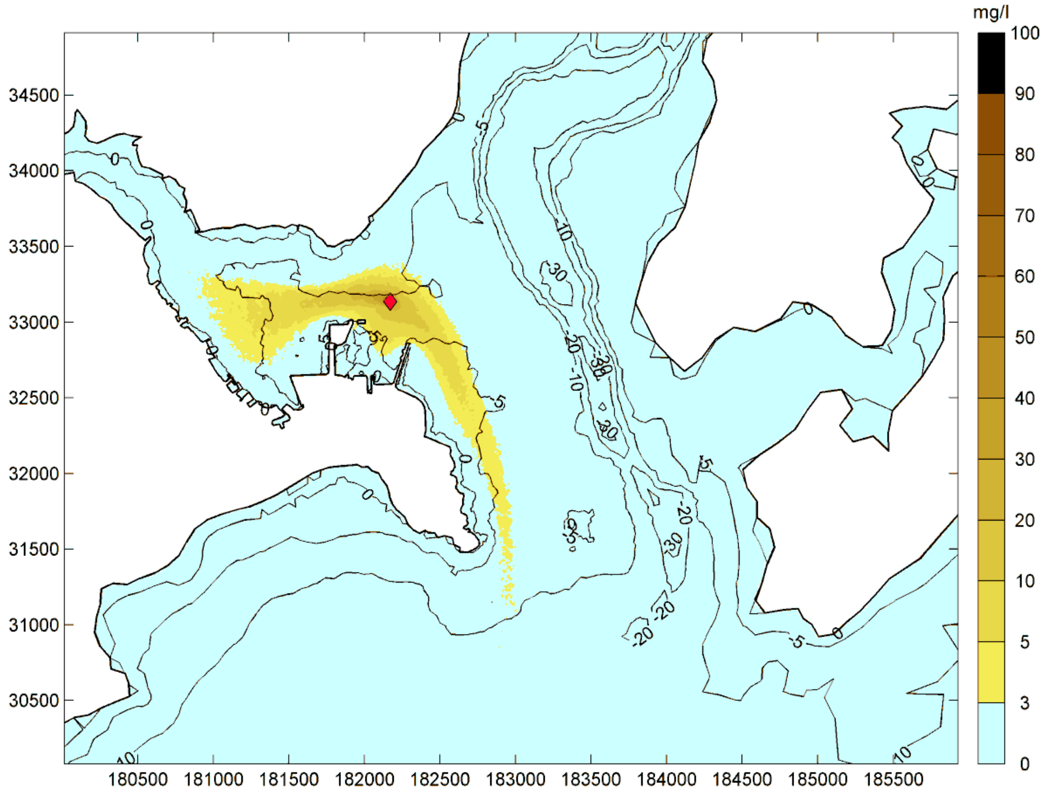


Figure 2.1: Maximum increase in suspended sediment concentration for backhoe dredging at Site B, spring tide

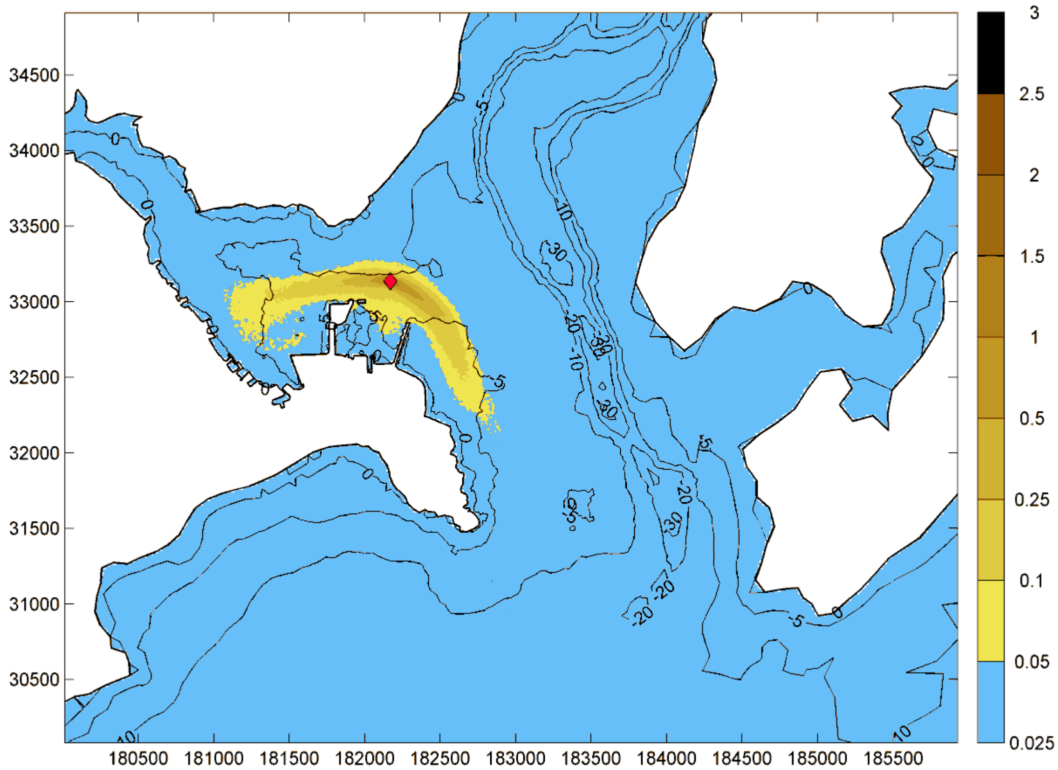


Figure 2.2: Maximum fine sediment deposition depth during backhoe dredging at Site B, spring tide

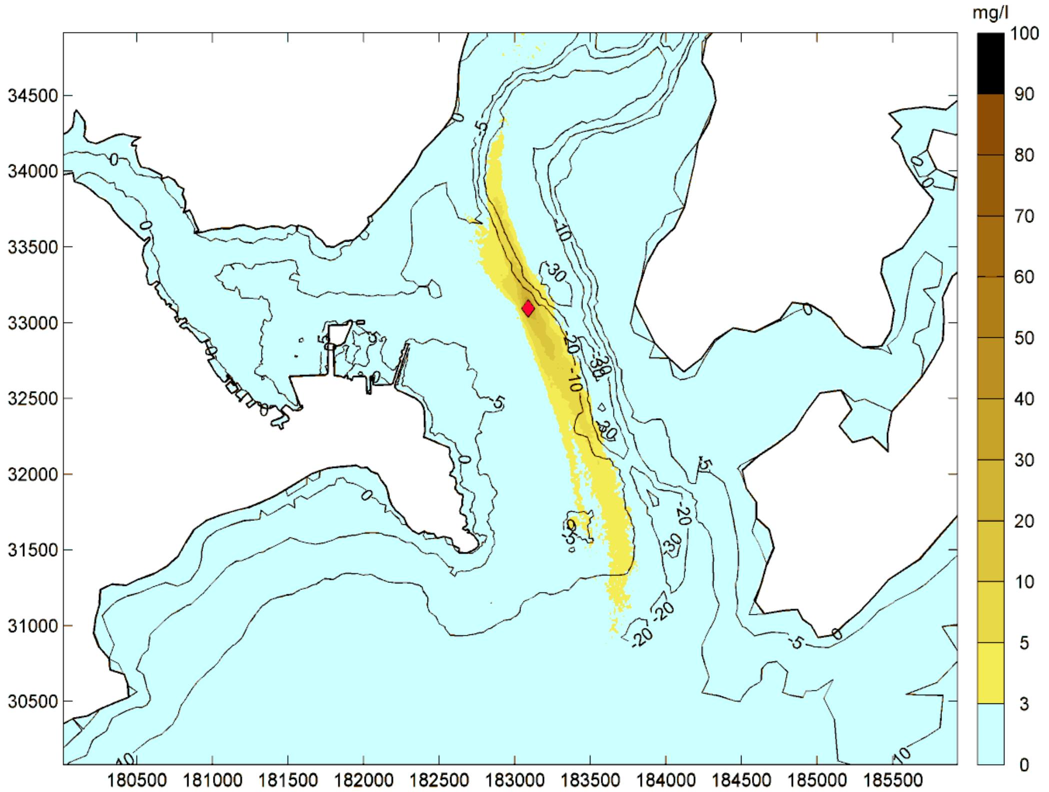


Figure 2.3: Maximum increase in suspended sediment concentration for backhoe dredging at Site C, spring tide

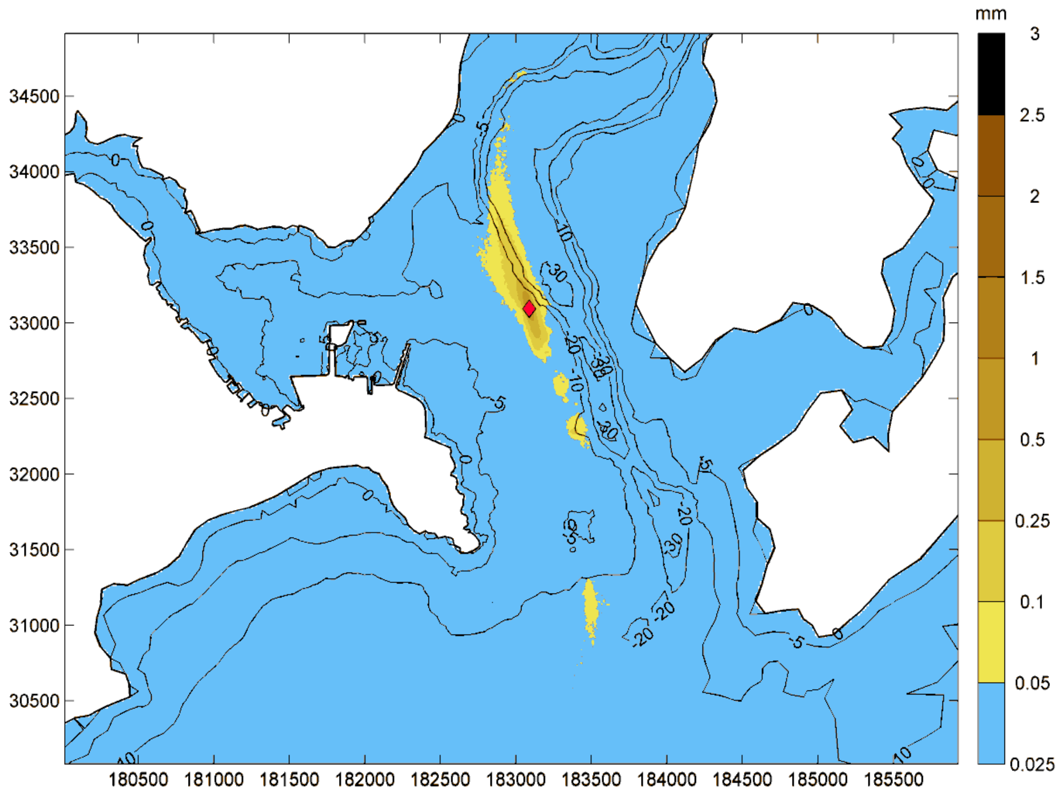


Figure 2.4: Maximum fine sediment deposition depth during backhoe dredging at Site C, spring tide

## 2.3. Comparison with trial dredge monitoring results

Monitoring of suspended sediment concentrations was undertaken during a trial dredge and relay of bed material containing maerl (Ecospan, 2012). The dredging operation was undertaken by a barge mounted backhoe dredger fitted with a 2 $m^3$ toothless grading bucket. No visor or other sediment release reduction method was used for the trial dredge.

The results indicate considerable variation in the increase in suspended sediment concentrations associated with the dredging; with 2 out of the 6 sets of dredging operations monitored showing no detectable plume. Of the other 4 some of the highest suspended sediment concentrations (up to 96 mg/l) are shown after the instrument reached the bed and therefore may be due to disturbance of the bed by the instrument; however even during the instrument descent suspended sediment concentrations of 50-70 mg/l are shown by the measurements. An example of the results is provided in Figure 2.5 which shows the vertical profile of suspended sediment concentration for dredging operations at Location 2. The maximum suspended sediment concentration is shown at 25 m distant from the dredging operation. The observed peak values then reduce to slightly over 10 mg/l at 50 m from the dredger and no plume is detectable at 100 m downstream from the dredger.

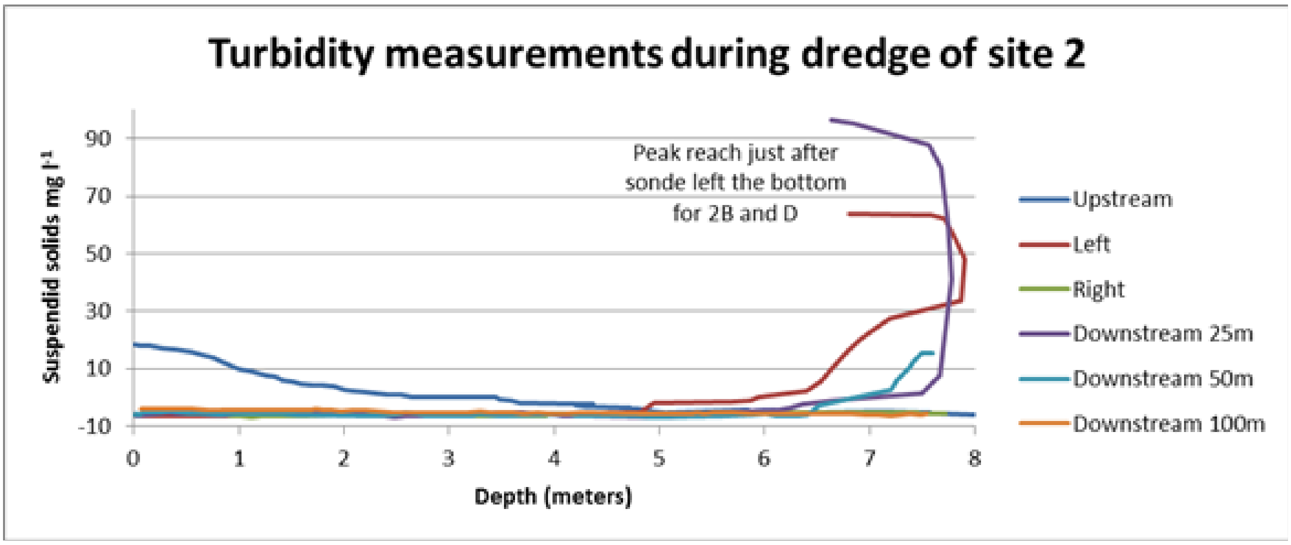


Figure 2.5: Trial site 2 Cruciform station during dredge Turbidity measurements

*Source: Ecospan (2012)*

The monitoring results confirm the view presented by the modelling of limited spatial extent of the sediment plume. For comparison Figure 2.6 shows the model results for sediment release at a site nearby Queens Quay. Circles indicating 25 m, 50 m and 100 m from the sediment release point are overlaid for reference. As might be expected the results, for a 5 m dredger bucket, show larger increases in suspended sediment concentration than those monitored with peak values of up to 150 mg/l occurring within 25 m of the dredger. These suspended sediment concentration fall to approximately 80 mg/l at 50 m distant from the dredger and 60 mg/l at 100 m from the dredger.

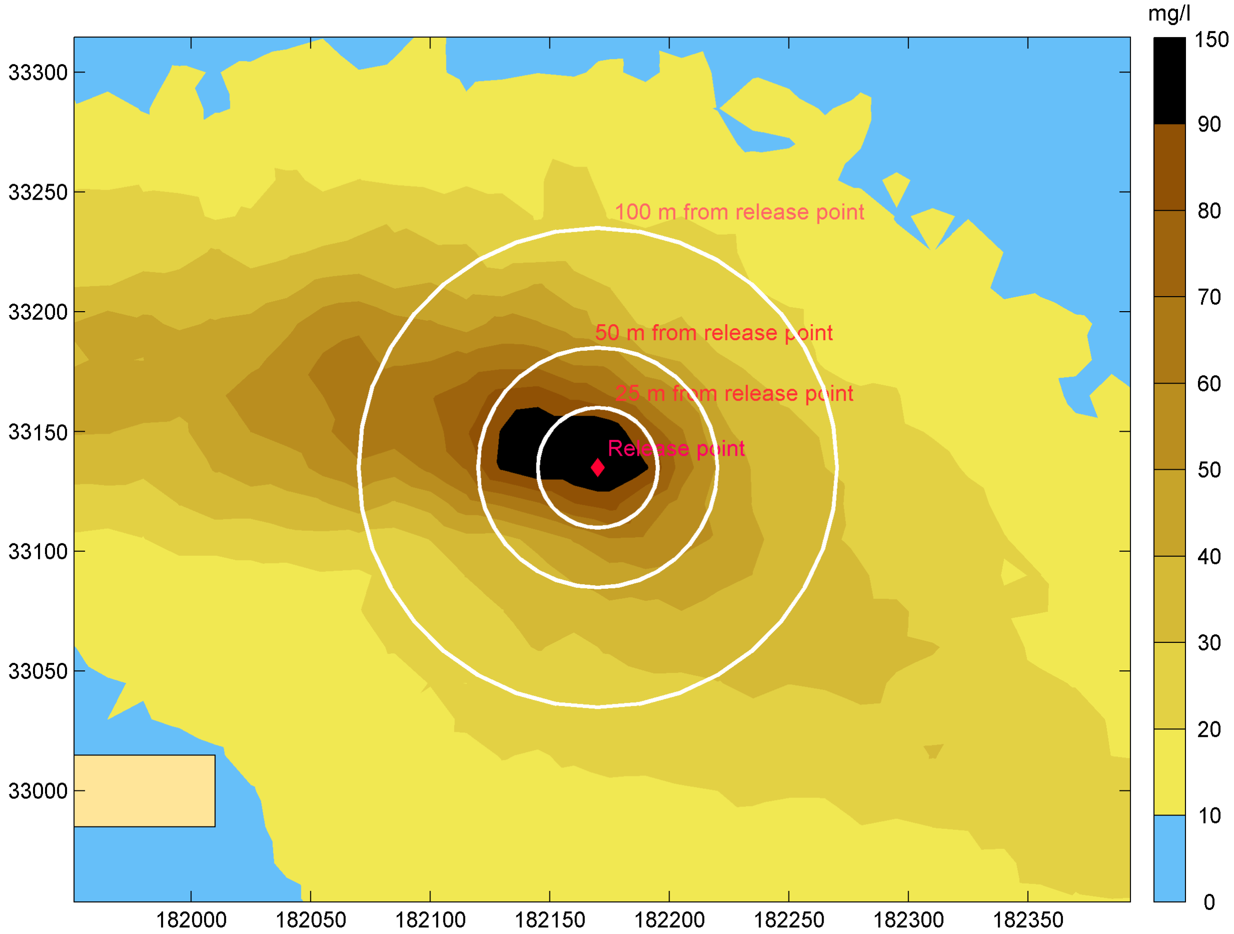


Figure 2.6: Maximum increase in suspended sediment concentration due to dredging at Site B

# 3. Summation of deposited material released during the dredge

HR Wallingford (2008) evaluated the long term total sediment deposition in a series of polygons (Figure 3.1). The estimates were based on the amounts of material depositing in each area during the sediment release modelling simulations. The results were presented in terms of total deposited mass and converted to a volume using an assumed dry density of 500 kg/m$^3$ and are repeated in Table 3.1, below for completeness From the deposited sediment volume and knowledge of the area of each polygon the average deposition depth could be calculated . The results suggested very low average deposition depths in the long term, all being less than 2 mm over the 6-12 months of the dredge with the potential rate of supply of sediment being minimised by the longer dredge period. The total amounts of fine sediment depositing during the dredge are unlikely to change the nature of the bed in the areas studied.

The reduced sediment release mass described above, reflecting the likely situation rather than the assumed precautionary scenario, would also significantly reduce the total fine sediment depositing. This may reduce the average depth of deposition to less than 1 mm over the 6-12 months of the dredge.

A proportion of the deposited sediment may, at some point, be re-eroded by, for example, storm wave events. The sediment settled from the plume will be a very small fraction of the fine sediment already present. The suspended sediment concentration increase during these resuspension events as shown by the mud modelling presented in HR Wallingford (2008) will therefore not be noticeably increased compared to that which would have occurred before the dredging. For reference an example of the modelled suspended sediment concentration for waves with 1 year return period waves from the south is shown in Figure 3.2. Concentrations of 16-30 mg/l (0.016-0.030 kg/m$^3$) are shown throughout the area of the dredge and in the areas seawards.

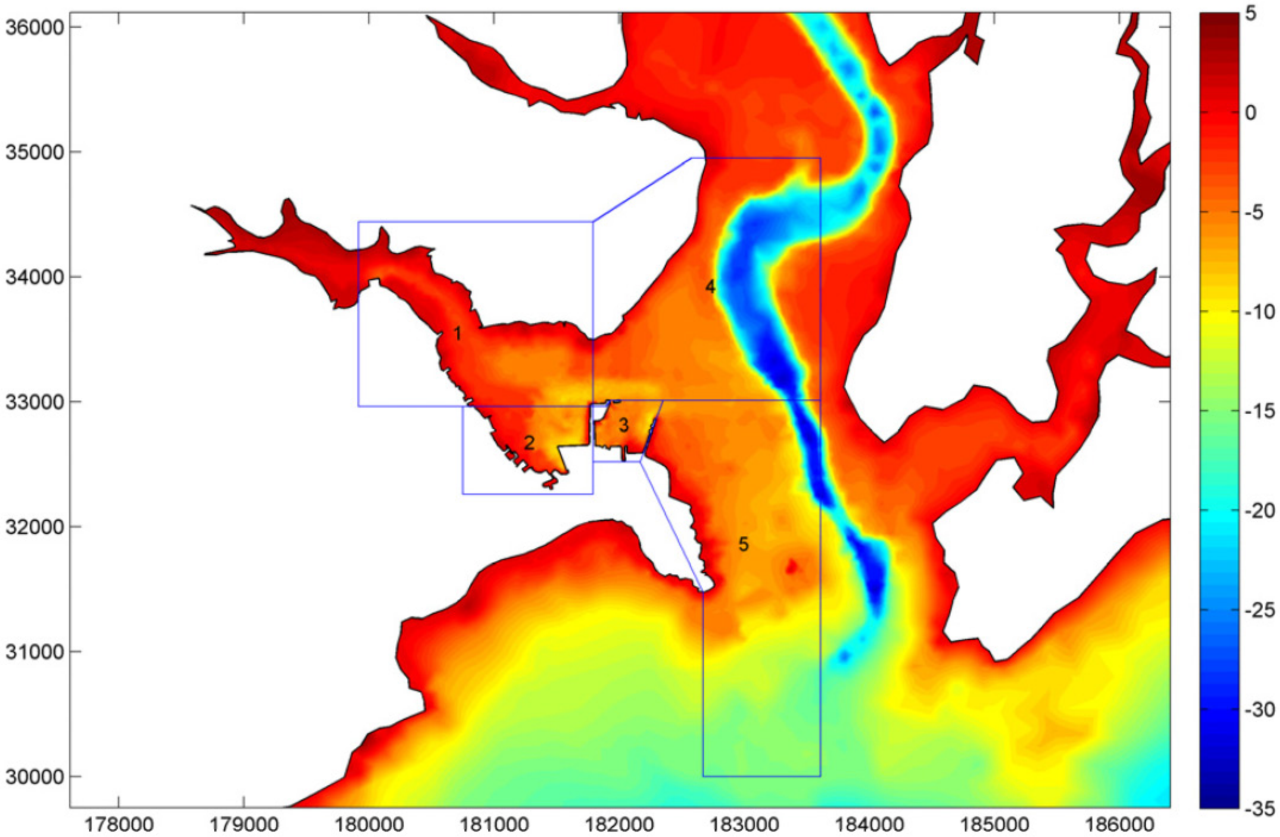


Figure 3.1: Polygons used for total deposition calculations

Table 3.1: Total deposition due to whole dredge

| Area | Total mass deposited (T) | Total volume deposited (m$^3$ @ density 0.5 T/m$^3$) | Area of (m$^2$) | Average depth of deposition (mm) |
|---|---|---|---|---|
| 1 | 292 | 600 | 110,100 | 0.5 |
| 2 | 195 | 400 | 329,000 | 1.2 |
| 3 | 106 | 200 | 162,000 | 1.3 |
| 4 | 2,160 | 4,300 | 2,488,000 | 1.7 |
| 5 | 1,633 | 3,300 | 2,909,000 | 1.1 |

*Source: HR Wallingford (2008)*

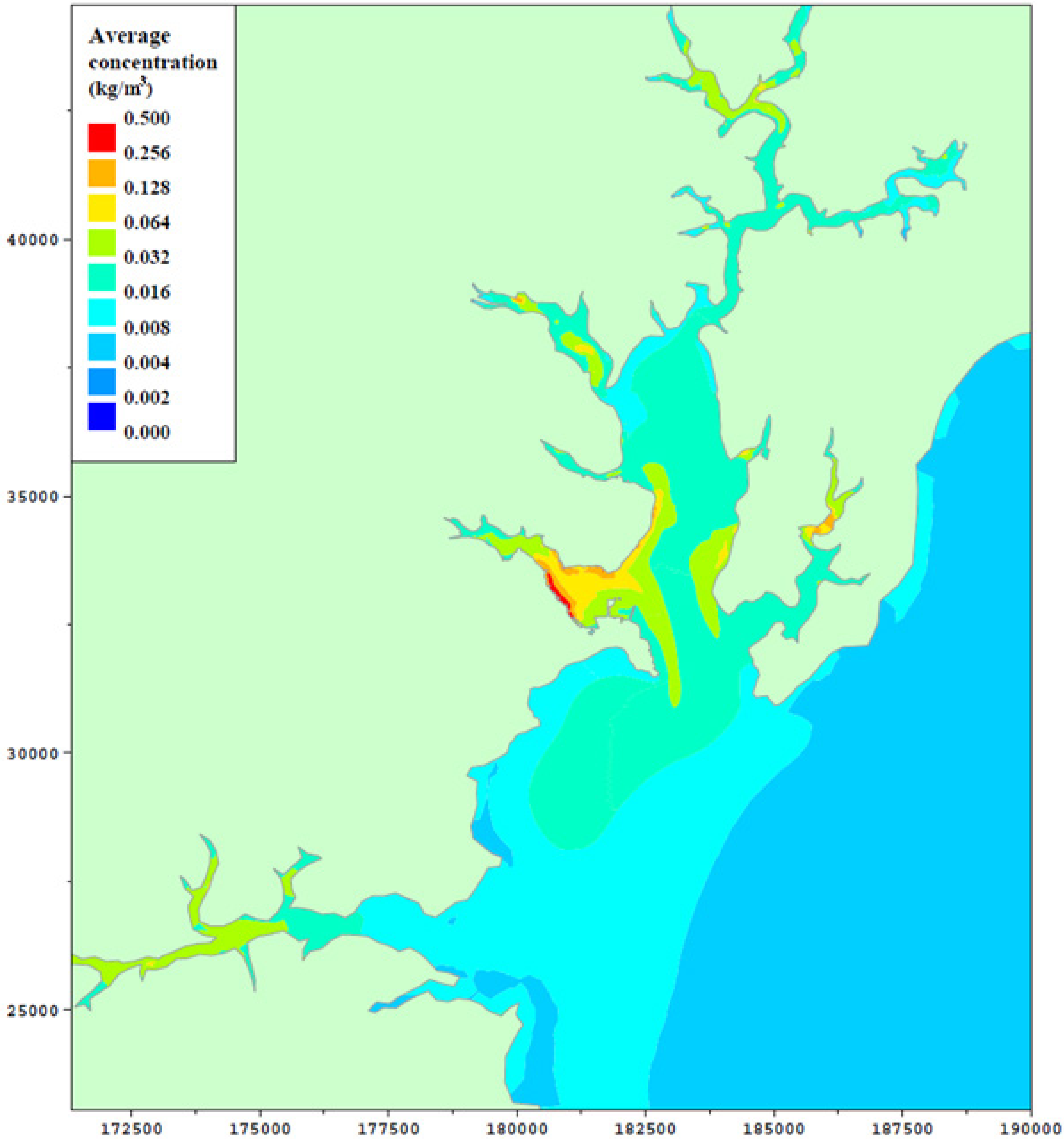


Figure 3.2: Maximum suspended sediment concentration for waves with 1 year return period waves from the south

*Source: HR Wallingford (2008)*

# 4. Infill in the dredged channel

The sand and mud transport modelling undertaken for the ES (HR Wallingford, 2008) predicted no overall change to potential sediment transport patterns or patterns of deposition or erosion in the harbour and wider coastal sea area. The only area with some change to sediment transport was in the completed dredged channel itself.

## 4.1. Mud

The mud transport modelling assumed the intertidal areas would be predominantly muddy with a potential to erode under storm wave condition and so supply sediment to the channel. The modelling confirmed the extremely low suspended sediment concentrations expected for calm conditions. Using a combination of the results for calm and storm conditions a prediction of 2,360 $m^3$/year of muddy infill in the area of the channel was made for the un-dredged (existing) bathymetry. In reality, no maintenance dredging is done in the channel area and therefore the identified material must be removed. This will either be by other combinations of tide and waves or by the forces of vessels' passage.

With the dredged channel in place the infill rate could be increased by a maximum of approximately 600 $m^3$/year assuming the existing processes which exclude sediment accumulation presently continue unchanged (a precautionary assumption). It is likely that the passage of larger vessels as are intended to use the channel will reduce the predicted fine sediment infill rate. Comparison of the simulations of the before and after patterns of deposition confirmed a negligibly small increase in average annual deposition rate of fine muddy sediment as approximately 2 mm/year (HR Wallingford. 2008).

This extremely small increased rate of fine sediment supply to the bed is unlikely to noticeably change the substrate within the channel post dredging.

## 4.2. Sand

Sand may deposit in the dredged channel directly from material in motion or the adjustment of the dredged side slopes shortly after the dredge. Side slope adjustment is considered in Section 5. This section focusses on deposition of sand from the background sand transport pattern.

The sand transport modelling assumed abundant sand supply throughout the model area. Therefore in areas such as Carrick Roads where gravels are more common, the model predictions are likely to be significant over-predictions. The bed grab data in the area (Figure 4.1) showed sand sized material was rare in the area of the channel with samples being dominated by fine sediment in Inner Falmouth Harbour or gravel size material in Carrick Roads. Furthermore the assessment of the material to dredge only included 3% sand, although there was also 23% sand or gravel with frequent maerl.

Modelling the existing conditions gave a total annual infill rate of 20 $m^3$/year, suggesting that presently the hydrodynamic forces exclude an overall accumulation of sand in the area of the proposed channel. Using the same assumption of abundant sand availability, sand infill in the dredged channel was predicted as up to 5,500 $m^3$/year. The predicted infill volume was dominated by infill on the south-eastern edge of the channel towards Carrick Roads where potential sand transport rates are highest due to increased currents and wave energy.

With the dredging in place the infill predicted occurred because the sand fluxes towards the channel were broadly unaltered but the increased water depth in the channel allowed deposition. Therefore deposition was seen at the edge of the channel. The reporting of the results suggested that a proportion of the increased infill would be a temporary factor whilst the dredged side slope adjusted as is often the case for dredged channels. Side slope adjustment is further discussed below. The potential area which may experience side slope adjustment is indicted in Figure 4.2.

It is considered that the likely long term rate of sand accumulation in the dredged channel is significantly less than the 5,500 $m^3$/year predicted by the precautionary modelling of the 'as dredged' bathymetry. Based on the assumption of abundant sand availability, long-term sand deposition rates are anticipated to be 10 mm/year on average (less than 1 mm per month) with 5-10 mm/year shown in the centre of the channel and 10-50 mm/year possible at the edge of the channel (Figure 4.2). Assuming a long term accretion rate of 10 mm/year throughout the area of the channel suggests a total infill rate of up to 2,500 $m^3$/year. A further reduction in the annual sand deposition rate would be expected based on the reduced availability of sand on the sea bed in the area (shown by Figure 4.1). The infill total would also be expected to be reduced by the effects of vessel passage in the completed channel, although the reduced mobility of sand sized material would suggest less of a reduction in infill compared to fine, muddy sediments.

Based on the low long-term sediment accumulation rate it remains our view that regular maintenance dredging is unlikely to be required in the proposed dredged channel.

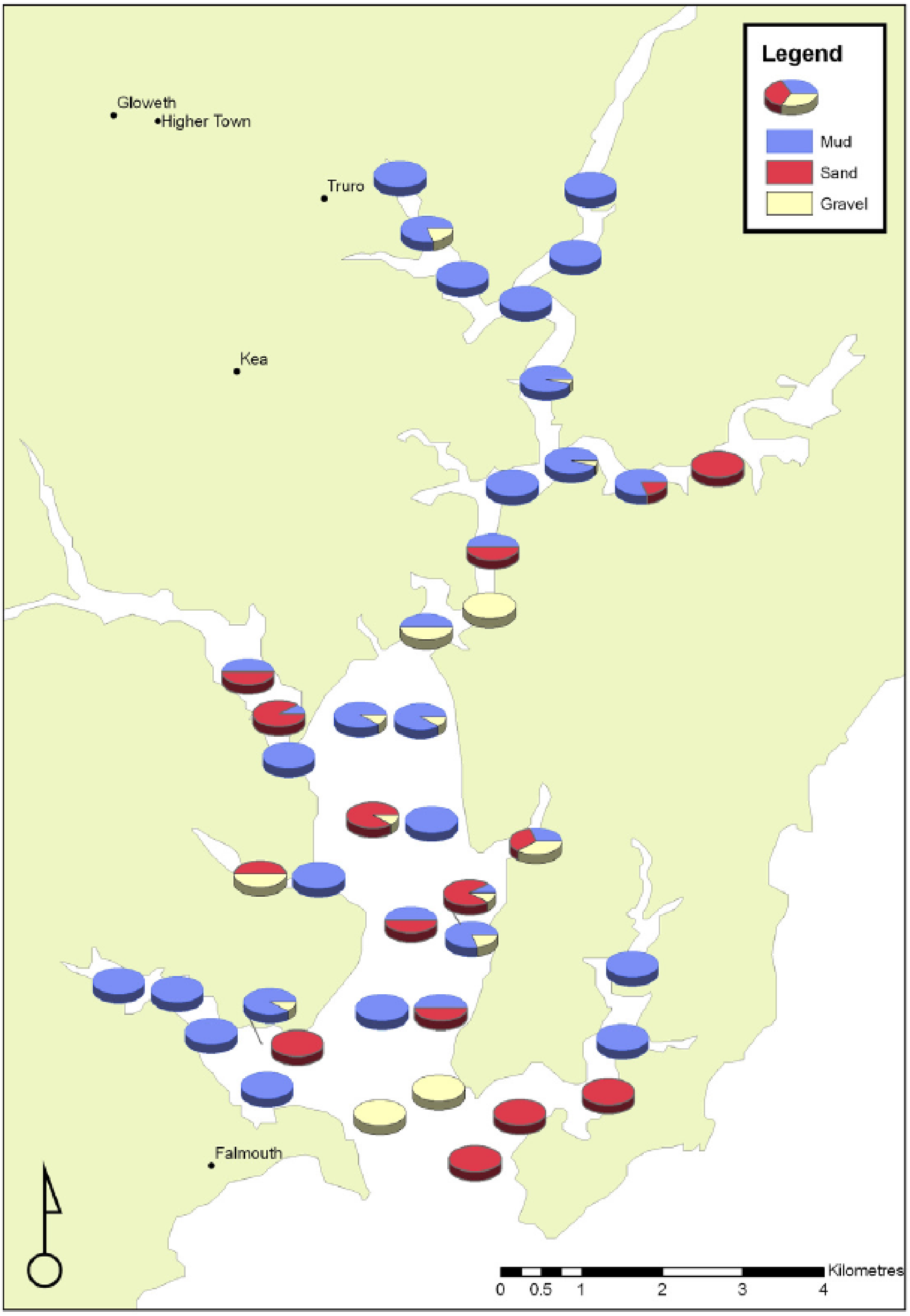


Figure 4.1: Surficial bed grab data

*Source: HR Wallingford (2008)*

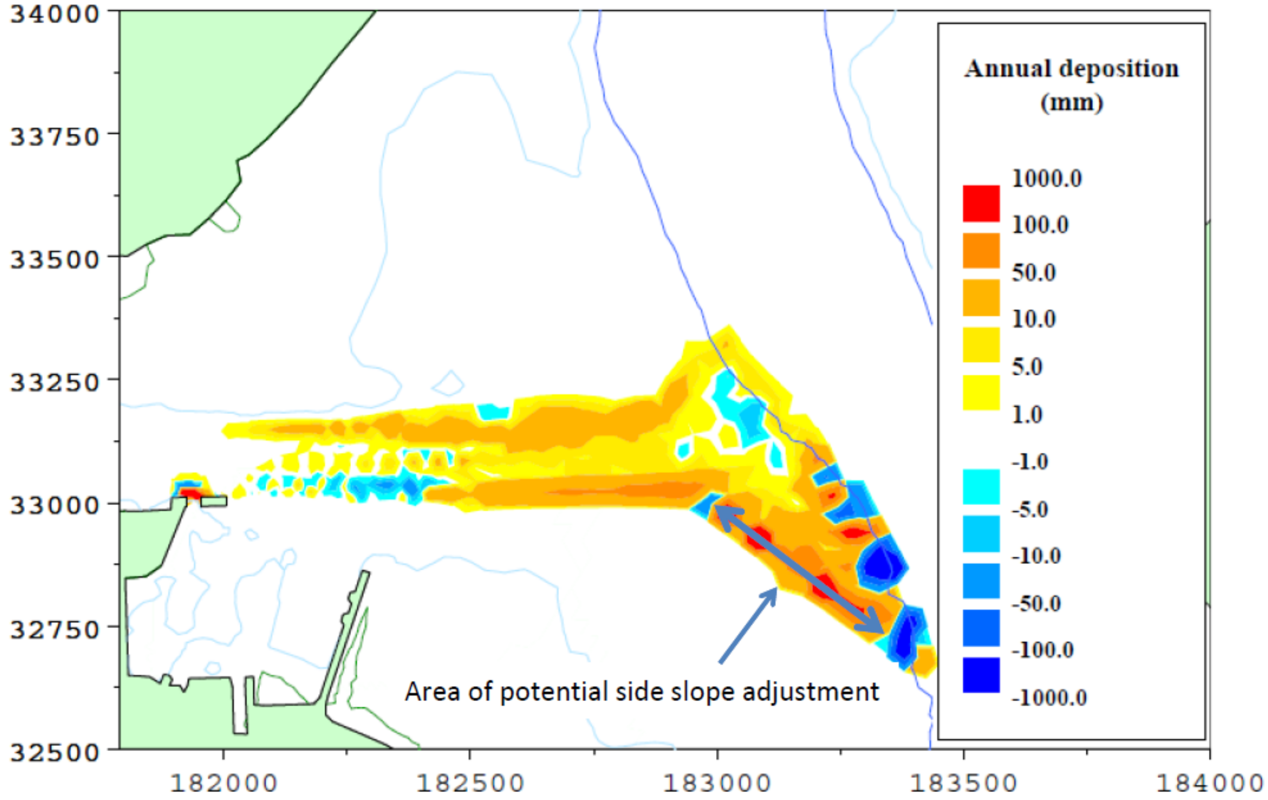


Figure 4.2: Predicted annual deposition of sand in dredged channel

*Source: HR Wallingford (2008)*

# 5. Side slopes

The sand transport modelling (HR Wallingford, 2008) reported that the area of largest predicted infill rate (along the south-eastern of the channel edge as indicated by Figure 4.2) would be a temporary factor whilst the dredged side slope adjusted, as is often the case for dredged channels. Slope adjustment is anticipated in this area as it is the part of the channel with the highest tidal currents, most exposure to wave forces and hence largest sand transport fluxes. This temporary factor resulted in the predicted sand deposition rate of 5,500 $m^3$/year as reported in HR Wallingford (2008) compared to the longer term sand infill rate of 2,500 $m^3$/year as described in Section 4.2.

The present outline channel design assumes side slopes of 1:5. The deepest depth of dredging is between 2.5 m and 3 m therefore the top of the side slope will be between 12.5 and 15 m from the bottom of the slope following dredging.

British Standard guidance BS6349-5 proposes appropriate slopes in “active water” as 1:4 for sandy clay, 1:6 for coarse sand and 1:12 for fine sand. Inspection of the particle size data from the vibrocores collected along the southern side of the proposed dredge area describes the top 1 m or so to be coarse sand sized material overlaying finer sediments and including some layers of clay. The observed sediment types, particularly the coarse sand sized material at the top part of the dredge suggests the 1:5 slope as dredged may adjust to a shallower slope in areas of higher wave activity.

Inspection of the available bathymetry data suggests natural side slopes of up to 1:10 are present in the area and therefore for a precautionary assessment the dredged side slopes may revert to these shallower slopes. A 1:10 slope would result in extending the distance from the bottom to the top of the slope from 15 m to 30 m.

Based on the model results which indicate a tendency for accumulation of sand sized material at the bottom of the side-slope (Figure 4.2), it is anticipated that most of the slope adjustment will occur due to sediment accumulation at the bottom of the slope. The observed bed material should exclude significant adjustment of the side slope by slumping of the coarse sand present beyond a slope of 1:6. The presence of clay in the deeper areas of the dredge should also minimise any erosion of undredged areas due to slumping. Therefore erosion at the top of the slope in the area shown by Figure 4.2 beyond a few metres from the top of the dredged slope is considered very unlikely.

Following side slope adjustment, which may occur during the first year following the dredge, depending on the number of storm wave occurrences, infill rates in the channel would reduce to the long term value described in Section 4.

# 6. References

Ecospan (2012). Monitoring Of Water Quality During Maerl Translocation Trials In Falmouth. Report ER12-227.

HR Wallingford (2008). Falmouth Cruise Terminal. Hydrodynamic and sedimentary Studies. Report EX5809.

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