

REPORT

Goodwin Sands Aggregate Dredging Environmental Statement

Volume III - Appendices

Client: Dover Harbour Board

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Appendix 2.1

Dredge Area Site Selection

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1 Introduction

1.1 Overview

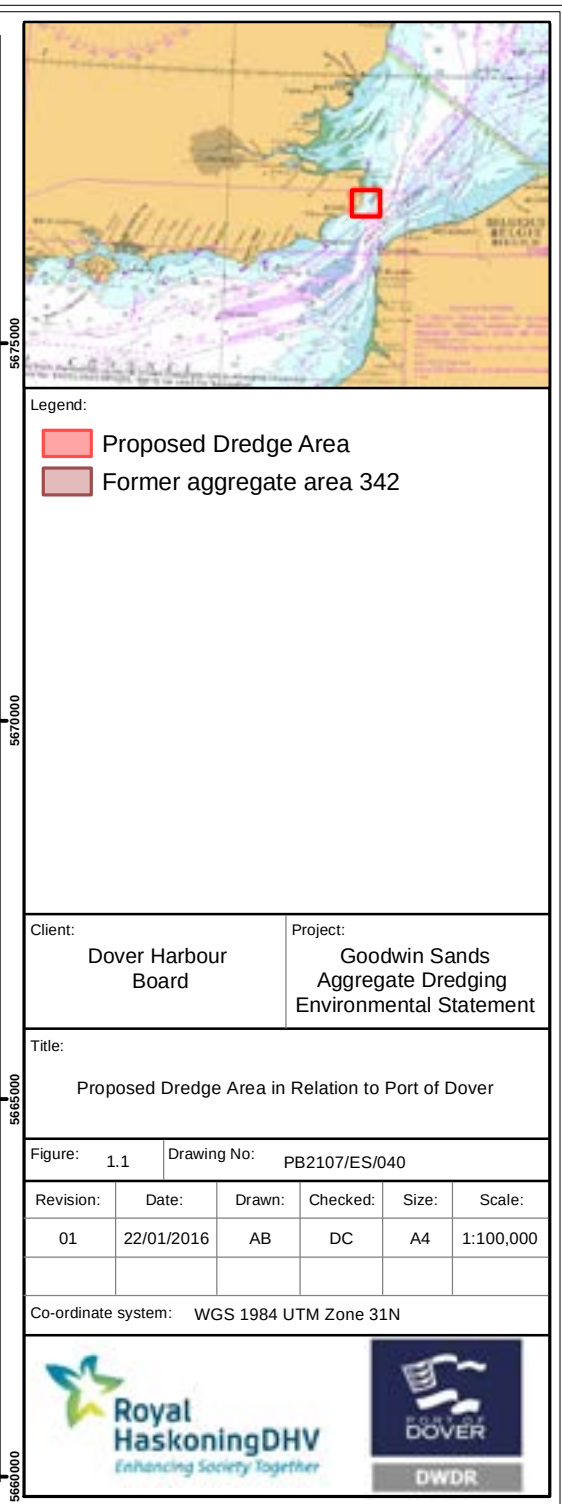
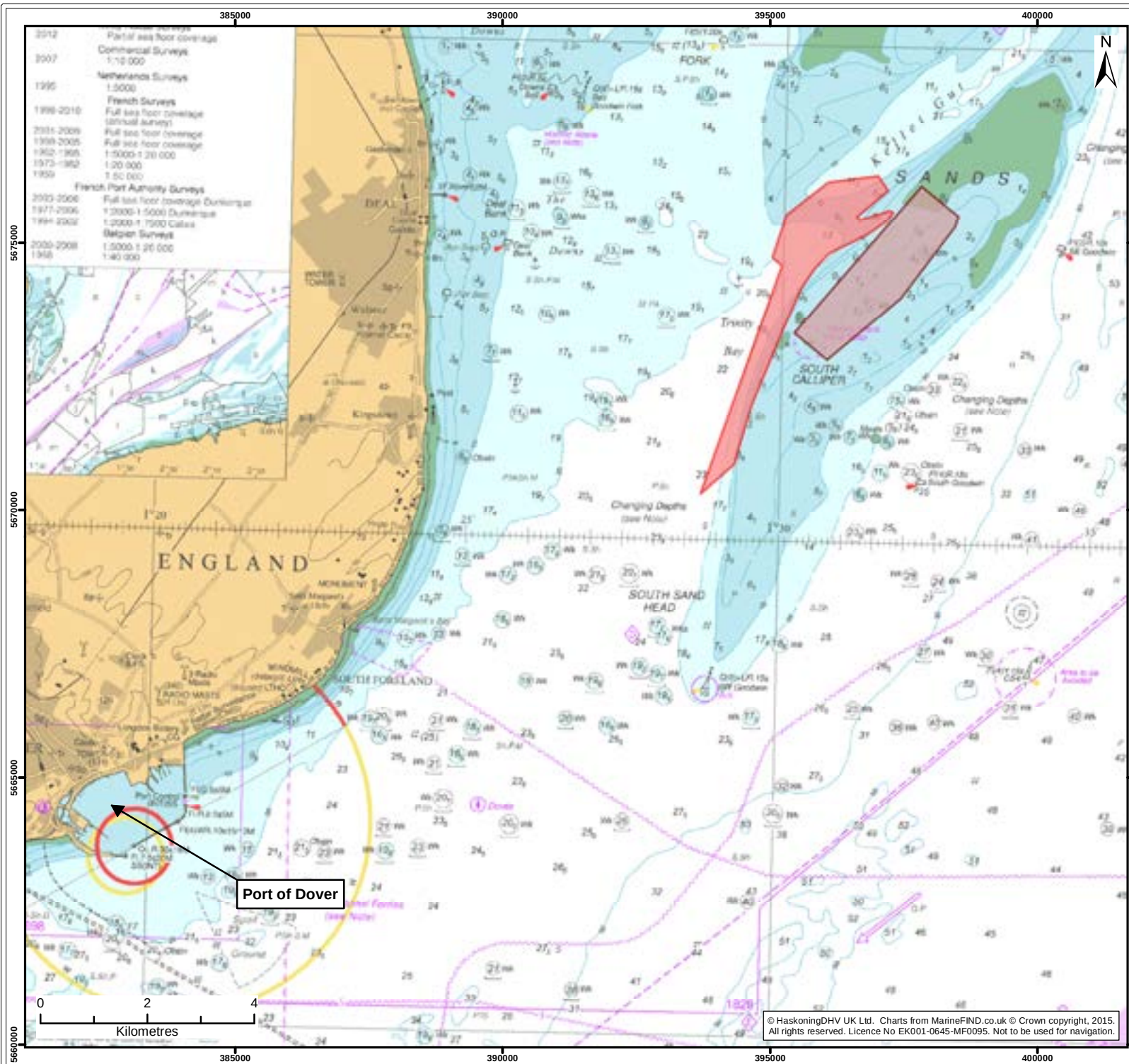
This appendix to the Environmental Statement (ES) describes in detail the processes followed and methods used to select the proposed dredge area at South Goodwin Sands (see **Figure 1.1**), supporting and expanding on **Section 2.2** of the ES. It describes the geophysical, geotechnical and ecological surveys undertaken and explains how physical, ecological and socio-economic constraints have been taken into account in the site selection.

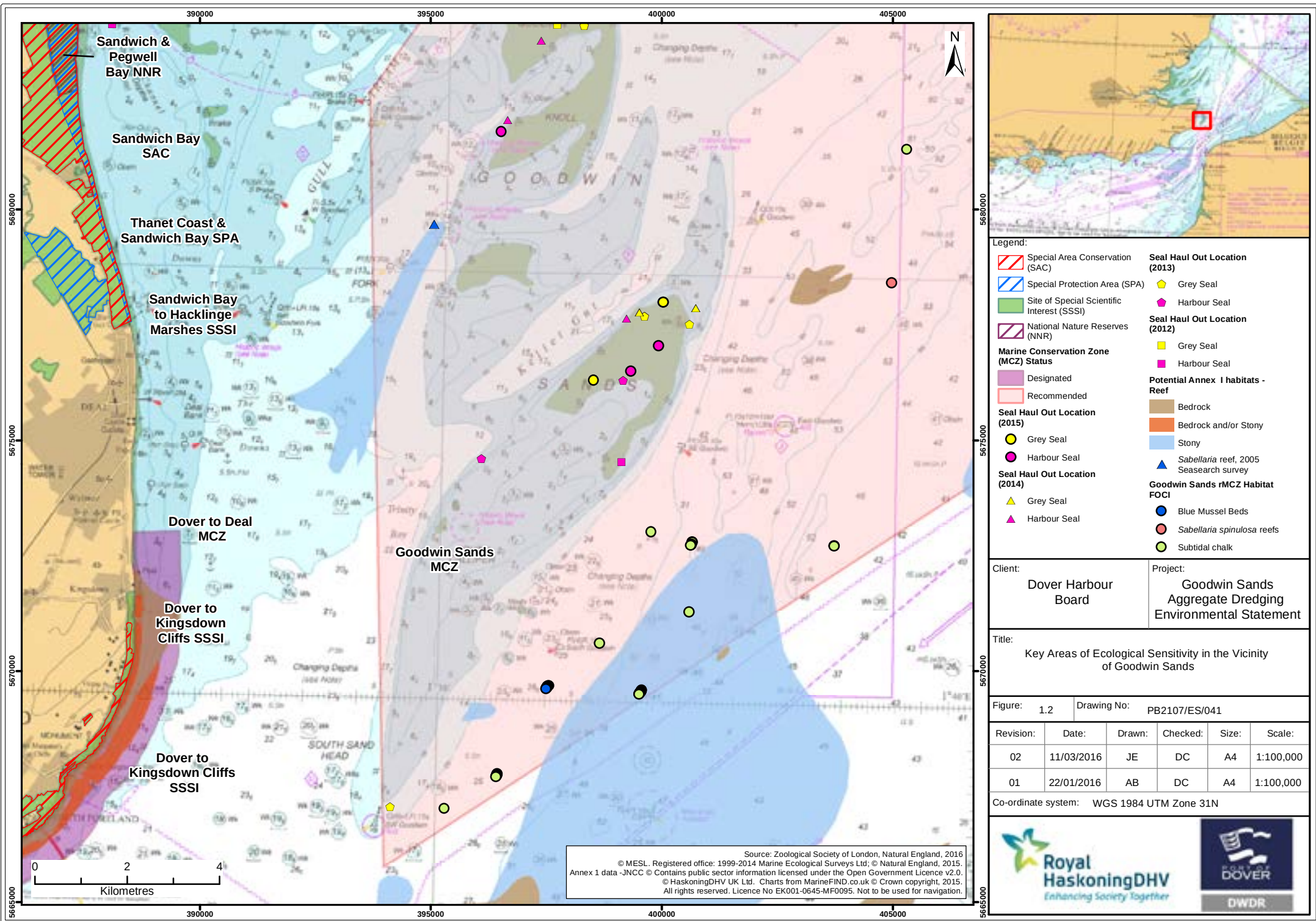
1.2 Exploration

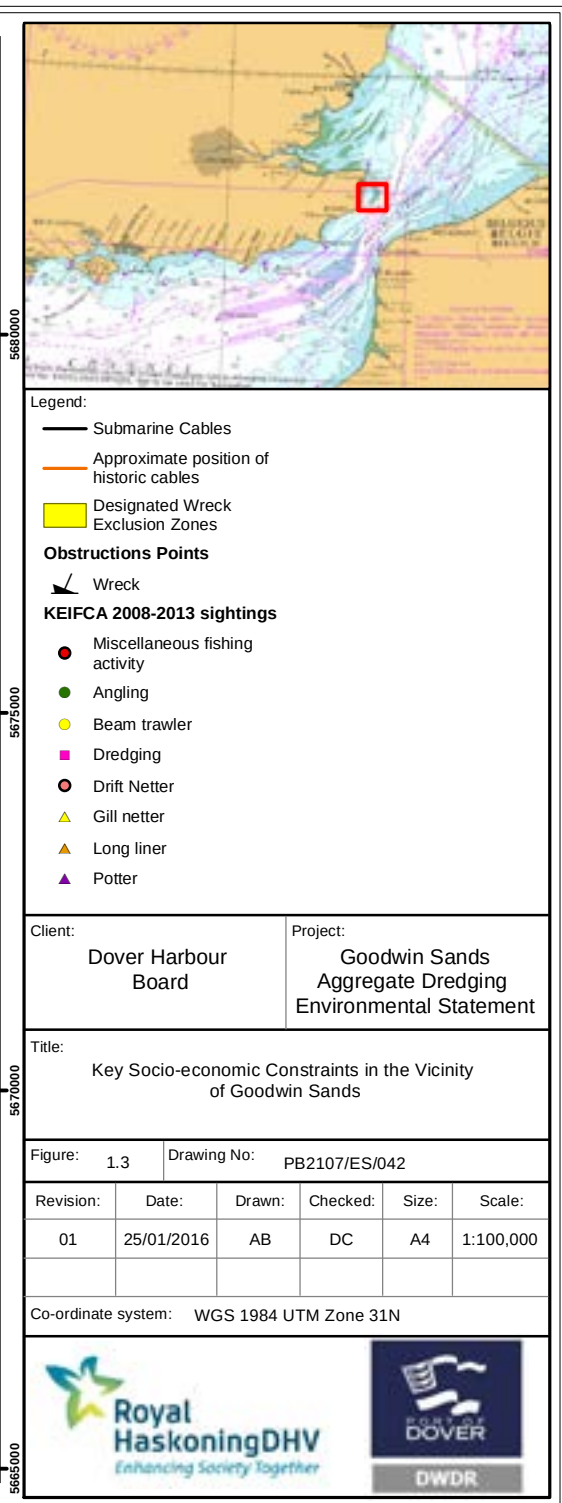
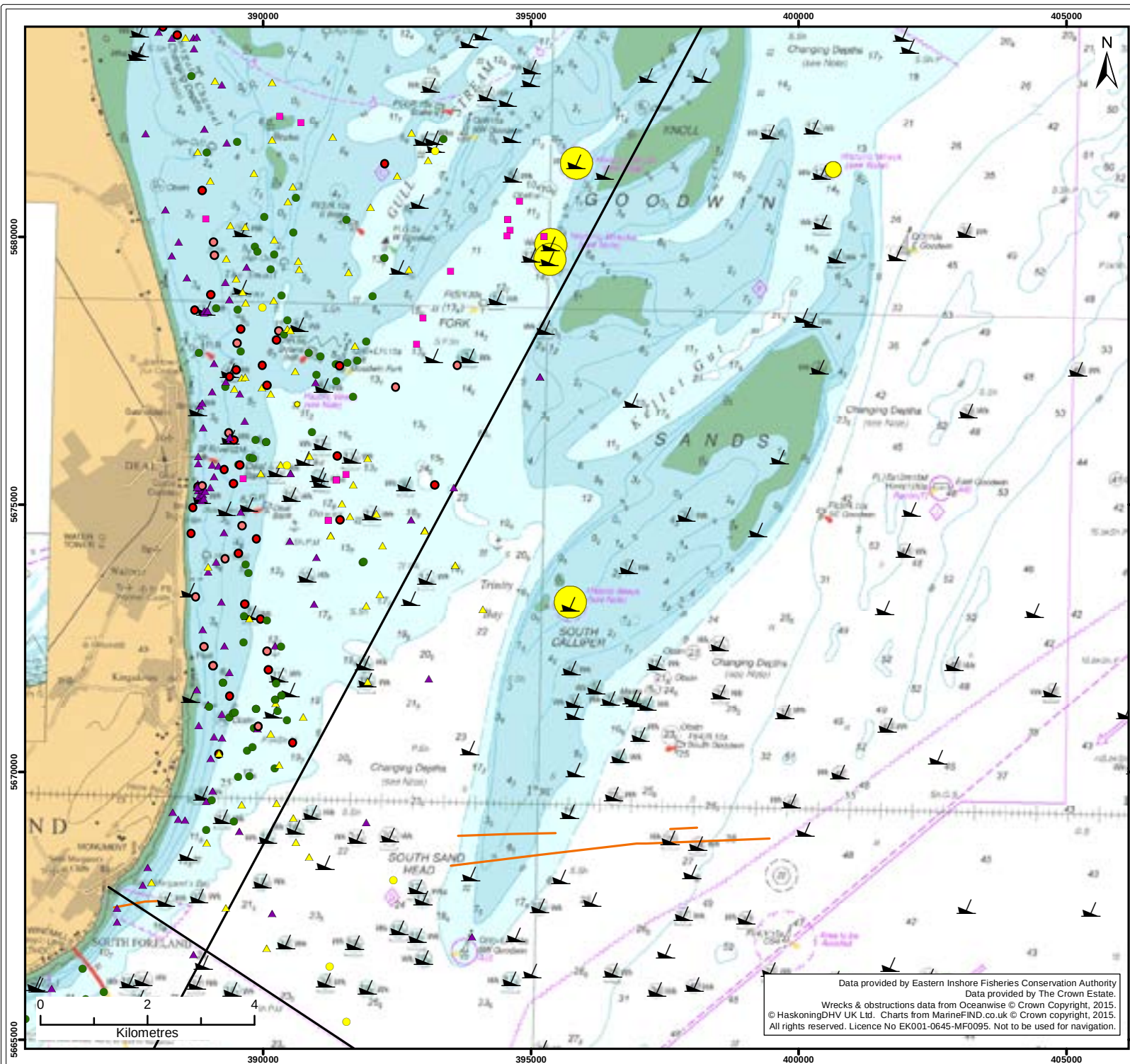
In May 2015 Royal HaskoningDHV and DHB identified an exploration area on South Goodwin Sands (formerly used for aggregate extraction) for exploration survey for aggregate dredging potential. To define the exploration area for survey the following tasks were undertaken;

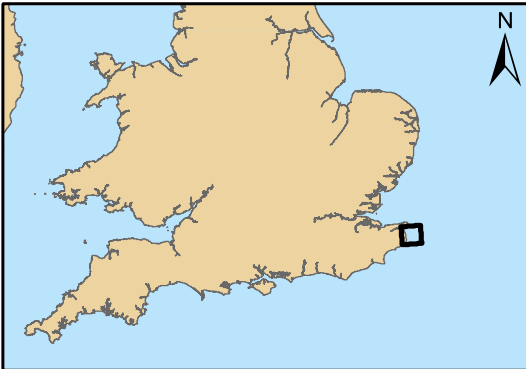
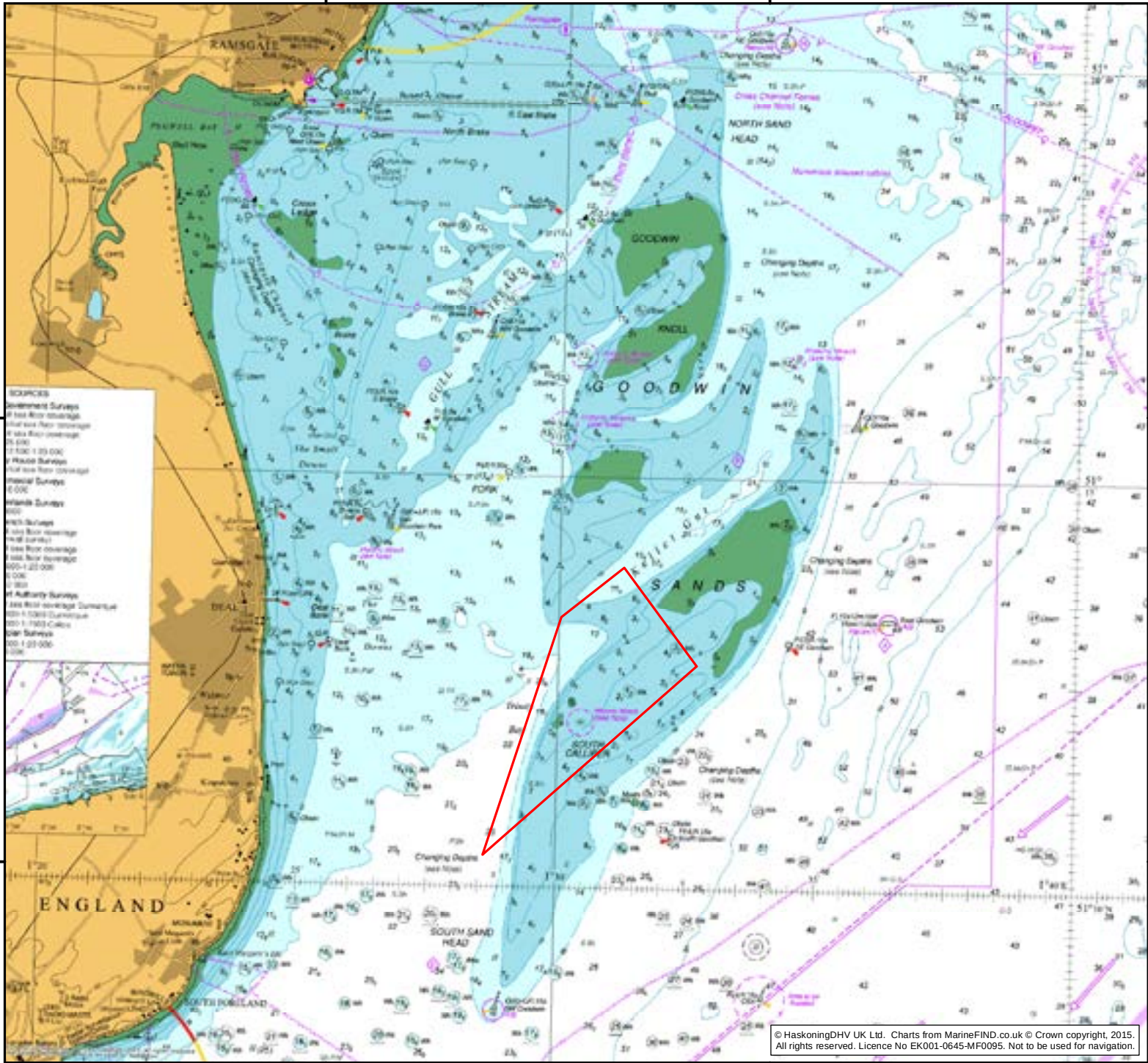
- Geographic Information System (GIS) mapping of Area 342, which was previously and successfully dredged by DHB (see **Figure 1.1**), against historic and current bathymetry data to understand how the sand bank system has evolved since the area was last dredged;
- Review of a Historical Bathymetry Changes Study produced by HR Wallingford in (2008). This study used three recent “epochs”, i.e. times when one or more detailed bathymetric surveys had been carried out covering the whole of the South Goodwin Sands. These epochs were used to provide an instantaneous “snapshot” at different times over the last 30 years, of the continually evolving sandbank, as possible. This work was used to inform the Wave Modelling undertaken in support of the EIA (see **Appendix 6.1**);
- GIS constraints mapping to identify areas of ecological and socio-economic sensitivity. Key constraints identified within the vicinity of Goodwin Sands are displayed in **Figures 1.2** and **1.3**;
- Review of the Goodwin Sands recommended Marine Conservation Zone (rMCZ) Selection Assessment Document (Balanced Seas, 2011) to identify areas of particular ecological sensitivity. This document identifies the features recommended for designation, including broad-scale habitats, habitat Features of Conservation Importance (FOCI) and geology and includes the information available to the Balanced Seas Regional Project on the location and distribution of these features;
- Review of British Geological Society (BGS) Seabed sediment data, accessed via <http://www.maremap.ac.uk/view/search/searchMaps.html>;
- UK Hydrographic Office (UKHO) bathymetry data incorporated into current Admiralty charts;
- Review of The Mineral Resources of the English Channel and Thames Estuary (BGS, 2013); and
- Consideration of publicly available commercial fisheries baseline data obtained from the Marine Management Organisation and the Kent and Essex Inshore Fisheries Conservation Authority (KEIFCA).

The output of this work was the exploration area shown in **Figure 1.4** and presented in the EIA Scoping Report. The exploration area covered an 11.6km² area located on the western side of South Calliper, extending from the Kellet Gut channel south west along the western side of the South Calliper sandbank.



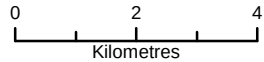






Legend:

Exploration Area



Client:	Dover Harbour Board	Project:	Goodwin Sands Aggregate Dredging Environmental Statement

Title:	Exploration Area

Figure:	1.4	Drawing No:	PB2107/ES/053

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
01	16/02/2016	JE	DC	A4	1:125,000

Co-ordinate system: WGS84 UTM Zone 31N



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1.3 Proposed Dredge Area Site Selection

The following exploration surveys were undertaken by EGS International in summer 2015 to inform the site selection process;

- Bathymetric survey using a multi-beam echo sounder (MBES) system. This survey provided full, high resolution bathymetric coverage across the exploration area with additional extended crosslines and perimeter lines to inform the physical process modelling. The bathymetry data collected is displayed in **Figure 1.5**.
- Side scan sonar survey (100% coverage) to map seabed features. Dual frequency side scan sonar was used to acquire high resolution acoustic data for the interpretation of the seabed features, including sediment distribution and any natural or man-made sonar contacts. An overview of the side scan sonar coverage (mosaic) is displayed in **Figure 1.6**.
- Sub-bottom profiler (seismic) survey to generate images of sub-bottom stratigraphy and structures. Two seismic systems (CHIRP and Boomer) were used to form the basis for interpretation of the shallow geology of the exploration area.
- Ecological survey which adopted a survey design approved by the MMO, the Centre for Environment, Fisheries and Aquaculture Sciences (Cefas), Natural England and the Environment Agency. The survey design followed the recommendations of Cefas and complied with the methodology set up for the Regional Seabed Monitoring Programme (RSMP) by Cefas and the aggregates industry (Cooper, 2013; Cooper and Mason, undated). More information on the survey design and results is provided in **ES Section 8 – Benthic Ecology** and **Appendix 8.1 – Benthic and Epibenthic Characterisation Report**.

Following completion of the exploration surveys a systematic site selection process was undertaken to delineate the optimum proposed dredge area. The site selection process incorporated data from the scheme surveys described above and the following information sources;

- Geographic Information System (GIS) mapping of constraints including physical, ecological and socio-economic datasets;
- Review of the Defra Goodwin Sands rMCZ Post-Survey Site Report (Defra, 2015) which details the findings of a dedicated seabed survey at the Goodwin Sands rMCZ. This survey was undertaken to provide direct evidence of the presence and extent of the broad-scale habitats and habitat FOCI that had been detailed in the original Site Assessment Document (Balanced Seas, 2011);
- GIS mapping of available commercial fisheries data (VMS, AIS, aerial surveillance and Kent and Essex Inshore Fisheries Conservation Authority patrol records);
- A specialist commercial and recreational fisheries baseline study undertaken by MacAlister Elliot and Partners (MEP) (see **Appendix 13.1**);
- Dredger operational constraints (e.g. vessel draft and water depth restrictions);
- The location of previous DHB dredging campaigns at South Goodwin Sands (including Area 342 as shown on **Figure 1.1**);
- Feedback from pre-EIA scoping consultation with Natural England and Historic England; and
- EIA scoping responses (see **ES Section 4 - Consultation** and **Appendix 4.1**).

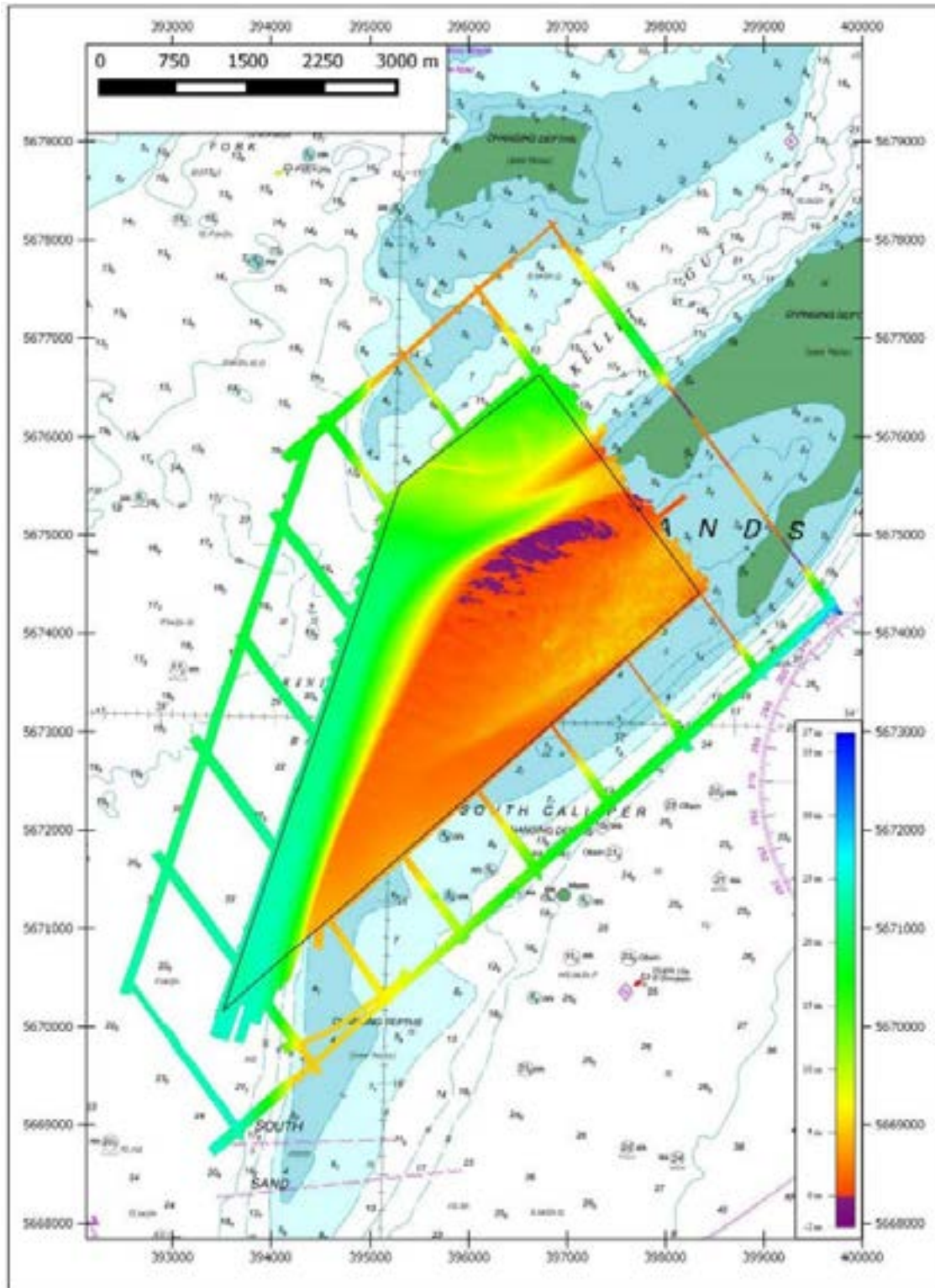
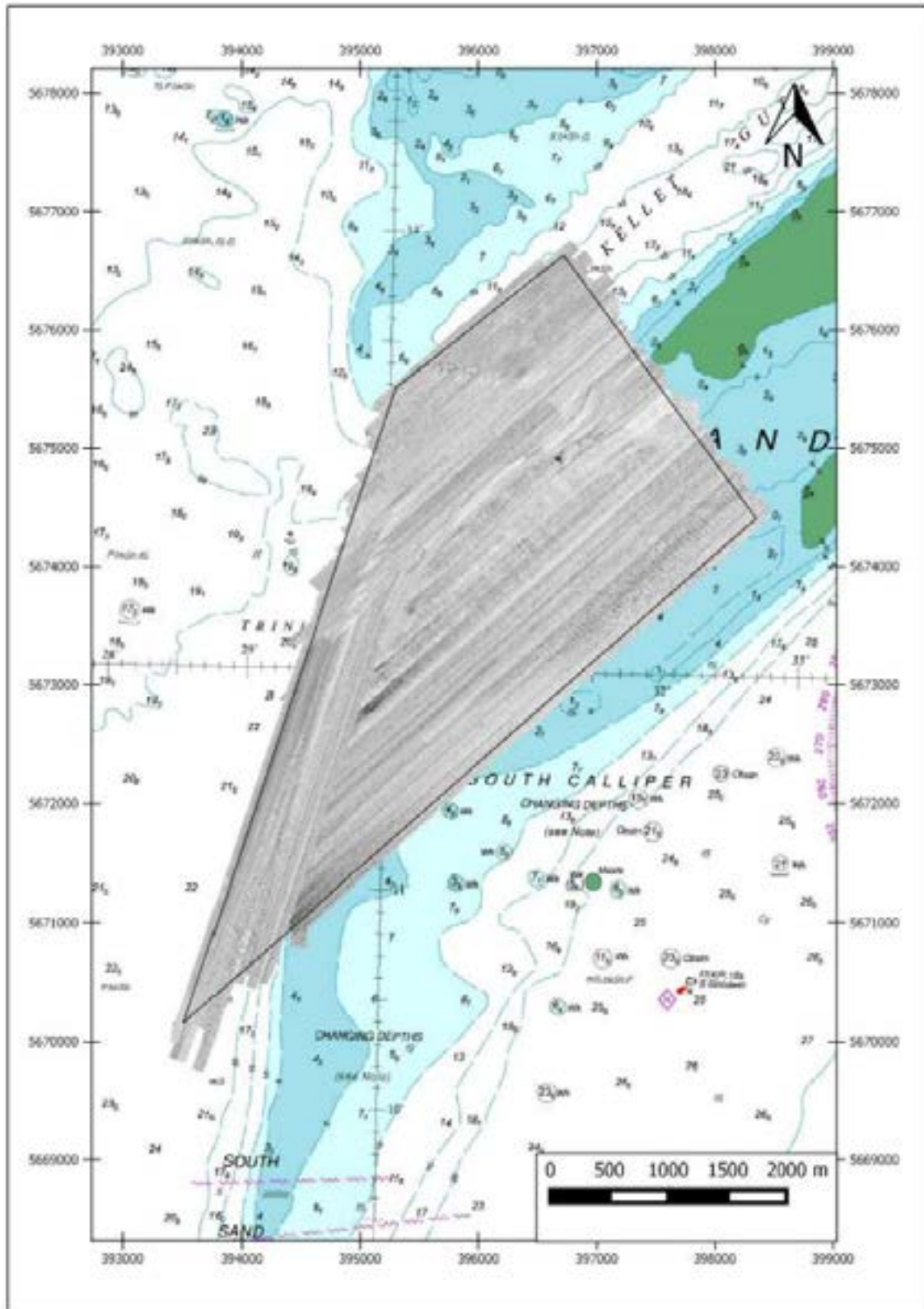


Figure 1.5 Overview of bathymetric coverage (depths relative to Chart Datum) (Drying heights, i.e. negative values above Chart Datum are shown in purple).



1.4 Site Selection Key Outcomes

The key outcomes of the site selection process and how relevant EIA scoping and other consultation responses were factored into the process are described below.

1.4.1 Resource (sand) thickness

Sub-bottom profiler seismic data was used to establish the type and thickness of seabed sediments. The proposed dredge area has been selected that includes adequate resource (sand) thickness to supply the required 2.5 million m³ of aggregate, including contingency for the event of new constraints within the proposed dredge area becoming evident during the scheme.

To be compared with the geotechnical (vibrocore) survey undertaken in December 2015. Draft lab results verify sub-bottom profiler data.

1.4.2 Avoidance of intertidal areas

Using high resolution multi-beam bathymetry data the proposed dredge area has been selected to avoid intertidal areas that could be used by seals as haul out sites. This is in accordance with the request within the Natural England scoping response (comment 2.14). The water depth within the proposed dredge area ranges from -6.1mCD to -25mCD.

Natural England scoping comment 2.13 highlights that *'the morphology of the bank is dynamic and the local bathymetry of the sand bank may have changed by the time dredging commences, meaning more areas of intertidal sand may be present'*.

DHB acknowledge this and confirm that a pre-dredge bathymetry survey will be undertaken to identify any changes to the local bathymetry. Exclusion zones would be put in place around any new intertidal areas present within the proposed dredge area. This would be required for both operational reasons (e.g. to avoid the dredger grounding) and ecological reasons (e.g. to avoid potential haul out sites).

1.4.3 Minimising changes to seabed topography

Natural England scoping comment 2.1 recommends that the dredge locations, zoning and intensity levels are managed to ensure that changes in seabed topography are minimised.

This recommendation has been followed in the site selection through:

- Limiting dredging to water depths greater than -6.1mCD to provide a buffer between dredging activity and intertidal areas;
- Leaving a layer of at least 0.5m of sediment in situ above the underlying rock (chalk) to maintain the bed material type present;
- Dredging to a maximum depth in the region of 2 - 4m to limit the extent of change to seabed topography; and
- Locating the proposed dredge area along the western side of the bank, which is an area more generally sheltered from incoming waves by the bank system itself, to minimise any impacts of the proposed dredging scheme on wave conditions and consequential morphological change to the bank.

1.4.4 Protected and charted wrecks

The exploration area included the *Admiral Gardner* Protected Wreck. The refined proposed dredge area avoids the *Admiral Gardner* and its 300m (radius) exclusion zone. The location of the wreck and its exclusion zone are displayed on **Figure 1.7**. No other designated or charted wrecks are located within the proposed dredge area.

1.4.5 Commercial fishing

The proposed dredge area has been designed to avoid areas where publically available data and a specialist fisheries study (MEP, 2015) (see **Appendix 13.1**) indicated intensive fishing effort occurs.

1.4.6 Annex I biogenic reef habitats

The proposed dredge area has been designed to avoid Annex I biogenic reef habitats. Data sources used to inform this were; the scheme specific ecological survey results (see **ES Section 8** and **Appendix 8.1**), Defra Goodwin Sands rMCZ Post-Survey Site Report (Defra, 2015) and JNCC Potential Annex I reef habitat dataset (JNCC, 2015). The scheme ecological survey report in **Appendix 8.1** concludes:

No evidence of any biogenic reef features was documented during the survey. Small abundances of Sabellaria spinulosa were recorded at 10 stations during the survey, although not at densities sufficient to constitute reef features in line with guidance in Hendrick and Foster-Smith (2006) and Gubbay (2007), where densities of several thousand individuals per m² are quoted as constituting even moderate quality reef.

Individuals of juvenile Mytilidae (mussel) were recorded at a total of nine stations within the exploration area and Secondary Impact Zone (SIZ) applied for the purposes of the survey (see **ES Section 8 – Benthic Ecology** for more information). The maximum number of juvenile Mytilidae recorded in a single sample was four individuals. Mussels were not recorded at sufficient densities to reflect the presence of biogenic reef features.

DHB also commissioned a scheme specific review of the exploration survey side scan data for Annex I reef habitat features (see **Appendix 8.2**). No areas of seabed rugosity inferring the presence of Annex I reef habitats were identified within the exploration area of Goodwin Sands. The results of this review are summarised within **ES Section 8**.

In their response to consultation on the EIA scoping report and exploration area Kent Wildlife Trust (KWT) made the following comments in relation to reef habitat:

Kent Wildlife Trust is very concerned at the potential direct loss of habitat at Goodwin Sands, the mussel beds and Sabellaria reefs being of particular concern. It is an important ecological area in its own right and falls within a recommended Marine Conservation Zone (MCZ).

Kent Wildlife Trust suggest a need to map the extent of the mussel beds and Sabellaria reefs. Kent Wildlife Trust has conducted Seasearch diving surveys at 3 sites in the rMCZ, and at one of those rossworm reef and blue mussel bed was recorded in 2005. However, since both features are ephemeral, our record serves as evidence that the site provides suitable habitat for these features rather than their presence in a particular location now.

DHB requested the Seasearch survey data highlighted by KWT and this data is displayed in **Figure 1.7**. As discussed above the proposed dredge area avoids Annex I biogenic reef habitat including mussel (*Mytilus/Modiolus*) beds and *Sabellaria* reefs. Based on the range of data sources used and the comprehensive nature of the scheme specific ecological survey when combined with review of the side

scan data for reef features it can be concluded with a high degree of confidence that there is no Annex I biogenic reef habitat present within the proposed dredge area.

Figure 1.7 displays the proposed dredge area with the relevant survey data and constraints information.

1.4.7 Coordinates of proposed dredge area

The coordinates of the proposed dredge area are provided below.

WGS84 UTM 31 N		WGS84 Degrees, Decimal Minutes	
Easting	Northing	Longitude E	Latitude N
393687.552	5670312.958	1 28.75062	51 10.46103
395208.5833	5674564.186	1 29.9812	51 12.77078
395036.1096	5674721.329	1 29.83033	51 12.85363
395300.3995	5675513.739	1 30.04342	51 13.28392
396077.309	5676124.497	1 30.70005	51 13.62185
397002.7675	5676241.235	1 31.493	51 13.69488
397196.7002	5675976.577	1 31.66413	51 13.55423
396610.9873	5675478.766	1 31.16965	51 13.2794
396658.1501	5675413.917	1 31.21128	51 13.24493
397215.2606	5675596.673	1 31.68662	51 13.34953
397288.9524	5675555.406	1 31.75062	51 13.32807
397176.9408	5675408.022	1 31.65695	51 13.24737
396797.3166	5675141.453	1 31.33552	51 13.09948
396092.1965	5674800.801	1 30.73587	51 12.90808
395827.1955	5674533.382	1 30.51295	51 12.76095
395563.105	5674128.285	1 30.29325	51 12.53957
395221.3403	5673356.725	1 30.01332	51 12.11968
394631.0193	5671922.349	1 29.53178	51 11.33953
394310.706	5670860.694	1 29.2756	51 10.7634

1.4.8 Consultation with Natural England on exploration and site selection processes and proposed dredge area

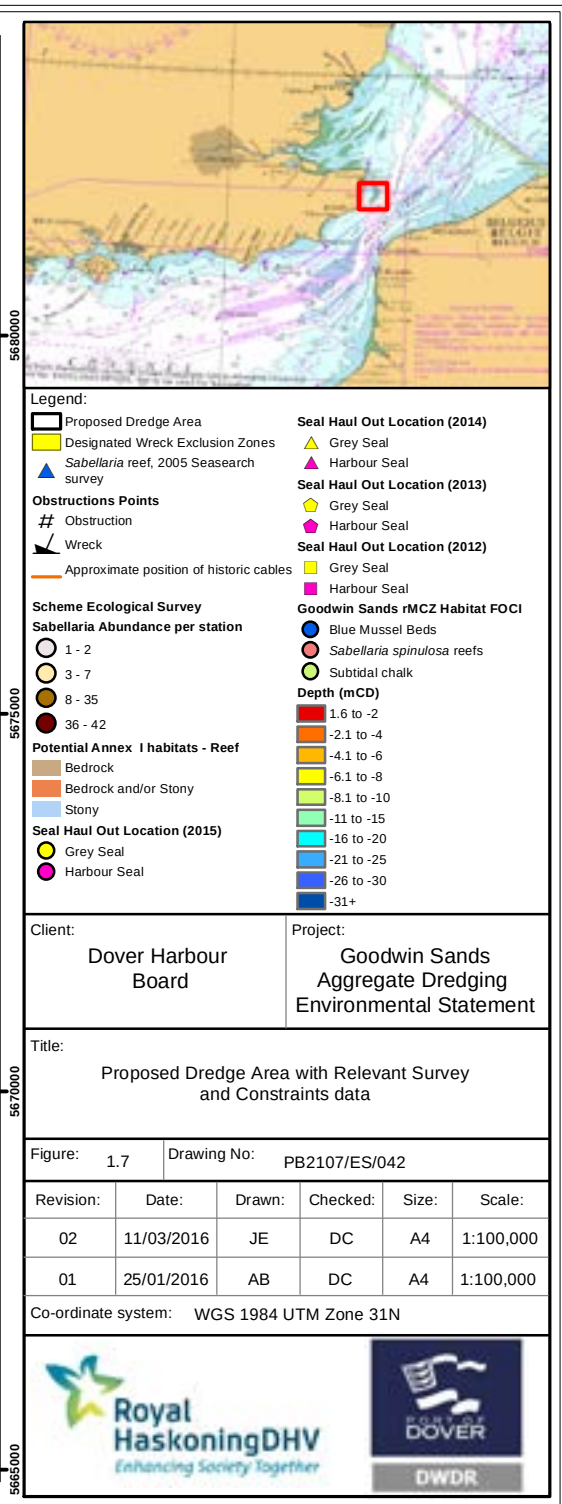
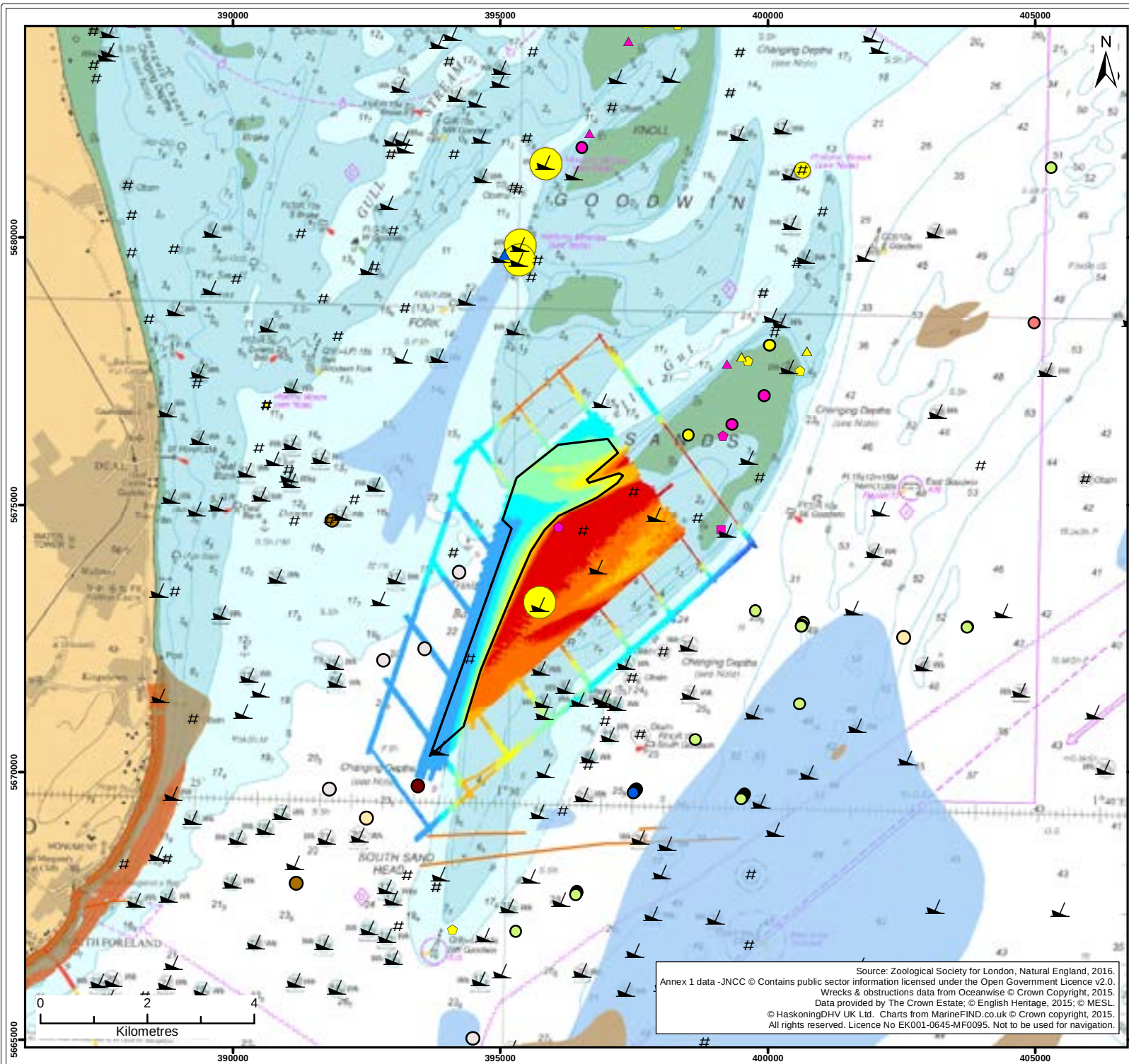
Following completion of the site selection process, DHB consulted Natural England via its Discretionary Advice Service (DAS). A technical note was submitted to Natural England in December 2015 to present the exploration and site selection processes followed (as documented above) and to request Natural England's feedback on these processes and the proposed dredge area identified.

Natural England's response, which is available in full in **Appendix 5.1**, includes the following feedback:

The information in the technical note is useful and provides clear evidence that the dredge area has been positioned away from areas which are of a high sensitivity.

In summary, the dredge area appears to be located in an appropriate position to minimise environmental impacts but there is still a need to further examine the outputs of the ecological survey and hydrodynamic/coastal processes study to fully understand the impacts.

The outputs of the ecological survey and the coastal processes and hydrodynamics studies are provided in full in **Appendix 8.1** and **Appendix 6.1-6.5** respectively.



References

Balanced Seas MCZ Project (2011) MCZ Selection Assessment Document. Available online at: http://jncc.defra.gov.uk/PDF/BS_FinalRecommendationsSites_Part3.pdf

BGS (2013) The Mineral Resources of the English Channel and Thames Estuary. Available online at: <http://www.thecrownestate.co.uk/media/5688/ei-south-england-sand-and-gravel-resources-map-report.pdf>

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Cooper, K.M. and Mason, C. (undated) Regional Seabed Monitoring Plan (RSMP). Protocol for Sample Collection and Processing. Version 4.0.

Defra (2015) Goodwin Sands rMCZ Post-survey Site Report. Contract Reference: MB0120. Report Number 35, Version 4. June 2015.

HR Wallingford (2008) Goodwin Sands Study of Historical Changes. Technical note DDM6067/TN01

JNCC (2015) Potential Annex I reef habitat dataset. Obtained from JNCC Offshore survey team.

MacAlister Elliot and Partners (2015) Preliminary Characterisation of Commercial, Recreational and Chartered Fishing Activity on the Goodwin Sands and Surrounding Area

MESL (2015) Goodwin Sands Exploration Area Sidescan Sonar Interpretation Report.



Appendix 2.2

Consideration of Alternatives

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1 Introduction

1.1 Context

This appendix to the Goodwin Sands ES presents the consideration given to alternative sources of significant quantities of aggregates (approx. 2,500,000m³) required for the construction of the new Dover Western Docks Revival (DWDR) scheme, specifically as fill material for land-reclamation (approx. 75%) and for construction of new sea walls (approx. 25%).

The Environmental Impact Assessment (EIA) process requires the developer to consider alternatives to the proposed scheme, including alternative sources of aggregates required to provide the volume and type of construction materials required by the DWDR scheme.

The EIA Directive 2014/52/EU stipulates the following when considering the alternatives for a project:

*“A description of the **reasonable** alternatives (for example in terms of project design, technology, location, size and scale) studied by the developer, which are **relevant** to the proposed project and its **specific** characteristics, and an **indication** of the **main reasons** for selecting the **chosen option**, including a **comparison** of the environmental effects.”*

1.2 Preferred Source

The preferred source of aggregates for the DWDR scheme is Goodwin Sands, an offshore sandbank system located in the Dover Strait at the eastern end of the English Channel, 12km to the north east of the DWDR site.

Goodwin Sands has a history of use as a source of aggregates, including aggregates for fill material for infrastructure projects. Five licences have been issued for aggregate extraction from five areas within North Goodwin Sands and South Goodwin Sands (293/1, 304, 342, 352 and 365), and over 9.5 million tonnes (6.3 million m³) of aggregates have been extracted from these areas between 1976 and 1998 (Natural England, 2012).

Dover Harbour Board (DHB) used Goodwin Sands as a source of aggregates in the 1970s to provide fill material for the construction of the hovercraft terminal. DHB also used South Goodwin Sands (Area 342) as a source of aggregates between 1984 and 1996 to provide fill material for land reclamation at the Eastern Docks. In addition, Goodwin Sands has been used as a source of aggregates for the construction of the Channel Tunnel Terminal and used for infrastructure development at the Port of Ramsgate.

Goodwin Sands is DHB's preferred source of aggregates for the construction of the DWDR for the following reasons:

- Successful track record of extraction and use of aggregates by DHB;
- Proximity to the DWDR site;
- Environmental advantages; and
- Lower cost relative to other commercial sources.

2 Screening of Alternatives

Three generic sources of aggregates have been identified as potential alternative sources to supply aggregates to the DWDR scheme. These are:

- Land based aggregate sources including quarries and pits;
- Marine based aggregate sources including licensed aggregate extraction areas and the beneficial (re)use of dredged material arising from capital and/or maintenance dredging sources; and
- Recycled and secondary materials including waste materials such as construction and demolition wastes and deposited dredged material.

These generic sources have been screened for their potential viability as reasonable and relevant alternative sources of aggregates for the DWDR scheme. Screening criteria included geographical location and availability of materials with suitable geotechnical properties and in suitable quantities.

The screening exercise is presented in **Table 1**.



Table 1 Screening of alternative sources of aggregates for the DWDR scheme

Option Description	Screening Outcome
Land based sources: (quarries / pits)	The majority of aggregates in the UK come from land based sources. There are a number of operational sand and gravel quarries in the South East of England. For the purposes of screening, it has been assumed, but not confirmed, that one or a combination of these quarries will be able to provide the necessary size and quantities of materials required for the DWDR scheme. Conclusion: Land based sources have been screened into further consideration in Section 3 onwards.
Marine based sources: aggregate extraction areas	There are a number of licenced marine aggregate extraction areas within 200km of the DWDR scheme. For the purposes of screening, it has been assumed, but not confirmed, that one or a combination of these licensed areas will be able to provide the necessary size and quantities of materials required for the DWDR construction. Conclusion: Marine aggregate extraction areas have been screened into further consideration in Section 3 onwards.
Marine based sources: capital dredging projects and/or maintenance dredging programmes	There are a number of regular maintenance dredging programmes at ports and harbours in and around the South East of England. There are occasional capital dredging projects at ports and harbours in and around the South East of England, and capital dredging will be undertaken during the DWDR scheme itself. For the purposes of screening, it has been assumed, but not confirmed, that one or a combination of maintenance dredging programmes and/or capital dredging projects will be able to provide the necessary size and quantities of materials required for the DWDR scheme. Conclusion: Aggregates (i.e. dredged material) arising from capital and/or maintenance dredging has been screened into further consideration in Section 3 onwards.
Land and marine based sources: recycled and secondary materials	Secondary and recycled aggregates are the by-products of various works and operations and are derived from a wide range of sources including construction and demolition waste, industrial waste, highway maintenance waste, used railway ballast, excavation works and utility operations. Secondary and recycled aggregates include, for example, construction and demolition (C&D) waste, Pulverised Fuel Ash (PFA) and furnace slag. These types of aggregates are not commonly used as fill material for land reclamation works which the material required for the DWDR scheme will primarily or entirely be used for. To screen the availability of secondary and recycled aggregates for the DWDR scheme, the Environment Agency (EA) Kent Waste Team was contacted for advice on possible sources within a reasonable 'economic' distance from Dover. As far as the EA is aware, there are no facilities close to Dover that would be able to supply the quantity of aggregates required (Jonathan Atkinson, EA, pers comm.). In



Option Description	Screening Outcome
	addition, Dover District Council (DDC) Building Control Department was contacted regarding information on major demolition works in the Dover area. DDC indicated that there have been a number of applications submitted for large demolition projects but it is unlikely that the volume of material generated would be in the region of the 2.5 million m³ of material required for the DWDR scheme (Danielle Sparkes, DDC, pers comm). In addition, dredged material that has been disposed of at non-hazardous landfill sites has also been considered for use at the DWDR scheme. There are two disposal sites that handle dredged material and inert C&D waste in Kent, at Rushenden Marshes and Burntwick Island. Both of these sites are located approximately 55km from the DWDR site. Attaining aggregates from these sites would require an assessment to determine whether they are geotechnically suitable and sufficiently uncontaminated to be used for the DWDR scheme. For the purposes of screening, it has been assumed, but not confirmed, that one or a combination of these recycled and secondary sources of aggregates will not be able to provide the necessary size and quantities of materials required for the DWDR scheme. Conclusion: Recycled and secondary materials have been screened out of further consideration.

3 Assessment of Screened in Options

The screened in alternatives considered in the following sections are:

- Land based sources of aggregates in the form of quarries (or pits); and
- Marine based sources of aggregates in the form of:
 - o other aggregate extraction areas; and
 - o maintenance dredging programmes and/or capital dredging projects.

The screened in alternatives are considered in relation to the following assessment criteria:

- Environmental sustainability in the form of:
 - o energy consumption due to extraction and processing; and
 - o energy consumption due to transport;
- Environmental impacts in the form of traffic, air quality, noise, etc.

Environmental sustainability is the principal assessment criterion used to consider the alternative land based and marine based sources of aggregates in relation to the preferred source of aggregates (i.e. the proposed extraction of marine aggregates from Goodwin Sands). Environmental sustainability has been chosen because it facilitates a direct and quantifiable comparison between the alternative and preferred sources of aggregates through calculations of the energy consumed due to aggregate extraction (i.e. by comparing quarrying and dredging methods) and the energy consumed due to aggregate transport between source and the DWDR scheme at Dover Harbour (i.e. by comparing road, rail and sea transport methods).

Environmental impacts are secondary criteria used to consider the alternative sources of aggregates. They have been chosen as secondary criteria because environmental impacts associated with alternative sources are less readily comparable, both directly and quantifiably, with environmental impacts associated with the preferred source.

4 Environmental Sustainability

Environmental sustainability can be considered in relation to the energy consumption associated with:

- Extracting, producing and processing aggregates at the source (i.e. quarries, dredging areas); and
- Transporting aggregates between the source and the point of use (i.e. the DWDR scheme at Dover Harbour).

4.1 Extracting, producing and processing aggregates

4.1.1 Energy consumption

The energy consumed in extracting, producing and processing aggregates for construction purposes can vary considerably (CIRIA, 2010). Construction materials such as sand and gravel require relatively little processing other than cleaning and sorting (i.e. compared to the processing of construction materials such as concrete and steel) which means their energy consumption depends largely on extracting and producing.

Indicative energy consumption rates are 1.8-4.0GJ/t (i.e. 277-500kWh/t) for quarried aggregates depending on waste rates (West et al, 1994, cited in Masters, 2001), and 0.03-0.12GJ/t (i.e. 8.33-33.33kWh/t) for marine aggregates depending on dredging method (BRE, 1994, cited in Masters, 2001).

More recent indicative energy consumption rates are 10kWh/t for sand and gravel sourced from pits (The Crown Estate, 2008) and 8kWh/tonne for marine aggregates involving short haul trips and 12kWh/tonnes for marine aggregates involving long haul trips (The Crown Estate, 2008).

4.1.2 Consideration of alternatives

On the basis of the potential energy consumed, it is concluded that:

- The environmental sustainability of the production of aggregates from land based sources (i.e. quarries and pits) and marine based sources (i.e. other aggregate extraction areas and maintenance and/or capital dredging) is similar to the environmental sustainability of the production of aggregates from the preferred option (i.e. aggregate extraction from Goodwin Sands).
- The environmental sustainability of alternative sources is neither more nor less acceptable than the environmental sustainability of the preferred option.

4.2 Transporting aggregates

4.2.1 Locations of land based sources

There are various geological sources of land based aggregates in England, although they are unevenly distributed throughout the country. In southern and eastern England where demand for aggregates is high, the land is predominantly low lying and lacks the hard rock resources available from the uplands of northern and western England. The regional imbalance in supply and demand means that large amounts of aggregates are transported from net producing areas to net importing areas; for example from Leicestershire and Somerset to South East England and London (Gunn et al, 2008).

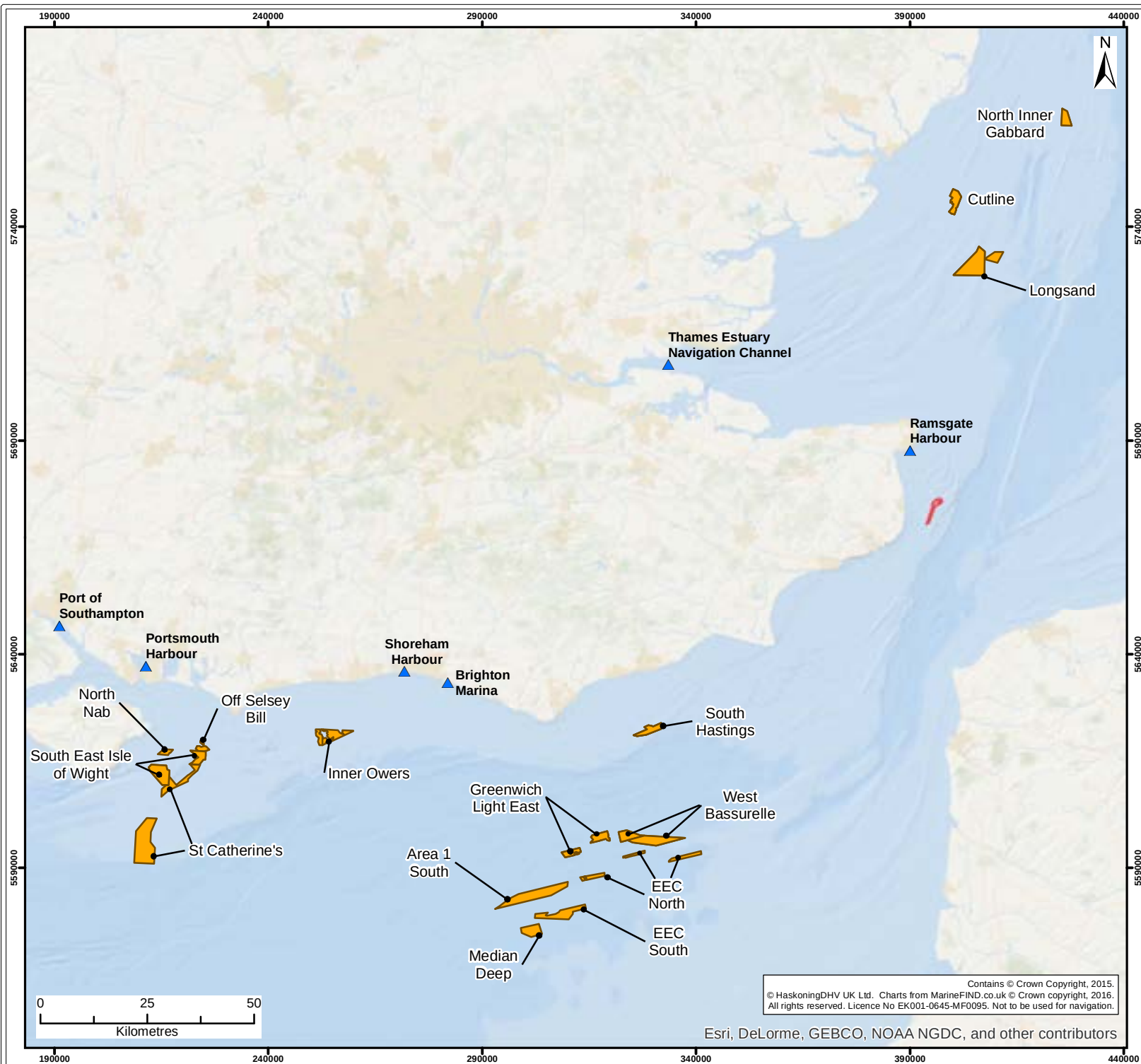
There are a number of quarries (or pits) in South East England within 60km of the DWDR scheme at Dover Harbour, as identified in **Table 2** (BGS, 2014). Of the quarries identified in **Table 2**, the nearest quarry offering sand and gravel aggregates is CEMEX's Denge Quarry, which is located approximately 35km from Dover Harbour. This quarry has been used to inform the assessment of environmental sustainability in relation to the energy consumed due to the transport of aggregates (see **Table 4**).

Table 2 Quarries within 60km of Dover Harbour (source: BGS, 2014)

Location	Grid Ref.	Distance from Dover (km)
Highstead Quarry, Herne Bay	TR 210 665	30km
Allens Bank, Lydd	TR040213	33km
Denge and Romney Quarry (Denge), Dungeness	TR 077 212	35km
Faversham Quarry, Faversham	TR 010 625	35km
Allington Rail Depot, Allington	TQ 745 578	60km
East Peckham Quarry (Hale Street Quarry), East Peckham	TQ 678 484	60km
Hermitage Lane Quarry (Hermitage), Maidstone	TQ 722 559	60km

4.2.2 Locations of marine based sources: aggregate extraction areas

Goodwin Sands is located in close proximity to the DWDR site at Dover Harbour (approximately 12km to the north east). As alternatives to Goodwin Sands, the closest marine aggregate extraction areas to Dover Harbour are situated at South Hastings to the south west (65km) and Longsand to the north (68km). Aggregate extraction areas within 200km from the DWDR scheme are identified in **Figure 1** and **Table 2**



Legend:

- Proposed Dredge Area
- Licensed Aggregate Sites
- Maintenance Dredging Areas

Client:

Dover Harbour
Board

Project:

Goodwin Sands
Aggregate Dredging
Environmental Statement

Title:

Licensed Marine Aggregate Dredging Areas
and Maintenance Dredging Locations

Figure: 2.2

Drawing No: PB2107/ES/055

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
01	25/02/2016	JE	DC	A4	1:1,250,000

Co-ordinate system: WGS 1984 UTM Zone 31N



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Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors

Table 2 Marine aggregate extraction areas within 200km of Dover Harbour (Source: The Crown Estate, 2016)

Location	Distance from Dover (km)
South Hastings	65
Longsand	68
Cutline	81
West Bassurelle	81
EEC North	81
Greenwich Light East EEC North and South	91
Greenwich Light East	91
Area 1 South	106
EEC South	107
North Inner Gabbard	109
Median Deep	118
Inner Owners	129
Off Selsy Bill	163
South East Isle of Wight	165
St Catherines	167
North Nab	170

Alternative marine sources of supply could potentially replace the aggregate sought from the Goodwin Sands. The resources currently extracted from the licensed areas to the north and south of Dover comprise fine aggregate (coarse sand or fine sand) or aggregate suitable for fill, and are used as construction aggregate and for concrete products (Bide et al, 2013). These areas have the supply pressures from existing customers with specific requirements that cannot be met from other areas, and it cannot be confirmed whether they could sufficiently supply the DWDR scheme with the required aggregates. Nevertheless, as a conservative assessment scenario, the South Hastings site is the closest aggregate extraction area to Dover Harbour and has been used to inform the assessment of environmental sustainability in relation to the energy consumed due to the transport of aggregates (see Table 4).

4.2.3 Locations of marine based sources: capital and maintenance dredging areas

Capital Dredging

There is the potential for dredged material derived from capital and maintenance dredging campaigns to be reused in the DWDR scheme. Capital dredging is an irregular activity and is often associated with the deepening and/or widening of navigable waters, alone or in combination with port and terminal expansion projects, to accommodate the larger commercial vessels increasingly used by global shipping companies.

There are some UK examples of where capital dredging has supplied material for construction purposes (e.g. land reclamation for port development), but many of these examples are where the capital dredging and re-use of dredged material has been coordinated within one scheme (e.g. London Gateway). Generally, capital dredging is not a predictable activity and source of sufficient and/or right material. This has been confirmed by a review of the Marine Management Organisation (MMO) Public Register, which did not identify any suitable capital dredge schemes in the South East region.

Additionally, advice has been sought directly from the MMO marine licencing team, who were unable to recommend an upcoming dredging scheme which could provide both the suitable type and volume of material required for the DWDR scheme.

DHB will be undertaking capital dredging for the DWDR scheme, including for vessel berthing pockets, vessel manoeuvring areas, and associated with the new marina. Dredged material arising from the DWDR capital dredging will largely comprise of silt and chalk, which is not suitable for use as aggregate for reclamation due to its geotechnical properties. Accordingly, dredged material arising from capital dredging is excluded from the remainder of this assessment.

Maintenance Dredging

Maintenance dredging is a more frequent and regular activity and is often associated with removing accumulations of deposited silt and other materials to maintain the advertised navigable water depths at existing port and terminals. **Table 3** identifies maintenance dredging activities within 200km of Dover Harbour that could supply the DWDR scheme with a source of dredged material. **Figure 1** illustrates the locations of these maintenance dredging activities.

The geotechnical properties of the dredged material are unknown, but it is assumed that some of it may be suitable for the DWDR scheme; however, much of the dredged material is likely to comprise silt and would be unsuitable to meet the DWDR scheme's geotechnical requirements and, particularly, when considered in terms of the quantities required for the DWDR scheme (i.e. 2.5Mm³).

Table 3 Maintenance dredging programmes within 200km of Dover Harbour (source: MMO, 2014 & MMO Public Register)

Location	Quantity/year (m ³)	Sediment Type	Distance from Dover (km)
Port of Southampton	200,000	Silt	187
HMNB Portsmouth	200,000	Silt	175
Ramsgate	120,000	Sand and silt	24
Shoreham	99,000	Sand	116
Brighton Marina	36,000	Sand and silt	106
Thames Estuary Navigation Channels	Unknown	Sand	75

The closest maintenance dredging operation is located at Ramsgate Harbour, 24km from the DWDR scheme. The majority of the dredged material arising from Ramsgate comprises silt, which is unsuitable as land reclamation or fill material and is deposited at licenced disposal sites (MMO, 2016). The remaining dredged material arising from Ramsgate comprises sand and is already assigned a beneficial use at Ramsgate Sands to maintain the beach and the standard of protection for the existing sea defences (MMO, 2016). Therefore, the dredged material arising from Ramsgate is not available for use within the DWDR scheme. The Thames Estuary is the next closest maintenance dredging area to Dover Harbour and has been used to inform the assessment of environmental sustainability in relation to the energy consumed due to the transport of aggregates (see **Table 4**).

4.2.4 Energy consumption

The energy consumed by transporting aggregates can vary considerably depending on the transport method. This assessment considers the following transport methods and is informed by the calculations published by The Crown Estate (2008):

- Road (i.e. heavy goods vehicles (HGVs));
- Rail (i.e. locomotive and wagons); and
- Sea (i.e. dredger).

The energy consumed by transporting aggregates is identified in **Table 4**. The calculations assume that in all cases, there is sufficient quantity and quality of aggregate available from those sites alone and at the

necessary times to supply the DWDR scheme (which is unlikely for the reasons described in the text above).

Table 4 Comparison of Energy Consumption from Transport of Aggregates to Dover Harbour

Source of Aggregates	Distance to Dover Harbour (km)	Transport Method	Fuel Consumed per Tonne of Aggregates per Kilometre (l/t-km)*	Total Fuel Consumed for 2.5M m ³ of Aggregates from Source to Dover Harbour (l)**
Highstead Quarry	30	Road	2.5	375,000,000
Highstead Quarry	30***	Rail	0.91	136,500,000
South Hastings aggregate extraction	65	Sea (dredger)	0.19	61,750,000
Thames Estuary maintenance dredging	75	Sea (dredger)	0.19	71,250,000
Goodwin Sands preferred option	12	Sea (dredger)	0.19	11,400,000

* Derived from The Crown Estate (2008)

** Assumes bulk density ratio of 1m³ = 2 tonnes of aggregates

*** Assumes direct rail route between quarry and Dover Harbour (which does not exist; see **Section 4.2**)

On the basis of the potential energy consumed, it is concluded that:

- The environmental sustainability of the transport of aggregates from alternative land based sources (i.e. quarries / pits), both by road and by rail, is less acceptable than the environmental sustainability of the transport of aggregates from alternative marine based sources (i.e. aggregate extraction areas and maintenance dredging programmes) by sea; and
- The environmental sustainability of the transport of aggregates from alternative marine based sources (i.e. aggregate extraction areas and maintenance dredging programmes) is less acceptable than the environmental sustainability of the transport of aggregates from Goodwin Sands (i.e. the preferred option).

5 Environmental Impacts

The impacts of aggregate extraction at the locations of the alternative and preferred sources will differ in relation to the nature and scale of extraction activities, the magnitude of environment changes, and the specific sensitivities and values of the environmental receptors at and around those locations. These impacts cannot be readily identified and directly compared between the alternative and preferred sources, so a brief qualitative assessment is made below (see **Section 5.1**), and a more detailed assessment is made for off-site impacts on the basis of importing aggregates to the DWDR scheme at Dover Harbour (see **Section 5.2**).

5.1 Impacts associated with aggregate extraction at the sources

For the purposes of this assessment, it is assumed that the alternative sources of aggregates (i.e. the quarries / pits, aggregate extraction areas, and maintenance dredging programmes considered in detail in **Section 4**) would have been subject to their own EIAs and consents (e.g. planning permission, marine licences, etc, as relevant) and, therefore, their impacts would have been judged by a regulatory authority or agency to be environmentally acceptable (taking into account any mitigation measures). If the same assumption is made for the preferred option in relation to aggregate extraction at Goodwin Sands, then it can be concluded that the extraction impacts are broadly similar (i.e. they are environmentally acceptable, taking into account any mitigation measures).

A potential exception to this conclusion would be if it were proposed that the alternative sources of aggregate were already subject to extraction impacts whereas the preferred source was not already subject to extraction impacts. In this case, the use of Goodwin Sands would increase the overall scale of aggregates extraction (i.e. at a regional or national level) and, therefore, would also increase the overall scale of environmental impacts. However, as discussed in **Section 1.2** Goodwin Sands has a history of use for aggregate extraction and, to a certain extent, has a history of environmental impacts associated with aggregate extraction.

5.2 Impacts associated with aggregate transport to Dover Harbour

5.2.1 Road transport

Land based sources (i.e. quarries / pits) offer alternative sources of aggregates to the preferred option (i.e. aggregate extraction at Goodwin Sands). As identified in **Section 4**, land based sources would require the aggregate to be transported to the DWDR scheme by road (see below) or by rail (see **Section 5.2.2**), which could have environmental impacts in and around Dover Harbour.

The local and regional road network in and around Dover already experiences high volumes of road traffic and DHB is seeking, where possible, to minimise the road traffic movements associated with the construction work for the DWDR scheme. On the basis that a HGV can transport 23 tonnes (The Crown Estate, 2008) of aggregates, which equates to 11.5m³ of aggregates, it is estimated that 217,391 deliveries would be required to transport aggregates from land based sources to Dover Harbour. These deliveries and the return journeys (i.e. empty HGVs) would generate 434,782 HGV movements. These HGV movements would be distributed across the three periods of four months (i.e. one year) over the construction programme (2016-2019) to coincide with when the DWDR construction works requires the aggregates. Assuming a seven day working week for construction of the DWDR scheme, this scenario would generate 1,191 HGV movements per day. It is anticipated that HGV movements at this scale would generate an unmanageable level of traffic congestion on Dover's local road network.

The HGV movements required to transport land based aggregates to the DWDR site would increase air quality and noise related impacts along and adjacent to the local road network. Dover District Council has designated an Air Quality Management Area (AQMA) along the A20 Trunk Road in Dover due to increased levels of nitrogen dioxide and it is anticipated that HGV movements on the local road network would contribute to elevated nitrogen dioxide levels within the AQMA. **Figure 2** shows the location of the AQMA.

On the basis of potential impacts on traffic, air quality and noise, it is concluded that the environmental impacts of the transport of aggregates from land based sources would be more significant than the transport of aggregates from marine based sources, including alternative marine based sources and the preferred option (i.e. Goodwin Sands).

5.2.2 Rail transport

Transporting aggregates over short distances by rail is viable in the appropriate circumstances, providing the right infrastructure is in place (i.e. railheads, intermodal wagons, unloading equipment and an established freight operating company) (Quarry Management, 2006). Transporting aggregates by rail can reduce road traffic pressure on the local road network, with one freight train typically replacing around 60 HGVs and reducing energy consumption and air pollutant emissions (KCC, 2012).

However, even if aggregates could be transported between a quarry and a rail head near Dover Harbour, HGV transportation would still be required to transport the aggregates to the DWDR site. Kent County Council (KCC) does not support the location of a road-to-rail freight interchange within the county (KCC, 2016). A recent example was the Kent International Gateway (KIG) application for a road-to-rail interchange. KCC and Maidstone Borough Council opposed this application because of the detrimental impact on traffic movements to the south-east of Maidstone and the questionable case for the benefits at this location (KCC, 2012).

On the basis that rail transport of land based sources of aggregates to DWDR scheme is not feasible without additional road transport, it is concluded that the environmental impacts of the transport of aggregates from land based sources would be more significant than the transport of aggregates from marine based sources, including alternative marine based sources and the preferred option (i.e. Goodwin Sands).

5.2.3 Sea transport

Alternative marine based sources and the preferred source would all involve a similar sea transport method for aggregates because they would all involve the use of a dredger. The alternative marine based sources are located at greater distances from Dover Harbour than the preferred source and, therefore, would result in increased impacts on air quality due to increased vessel emissions and could result in additional noise and visual impacts due to an extended construction programme for the DWDR scheme.

On this basis, it is concluded that the environmental impacts of the transport of aggregates from marine based sources would be more significant than the transport of aggregates from the preferred option (i.e. Goodwin Sands).

6 Conclusion

This consideration of potential alternative sources of aggregates for the DWDR scheme has considered the following potential sources:

- Land based sources including quarries;
- Marine based sources including aggregate extraction areas and other sources of dredged material; and
- Land and/or marine based sources of recycled and secondary materials.

No reasonable alternative sources of aggregates have been identified (compared to the preferred source at Goodwin Sands) in terms of known geotechnical properties, readily available quantities, and readily available supply times in relation to the construction requirements of the DWDR scheme.

No geographically closer sources of aggregates have been identified (compared to the preferred source at Goodwin Sands) and, therefore, the alternatives are less environmentally sustainable particularly in terms

of energy consumption and are less environmentally acceptable in terms of impacts associated with air quality and noise emissions.

These findings accord with Minerals Policy Statement (MPS 1) (DCLG, 2006) that notes that marine aggregates are an important source of aggregates for the southern UK market and:

- Aims to “encourage the supply of marine-dredged sand and gravel to the extent that environmentally acceptable sources can be identified and exploited, within the principles of sustainable development”; and
- Notes that: “land-based and marine-based construction aggregate resources are unevenly distributed and many regions are heavily dependent on supplies from other areas. Marine aggregates contribute to diversity of supply and deliver high quality aggregate into the centre of areas of high demand with minimum disruption”.

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Appendix 4.1

MMO Screening and Scoping Opinion

MMO SCREENING OPINION



**Marine
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Ms Sharon Higenbottam
Dover Harbour Board
Dover Harbour Board,
Harbour House,
Dover
CT17 9BU

Our reference:
EIA/2015/00023

24 September 2015

Dear Ms Higenbottam

THE MARINE WORKS (ENVIRONMENTAL IMPACT ASSESSMENT) REGULATIONS 2007, AS AMENDED: SCREENING OPINION

Proposal:

Dover Harbour Board proposes to dredge aggregate from Goodwin Sands, located off the South Coast of Kent, 12km from Dover Harbour. The proposed extraction volume over six years will be 25,000,000m³. Extraction is anticipated to take place in two stages (August 2016 - November 2017 and March 2022 - August 2022).

The MMO (as Licensing Authority) has received a request for a screening opinion on whether the proposed works would fall under the requirements of the Marine Works (Environmental Impact Assessment) Regulations 2007, as amended ("the Regulations"). The Regulations implement EU Directive 2011/92/EU 'on the assessment of the effects of certain public and private projects on the environment' (the 'EIA Directive') in relation to certain marine works.

The MMO must determine whether the works envisaged are a project listed in Annex I or Annex II of the EIA Directive. For projects listed under Annex I, EIA is mandatory. If the project is determined to fall under Annex II, consideration should be given to the nature of the project, having regard to its size, the scope of the works and its location. The MMO must consider all elements of a project when making marine licensing decisions.

When considering the nature, scale and location of the proposed project, it is the opinion of this Licensing Authority that the works as described in the information provided would fall under Annex II of the EIA Directive.

Conclusion

This Licensing Authority has determined that the proposal described above requires an Environmental Impact Assessment under the Marine Works (Environmental Impact Assessment) Regulations 2007, as amended.



**INVESTORS
IN PEOPLE**

Yours faithfully,

A handwritten signature in blue ink, appearing to read 'D Morris', enclosed within a light blue rectangular border.

David Morris
Marine Licensing Case Officer
Her Majesty's Government – Marine Management Organisation
T: 0191 376 2558
E: David.morris@marinemanagement.org.uk

MMO SCOPING OPINION

Annex 1

In accordance with the Marine Works (Environmental Impact Assessment (EIA) Regulations 2007 as amended, the Environmental Statement (ES) must include the information set out in Schedule 3 of the Regulations, this information is necessary to assess the environmental effects of the project. A copy of Schedule 3 is attached as Annex 2 to the main letter, for your reference.

1.0. Overview of the proposal

- 1.1. Dover Harbour Board is applying for permission to dredge aggregate from Goodwin Sands, located off the South Coast of Kent, 12km from Dover Harbour. The aggregate will be for use in the Dover Western Docks Revival (DWDR) development. The proposed extraction volume over six years will be 25,000,000m³. Extraction is anticipated to take place in two stages (August 2016 – November 2017, and March 2022 – August 2022).

2.0. General comments

- 2.1. To help aid the understanding of the overall impact of the proposed activity the draft ES must include the number of years the licence will cover and the estimates of average and maximum annual tonnage to be extracted.
- 2.2. Statements and conclusions included in the ES must be supported by recent empirical evidence or scientific publications. Any conclusions must be based on expert judgements, which must be clearly described and discussed in the text. The level of uncertainty or confidence associated with each significance assessment must present the type of evidence used and how it was incorporated into the assessment.
- 2.3. The likely routes to be taken by dredgers to and from the application area must be specified within the ES.
- 2.4. A description of the geology and geomorphology of the application area and its surroundings, including the nearby coast, indicating where possible, its recent evolution.
- 2.5. Details of the other dredging activities in the vicinity of the proposed licence area must be presented the ES.
- 2.6. Whether screening is to be undertaken must be made clear within the ES.

3.0. Fisheries

- 3.1. The potential impacts on fish and the commercial and recreational fisheries industry and the data and information identified are appropriate. The scoping report also identified the need for a desk based fisheries assessment, further herring (*Clupea harengus*) and sand eel (*Ammodytidae*) studies and a baseline commercial and recreational fisheries study, which will be appropriate to address any deficiencies in the

current data available to inform EIA.

- 3.2. Best practice and mitigation measures have been identified within the report. However, until the physical surveys have been carried out and quantitative and qualitative data has been acquired and collated, there is insufficient information to draft accurate fisheries mitigation measures. Future mitigation may however include seasonal dredging restrictions depending on the outcomes of the analysis.
- 3.3. A desk based assessment of larger/adult demersal species and pelagic species present in the application area is required.
- 3.4. Cefas beam trawl surveys are conducted in the Eastern English Channel in ICES divisions VIId and IVc (including ICES rectangles 31F1 and 32F1). Data from these trawls may provide a source of fisheries information. Information can be downloaded from the ICES DATRAS website <http://datras.ices.dk/Home/Default.aspx>
- 3.5. It is appreciated that a night time survey for sand eels is not feasible, and the habitat based approach and data collected from epibenthic trawls can be used to provide a sand eel assessment is supported. In addition to epibenthic trawl data, the numbers of sand eels found in benthic grabs must be recorded.
- 3.6. Dover Sole (*Solea solea*) spawning season is from March to June, not April to June as stated on p75.
- 3.7. Thornback rays (*Raja clavata*) are not protected under Schedule 5 of the Wildlife and Countryside Act 1981 as stated on page 76. They are however included in the OSPAR List of threatened or declining species and listed as 'Near Threatened' on the IUCN red list.

4.0. Shellfisheries

- 4.1. It is agreed that the most important commercial species, by value and tonnage landed are whelk (*Buccinum undatum*). Close consultation with the fishing industry and Kent and Essex IFCA will assist in ascertaining the spatial distribution of the fishery in relation to the proposed extraction site. The use of VMS data will be limited as the majority of vessels targeting whelks are likely to be <12m in length and therefore are not captured by VMS. It must be noted that VMS systems have only been required on vessels 12-15m in length since 2013. Prior to this it was only a requirement for vessels of 15m and over and considered in any assessment of this data.
- 4.2. There is likely to be some potting for crab (*Cancer pagurus*) and lobster (*Homarus gammarus*) in the vicinity of the proposed dredge area, which must be stated within the ES.
- 4.3. The impacts of screening dredged aggregate on shellfisheries must be considered if screening is to be undertaken.

5.0. Coastal Processes

- 5.1. In Table 21.1, page 138, the identification of mitigation measures are considered as part of the EIA process, but no mitigation and monitoring measures are identified. Mitigation measures must be included in the ES.
- 5.2. Section 6.4.2 - If the exact location and dredge depth is not known prior to the modelling work being undertaken, the realistic worst case scenario with regard to seabed lowering must be used i.e. the extraction scenario that is likely to result in the biggest changes to waves, tidal currents, sediment transport and morphology.
- 5.3. The numerical outputs of the hydrodynamic model must be discussed with respect to the environmental receptors being assessed and what the likely ecological significance of any changes in hydrodynamics will be. For example if the model predicts a 5% change in significant wave height at a location, it is important to be clear in what this will mean for sediment stability, particle size distribution and morphology.
- 5.4. Section 2.7.1 outlines Dover Harbour Board's (DHB) proposal to zone the dredging works in a way which minimises environmental impact. The dredge locations, zoning and intensity levels must be managed to ensure that changes in seabed topography are minimised as significant changes in seabed topography have the potential to:
 - reduce slope stability potentially causing slippage of the bank and a reduction in intertidal area (which would have effects on seal haul out behaviour);
 - alter localised water movements affecting the activity and location of local fish populations; and
 - change physical conditions at the seabed increasing sediment disturbance levels and changing particle size distribution.

6.0. Nature Conservation Designations

- 6.1. Section 4.4.3 identifies that the application area is wholly within Goodwin Sands recommended Marine Conservation Zone (rMCZ). This site has been put forward for designation for the following features:

Broad-scale habitats:

- A3.2 moderate energy infralittoral rock;
- A4.2 moderate energy circalittoral rock;
- A5.1 Subtidal coarse sediment; and
- A5.2 Subtidal sand.

Habitat Features of Conservation Importance (FOCI):

- Blue mussel beds; and
- Rossworm (*Sabellaria spinulosa*) reef.

Geology:

- Eastern English Channel outburst flood features.

- 6.2. Section 4.4.3 states the site falls within Tranche 3 of the designation process, which is not currently deemed a designated site or subject to public consultation. Consequently the marine licence application would not require an MCZ assessment. It is likely that the site will be considered for designation in the future under Tranche 3 of Defra's MCZ designation programme, therefore it is recommended that the possible impacts to the rMCZ features are considered.
- 6.3. It must be noted that the features identified as part of the MCZ are listed as habitats and species of importance under OSPAR convention and Section 41 of the Natural Environment and Rural Communities (NERC) act 2006.
- 6.4. Section 5.5 provides details, such as the location and approximate distance of the exploration area to the Thanet Coast Site of Special Scientific Interest (SSSI). This information must be provided in the ES for the remaining SSSI's (Sandwich Bay to Hacklinge Marshes, Dover to Kingsdown Cliffs and Folkestone Warren SSSI's) as this is not currently identified.

7.0. Benthic and Fish Ecology

- 7.1. The scoping document does not give any commitment to employ the Cooper (2012) methodology, however the benthic baseline survey plan outlined (Section 9.4) has been designed to allow its use. The methodology outlined in Cooper (2012) must be referenced in the ES.
- 7.2. Section 9.4 is unclear whether the benthic impact assessment will be based on sensitivity assessments undertaken for each biotope in the exploration area or whether it will use a single representative biotope for the whole area. Whichever methodology is used it is important that the assessment represents the most sensitive biotopes, specifically those with higher levels of intolerance to abrasion and substratum removal.
- 7.3. The survey methodology must follow version four of the Regional Seabed Monitoring Plan (RSMP) protocols document. A copy of methodology is attached as Annex 3 to the main letter.
- 7.4. The results of the Goodwin Sands benthic characterisation survey (i.e. macrofauna and sediment particle size data) must be made available to Cefas to assist with the identification of sediment acceptable change limits (ACL) regionally. The ACL identified by Cefas will be used by the developer for assessment of future monitoring data.

8.0. Marine Mammals

- 8.1. Section 11, Table 11.2 identifies that a large proportion of the grey seals observed in the Thames Estuary during the August 2014 survey appear to

be hauling out at South Kellet Gut. It is not clear in the Scoping Report exactly where within the South Kellet Gut area the seals are hauling out. This must be clarified in the ES as any persistent impacts to the South Kellet area could be disruptive to the seal population.

- 8.2. The Scoping Report, infers that there are unlikely to be any grey seal haul out sites in the application area. However, the morphology of the bank is dynamic and the local bathymetry of the sand bank may change by the time dredging commences, which means more areas of intertidal sand could be present. This will need to be considered further in the ES.
- 8.3. Table 11.4 outlines that the EIA will address the correct range of potential impacts to marine mammals. Potential mitigation or avoidance measures which reduce the risk of these impacts reaching significant levels must be proposed within the ES, for example, a commitment not to dredge intertidal areas preventing a direct loss of intertidal extent and no dredging to taking place close to exposed sandbanks at low tide in order prevent disturbance to seals on the sand.

9.0. Ornithology

- 9.1. Section 12 states that a number of designated coastal sites within the study area have ornithological interest features. It is unclear within the Scoping Report how Special Protected Areas (SPAs) will be screened into the EIA. It is common practice to use the mean max foraging ranges presented in Thaxter *et al.* (2012). The presence of an extraction area within the foraging range of an SPA bird will provide justification to screen the SPA into a test of likely significant effect (LSE) under the Habitats Regulations Assessment. Thaxter *et al.* (2012) must therefore be employed to robustly screen whether any SPAs could be affected.

10.0. Habitats Regulations Assessment

- 10.1. Section 19 identifies several designated sites to be considered in the Habitats Regulation Assessment section of the EIA. The potential pressures and sites are correct but there is a need to improve the screening methodology used to identify relevant SPAs. It is agreed that the risk to sites designated under the Habitats Directive appear to be very small but an opinion cannot be formed on the significance of any impact until the ES is reviewed.

11.0. Cumulative Impact Assessment

- 11.1. Section 20.2 identifies other plans or projects taking place in the vicinity of the application area which the ES will consider as part of cumulative impact assessment. Fishing impacts must be properly assessed in-combination with other offshore development in the ES. It is acknowledged that the initial results of the fisheries assessment indicate that commercial fishing activity in the application area is limited.

12.0. Archaeology

- 12.1. Any geophysical, or geotechnical data that is collected and used to inform the historic baseline must be assessed by an accredited archaeological contractor.
- 12.2. The consideration for a magnetometer survey to identify any unexploded ordnance (UXO) and anomalies with archaeological potential is an appropriate and important measure to inform the baseline assessment. A full coverage survey must be undertaken across the site and the results interpreted by an accredited archaeological contractor.
- 12.3. The draft ES must address the historic environment features that may be affected by the activity, including the remains of wreckage from vessels and aircraft, and the archaeological evidence of possible human activity.
- 12.4. It is noted that within Section 1.8 'Study Area', the relevant heritage assets and archaeological sites designated and non-designated have not been listed. Given the importance of the sites in this area the ES must maintain a clear recognition throughout the ES, especially when considering broader environmental impacts. This is similarly the case for Section 6.1.1 'Summary of Approach'.
- 12.5. In order for the ES to function systematically as a standalone document cross-referencing to relevant information to fully understand the impacts to the historic environment as part of a multidisciplinary approach must be undertaken.
- 12.6. Section 9.4 'EIA Investigation' and Section 9.4.1 'Ecological characterisation and pre-dredge monitoring survey' – It is noted that there is a requirement for grab samples from predetermined seabed stations. The survey vessels and grab operators must take appropriate action to maintain clear of record of heritage assets identified during the survey. Vigilance must be maintained when grab samples are undertaken and should artefacts of archaeological interest be recovered they must be reported through the Marine Aggregate Industry Protocol for Reporting Finds of Archaeological Interest.
- 12.7. The Historic Seascape Character and the Setting must be considered within the ES. The assessment must consider whether dredging could impact the setting of assets on the Kent coast and there should be specific consideration of Goodwin Sands and the spatial relationship between the proposed activity and the wrecks designated under the Protection of Wreck Act. The archaeological consultant preparing the desk based assessment must look to incorporate the individual Protections of Wreck Act 1973 sites assessment and monitoring reports. The ES must look to incorporate The Goodwin Sands and the Downs, off Kent Overview of Archaeological Investigations (Ref: 53111.02k-27February 2012), produced by Wessex Archaeology.

Conclusion

In conclusion, the MMO advises that all the points raised above are addressed within the ES submitted as part of the Goodwin Sands aggregate dredging marine licence application.

Annex 2

The Marine Works (Environmental Impact Assessment) Regulations

SCHEDULE 3

INFORMATION TO BE INCLUDED IN AN ENVIRONMENTAL STATEMENT

1. A description of the project and of the regulated activity, including details of the following matters—

- (a) the location, size and nature of the project and the regulated activity;
- (b) the quantity and nature and source of the materials to be used in the course of the project and the regulated activity;
- (c) the quantity, nature and source of any items or materials to be deposited in the sea in the course of the project and the regulated activity; and
- (d) the working methods to be used in the course of the project and the regulated activity.

2. A description of the aspects of the environment likely to be significantly affected by the project and the regulated activity, including—

- (a) human beings, fauna and flora;
- (b) soil, water, air, climate and the landscape;
- (c) material assets and the cultural heritage; and
- (d) the interaction between any two or more of the things mentioned in the preceding sub-paragraphs.

3.—(1) A description, complying with sub-paragraph (2), of the likely significant effects of the project and the regulated activity on the environment resulting from—

- (a) the nature of the activities to be carried out and the manner in which they are to be carried out;
- (b) the use of natural resources;
- (c) the emission of pollutants;
- (d) the creation of nuisances; and
- (e) the elimination of waste.

(2) The description should cover each of the following categories of effect—

- (a) direct and indirect effects;
- (b) secondary effects;
- (c) cumulative effects;
- (d) short-term, medium-term and long-term effects;
- (e) permanent and temporary effects; and
- (f) positive and negative effects.

4. The forecasting methods used by the applicant to assess the main effects that the project and the regulated activity are likely to have on the environment.

5. A description of the measures envisaged to prevent, reduce and offset any significant adverse effects of the project and the regulated activity on the environment.

6. An outline of the main alternatives studied by the applicant and an indication of the main reasons for the applicant's choice, taking into account the environmental effects of those alternatives and the project as proposed.

7. A non-technical summary of the information provided under paragraphs 1 to 6.

8. Any difficulties, such as technical deficiencies or lack of knowledge, encountered in compiling any information of a kind specified in paragraphs 1 to 6.

Appendix 4.2

Scoping Consultation Responses

Table of Contents

1	Table of Consultation Comments received from the MMO	2

Table of Consultation Comments received from the MMO

The table below summarises the comments on the EIA process for the proposed Goodwin Sands Aggregate Dredging that were received by the Marine Management Organisation (MMO) from the various organisations consulted in relation to the MMO's Scoping Opinion (see **Appendix 4.1**). The table below also identifies the section in the ES (**Volume II**) where the comments have been addressed.

Date Received	ES Topic	Organisation	Comment	Section where addressed in the ES
25/09/2015	General	MMO -Scoping Opinion	This Licensing Authority has determined that the proposal described above requires an Environmental Impact Assessment under the Marine Works (Environmental Impact Assessment) Regulations 2007, as amended.	N/A
25/09/2015	General; Description of the Proposed Scheme	MMO -Scoping Opinion	To help aid the understanding of the overall impact of the proposed activity the draft ES must include the number of years the licence will cover and the estimates of average and maximum annual tonnage to be extracted.	ES Section 2 –Description of the Proposed Scheme
25/09/2015	General	MMO -Scoping Opinion	Statements and conclusions included in the ES must be supported by recent empirical evidence or scientific publications. Any conclusions must be based on expert judgements, which must be clearly described and discussed in the text. The level of uncertainty or confidence associated with each significance assessment must present the type of evidence used and how it was incorporated into the assessment.	Addressed throughout ES
25/09/2015	General; Description of the Proposed Scheme	MMO -Scoping Opinion	The likely routes to be taken by dredgers to and from the application area must be specified within the ES.	ES Section 2 –Description of the Proposed Scheme

Date Received	ES Topic	Organisation	Comment	Section where addressed in the ES
25/09/2015	Coastal Processes and Hydrodynamics	MMO -Scoping Opinion	A description of the geology and geomorphology of the application area and its surroundings, including the nearby coast, indicating where possible, its recent evolution must be specified in ES.	ES Section 6 – Coastal Processes and Hydrodynamics
25/09/2015	Cumulative Impact Assessment	MMO -Scoping Opinion	Details of the other dredging activities in the vicinity of the proposed licence area must be presented the ES.	ES Section 17 – Cumulative Impact Assessment
25/09/2015	General; Description of the Proposed Scheme	MMO -Scoping Opinion	Whether screening is to be undertaken must be made clear within the ES.	ES Section 2 –Description of the Proposed Scheme.
25/09/2015	Fish Ecology; Commercial and Recreational Fisheries	MMO -Scoping Opinion	The potential impacts on fish and the commercial and recreational fisheries industry and the data and information identified are appropriate. The scoping report also identified the need for a desk based fisheries assessment, further herring (<i>Clupea harengus</i>) and sand eel (<i>Ammodytidae</i>) studies and a baseline commercial and recreational fisheries study, which will be appropriate to address any deficiencies in the current data available to inform EIA.	ES Section 9 –Fish Ecology, ES Section 13 – Commercial and Recreational Fisheries
25/09/2015	Fish Ecology; Commercial and Recreational Fisheries	MMO -Scoping Opinion	Best practice and mitigation measures have been identified within the report. However, until the physical surveys have been carried out and quantitative and qualitative data has been acquired and collated, there is insufficient information to draft accurate fisheries mitigation measures. Future mitigation may however include seasonal dredging restrictions depending on the outcomes of the analysis.	ES Section 9 – Fish Ecology, ES Section 13 – Commercial and Recreational Fisheries

Date Received	ES Topic	Organisation	Comment	Section where addressed in the ES
25/09/2015	Fish Ecology; Commercial and Recreational Fisheries	MMO -Scoping Opinion	A desk based assessment of larger/adult demersal species and pelagic species present in the application area is required	ES Section 9 – Fish Ecology, ES Section 13 – Commercial and Recreational Fisheries
25/09/2015	Fish Ecology; Commercial and Recreational Fisheries	MMO -Scoping Opinion	Cefas beam trawl surveys are conducted in the Eastern English Channel in ICES divisions VIIId and IVc (including ICES rectangles 31F1 and 32F1). Data from these trawls may provide a source of fisheries information. Information can be downloaded from the ICES DATRAS website http://datras.ices.dk/Home/Default.aspx	ES Section 9 – Fish Ecology, ES Section 13 – Commercial and Recreational Fisheries
25/09/2015	Fish Ecology	MMO -Scoping Opinion	It is appreciated that a night time survey for sand eels is not feasible, and the habitat based approach and data collected from epibenthic trawls can be used to provide a sand eel assessment is supported. In addition to epibenthic trawl data, the numbers of sand eels found in benthic grabs must be recorded.	ES Section 9 – Fish Ecology
25/09/2015	Fish Ecology; Commercial and Recreational Fisheries	MMO -Scoping Opinion	Dover Sole (<i>Solea solea</i>) spawning season is from March to June, not April to June as stated on p75.	ES Section 9 – Fish Ecology, ES Section 13 – Commercial and Recreational Fisheries

Date Received	ES Topic	Organisation	Comment	Section where addressed in the ES
25/09/2015	Fish Ecology	MMO -Scoping Opinion	Thornback rays (<i>Raja clavata</i>) are not protected under Schedule 5 of the Wildlife and Countryside Act 1981 as stated on page 76. They are however included in the OSPAR List of threatened or declining species and listed as 'Near Threatened' on the IUCN red list	ES Section 9 – Fish Ecology
25/09/2015	Fish Ecology; Commercial and Recreational Fisheries	MMO -Scoping Opinion	It is agreed that the most important commercial species, by value and tonnage landed are whelk (<i>Buccinum undatum</i>). Close consultation with the fishing industry and Kent and Essex IFCA will assist in ascertaining the spatial distribution of the fishery in relation to the proposed extraction site. The use of VMS data will be limited as the majority of vessels targeting whelks are likely to be <12m in length and therefore are not captured by VMS. It must be noted that VMS systems have only been required on vessels 12-15m in length since 2013. Prior to this it was only a requirement for vessels of 15m and over and considered in any assessment of this data.	ES Section 9 – Fish Ecology, ES Section 13 – Commercial and Recreational Fisheries
25/09/2015	Commercial and Recreational Fisheries	MMO -Scoping Opinion	There is likely to be some potting for crab (<i>Cancer pagurus</i>) and lobster (<i>Homarus gammarus</i>) in the vicinity of the proposed dredge area, which must be stated within the ES.	ES Section 13 – Commercial and Recreational Fisheries
25/09/2015	Commercial and Recreational Fisheries	MMO -Scoping Opinion	The impacts of screening dredged aggregate on shellfisheries must be considered if screening is to be undertaken.	ES Section 13 – Commercial and Recreational Fisheries

Date Received	ES Topic	Organisation	Comment	Section where addressed in the ES
25/09/2015	General	MMO -Scoping Opinion	In Table 21.1, page 138, the identification of mitigation measures are considered as part of the EIA process, but no mitigation and monitoring measures are identified. Mitigation measures must be included in the ES.	Addressed throughout ES
25/09/2015	Coastal Processes and Hydrodynamics	MMO -Scoping Opinion	Section 6.4.2 - If the exact location and dredge depth is not known prior to the modelling work being undertaken, the realistic worst case scenario with regard to seabed lowering must be used i.e. the extraction scenario that is likely to result in the biggest changes to waves, tidal currents, sediment transport and morphology.	ES Section 6 – Coastal Processes and Hydrodynamics
25/09/2015	Coastal Processes and Hydrodynamics	MMO -Scoping Opinion	The numerical outputs of the hydrodynamic model must be discussed with respect to the environmental receptors being assessed and what the likely ecological significance of any changes in hydrodynamics will be. For example if the model predicts a 5% change in significant wave height at a location, it is important to be clear in what this will mean for sediment stability, particle size distribution and morphology.	ES Section 6 – Coastal Processes and Hydrodynamics
25/09/2015	Coastal Processes and Hydrodynamics	MMO -Scoping Opinion	Section 2.7.1 outlines Dover Harbour Board's (DHB) proposal to zone the dredging works in a way which minimises environmental impact. The dredge locations, zoning and intensity levels must be managed to ensure that changes in seabed topography are minimised as significant changes in seabed topography have the potential to: • reduce slope stability potentially causing slippage of the bank and a reduction in intertidal area (which would have effects on seal haul out behaviour); • alter localised water movements affecting the activity and location of local fish populations; and • change physical conditions at the seabed increasing sediment disturbance levels and changing particle size distribution	ES Section 6 – Coastal Processes and Hydrodynamics

Date Received	ES Topic	Organisation	Comment	Section where addressed in the ES
25/09/2015	Nature Conservation Designations	MMO -Scoping Opinion	Section 4.4.3 states the site falls within Tranche 3 of the designation process, which is not currently deemed a designated site or subject to public consultation. Consequently the marine licence application would not require an MCZ assessment. It is likely that the site will be considered for designation in the future under Tranche 3 of Defra's MCZ designation programme, therefore it is recommended that the possible impacts to the rMCZ features are considered	ES Section 5 – Nature Conservation Designations. The MMO has confirmed that an MCZ assessment will not be required for the proposed scheme.
25/09/2015	Nature Conservation Designations, Benthic Ecology	MMO -Scoping Opinion	It must be noted that the features identified as part of the MCZ are listed as habitats and species of importance under OSPAR convention and Section 41 of the Natural Environment and Rural Communities (NERC) act 2006.	ES Section 5 – Nature Conservation Designations
25/09/2015	Nature Conservation Designations	MMO -Scoping Opinion	Section 5.5 provides details, such as the location and approximate distance of the exploration area to the Thanet Coast Site of Special Scientific Interest (SSSI). This information must be provided in the ES for the remaining SSSI's (Sandwich Bay to Hacklinge Marshes, Dover to Kingsdown Cliffs and Folkestone Warren SSSI's) as this is not currently identified.	ES Section 5 – Nature Conservation Designations
25/09/2015	Benthic Ecology	MMO -Scoping Opinion	The scoping document does not give any commitment to employ the Cooper (2012) methodology, however the benthic baseline survey plan outlined (Section 9.4) has been designed to allow its use. The methodology outlined in Cooper (2012) must be referenced in the ES.	ES Section 8 – Benthic Ecology
25/09/2015	Benthic Ecology	MMO -Scoping Opinion	Section 9.4 is unclear whether the benthic impact assessment will be based on sensitivity assessments undertaken for each biotope in the exploration area or whether it will use a single representative biotope for the whole area. Whichever methodology is used it is important that the assessment represents the most sensitive biotopes, specifically those with higher levels of intolerance to abrasion and substratum removal.	ES Section 8 – Benthic Ecology

Date Received	ES Topic	Organisation	Comment	Section where addressed in the ES
25/09/2015	Benthic Ecology	MMO -Scoping Opinion	The survey methodology must follow version four of the Regional Seabed Monitoring Plan (RSMP) protocols document	ES Section 8 – Benthic Ecology
25/09/2015	Benthic Ecology	MMO -Scoping Opinion	The results of the Goodwin Sands benthic characterisation survey (i.e. macrofauna and sediment particle size data) must be made available to Cefas to assist with the identification of sediment acceptable change limits (ACL) regionally. The ACL identified by Cefas will be used by the developer for assessment of future monitoring data.	ES Section 8 – Benthic Ecology
25/09/2015	Marine Mammals	MMO -Scoping Opinion	Section 11, Table 11.2 identifies that a large proportion of the grey seals observed in the Thames Estuary during the August 2014 survey appear to be hauling out at South Kellat Gut. It is not clear in the Scoping Report exactly where within the South Kellat Gut area the seals are hauling out. This must be clarified in the ES as any persistent impacts to the South Kellat area could be disruptive to the seal population.	ES Section 10 – Marine Mammals
25/09/2015	Marine Mammals	MMO -Scoping Opinion	The Scoping Report, infers that there are unlikely to be any grey seal haul out sites in the application area. However, the morphology of the bank is dynamic and the local bathymetry of the sand bank may change by the time dredging commences, which means more areas of intertidal sand could be present. This will need to be considered further in the ES.	ES Section 10 – Marine Mammals
25/09/2015	Marine Mammals	MMO -Scoping Opinion	Table 11.4 outlines that the EIA will address the correct range of potential impacts to marine mammals. Potential mitigation or avoidance measures which reduce the risk of these impacts reaching significant levels must be proposed within the ES, for example, a commitment not to dredge intertidal areas preventing a direct loss of intertidal extent and no dredging to taking place close to exposed sandbanks at low tide in order prevent disturbance to seals on the sand.	ES Section 10 – Marine Mammals

Date Received	ES Topic	Organisation	Comment	Section where addressed in the ES
25/09/2015	Ornithology	MMO -Scoping Opinion	Section 12 states that a number of designated coastal sites within the study area have ornithological interest features. It is unclear within the Scoping Report how Special Protected Areas (SPAs) will be screened into the EIA. It is common practice to use the mean max foraging ranges presented in Thaxter et al. (2012). The presence of an extraction area within the foraging range of an SPA bird will provide justification to screen the SPA into a test of likely significant effect (LSE) under the Habitats Regulations Assessment. Thaxter et al. (2012) must therefore be employed to robustly screen whether any SPAs could be affected.	ES Section 11 - Ornithology
25/09/2015	Nature Conservation Designations	MMO -Scoping Opinion	Section 19 identifies several designated sites to be considered in the Habitats Regulation Assessment section of the EIA. The potential pressures and sites are correct but there is a need to improve the screening methodology used to identify relevant SPAs. It is agreed that the risk to sites designated under the Habitats Directive appear to be very small but an opinion cannot be formed on the significance of any impact until the ES is reviewed.	ES Section 5 – Nature Conservation Designations
25/09/2015	Cumulative Impact Assessment	MMO -Scoping Opinion	Section 20.2 identifies other plans or projects taking place in the vicinity of the application area which the ES will consider as part of cumulative impact assessment. Fishing impacts must be properly assessed in-combination with other offshore development in the ES. It is acknowledged that the initial results of the fisheries assessment indicate that commercial fishing activity in the application area is limited.	ES Section 17 – Cumulative Impact Assessment
25/09/2015	Archaeology and Historic Environment	MMO -Scoping Opinion	Any geophysical, or geotechnical data that is collected and used to inform the historic baseline must be assessed by an accredited archaeological contractor	ES Section 15 – Archaeology and Historic Environment

Date Received	ES Topic	Organisation	Comment	Section where addressed in the ES
25/09/2015	Archaeology and Historic Environment	MMO -Scoping Opinion	The consideration for a magnetometer survey to identify any unexploded ordnance (UXO) and anomalies with archaeological potential is an appropriate and important measure to inform the baseline assessment. A full coverage survey must be undertaken across the site and the results interpreted by an accredited archaeological contractor	ES Section 15 – Archaeology and Historic Environment
25/09/2015	Archaeology and Historic Environment	MMO -Scoping Opinion	The draft ES must address the historic environment features that may be affected by the activity, including the remains of wreckage from vessels and aircraft, and the archaeological evidence of possible human activity	ES Section 15 – Archaeology and Historic Environment
25/09/2015	Archaeology and Historic Environment	MMO -Scoping Opinion	It is noted that within Section 1.8 'Study Area', the relevant heritage assets and archaeological sites designated and non-designated have not been listed. Given the importance of the sites in this area the ES must maintain a clear recognition throughout the ES, especially when considering broader environmental impacts. This is similarly the case for Section 6.1.1 'Summary of Approach'.	ES Section 15 – Archaeology and Historic Environment
25/09/2015	Archaeology and Historic Environment	MMO -Scoping Opinion	In order for the ES to function systematically as a standalone document cross-referencing to relevant information to fully understand the impacts to the historic environment as part of a multidisciplinary approach must be undertaken.	ES Section 15 – Archaeology and Historic Environment

Date Received	ES Topic	Organisation	Comment	Section where addressed in the ES
25/09/2015	Archaeology and Historic Environment	MMO -Scoping Opinion	Section 9.4 'EIA Investigation' and Section 9.4.1 'Ecological characterisation and pre-dredge monitoring survey' – It is noted that there is a requirement for grab samples from predetermined seabed stations. The survey vessels and grab operators must take appropriate action to maintain clear of record of heritage assets identified during the survey. Vigilance must be maintained when grab samples are undertaken and should artefacts of archaeological interest be recovered they must be reported through the Marine Aggregate Industry Protocol for Reporting Finds of Archaeological Interest.	ES Section 15 – Archaeology and Historic Environment
25/09/2015	Archaeology and Historic Environment	MMO -Scoping Opinion	The Historic Seascape Character and the Setting must be considered within the ES. The assessment must consider whether dredging could impact the setting of assets on the Kent coast and there should be specific consideration of Goodwin Sands and the spatial relationship between the proposed activity and the wrecks designated under the Protection of Wreck Act. The archaeological consultant preparing the desk based assessment must look to incorporate the individual Protections of Wreck Act 1973 sites assessment and monitoring reports. The ES must look to incorporate The Goodwin Sands and the Downs, off Kent Overview of Archaeological Investigations (Ref: 53111.02k-27February 2012), produced by Wessex Archaeology.	ES Section 15 – Archaeology and Historic Environment
Not provided	Commercial and Recreational Fisheries	MMO South Eastern	Outline fishing activity and any other legitimate users of the sea in the area of application (include number and type of vessels, home ports etc. List industry contacts as necessary)	ES Section 13 – Commercial and Recreational Fisheries

Date Received	ES Topic	Organisation	Comment	Section where addressed in the ES
Not provided	Commercial and Recreational Fisheries	MMO South Eastern	Are there any comments on the likelihood that these activities will interfere with fishing operations or other legitimate users of the sea in the area of the application (i.e. interference with static gear/traditional fishing grounds, navigation measures)	ES Section 13 – Commercial and Recreational Fisheries
Not provided	Commercial and Recreational Fisheries; Benthic Ecology; Fish Ecology	MMO South Eastern	Are there any comments on the likelihood that these activities will have an impact on fish/shellfish stocks (i.e. smothering fish beds)	ES Section 9 – Fish Ecology. ES Section 13 Commercial and Recreational Fisheries
Not provided	Commercial and Recreational Navigation; Commercial and Recreational Fisheries	MMO South Eastern	Highlight any seasonality to the local fisheries (i.e. periods when proposed activity would be unacceptable and the reasons for this)	ES Section 13 Commercial and Recreational Fisheries
Not provided	Commercial and Recreational Fisheries	MMO South Eastern	Are there any comments on whether local industries, if known, are aware of the proposals?	ES Section 13 Commercial and Recreational Fisheries
Not provided	Commercial and Recreational Fisheries	MMO South Eastern	Please provide further information on proposal awareness as appropriate (i.e. has the MMO attended any meetings, if so please provide a summary. What are the local views? Any press articles? Has fisheries liaison been organised)	ES Section 13 Commercial and Recreational Fisheries
Not provided	Nature Conservation Designations	MMO South Eastern	Does the application fall within any conservation areas?	ES Section 5 - Nature Conservation Designations

Date Received	ES Topic	Organisation	Comment	Section where addressed in the ES
Not provided	Commercial and Recreational Fisheries	MMO South Eastern	Suggest any conditions MMO would like to see imposed to mitigate impact of works and/or assist monitoring and enforcement.	ES Section 13 Commercial and Recreational Fisheries
Not provided	Other Commercial and Recreational Activities	MMO South Eastern	Are there any comments on the likelihood that these activities will have an impact on other users of the sea. If known give details.	ES Section 15 – Other Commercial and Recreational Activities
14/09/2015	EIA Process	Natural England	<u>Environment Impact Assessment Methodology</u> Determinations of impact significance within the Environment Statement (ES) should follow a transparent and robust methodology. This methodology should be clearly presented within the ES in order to give the reader confidence in the validity of the determinations. Statements and conclusions included in the ES should be supported by recent empirical evidence or scientific publications. If it is necessary to make conclusions based on expert judgements this should be clearly described and discussed in the text. Furthermore, the level of uncertainty/ confidence associated with each significance assessment should clearly present the type of evidence used and state how it was incorporated into the assessment.	ES Section 3 - Legislation, Planning and Policy Context & EIA Process

Date Received	ES Topic	Organisation	Comment	Section where addressed in the ES
14/09/2015	Description of the Proposed Scheme, Coastal Processes and Hydrodynamics	Natural England	DHB are applying for a Marine Licence to extract a maximum annual tonnage of 2.5 million tonnes of aggregate over an un-defined period, however according to Section 2.5, it is likely to be 6 years. Section 2.7.1 outlines DHB's proposal to zone the dredging works in a way which minimises environmental impact. Natural England recommend that the dredge locations, zoning and intensity levels are managed to ensure that changes in seabed topography are minimised as significant changes in seabed topography have the potential to; • reduce slope stability potentially causing slippage of the bank and a reduction in intertidal area (which would have effects on seal haul out behaviour); • alter localised water movements affecting the activity and location of local fish populations; • change physical conditions at the seabed increasing sediment disturbance levels and changing particle size distribution.	ES Section 2 – Description of the Proposed Scheme, ES Section 5 – Coastal Processes and Hydrodynamics
14/09/2015	Nature Conservation Designations; Benthic Ecology	Natural England	Section 4.4.3 correctly identifies that the application area is wholly within Goodwin sands recommend Marine Conservation Zone (rMCZ). This site has been put forward for designation of the following features: <u>Broad-scale habitats</u>: • A3.2 moderate energy infralittoral rock • A4.2 moderate energy circalittoral rock • A5.1 Subtidal coarse sediment • A5.2 Subtidal sand <u>Habitat FOCI</u> • Blue mussel beds • Rossworm (Sabellaria spinulosa) reef <u>Geology</u> - Eastern English Channel outburst flood features.	ES Section 5 Nature Conservation Designations The MMO has confirmed that an MCZ assessment will not be required for the proposed scheme.

Date Received	ES Topic	Organisation	Comment	Section where addressed in the ES
14/09/2015	Nature Conservation Designations; Benthic Ecology	Natural England	Section 4.4.3 also outlines that because the site falls within Tranche 3 of the designation process, it is not currently deemed a designated site or subject to public consultation. Consequently the marine licence application would currently not require an MCZ assessment. There is the strong possibility that the site may be considered for designation in the future under Tranche 3 of Defra's MCZ designation programme. It is therefore at the MMOs discretion as to how they consider impacts to the rMCZ and the level of protection they deem appropriate. Whilst not currently designated as an MCZ it is worth noting that the features identified as part of the MCZ are listed as habitats and species of importance under OSPAR convention and section 41 of the NERC act and should be given due regard by the MMO when discharging their duties. It is also important to note that the timeline for Tranche 3 designation is not clear meaning there is the potential that the MCZ may be subject to public consultation and (liable for an MCZ assessment) before the granting of the licence. However due to the fact that dredging is proposed to start on August 2016, the likelihood of this is small.	ES Section 5 -Nature Conservation Designations. The MMO has confirmed that an MCZ assessment will not be required for the proposed scheme.
14/09/2015	Nature Conservation Designations	Natural England	Section 5.5 identifies Sites of Special Scientific Interest (SSSI) within the study area. It is noted that details such as location and approximate distance to the exploration area are provided for Thanet Coast SSSI within the text. However further information such as this will need to be provided in the ES for the remaining SSSI's (Sandwich Bay to Hacklinge Marshes, Dover to Kingsdown Cliffs and Folkestone Warren SSSI's) where this detail is not currently identified.	ES Section 5 Nature Conservation Designations
14/09/2015	Coastal Processes and Hydrodynamics and General	Natural England	Section 6.1.1 states that any induced changes in hydrodynamics will be considered as environmental effects, and will only be considered impacts where these effects cause changes to a receptor such as benthic ecology. Natural England agrees that this approach is appropriate.	ES Section 5 – Coastal Processes and Hydrodynamics and incorporated throughout EIA receptor assessments

Date Received	ES Topic	Organisation	Comment	Section where addressed in the ES
14/09/2015	Description of Proposed Scheme; Coastal Processes and Hydrodynamics	Natural England	Section 6.4.2 outlines that DHB are undertaking a numerical hydrodynamic modelling study to understand how dredging will affect waves, tidal flows, sediment transport and sediment release from dredging. However it is not clear on the extraction scenario that will be used in the modelling study; for example, details of where in the application area the dredging will take place, the depth of sediment that will be removed and over what spatial area are not currently identified. DHB are not likely to know the details of the above until following the results of the geo technical survey analysis. If the exact location and depth dredged is not known prior to the modelling work being undertaken we recommend that the EIA uses the realistic worst case scenario with regard to seabed lowering i.e. the extraction scenario that is likely to result in the biggest changes to waves, tidal currents, sediment transport and morphology.	ES Section 5 – Coastal Processes and Hydrodynamics
14/09/2015	Coastal Processes and Hydrodynamics and General	Natural England	It is important that the numerical outputs of the hydrodynamic model are discussed with respect to the environmental receptors being assessed and what the likely ecological significance of any changes in hydrodynamics will be. For example if the model predicts a 5% change in significant wave height at a location, it is important to be clear what this will mean for sediment stability, particle size distribution and morphology.	ES Section 5 – Coastal Processes and Hydrodynamics and incorporated throughout receptor assessments

Date Received	ES Topic	Organisation	Comment	Section where addressed in the ES
14/09/2015	Benthic Ecology	Natural England	As part of the Regional Seabed Monitoring Programme (RSMP), the aggregate industry have developed a methodology, which is outlined in Cooper (2012), that sets limits for acceptable change in sediment particle size composition following marine aggregate dredging. Using the pre dredge baseline benthic dataset the different seabed types found in the application area (defined by their faunal assemblage) are given thresholds or limits with respect to their particle size curves. Any change beyond these limits would likely result in a differing faunal community colonising that area at the cessation of dredging. This method whilst still subject to continuing development is a quantifiable way to monitor and manage seabed condition so that it supports full seabed recovery (to pre dredge conditions). The scoping document does not state any commitment to employ this methodology however the benthic baseline survey plan outlined in the scoping report (section 9.4) has been designed to allow its use. We would recommend that the methodology outlined in Cooper (2012) is employed as license condition and referenced in the EIA.	ES Section 8 – Benthic Ecology
14/09/2015	Benthic Ecology	Natural England	It is unclear from section 9.4 whether the benthic impact assessment will be based on sensitivity assessments undertaken for each biotope in the exploration area or whether it will use a single representative biotope for the whole area. Whichever methodology is chosen it is important that the assessment fully represents the most sensitive biotopes, specifically those with higher levels of intolerance to abrasion and substratum removal.	ES Section 8 – Benthic Ecology
14/09/2015	Fish Ecology	Natural England	Section 10.4 identifies that further trawls and surveys will be undertaken. Natural England would recommend also referring to Cefas for discussions surrounding herring methodologies.	ES Section 9 – Fish Ecology

Date Received	ES Topic	Organisation	Comment	Section where addressed in the ES
14/09/2015	Marine Mammals	Natural England	Section 11, Table 11.2 identifies that a large proportion of the grey seals observed in the Thames Estuary during the August 2014 survey appeared to be hauling out at S Kellet Gut, specifically 308 individuals from a Thames estuary total of 449 (approx. 69%). S Kellet Gut is identified in table 11.2 as 2.5km from the exploration area. It is not clear in the Scoping Report exactly where within the S Kellet Gut area these seals are hauling out, however the admiralty chart displayed in Figure 1.3 shows Kellet Gut to be directly adjacent to the exploration area and at some points extends into the application area meaning dredging may take place close to important haul out sites. The scoping document identifies that some grey seals display high site fidelity increasing the likelihood of any persistent impacts to the South Kellet area being disruptive to the seal population.	ES Section 10 –Marine Mammals
14/09/2015	Coastal Processes and Hydrodynamics; Marine Mammals	Natural England	The Scoping Report states that the admiralty chart data shows there to be very little sandbank exposed at low water in the application area, inferring that there are unlikely to be any haul out sites in the application area. However the morphology of the bank is dynamic and the local bathymetry of the sand bank may have changed by the time dredging commences; meaning more areas of intertidal sand may be present. This will need to be considered.	ES Section 10 –Marine Mammals
14/09/2015	Marine Mammals	Natural England	Table 11.4 outlines that the EIA will address the correct range of potential impacts to marine mammals. However, as part of the EIA we would like to see potential mitigation or avoidance measures proposed which reduce the risk of these impacts reaching significant levels. For example, whilst the size of dredgers used will make it unlikely to occur, we would like to see a commitment not to dredge intertidal areas thus preventing direct loss of intertidal extent. We would also request that they do not actively dredge close to exposed sandbanks at low tide to prevent disturbing seals on the sand.	ES Section 10 –Marine Mammals

Date Received	ES Topic	Organisation	Comment	Section where addressed in the ES
14/09/2015	Ornithology	Natural England	It is noted from Section 12 that a number of internationally and nationally designated coastal sites within the study area have ornithological interest, however it is unclear how it has been defined which SPAs to screen into the EIA. It is common practice to use the mean max foraging ranges presented in Thaxter et al. (20121) to identify whether the dredge areas are within the foraging range of any bird species connected to a SPA. We deem the presence of an extraction area within the foraging range of an SPA bird as justification for screening that SPA into a test of likely significant effect (LSE). A sensitivity assessment of the pathways between dredging activity and bird function and condition is then used to determine whether there is likely to be a significant effect on the SPA conservation objectives. Therefore whilst we agree that the application area does appear to be distant from any SPA, it is important that the screening process is undertaken robustly and transparently and therefore we recommend using this methodology.	ES Section 11 – Ornithology, ES Section 5 – Nature Conservation Designations. Natural England confirmed that a HRA would be required for the proposed scheme.
14/09/2015	Nature Conservation Designations	Natural England	Section 19 identifies a number of designated sites to be considered in the Habitats Regulation Assessment section of the EIA. The potential pressures and sites do appear correct but as mentioned above in 2.1.2 there is still a need to improve the screening methodology used to identify relevant SPAs. We agree with the authors that the risk to sites designated under the Habitats Directive appears to be very small but we cannot form an opinion on the significance of any impact until we have reviewed the EIA.	ES Section 5 – Nature Conservation Designations. Natural England has confirmed that a HRA is not required for the scheme.

Date Received	ES Topic	Organisation	Comment	Section where addressed in the ES
14/09/2015	Cumulative Impact Assessment, Commercial and Recreational Fisheries	Natural England	Section 20.2 identifies other plans or projects taking place in the vicinity of the application area which the EIA will consider as part of cumulative impact assessment. It is important that fishing impacts are also properly assessed in combination with other offshore development (the impacts are not provided for background information or as part of the baseline), however we acknowledge that the initial results of the fisheries assessment indicate that commercial fishing activity in the application area is limited.	ES Section 13 – Commercial and Recreational Fisheries, ES Section 17 – Cumulative Impact Assessment
14/09/2015	General	Natural England	Overall, the Scoping Report provided is clearly presented, well-structured and includes a large amount of useful detail and maps. The Scoping Report outlines the correct range of potential impacts that need to be assessed for a robust EIA.	N/A
01/09/2015	General	Environment Agency	We have reviewed the EIA and the WFD compliance assessment within it. We find the conclusions acceptable and have no further comment to make.	ES Appendix 7.1 – Water Framework Directive Compliance Assessment
11/09/2015	Fish Ecology; Commercial and Recreational Fisheries	Cefas	The potential impacts on fish and commercial and recreational fisheries industry have been identified and the data and information given is sufficient for a scoping report. The report has identified the need for desk based assessments and further study for herring (<i>Clupea harengus</i>) and sand eel (<i>Ammodytidae</i>) and a baseline study of commercial and recreational fisheries. These should address deficiencies and provide data for the EIA.	ES Section 13 – Commercial and Recreational Fisheries, ES Section 9 – Fish Ecology

Date Received	ES Topic	Organisation	Comment	Section where addressed in the ES
11/09/2015	Fish Ecology; Commercial and Recreational Fisheries	Cefas	Some best practice and mitigation measures have been identified in the report. We note that dredging is due to commence in early 2016. Mitigation might include postponing dredging until certain species' spawning seasons have ended. However, until the physical surveys have been carried out and quantitative and qualitative data acquired, there is insufficient information available with which to draw up accurate fisheries mitigation measures.	ES Section 9 – Fish Ecology
11/09/2015	Fish Ecology; Commercial and Recreational Fisheries	Cefas	To note that the scientific beam trawl is predominantly used to sample epibenthic species and will also sample small bodied fish and juveniles. The method will not adequately sample larger and/or adult demersal species. Additionally the method will not sample pelagic species present in the area. Therefore we would suggest a further methodology is required to adequately sample larger/adult demersal species and pelagic species.	ES Section 13 – Commercial and Recreational Fisheries, ES Section 9 – Fish Ecology
11/09/2015	Commercial and Recreational Fisheries	Cefas	We promote and encourage good relations with fishermen and those working in the industry. We endorse the study of commercial and recreational fisheries commissioned as part of the EIA.	ES Section 13 – Commercial and Recreational Fisheries
11/09/2015	Commercial and Recreational Fisheries	Cefas	Cefas beam trawl surveys are conducted in the Eastern English Channel in ICES divisions VIIId and IVc (including ICES rectangles 31F1 and 32F1). Data from these trawls may provide a source of fisheries information. Information can be downloaded from the ICES DATRAS website http://datras.ices.dk/Home/Default.aspx	ES Section 13 – Commercial and Recreational Fisheries

Date Received	ES Topic	Organisation	Comment	Section where addressed in the ES
11/09/2015	Fish Ecology	Cefas	We appreciate that a night time survey for sand eels isn't suitable due to safety concerns of operating at night in an area with challenging conditions and support the habitat based approach and data collected from epibenthic trawls can be used to provide a sand eel assessment. In addition to epibenthic trawl data, we recommend that numbers of sand eels found in benthic grabs also be recorded.	ES Section 9 – Fish Ecology
11/09/2015	Fish Ecology; Commercial and Recreational Fisheries	Cefas	We support the specific herring assessment that will be undertaken as part of the EIA.	ES Section 9 – Fish Ecology
11/09/2015	Benthic Ecology	Cefas	We are pleased to see the Regional Seabed Monitoring Plans (RSMP) 'limits of acceptable change for sediment composition' in use to ensure habitat recovery for future spawning and habitat activity.	ES Section 8 – Benthic Ecology
11/09/2015	Fish Ecology; Commercial and Recreational Fisheries	Cefas	Please note that Dover Sole (<i>Solea solea</i>) spawning season is from March to June, not April to June as stated on p.75.	ES Section 13 – Commercial and Recreational Fisheries, ES Section 9 – Fish Ecology
11/09/2015	Fish Ecology; Commercial and Recreational Fisheries	Cefas	Thornback rays (<i>Raja clavata</i>) are not protected under Schedule 5 of the Wildlife and Countryside Act 1981 as stated on p76. However, they are included in the OSPAR List of threatened or declining species and listed as 'Near Threatened' on the IUCN red list.	ES Section 13 – Commercial and Recreational Fisheries

Date Received	ES Topic	Organisation	Comment	Section where addressed in the ES
12/09/2015	Commercial and Recreational Fisheries	Cefas	We agree that the most important commercial species, by value and tonnage landed is whelk (<i>Buccinum undatum</i>). As always Cefas would recommend close consultation with the fishing industry and Kent and Essex IFCA to ascertain the spatial distribution of the fishery in relation to the proposed extraction site. The surveillance sightings data provide an insight into the distribution of the fishery but consultation with the industry would expand on this. The use of VMS data will be limited as the majority of vessels targeting whelks are likely to be <12m length and so not captured by VMS. It is also worth noting that VMS systems have only been required on vessels 12-15m in length since 2013, prior to this it was only a requirement for vessels of 15m and over and so careful consideration of this data will be required.	
13/09/2015	Commercial and Recreational Fisheries	Cefas	There is likely to be some potting for crab (<i>Cancer pagurus</i>) and lobster (<i>Homarus gammarus</i>) in the vicinity of the proposed dredge area.	ES Section 13 – Commercial and Recreational Fisheries
14/09/2015	Fish Ecology; Commercial and Recreational Fisheries	Cefas	There is no mention of whether screening of the aggregate will be undertaken and the impacts of this should be covered in the EIA if it is to be employed.	ES Section 2 – Description of the Proposed Scheme. Screening will not be undertaken as part of the proposed scheme.
15/09/2015	General	Cefas	The description of the environment and potential impacts are accurate for the scoping stage of the application. Cefas are satisfied with the range of investigations the applicant will undertake to inform the EIA, including surveys and modelling.	Addressed throughout ES

Date Received	ES Topic	Organisation	Comment	Section where addressed in the ES
16/09/2015	Coastal Processes and Hydrodynamics	Cefas	At this stage no mitigation and monitoring measures were identified for marine processes. In Table 21.1, page 138, the identification of mitigation measures is considered as part of the EIA process and mitigation measures will probably be included in the draft ES. Cefas expects the applicant to consider in the Environmental Statement the implementation of monitoring measures to verify the findings of the Environmental Impact Assessment by the dredging activity.	ES Section 5 – Coastal Processes and Hydrodynamics
17/09/2015	Benthic Ecology	Cefas	The proposed survey design was developed in consultation with Cefas, and will therefore meet the needs of the RSMP approach.	ES Section 8 – Benthic Ecology
18/09/2015	Benthic Ecology	Cefas	Survey methodology should follow version 4 of the RSMP protocols document (attached to my advice). Note that the formal QA steps will not be required in this case.	ES Section 8 – Benthic Ecology
19/09/2015	Benthic Ecology	Cefas	I would like to request that the results of the Goodwin Sands benthic characterisation survey survey (i.e., macrofauna and sediment particle size data) are made available to Cefas to assist with the identification of sediment acceptable change limits (ACL) regionally. The ACL identified by Cefas will be used by the developer for assessment of future monitoring data.	ES Section 8 – Benthic Ecology

Date Received	ES Topic	Organisation	Comment	Section where addressed in the ES
10/09/2015	Archaeology and Historic Environment	Historic England	We note that DHB identified the resource in this area of Goodwin Sands using geophysical survey techniques, with the interpreted results of this survey and a subsequent geotechnical survey, proposed to determine possible dredging zone(s). We further note extraction is being planned over two independent stages; August 2016 to November 2017; and March 2022 to August 2022. As a general point, we would wish to see clearly set out in any ES submitted to support a marine licence application the duration and terms of the licence applied for (i.e. the number of years the licence will cover and estimates of average and maximum annual tonnage), to aid our understanding of the overall impact of the proposed extraction works.	ES Section 14 – Archaeology and Historic Environment
10/09/2015	Archaeology and Historic Environment	Historic England	We note from Section 2 'Description of the Proposed Scheme' that further geophysical surveys are anticipated in the summer of 2015, including, multi-beam echo sounder (MBES) system; sidescan sonar survey (100% coverage); and sub-bottom profiler (seismic). Any such geophysical, or geotechnical data, that is collected and will be used to inform the historic environment baseline, upon which the EIA is based, should be fully assessed by an accredited archaeological contractor with sufficient relevant experience in such assessments. It is also advisable for an accredited archaeologist to be involved in the design of the survey, in order to ensure that the data collected is suitable for archaeological assessment.	ES Section 14 – Archaeology and Historic Environment

Date Received	ES Topic	Organisation	Comment	Section where addressed in the ES
10/09/2015	Archaeology and Historic Environment	Historic England	It was also noted that DHB is considering the potential requirement for magnetometer survey to be utilised for archaeological purposes, we believe this to be an appropriate and important measure of baseline assessment of potential features of the historic environment within the Goodwin Sands region. This is crucial considering that even the full extent of established known sites, such as the <i>Rooswijk</i> wreck site for instance, the extent of which is still unknown and incorporates much of the 150m radius protected area (see link in response for web info). Therefore, we request that such a survey is administered across these sites, with full coverage and interpreted by an accredited archaeological contractor.	ES Section 14 – Archaeology and Historic Environment. It was agreed with Historic England that a magnetometer survey was not required for the proposed scheme.
10/09/2015	Archaeology and Historic Environment	Historic England	An ES submitted in support of this licence application must address the requirements of Environmental Impact Assessment (EIA), which are inclusive of the historic environment. In brief outline the historic environment features that may be affected by these developments include remains of wreckage from vessels and aircraft, and the archaeological evidence of possible human activity on former land surfaces now submerged by higher sea levels.	ES Section 14 – Archaeology and Historic Environment
10/09/2015	Archaeology and Historic Environment	Historic England	Whilst an overview of the historic environment interests have been adequately indicated within the Scoping Report, we noted within Section 1.8 'Study Area', the relevant heritage assets and archaeological sites designated and non-designated have not been listed. As such, given the importance of the sites we request that the ES maintains a clear recognition throughout of such levels of significance especially when considering broader environmental impacts. This was similarly observed within Section 6.1.1 'Summary of Approach'.	ES Section 14 – Archaeology and Historic Environment

Date Received	ES Topic	Organisation	Comment	Section where addressed in the ES
10/09/2015	Archaeology and Historic Environment	Historic England	We note from Section 6.3.1 'Changes in Bathymetry' and Section 6.3.5 'Changes in sediment transport' that the seabed may become subject to periods of lowering sediment levels. During such times, changes may be reflected in associated indirect effects on the wave, tide and sediment regimes. Moreover, extraction may cause changes to the local and regional sediment transport pathways. We note such detail is captured as a requirement for consideration with any ES, however we require for the ES to function systematically and coherently as a standalone document, and there is a need therefore for cross-referencing to relevant information to fully understand impacts to the historic environment, as part of a multidisciplinary approach.	ES Section 5 Coastal Processes and Hydrodynamics, ES Section 14 – Archaeology and Historic Environment

Date Received	ES Topic	Organisation	Comment	Section where addressed in the ES
10/09/2015	Archaeology and Historic Environment	Historic England	We note from Section 9.4 'EIA Investigations', and specifically in Section 9.4.1 'Ecological characterisation and pre-dredge monitoring survey' that there is a requirement for grab samples from predetermined seabed stations. Whilst we have no general concerns in regards to this approach, we would like to comment on two elements related to the planning of such surveys. The first is that the survey vessel and grab operators must take appropriate action to remain clear of recorded heritage assets during the survey. Secondly, through the operation of grab sampling equipment we request that vigilance is maintained should artefacts of archaeological interest be recovered, and that they are reported through the Marine Aggregate Industry Protocol for Reporting Finds of Archaeological Interest. By way of illustrating this point, during a recent benthic trawl survey commissioned by London Gateway Ports in the Thames Estuary, a medieval jar fragment dating to the 13th century was discovered. Admittedly, whilst this is a different technique from what is being proposed, it does demonstrate the possibility for archaeological finds during such operations in areas of high archaeological potential.	ES Section 14 – Archaeology and Historic Environment

Date Received	ES Topic	Organisation	Comment	Section where addressed in the ES
10/09/2015	Archaeology and Historic Environment	Historic England	We note that both the Historic Seascape Character and the Setting will be addressed within any forthcoming ES, with the assessment aiming to consider whether dredging could impact the setting of any assets on the Kent coast, including those that may incorporate Goodwin Sands within their setting. Furthermore, we note: 'Specific considerations for Goodwin Sands will include spatial association of the wrecks designated under the Protection of Wreck Act, particularly those lost during the Great Storm of 1703, and the historic relationship between these wrecks'. We welcome this approach, and in order to inform this assessment we recommend for the archaeological consultant preparing the desk-based assessment to look to incorporate individual Protection of Wreck Act 1973 sites assessment and monitoring reports (such as the one referenced for the Rooswijk wreck site). Additionally in addressing wider considerations (also those associated to changes in bathymetry and sediment transport) the ES may look to incorporate The Goodwin Sands and the Downs, off Kent Overview of Archaeology Investigations) (Ref: 53111.02k-27-February 2012) produced by Wessex Archaeology.	ES Section 14 – Archaeology and Historic Environment
10/09/2015	Archaeology and Historic Environment	Historic England	We note that although there is potentially a low likelihood of impacting pre-historic archaeology, given the relatively limited existing datasets to prescribe such determinations, any ES produced will capture information from geotechnical and geophysical investigations to inform a baseline. In light of this proposal we are inclined to agree, as this will ensure the developer has sufficiently addressed all potential features of the historic environment, and ensure they have peace of mind and that they will not be causing any undue harm to individual receptor types.	ES Section 14 – Archaeology and Historic Environment

Date Received	ES Topic	Organisation	Comment	Section where addressed in the ES
10/09/2015	Archaeology and Historic Environment; Other Commercial and Recreational Activities	Historic England	We note consideration will be paid to assessing potential impacts of the proposed scheme on other sea users, such as scuba diving, with particular attention to: impacts to scuba divers through reduced visibility due to sediment plume and impacts to scuba divers through exclusion from wreck sites due to dredging activity. It should be noted that whilst these activities will not always have a direct involvement with the features of the historic environment, such limiting factors may have some level of impact to the enjoyment, appreciation and important observations divers can make relative to historic shipwrecks within the site specific and wider study area. Therefore we request that these interest groups are consulted to ascertain the most realistic assessment of impact possible.	ES Section 14 – Archaeology and Historic Environment, ES Section 15 –Other Commercial and Recreational Activities
10/09/2015	Archaeology and Historic Environment	Historic England	In light of the content within Section 1.9-Scope of this EIA Process- it is a clear requirement for the ES to understand and set out the extraction process from source to site to accommodate opportunities for appropriate levels and mechanisms of mitigation for the known and potential historic environment interests within, and close to the proposed development.	ES Section 14 – Archaeology and Historic Environment
10/09/2015	Archaeology and Historic Environment	Historic England	The developer should therefore be made aware, that Historic England may consider requesting to the MMO additional measures of mitigation to the standard marine aggregate extraction mitigation methods. These additional measures will be more consistent to the approaches undertaken for capital dredge works, given the intrinsic potential the Goodwin Sands offers for significant evidence of seafaring throughout history. Such measures may therefore be best qualified and detailed within a Written Scheme of Investigation, to manage such potential in light of the extraction, transport and offloading processes that may be proposed in any ES.	ES Section 14 – Archaeology and Historic Environment

Date Received	ES Topic	Organisation	Comment	Section where addressed in the ES
10/09/2015	Archaeology and Historic Environment	Historic England	We are content that the scope of the proposed EIA to be undertaken, as set out in the scoping report referenced above, taking into account the points detailed above in this letter, will be sufficient in order to form an effective ES in which mitigation strategies to protect the historic environment can be developed.	ES Section 14 – Archaeology and Historic Environment
10/09/2015	Archaeology and Historic Environment	Historic England	We would like to reiterate the importance of the collection of suitable geophysical and geotechnical survey data to feed into the analysis, including the potential use of a magnetometry survey, and the need for detailed investigation into the known and potential maritime and aviation archaeology of the area, as outlined above. It is also important to reiterate our earlier point regarding the inclusion of prehistoric receptors in the assessment of the survey data, despite the low potential of the area, in order to provide complete coverage of receptors within the EIA.	ES Section 14 – Archaeology and Historic Environment
10/09/2015	Archaeology and Historic Environment	Historic England	We request the need for archaeological reports produced as part of this development to be recorded via OASIS (Online Access to the Index of archaeological investigations).	ES Section 14 – Archaeology and Historic Environment
10/09/2015	Archaeology and Historic Environment	Historic England	With the inclusion of the points raised in the ES, we currently do not consider that the proposal will cause significant adverse impacts to the historic environment. As such, we have no further comments to provide at this stage, and we look forward to having the opportunity to review the detail of the draft ES when it is made available.	ES Section 14 – Archaeology and Historic Environment

Date Received	ES Topic	Organisation	Comment	Section where addressed in the ES
29/09/2015	Fish Ecology	Natural England	In summary our concerns around sandeel were raised by two factors: There are reports of sandeel spawning in the vicinity of the Goodwin sands/Dover Straits by authors such as Coull et al (1998) which was revisited by Ellis et al in 2012. In addition to more historic records such as those in Macer; (1965). 2) Long standing generic understanding of sandeel behaviour shows some preference for the utilisation of sandbank slopes and crests which occur in shallow water with high levels of productivity and a seabed consisting of fine to coarse well oxygenated sand. It is also known that sandeel show fidelity to defined areas of seabed and do not tend to travel to other locations to spawn. The extraction area appears to have these broad characteristics. Such generic behaviour is outlined in papers such as Wright et al (2000), Reay (1970). As a consequence we highlighted that there is a risk that sandeel maybe be present on the Goodwin Sands and could be spawning there. The fact that dredging will potentially take place during the night and during the winter when the sandeel are immobile and buried in the shallow sediment increases the risk of direct injury to individuals. In addition dredging has the potential to alter the particle size distribution curves within the active extraction area meaning the area (if used by sandeel) may no longer be suitable for sandeel if significant changes were to occur. You highlighted in your scoping document you would use the assessment methodology outlined by Marinspace et al (2013) and would examine the results of the beam trawl surveys to identify the likelihood of sandeel being present along with other data sources. This seemed reasonable to us hence no further comment was made in our response. There are a couple of concerns that the regional assessments done by Marinspace et al do not cover the Goodwin Sands and available data in the region is sparse, which is why we suggested the need for sandeel specific surveys in the RAG meeting. We are happy to have a look at your initial plans, outline assessments or have further discussions regarding the approach to be used in the assessment and the	ES Section 9 – Fish Ecology

Date Received	ES Topic	Organisation	Comment	Section where addressed in the ES
			level of risk around the sandeel assessment for the application if you would find this useful. However this will be charged under our Discretionary Advice Service.	
20/10/2015	Nature Conservation Designations; Benthic Ecology.	Kent Wildlife Trust	<u>Precautionary principle and the MMO's "sequential assessment process"</u> Kent Wildlife Trust understands that the purpose of proposed aggregate extraction at Goodwin Sands is to provide infill for the DWDR scheme. It is our understanding also that investigations within a 50km squared zone of Goodwin Sands are currently being undertaken, in order to locate more precise areas for extraction. However, Kent Wildlife Trust is very concerned at the potential direct loss of	ES Section 5 – Nature Conservation Designations. ES Section 8 – Benthic Ecology The MMO has confirmed that an MCZ assessment will not be required for the proposed scheme.

Date Received	ES Topic	Organisation	Comment	Section where addressed in the ES
			habitat at Goodwin Sands, the mussel beds and Sabellaria reefs being of particular concern. It is an important ecological area in its own right and falls within a recommended Marine Conservation Zone (MCZ). We would like to draw your attention to the “sequential assessment process” recently introduced by the MMO for assessment of plans or projects affecting sites put forward for designation as an MCZ. Whilst we accept what is stated in the scoping report (page 23), that this particular area is currently “recommended MCZ” status, rather than “proposed”, we would suggest that this good practice approach should nevertheless be taken. We feel that the sensitivity of this valuable marine zone, in addition to the lack of certainty of the wider, indirect impacts of the scheme, means that the precautionary principle should be applied in this case. We would recommend that extraction sites should be sought elsewhere for this infill aggregate and that Goodwin Sands should only be considered as a “last resort”, after other alternatives have been thoroughly investigated and ruled out. Not included within MMO Scoping Opinion.	
20/10/2015	Nature Conservation Designations	Kent Wildlife Trust	We also consider that the EIA scoping should include the potential impact upon the Dover to Deal proposed MCZ. This MCZ was included in the public consultation process and therefore should be a material consideration, in addition to being considered as part of the sequential assessment process described above. Not included within MMO Scoping Opinion.	ES Section 5 – Nature Conservation
20/10/2015	General	Kent Wildlife Trust	We would expect an Environmental Impact Assessment (EIA) to consider the environmental impacts of such a scheme, and give equal weight to this environmental impact against economic considerations. We do not feel that this has been well represented in this scoping report and that overriding economic considerations are overshadowing consideration of the high biodiversity value of the area.	ES Appendix 2.2 – Consideration of Alternatives

Date Received	ES Topic	Organisation	Comment	Section where addressed in the ES
20/10/2015	Description of the Proposed Scheme; General	Kent Wildlife Trust	<u>Consideration of alternatives</u> A key part of an effective EIA is the consideration of alternatives. We feel that this scoping report is too “light touch” on this area of work. We would expect to see further investigation of alternative sources of aggregate in the final EIA report, such as river dredging, to have been more thoroughly explored.	
20/10/2015	General; Benthic Ecology	Kent Wildlife Trust	<u>Survey information</u> Kent Wildlife Trust is pleased to note that further baseline information will be provided from ecological survey in the later stages of EIA (page 84). We would like to emphasise the importance of more thorough survey of the habitats and species present, as in our view this needs to be beyond the scope and level of detail of mapping already carried out by CEFAS. This relates in particular to the need to map the extent of the mussel beds and Sabellaria reefs (referred to on page 64, 69 and 77 of the scoping report). We would like full survey and potential impacts considered for these particularly valuable habitat types in the final EIA report. Regarding the sharing of survey data, Kent Wildlife Trust has conducted Seasearch diving surveys at 3 sites in the rMCZ, and at one of those we recorded rosworm reef and blue mussel bed. We therefore have a single point record of these two MCZ Features of Conservation Importance from 2005. We can provide the position if that is helpful. However, since both features are ephemeral, our record serves as evidence that the site provides suitable habitat for these features rather than their presence in a particular location now.	ES Section 8 – Benthic Ecology

Date Received	ES Topic	Organisation	Comment	Section where addressed in the ES
20/10/2015	Coastal Processes and Hydrodynamics	Kent Wildlife Trust	<u>Indirect impacts and Sandwich and Pegwell Bay</u> Kent Wildlife Trust is concerned that modelling cannot accurately predict direct and indirect impacts on a complex, interrelated system such as the Goodwin Sands and its surrounding area. We are also concerned that the modelling proposed in the scoping report is too narrow in focus- it does not appear to extend as far as Sandwich and Pegwell Bay and we would like this to be scoped into the modelling work. We are concerned that there may be unpredicted negative impacts upon this site of complex mosaics of coastal habitats and internationally important bird populations. Sandwich and Pegwell Bay is managed by Kent Wildlife Trust, is of national and international importance for its nature conservation value and has protected site status (SPA, SAC, RAMSAR, NNR, SSSI). Not included within MMO Scoping Opinion.	ES – Section 6 Coastal Protection and Hydrodynamics, ES Section 6 – Nature Conservation Designations
20/10/2015	Benthic Ecology	Kent Wildlife Trust	<u>Habitat Regulations Assessment</u> Kent Wildlife Trust does not agree with the content of the scoping report with regard to Habitat Regulations Assessment (HRA), in particular the statement on page 21 that, “the proposed dredging would not directly impact the interest features of these sites”. This potential impact should not be scoped out at this stage, as it has not yet been determined that there would not be a significant effect on Sandwich and Pegwell Bay (page 135). An appropriate assessment should therefore be carried out by the competent authority. Indeed, the scoping report acknowledges that Goodwin Sands is considered to supply sand to the foreshore of East Kent (page 37). The report also acknowledges the role of Goodwin Sands for protecting the East Kent coast from direct wave attack (page 36).	ES Section 5 – Nature Conservation Designations. Natural England confirmed a HRA was not required for the scheme.
20/10/2015	Marine Mammals	Kent Wildlife Trust	<u>Haul out sites for common and grey seals</u> We are pleased to note that the impact of the proposals upon common and grey seals will be considered in the further stages of the EIA process, including any direct loss of haul-out sites at Goodwin Sands, reduced foraging areas in the vicinity of Goodwin Sands and potential seal injuries from the dredging process.	ES Section 10 – Marine Mammals

Date Received	ES Topic	Organisation	Comment	Section where addressed in the ES
20/10/2015	General	Kent Wildlife Trust	<u>Seascape Character Assessment</u> A Seascape Character Assessment for the Dover Strait has recently been produced and adopted by Kent County Council . Goodwin Sands is defined within Area 13A: Inshore Sandbanks and Shoals. We would recommend that this document is taken into consideration within your proposals for Goodwin Sands and also the wider Port of Dover development.	ES Section 14 – Archaeology and Historic Environment

Appendix 4.3

Pre-EIA Submission Consultation

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1 Introduction

1.1 Overview

This appendix to the Environmental Statement (ES) records the feedback received in response to consultation letters issued by Dover Harbour Board (DHB) to stakeholders that were not consulted separately during the EIA Scoping phase or through consultation meetings held throughout the EIA process (see **Section 4 – Consultation** for more information). The consultation letter issued to stakeholders included the following;

- An introduction to the proposed aggregate dredging scheme and the wider Dover Western Docks Revival (DWDR) scheme;
- A map showing the exploration area at South Goodwin Sands (within which the proposed dredge area is located);
- Details on the dredging methodology proposed;
- An explanation of the EIA and consenting processes;
- A link to the EIA Scoping report on the Port of Dover website; and
- Specific requests for information or feedback, where relevant.

Table 1 below records the responses received from each organisation which are relevant to the EIA, consenting process and/or scheme design.

DHB also consulted stakeholders in relation to the scheme ecological survey undertaken in July 2015 (see **Section 8 – Benthic Ecology**), specifically where there was potential for the survey operations to interact with other marine activities. Where relevant, responses to this consultation are included in **Table 1** below.

1.2 Summary of Consultation

Table 1 Consultation Responses

Organisation	Date received	ES Topic	Comment	Section where addressed in ES
501 Divers Folkestone	15/01/2016	Other Human Activities	We are confident that the proposed dredging scheme will affect diving in the area as well as those that depend on it to earn a living. We would appreciate updates on the project as it progresses so that the club and other dive boats can be informed.	Section 15 – Other Commercial and Recreational Activities
Angling Trust	Not provided	Commercial and Recreational Fisheries	No response received to letter sent on 7 th December 2015.	N/A
Balfour Beatty (Thanet Offshore Wind Farm)	Not provided	Other Human Activities; CIA	No response received to letter sent on 7 th December 2015.	N/A
Black Cat	22/02/2016	Other Human Activities	We are supporting of the regeneration goals of the Board, and see the economic logic of sourcing material locally to achieve these goals. Our concerns with regard to extractions from the Goodwin's are: - We fear that this will have an adverse effect on water clarity during operations. What mitigation measures have been considered? - The proposed area if one we visit regularly. Is a legally enforceable exclusion zone proposed? - Is the extraction process restricted as building works are when granted planning permission? Our diving is centred around 51 11.625 N 001 31.000. We also dive the cluster of wrecks to the south east which is outside the proposed area, and various marks all along the Kellet Gut, of which the south western end falls within the dredge area.	Potential impacts on diving are assessed in Section 15. The dredging scheme would be permitted through a Marine Licence, which would include licence conditions. See Section 3. Mitigation/safety measures with regards to navigation are proposed in Section 13 – Commercial and Recreational Navigation.

Organisation	Date received	ES Topic	Comment	Section where addressed in ES
British Divers Marine Life Rescue	08/01/2016	Coastal Processes and Hydrodynamics; Nature Conservation Designations; Benthic Ecology; Marine Mammals; Coastal Protection and Flood Defence	The coastal processes surrounding the Goodwin Sands are highly variable and difficult to predict. Removal of large quantities of the sands may also impact local coastal defences and create a flooding risk. The seal group that frequents the Sands is of international importance and may be adversely impacted by the noise pollution that is likely to arise from the proposed dredging operations. Dredging will also impact seal food supply and breeding success. Concern raised with regards to potential impact on Goodwin Sands rMCZ. Alternative sources should be considered.	Coastal processes are described in Section 6. Potential impacts on coastal protection and flood defence are considered in Section 16 and the Coastal Impact Study (Appendix 16.1). Potential impacts on seals are assessed in Section 10. The potential impact on Goodwin Sand rMCZ is considered in Sections 5 & 8. Alternative sources of aggregate are considered in Appendix 2.2.
British Sub Aqua Club	11/12/2015	Other Human Activities	Our club have dived at Hallsands in Devon many times over the years and are aware of the potential risks of dredging sandbanks that have protected coasts until storms destroy coastal areas due to removal of the offshore sand banks.	Potential impacts on coastal protection and flood defence are considered in Section 16 and the Coastal Impact Study (Appendix 16.1).
BT Subsea Centre of Excellence	24/07/2015	Other Human Activities	BT can confirm that all of the cables mentioned in correspondence in relation to the Marine Ecological Survey are out of service and will not be impacted by the survey.	Potential impacts to marine cables are assessed in Section 15 .
Canterbury City	10/12/2015	Coastal Processes and	Dover District Council is the risk management authority for much of the coastline that	Draft modelling reports

Organisation	Date received	ES Topic	Comment	Section where addressed in ES
Council		Hydrodynamics	may be affected by the proposed Goodwin Sands Aggregate Dredging Scheme. Canterbury City Council are the lead authority for the Southeast Coastal Monitoring Programme and responsible for monitoring the beaches along the frontage. Until the HR Wallingford coastal processes model outputs are available (nearshore wave climate, tidal currents), it is very difficult to comment on what impact the proposed dredging may have on the adjacent coastline. We feel that this modelling data should be made available for consultees prior to the MMO application.	were circulated to Coastal Processes and Coastal Protection Working Group (including CCC) for comment on 1st February 2016. No comments were received from CCC. The modelling reports are provided at Appendix 6.1-6.4 of this ES.
Canterbury Divers	02/02/2016	Other Human Activities	The Goodwin Sands provide a resting area for grey and common seals at low tide and common seals have been known to birth pups there. Females give birth to a single pup in June or July each year. In terms of potential damage to historic wrecks in the direct affected area coloured pink on your enclosed map we would like to make the following comment: The Admiral Gardiner sank in that area in 1809. There are two other charted wrecks in the vicinity. An unknown stern of one and a larger, the Northeastern Victory which sank there in 1946 and is large and shallow although heavily salvaged and broken. There are two additional uncharted wrecks that we are aware of, one known to local fishermen as 'the East Indiaman' which was taken off the charts in 2010 and a larger wreckage which was removed from the chart in 2001. There are likely to be numerous other smaller craft and aircraft also in the vicinity. We also have concerns of the visibility being affected for diving purposes. The local area, south of the site extending into the English Channel and along the coastline stretching from Dover, Folkestone, Sandgate and into Hythe bay will be adversely affected. These areas contain a number of frequently dived local wrecks on which recreational and other diving may well be adversely affected by your proposed works.	Potential impacts on seals are assessed in Section 10. Potential impacts on wrecks are assessed in Section 14 – Archaeology and Historic Environment Potential impacts on diving are assessed in Section 15.
Channel Divers	Not provided	Other Human Activities	No response received to letter sent on 22 nd January 2016.	N/A
Department for	04/02/16	General	Telephone call to DCMS on 4 th February 2016 confirmed that DCMS had no comments	N/A

Organisation	Date received	ES Topic	Comment	Section where addressed in ES
Culture, Media and Support (DCMS)			to make on proposed scheme.	
Deal and Walmer Inshore Fisheries Association	Not provided	Commercial and Recreational Fisheries	No response received to letter sent on 7 th December 2015.	N/A
Department for Environment Food and Rural Affairs (DEFRA)	Not provided	General	No response received to letter sent on 7 th December 2015	N/A
Department of Transport	06/01/2016	General	Dredging operations are not something which our team is currently involved with.	N/A
Dive 125	14/12/2015	Other Human Activities	The most important things for us or any dive boat operating out of Dover will be the following: Advance notice of when and where any extraction is taking place (both for advance planning and short term changes) Any estimates you have about the sediment 'plume' caused by the extraction, we have our own knowledge of the tides but with the complex flow of tides in the area the more information the better. We usually run with the tide so running up to slack at Dover HW+4-5 hours we will be to the North and East of Dover and running to the Dover-2hr slack we will be to the West of Dover Typically we visit sites on weekends and Bank Holidays. However, between June and September, we plan to be chartering daily (weather permitting) Our homeport is Eastbourne but we plan to be at Dover for a few weeks in 2016/2017 depending on demand. Therefore, as much advance notice of when extraction will take place will help us and our customers plan their trips from Dover or even look at an alternative port/area.	Potential impacts on diving are assessed in Section 15.

Organisation	Date received	ES Topic	Comment	Section where addressed in ES
			Looking at my charts and using an estimation of the 'plume' affecting say 10nm up/down tide, the following dive sites may be compromised in the short term by the extraction: Any wrecks between the extraction zone and the Port of Dover including the popular: - Loanda - Queen 51 - Toward 51 - WA Scholten Maybe as far as the 2 most popular local wrecks of Anglia and Pomerania Wrecks to the North of the extraction zone up to and including: - Tina Primo - UKHO 13827 - UKHO 1375 - UKHO 13730 Key points we would like to make are the following: - It's not going to improve the underwater visibility; - We don't know how much worse it will be; and - Advance notice of when and where extraction is planned will be important so we can plan our trips accordingly. The regeneration of Dover Western will make it a lot easier to run dive trips from Dover with the increase in all tides moorings. In addition, a more pleasant overall area may increase the number of visiting divers who are the main tourists to the area on either weekend short breaks or longer holidays.	

Organisation	Date received	ES Topic	Comment	Section where addressed in ES
Dover Sea Safari	Not provided	Other Human Activities	No response received to letter sent on 7 th December 2015	N/A
Dover Sub Aqua Club	Not provided	Other Human Activities	No response received to letter sent on 15 th February 2015	N/A
Downs Sailing Club	07/01/2016	Commercial and Recreational Navigation	We do not sail near the Goodwins or the proposed dredge area.	N/A
East Kent Maritime Trust	Not provided	Archaeology and Historic Environment	No response received to letter sent on 7 th December 2015	N/A
Folkestone Harbour	Not provided		No response received to letter sent on 7 th December 2015	N/A
Full Throttle Boat Charters	Not provided	Other Human Activities	No response received to letter sent on 7 th December 2015	N/A
Horizon Sea Safaris	Not provided	Other Human Activities	No response received to letter sent on 7 th December 2015	N/A
Kent Coastal Networks	Not provided	General	No response received to letter sent on 7 th December 2015	N/A
Kent County Council	15/01/2016	Archaeology and Historic Environment	<i>Highway and Transport</i> No comment <i>Flood Risk</i> No comment <i>Heritage</i> The area covered by the MMO licence application is of high historic environment significance. Historic England will take the lead on advising on historic environment matters for the MMO licence but KCC Heritage. <i>Seascape</i> The Goodwin Sands are important are for biodiversity as a spawning ground for a range	Potential impacts on the historic environment are assessed in Section 14 – Archaeology and Historic Environment Seascape character assessment and LVIA is outside the EIA scope agreed with the MMO and statutory advisers through the EIA Scoping process and has not been undertaken.

Organisation	Date received	ES Topic	Comment	Section where addressed in ES
			of benthic and pelagic species, a haul out area for grey and harbour seals and a foraging habitat for seabirds. These natural sensitivities, along with the historic sensitivities (covered above) and aesthetic qualities are all described in a new study, the Seascape Character Assessment (SCA) for the Dover Strait. This study will be used by the MMO as part of the evidence base for the South East Marine Plan and is now being used by coastal authorities between Margate and Dungeness as part of their planning strategy and development control work. It covers the marine area between Kent and Nord Pas-de-Calais. This SCA should be used as part of the EIA for this licence application, particularly for the Local Visual Impact Assessment (LVIA), but it will be useful for other areas within the EIA. Government guidelines recommend that if an SCA is available it should be used within a LVIA. We do not have specific comments on the environmental issues of this dredging scheme; rather we are recommending that the sections within the SCA relevant to Goodwin Sands are reviewed and any recommendations incorporated into the EIA. We would hope that the SCA may also be used within the Coastal Impact Study. The relevant pages are 71 – 74 and 163 – 167.	
Kent Mammal Group	10/12/2015	Marine Mammals	The Kent Mammal Group is not an organisation that provides any comment with regard to development schemes and their environmental impacts and associated mitigation. The Group encourages the recording of mammals within and around the county of Kent and using this information to help report on distribution and perceived status. The records collected are also forwarded on to the Kent and Medway Biological Records Centre (KMBRC) based at Brogdale and I recommend requesting from them a relevant records search for species within an appropriate radius of the development area.	Section 10 includes data obtained from the KMBRC.
Kent Ornithological Society	Not provided	Ornithology	No response received to letter sent on 7 th December 2015	N/A
Kingsdown Divers	Not provided	Other Human Activities	No response received to letter sent on 15 th February 2016	N/A
Level 3 Communications	Not provided	Other Human Activities	No response received to letter sent on 7 th December 2015	N/A
Maidstone Scuba	Not provided	Other Human Activities	No response received to letter sent on 15 th February 2016	N/A

Organisation	Date received	ES Topic	Comment	Section where addressed in ES
School				
Marine Conservation Society	Not provided	Nature Conservation Designations; Benthic Ecology; Fish Ecology; Marine Mammals	No response received to letter sent on 22 nd January 2016	N/A
Ministry of Defence	10/12/2015	General	Thank you for consulting the MOD on this matter at this early stage; we will also be consulted on the associated marine licence. I can confirm that the MOD has no safeguarding objections to the proposals.	N/A
Mutiny Diving	Not provided	Other Human Activities	No response received to letter sent on 7 th December 2015	N/A
National Trust	Not provided	General	No response received to letter sent on 7 th December 2015	N/A
Nemo Link Electrical Interconnector	Not provided	Other Human Activities	No response received to letter sent on 7 th December 2015	N/A
Neptune Charter Boat	Not provided	Other Human Activities	No response received to letter sent on 15 th February 2016	N/A
New Under Ten Fisheries Association	Not provided	Commercial and Recreational Fisheries	No response received to letter sent on 7 th December 2015	N/A
National Federation of Fishermen's Organisations	12/01/2016	Commercial and Recreational Fisheries	I can confirm that we have no comments to make in response to your consultation.	N/A
National Federation of Fishermen's Organisations – South East	Not provided	Commercial and Recreational Fisheries	No response received to letter sent on 7 th December 2015	N/A
Oil and Gas Authority (DECC)	08/01/2016	General	The Oil and Gas Authority have no comments.	N/A
Ramsgate Fishing Charter	Not provided	Other Human Activities	No response received to letter sent on 7 th December 2015	N/A

Organisation	Date received	ES Topic	Comment	Section where addressed in ES
RIB Request	Not provided	Other Human Activities	No response received to letter sent on 7 th December 2015	N/A
Royal Cinque Ports Yacht Club	Not provided	Commercial and Recreational Navigation	No response received to letter sent on 7 th December 2015	N/A
Royal Temple Yacht Club	16/12/15	Commercial and Recreational Navigation	The preferred route for the Round the Goodwin Race is to follow a track outside the main cardinal and lateral buoys situated around the Goodwins, for example: • Start line offshore Ramsey • Goodwin Knoll Buoy • East Goodwin Buoy • East Goodwin Light Vessel • South Goodwin Buoy • South West Goodwin Buoy • North West Goodwin Buoy • Finish line offshore Ramsgate The above course is not definitive, but the objective is to keep the fleet a safe distance away from any obstructions, including the Sands. Dependant on tides, the course may be raced in the opposite direction i.e. anti-clockwise. Other sailing activities carried out by RTYC and its members include racing and cruising both inshore and offshore of the Sands, but again the objective would generally be to remain a safe distance away from the Sands. It is possible that some of members may sometimes use the Kellett Gut channel for a shortened Goodwins cruise. If the dredging scheme goes ahead, we presume that the appropriate notice to mariners will be issued, so that our members will be informed of your activities and will therefore be able to plan their routes accordingly. It is requested that in addition to the notice to mariners, RTYC are kept directly informed by the Dover Harbour Board. The 2016 Round the Goodwins race is scheduled for 24th July 2016.	Section 13 – Commercial and Recreational Navigation
Royal Yachting Association	29/03/16	Commercial and Recreational Navigation	No concerns have been raised by RYA members to date. Although not yet formally consulted by the MMO consider it unlikely that the proposal would impact on	Section 13 – Commercial and

Organisation	Date received	ES Topic	Comment	Section where addressed in ES
			recreational boating.	Recreational Navigation
Royal Society for the Protection of Birds (RSPB)	18/01/2016	Ornithology	The RSPB have no comment to make on the proposed development.	N/A
Sea Searcher Boat Trips	Not provided	Other Human Activities	No response received to letter sent on 22 nd January 2016	N/A
Sea Watch Foundation	Not provided	Marine Mammals	No response received to letter sent on 7 th December 2015	N/A
Shellfish Association of Great Britain	Not provided	Fish Ecology; Commercial and Recreational Fisheries	No response received to letter sent on 7 th December 2015	N/A
Shepway District Council	Not provided	General	No response received to letter sent on 22 nd January 2016	N/A
Shornccliffe Dive Centre	Not provided	Other Human Activities	No response received to letter sent on 4 th February 2016	N/A
South East Coastal Group	Not provided	General	No response received to letter sent on 7 th December 2015	N/A
Subsea Cables UK	08/01/2016	Other Human Activities	Although Subsea Cables UK has no comments to make as a body, we have forwarded the information to our Members who may wish to respond individually, although I anticipate such responses will be very few given the area for the dredging scheme will have no impact on their subsea assets.	N/A
Thanet Coast Project	Not provided	General	No response received to letter sent on 25 th June 2015	N/A
Thanet District Council	Not provided	General	No response received to letter sent on 7 th December 2015	N/A
Thanet Fisherman's Associated	Not provided	Commercial and Recreational Fisheries	No response received to letter sent on 25 th June 2015	N/A

Organisation	Date received	ES Topic	Comment	Section where addressed in ES
Port of Ramsgate	Not provided	Commercial and Recreational Navigation	No response received to letter sent on 7 th December 2015	N/A
The Sandwich Port and Haven	11/01/2016	Coastal Processes and Hydrodynamics; Archaeology and Historic Environment	Sandwich Port and Haven have the following concerns in respect of the proposed dredging scheme: - The Ramsgate Channel has minimal flow of tide sufficient to keep the channel wide enough and deep enough. The situation is marginal. Our concerns are that the flow rates are maintained (or enhanced). We are therefore fearful that the abstraction of such a large quantity of material from Goodwins Sands will allow freer flow of the tides in the area of abstraction at the expense of that of Ramsgate Channel. We would appreciate a review of a copy of your Hydrographic Impact Assessment addressing the consequences of abstraction, in so far as it will affect the area between Deal and Broadstairs. - The historic wreck situated within the curtilage of the proposed dredge area will, without doubt, be detrimentally affected by the removal of such a large amount of sand from that local area. We would ask what counter measures will be put in place, and, what the outcome of your Hydrographic Impact Assessment for this wreck is, and any other wrecks that might be revealed as a result of the works.	Coastal processes are described in Section 6. This includes an assessment of the potential effects of the scheme on waves, tidal currents and sediment transport. The supporting modelling reports are provided in Appendices 6.1-6.4. Potential impacts on coastal protection and flood defence are considered in Section 16 and the Coastal Impact Study (Appendix 16.1). Potential impacts on the historic environment are assessed in Section 14 – Archaeology and Historic Environment
UK Hydrographic Office	Not provided	Commercial and Recreational Navigation	No response received to letter sent on 7 th December 2015	N/A
UK Verizon	07/01/2016	Other Human Activities	Base on the distance between the proposed dredging area on Goodwin Sands and our asset, the Ulysses submarine telecommunications cable, we have no comments or concerns.	Potential impacts to marine cables are assessed in Section 15 .

Organisation	Date received	ES Topic	Comment	Section where addressed in ES
Zoological Society of London	09/02/2016	Marine Mammals	Section 11 of the EIA Scoping Report references ZSL's Thames Seal Programme; however focused analyses of the raw data are needed to understand the importance of the Goodwin Sands Complex and proposed Exploration Area for harbour and grey seals in the Greater Thames Estuary. Following your letter on 7 December 2015, we have completed initial analysis of these data and believe the Goodwin Sands Complex is very important for both the harbour seal and grey seal populations in the region. We believe that the Exploration Area could be located on an important harbour seal foraging ground, which is likely to be negatively impacted by the proposed dredging activity. Telemetry data shows that harbour seals are likely to use the Exploration Area year-round, as tagged harbour seals are present in both February and June. We have concerns that the proposed dredging activity would disturb the large number of harbour seals and grey seals that use the Goodwin Sands Complex to haul out. Even if dredging does not occur on the sandbank where seals are hauled out, we believe that the physical presence of a dredger close by could cause grey seals and harbour seals to abandon their haul out site during dredging operations. If dredging is approved, we strongly recommend to avoid dredging activity during the harbour seal breeding season (June to July), the harbour seal moult period (August) and the grey seal breeding season/moult period (November to January) to reduce the chances of negatively impacting the populations. We also have evidence that Pegwell Bay/River Stour, close to the Exploration Area, is one of four harbour seal breeding sites in the Greater Thames Estuary. We plan to complete a harbour seal breeding survey in July 2015 to confirm this (funding dependent), but would recommend that the importance of this area is carefully considered during the EIA process. Finally, we would like to express our concerns that the Exploration Area is located on the Goodwin Sands Recommended Marine Conservation Zone. ZSL is supportive of the Goodwin Sands Marine Conservation Zone being fully implemented and agree with all comments provided by the Kent Wildlife Trust in their letter to the Dover Harbour Board on 20 October 2015	Since the exploration area was identified DHB has undertaken a site selection process (see Appendix 2.1) to delineate the optimum proposed dredge area. The proposed dredge area avoids intertidal sandbanks and thereby seal haul out sites. ZSL Thames Seal Programme data has been requested and received from ZSL to inform the EIA. Potential impacts on seals are assessed in Section 10.

Appendix 5.1

Natural England Response to DAS Request

Date: 21 January 2016
Our ref: 173939
Your ref: Goodwin Sands Aggregate Dredging IEMN001D01



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BY EMAIL ONLY

Discretionary Advice Service (Charged Advice) DAS 1947

South Goodwin Sands Aggregate Dredging: Port of Dover

Dear David

Thank you for your consultation which was received on 23/12/15.

This advice is being provided as part of Natural England's Discretionary Advice Service. Royal Haskoning DV on behalf of Dover Harbour Board has asked Natural England to provide advice upon the following technical note:

Goodwin Sands Aggregate Dredging - Natural England DAS Request on Proposed Dredge Area and HRA requirement: Ref IEMN001D01

This advice is provided in accordance with the Quotation and Agreement dated 9/12/15.

My understanding of the technical note:

Part 1 outlines the site selection process employed by the Port of Dover when identifying the proposed dredge area on Goodwin Sands. It outlines both the information sources and restraints encountered by the port. It also explains how Natural England's previous comments have been acknowledged and addressed in the selection process.

Part 2 addresses a query we made in our scoping response regarding the potential impact on birds and the subsequent need to identify if any of these ornithological impacts could be linked to Special Protection Areas, thus triggering the need for a Habitats Regulations Assessment. RHDHV and PoD are seeking confirmation from NE on the conclusion and reasoning presented in the report that a HRA is not required for the scheme.

Part 1) Natural England comments

The information in the technical note is useful and provides clear evidence that the dredge area has been positioned away from areas which are of a high sensitivity.

I agree that the proposed dredge area does not appear to support biogenic reef as there are low numbers of both Sabellaria and Mytilidae recorded in the grab survey. I however would need to see further analysis of the acoustic data in conjunction with the results of the grab survey prior to dredging to fully confirm the absence of any impact. I would request this analysis be undertaken as part of the

EIA and through a 'sensitive species and habitats review' presented as part of the pre dredge requirements of the marine licence. The review would present an integrated analysis of both acoustic and in-situ data sets. Any areas where the data suggests the presence of biogenic reef is possible will need to be identified by an exclusion zone which prevents dredging of those areas.

I agree that restricting dredge operations below the -8.1mCD contour will offer a spatial buffer between the vessel and intertidal areas, which will prevent significant disturbance to seals hauled out on areas of exposed sand. It will also reduce the risk of slumping or other morphological impacts which could reduce the area of intertidal sand.

The technical note states that seabed lowering will be in the range of 2 – 4 metres. As the note suggests, this level of morphological change does not appear likely to result in changes which would be significant to the ecological or physical functioning of the site. However, I would like to see the results of the hydrodynamic modelling study which will indicate any potential impacts to water flow wave and sediment flux before I can fully confirm this prediction.

In summary, the dredge area appears to be located in an appropriate position to minimise environmental impacts but there is still a need to further examine the outputs of the ecological survey and hydrodynamic/coastal processes study to fully understand the impacts.

Part 2) Natural England Comments

The information in the technical note is useful and provides a detailed justification for screening out any link between ornithological impacts at the dredge site and any SPA. We agree with the reasoning and conclusions presented in the report and agree that the application is not likely to result in a significant impact on any SPA.

As suggested in the technical note we recommend that the information presented in the note is included as part of the Environmental Statement in order that the MMO can reach their determination with regard to the habitats regulations assessment.

For any queries relating to the content of this letter please contact me using the details provided above.

Yours sincerely

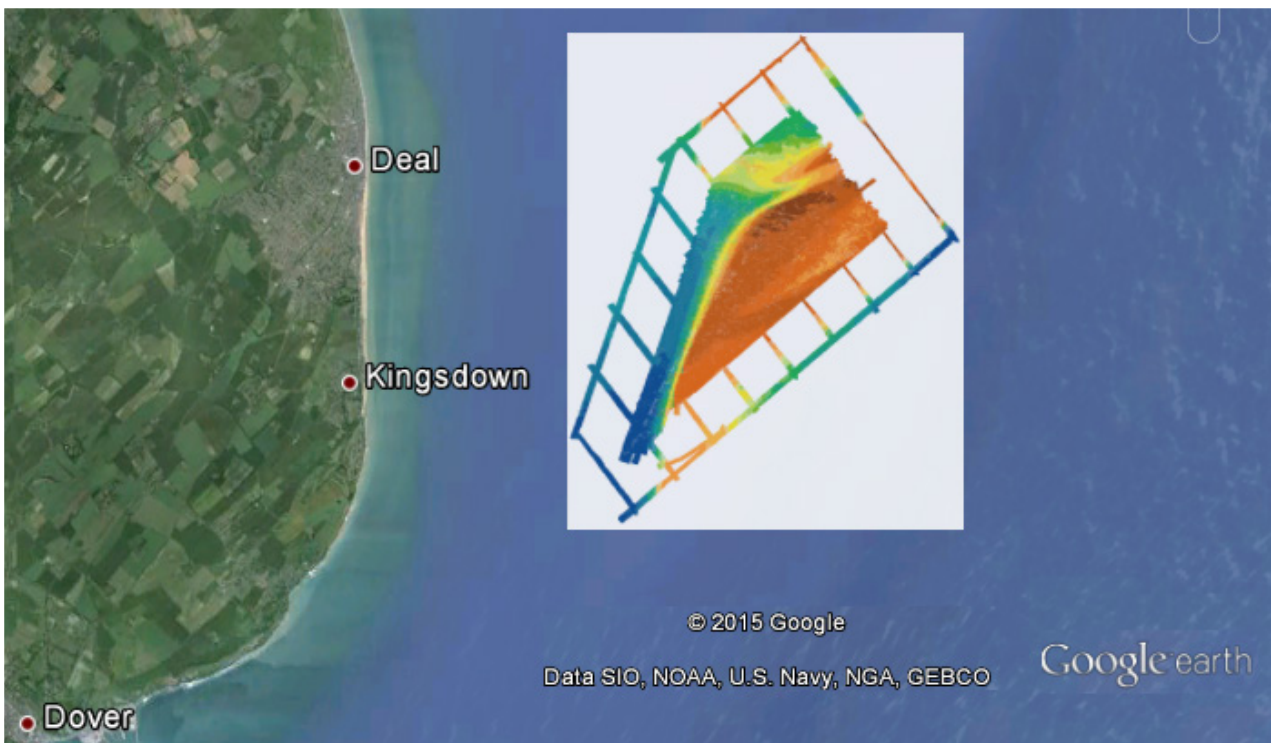
Mark Johnston
Senior Environmental Specialist – Marine Operations

Appendix 6.1

Goodwin Sands Aggregate Dredging Coastal Impact Study and
EIA – Wave Modelling

Goodwin Sands Aggregate Dredging Coastal Impact Study and EIA

Wave modelling



Document information

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Approved



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Executive Summary

Dover Harbour Board (DHB) is proposing to dredge sand and gravel from the South Goodwin Sands off the coast of Kent for use as fill material for the Dover Western Docks Revival development at the Port. DHB is proposing to dredge up to 2.5 million m³ of sand and gravel from the subtidal parts of the South Calliper sandbank at the South Goodwin Sands, located approximately 12 km north east of the Port of Dover (Figure 1.1). Marine aggregate dredging requires a Marine Licence from the Marine Management Organisation (MMO). Royal HaskoningDHV, on behalf of the DHB, is undertaking an Environmental Impact Assessment (EIA) to support the application for a Marine Licence for consent to dredge.

HR Wallingford is providing inputs to the EIA and Coastal Impact Study (CIS), establishing the magnitude, spatial extent and duration of changes to the physical environment directly caused by the proposed aggregate dredging. The focus of the modelling described in this report is on changes in waves caused by dredging on the Goodwin Sands. As is now standard practice in such studies, this assessment is carried out for very large and extremely rare wave conditions. In this study 1 in 200 year wind and wave conditions were considered as these would pose a high risk to the coastline and its coastal defences under baseline conditions. More common wave conditions were also modelled as input to the sediment transport and morphology study.

The modelling indicates very little change in wave height as a result of the proposed dredging. The main effect was caused by a slight difference in the way waves refract around the edge of the sandbank leading to a slight redistribution of the wave energy. The predicted changes in significant wave height (H_s) due to dredging are limited in spatial extent with no predicted effect extending to the coastline. The magnitude of change in significant wave height is limited to 0.02-0.10 m within an area extending at most 4 km from the edge of the proposed dredging area, even under the extreme conditions tested.

To put these changes into context the wave modelling also considered historical bathymetries to show the variation in wave conditions resulting from the evolution of the Goodwin Sands and nearby sandbanks. The modelling of historical bathymetries indicates more variation in significant wave height than was predicted with the post-dredging bathymetries. It is noted that some of these differences may be attributed to the use of more refined / recent bathymetry data sources in the present day model bathymetry in areas away from the study area compared to the historical bathymetries. However it is clear that the changes in wave conditions due to the variability of the sandbanks are significantly greater than the effects of the proposed dredging.

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1. Introduction

Dover Harbour Board (DHB) is proposing to dredge sand and gravel from the South Goodwin Sands off the coast of Kent for use as fill material for the Dover Western Docks Revival development at the Port. DHB is proposing to dredge up to 2.5 million m³ of sand and gravel from the subtidal parts of the South Calliper sandbank at the South Goodwin Sands, located approximately 12 km north east of the Port of Dover (Figure 1.1). Marine aggregate dredging requires a Marine Licence from the Marine Management Organisation (MMO). Royal HaskoningDHV, on behalf of the DHB, is undertaking an Environmental Impact Assessment (EIA) to support the application for a Marine Licence for consent to dredge.

HR Wallingford first considered the required studies to support dredging on the Goodwin Sands in 2008 when a phased, outline scope was proposed; including a historical bathymetric review and wave modelling to inform a Coastal Impact Study (CIS). The historical bathymetric review covering the period 1986-2006 was completed and reported on in HR Wallingford (2008).

For the present study HR Wallingford is providing inputs to the EIA and CIS, establishing the magnitude, spatial extent and duration of changes to the physical environment directly caused by the proposed aggregate dredging. The focus of the computer modelling described in this report is on changes in waves caused by dredging on the Goodwin Sands rather than modelling extreme waves as might be undertaken to analyse coastal flooding due to extreme overtopping or provide design conditions at the coast. Therefore in this study individual severe **offshore** conditions were required as boundary conditions. As is now standard practice in aggregate studies, this assessment is carried out for very large and extremely rare wave conditions. In this study 1 in 200 year wind and wave conditions were considered as these pose a high risk of coastal defence failure and consequential coastal flooding. In this context, 1 in 200 year conditions are extreme cases with a statistically derived probability of occurring once every 200 years.

The proposed dredge area lies close to various sensitive locations including protected wrecks, designated areas, anchorages and sites associated with particular ecological value such as seal haul out sites and *sabellaria spinulosa* reef as shown in Figure 1.2. The potential for the proposed dredging to change the physical processes at these sites requires particular attention.

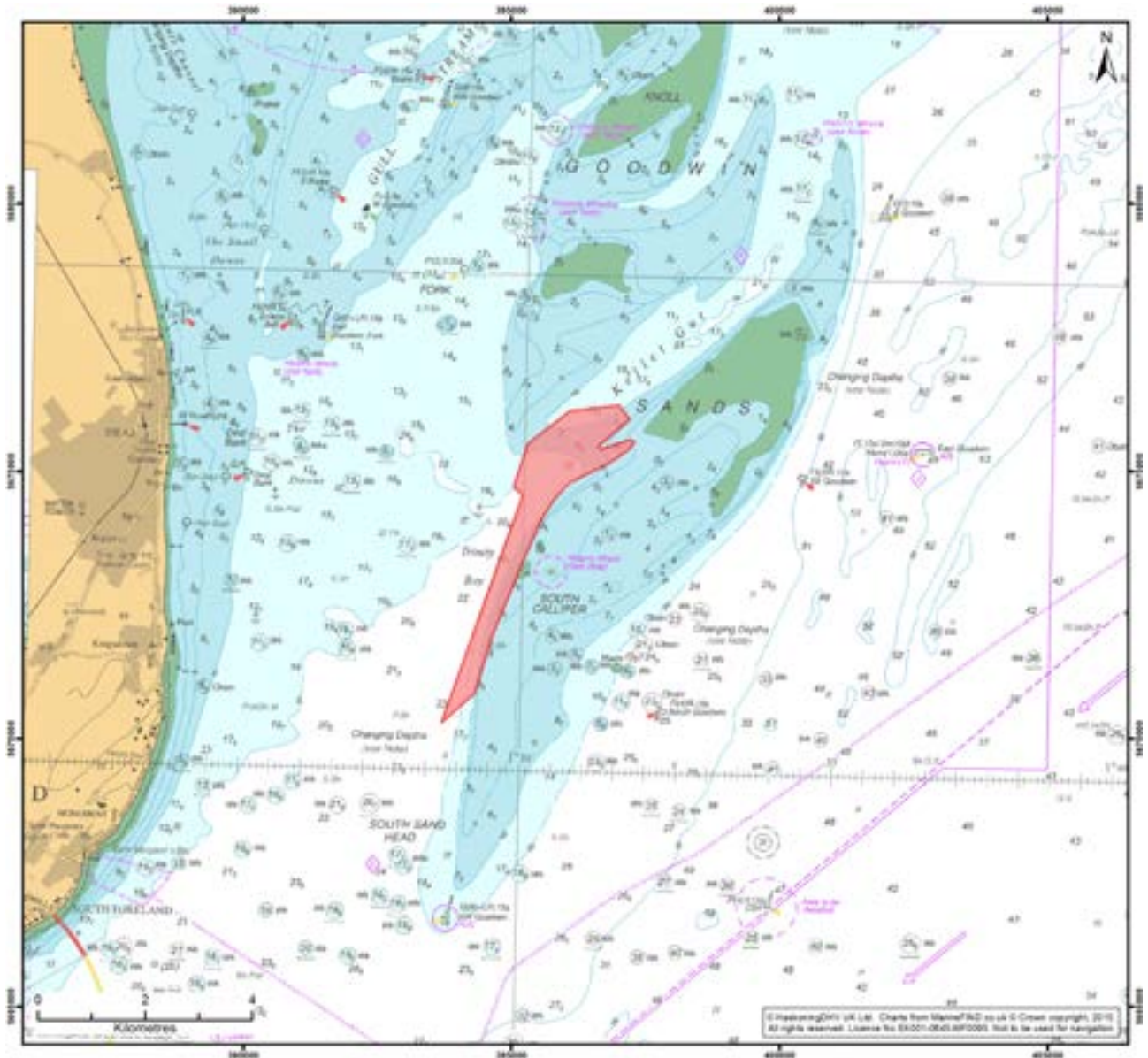


Figure 1.1: Location of proposed aggregate dredging area

Source: RHDHV Drawing PB2107_ES_003

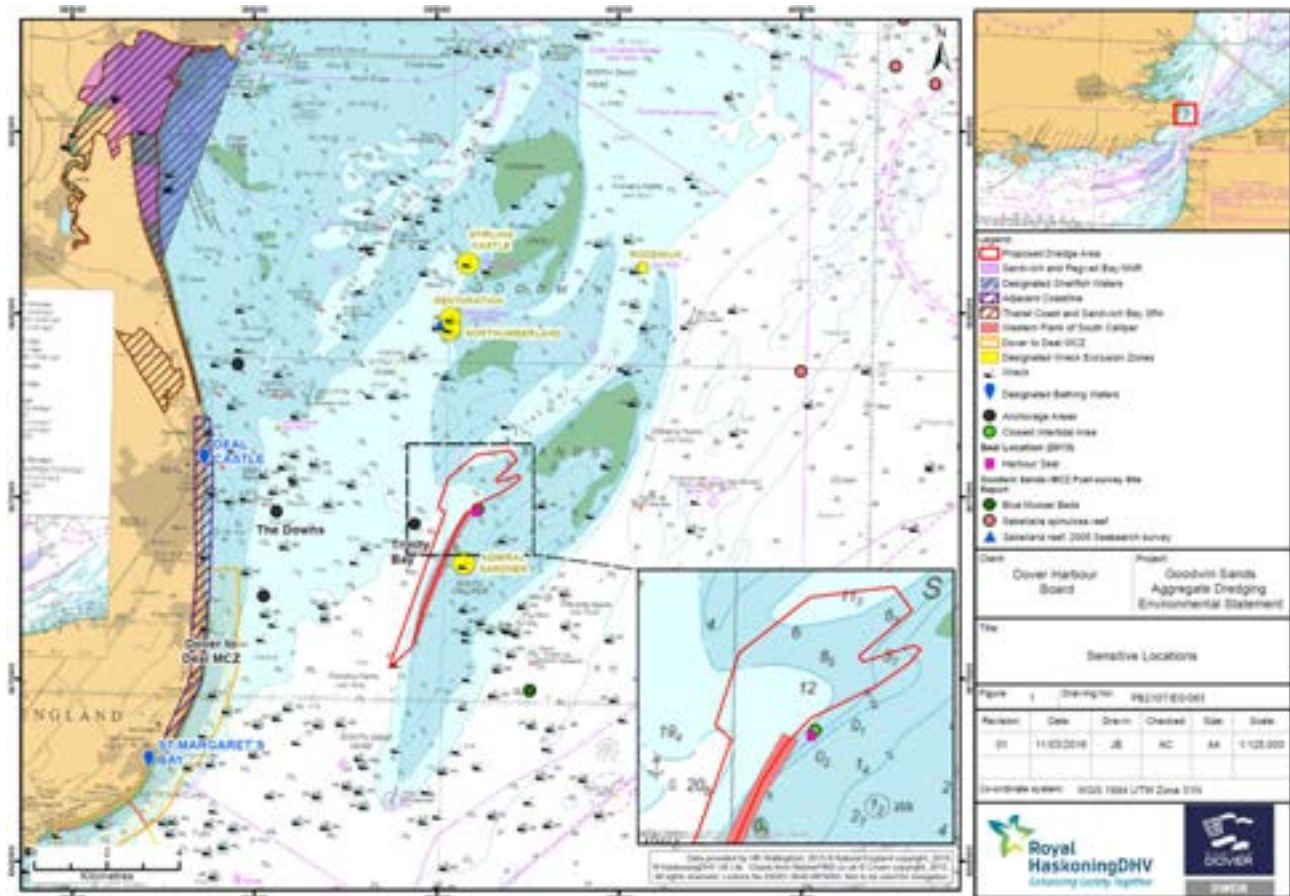


Figure 1.2: Sensitive locations in area of proposed aggregate dredging area

Source: RHDHV drawing PB2107_ES_063

2. Scenarios tested

2.1. Historical, baseline and post-dredging scenarios

The conditions represented in the models are briefly described as:

- A “baseline” case, that is the present-day bathymetry without dredging;
- A post-dredging scenario, Scenario 1, dredging 1.12 m depth of aggregates in Area 1 (see Figure 2.2);
- A post-dredging scenario, Scenario 2, dredging 1.95 m depth of aggregates in Area 2 (see Figure 2.2).

Scenario 1 covers the full dredge area being applied for. Scenario 2 represents the same volume of dredging within a sub area in the northern section of the proposed dredge area within which the majority of the resource has been identified.

It is proposed that up to approximately 2.5 million m³ of material will be dredged from Goodwin Sands and transported to Dover for use as aggregate in the Western Docks project. As has been used for aggregate studies elsewhere the amount of sediment removed has been increased by 60% in the modelling studies to provide a precautionary view of the potential impact of the dredge. Hence, both the scenarios involve removal of approximately 4,000,000 m³ of material from areas identified as having sand; leaving a layer of at least 0.5 m of sand in those areas after the dredge in accordance with established practice to facilitate recovery of benthic communities.

In addition to baseline and dredged conditions, historical representations of the Goodwin Sands and the other nearby sandbanks were used in the wave model to assess the variation in wave conditions resulting from the evolution of the seabed over time. These historical cases can be briefly described as:

- A “1995-98” case; the best estimate of the bathymetry in the late 1990s;
- A “2006” case; the best estimate of the bathymetry in 2006.

The vertical datum used for this study is Mean Sea Level (MSL). For ease of reference, levels are often reduced to mCD (Deal) in the figures of this report.

2.2. Bathymetry data

2.2.1. Baseline and post-dredging bathymetries

The area of the EGS International Ltd bathymetry survey collected for the present project in mid-2015 is shown in Figure 2.1. It is shown to provide a reasonable coverage of the South Goodwin Sands and covers the whole of the resource exploration area. It is noted that the southernmost face of the sandbank is only defined by transverse cross-sections extending about one kilometre away from the main survey area. These data allow the wave paths across the Goodwin Sands to be represented accurately in the models, which will be important when considering possible changes to the physical environment.

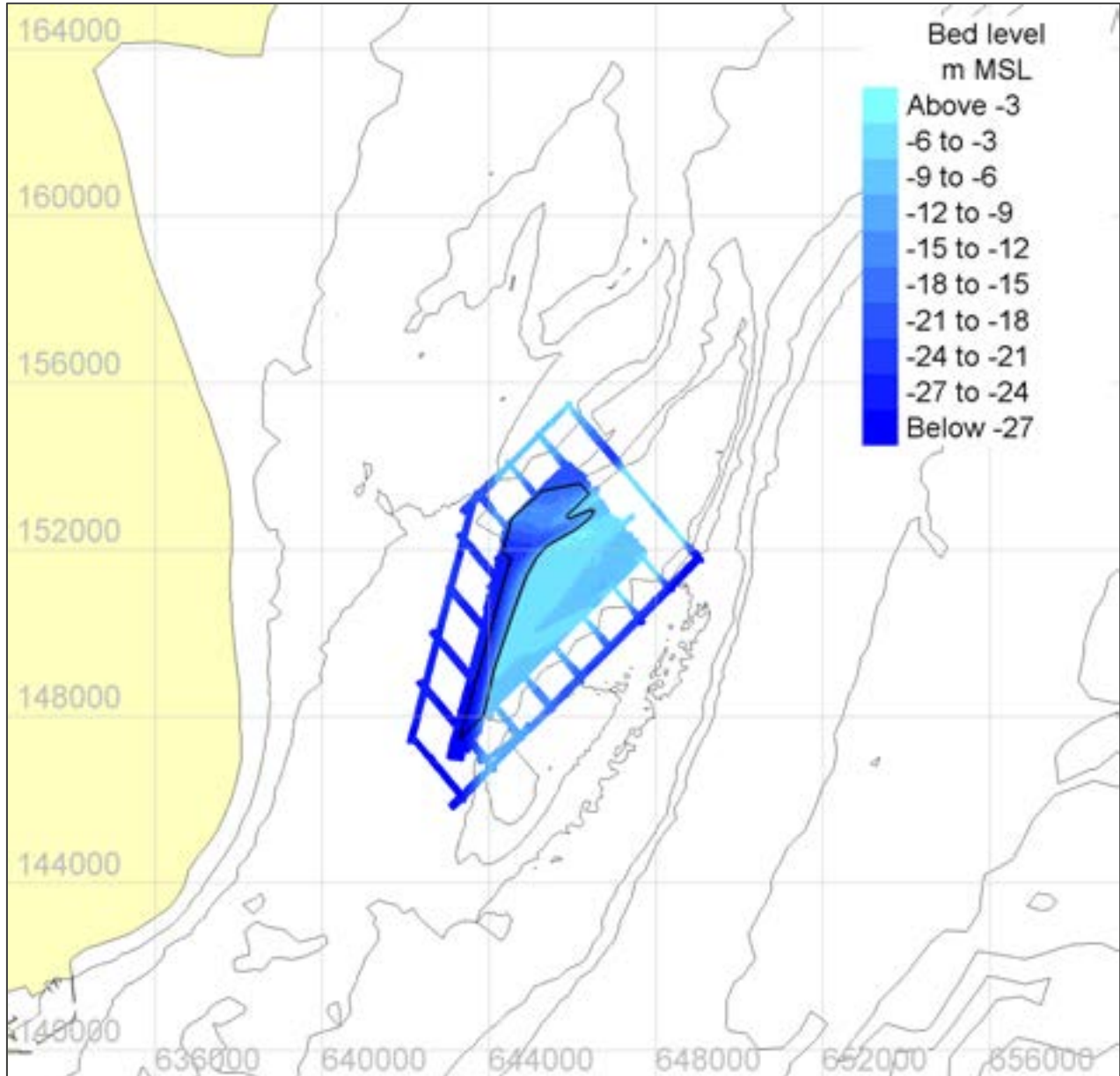


Figure 2.1: Spatial extent of the 2015 bathymetric survey of Goodwin Sands, with proposed dredge area indicated by the black polygon

Source: Data from EGS International Ltd (2015)

Additional bathymetry data for the rest of the model area were taken from:

- Recent TruDepth bathymetry from SeaZone, using the latest available survey data from the United Kingdom Hydrographic Office (UKHO); and,
- Nautical Chart data in European (non-UKHO) waters.

Bathymetry data from these different sources were merged for use in the baseline models, where more recent / resolved data took precedence over older or less resolved data. The representation of the baseline and post-dredged bathymetries, for use in the wave model, is shown in Figure 2.2. The same data were

used to develop the representations of the baseline and post-dredging bathymetries used for the flow and sediment transport models.

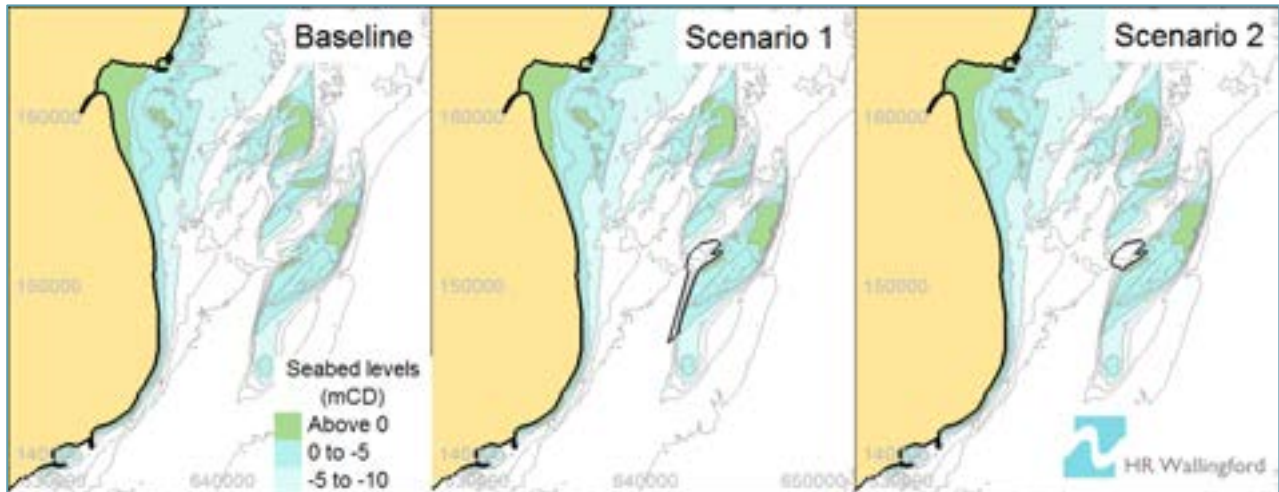


Figure 2.2: Baseline and two post-dredging bathymetries used in the wave model, with proposed dredge area indicated by the black polygon

2.2.2. Historical bathymetries

Bathymetry data for the historical representations of the seabed were taken from earlier HR Wallingford studies of the Goodwin Sands (2008). In these studies, three recent “epochs”, i.e. times when one or more detailed bathymetric surveys had been carried out covering the whole of the South Goodwin Sands, were considered. These epochs provided as good an instantaneous “snapshot”, at different times over the last 30 years, of the continually evolving sandbank, as possible. After review of all the available data sets, the following data were obtained from SeaZone:

- 1986 – 1988 surveys as fair-sheets (scanned and provided in digital form);
- 1995 – 1998 surveys as fair-sheets (scanned and provided in digital form);
- 2006 charted data obtained as contour lines.

The 1986-1988 data were later discarded on the grounds that the data were sparser than anticipated; following transect lines rather than providing a good coverage of the sandbanks. Figure 2.3 and Figure 2.4 illustrate the extent of the 1995-98 and 2006 data respectively.

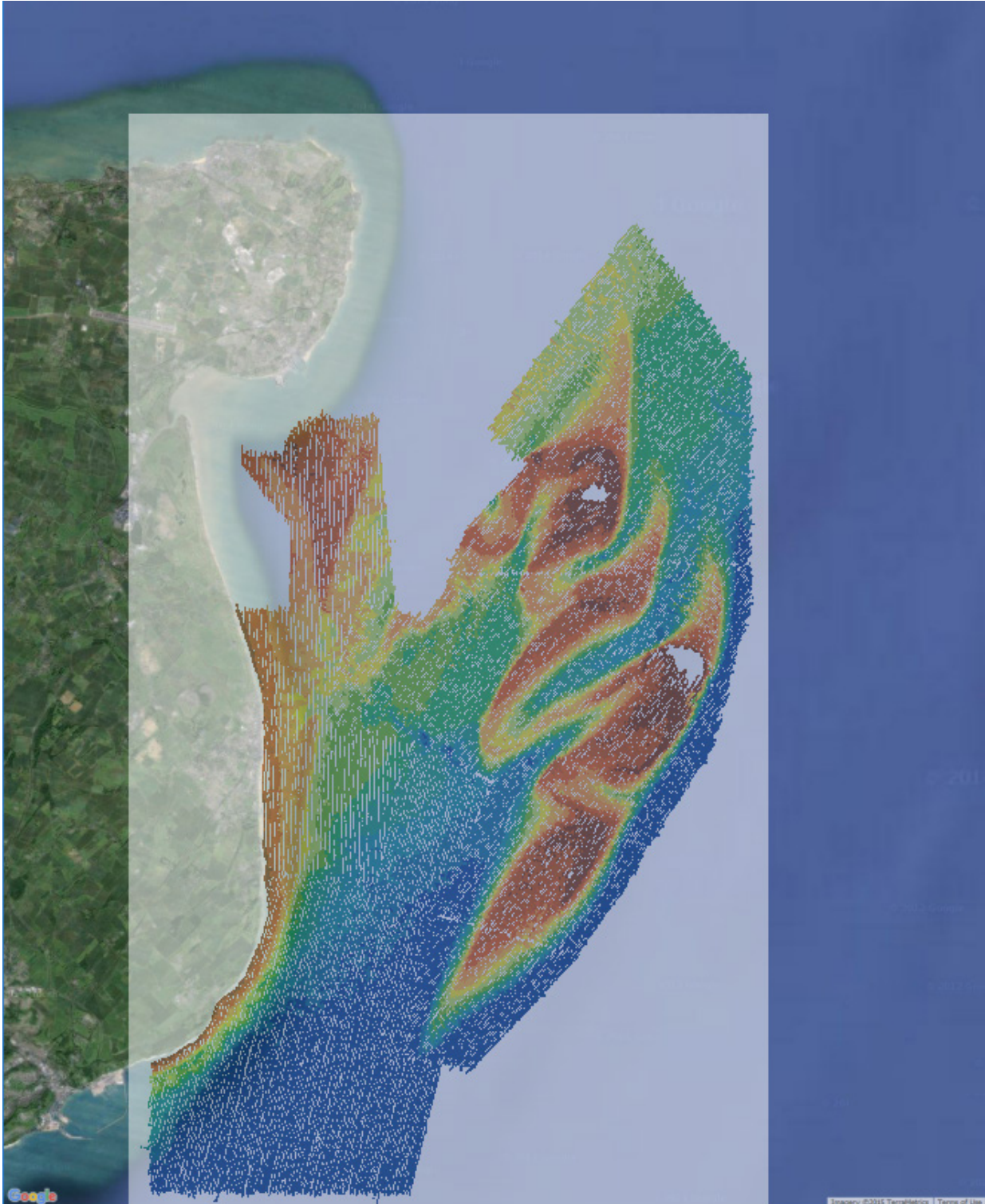


Figure 2.3: Spatial extent of the 1995-1998 TruDepth data, overlaid on Google imagery

Source: HR Wallingford (2008)

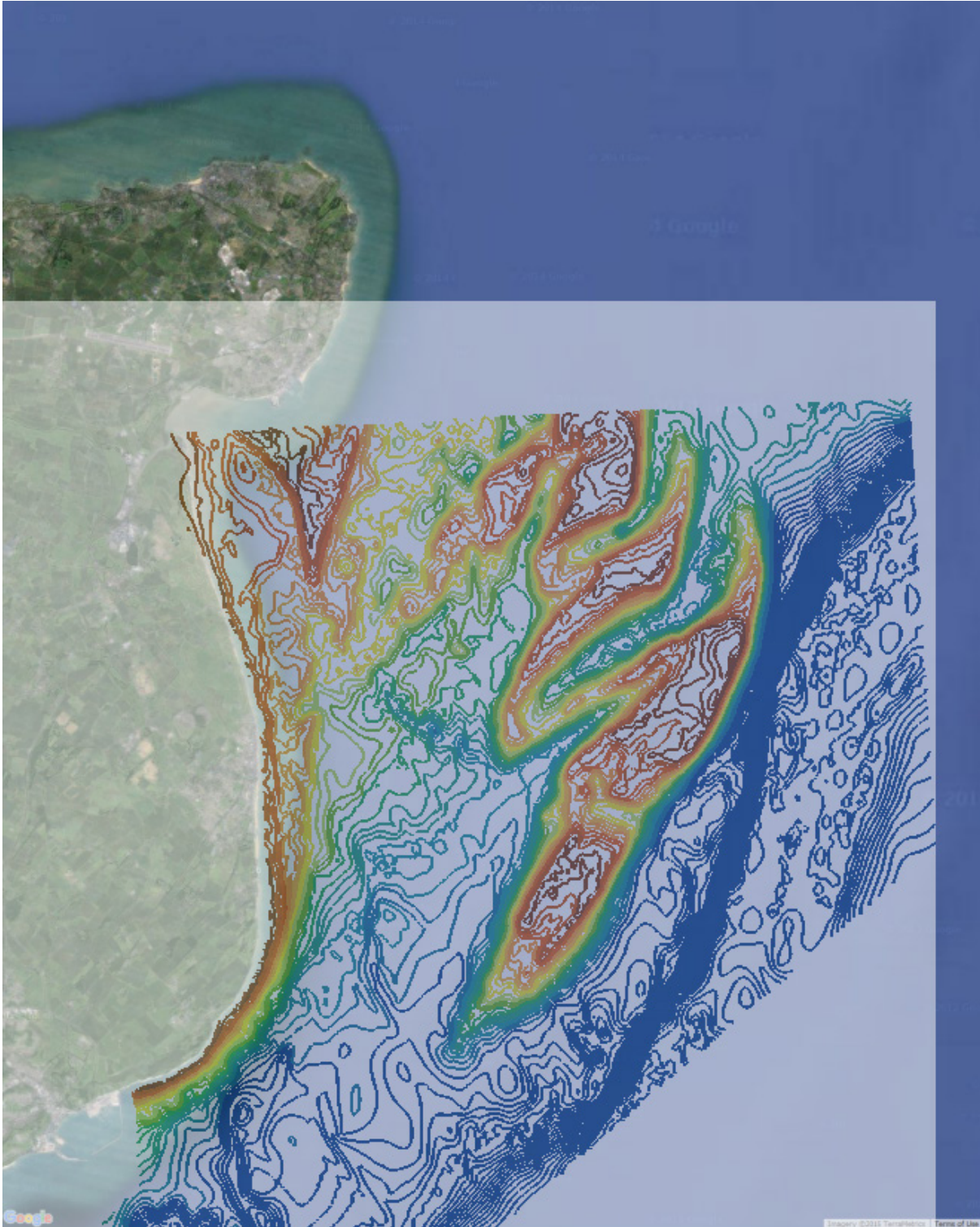


Figure 2.4: Spatial extent of the 2006 charted data, overlaid on Google imagery

Source: HR Wallingford (2008)

The data for each epoch were supplemented with Nautical Chart data for the rest of the model area, and the combination of the different sources of data was made such that more recent / resolved data always took precedence over older or less resolved data. The representation of the historical bathymetries, for use in the wave model, is shown in Figure 2.5. The baseline bathymetry is also reproduced in Figure 2.5 for reference.

It should be noted that aggregate dredging was continuing on the South Goodwin Sands during the period of the 1995-1998 data and therefore the bed levels include some anthropogenic influence and the bed changes shown between 1995-98 and 2006 are not only due to natural processes.

It is noted that the use of more refined / recent bathymetry data sources in the baseline seabed representation away from the sandbanks than in the historical representations results in differing seabed levels offshore of the Goodwin Sands. This is not shown at the resolution of Figure 2.5.

The bed differences shown in Figure 2.5 around South Goodwin Sands are notable with a reduction in the area above Chart Datum (particularly in the area near the proposed dredging), a coalescence of the two bank sections shown in 1995-98 to one continuous bank in 2015 and an extension of the southern end of the bank towards the south and west. These are major morphological changes which are likely to be due to the long term tidal and wave forcing rather than anthropogenic influences such as aggregate dredging.

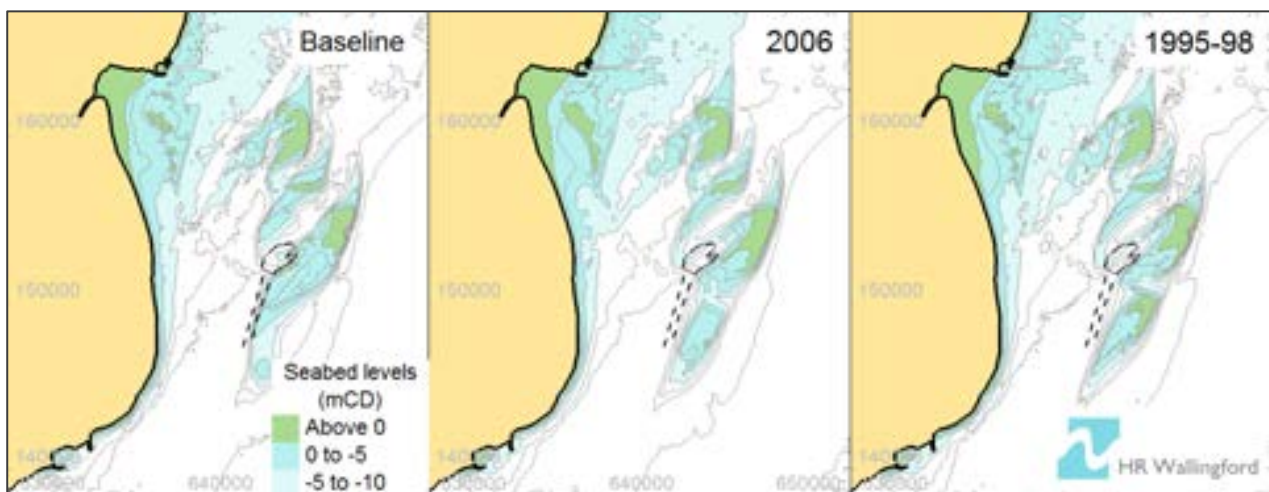


Figure 2.5: Baseline and two historical bathymetries used in the wave model, with proposed dredge area indicated by the black, dashed polygon

2.3. Wave conditions simulated

It is now standard practice in coastal impact studies to consider very large and extremely rare wave conditions that would pose a high risk to the coastline and its coastal defences. Following model validation, the test cases run in the wave model were, therefore, focused on 1 in 200 year return period wave conditions from a range of 4 directions: north-easterlies from the North Sea, locally generated east and south-easterlies, and south-westerlies from the English Channel. Because the extent and effects of changes in wave conditions will be closely related to the tidal level at the time, the wave modelling has been carried out for 3 water levels: Mean Low Water Springs, Mean High Water Springs and an extreme 1 year water level including allowance for sea level rise (SLR). Table 3.3 in Section 3.4 presents the conditions considered in this study in more detail.

3. Wave modelling

3.1. Model applied

Modelling waves in the Dover Strait is a complex task, involving consideration of the effects of the Goodwin Sands and other nearby sandbanks on waves propagating from a variety of directions, as well as local wave generation. In order to transform the chosen offshore wave conditions over the area of the Goodwin Sands, and also account for wind-wave generation over the same area, a SWAN¹ wave transformation model was set up. SWAN is an internationally adopted model developed by the Technical University of Delft. It is a public-domain 3rd generation spectral wave model representing the following processes acting on a complete directional wave spectrum:

- Wave growth due to the wind;
- Wave shoaling and refraction;
- Wave reflections and far-field diffraction;
- Depth-induced breaking, bottom friction and white-capping; and
- Non-linear wave-wave interactions.

The SWAN model is ideally suited to the transformation of wave energy spectra, under continued wind growth, where wave conditions (and in this case *changes* in wave conditions between model runs) are required over the entire model area. It is, therefore, an appropriate model to address the effects of dredging on the Goodwin Sands.

A nested grid system was used in this study, with a coarse resolution (500 m) outer grid covering the Dover Straits and the Thames Estuary, extending across to the French / Belgian / Dutch coast to include the full wave generation area. A finer resolution (100 m) inner grid was defined between Dover and Margate, extending about 18 km offshore. Figure 3.1 shows the extent and resolution of the system of SWAN nested grids. The locations of the UK Met Office (UKMO) European Waters model grid points used to drive the wave model are also shown in Figure 3.1 (yellow pins).

3.2. Boundary conditions

UK Met Office model points close to the SWAN model boundaries were selected to define the offshore wave conditions (point 62, 41 for north to easterlies; point 65, 39 for south-westerlies). The data at these boundary points includes all the wave generating processes outside the model area.

A point inside the model domain (point 63, 41) was selected to give wind conditions more representative of those over the study area, and therefore model the more locally generated wind wave conditions. Wave and wind data were obtained at these points covering a period of almost 20 years between 15/10/1986 and 31/03/2006. This long data period is appropriate to derive 1 in 200 year return period wave conditions for an impact study, the aim of which is to assess changes to the physical environment.

¹ Simulating WAVes Nearshore (SWAN)



Figure 3.1: SWAN wave model extent and grids, UKMO European Waters model grid points (yellow pins) and wave measurement locations (blue pins)

3.3. Validation

3.3.1. Data sources

It was originally proposed to validate the wave model against wave data from the Channel Coast Observatory at Goodwin Sands. Wave parameters at this location (51°14'48.16"N 1°28'52.03"E) are recorded using a Datawell Directional WaveRider Mk III buoy. The data buoy was first deployed on 06 June 2008 and has been recording since then. Unfortunately this does not overlap with the period when the UK Met Office European Waters model offshore data (used to drive the wave model) is available.

The Channel Coast Observatory, however, holds historical data at Deal Pier. This is directly onshore of the Goodwin Sands, and as such is ideally suited for validation of the wave model. Wave parameters at the Deal Pier location (51°13' 25.652"N 01°24' 33.332"E) are recorded using a Rosemount WaveRadar Rex. The instrument was installed on Deal Pier on 25 August 2005, giving an overlap period of just over seven months with the UK Met Office model offshore data.

The location of the Goodwin Sands and the Deal Pier instruments is marked with blue pins in Figure 3.1.

Initial quality checks of the Deal Pier records indicated that the peak wave periods T_p did not correlate well with those from the Goodwin Sands buoy for the times when both instruments were recording, casting some doubt as to the reliability of the Deal Pier wave periods. A high frequency cut-off is also apparent in the records, with no mean wave period observed under 3 seconds (s). For these reasons, the observed wave

periods were discarded and comparison with modelled wave periods not attempted in this study. The validation exercise concentrated rather on agreement in significant wave height.

Analysis of the wave height data at Deal Pier for the calibration period did not suggest the waves were depth limited by their location near the coastline. Therefore the data was considered appropriate to calibrate the wave model.

3.3.2. Significant wave heights

The 2006 historical seabed map (see Section 2.2.2) was used in the validation runs as this was closest bathymetry dataset to the period of observations.

It is our experience that wave model results are most sensitive to the wave growth formulation and associated wind speed. Sensitivity to the following different combinations of wave growth formulation and scaling of the wind speed were, therefore, investigated in this analysis:

- Komen wind growth formulation, with model wind speeds unmodified;
- Komen wind growth formulation, with model wind speeds marked up by 10%;
- WestHuysen wind growth formulation, with model wind speeds unmodified;
- WestHuysen wind growth formulation, with model wind speeds marked up by 10%.

The results of this analysis are presented below in the form of time histories of observed (continuous line) and predicted (dots) significant wave height at Deal Pier during the first two months of observations.

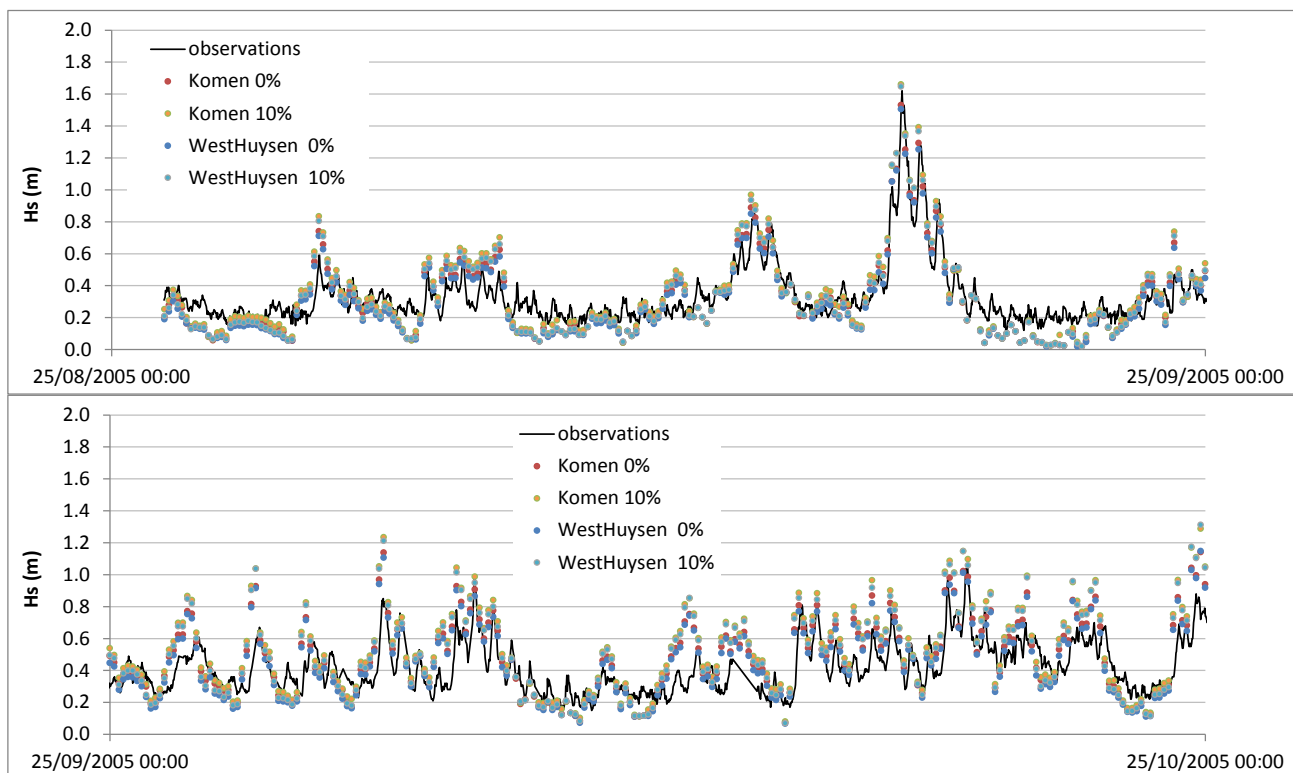


Figure 3.2: Time histories of observed and predicted significant wave height at Deal Pier

The results of the validation tests show that closer agreement with observed wave heights was reached without scaling up the source wind speeds applied over the model area. Marginally better agreement was reached overall with the Komen wind growth formulation. This is in line with our previous experience in this area. A scatter plot of SWAN predicted vs. observed significant wave height is shown in Figure 3.3 for the period during which both observations and offshore wind/wave data were available. This figure indicates a slight positive bias for big events, meaning that the model tends to slightly over-estimate the significant wave height at Deal Pier for waves greater than about 0.25 m.

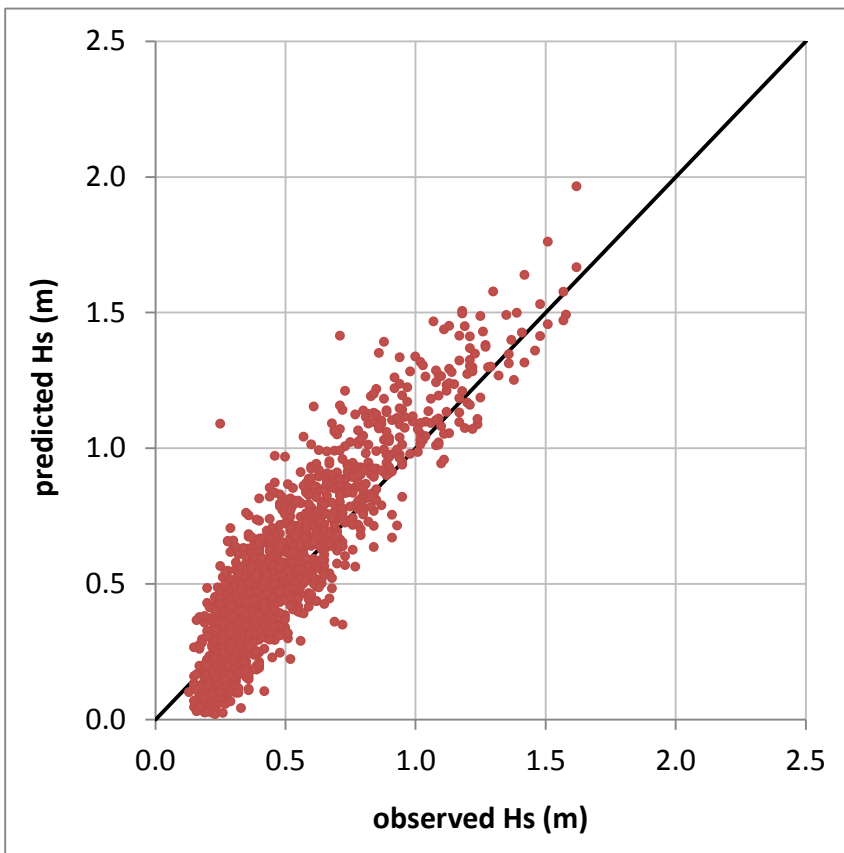


Figure 3.3: SWAN predicted vs. observed significant wave height at Deal Pier

3.3.3. Suitability of the wave model for this assessment

The comparison of observed and predicted wave height at Deal Pier (Figure 3.3) shows the wave model is able to represent adequately the significant wave heights at the coastline using the applied forcing conditions. By extension, it is deemed suitable to predict wave conditions over the study area including the effect of the Goodwin Sands on waves at the coastline and, of equal or greater importance here, any changes in wave height likely to be caused by introduction of the dredging of the Goodwin Sands.

3.4. Scenario testing

The SWAN model was run for the baseline present-day bathymetry and for the 2 post-dredging scenarios presented in Section 2.2.1. Historical bathymetries were subsequently tested to assess the natural variation in wave conditions resulting from the natural evolution of the Goodwin Sands and nearby sandbanks, and so

put any effects of the dredging into context. The 1 in 200 year return period wave conditions were tested, from a range of 4 directions and at 3 water levels.

3.4.1. Boundary wave conditions

Data from the UK Met Office model points 62, 41 and 65, 39 close to the SWAN model boundaries (locations shown in Figure 3.1) were obtained covering a period of almost 20 years between 15/10/1986 and 31/03/2006. The distribution of waves from the data at the two points is shown in Figure 3.4 and Figure 3.5.

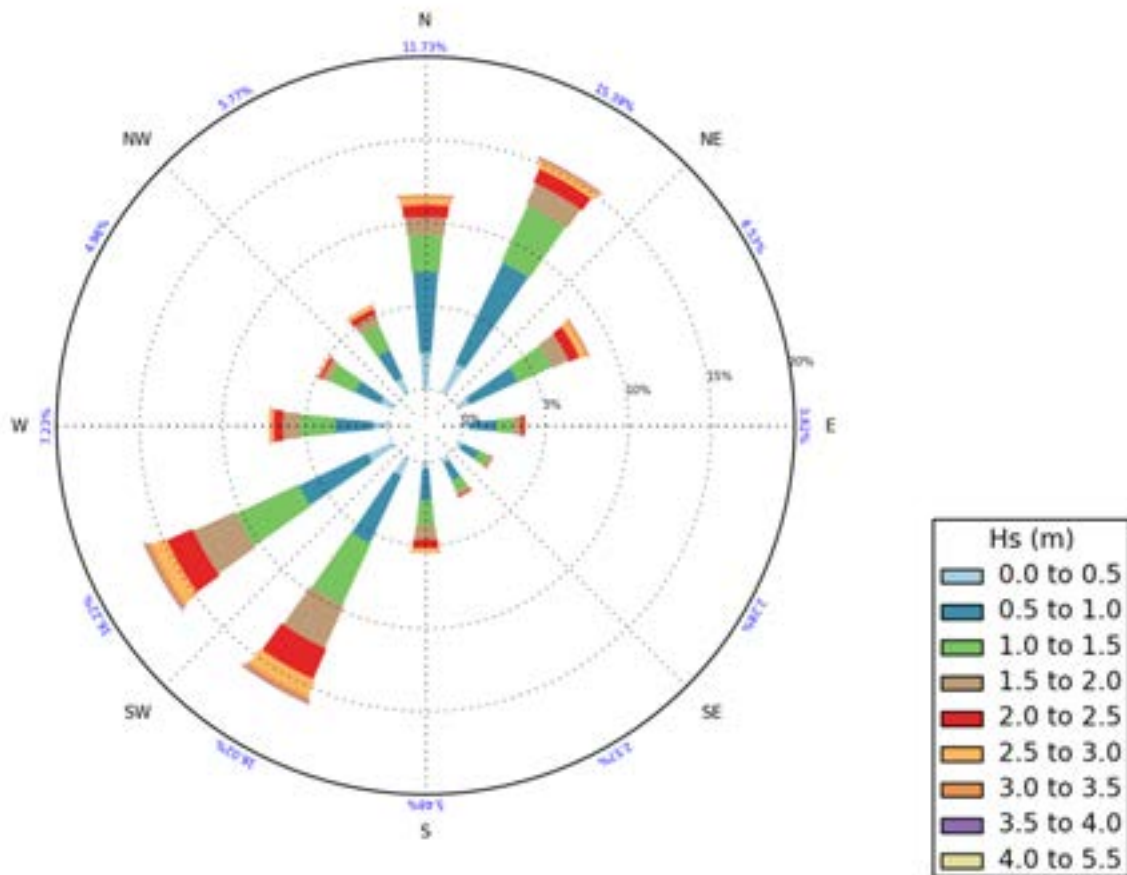


Figure 3.4: UKMO model point 62,41 wave rose

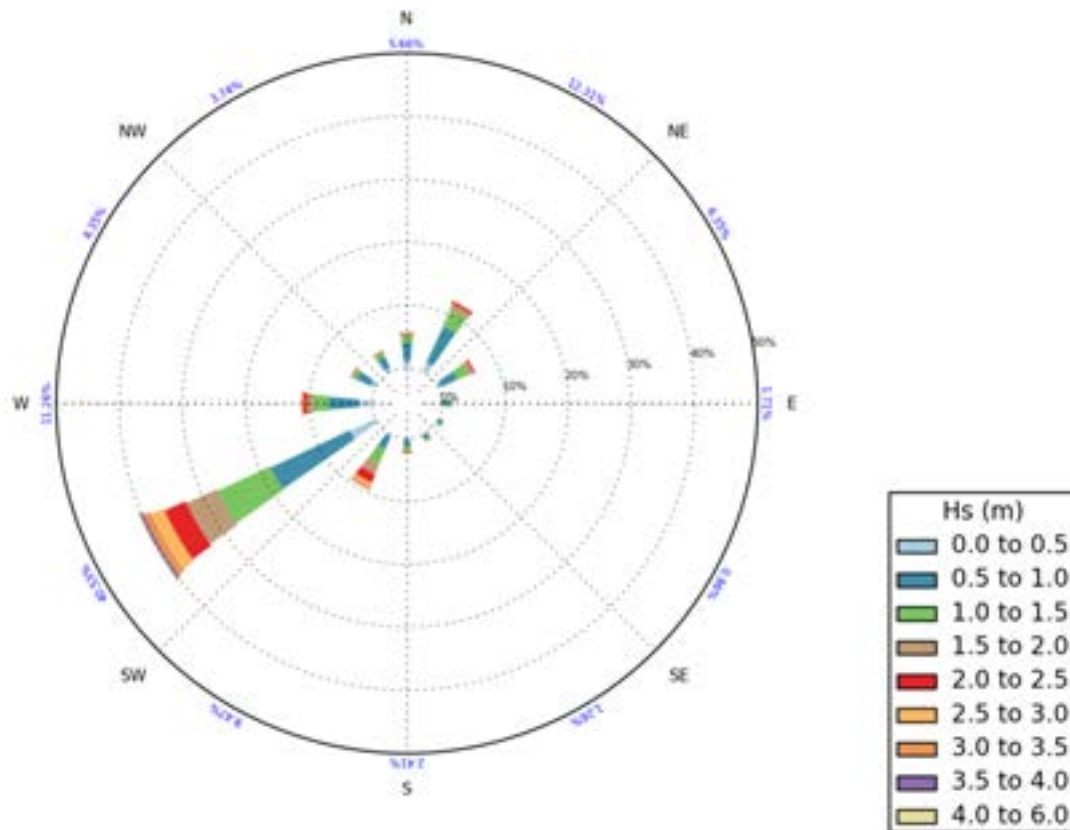


Figure 3.5: UKMO model point 65,39 wave rose

These data were analysed to provide estimates of 1 in 200 year return period wave conditions from the North Sea and from the English Channel respectively (Table 3.1).

Table 3.1: Estimated 1 in 200 year return period extreme wave conditions

Direction (°N)	H _s (m)	T _p (s)
30	5.2	10.7
90	4.4	10.1
240	6.8	11.9

3.4.2. Wind conditions

Data from the UK Met Office model point 63,41 (location shown in Figure 3.1 and summarised in Figure 3.6) were obtained and analysed to provide estimates of 1 in 200 year return period wind conditions generating local waves (Table 3.2).

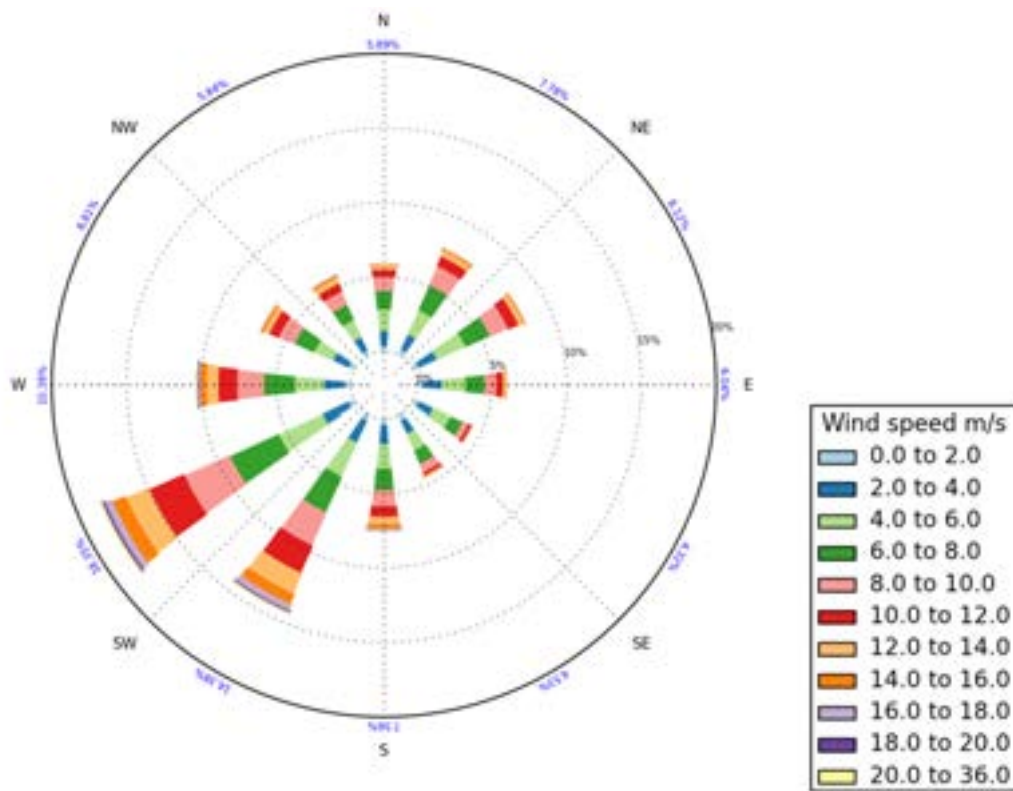


Figure 3.6: UKMO model point 63,41 wind rose

Table 3.2: Estimated 1:200 year return period wind speeds offshore Goodwin Sands

Direction (°N)	Wind speed (m/s)
90	18.6
120	19.5

The winds required to sustain the 1 in 200 year return period waves from 30°N and 240°N (Table 3.1) were estimated separately as 25.8 m/s and 33.5 m/s respectively. It is noted that they do not correspond to 1:200 year return period winds.

3.4.3. Sea levels

From Admiralty tide tables for 2015, MHWS and MLWS for Deal are 6.3 and 0.9 mCD, respectively. The model was also run for an extreme water level, including sea level rise, for the effects of future climate change to be considered. The 1 year water level at Deal was estimated to be 7.1 mCD based on design sea levels published by the Environment Agency (2011), to which a 0.5 m allowance for climate change was added corresponding to a period 50 to 100 years into the future.

3.4.4. List of model runs

Compiling the information in Sections 3.4.1-3.4.3 gives the model runs listed in Table 3.3. Wave conditions 1 and 2 are for waves from the North Sea, wave condition 3 is for locally wind generated waves, and wave condition 4 is for waves from the English Channel.

Table 3.3: Wave model impact assessment runs

Wave condition	Boundary wave condition			Wind condition		Sea levels
	H _s	T _p	Dir	Speed	Dir	
	(m)	(s)	(°N)	(m/s)	(°N)	(mCD)
1	5.2	10.7	30	25.8	30	0.9, 6.3 and 7.6
2	4.4	10.1	90	18.6	90	0.9, 6.3 and 7.6
3	--	--	--	19.5	120	0.9, 6.3 and 7.6
4	6.8	11.9	240	33.5	240	0.9, 6.3 and 7.6

The model runs concentrated on waves at high and low water: high water was chosen because this is when the waves have most effect on coastal defences and low water was chosen as this condition gives the greatest proportional change in water depth due to the dredging so would be expected to be the time when the effects of the dredging are most pronounced.

The effect of tidal currents was not included in the scenario testing. The footprint of change to current due to the dredge was shown to be small by the tidal flow modelling (HR Wallingford, 2016a) so any effect of current on waves would be extremely similar for the baseline and post-dredging cases.

The wave model was also run for more frequent conditions to provide input into the sediment transport studies. This is discussed in the sediment transport modelling report (HR Wallingford, 2016b).

3.5. Model results

3.5.1. Differences in wave conditions due to dredging

The results of the wave modelling for the baseline and post-dredging scenarios are presented in Figure 3.7 to Figure 3.10. Each figure comprises three parts: a left pane showing area plots of baseline significant wave heights; and middle and right panes showing area plots of differences in significant wave height between post-dredged and baseline cases. A minimum threshold value of 0.02 m was adopted in the figures below to show any changes in significant wave height. Reductions in wave heights predicted to be caused by the dredging are shown in green and increases in pink. The sandbank locations, as represented in the baseline model, are indicated by schematised dashed lines for reference.

3.5.2. Historical differences

Results for the historical scenarios are presented in Figure 3.11 to Figure 3.14 in the forms of significant wave height from individual model runs, for the baseline bathymetry, and difference in significant wave height between historical and baseline conditions. Changes in significant wave height greater than 0.02 m, predicted to be caused by the natural movement of the sandbanks are shown in pink for increases and green for decreases. The sandbank locations, as represented in the baseline / historical models, are indicated by schematised dashed lines for context.

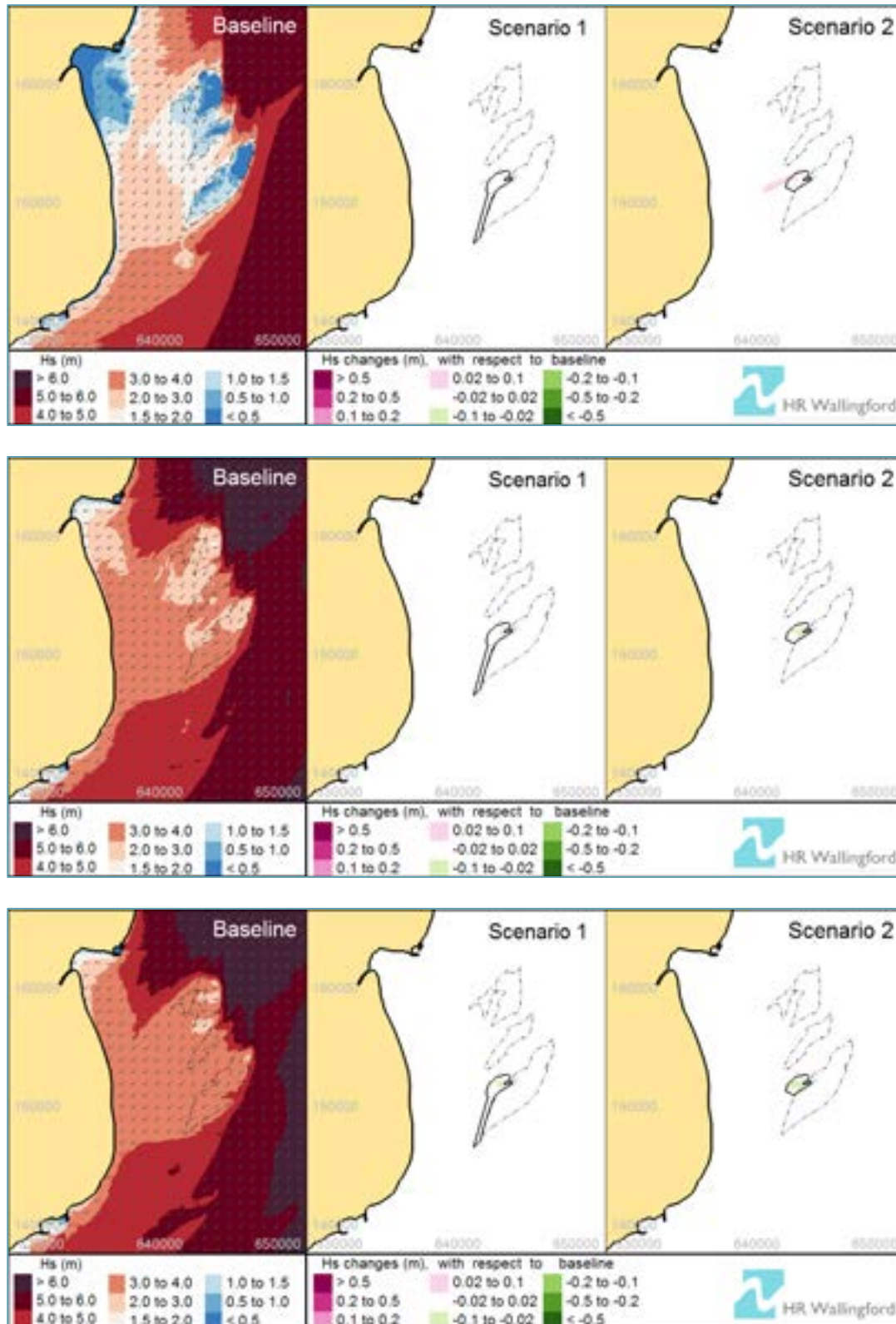


Figure 3.7: 1 in 200 year return period wave conditions from 30°N at MLWS (top), MHWS (middle) and 1 year water level with SLR (bottom): Baseline H_s and differences due to dredging. Proposed dredge area is indicated by a black polygon

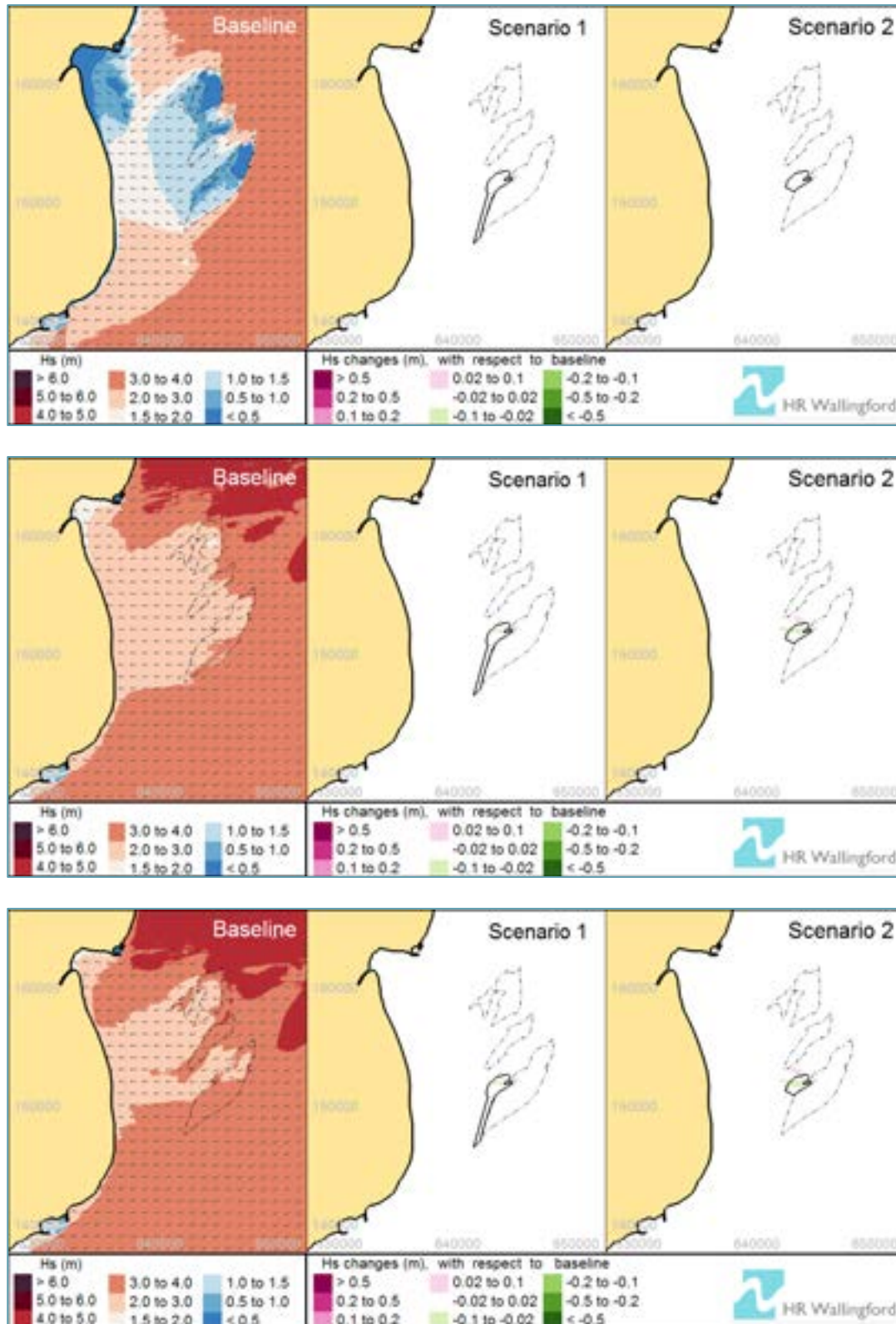


Figure 3.8: 1 in 200 year return period wave conditions from 90°N at MLWS (top), MHWS (middle) and 1 year water level with SLR (bottom): Baseline H_s and differences due to dredging. Proposed dredge area is indicated by a black polygon

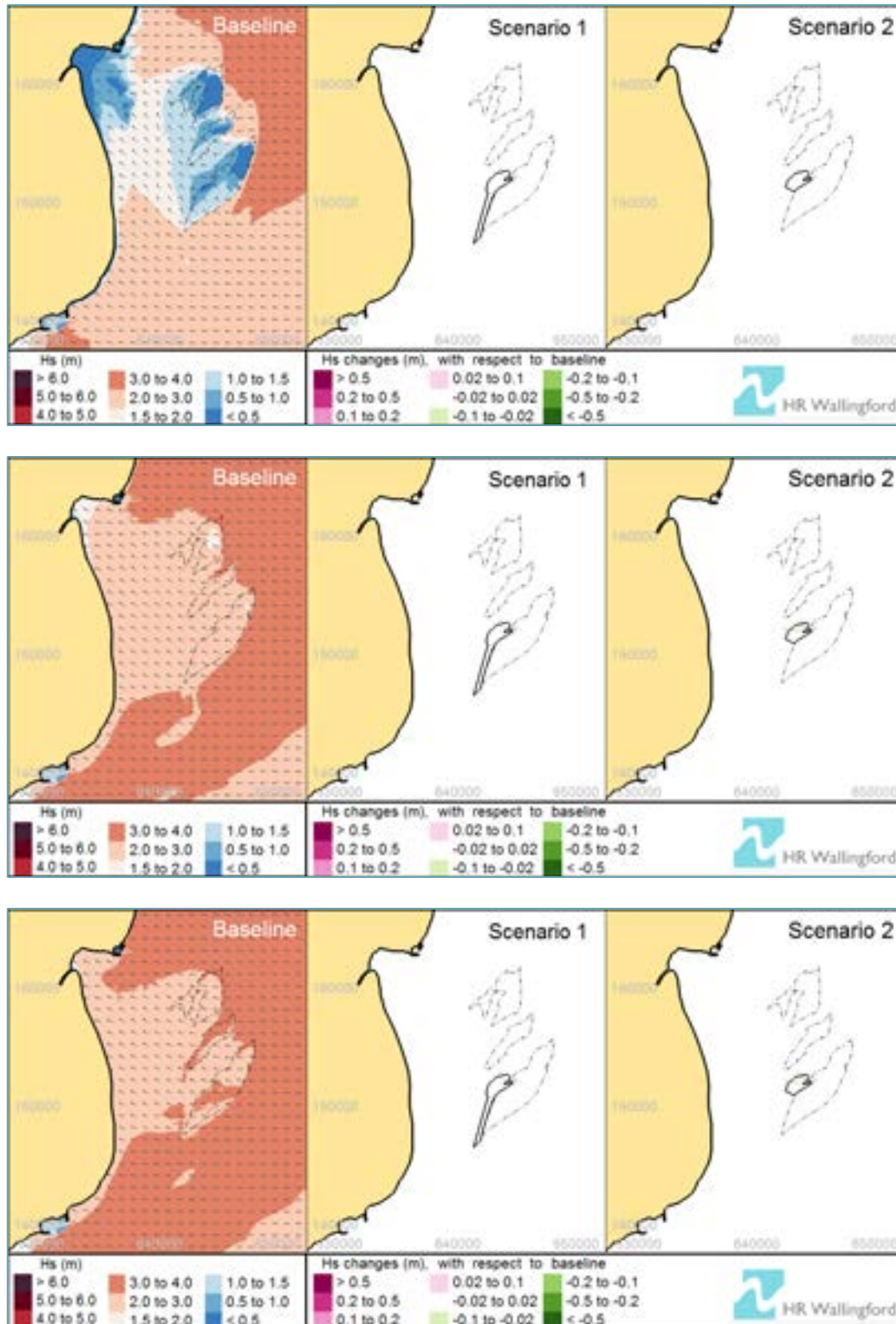


Figure 3.9: 1 in 200 year return period wave conditions from 120°N at MLWS (top), MHWS (middle) and 1 year water level with SLR (bottom): Baseline H_s and differences due to dredging. Proposed dredge area is indicated by a black polygon

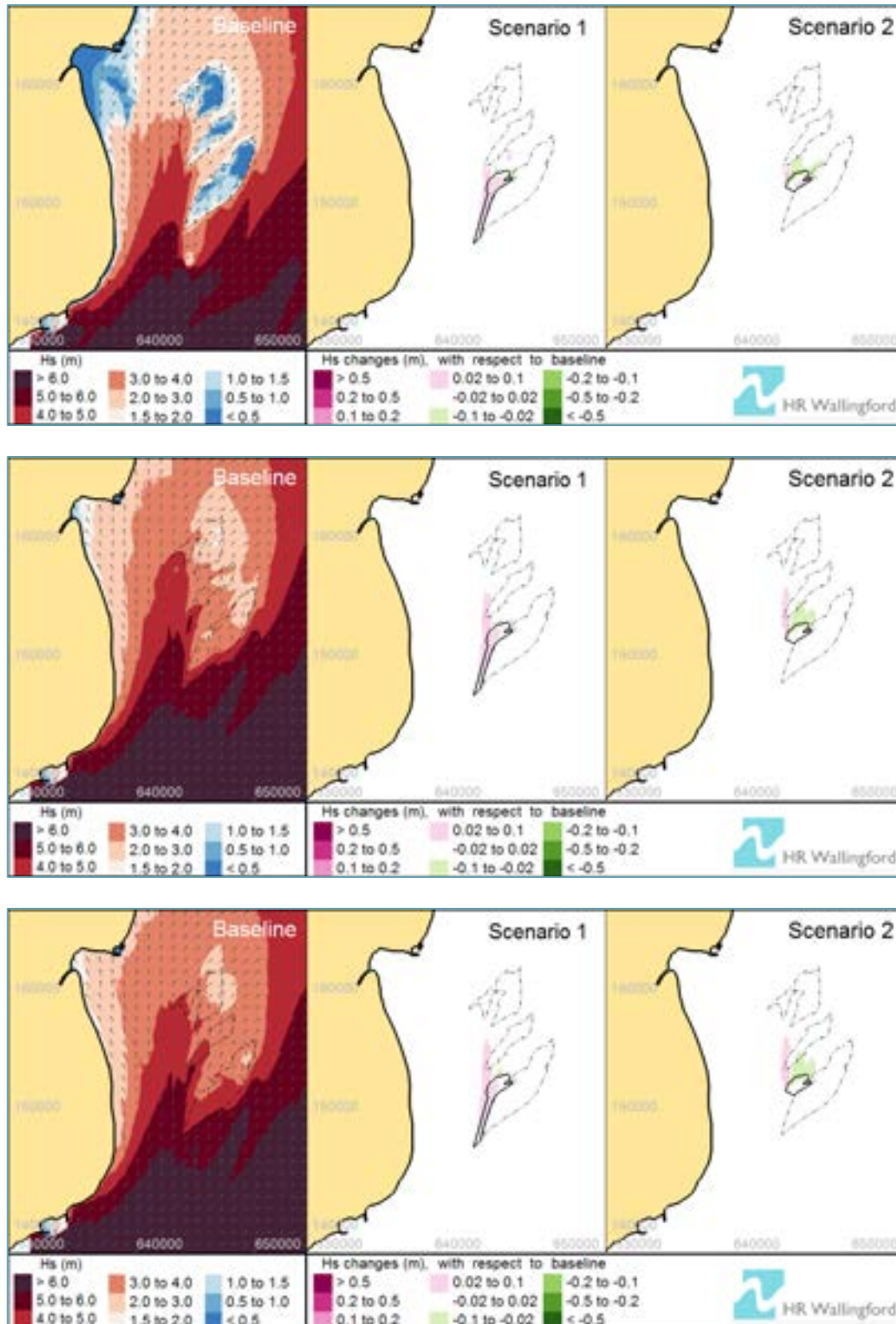


Figure 3.10: 1 in 200 year return period wave conditions from 240°N at MLWS (top), MHWS (middle) and 1 year water level with SLR (bottom): Baseline H_s and differences due to dredging. Proposed dredge area is indicated by a black polygon

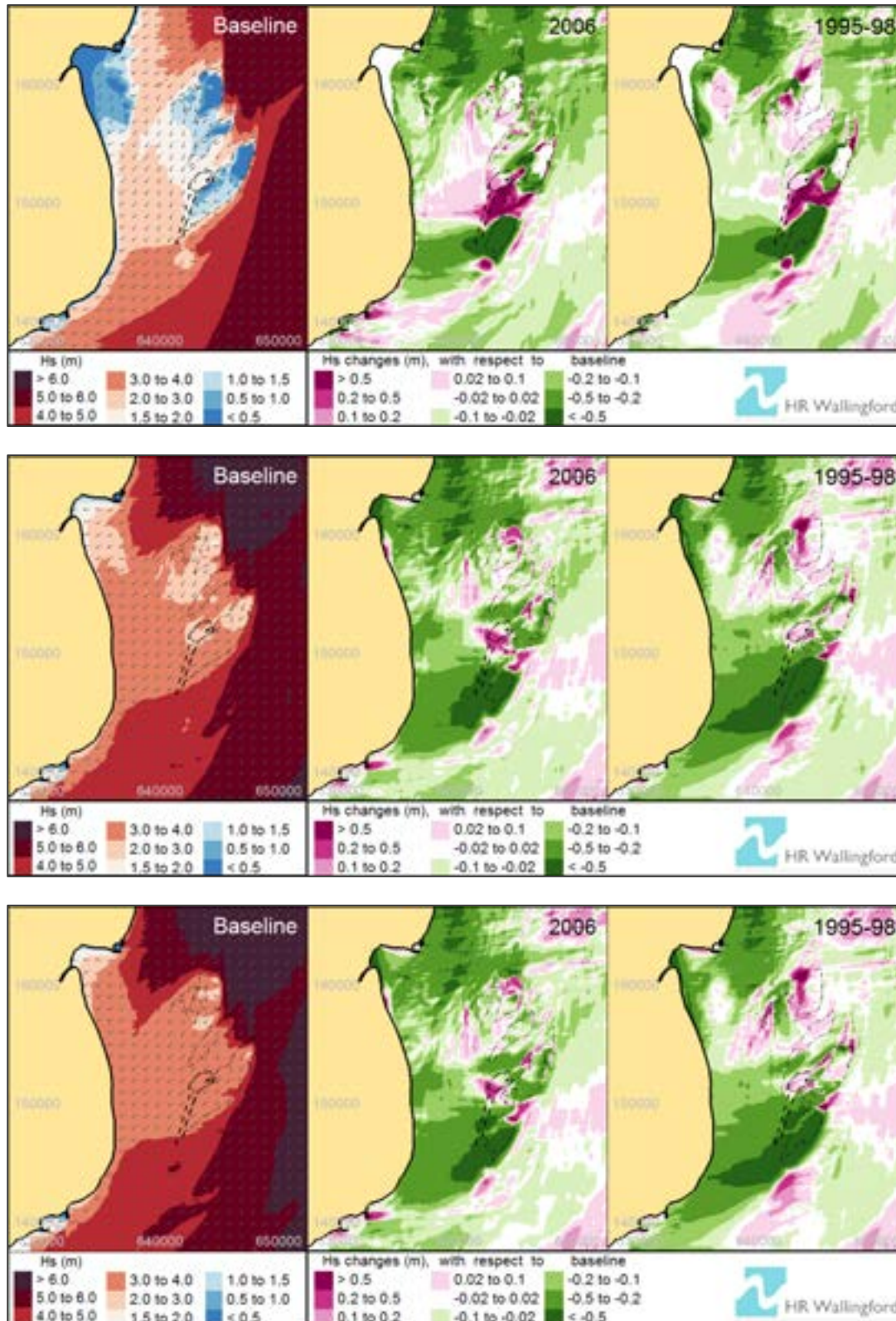


Figure 3.11: 1 in 200 year return period wave conditions from 30°N at MLWS (top), MHWS (middle) and 1 year water level with SLR (bottom): Baseline and differences due to bathymetric change. Proposed dredge area is indicated by a dashed, black polygon

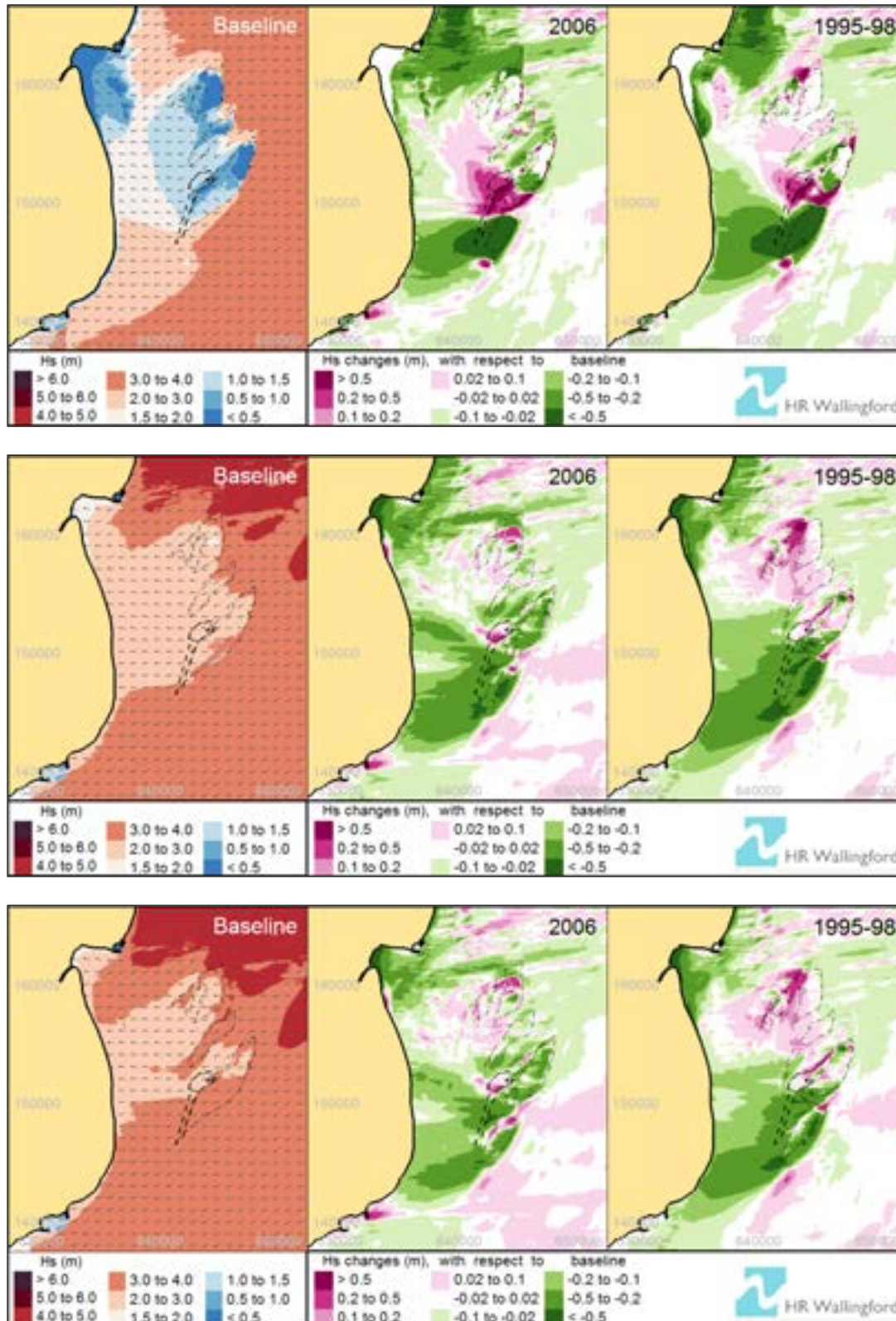


Figure 3.12: 1 in 200 year return period wave conditions from 90°N at MLWS (top), MHWS (middle) and 1 year water level with SLR (bottom): Baseline and differences due to bathymetric change. Proposed dredge area is indicated by a dashed, black polygon

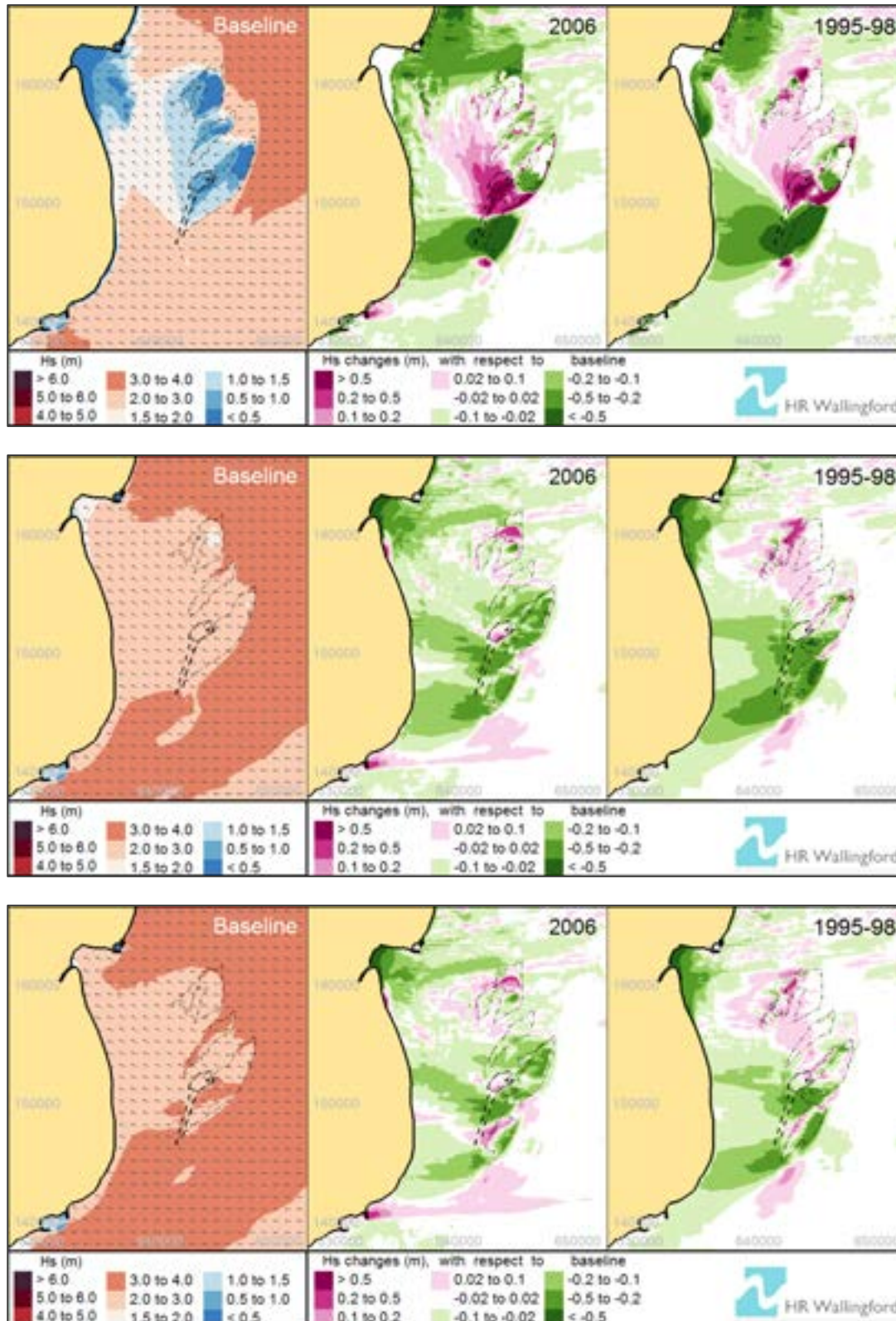


Figure 3.13: 1 in 200 year return period wave conditions from 120°N at MLWS (top), MHWS (middle) and 1 year water level with SLR (bottom): Baseline and differences due to bathymetric change. Proposed dredge area is indicated by a dashed, black polygon

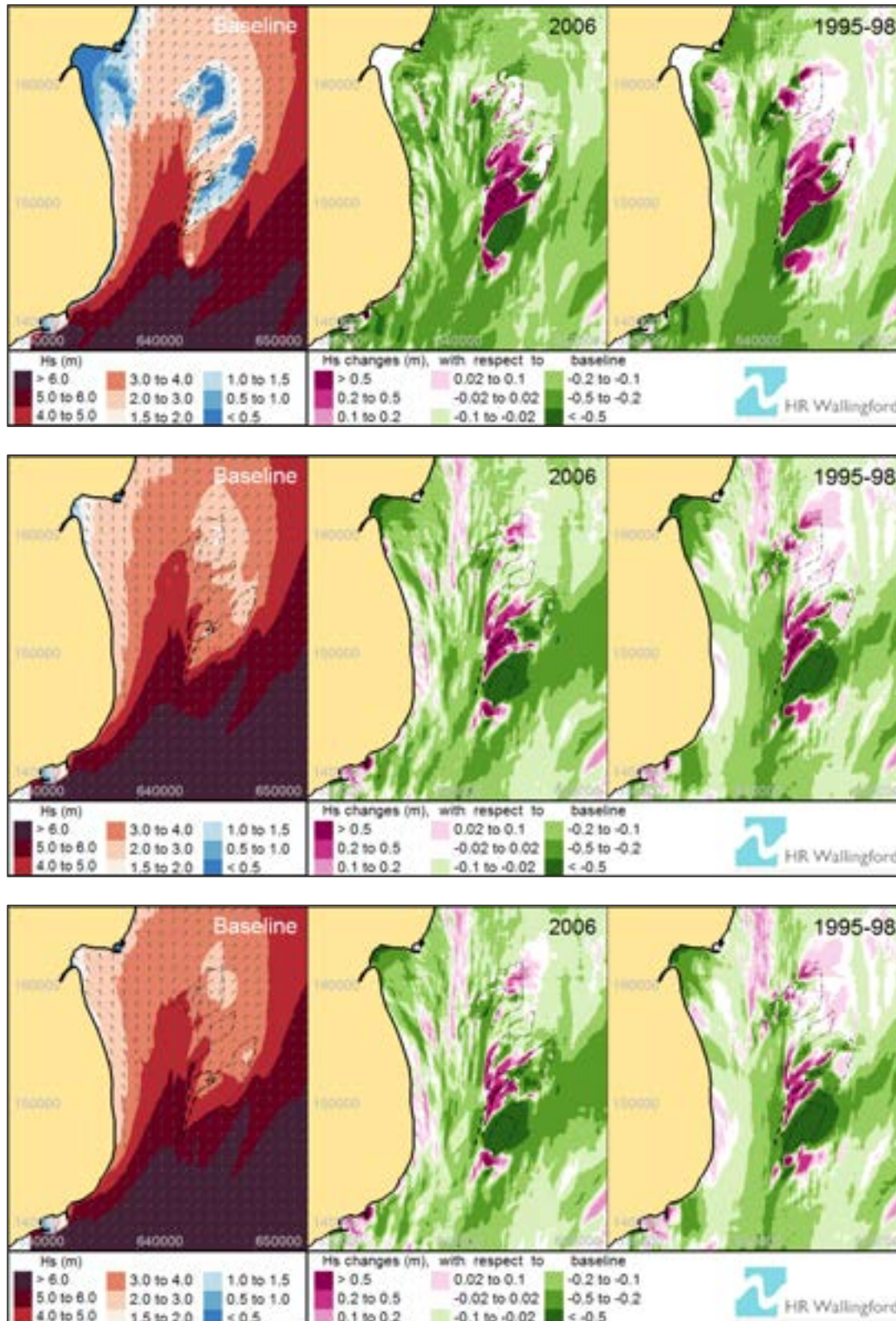


Figure 3.14: 1 in 200 year return period wave conditions from 240°N at MLWS (top), MHWS (middle) and 1 year water level with SLR (bottom): Baseline and differences due to bathymetric change. Proposed dredge area is indicated by a dashed, black polygon

4. Discussion

4.1. Predicted effects of dredging on wave conditions

This study has used project-specific survey data collected over the Goodwin Sands exploration area by EGS International Ltd supplemented by the most recent available bathymetric data over the study area. It has used a state-of-the-art wave model to test 1 in 200 year wave conditions, as is now standard practice in Coastal Impact Studies, to see if the proposed dredging on the Goodwin Sands could have any effect on wave conditions in the coastal areas.

The result plots, shown in Figure 3.7 to Figure 3.10, illustrate increases and decreases in significant wave height (H_s) above and below a threshold of ± 0.02 m. Smaller differences would be insignificant, and hardly measureable in reality.

The modelling indicated very little change in wave height as a result of the proposed dredging. The main effect was caused by a slight difference in the way waves refract around the edge of the sandbank leading to a slight redistribution of the wave energy. The predicted changes in significant wave height due to dredging are limited in spatial extent and are generally limited to 0.02-0.10 m, even under the extreme conditions tested. No effect is predicted at the coastline for any of the modelled wave conditions (Figure 3.7 to Figure 3.10).

With wind/wave conditions from 90°N (Figure 3.8) and wind/wave conditions from 120°N (Figure 3.9) the predicted changes in the significant wave height caused by the dredging are minimal, sometimes less than the 0.02 m threshold, as a consequence of the shorter wave period and smaller wave height approaching the Goodwin Sands from these directions.

Wave conditions from 240°N (Figure 3.10) show the greatest extent of changes to the significant wave height. This can be attributed to waves from this direction travelling along the axis of the dredging area and propagating further in that direction than they would without the dredging.

Both dredging scenarios tested, either the full proposed dredge area being applied for (Scenario 1) or deeper dredging only within the northern section of the area (Scenario 2), appear to give acceptable levels of change in wave conditions. Negligible change in wave conditions is predicted at the coastline.

4.2. Footprint of effect

The wave modelling has predicted the effect of the dredging on extreme waves for a range of incoming wave directions and water levels. To identify an overall footprint of change to wave conditions due to the proposed dredge (shown in red on Figure 4.1), the area within which the wave height is changed by more than 0.02 m (increase or decrease) for any of the simulations has been plotted (blue outline on Figure 4.1). The threshold of 0.02 m does not necessarily suggest a significant effect will occur within this area however for changes in wave height smaller than this value any effect on waves can be considered as negligible. It should also be noted that the simulated conditions are for extreme wave conditions, for more typical waves the area of change to wave height of 0.02 m would be much smaller.

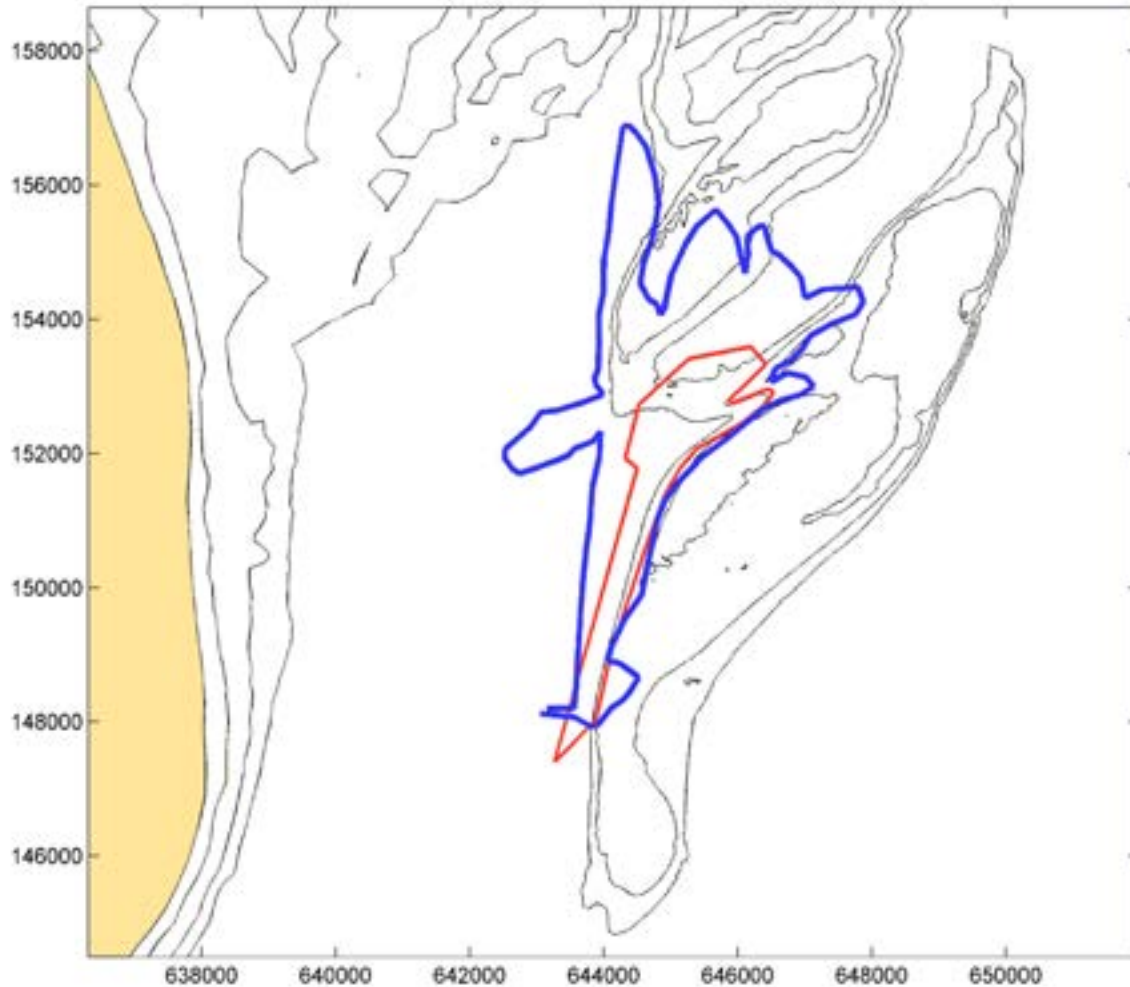


Figure 4.1: Summary footprint of effect of dredging on waves – Scenario 1

The footprint of effect does not extend to any of the sensitive locations as shown in Figure 1.2 with the exception of one wreck site which is at the northernmost extent of the footprint of effect, some 4 km distant from the edge of the proposed dredge area. Sediment transport modelling has been used to investigate any implication of the changes in wave height, combined with tidal currents, on sediment transport and patterns of seabed erosion and deposition. No effect on seabed erosion or deposition was shown at the identified wreck site (HR Wallingford 2016b).

4.3. Historical context

To put the predicted changes into context, the modelling also considered historical bathymetries to predict the natural variation in wave conditions resulting from the natural evolution of the Goodwin Sands and nearby sandbanks. The results plotted in Figure 3.11 to Figure 3.14, illustrate increases and decreases in significant wave height using the same colour scale as in Figure 3.7 to Figure 3.10.

The simulated results indicate significantly more natural variation in significant wave height than was the case with the post-dredging bathymetries. It is noted that some of these differences may be attributed to the use of more refined / recent bathymetry data sources in the present day seabed representations away from

the sandbanks than in the historical representations. Despite this factor it is clear that the changes in wave conditions due to the natural variability of the sandbanks are significantly greater than the effects of the proposed dredging.

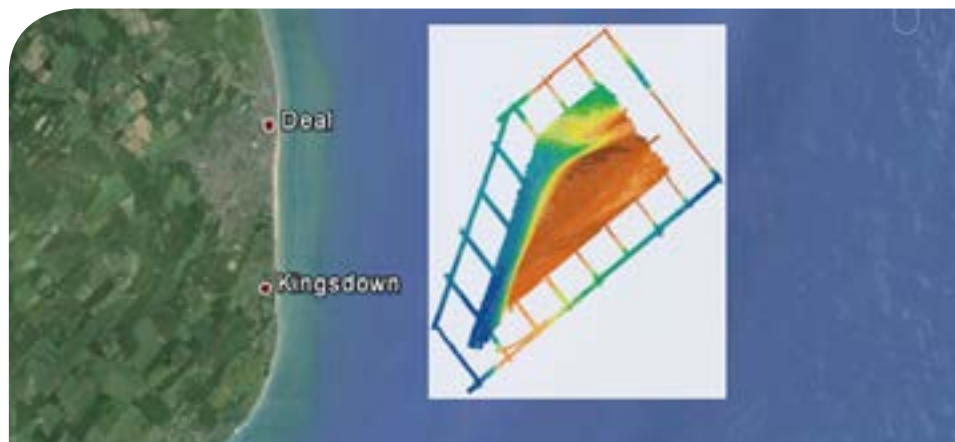
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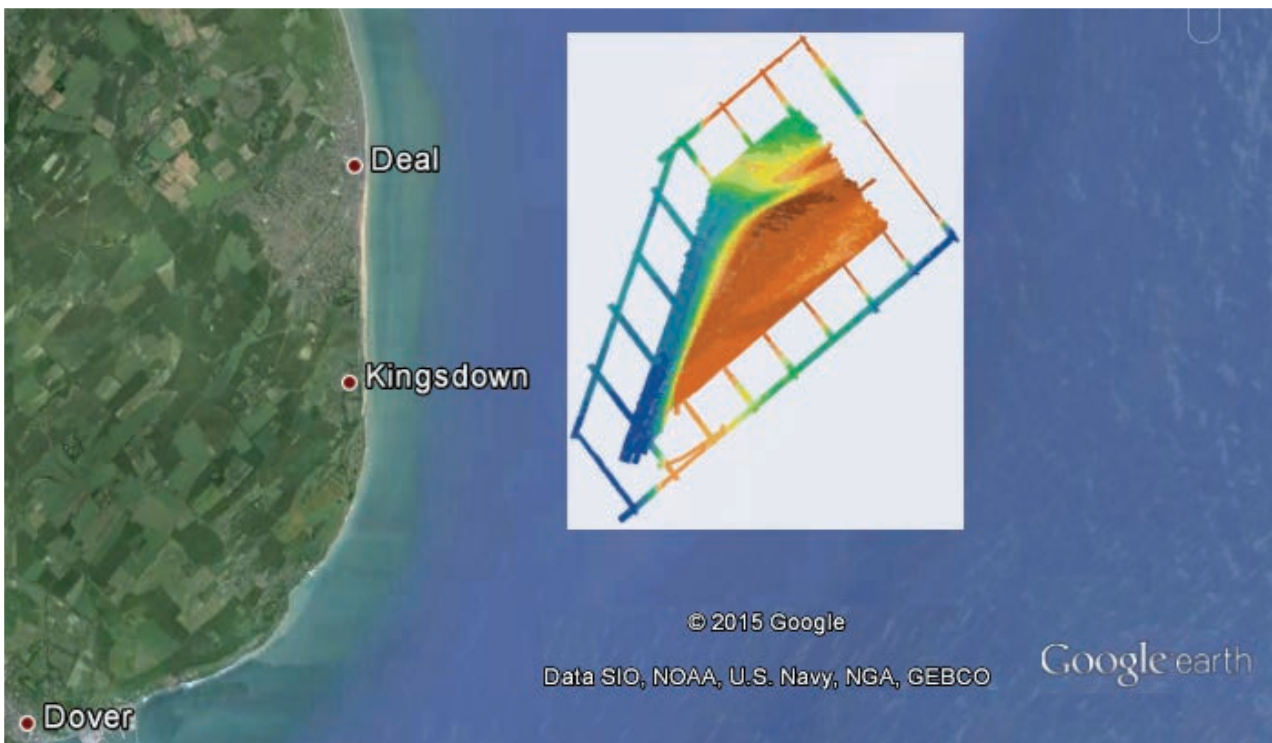
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Appendix 6.2

Goodwin Sands Aggregate Dredging Coastal Impact Study and
EIA – Tidal Flow Modelling

Goodwin Sands Aggregate Dredging Coastal Impact Study and EIA

Tidal flow modelling



Document information

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Document authorisation

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Executive Summary

Dover Harbour Board (DHB) is proposing to dredge sand and gravel from the South Goodwin Sands off the coast of Kent for use as fill material for the Dover Western Docks Revival development at the Port. DHB is proposing to dredge up to 2.5 million m³ of sand and gravel from the subtidal parts of the South Calliper sandbank at the South Goodwin Sands, located approximately 12 km north east of the Port of Dover (Figure 1.1). Marine aggregate dredging requires a Marine Licence from the Marine Management Organisation (MMO). Royal HaskoningDHV, on behalf of the DHB, is undertaking an Environmental Impact Assessment (EIA) to support the application for a Marine Licence for consent to dredge.

HR Wallingford is providing inputs to the EIA and Coastal Impact Study (CIS), establishing the magnitude, spatial extent and duration of any changes to the physical environment. The focus of the modelling described in this report is on changes in tidal currents caused by dredging at the Goodwin Sands.

An existing 2D, depth averaged flow model of the English Channel and Southern North Sea has been locally refined in the area of Goodwin Sands. The model was validated for currents in the area of the proposed dredge against data collected at the site for the present EIA studies.

The model was run for a period of more than one month for the existing and post-dredge cases and the differences in currents plotted. All of the current speed differences due to the dredging in excess of 0.05 m/s have been found to be within about 1 km from the proposed dredging area. Hence no widespread effect on tidal currents due to the proposed dredging is anticipated.

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1. Introduction

Dover Harbour Board (DHB) is proposing to dredge sand and gravel from the South Goodwin Sands off the coast of Kent for use as fill material for the Dover Western Docks Revival development at the Port. DHB is proposing to dredge up to 2.5 million m³ of sand and gravel from the subtidal parts of the South Calliper sandbank at the South Goodwin Sands, located approximately 12 km north east of the Port of Dover (Figure 1.1). Marine aggregate dredging requires a Marine Licence from the Marine Management Organisation (MMO). Royal HaskoningDHV, on behalf of the DHB, is undertaking an Environmental Impact Assessment (EIA) to support the application for a Marine Licence for consent to dredge.

HR Wallingford first considered the required studies to support dredging at the Goodwin Sands in 2008 when a phased, outline scope was proposed; including a historical bathymetric review and wave modelling to inform a Coastal Impact Study (CIS). The historical bathymetric review covering the period 1986-2006 was completed and reported on in HR Wallingford (2008).

For the present project HR Wallingford is providing inputs to the EIA and CIS, establishing the magnitude, spatial extent and duration of any changes to the physical environment directly caused by dredging on the Goodwin Sands. The focus of the modelling described in this report is on changes in tidal currents caused by dredging on the Goodwin Sands. The flow model results were also required as input to the modelling of sediment transport and morphological change.

The proposed dredge area lies close to various sensitive locations including protected wrecks, designated areas, anchorages and sites associated with particular ecological value such as seal haul out sites and *sabellaria spinulosa* reef as shown in Figure 1.2. The potential for the proposed dredging to change the physical processes at these sites requires particular attention.

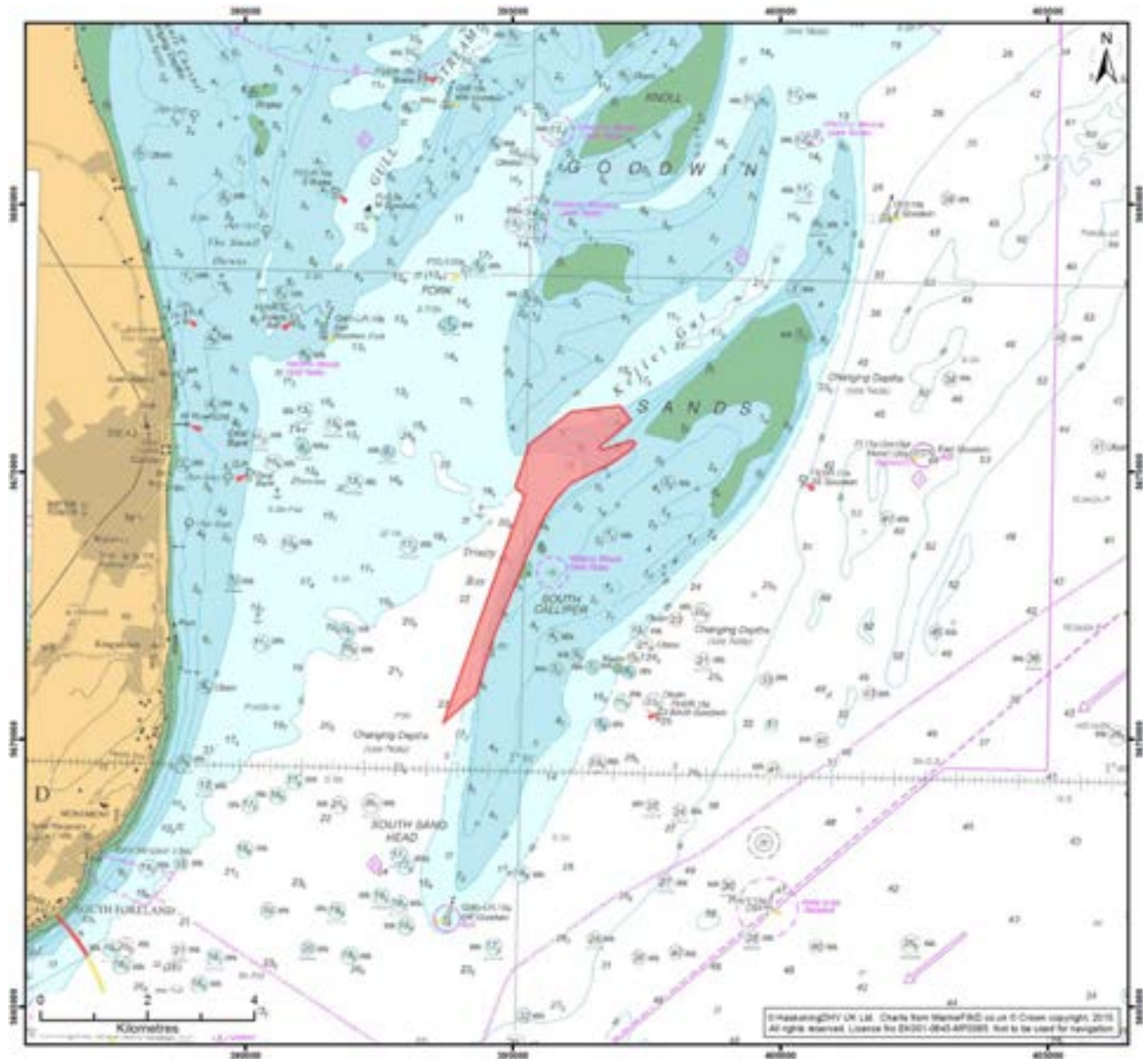


Figure 1.1: Location of proposed aggregate dredging area

Source: PHDHV Drawing PB2107_ES_003

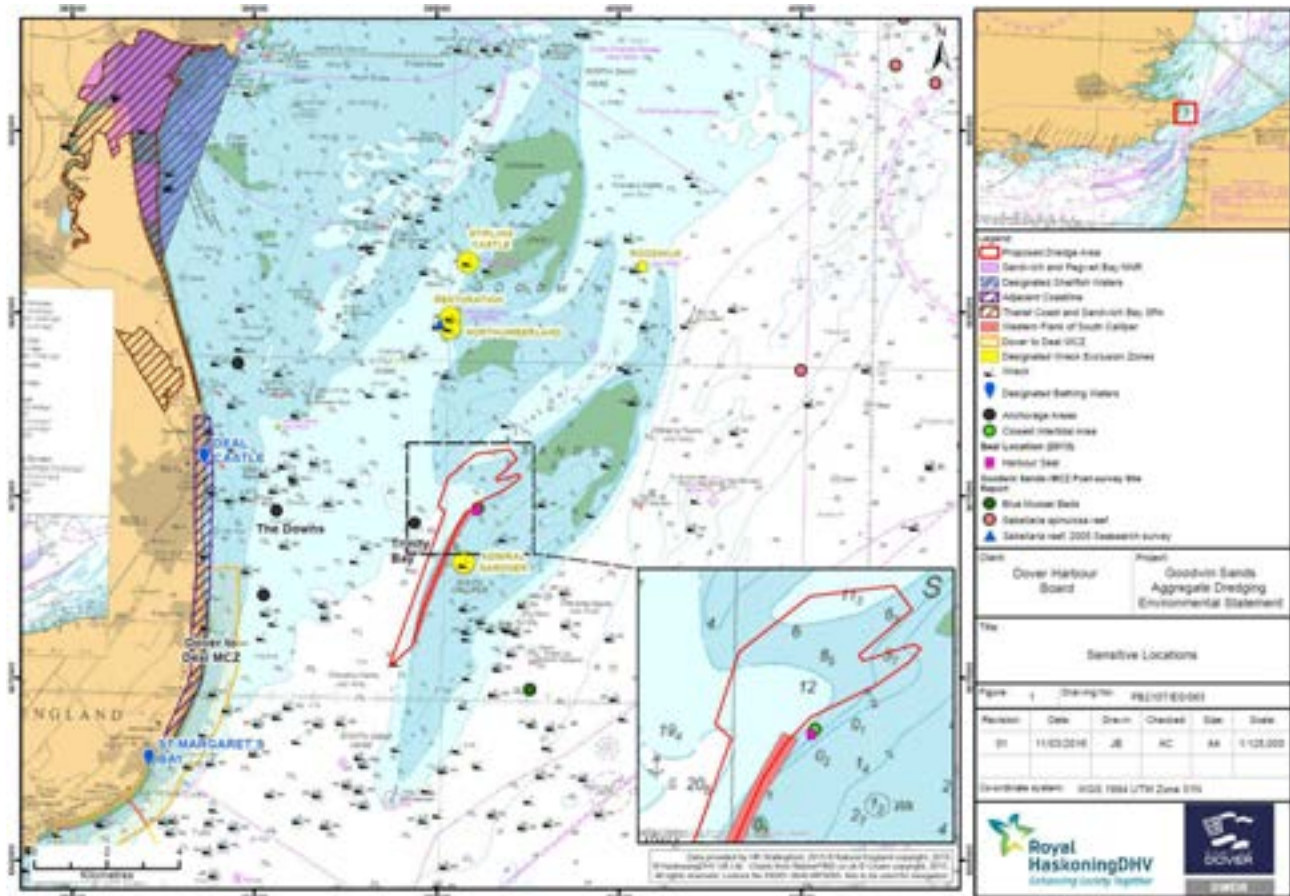


Figure 1.2: Sensitive locations in area of proposed aggregate dredging area

Source: RHDHV drawing PB2107_ES_063

2. Scenarios tested

2.1. Historical, baseline and built scenarios

The conditions represented in the models are summarised as:

- A “baseline” case, that is the present-day bathymetry without dredging;
- A post-dredging scenario, dredging up to 1.12 m depth of aggregates in the full dredge area being applied for.

The scenario with dredging covering the full dredge area being applied for was modelled to provide the largest spatial extent of an effect on tidal currents.

It is proposed that up to approximately 2.5 million m³ of material will be dredged from Goodwin Sands and transported to Dover for use as aggregate in the Western Docks project. As has been used for aggregate studies elsewhere the amount of sediment removed has been increased by 60% in the modelling studies to provide a precautionary view of the potential impact of the dredge. Hence, the post-dredging scenario involved removal of approximately 4,000,000 m³ of material from areas identified as having sand. A layer of at least 0.5 m of sand was left in the dredged areas in accordance with established practice to facilitate recovery of benthic communities. Removal of this volume resulted in the average depth of dredging of 1.12 m as modelled.

2.2. Bathymetry data

2.2.1. Baseline and post-dredging bathymetries

The area of the EGS International Ltd bathymetry survey collected for the present project in mid-2015 is shown in Figure 2.1. The survey provided detailed bathymetry data in the full area of resource exploration undertaken by DHB surrounded by sections at 1 km spacing to capture the form of the sandbank immediately surrounding the exploration area. The survey is shown to provide a reasonable coverage of the South Goodwin Sands. It is noted that the southernmost face of the sand bank is only defined by the transverse cross-sections extending about one kilometre away from the main survey area.

Additional bathymetry data for the rest of the model area were taken from:

- Recent TruDepth bathymetry from SeaZone, using the latest available survey data from the UKHO,
- Nautical Chart data in European (non-UKHO) waters.



Figure 2.1: Spatial extent of the 2015 bathymetric survey of the Goodwin Sands, with proposed dredge area indicated by the black polygon

Source: EGS International Ltd (2015)

Bathymetry data from these different sources were merged for use in the baseline model, where more recent / resolved data took precedence over older or less resolved data. The data was converted to be relative to Mean Sea Level (MSL) which is a flat vertical datum required by a model covering a large area of sea rather than using Chart Datum (CD) which, as it is a measure of lowest astronomical tide level, varies throughout the model area.

The model representation of the baseline and post dredged bathymetries, for use in the tidal flow model, are shown in Figure 2.2 and Figure 2.3. Figure 2.4 shows the difference in bathymetry inserted into the model to represent the proposed dredging.

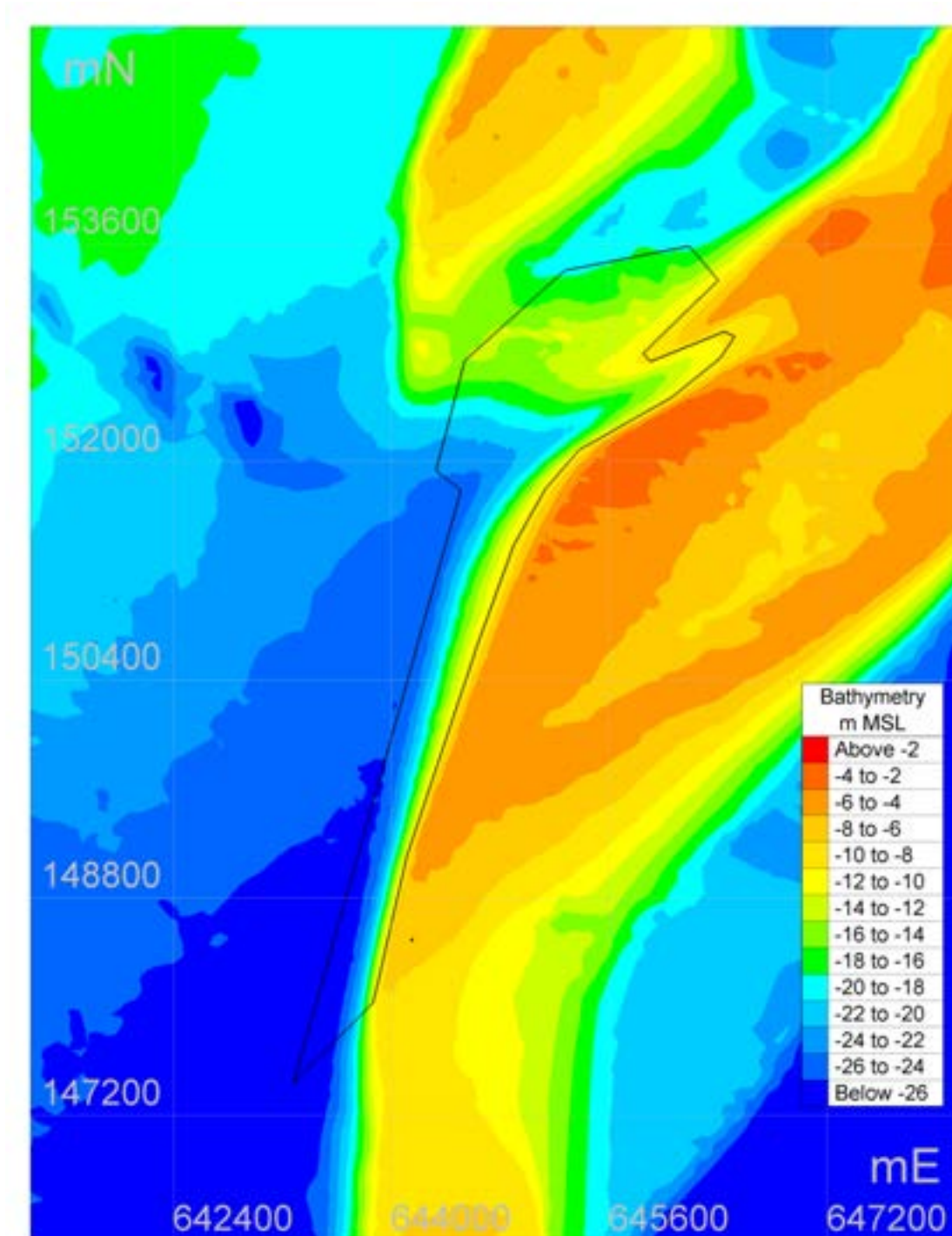


Figure 2.2: Baseline case model bathymetry, with proposed dredge area indicated by the black polygon

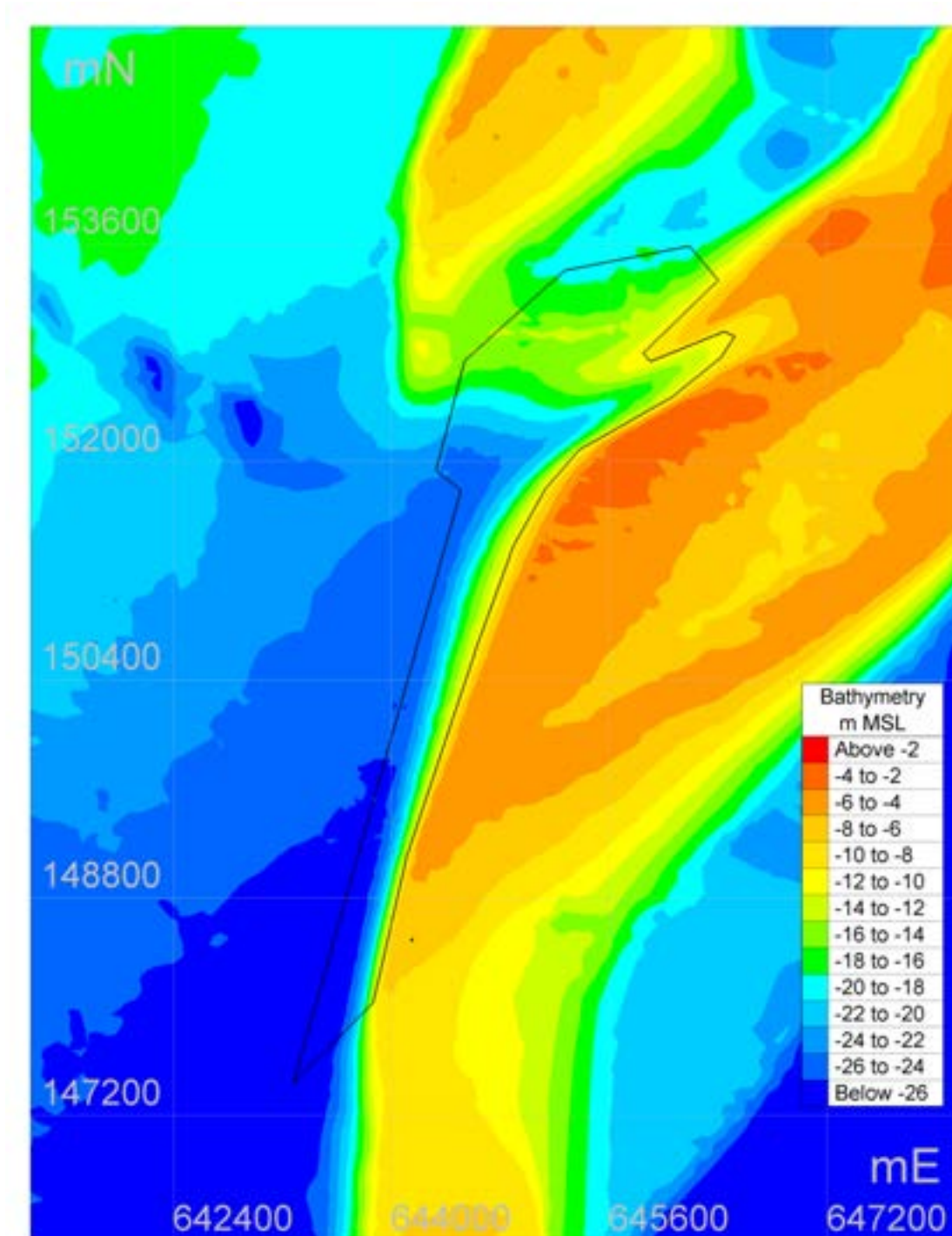


Figure 2.3: Post dredging case model bathymetry, with proposed dredge area indicated by the black polygon

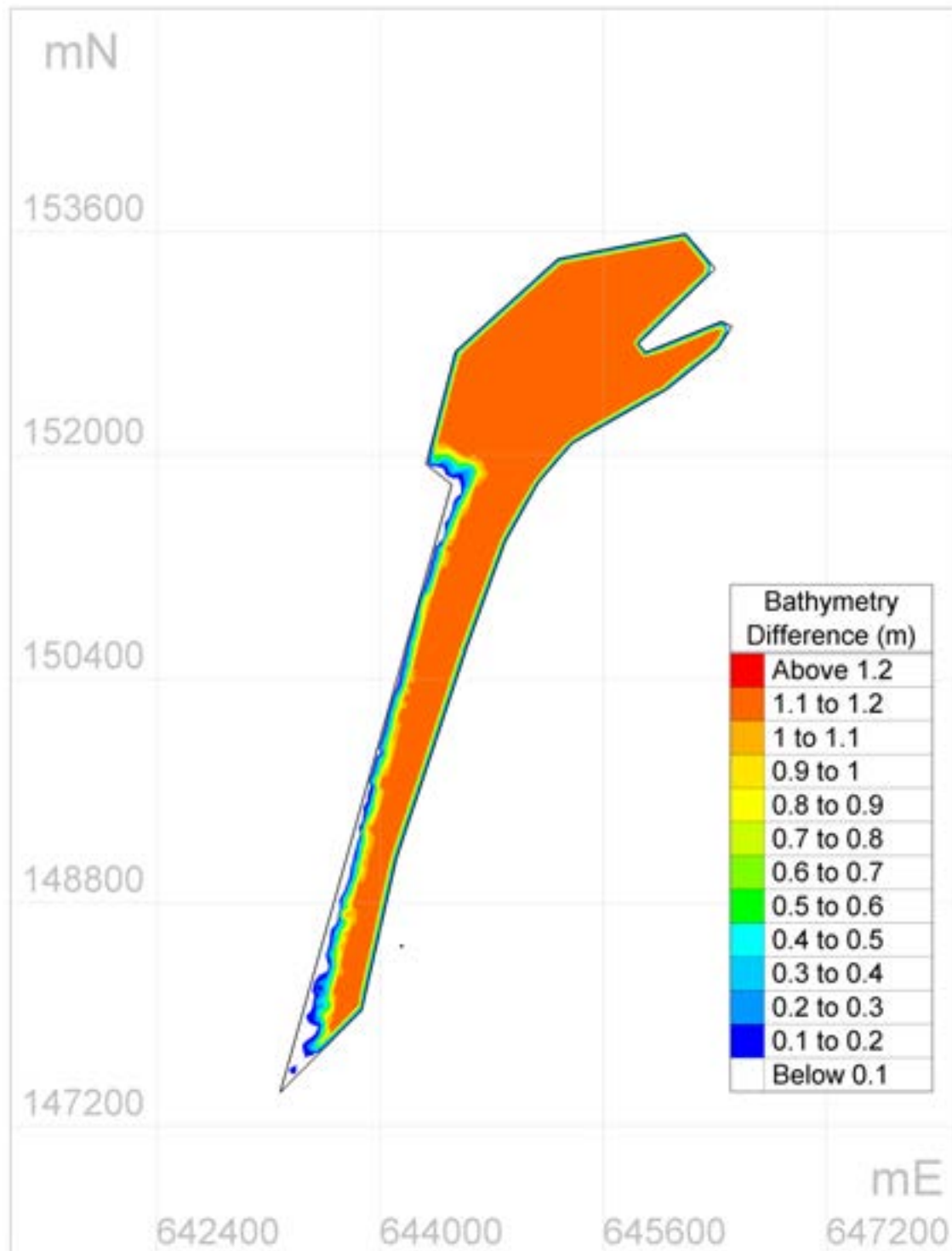


Figure 2.4: Change in bathymetry associated with the proposed dredging, with proposed dredge area indicated by the black polygon

3. Tidal flow modelling

3.1. Model applied

TELEMAC-2D was used to model an area covering the eastern English Channel and the southern North Sea. A two dimensional depth averaged flow model was considered suitable for this project because strong currents occur in the area of interest (up to 1.5 m/s) so stratification effects are unlikely to be significant influences on the vertical variation in current magnitude. In these circumstances a logarithmic current magnitude profile as used by a 2D, depth averaged model is considered acceptable.

The largest mesh size was on the model outer boundary and is 25,000 m. The smallest mesh size was at the area of proposed dredging and was approximately 50 m which provides a good resolution of the dredged depression. Figure 3.1 shows the model domain and mesh. The model coordinate system is British National Grid (OSGB36). The model vertical datum is Mean Sea Level, which is assumed to be constant over the area.

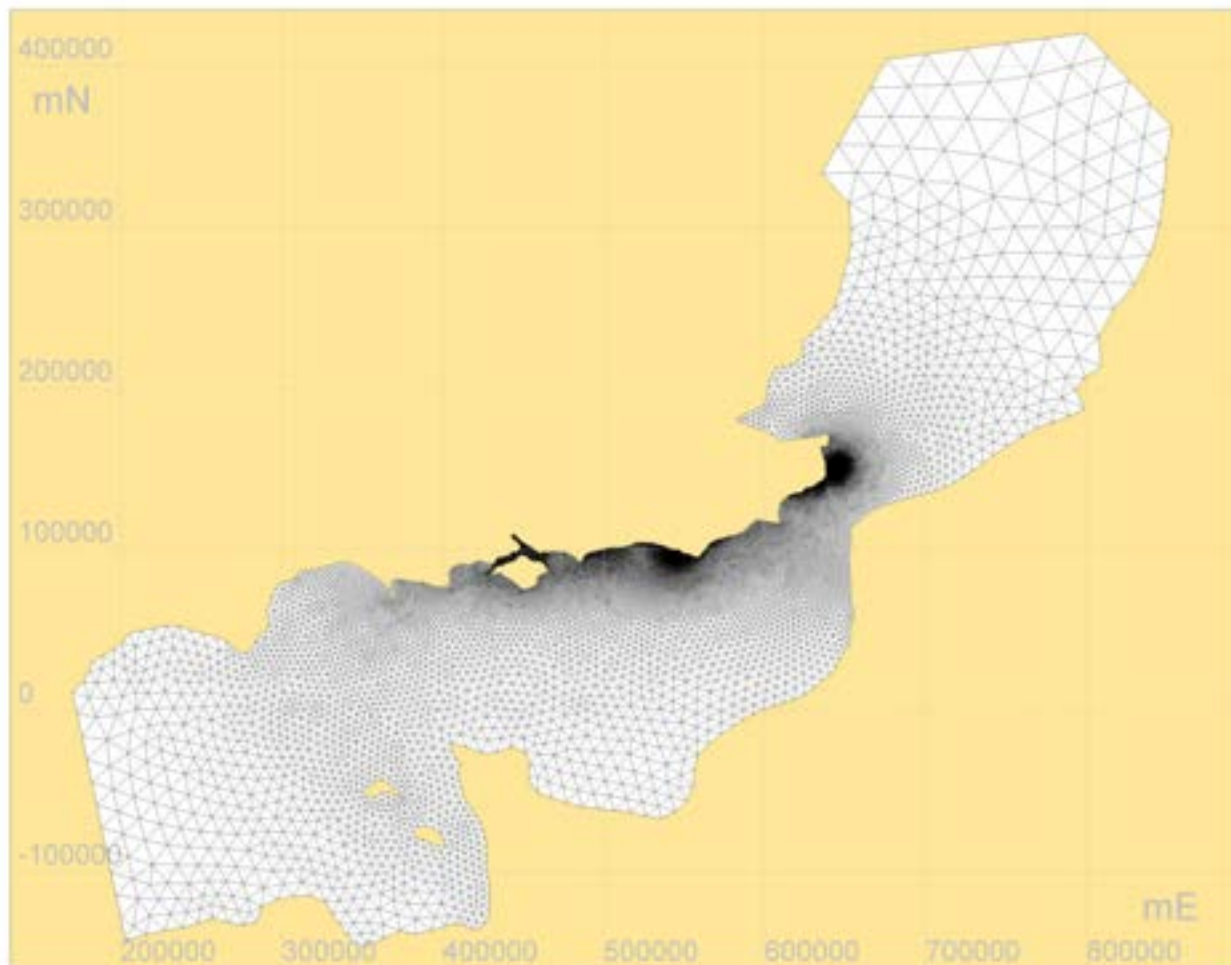


Figure 3.1: TELEMAC-2D model extent and mesh

The model is driven by imposing the water surface elevation at the North and West open boundaries. The imposed elevation is derived using the TPXO European Shelf harmonic constituents. The TPXO model has a resolution of 1/30 degree (approximately 3.7 km).

The effect of wind was not included as the tidal currents are strong and winds are not expected to have a significant influence on the currents in the area of interest.

3.2. Model validation

The model has been calibrated for use at other locations, however to confirm the model's performance at the study area around Goodwin Sands a validation exercise was required.

Acoustic Doppler Current Profiler (ADCP) current observations have been collected for the present project at the point indicated on Figure 3.2. The period of the ADCP measurements was from 30th July 2015 to 22nd September 2015. This period has been used for the TELEMAC-2D model simulations. The model simulation runs from 30th July 2015 to 23rd September 2015. The ADCP deployment is described fully in EGS (2015).

A number of model runs have been done with different values of the Nikuradse roughness length for seabed friction. Some runs used a uniform roughness length throughout the model. Other runs used a higher value of friction in the shallow water areas in the region of the bathymetry survey. This enhanced friction was intended to allow for the effects of the mega-ripples and sand waves known to be present on Goodwin Sands. The data for each 'bin' (i.e. each sub section of the vertical profile) recorded by the ADCP have been processed to give the depth averaged observed current speed and direction for each time. The Mean Absolute Error (MAE, the average difference between observed and modelled depth average current) on the current speed at the ADCP location was calculated for each run. The MAE of the modelled water elevation at Deal Pier (the closest, well established, permanent tide gauge) was also calculated for each run, comparing to the synthesised water elevation time series derived from tidal harmonics.

Many sediment transport equations are based on the current speed cubed. Therefore, to provide a measure of model accuracy which might be related to sediment transport rates the MAE of the observed and simulated speeds raised to the power of three was also calculated and included in Table 3.1.

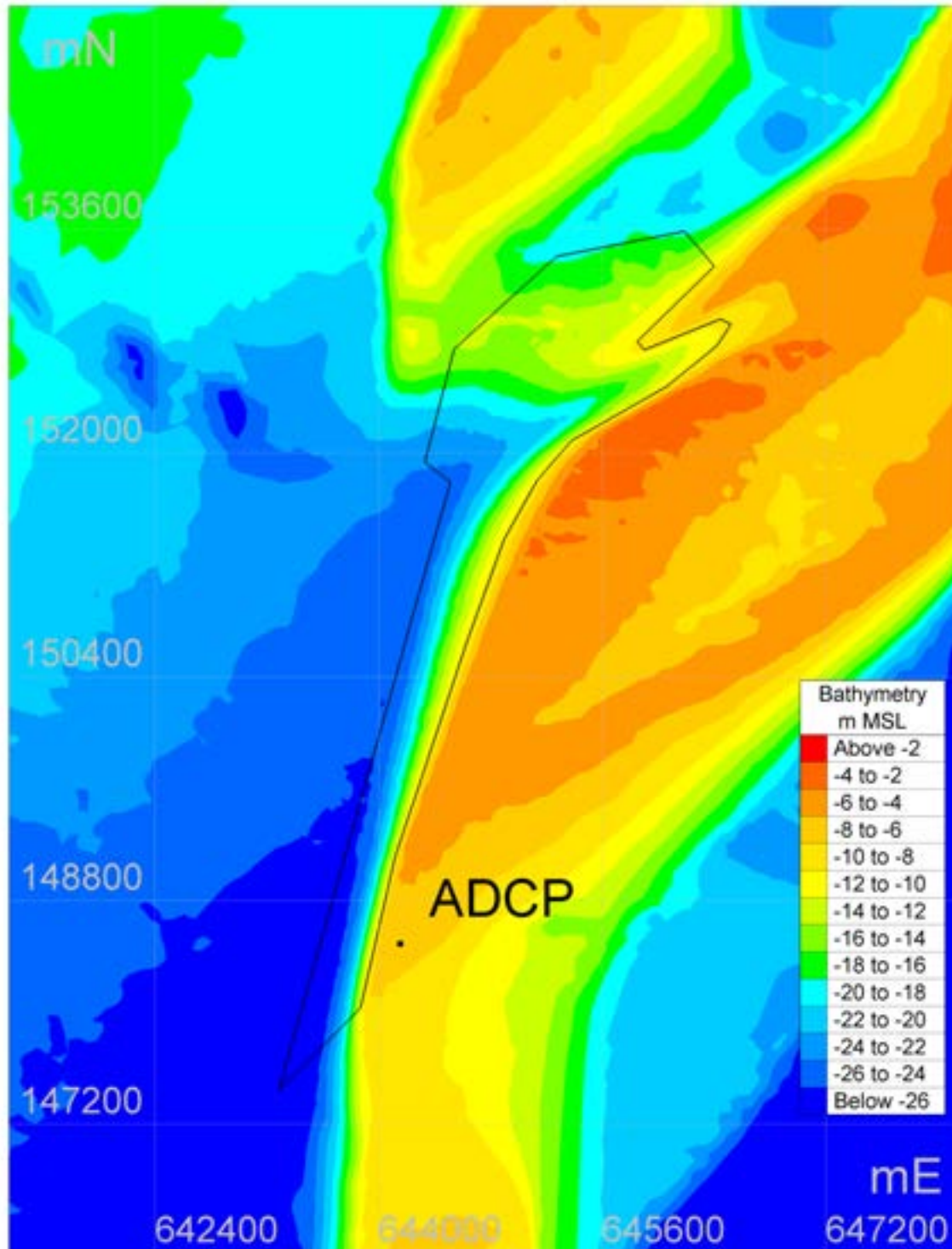


Figure 3.2: Location of ADCP measurements at Goodwin Sands, with proposed dredge area indicated by the black polygon

Table 3.1 shows that the smallest errors on both current speed and water elevation were obtained in the runs that had a roughness length of 0.2 m and 0.5 m implemented locally. Comparison of the speed and direction time series indicated that the best agreement with the ADCP measurements was achieved by the run with the roughness length of 0.2 m locally.

This run is used as the basis for all subsequent results presented in this report. The mean error of 0.1 m/s is small compared to the range of currents observed with maximum depth average currents of more than 1.5 m/s. The tide range at Deal is more than 6 m during spring tide periods so the mean error in tidal level of 0.09 m is also small in comparison.

Table 3.1: Model validation results – Mean Absolute Error (MAE)

Roughness length (m)	MAE of model current speed compared to ADCP (m/s)	MAE of model current speed cubed compared to ADCP current speed cubed (m/s) ³	MAE of tidal elevation at Deal Pier (m)
0.05	0.14	0.33	0.09
0.10	0.10	0.21	0.13
0.25	0.11	0.23	0.20
0.05 (0.2 locally)	0.10	0.21	0.09
0.05 (0.5 locally)	0.10	0.20	0.09
0.05 (1.0 locally)	0.12	0.26	0.09

Figure 3.3 to Figure 3.8 show a series of time histories of speed and direction for 7 day periods; following convention the current direction is the direction in which the current is flowing. These figures plot the depth averaged ADCP measurements together with the model result at the ADCP location. Good agreement can be seen between the model and the measurements including the dominance of flood tide current speed over ebb tide at this location.

The only areas of slight concern are some over-prediction of current speed during the low neap period of the 5th to 8th September and some curious short sharp periods of high current during the period 31st August to 3rd September (Figure 3.7). The latter is a curious feature especially as there is no sign of it on similar (large) size currents on 2nd to 4th August (Figure 3.3) or even on the overnight tides of 31st August to 1st September or 1st September to 2nd September. For these periods the observed current suddenly increases to its greatest magnitude late in the west-going (ebb) tidal period, for example, from 1.2 m/s to 1.8 m/s on the 1st September giving the strongest current measured during the whole ADCP deployment.

The origin of this feature, which occurs on some spring tides (but not others), is hard to establish. It is seen in several bins so is unlikely to be random noise. It occurs close to low water so may be related to formation of bed features for comparatively short periods which reduce water depths and produce jetting of the currents at the site of the ADCP. This seems a possible explanation as periods of burial of the meter by sediment occurred during the deployment. Such a phenomenon could cause high current when the water is low either by the mobile bed features being of a suitable shape to produce the enhanced currents or by the effect of waves on the bank being sufficient to drive a current when the water level is low. The hypothesis of increased currents being caused by burial is backed up by the high currents recorded during the period 13th – 16th September (Figure 3.9) when burial of the meter was reported by EGS (2015).

Figure 3.10 plots a time series of model elevation at Dover together with the elevation derived from C-MAP. Figure 3.11 is the equivalent figure for Deal. Generally good agreement can be seen, with the model slightly under-predicting the tidal amplitude.

The model is considered to be well calibrated in comparison to the observed current speeds and directions with the exception of what appear to be unusual and short lived current speed spikes during spring tides at the start of September. Understanding the origin of this phenomenon, which occurs only on a couple of days during the 54 day survey period, is not considered significant for the purpose of the prediction of the long-term impacts of the proposed dredging at Goodwin Sands on tidal flows.

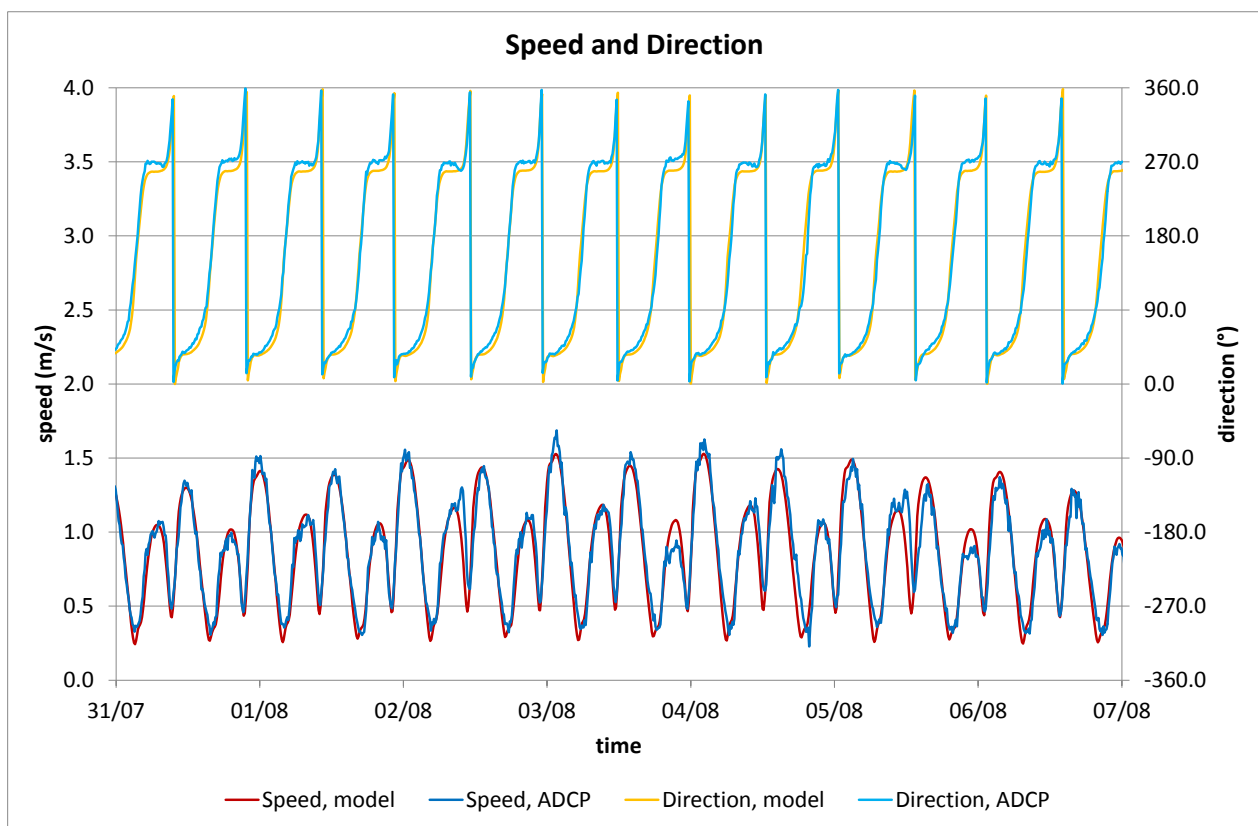


Figure 3.3: Comparison of modelled and observed depth average currents 31/07/15 – 07/08/15

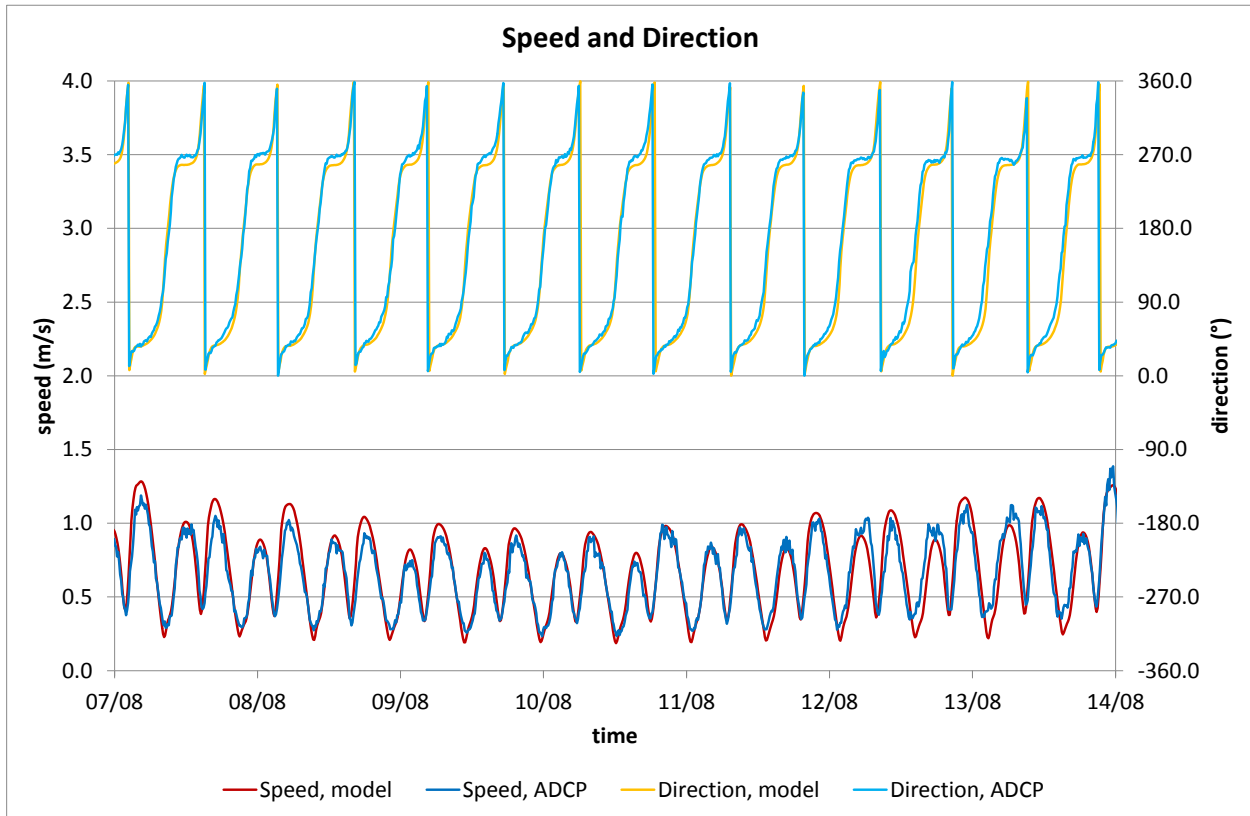


Figure 3.4: Comparison of modelled and observed depth average currents 07/08/15 – 14/08/15

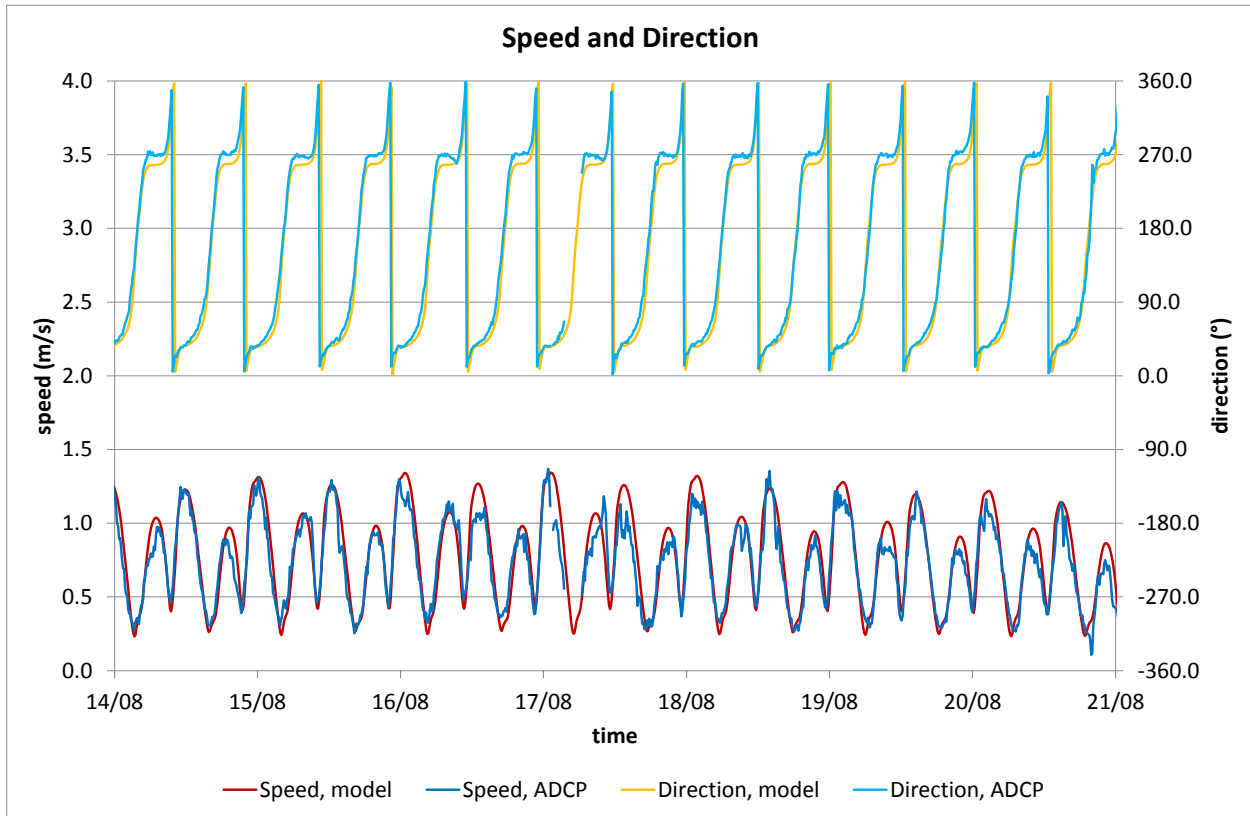


Figure 3.5: Comparison of modelled and observed depth average currents 14/08/15 – 21/08/15

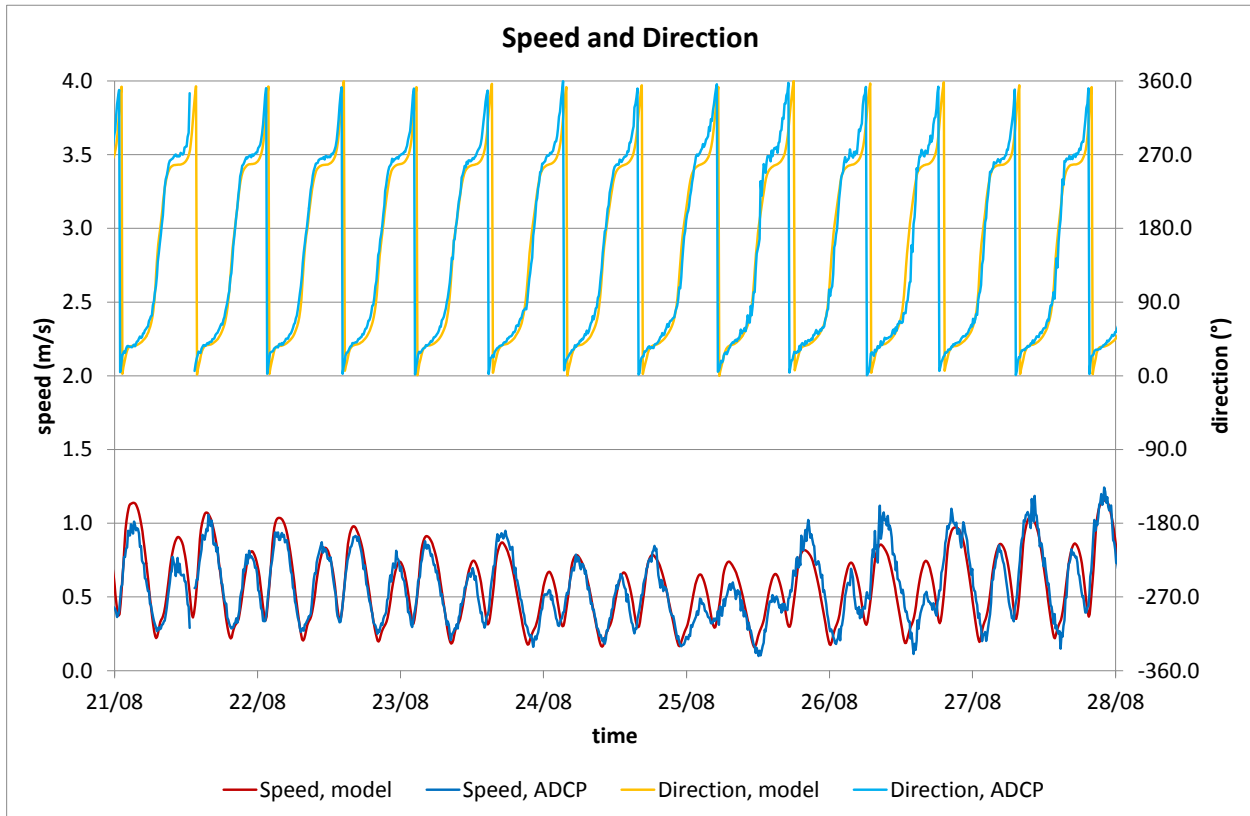


Figure 3.6: Comparison of modelled and observed depth average currents 21/08/15 – 28/08/15

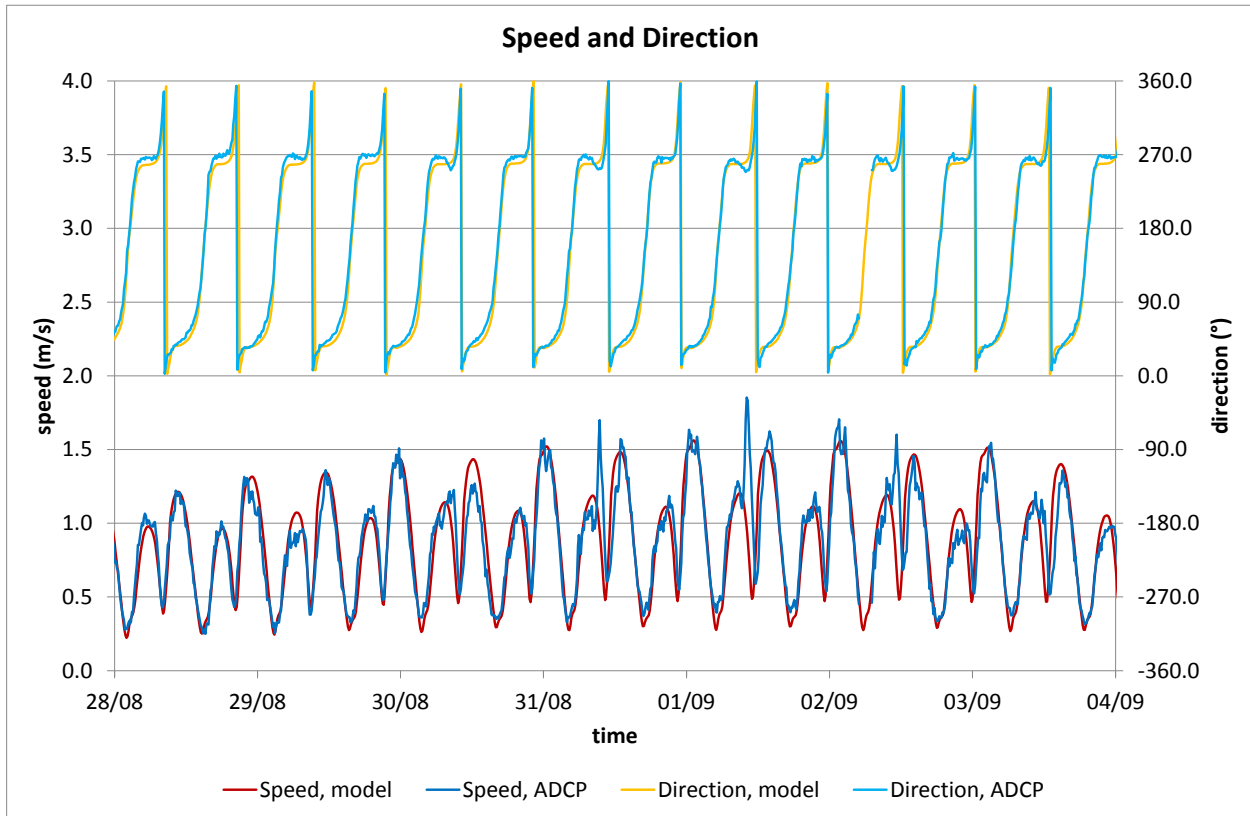


Figure 3.7: Comparison of modelled and observed depth average currents 28/08/15 – 04/09/15

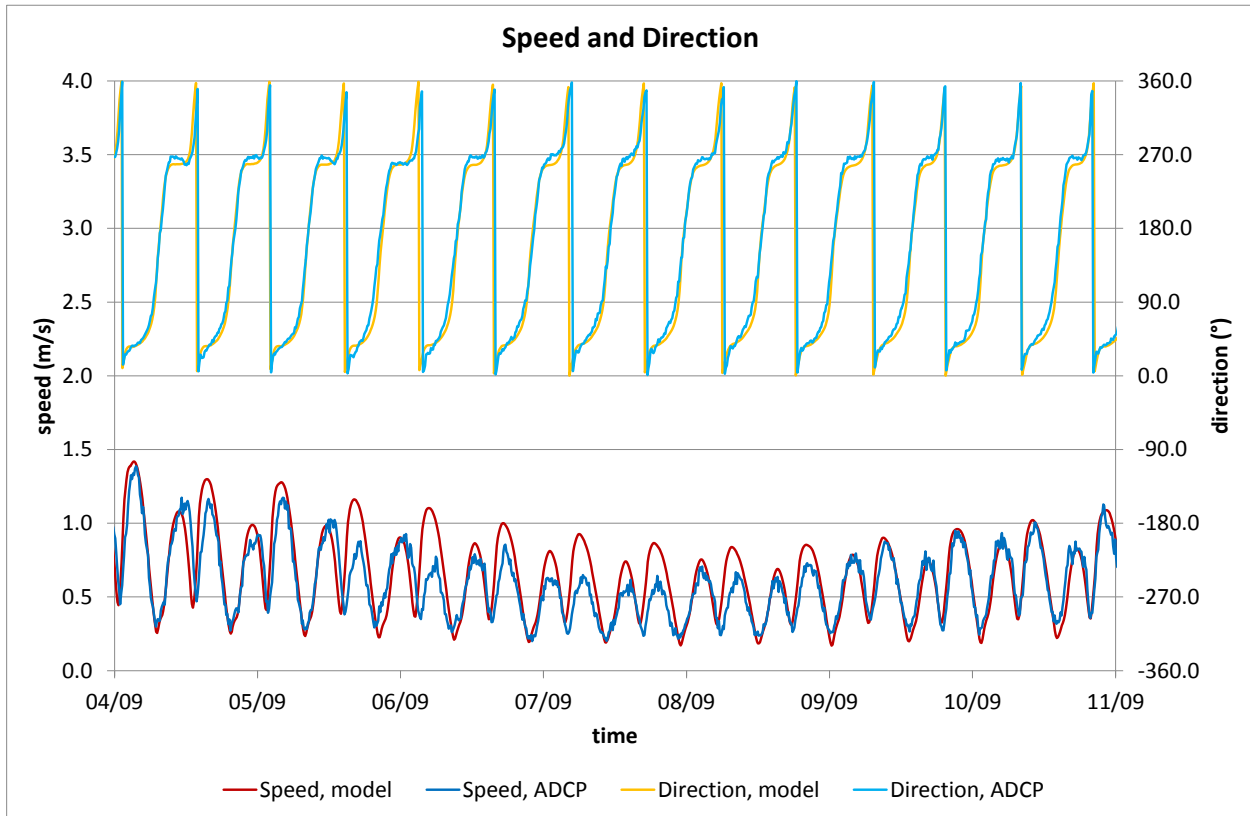


Figure 3.8: Comparison of modelled and observed depth average currents 04/09/15 – 11/09/15

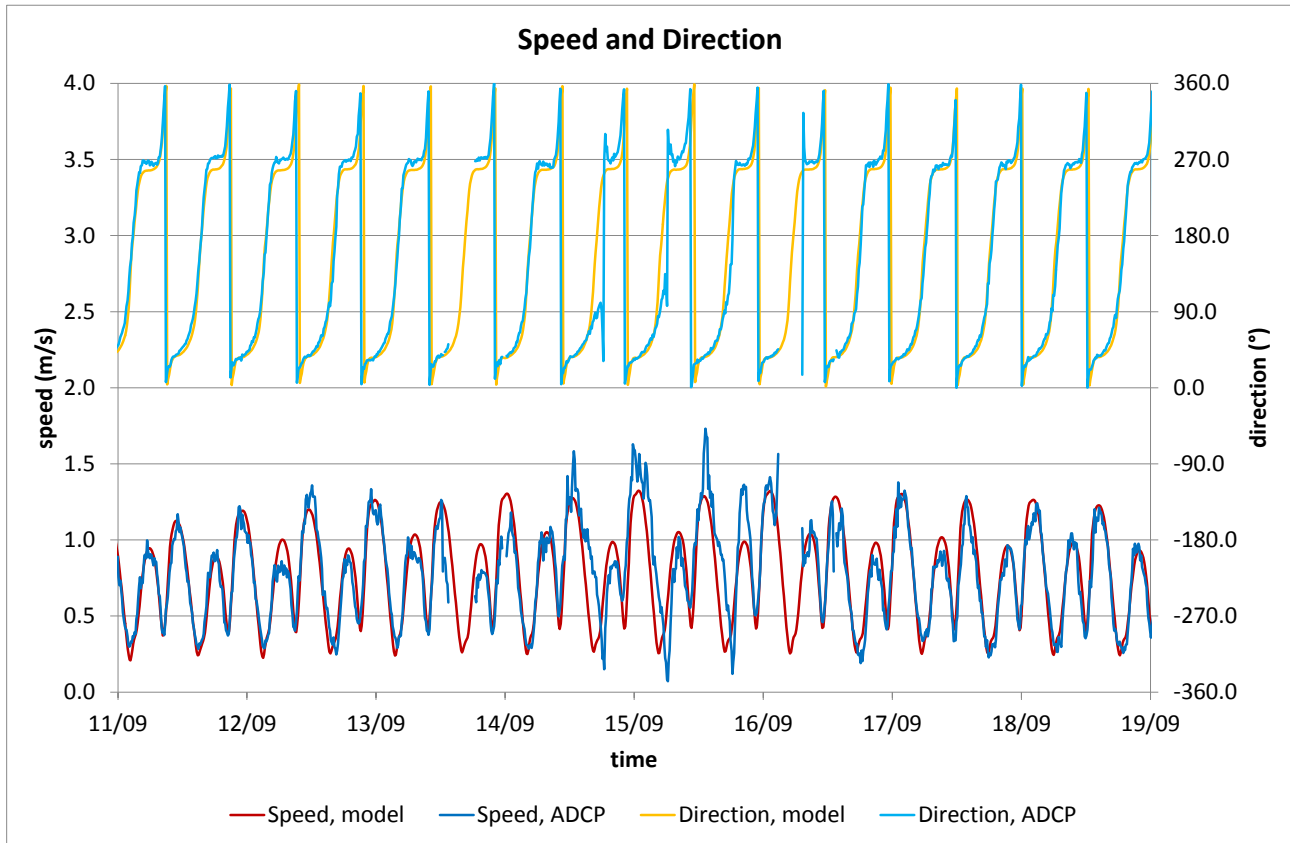


Figure 3.9: Comparison of modelled and observed depth average currents 11/09/15 – 19/09/15

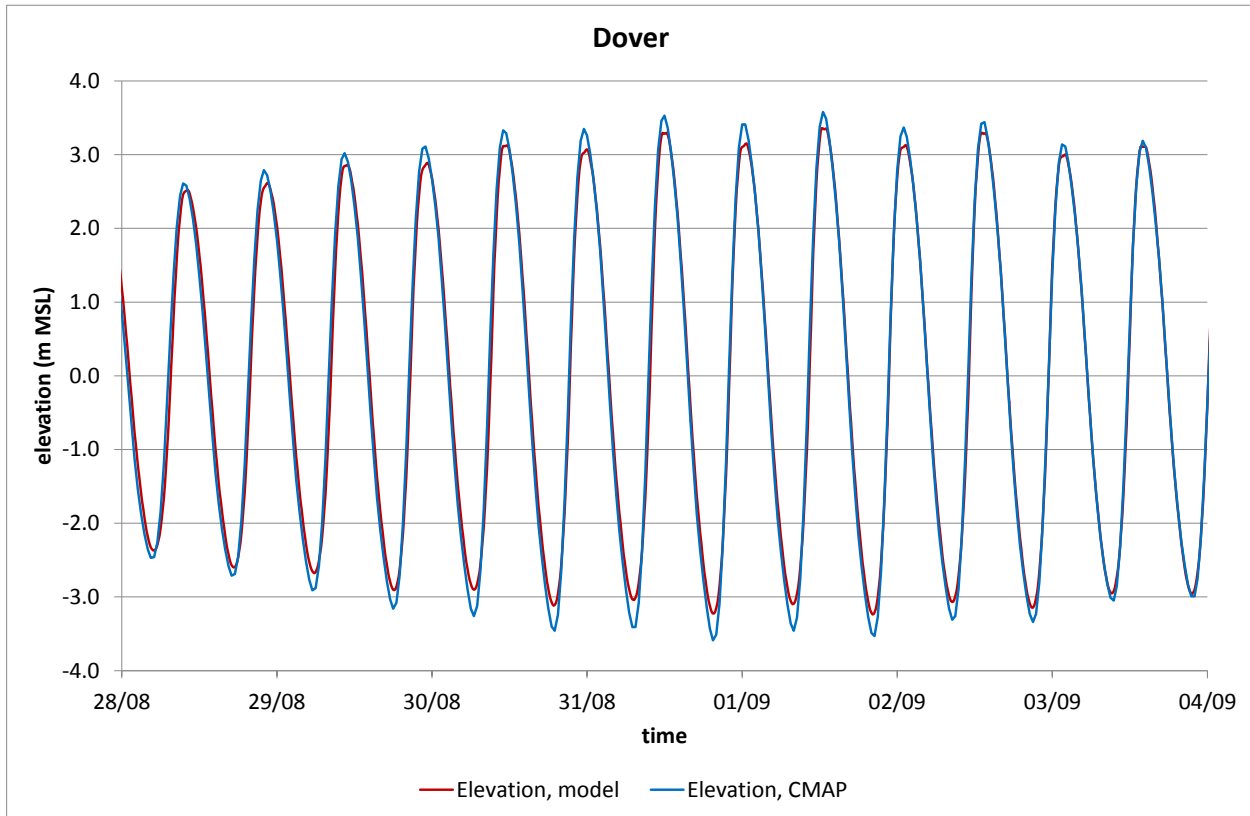


Figure 3.10: Comparison of modelled and synthesized tidal elevation at Dover 28/08/15 – 04/09/15

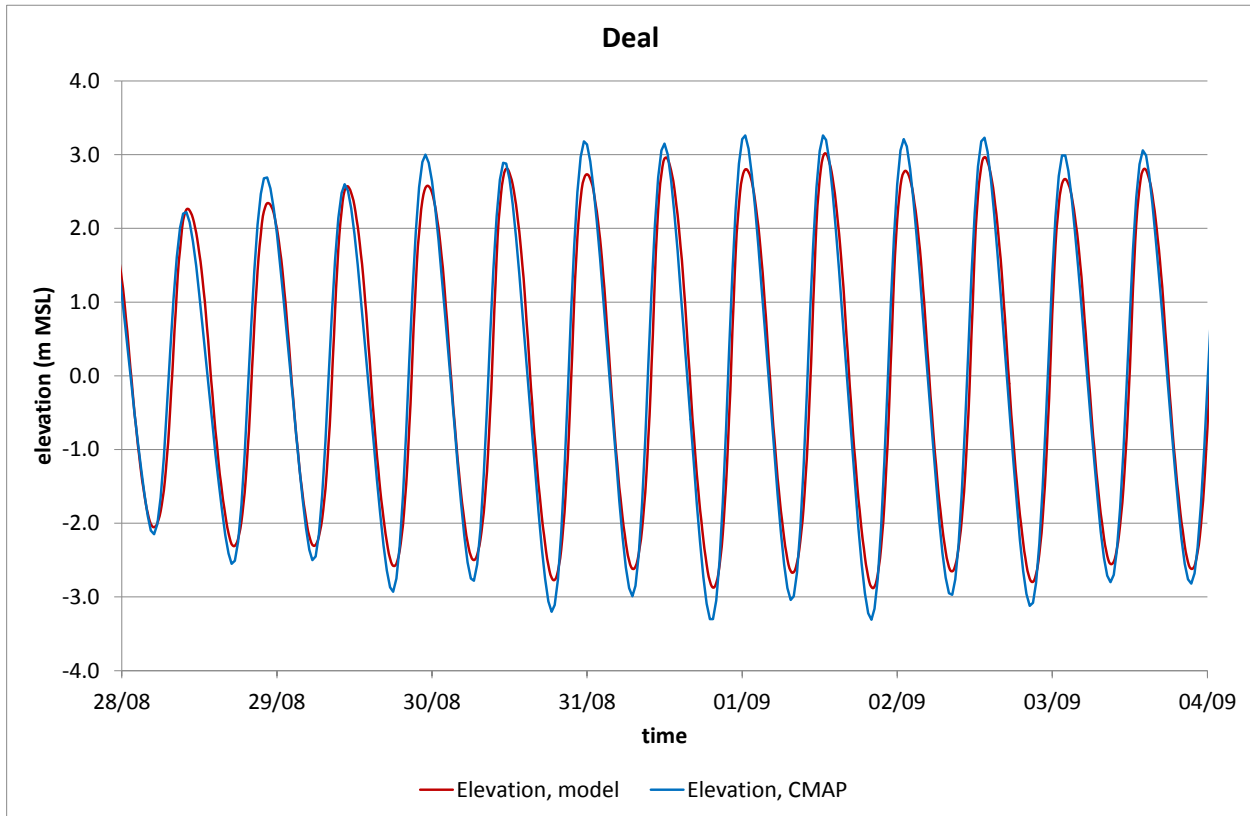


Figure 3.11: Comparison of modelled and synthesized tidal elevation at Deal 28/08/15 – 04/09/15

3.3. Predictive runs

The TELEMAC-2D model was re-run for the same simulation period as used for the validation exercise with the dredging completed, using the bathymetry illustrated in Figure 2.3. The difference between the model depth average current speed with dredging and without dredging was calculated.

Figure 3.12 to Figure 3.15 plot snapshots of the velocity vectors superimposed on speed coloured contours for four times using the baseline (pre-dredge) bathymetry. For reference the outline of the dredged area is also plotted on these figures as a black polyline. Figure 3.12 shows the current pattern for the time of maximum flow to the north (01:00, 01/09/15). Figure 3.13 shows equivalent results for the time of maximum flow to the south (09:00, 01/09/15). Figure 3.14 is the situation at the time at which there is the largest speed increase (09:50, 01/09/15) and Figure 3.15 shows the model results at the time at which there is the largest speed reduction predicted (22:40, 31/08/15).

These four times capture the range of effects of the dredge at the times of largest currents and the largest effect of the dredge at any time in the simulation. In this way the complete footprint of effect of the proposed dredging on tidal currents can be understood.

Figure 3.16 to Figure 3.19 plot the speed difference at the same times as the velocity vector figures. The largest effects of the dredging are shown by Figure 3.18 and Figure 3.19. Figure 3.18 shows that the

maximum speed increase is between 0.15 and 0.2 m/s. Figure 3.19 shows that the maximum speed decrease is between 0.1 and 0.15 m/s.

All of the current speed differences due to the dredging in excess of 0.05 m/s have been found to be within about 1 km from the proposed dredging area. Hence no widespread effect on tidal currents due to the proposed dredging is anticipated.

3.4. Footprint of effect

The tidal flow modelling has predicted the effect of the dredging on tidal currents for various tidal ranges. To provide a footprint of potential effect on tidal currents associated with the dredge the absolute (positive or negative) differences in the pre and post-dredge tidal current speeds have been calculated every 10 minutes during the 54 day simulation. The maximum current speed difference predicted at any stage of the simulation was then calculated and compared to the maximum current speed predicted. A 5% threshold was used to show the area within which any effect on tidal currents might be detectable as shown by Figure 3.20. The threshold of 5% does not necessarily suggest a significant effect will occur within this area however for changes in current smaller than this value any effect of the dredging on tidal currents can be considered as negligible. It can be seen that the predicted footprint of effect on tidal currents does not extend to any of the sensitive sites shown in Figure 1.2.

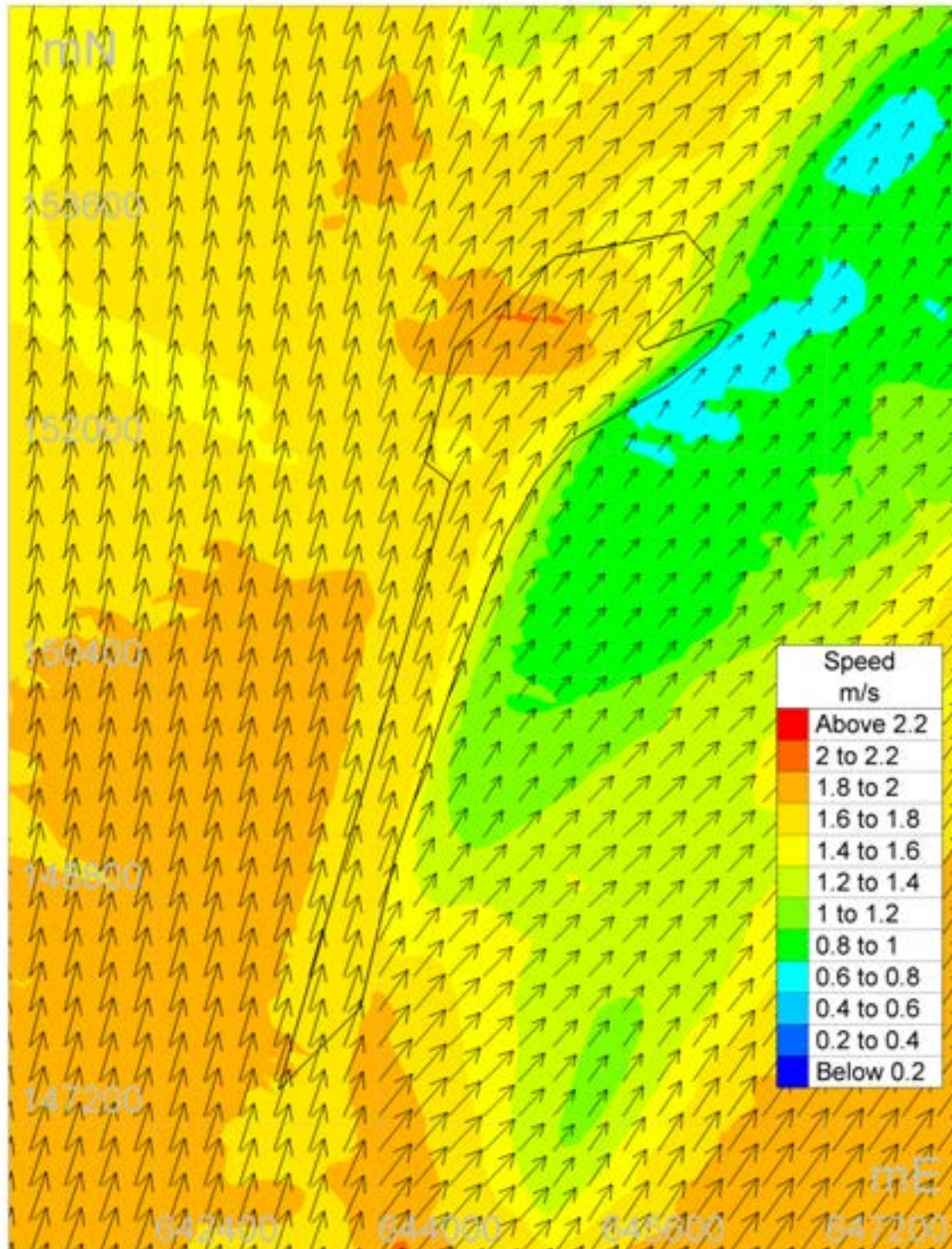


Figure 3.12: Baseline tidal current at time of maximum current towards the north, with proposed dredge area indicated by the black polygon

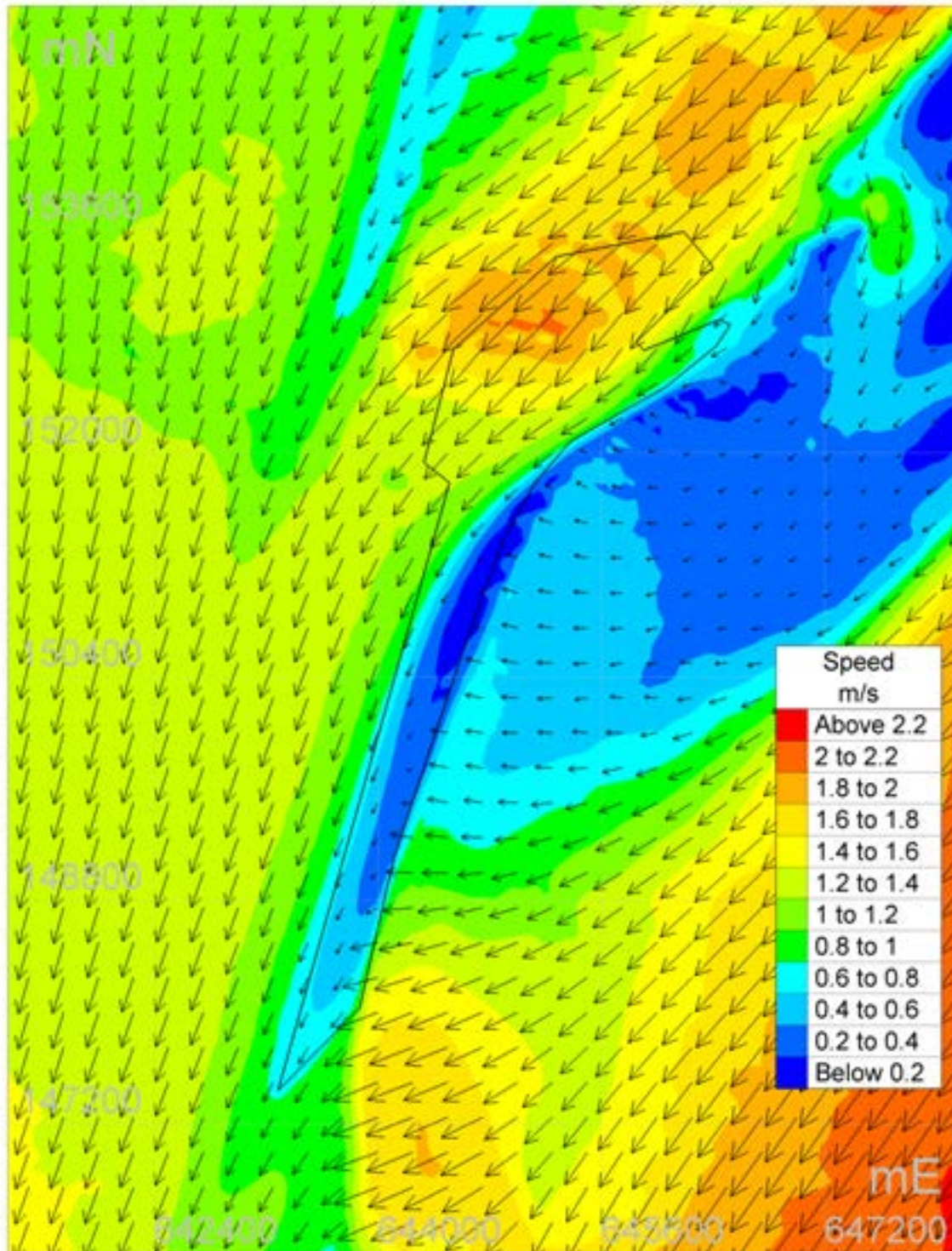


Figure 3.13: Baseline tidal current at time of maximum current towards the south, with proposed dredge area indicated by the black polygon

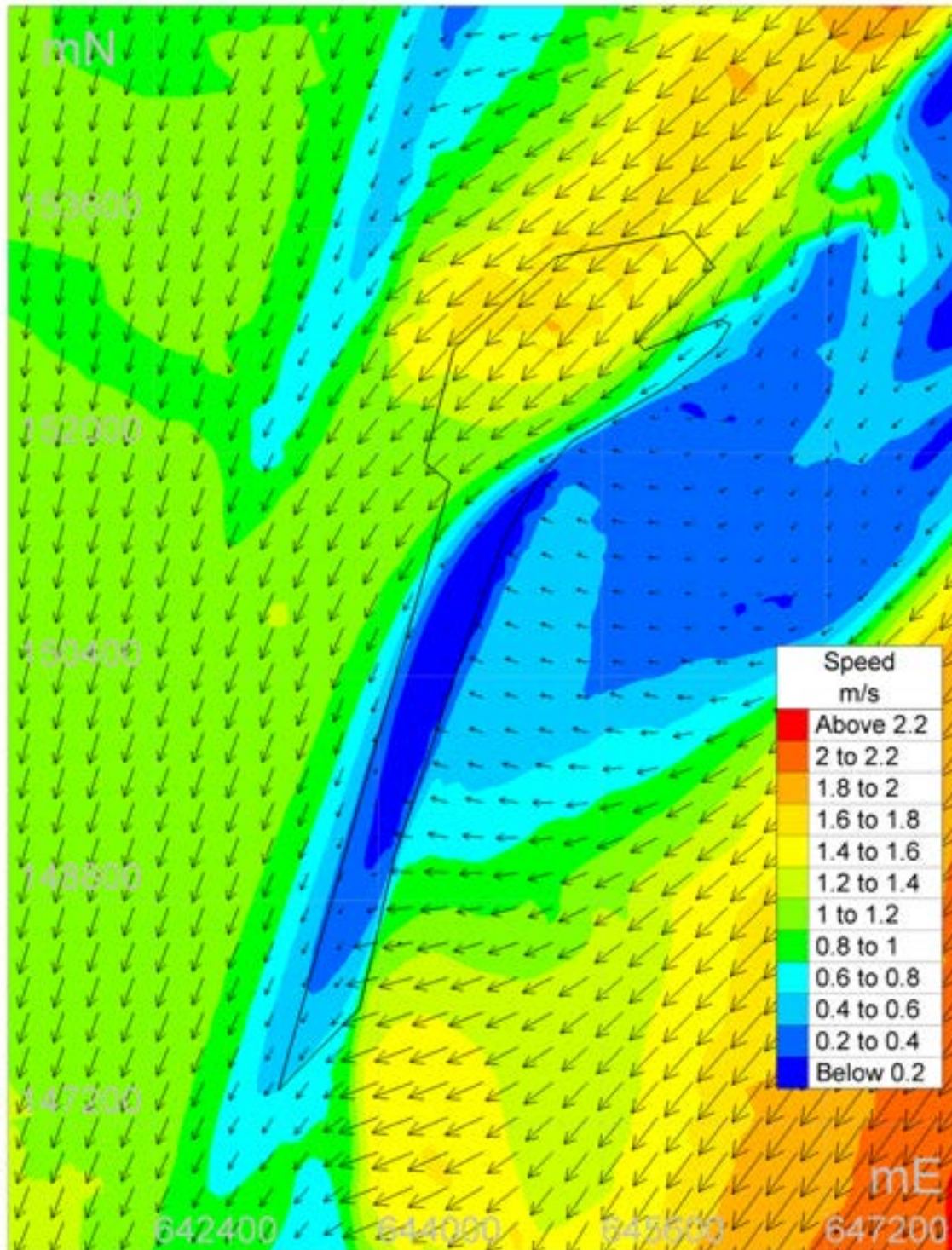


Figure 3.14: Baseline tidal current at time of maximum current increase, with proposed dredge area indicated by the black polygon

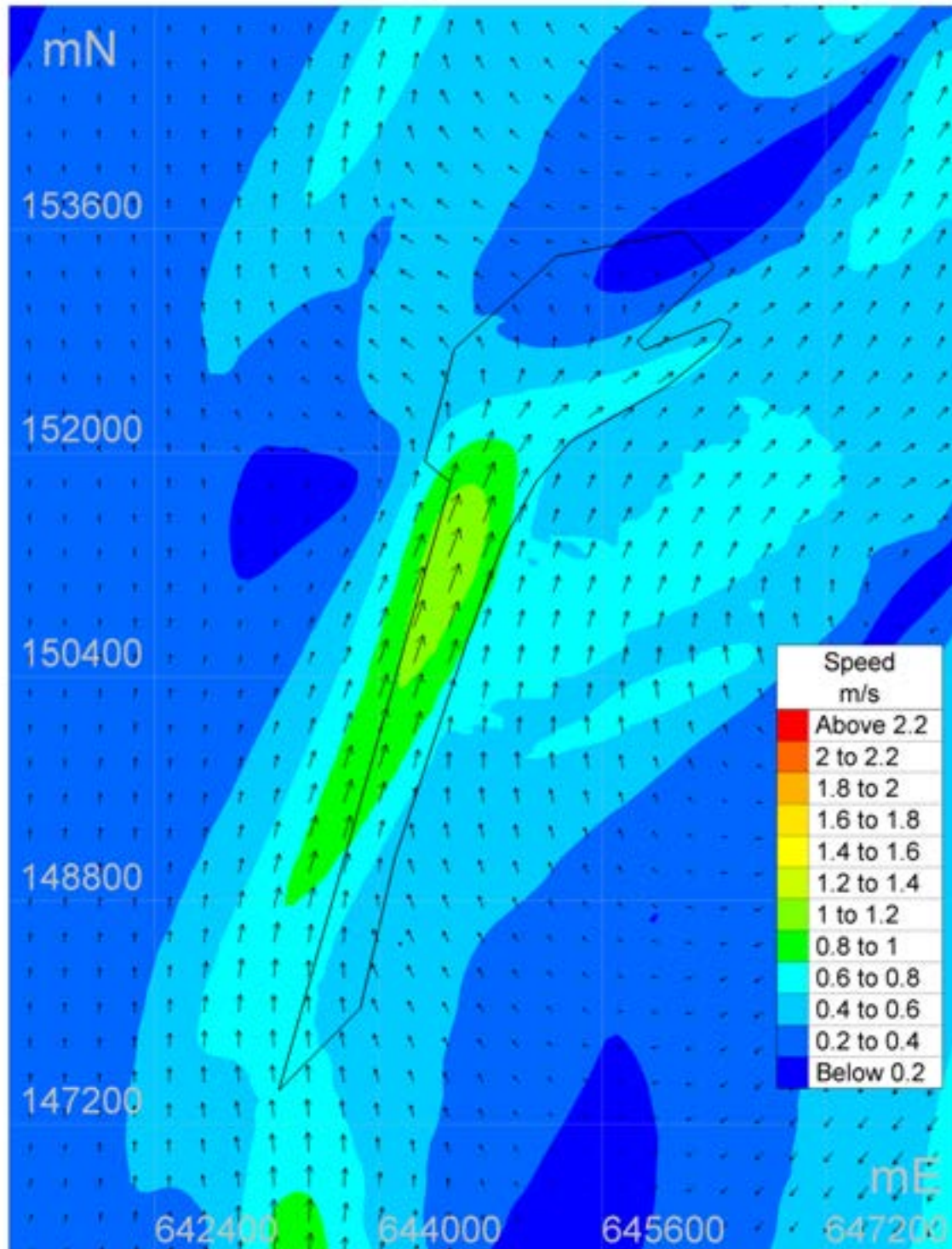


Figure 3.15: Baseline tidal current at time of maximum current reduction, with proposed dredge area indicated by the black polygon

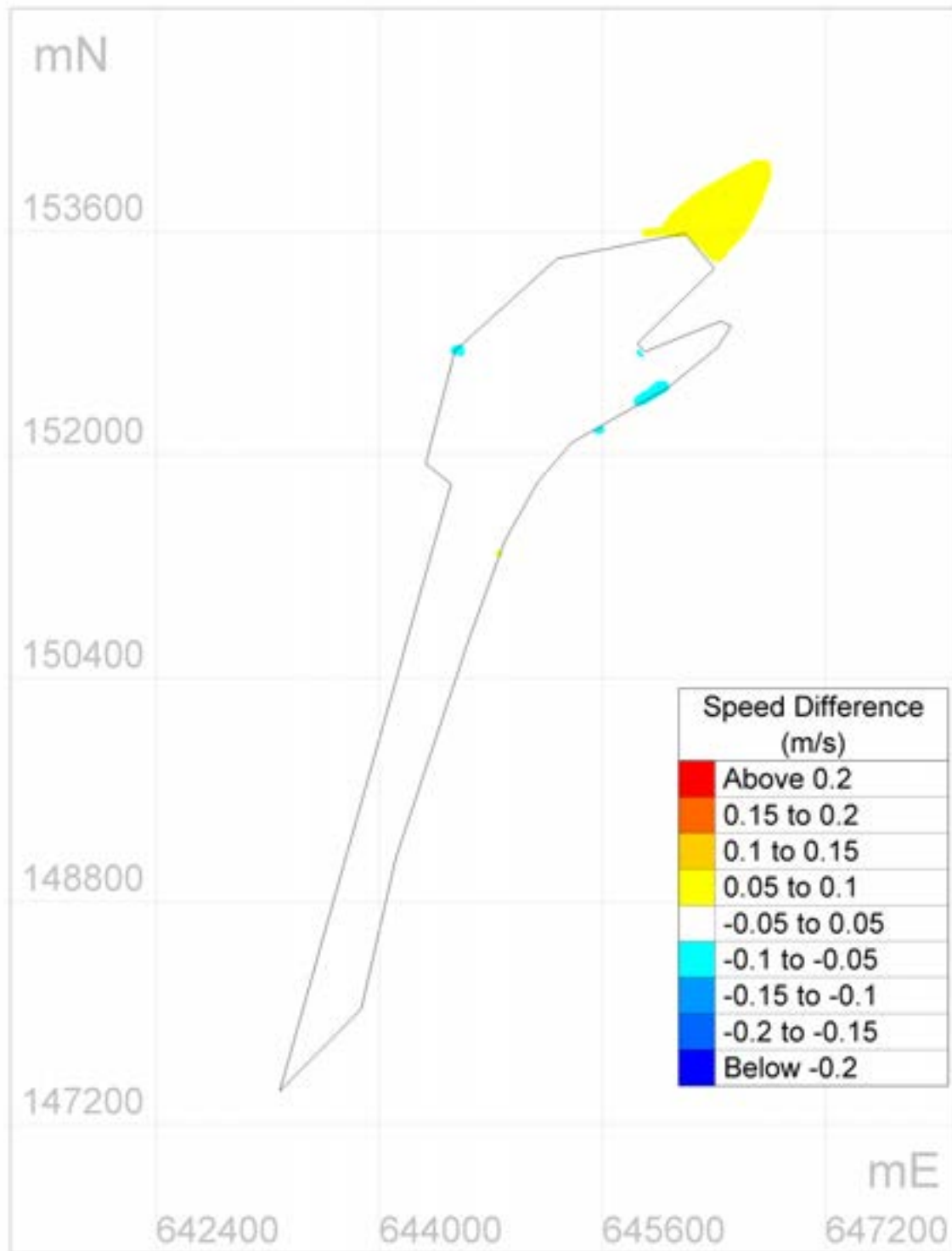


Figure 3.16: Difference in tidal current at time of maximum current towards the north, with proposed dredge area indicated by the black polygon

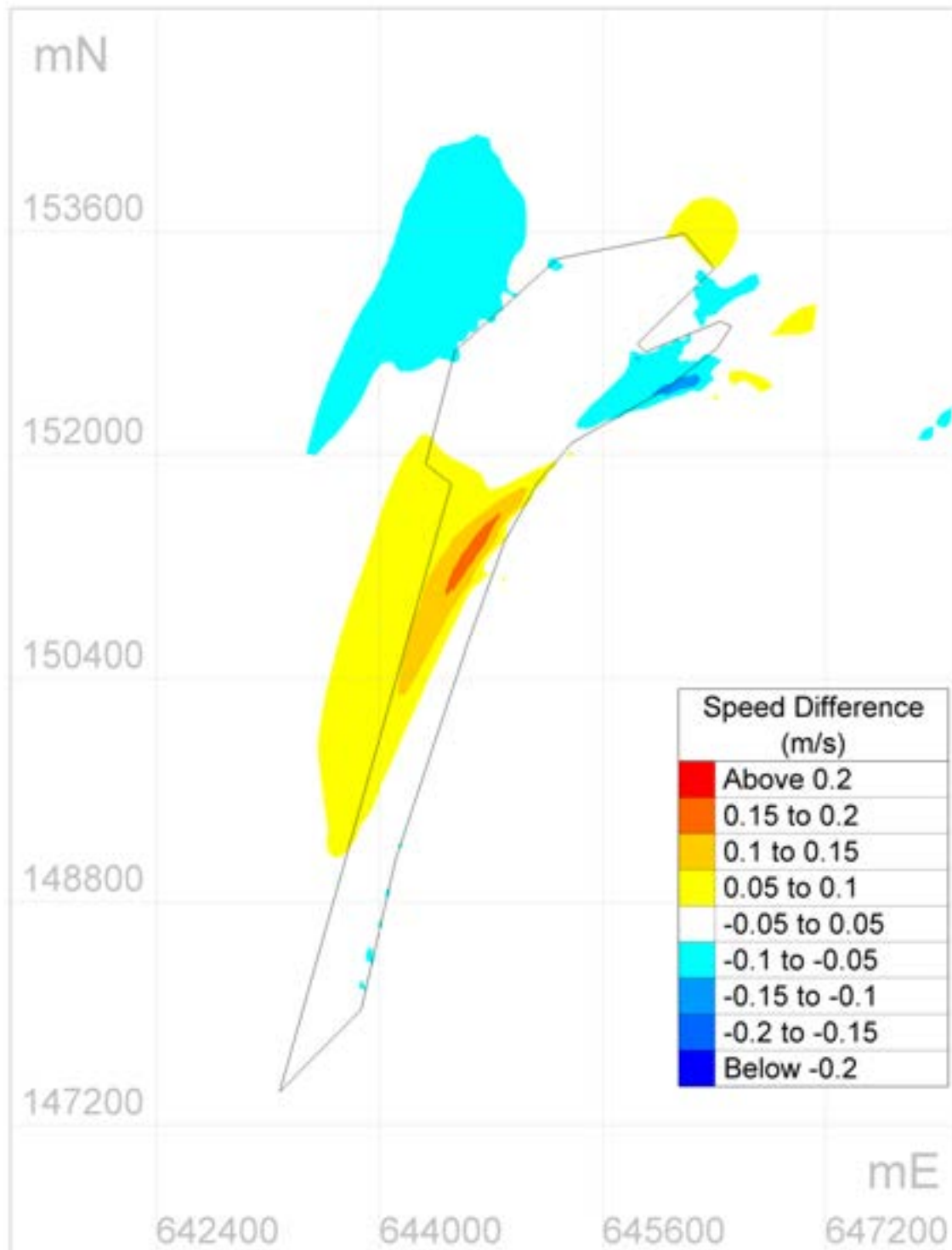


Figure 3.17: Difference in tidal current at time of maximum current towards the south, with proposed dredge area indicated by the black polygon

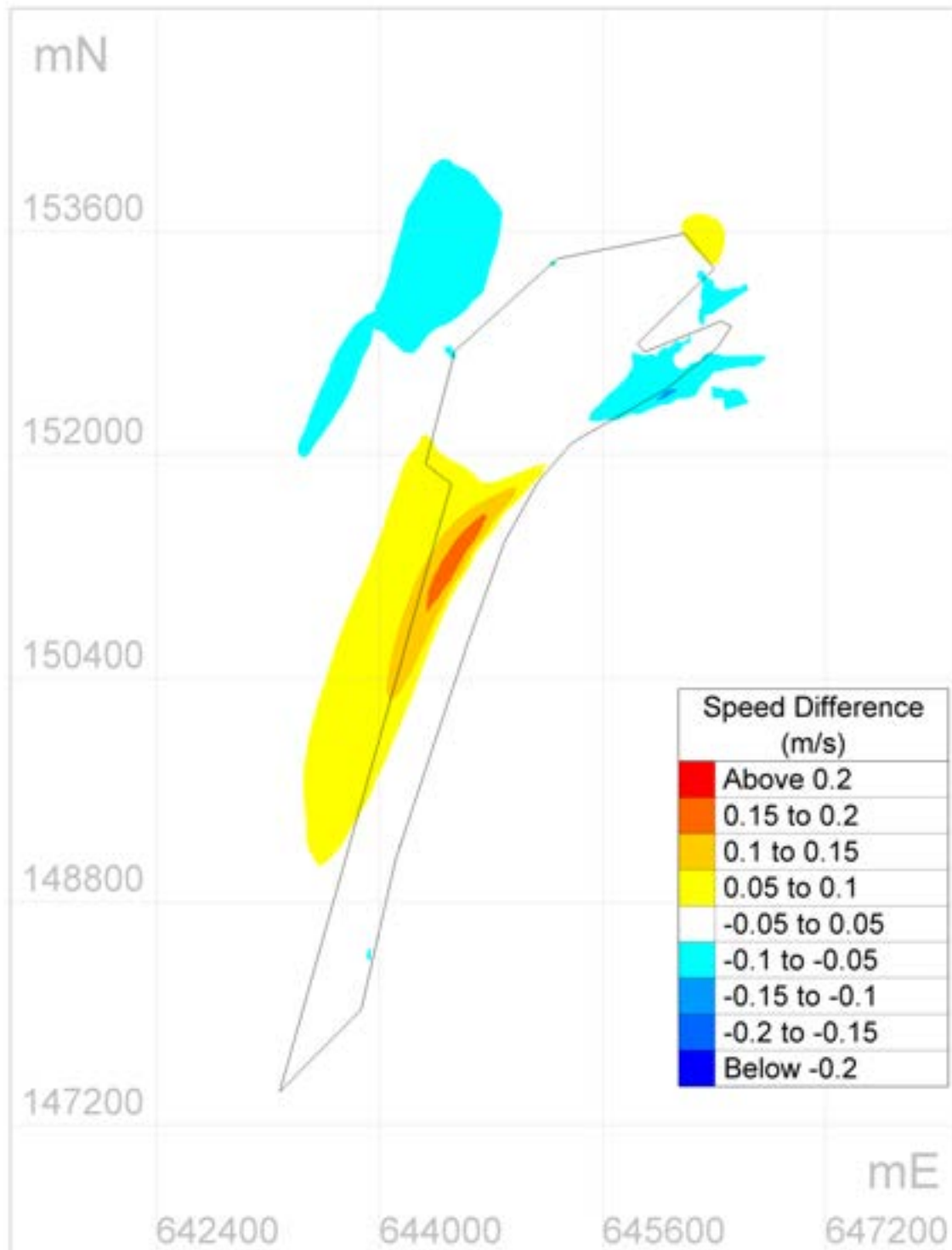


Figure 3.18: Difference in tidal current at time of maximum current increase, with proposed dredge area indicated by the black polygon

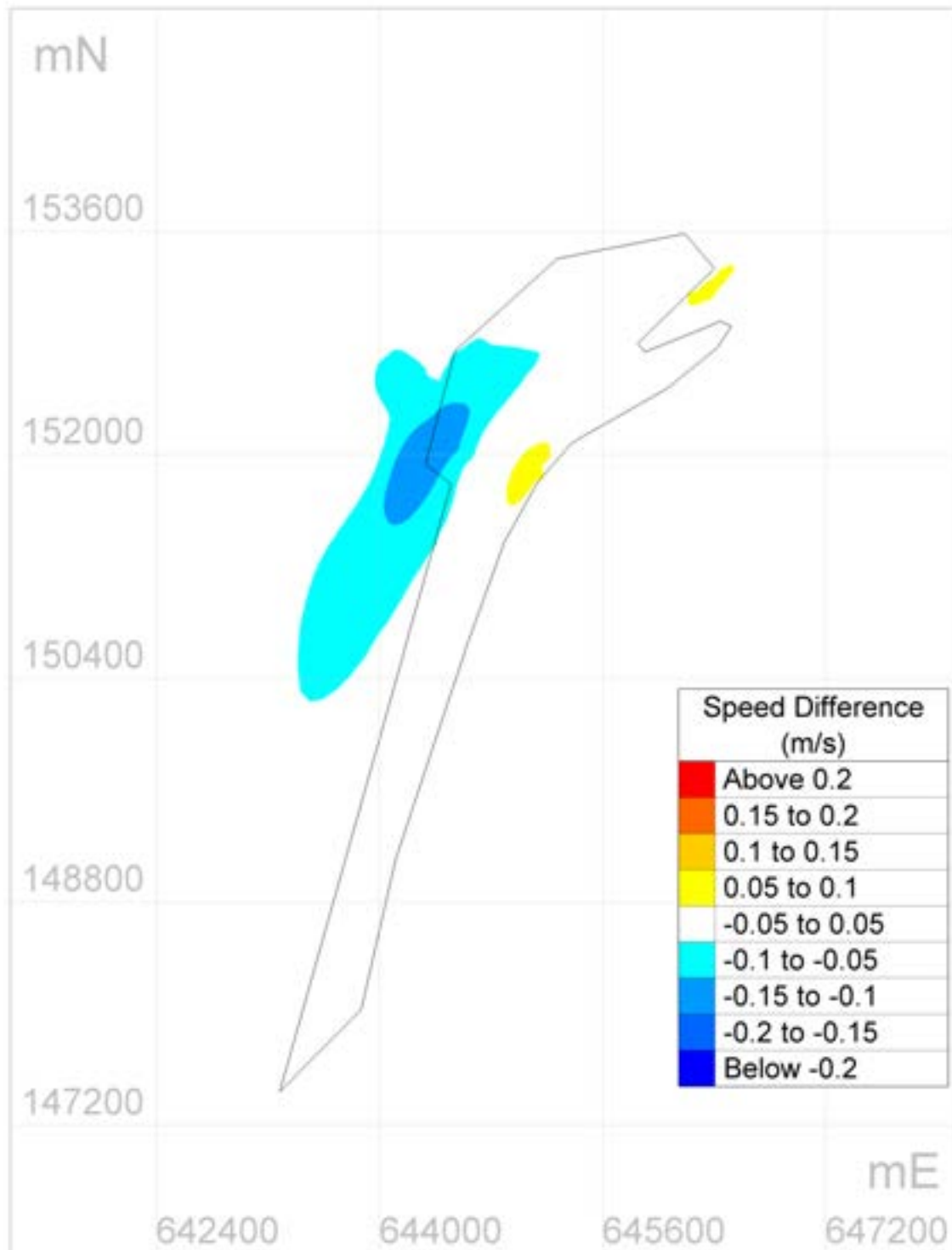


Figure 3.19: Difference in tidal current at time of maximum current decrease, with proposed dredge area indicated by the black polygon

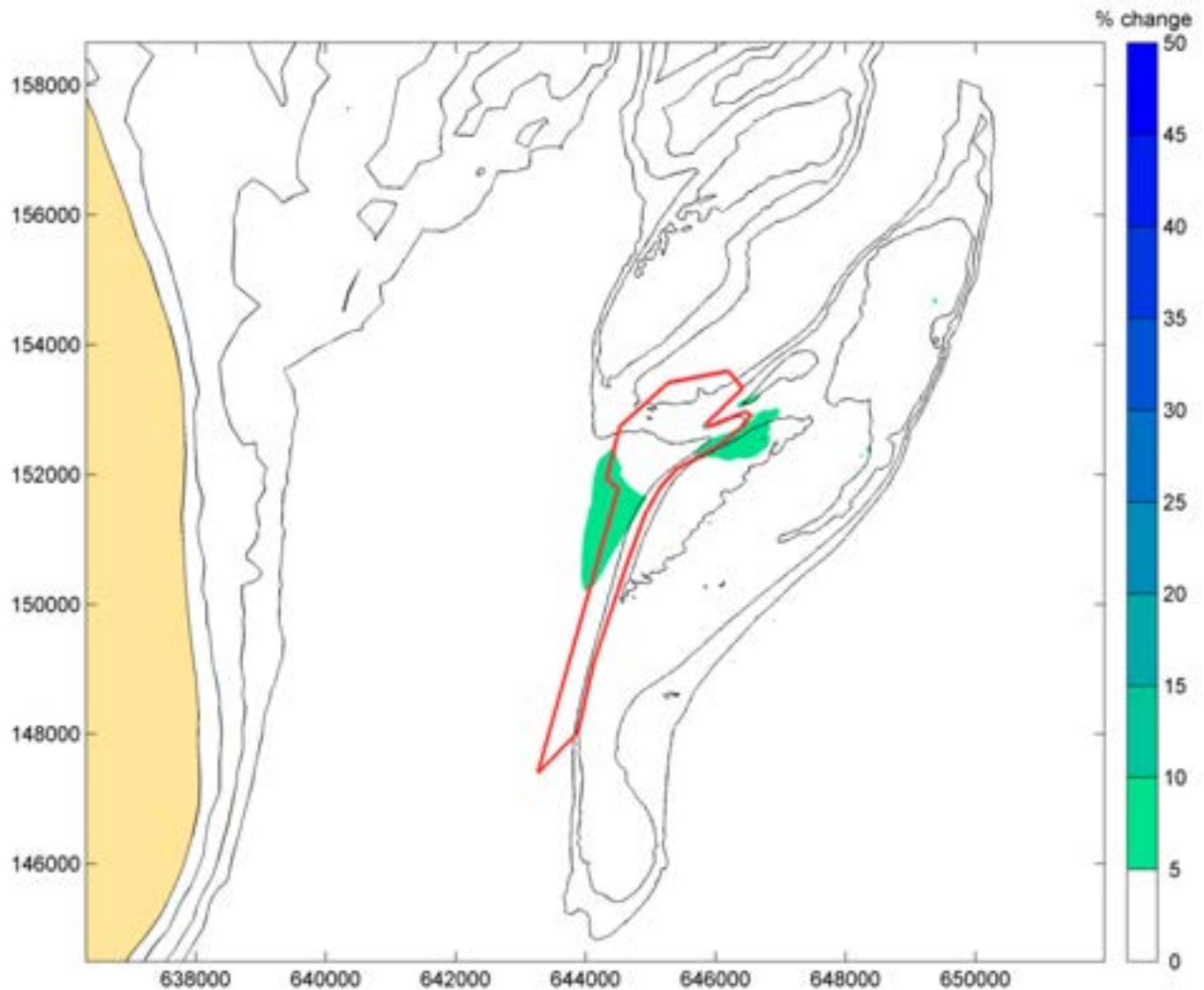
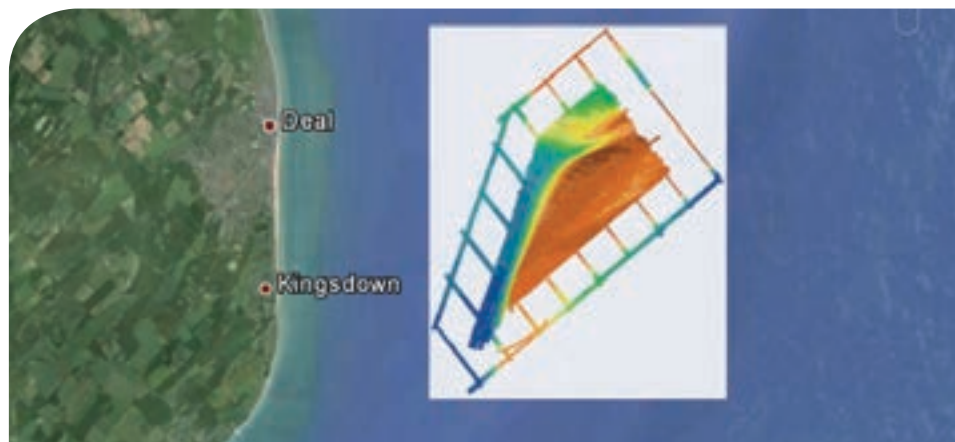


Figure 3.20: Footprint of effect of dredging on tidal currents

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- EGS (2015). Goodwin Sands geophysical Survey. Operations Report. EGS Job No. 5432.
- HR Wallingford (2008). Goodwin Sands, Study of historical changes. Technical Note DDM6067_TN01.



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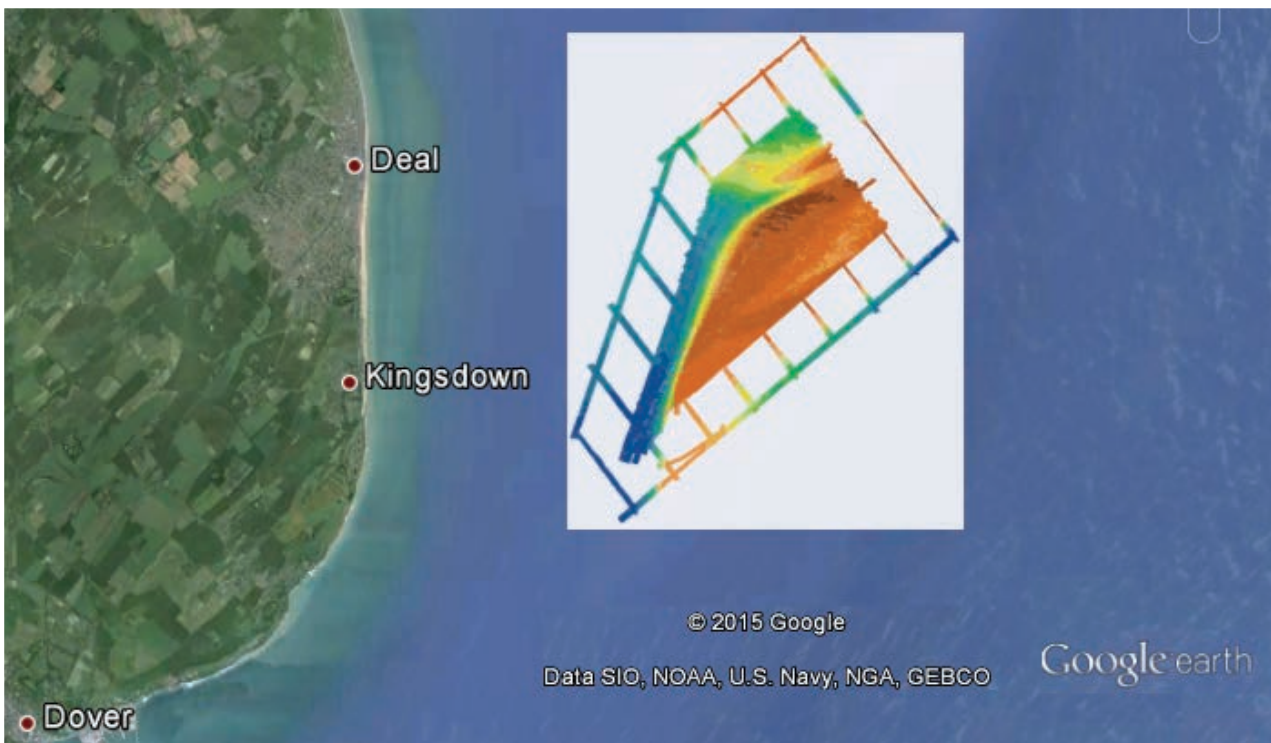
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Appendix 6.3

Goodwin Sands Aggregate Dredging Coastal Impact Study
and EIA – Sediment Dispersion Modelling

Goodwin Sands Aggregate Dredging Coastal Impact Study and EIA

Sediment dispersion modelling



Document information

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Prepared



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Executive Summary

Dover Harbour Board (DHB) is proposing to dredge sand and gravel from the South Goodwin Sands off the coast of Kent for use as fill material for the Dover Western Docks Revival development at the Port. DHB is proposing to dredge up to 2.5 million m³ of sand and gravel from the subtidal parts of the South Calliper sandbank at the South Goodwin Sands, located approximately 12 km north east of the Port of Dover (Figure 1.1). Marine aggregate dredging requires a Marine Licence from the Marine Management Organisation (MMO). Royal HaskoningDHV, on behalf of the DHB, is undertaking an Environmental Impact Assessment (EIA) to support the application for a Marine Licence for consent to dredge.

HR Wallingford is providing inputs to the EIA and Coastal Impact Study (CIS), establishing the magnitude, spatial extent and duration of any changes to the physical environment directly caused by dredging on the Goodwin Sands. The focus of the modelling described in this report is on the footprint of sediment dispersion predicted to arise during the proposed dredging.

To provide a precautionary view of the impact of sediment release during dredging, the present modelling has assumed that the dredging will be undertaken using a medium-sized dredger of around 8,500 m³ capacity which is at the upper end of dredger sizes expected to be used.

The sediment dispersion modelling used in this study is the high level approach which has been applied in previous Marine Aggregate Regional Environmental Assessment (MAREA) studies, to identify the footprint of potential impact arising from dredging plumes. Here the footprint is the area which may be affected at any time over the entire dredging operation. The method does not represent the plume at a single, specific, moment in time. Footprints of impact are established for *fine sediment* (silt/clay with a grain size less than 63 µm) and *fine sand* (grain size between 63 µm and 250 µm) which will be released in the dredging overflow.

The conclusions of the study are:

Suspended sediment concentrations

- Peak increases of suspended *fine sediment* concentration of more than 10 mg/l and 20 mg/l above background are expected to be confined within a footprint extending up to 1.5 km and 1 km, respectively, from the eastern boundary of the dredging area. On the west side of the dredging area the footprint of the fine sediment plume is aligned with the edge of the dredging area. The 50 mg/l footprint is aligned closely with the dredging area boundary in all directions.
- Peak increases of suspended *fine sand* concentration of more than 10 mg/l, 20 mg/l and 50 mg/l above background are predicted to occur over a larger footprint than that of the *fine sediment* due to the larger amount of fine sand anticipated to be released by the dredging. The 10 mg/l footprint contour extends 1.5-2 km from the dredging area to the north and east and less than this to the south and west. The 20 mg/l footprint is similar and extends 1-1.3 km from the dredging area to the north and east and less than this to the south and west. The 50 mg/l footprint extends less than 500 m from the dredging area.
- Within the region, suspended sediment concentrations typically vary between 10 and 50 mg/l and, during storms; suspended sediment concentrations of up to 200 mg/l have been measured. In this context, and given that dredging leading to sediment release will only occur for a small proportion of the dredge cycle,

the predicted changes do not represent a material change to the transport of suspended sediment in and around the proposed dredging location except in close proximity (within 2 km) to the dredging.

Deposition

- Deposition of fine sediment from the plume is predicted to be minimal. Deposition of sand from the plume will occur within the plume footprint and will not cause any significant substrate change.

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1. Introduction

Dover Harbour Board (DHB) is proposing to dredge sand and gravel from the South Goodwin Sands off the coast of Kent for use as fill material for the Dover Western Docks Revival development at the Port. DHB is proposing to dredge up to 2.5 million m³ of sand and gravel from the subtidal parts of the South Calliper sandbank at the South Goodwin Sands, located approximately 12 km north east of the Port of Dover (Figure 1.1). Marine aggregate dredging requires a Marine Licence from the Marine Management Organisation (MMO). Royal HaskoningDHV, on behalf of the DHB, is undertaking an Environmental Impact Assessment (EIA) to support the application for a Marine Licence for consent to dredge.

HR Wallingford first considered the required studies to support dredging on the Goodwin Sands in 2008 when a phased, outline scope was proposed; including a historical bathymetric review and wave modelling to inform a Coastal Impact Study (CIS). The historical bathymetric review covering the period 1986-2006 was completed and reported on in HR Wallingford (2008).

For the present project HR Wallingford is providing inputs to the EIA and CIS, establishing the magnitude, spatial extent and duration of any changes to the physical environment directly caused by dredging on the Goodwin Sands. The focus of the modelling described in this report is on the footprint of sediment dispersion predicted to arise during the proposed dredging.

The proposed dredge area lies close to various sensitive locations including protected wrecks, designated areas, anchorages and sites associated with particular ecological value such as seal haul out sites and *sabellaria spinulosa* reef as shown in Figure 1.2. The potential for the proposed dredging to change the physical processes at these sites requires consideration.

1.1. Report structure

The remainder of this report is structured as follows:

- Chapter 2 Provides a brief description of the proposed dredging and the physical processes leading to sediment plume release;
- Chapter 3 Explains the methodology used to derive the footprints of sediment plumes arising from the proposed dredging;
- Chapter 4 Background sediment concentrations;
- Chapter 5 Presents the results of the study;
- Chapter 6 Presents the conclusions of the study.

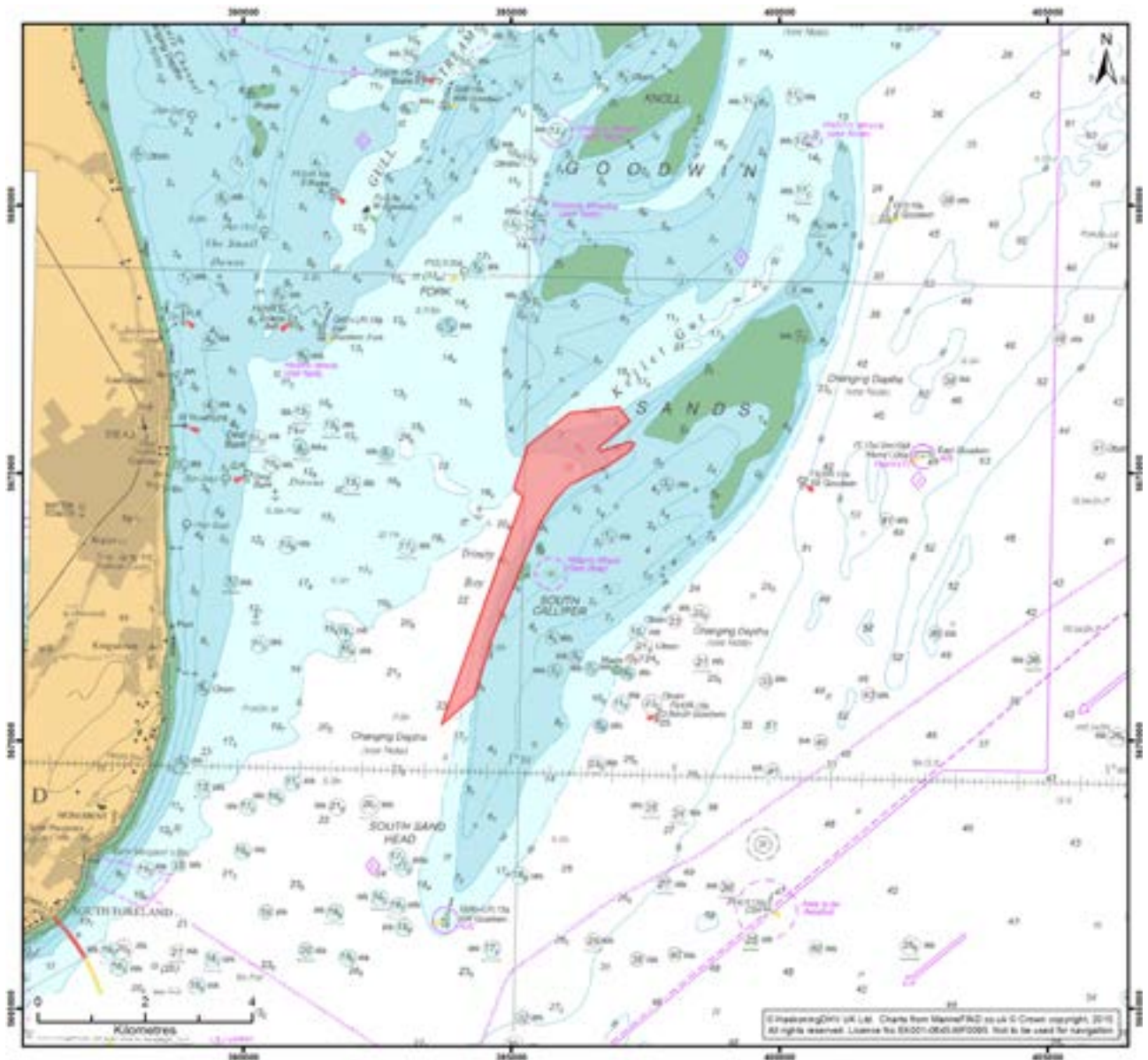


Figure 1.1: Location of proposed aggregate dredging area

Source: PHDHV Drawing PB2107_ES_003

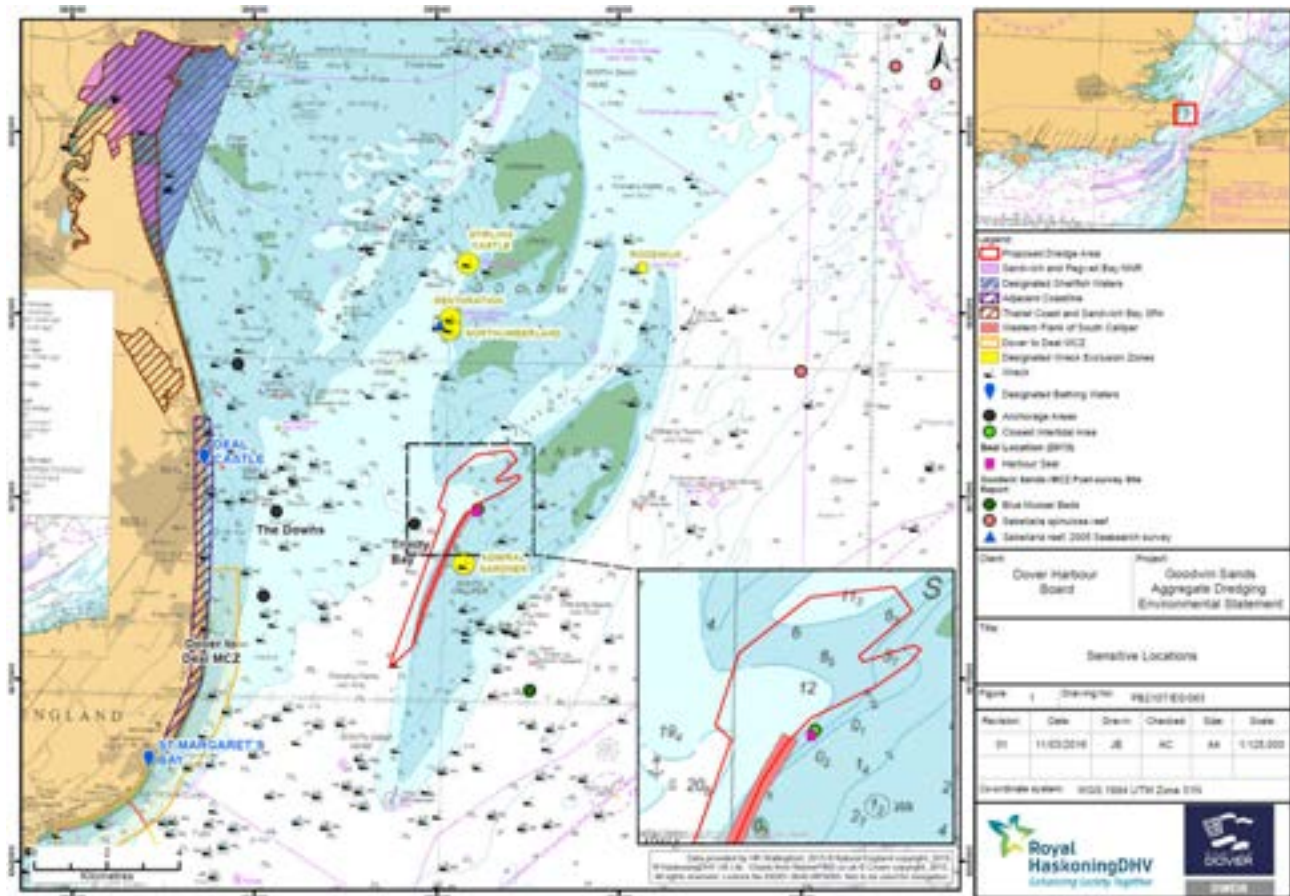


Figure 1.2: Sensitive locations in area of proposed aggregate dredging area

Source: RHDHV drawing PB2107_ES_063

2. Proposed dredging operations and the mechanism of release

The proposed dredging will take place within the area shown in Figure 1.1. It is proposed that up to approximately 2.5 million m³ of material will be dredged from Goodwin Sands and transported to Dover for use as aggregate in the Western Docks project. The dredging is planned to be undertaken by one or two TSHDs, each with a capacity of approximately 5,000 m³, although the actual capacity will depend on the dredging contractor appointed and it is possible that larger dredgers could be used, up to a maximum capacity of 8,500 m³. For the purposes of the sediment dispersion modelling study a precautionary view has been taken and dredger capacity of 8,500 m³ has been used.

Figure 2.1 describes the types of processes which can generate a sediment plume during the operation of a TSHD. The plumes arising from TSHDs are caused by the discharge (or “overflow”) of sediment-laden water from the hopper (usually through the hull of the dredger but sometimes over the ship-sides) which can form surface or near bed plumes. The introduction of this sediment, which can have significant initial momentum, into the water column results in a body of water denser than the surrounding water that descends towards the seabed. For dredgers which release overflow from the hull, (under normal loading) the plume ejected from the hull of the dredger creates both a dynamic plume (which descends rapidly towards the bed) and an often visible surface plume from the material which does not descend directly to the seabed with the dynamic plume.

Available evidence from measurements (e.g. Whiteside *et al.*, 1995; John *et al.*, 2000; Spearman *et al.*, 2003; and Aarninkhof *et al.*, 2010) indicates that the bulk of the overflow sediment forms a dynamic plume whilst the surface plume represents a small proportion of the sediment released in the overflow. Typically, this proportion is around 15% or less (Spearman *et al.*, 2011; Spearman, 2014).

The dynamic plume eventually impacts with, and collapses onto, the bed to form a bed plume which may not initially mix with the overlying waters, depending on the density difference between this layer and the ambient concentrations and the magnitude of the ambient currents (and wave action). As sediment settles out of this layer, and the thickness of the layer is reduced by further collapse, mixing will at some point occur and this layer may be re-entrained into the waters above to contribute to the passive plume. The sediment released onto the bed from the dynamic plume may mix with the overlying waters in time (depending on the currents and waves) but is not normally measurable as part of the dispersing plume due to its low rate of entrainment and position extremely close to the seabed.

Disturbance by the TSHD drag-head also plays a small role, although typically the release of fine sediment from the drag-head is less than 1% of that from the overflow (Hitchcock *et al.*, 1999; HR Wallingford and Dredging Research Ltd., 2005; Deltares *et al.*, 2009).

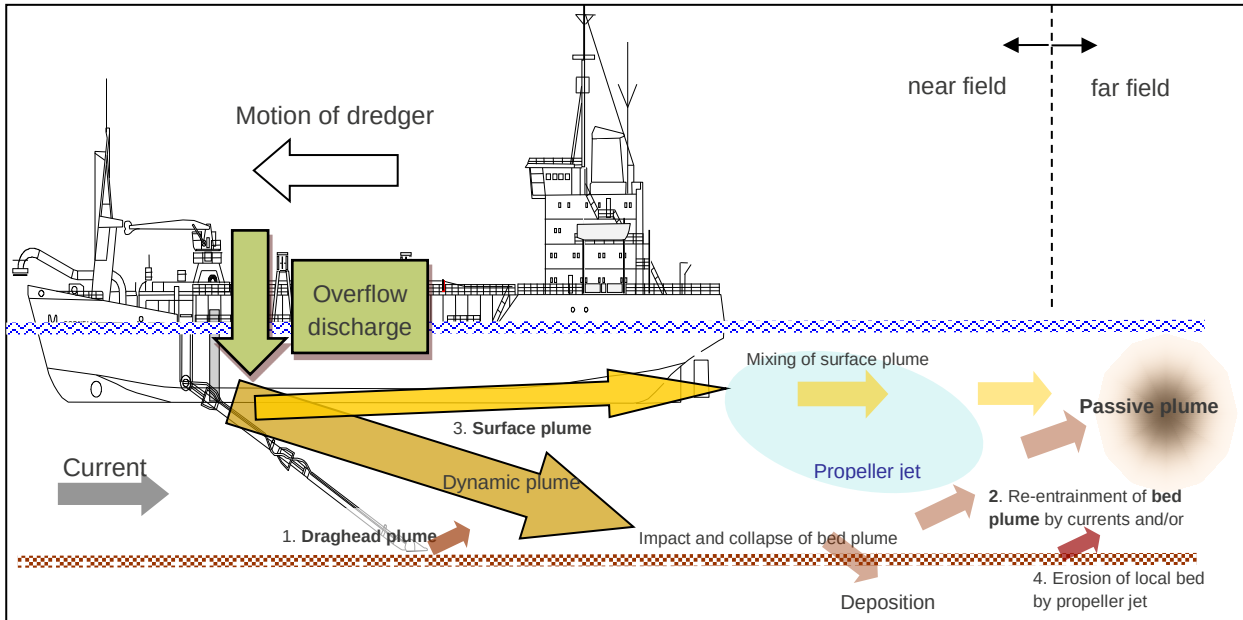


Figure 2.1: General mechanisms for release of sediment arising from TSHD dredging

Source: Spearman et al. (2011)

3. Methodology

The sediment dispersion modelling used in this study is the high level approach which has been widely applied in previous Marine Aggregate Regional Environmental Assessment (MAREA) studies to identify the footprint of the potential impact of dredging. Assessments using this method have been accepted by the regulatory bodies. The method does not represent the plume at a single, specific, moment in time but instead identifies the area which may be affected by the plume over the whole of the dredging operation.

3.1. Release of sediment from the proposed dredging operations

The release of sediment from the proposed dredging operations was calculated using the TASS hopper model developed by HR Wallingford (Spearman *et al.*, 2011; Spearman, 2014). This model reproduces the mixing and deposition processes inside the hopper (on the basis of the *in situ* sediment, the TSHD characteristics and the nature of the dredging operation) and predicts the particle size distribution, and water and sediment discharge of the overflow. The model has been validated to dredging operations performed in different locations, different sediment types and different vessels.

The *in situ* particle size distribution was derived from bed sampling data (nine samples taken from within the dredging area) made available by Royal Haskoning DHV. The *in situ* sediment in the resource area on the whole has a very low fine sediment ($D < 63 \mu\text{m}$) content and the grading is focused closely around fine and medium sand. The average particle size grading from these bed samples is shown in Figure 3.1. Note that the particle size distributions of the *in situ* sediment and the sediment remaining in the hopper are extremely similar owing to the low content of sediment particles under $150 \mu\text{m}$ in size.

This was used in the TASS model to predict the nature of the overflow sediment and discharge. The predicted average rate of release of fine sediment ($D < 63 \mu\text{m}$) over the overflow period during the hopper filling was 8.2 kg/s. The predicted average rate of release of fine sand ($63 \mu\text{m} < D < 250 \mu\text{m}$) over the overflow period was 126 kg/s. As discussed in Section 2, typically only 15% (or less) of these releases is likely to form a passive plume. This represents the source term used in the plume modelling. Within the plume modelling, the fine sediment (silt/clay) particles were represented as flocs (aggregated sediment particles help together by electro-static, chemical or organic bonds) with a very low settling velocity. The fine sand fraction was represented as a single fraction, with a settling velocity representing the mass-weighted average (10 mm/s) of the various fractions in this size range.

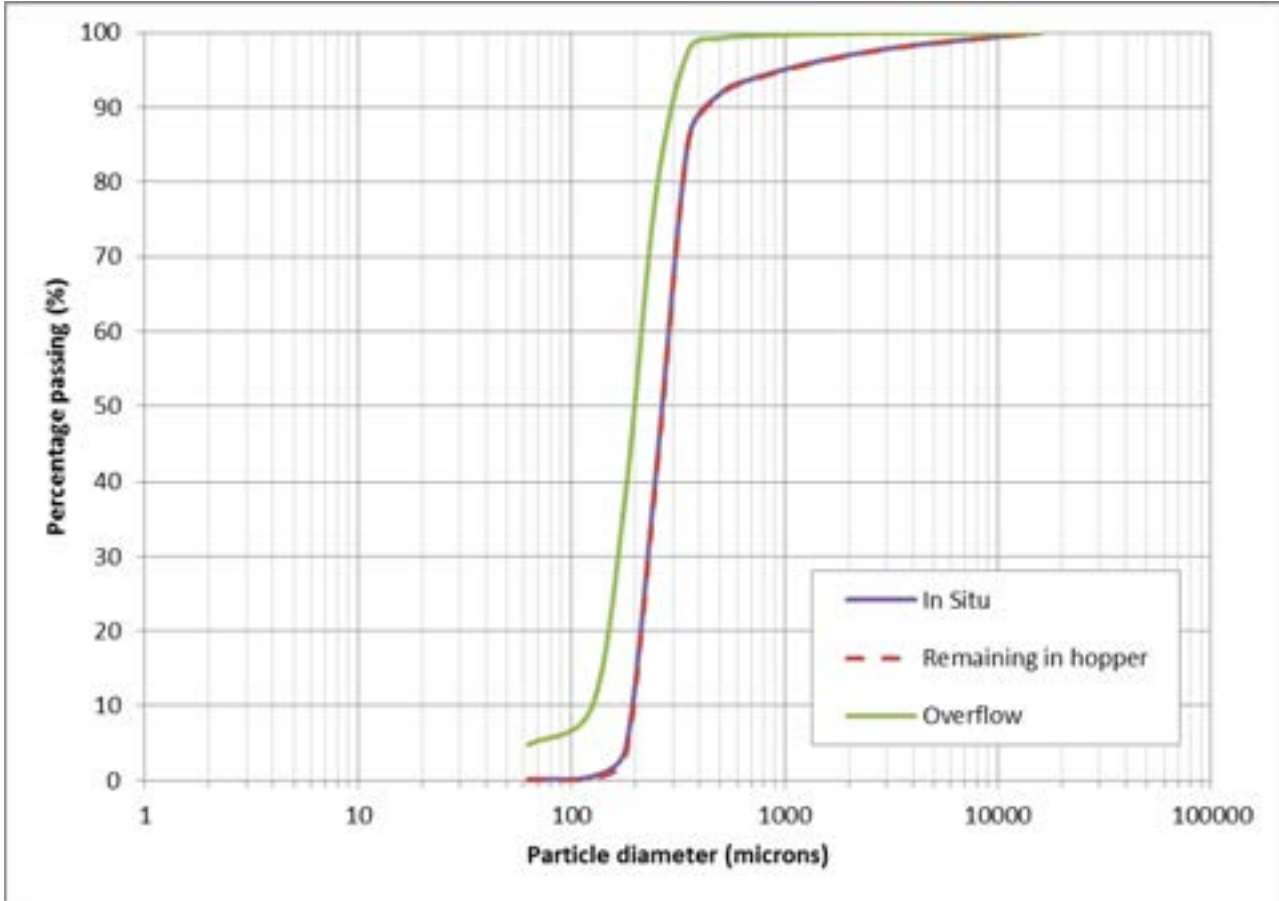


Figure 3.1: Predicted *in situ*, hopper and overflow particle size distributions

3.2. Characterisation of the decay of sediment plumes

In this section the physical basis between the plume dispersion, the rate of sediment input and the environmental factors is examined. Assuming, without loss of generality, that the current flow is in the x-direction and that the dispersion in the x-direction is small compared to the advection, then the depth-averaged concentration of the plume is given by (Fischer *et al.*, 1979):

$$\frac{\partial c}{\partial t} + u \frac{\partial c}{\partial x} = k_y \frac{\partial^2 c}{\partial y^2} - \frac{w_s c}{h} \quad (1)$$

The solution of which is given by:

$$c(x, y) = \frac{\dot{M}}{uh(4\pi k_y \frac{x}{u})^{1/2}} \exp\left(-\frac{y^2}{4k_y \frac{x}{u}} - \frac{w_s x}{uh}\right) \quad (2)$$

where $c(x, y)$ is the depth-averaged suspended sediment concentration in the plume (above background); $\dot{M}$ is the rate of sediment input to the water column from the dredger; u is the depth-averaged current speed, k_y is the transverse dispersion coefficient of the plume (i.e. in the y direction); w_s is the settling velocity of the sediment in the plume and h is the water depth.

This equation is valid when the time of plume development, t , is large compared to the value $2k_y/u^2$ (Fischer *et al.*, 1979).

Rearranging Equation (2) in terms of x , allowing for the fact that the dredger is a moving source with speed u_d , and setting $c_{y=0}$ to be the (depth-averaged) concentration in the centre of the plume results in:

$$x = \left[\frac{\dot{M}}{(u_d - u)h c_{y=0}} \frac{1}{\sqrt{4\pi k_y \frac{1}{u}}} \exp \left\{ -\frac{w_s}{uh} x \right\} \right]^2 \quad (3)$$

In the case where the overflow plume is composed of fine sediment, and w_s is small, the solution of Equation (3) simplifies to:

$$x = \frac{\dot{M}_{fine}^2}{4\pi\alpha(u_d - u)^2 h^3 c_{y=0}^2 \sqrt{C_D}} \quad (4)$$

where α is the constant of proportionality in the evaluation of the transverse diffusion coefficient, $K_y = \alpha h u_*$ (Fischer *et al.*, 1979), u_* is the friction velocity and C_D is the drag coefficient.

Where w_s is not small the solution to Equation 3 is given by:

$$x = \frac{uh}{w_s} W \left(\frac{\dot{M}^2 w_s}{4\pi\alpha(u_d - u)^2 u h^4 c_{y=0}^2 \sqrt{C_D}} \right) \quad (5)$$

where $W(z)$, the complex function in the bracket of Equation 5, is known as *Lamberts W* function. An asymptotic formula for $W(z)$ which yields sufficiently accurate results is given by Corless *et al.* (1996).

In this report Equations 4 and 5 are used to define the distance over which the fine sediment ($D < 63 \mu\text{m}$) and fine sand ($63 \mu\text{m} < D < 250 \mu\text{m}$) plumes will decay to background conditions. The vast majority of coarser sand fractions will fall to the bed rapidly in the vicinity of the dredging. Equations 4 and 5 have been shown to be a reliable estimator of the dispersion of aggregate dredging operations (Spearman, 2015).

3.3. Modelling to derive dredging footprint

The approach used in this study is realistic and evidence-based (e.g. Spearman, 2015), to provide information which can be used to assess potential impact. The approach is used to estimate the potential footprints of changes in suspended sediment concentration of *fine sediment* ($D < 63 \mu\text{m}$) and *fine sand* ($63 \mu\text{m} < D < 250 \mu\text{m}$) fractions which will be released in the dredging overflow. Note that these footprints do not represent the dredging plume at specific moments in real time, but instead identify the *envelope* of change resulting from the whole dredging operation.

The approach is based on the following key elements:

- A physically based algorithm which allows the (maximum) distance over which plumes can be expected to reduce to (quasi-) background conditions for a given operation and hydrodynamic conditions;
- An evidence-based assessment of the expected decay of the suspended sediment concentrations between release and the identified distance over which plume decay occurs;
- Use of a particle-tracking model (in this case, based on the SEDPLUME-RW code) to track the advection of sediment particles (released within the particle tracking model) over the distance identified by the evidence-based algorithm;

- Release of sediment particles at every time-step from positions at all locations around the boundary of the dredging area (i.e. the area shown in Figure 1.1) with each particle tracked over the course of a representative spring/neap tide until it has travelled the distance identified by the algorithm;
- The identification of the impact footprint as the envelope of all of the particles released (see Figure 3.2 which is a schematic figure used to illustrate the idea of how the model is used to define the footprint of the plume and not specific to Goodwin Sands); and

The footprint derived from this study is a combined envelope of footprints of dredging for both spring and neap tides.

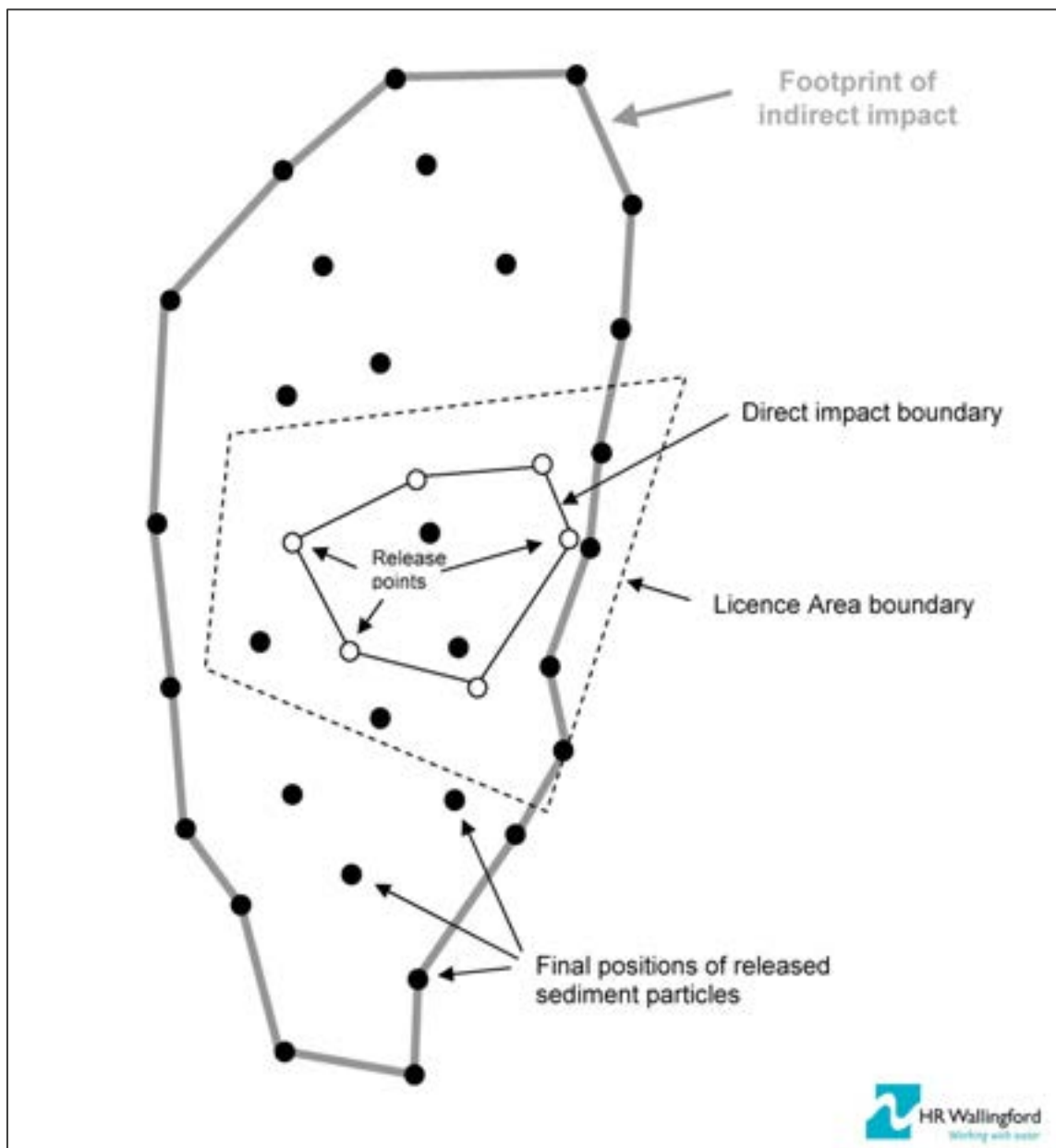


Figure 3.2: Explanatory schematic figure showing how the footprint of indirect impact is established from the plume model results

Source: HR Wallingford (2011)

3.4. Flow model used to derive footprint

TELEMAC-2D was used to model an area covering the southern North Sea as far north as Den Helder and Cromer and the English Channel as far west as Lizard Point and Ile d'Ouessant (Figure 3.3). A two dimensional depth averaged flow model was considered suitable for this project because strong currents occur in the area of interest (up to 1.5 m/s) so water column stratification effects are unlikely to be significant influences on the vertical variation in current magnitude. The largest mesh size was on the model outer boundary and is 25,000 m. The smallest mesh size was at the area of proposed dredging and was approximately 50 m. Figure 3.3 shows the model domain and mesh. A detailed description of the flow model and its calibration is presented in HR Wallingford (2015).

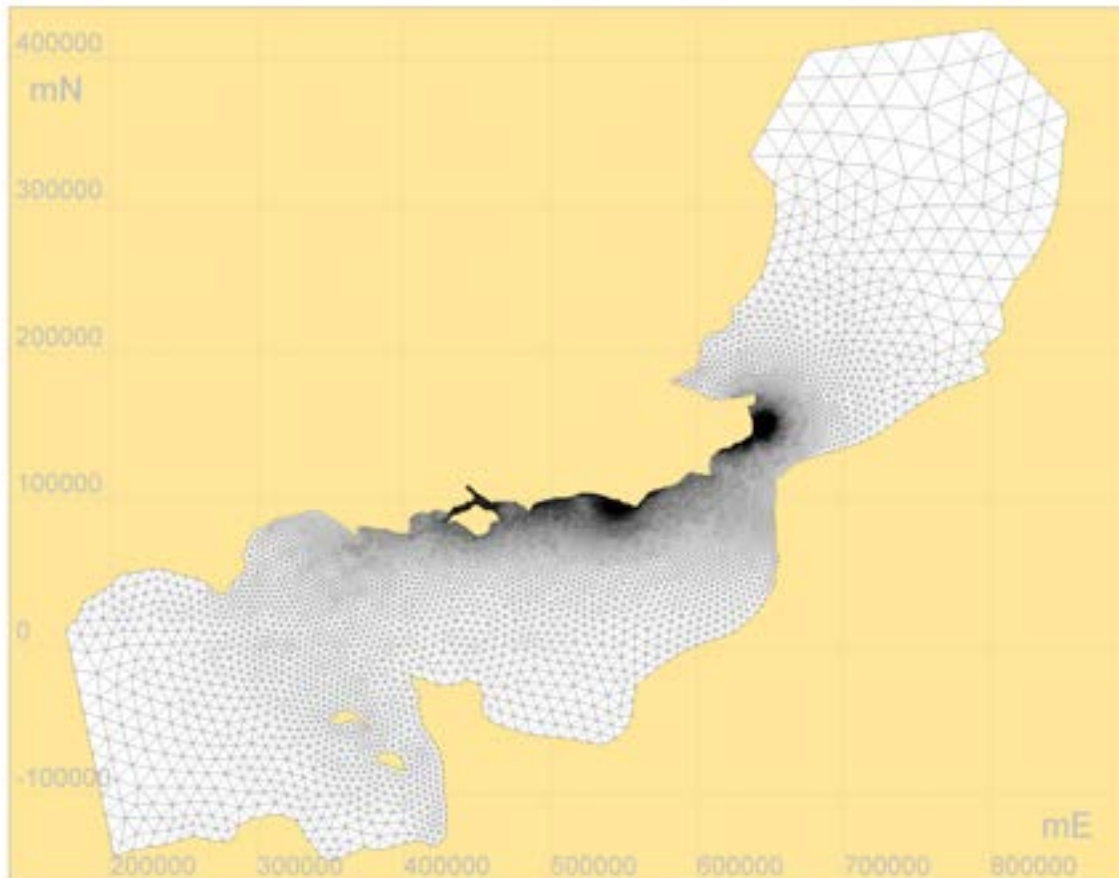


Figure 3.3: TELEMAC-2D model extent and mesh

The outputs from the flow modelling were used to drive the plume dispersion model. The peak current patterns flowing north and south are shown in Figure 3.4 and Figure 3.5. Predicted current speeds within the dredging area are in the region of 2 m/s but much lower current speeds are experienced over the bank immediately to the east of the dredging area. The peak northward flow is close to local high water and the peak southward flow is at a time close to low water which is reflected by the effect of the bank in reducing currents.

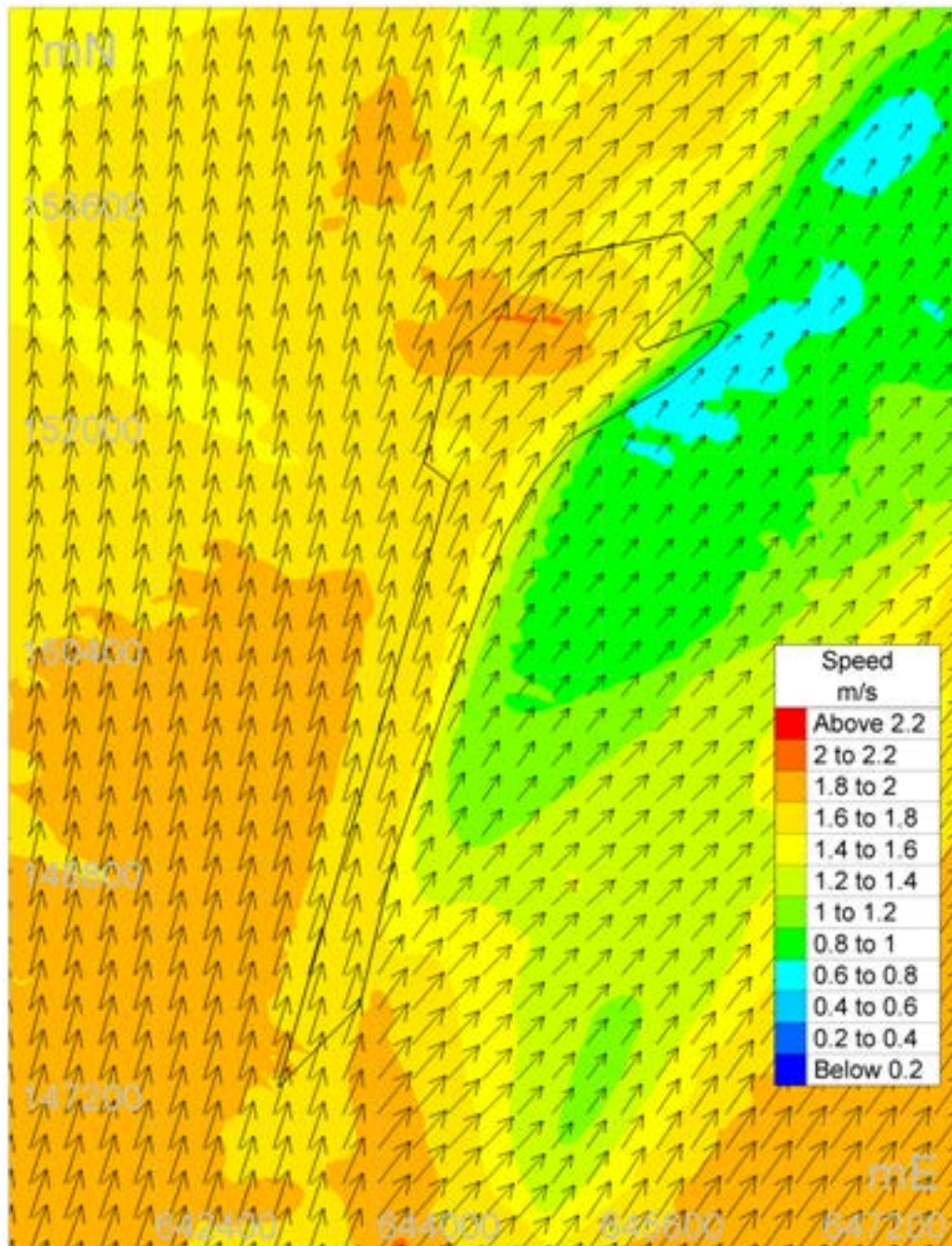


Figure 3.4: Baseline tidal current at time of maximum current towards the north. The proposed dredging area is shown as a black polygon.

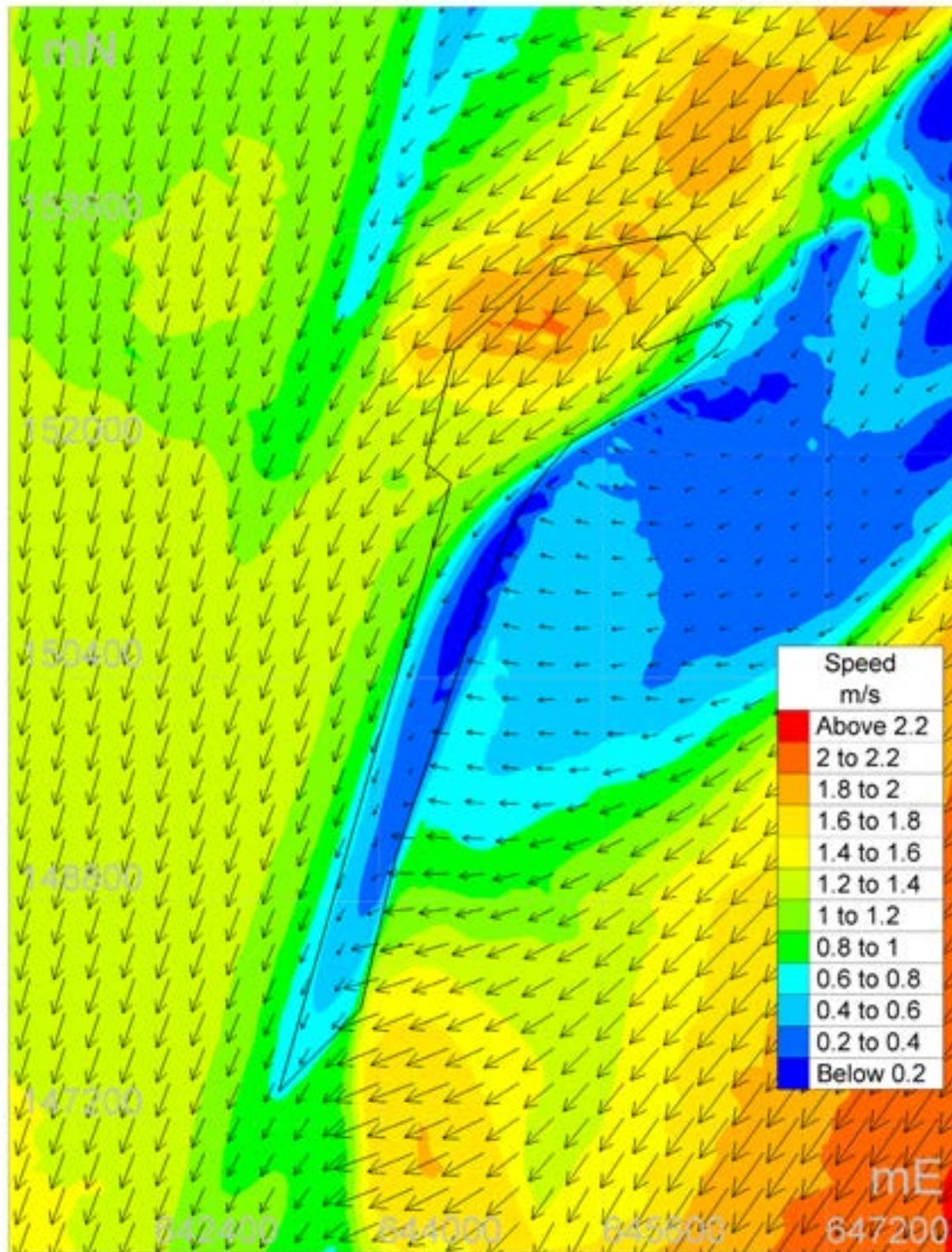


Figure 3.5: Baseline tidal current at time of maximum current towards the south. The proposed dredging area is shown as a black polygon.

4. Background sediment concentrations

Suspended sediment concentrations in the English Channel have a high level of natural spatial and temporal variation. Suspended sediment concentrations in the English Channel around the Straits of Dover have a high level of natural spatial and temporal variation. Observed concentrations are highest close to the coast, with near bed concentrations of 6 mg/l to 75 mg/l reported over an 18 month period (Lafite *et al.*, 2000).

Observed concentrations at Dover and further south, i.e. broadly within the same inshore part of the English Channel as the proposed dredging, under different wave conditions are available from an investigation undertaken by HR Wallingford as part of the studies supporting the construction of the Channel Tunnel. Six inshore monitoring stations were used to measure the near bed suspended concentration levels near the location of Shakespeare Cliffs and four distant monitoring stations – two at Dover Harbour and two at Folkestone Harbour – were also used. The main conclusion from the study was the sediment concentration at all six monitoring stations was primarily dependent on the degree of wave energy incident on the coast. Average monthly concentrations varied from over 200 mg/l in the stormiest conditions to 10 mg/l in the least stormy conditions. Using the results of the correlation studies, the background suspended concentrations for a 0.2 year return period incident NE wave and a 0.2 year return period SSW wave are approximately 100 mg/l and 150 mg/l respectively.

5. Results

5.1. Significance of the predicted plume footprints

To evaluate the footprint of impact, the footprints for the peak concentration increases from dredging of 10 mg/l, 20 mg/l and 50 mg/l were predicted using the methodology described in Section 3. This assumes dredging will be carried out within the whole of the proposed Goodwin Sands dredging area.

The 50 mg/l increase represents a change in suspended concentration which is in the region of the typical variation in natural background concentration resulting from the tidal signal. The 10 mg/l and 20 mg/l concentration increases represent increases less than the natural tidal variation.

5.2. The extent of the predicted plume footprints

5.2.1. Footprint of the fine sediment plume

For the fine sediment simulation (silt/clay with a grain size less than 63 µm) the footprint for the peak concentration increases of 10 mg/l, 20 mg/l and 50 mg/l above background are shown in Figure 5.1 overlaid on the bathymetry (shown as depth in metres below Mean Sea Level (MSL)). All three of these concentration increase contours hug the perimeter of the dredging area on the west indicating rapid dispersion of the plume. Over the bank to the east of the dredging area the 10 mg/l and 20 mg/l plume footprints extend further, owing to the shallower water and asymmetry in the current speeds. The 10 mg/l footprint extends up to 1.5 km from the eastern boundary of the dredging area while the 20 mg/l footprint extends up to 1 km from the eastern boundary of the dredging area. Note that the 50 mg/l footprint is aligned closely with the dredging area boundary.

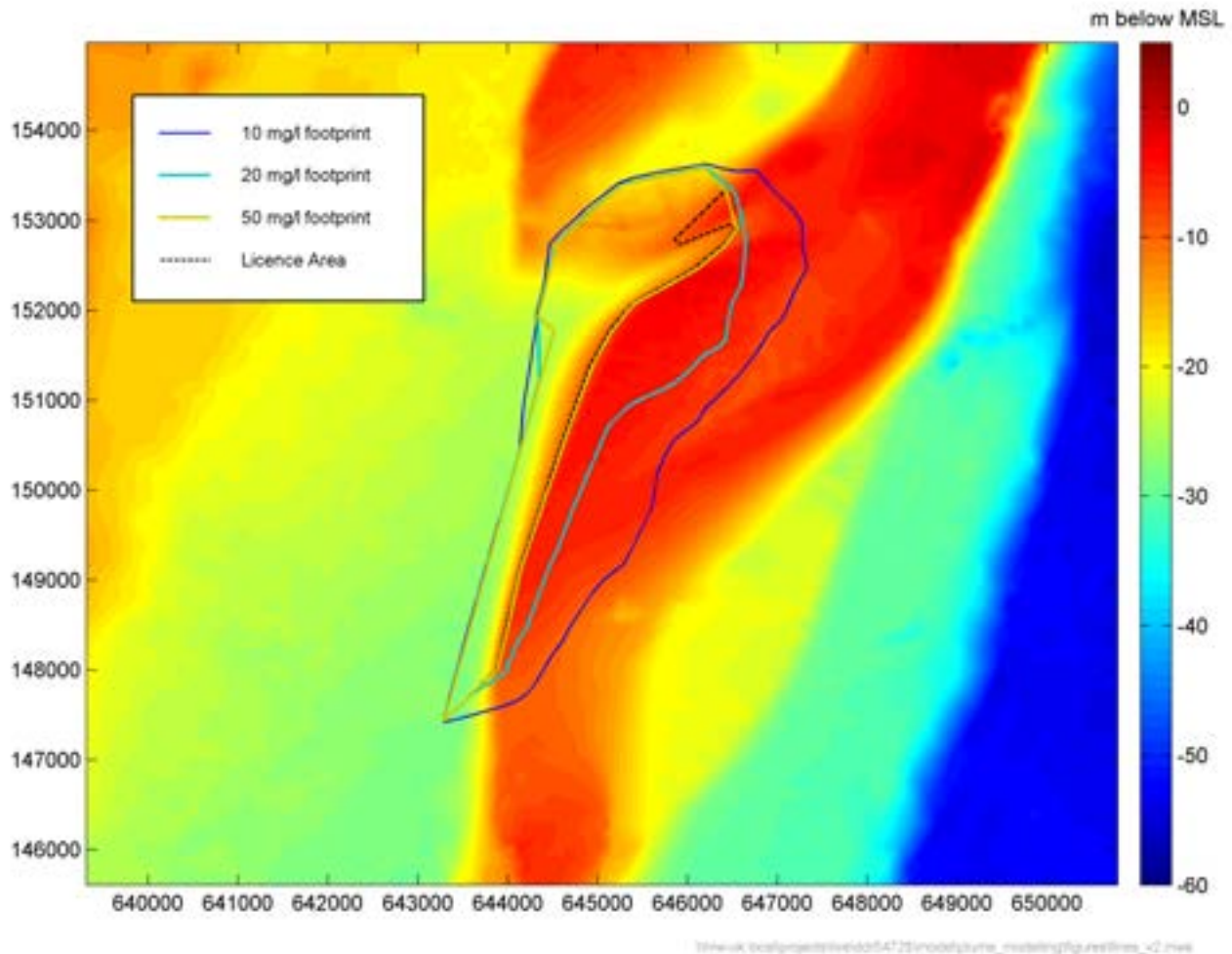


Figure 5.1: Footprint of peak concentration increases in fine sediment suspended sediment concentration resulting from the proposed dredging

5.2.2. Footprint of the fine sand plume

The footprint for the peak concentration increases of 10 mg/l, 20 mg/l and 50 mg/l above background of fine sand (grain size between 63 μm and 250 μm) are shown in Figure 5.2 overlaid on the bathymetry (shown as depth in metres relative to MSL). The much larger release rate of fine sand (compared to the fine sediment [silt/clay] release discussed in Section 5.2.1) contributes to a greater extent of the plume. This factor in increasing the plume extent is mitigated by the much greater rate of settling and deposition associated with the fine sand. The 10 mg/l footprint contour extends 1.5-2 km from the dredging area to the north and east and less than this to the south and west. The 20 mg/l footprint is similar and extends 1-1.3 km from the dredging area to the north and east and less than this to the south and west. The 50 mg/l footprint extends less than 500 m from the dredging area.

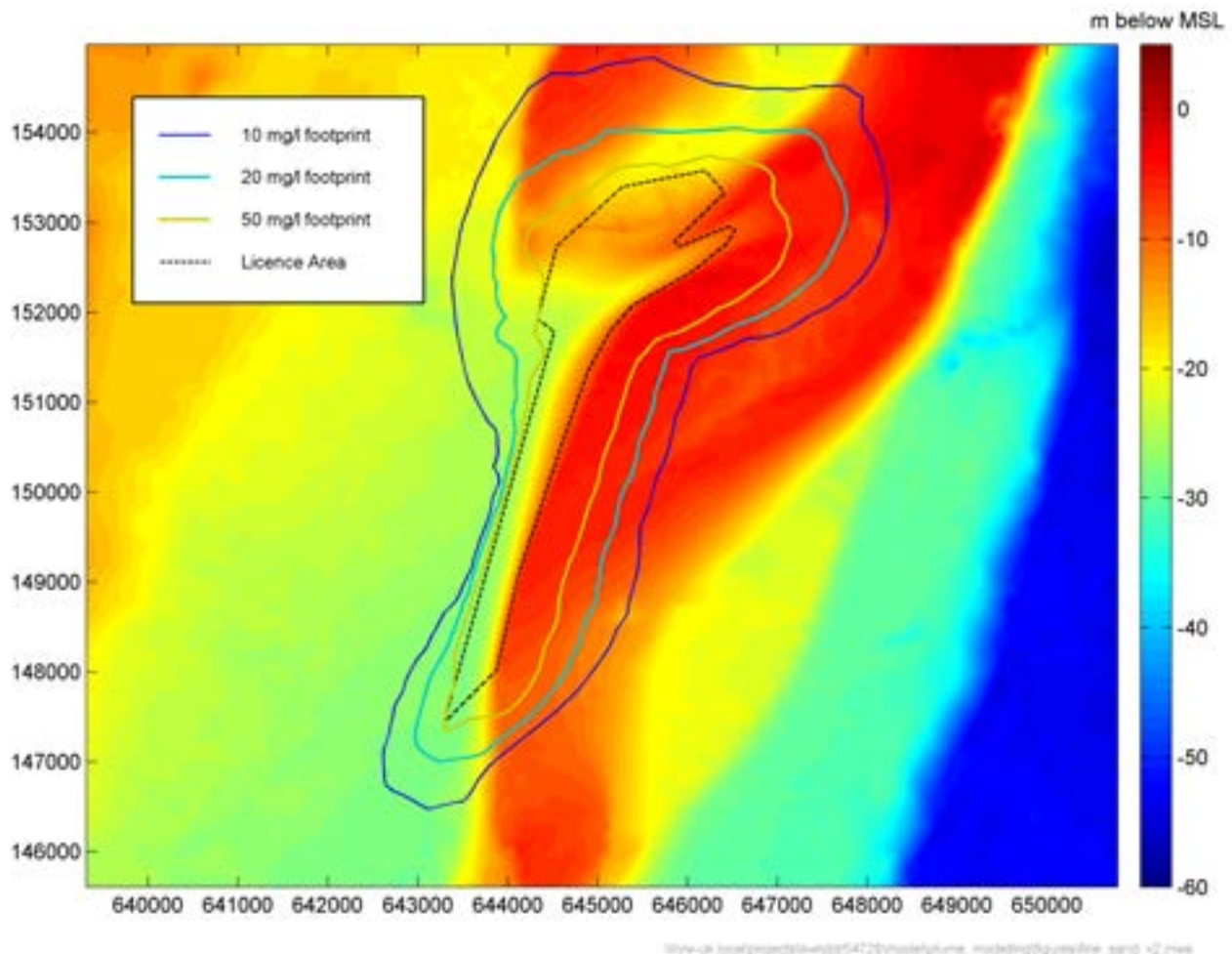


Figure 5.2: Footprint of peak concentration increases in fine sand suspended sediment concentration resulting from the proposed dredging

5.3. The nature of predicted increases in suspended sediment within the plume footprint

This footprint of predicted increases in suspended sediment concentration should be considered in the context of background concentrations which commonly vary between 10 – 50 mg/l and vary up to 200 mg/l during storms (see Section 4). In this context, the predicted changes within the plume footprint do not represent a material change to the transport of suspended sediment in and around the proposed dredging location. Given the need to deliver and discharge the load before returning to resume dredging, any changes as discussed above would occur in a sub-area of the proposed dredging area for only a small portion of the time during the dredging operation. The temporal and spatial factors add to the view that the predicted fine sediment and fine sand footprints identified in this study are unlikely to represent a noticeable effect on the sediment regime of the area.

Comparison of Figure 5.1 and Figure 5.2 with the locations of sensitive locations (Figure 1.2) shows that the identified ecologically sensitive sites of *Sabellaria spinulosa* reef or blue mussel beds are outside the footprint of increased suspended sediment concentration associated with the proposed dredging.

5.4. The nature of deposition of sediment within the plume footprint

The proposed dredging will predominantly release a mixture of fine and medium sand from the overflow, with a small amount of fine sediment. The fine sediment will be released into the water column to form a passive plume which will disperse into the background. The fine sand will fall to the bed over a larger footprint and then become part of the background sediment transport regime. Medium sand and coarser particles will fall to the bed within the immediate vicinity of the dredging and form part of the background sediment transport regime.

Any deposition of fine sediment from the plume onto the bed at slack water will be of the order of a fraction of a millimetre in thickness and will be re-suspended on the following tide. The sand will fall rapidly to an already sandy bed within the plume footprint and will not change the bed substrate to any significant extent.

As no increase in suspended sediment concentration is predicted at the *Sabellaria spinulosa* reef or blue mussel beds shown in Figure 1.2 no increase in sediment deposition at these sites due to the proposed dredging is anticipated.

6. Conclusions

A sediment dispersion study has been completed to identify the footprint of sediment plumes arising from proposed dredging at Goodwin Sands. The method assumes continuous release of sediment from all points on the boundary of the proposed dredging area and is, hence, highly conservative.

Implications for suspended sediment concentrations

- Peak increases of suspended *fine sediment* concentration of more than 10 mg/l and 20 mg/l above background are expected to be confined within a footprint extending up to 1.5 km and 1 km, respectively, from the eastern boundary of the dredging area. On the west side of the dredging area the footprint of the fine sediment plume is aligned with the edge of the dredging area. The 50 mg/l footprint is aligned closely with the dredging area boundary in all directions.
- Peak increases of suspended *fine sand* concentration of more than 10 mg/l, 20 mg/l and 50 mg/l above background are predicted to occur over a larger footprint than that of the *fine sediment* due to the larger amount of fine sand anticipated to be released by the dredging. The 10 mg/l footprint contour extends 1.5-2 km from the dredging area to the north and east and less than this to the south and west. The 20 mg/l footprint is similar and extends 1-1.3 km from the dredging area to the north and east and less than this to the south and west. The 50 mg/l footprint extends less than 500 m from the dredging area.
- Within the region, suspended sediment concentrations typically vary between 10 and 50 mg/l and, during storms; suspended sediment concentrations of up to 200 mg/l have been measured. In this context, and given that dredging leading to sediment release will only occur for a small proportion of the dredge cycle, the predicted changes do not represent a material change to the transport of suspended sediment in and around the proposed dredging location except in close proximity (within 2 km) to the dredging.

Implications for deposition

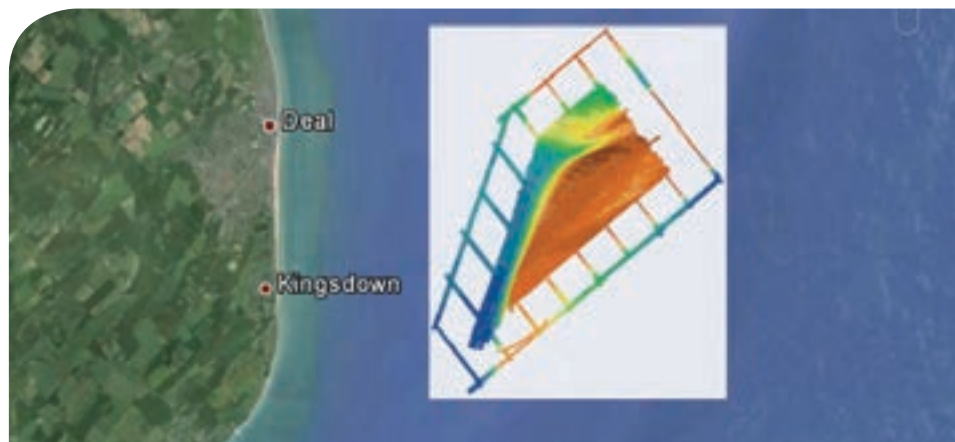
- Deposition of fine sediment from the plume is predicted to be minimal. Deposition of sand from the plume will occur within the plume footprint and will not cause any significant substrate change.

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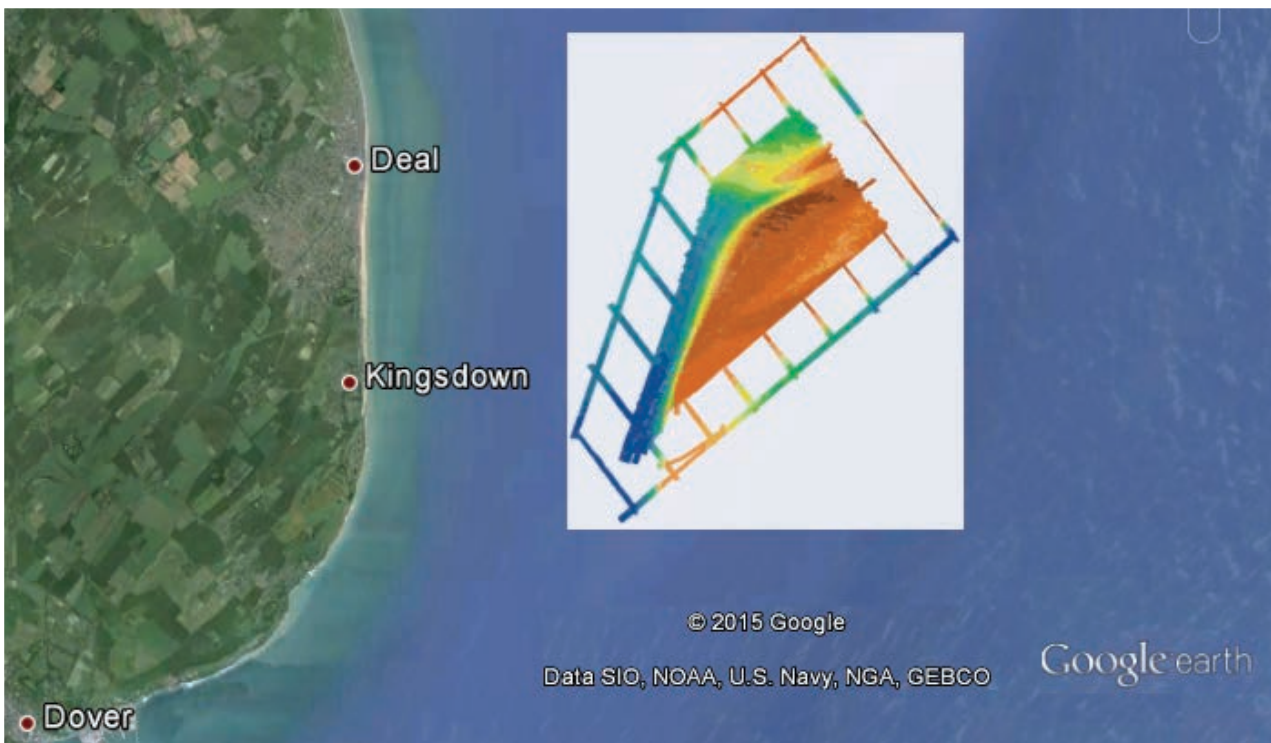
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Appendix 6.4

Goodwin Sands Aggregate Dredging Coastal Impact Study and
EIA – Sediment Transport and Morphology

Goodwin Sands Aggregate Dredging Coastal Impact Study and EIA

Sediment Transport and Morphology



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Executive Summary

Dover Harbour Board (DHB) is proposing to dredge sand and gravel from the South Goodwin Sands off the coast of Kent for use as fill material for the Dover Western Docks Revival development at the Port. DHB is proposing to dredge up to 2.5 million m³ of sand and gravel from the subtidal parts of the South Calliper sandbank at the South Goodwin Sands, located approximately 12 km north east of the Port of Dover (Figure 1.1). Marine aggregate dredging requires a Marine Licence from the Marine Management Organisation (MMO). Royal HaskoningDHV, on behalf of the DHB, is undertaking an Environmental Impact Assessment (EIA) to support the application for a Marine Licence for consent to dredge.

HR Wallingford is providing inputs to the EIA and Coastal Impact Study (CIS), establishing the magnitude, spatial extent and duration of changes to the physical environment. The focus of the modelling described in this report is on changes in sediment transport and morphology caused by the proposed dredging on the Goodwin Sands.

The sediment transport model SISYPHE has been used to calculate the sediment transport patterns and rates around Goodwin Sands. The results from simulations with and without the proposed aggregate dredging have been compared to assess the impact of the dredging on the sediment transport and consequential seabed changes.

The modelling suggested only small changes in the residual sediment transport and erosion/deposition pattern due to the proposed dredging. These changes are all close to the proposed dredging area and in most locations are evidenced by a reduction in predicted potential erosion rate within the dredging area, and a reduction of potential deposition rate in the deeper channel areas next to the dredging area. No impact on the sediment transport processes which control the naturally changing form of the South Goodwin Sands, including the intertidal areas of the sandbanks, is predicted.

The sediment transport results suggest that there is a small northward sediment transport pathway from the Straits of Dover, which feeds Goodwin Sands with additional material, although the amount of material available for transport there is very limited. Little or no sediment escapes from the banks of the Goodwin Sands to the north. This suggests that the volume of the banks is expected to be stable, perhaps even growing at a very slow rate.

This view of a generally stable bank volume is confirmation of earlier work that concluded that the volume of the sandbanks is constant or gradually increasing.

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1. Introduction

1.1. Background to the modelling study

Dover Harbour Board (DHB) is proposing to dredge sand and gravel from the South Goodwin Sands off the coast of Kent for use as fill material for the Dover Western Docks Revival development at the Port. DHB is proposing to dredge up to 2.5 million m³ of sand and gravel from the subtidal parts of the South Calliper sandbank at the South Goodwin Sands, located approximately 12 km north east of the Port of Dover (Figure 1.1). Marine aggregate dredging requires a Marine Licence from the Marine Management Organisation (MMO). Royal HaskoningDHV, on behalf of the DHB, is undertaking an Environmental Impact Assessment (EIA) to support the application for a Marine Licence for consent to dredge.

HR Wallingford first considered the required studies to support dredging on the Goodwin Sands in 2008 when a phased, outline scope was proposed; including a historical bathymetric review and wave modelling to inform a CIS. The historical bathymetric review covering the period 1986-2006 was completed and reported on in HR Wallingford (2008).

For the present study HR Wallingford is providing inputs to the EIA and CIS, establishing the magnitude, spatial extent and duration of changes to the physical environment directly caused by the proposed aggregate dredging. The focus of the computer modelling described in this report is on changes, caused by dredging, on the wave and flow conditions and consequential changes in sediment transport patterns in and around Goodwin Sands, the adjacent sandbank system, in the nearshore waters and along the adjacent coastal areas.

The proposed dredge area lies close to various sensitive locations including protected wrecks, designated areas, anchorages and sites associated with particular ecological value such as seal haul out sites and sabellaria spinulosa reef as shown in Figure 1.2. The potential for the proposed dredging to change the physical processes at these sites requires particular attention.

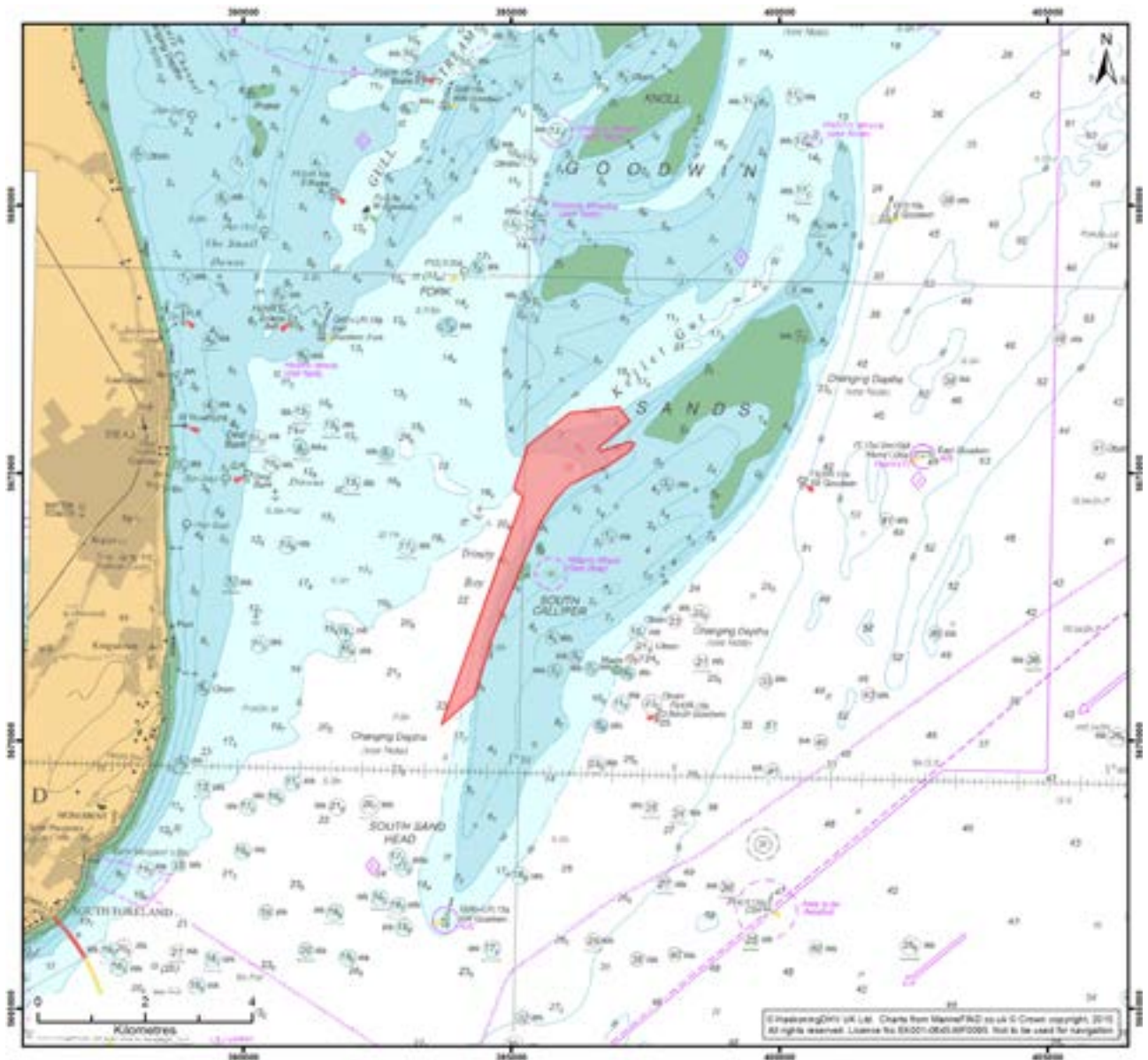


Figure 1.1: Location of proposed aggregate dredging area

Source: PHDHV Drawing PB2107_ES_003

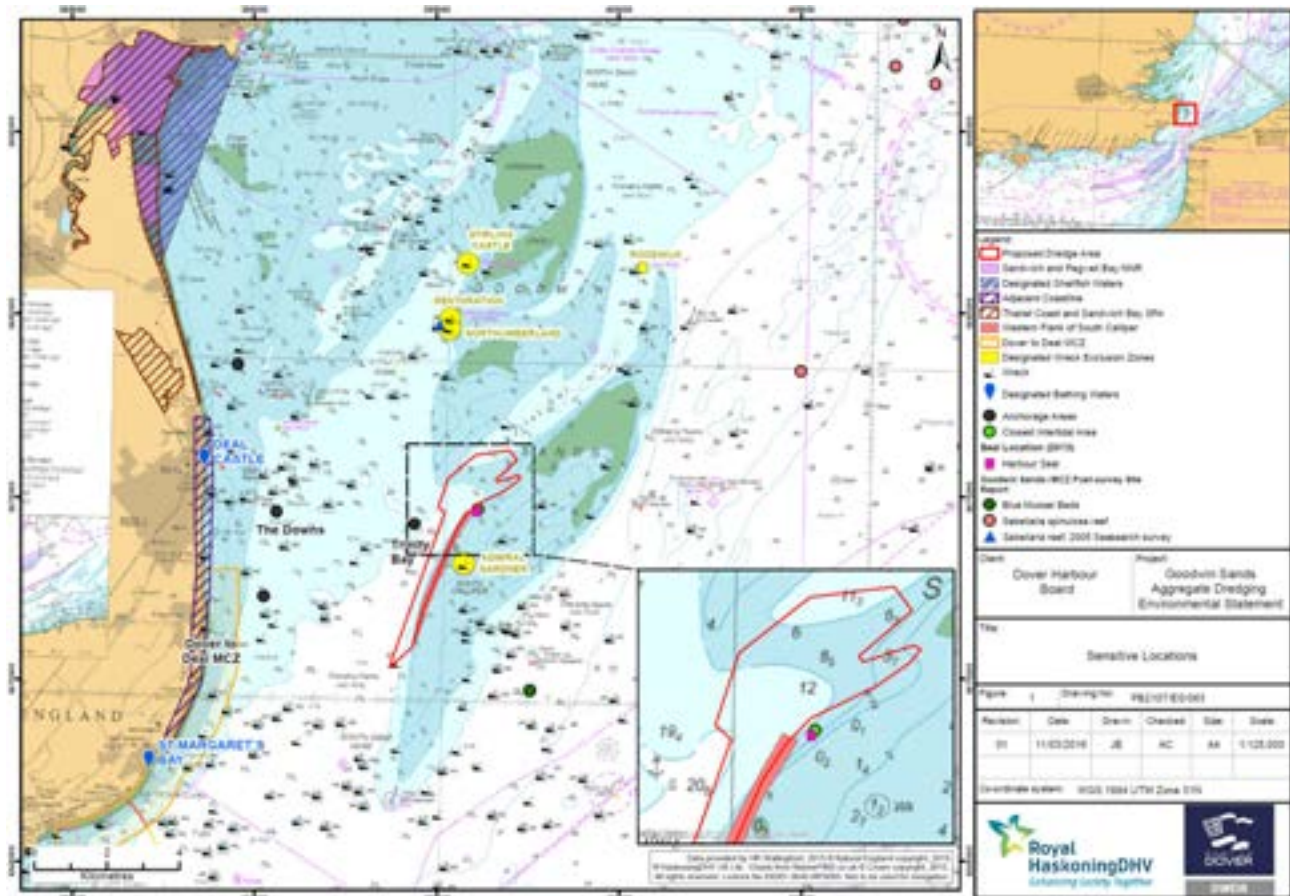


Figure 1.2: Sensitive locations in area of proposed aggregate dredging area

Source: RHDHV drawing PB2107_ES_063

2. Modelling approach

2.1. Sediment model

For this element of the study the validated, finite element based, depth-averaged flow model TELEMAC-2D and the integrated sediment transport model were employed to simulate sediment transport by tidal flows, enhanced by waves.

To simulate non-cohesive (sandy) sediment transport, the SISYPHE sediment transport module of the TELEMAC system was used. SISYPHE is the state-of-the-art sediment transport model used at HR Wallingford, capable of modelling sedimentary systems containing very fine to medium sands (with median grain diameters between 60 and 500 microns) which move along with the flow either in suspension or as bed load. The main factors controlling sand transport included in the model are: advection by currents, settlement under gravity, wave stirring, turbulent diffusion in all directions and exchange of sediment between the flow and the bed. Appendix A provides a technical description of the SISYPHE model.

Both TELEMAC-2D and SISYPHE use an unstructured triangular model mesh. This mesh allows complex coastlines and seabed features to be modelled accurately with user defined levels of detail applicable in a particular area of interest. Larger model mesh elements are used to remove the model's imposed boundary conditions away from the area of interest.

For this study, TELEMAC-2D, SISYPHE and the wave model SWAN have been run. The flow and sediment models are run fully coupled, with the orbital velocities being provided by the wave model fed back into TELEMAC-2D. The establishment and calibration of the flow model is described in HR Wallingford (2015b).

The SWAN wave model was used to simulate the propagation of wave energy through the model domain. For this element of the study, the structured grid version of SWAN was employed, which uses a finite difference mesh that covers an equivalent extent to the flow model mesh. To simulate the effects of varying water levels on the wave propagation, the SWAN model takes water level input from the flow model. The results from the wave model are then interpolated onto the nodes of the unstructured flow model mesh. For more information on the wave modelling undertaken see HR Wallingford (2015a).

The results from the wave simulation and the flow simulation were then combined to serve as input to SISYPHE to calculate the sediment transport patterns and resulting bed change infill.

2.2. Scenarios tested

The conditions represented in the models are briefly described as:

- A “baseline” case, that is the present-day bathymetry without dredging;
- A “just after dredging” scenario (Scenario 1), referring to the seabed bathymetry immediately after the full dredging of about 4,000,000 m³, achieved by dredging 1.12 m depth of aggregates but leaving at least 0.5 m of sand in accordance with established practice to facilitate recovery of benthic communities (see Figure 3.2).

The removed volume, described above, is a 60% enhancement of the target volume to be removed of 2,500,000 m³ as is typically done to provide precautionary impact predictions for aggregate dredging studies.

The vertical datum used for this study is Mean Sea Level (MSL). For convenience, levels are often reduced to mCD (Chart Datum at Deal) in the figures of this report.

3. Data sources

3.1. Bathymetry

The area of the EGS International Ltd bathymetry survey undertaken in 2015 is shown in Figure 3.1. It is shown to provide a good coverage of the South Goodwin Sands. It is noted that the southernmost face of the sandbank is only defined by transverse 1 km spaced, cross-sections extending about one kilometre away from the main survey area.

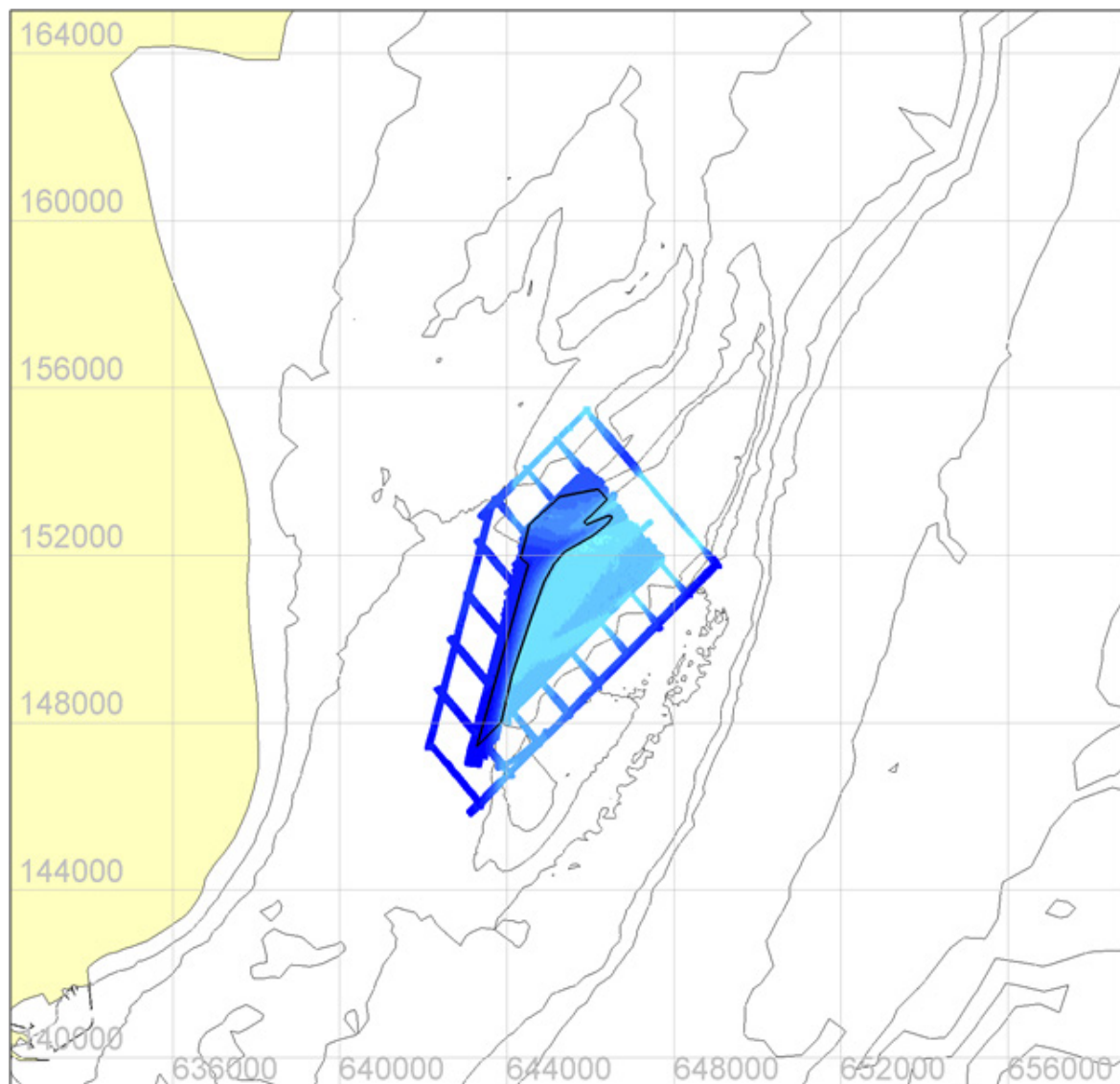


Figure 3.1: Spatial extent of the 2015 bathymetric survey of the Goodwin Sands. Proposed dredge area shown as black polygon.

Source: EGS International Ltd (2015)

Additional bathymetry data for the rest of the model area were taken from:

- recent TruDepth bathymetry from SeaZone, using the latest available survey data from the Admiralty;

- nautical chart data in European waters.

Bathymetry data from these different sources were merged for use in the baseline models, where more recent / resolved data took precedence over older or less resolved data. The representation of the baseline and post dredged bathymetries, for use in the sediment transport model, is shown in Figure 3.2. The same data were used to develop the representations of the baseline and post dredging bathymetries in the flow and wave models.

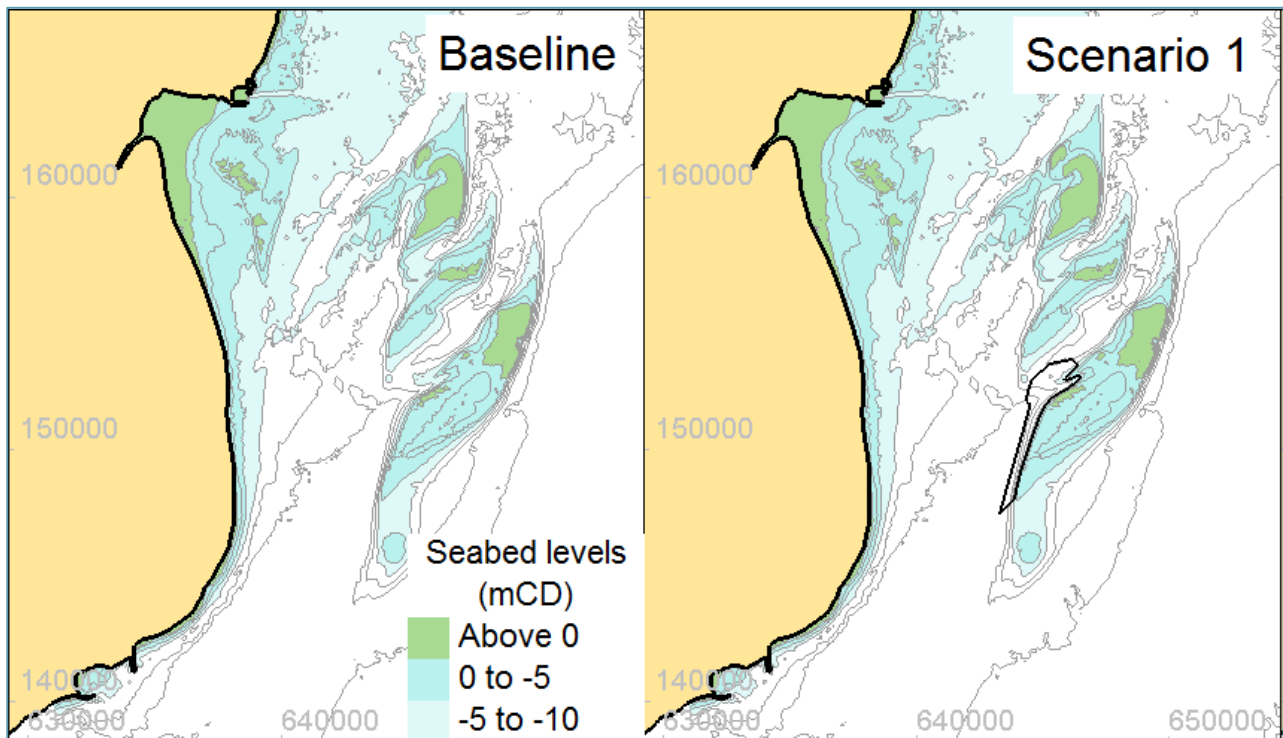


Figure 3.2: Baseline and post-dredging bathymetries used in the sediment transport model (black polygon on right hand image shows proposed dredging area)

3.2. Sediment

The composition of the seabed sediments around the aggregate dredging area is very mixed, with median grain sizes ranging from 168 microns to 37 mm. Surficial bed grab data taken for a benthic survey as part of the project (Marine Ecological Surveys Ltd, 2015) shows South Goodwin Sands as being predominantly fine (125-250 μm) and medium (250-400 μm) sand (Figure 3.3). As the sediment transport fluxes are expected to be dominated by the finer sediment fractions, the modelling has sought to investigate the worst case scenario of a uniform bed material of 100 μm . This will identify the largest potential sediment transport rates and hence show the largest potential change in these rates and the largest likely range of morphological change associated with the proposed dredge. For the purposes of the study abundant sand was assumed to be present throughout the model domain.

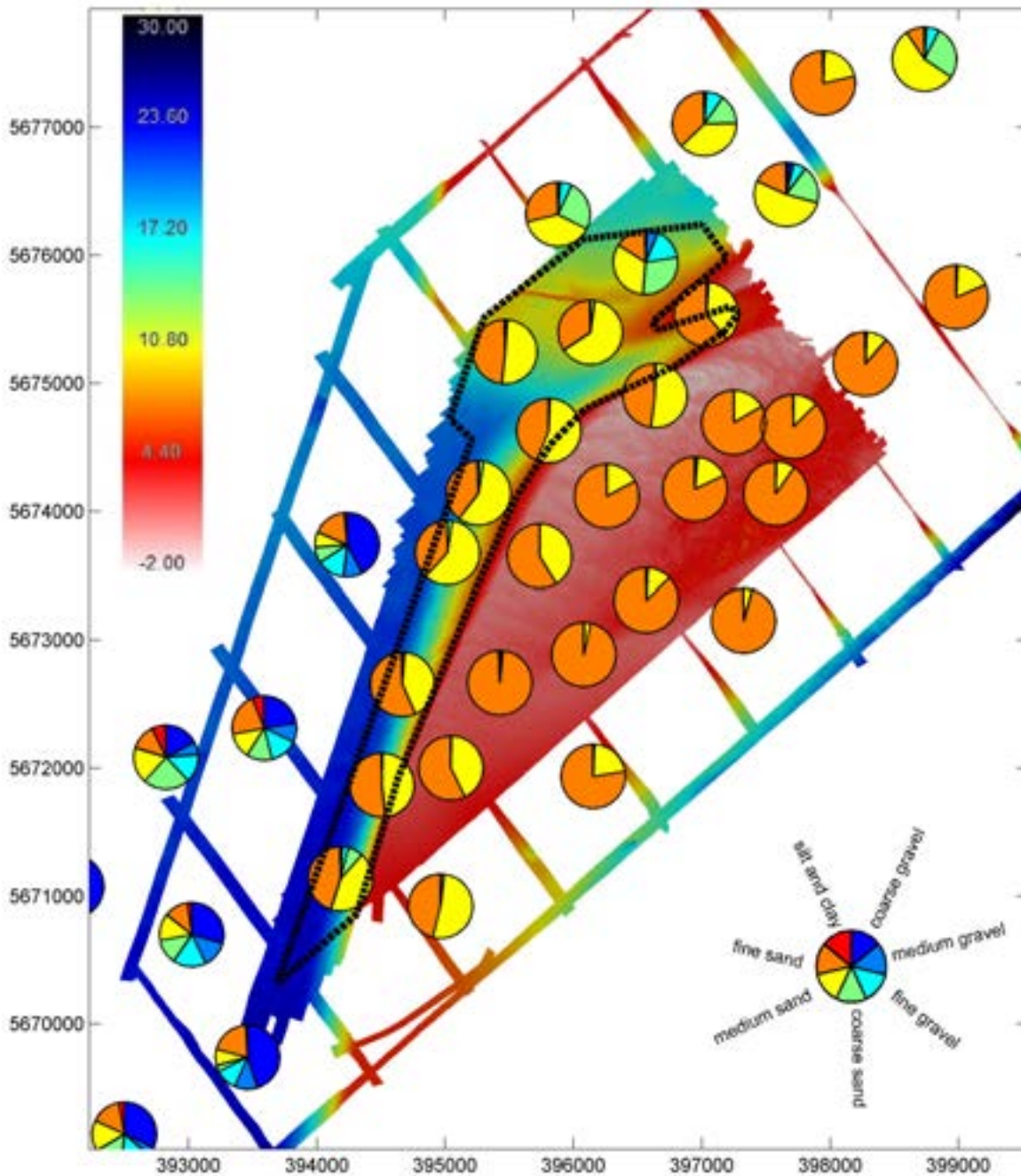


Figure 3.3: Surficial sediment types present at South Goodwin Sands

Source: Marine Ecological Surveys Ltd (2015)

3.3. Hydrodynamic inputs

The sediment transport modelling uses the calibrated flow and wave models of the present study (described in HR Wallingford, 2015a and 2015b). It uses the first spring neap cycle modelled in the flow model report, considered to be a typical cycle representative for the local flow conditions. The wave model is applied for a set of conditions to represent the yearly averaged sediment transport conditions. The choice of wave conditions is described in Section 3.4.

3.4. Representative wave conditions

For morphodynamic predictions, sediment transport is calculated for a typical tidal cycle combined with a representative wave condition, following Chesher *et al* (2005). This method uses energy considerations to derive representative wave height, which gives the same sediment transport rates for one wave condition as would result from modelling using a whole year's wave climate. This representative wave height H_{rep} is calculated for every relevant wave direction using:

$$H_{rep} = \left(\frac{\sum_{i=1}^n f_i H_i^{\vartheta}}{\sum_{i=1}^n f_i} \right)^{\frac{1}{\vartheta}},$$

in which H_i is the wave height of wave i from the wave climate that occurs with frequency f_i . Finally, ϑ is a power, which should be equal to 4.3 for situations with wave driven currents, where wave breaking is important or 2.4 for situations where only wave stirring is important. A value of 2.4 has been used in the present study as the sediment transport is due to currents with wave stirring.

From the open source UKMO wave data, which covers a period of 30 years, the offshore wave climate at the study area was extracted as presented in Table 3.1.

Table 3.1: Wave climate data, with counts in parts per 100,000

Direction (°N)→		346	16	46	76	106	136	166	196	226	256	286	316
↓Height, H _s (m)		15	45	75	105	135	165	195	225	255	285	315	345
0	to 0.5	2549	907	263	151	121	103	121	278	1407	1761	1315	1645
0.5	to 1	7872	3883	1953	1139	920	911	1238	2106	5001	3549	2535	3099
1	to 1.5	3586	2844	1790	742	445	512	886	2788	4860	2868	2279	1871
1.5	to 2	1466	1222	806	297	141	190	518	2138	3730	1576	704	1115
2	to 2.5	820	840	495	109	30	46	237	1144	2514	1222	432	701
2.5	to 3	473	350	270	23	9	9	60	610	1514	632	201	436
3	to 3.5	256	100	55		2		21	173	580	306	117	238
3.5	to 4	57	64					2	36	194	139	18	48
4	to 4.5	18	18					2	4	53	48	11	16
4.5	to 5									11	16	4	7
5	to 5.5										2		4
5.5	to 6										5		
6	to 6.5							2	278	1407	1761	1315	1645
Probability of occurrence (%)		17.1	10.2	5.6	2.5	1.7	1.8	3.1	9.3	19.9	12.1	7.6	9.2

Using the calculation above, the representative waves were determined (Table 3.2) from this wave climate. All waves with a direction between 226 and 255 degrees north are neglected as these waves propagate offshore and therefore any effects of the dredging will not influence the coastline. The remaining directions are grouped in pairs to derive 3 wave events that together represent 80% of the time. The remaining time is assumed to have a calm sea state.

Table 3.2: Wave model runs for input in the sediment transport model

Boundary wave condition			Wind condition		Sea levels
H _s	T _p	Dir	Speed	Dir	
(m)	(s)	(°N)	(m/s)	(°N)	(mCD)
1.39	6.2	350	10.7	350	1.50 and 3.56
1.47	5.9	41	11.6	41	1.50 and 3.56
1.74	6.7	231	12.3	231	1.50 and 3.56

Results for the wave modelling on the baseline bathymetry are presented in Figure 3.4 in the form of area plots of significant wave height from individual representative model runs.

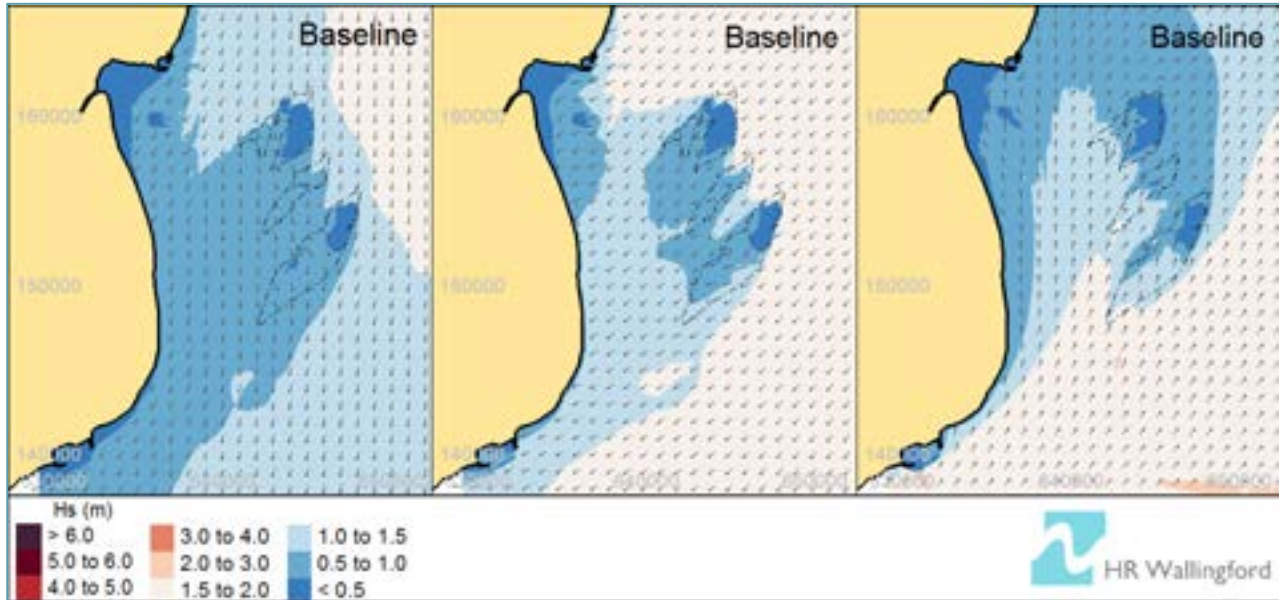


Figure 3.4: Baseline H_s at Mean Low Water with “representative” wind/wave conditions. Incident boundary wave directions from, left to right, 350°N, 41°N and 231°N.

4. Model results

The model simulations are presented by plotting the pattern and rate of sediment flux and by the predicted rate of bed change. The sediment flux is also summed over the simulated period to provide a view of the residual transport pattern – i.e. with the tidal variation removed.

The sediment modelling reveals that there is significant potential sediment transport in the area around Goodwin Sands. At the time of peak northward flow, the sediment transport is northward over the whole area. Contrastingly, during at the time of peak southward flow, whilst the sediment transport is southward in the deeper channels, very little transport is shown in the shallower areas between the sandbanks and the coast. The peak transport rates are about $2 \times 10^{-3} \text{ m}^2/\text{s}$, or $7 \text{ m}^3/\text{m}/\text{hour}$ (Figure 4.1 and Figure 4.2).

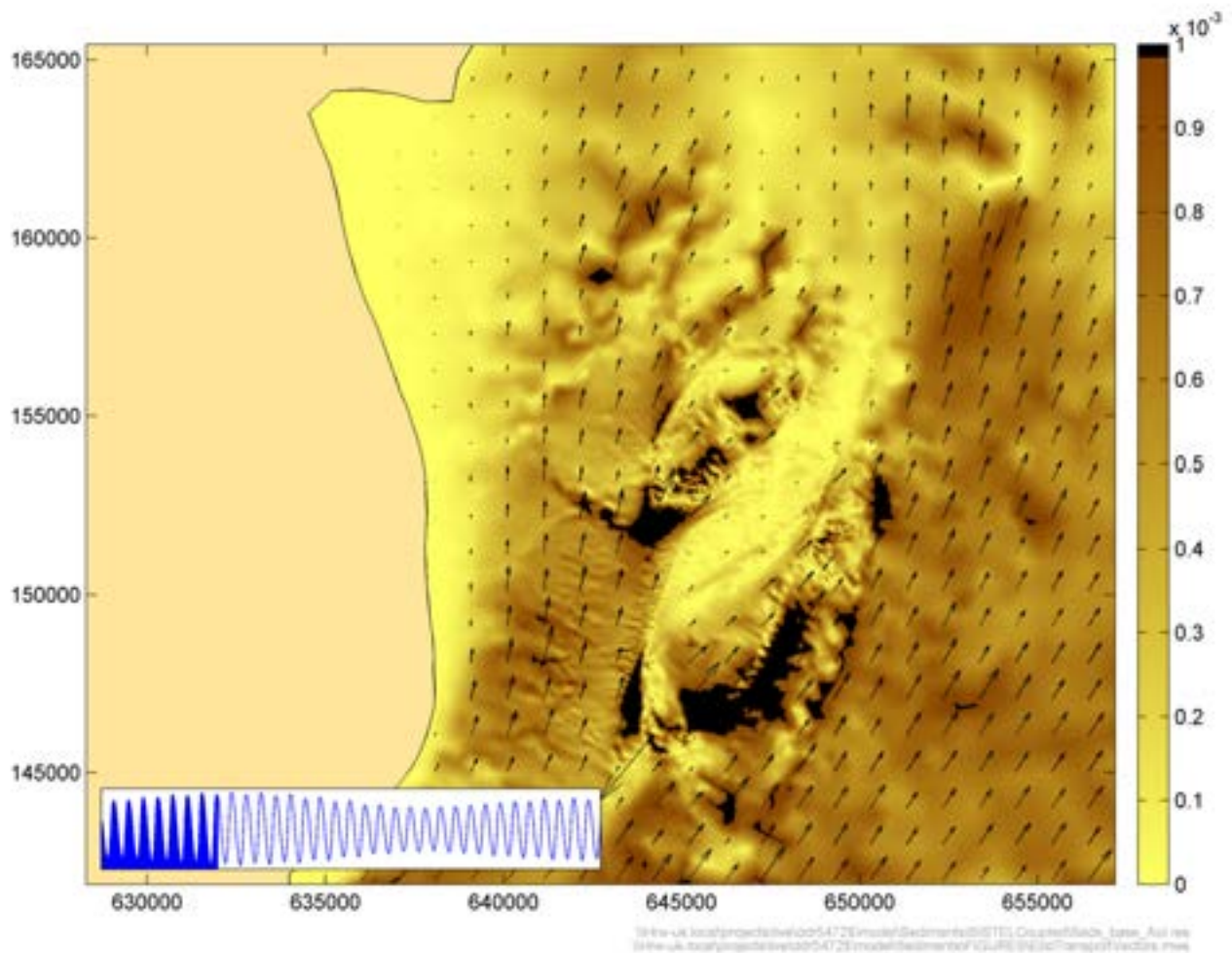


Figure 4.1: Peak northward sediment transport (colours and scaled vectors). The time series in blue shows the water level at the time of the plot

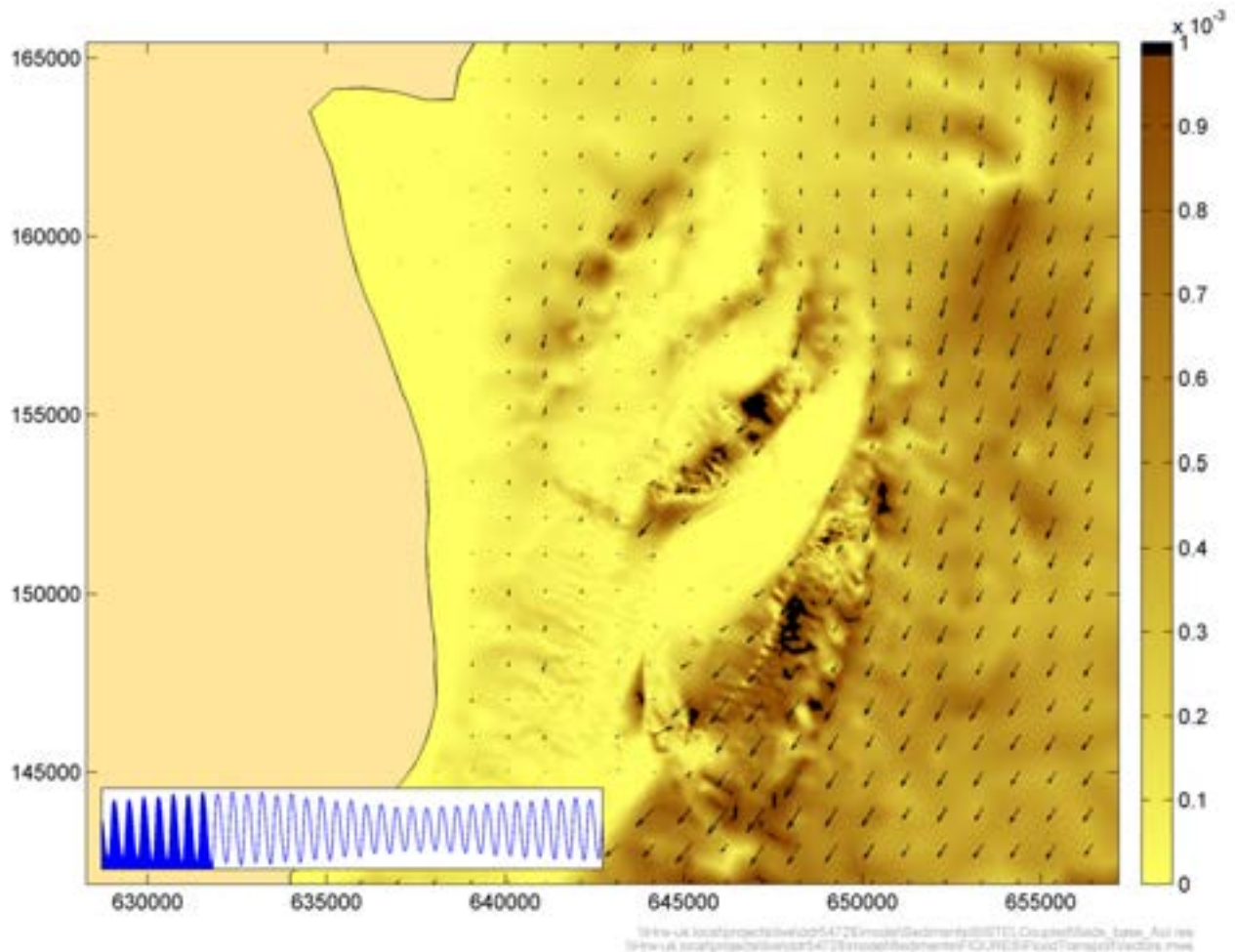


Figure 4.2: Peak southward sediment transport (colours and scaled vectors). The time series in blue shows the water level at the time of the plot

Averaged over the spring-neap cycle, the residual transport shows a sediment recirculation pattern around Goodwin Sands (Figure 4.3). The vectors show the sediment transport rates averaged over a spring-neap cycle, while the colours quantify the magnitude of the residual transport rates for the baseline situation. The highest values, near the slopes of Goodwin Sands, are about $0.0002 \text{ m}^2/\text{s}$, roughly 10% of the peak transport rates. In general, however, the residual transport rates are lower than this.

The pattern of residual sediment transport is dominated by the clockwise circulation around the sandbank system. This circulation cell is the driving mechanism for the sandbank maintenance. The model results indicate a potential sediment feed to the bank system from the south, with all residual transport going north. However, the actual amounts of material supplied are likely to be small, as there is very little sand present south of Goodwin Sands. To the north of the study area, the residual transport vectors are very small. This suggests that there is a little loss of material to the northwest of the banks, and potentially a small gain from the northeast.

As presented by Figure 4.3, comparison of the residual sediment transport vectors of the baseline case (white vectors) with those calculated for the dredged case (black vectors) show that the dredging has a very limited effect on the transport pattern. At the location of the dredging, the residual transport rates reduce, indicating that the system will compensate the deepening by depositing more/eroding less within the proposed dredge area (indicated by the green polygon). Additionally, small reductions of the residual transport rate are visible to the south, west and north of the dredging area. This suggests that minor changes in seabed composition may occur over time in this area due to reduced erosion or increased deposition. The important conclusion is that there are no significant deviations of sediment transport vectors from the baseline directions and hence the pattern of sediment circulation is not affected by the dredging.

The interpretation of the residual transport pathways is confirmed by the erosion and deposition pattern plotted below. Showing bed change is complicated as the same change could be an increase in erosion or reduction in deposition, depending on the background process occurring. The two figures below separate the changes in areas of baseline erosion (left frame) from areas of baseline deposition (right frame). Small but significant changes are predicted over the dredging location. These are mostly occurring as a reduction of the potential erosion rate (Figure 4.4, left frame) in areas where the model predicts erosion for the baseline situation. In locations where the baseline model predicts deposition, the impact is mostly a reduction of the deposition rate (Figure 4.4, right frame). By comparison of Figure 4.4 with Figure 1.2 it can be seen that no change in potential erosion or deposition patterns are predicted at the identified sensitive sites.

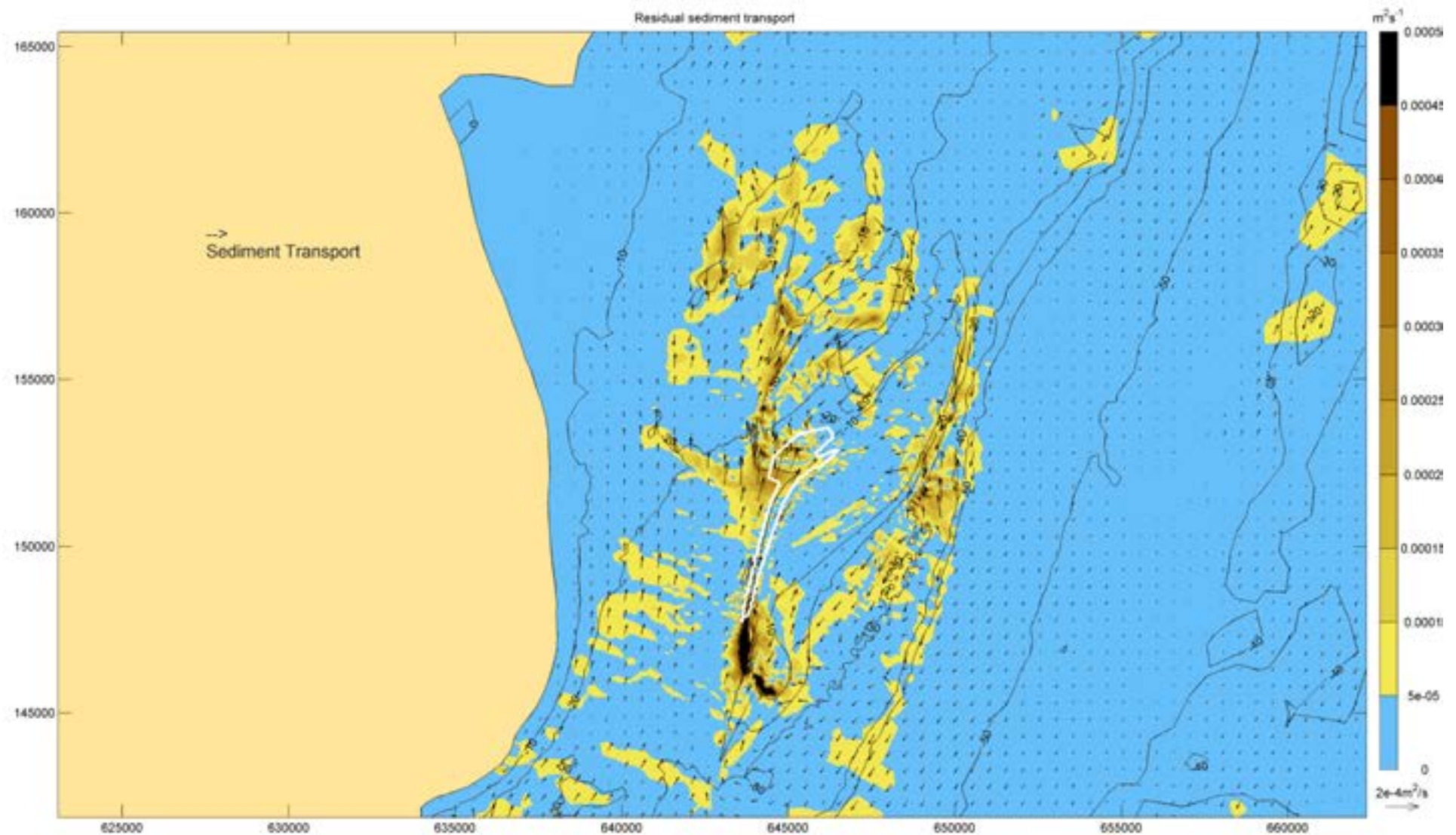


Figure 4.3: Residual sediment transport vectors and rates (colours). The isolines show the seabed levels, the dredging area is denoted by the white polygon

Source: \\hrw-uk.local\projects\live\ddr5472\$\model\Sediments\FIGURES\ TransportVectorsPolygon.png

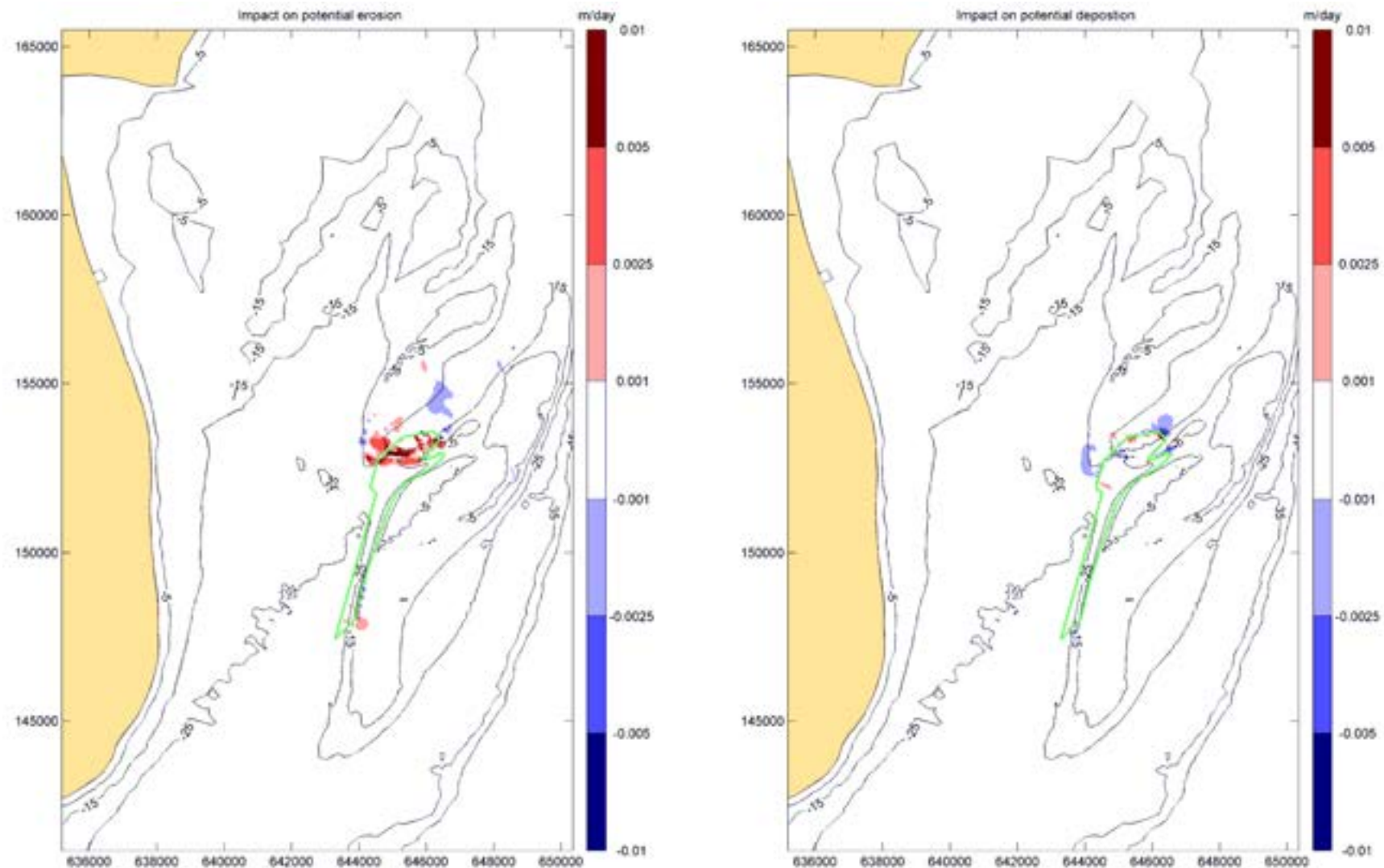


Figure 4.4: Changes in erosion (left) and deposition (right). Red indicates a larger increase in bed level due to the aggregate dredging, blue a lower increase in bed level

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5. Analysis of historical data analysis

Bathymetry data for the historical representations of the seabed were taken from earlier HR Wallingford (2008) studies of the Goodwin Sands. In these studies, three recent “epochs” were studied, i.e. times when one or more detailed bathymetric surveys had been carried out covering the whole of the South Goodwin Sands. These datasets were considered to provide a series of good snapshots of the continually evolving sandbank at different times over the last 30 years. After review of all the available data sets, the following data were obtained:

- 1986 – 1988 surveys as fair-sheets (scanned and provided in digital form);
- 1995 – 1998 surveys as fair-sheets (scanned and provided in digital form);
- 2006 charted data obtained as contour lines.

The 1986-1988 data were later discarded on the grounds that the data were sparser than the other surveys with a risk of unrepresentative results; following transect lines rather than providing a good coverage of the sandbanks. Figure 5.1 and Figure 5.2 illustrate the extent of the 1995-98 and 2006 data respectively.

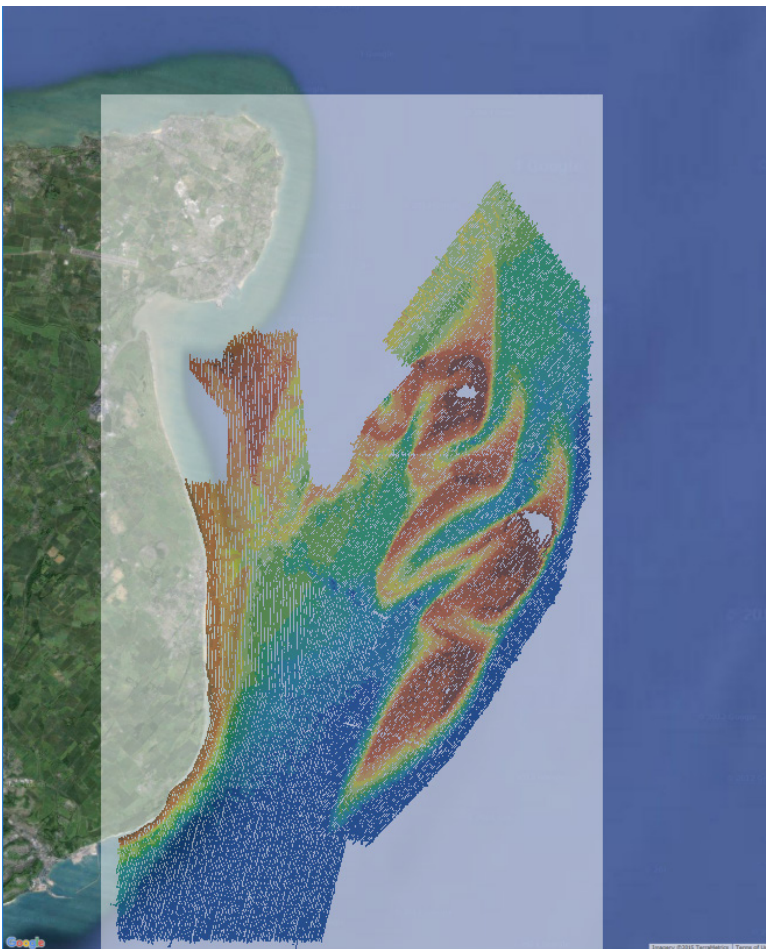


Figure 5.1: Spatial extent of the 1995-1998 TruDepth data, overlaid on Google imagery

Source: HR Wallingford (2008)

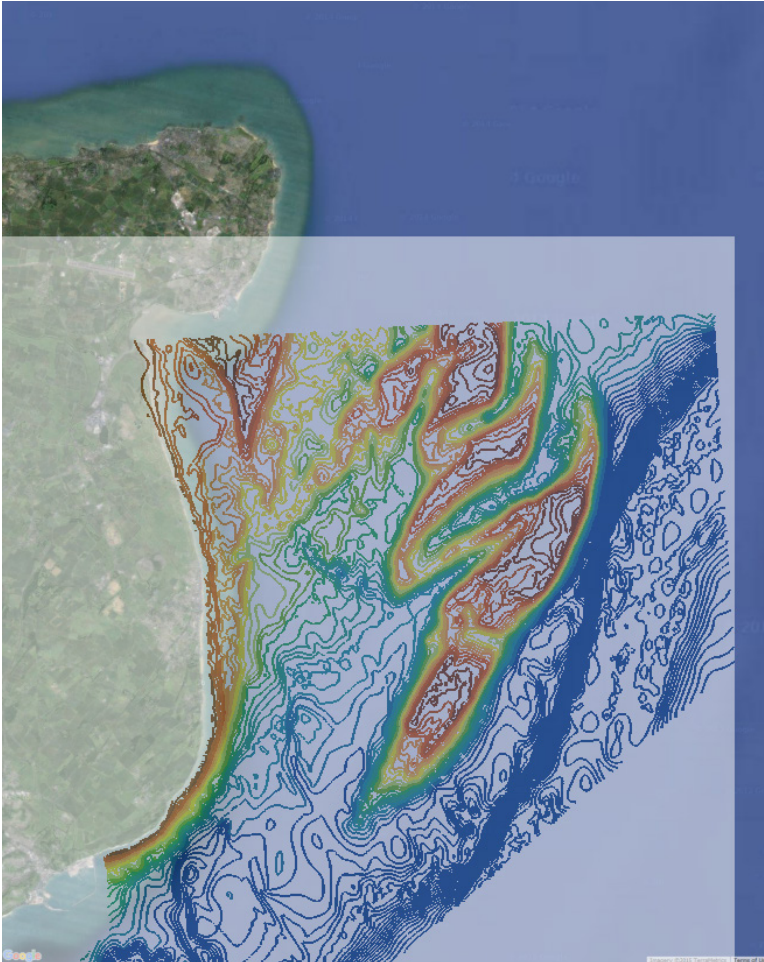


Figure 5.2: Spatial extent of the 2006 charted data, overlaid on Google imagery

Source: HR Wallingford (2008)

The data for each epoch were supplemented with nautical chart data for the rest of the model area, and the combination of the different sources of data was made such that more recent / resolved data always took precedence over older or less resolved data. The representation of the historical bathymetries, for use in the wave model, is shown in Figure 5.3. The baseline bathymetry is also reproduced in Figure 5.3 for reference.

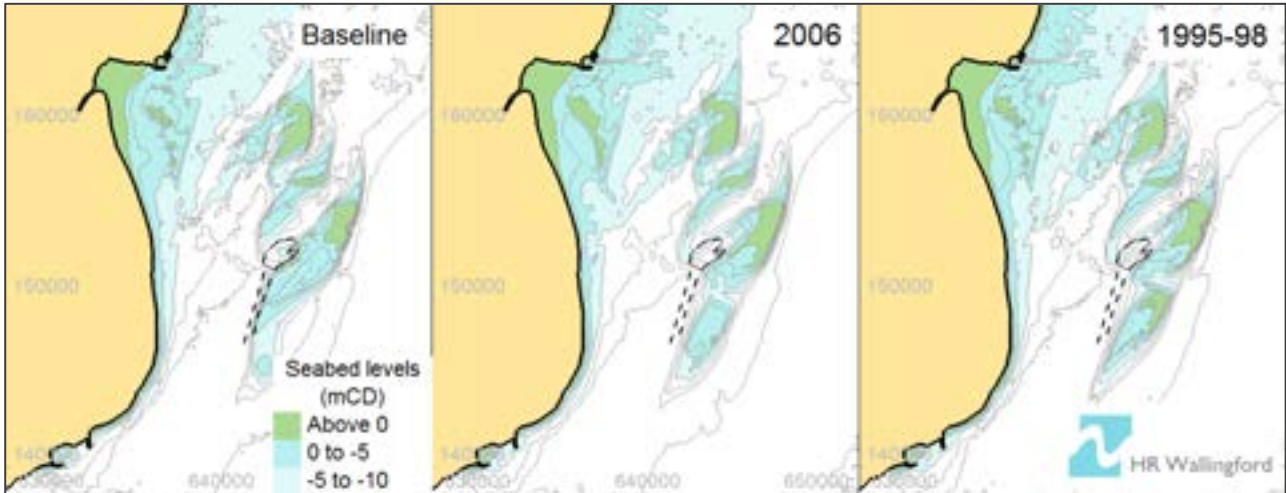


Figure 5.3: Baseline and two historical bathymetries used in the wave model

The historical bathymetry data from 1995 to the present show that the sandbank system is changing. From a configuration with four sandbanks, the system is changing into a three bank configuration where the two most southern banks are merging into one as the southernmost bank migrates north. On the southern end, potentially a new fourth bank has started to form, which is expected to grow in size over the next decade. The bathymetric changes observed are many meters in some locations.

On the northern end of the bank system, there is little change in the bathymetry, the observed differences can be explained by changes in resolution of the survey data alone. This suggests very little residual transport for this northern part as is shown by the sediment transport modelling.

The previous study of Goodwin Sands, by HR Wallingford (2008), suggested that the volume of the bank is stable, and possibly marginally increasing. The latest data supports that conclusion.

6. Bedforms analysis

The high resolution data collected during the summer of 2015 for the present project was assessed to identify bedforms. The input data used for the analysis was the raw data from the survey without adjustment to the vertical datum of Mean Sea Level as used for the modelling; hence the depths in the following figures are relative to Chart Datum.

Four types of bedforms can be identified: ripples, dunes related to wave action, flow related dunes and sandwaves. Large sandwaves are present on top of the bank (Figure 6.1). These sandwaves are visible all along the dredging area. The sandwaves generally are asymmetric, with the steeper side facing north, indicating that the residual transport is northward.

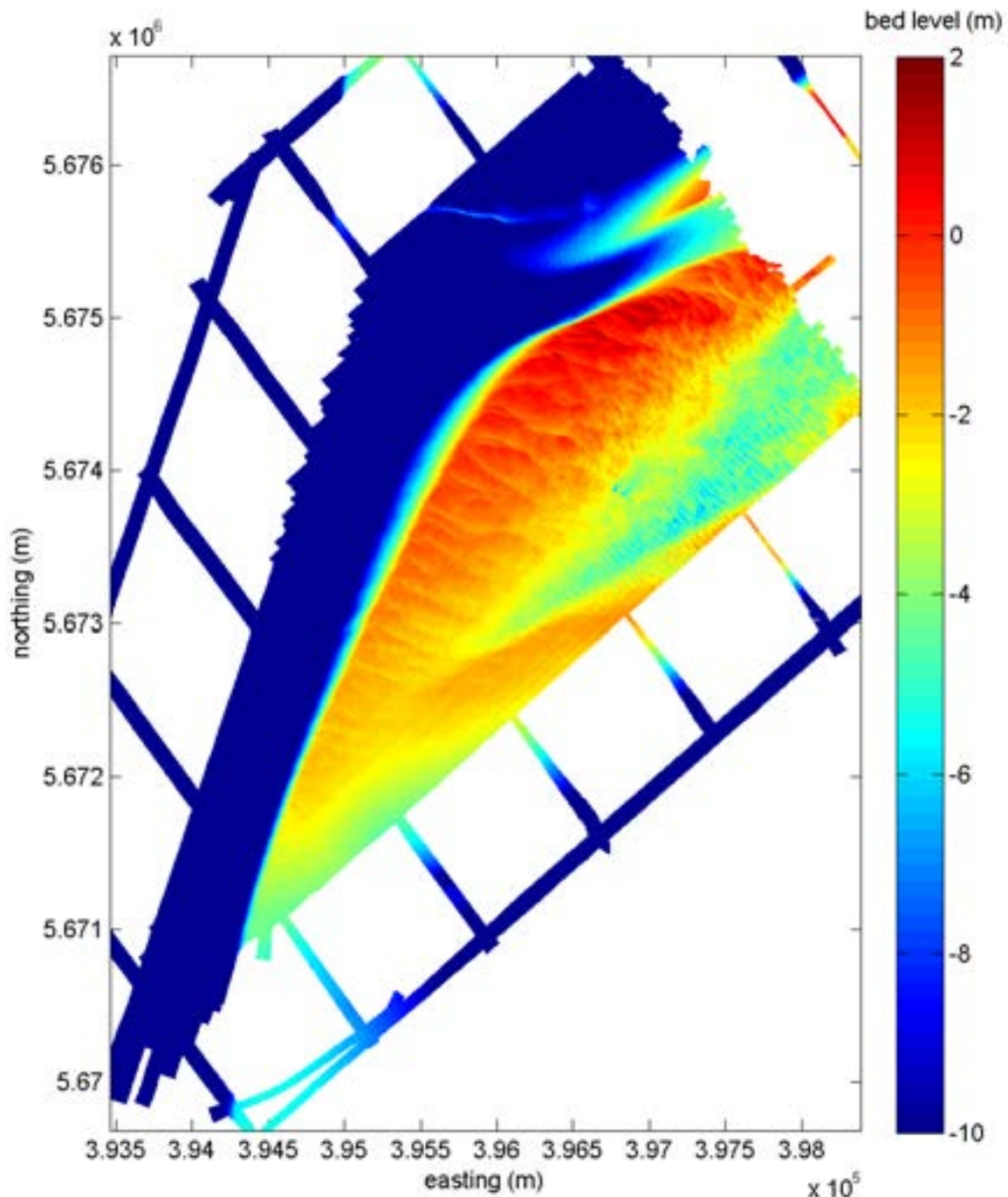


Figure 6.1: Bathymetry data showing asymmetric sandwaves on top of South Goodwin Sands

On the shallowest northern part of the bank, large dunes are visible, with a height of up to about 2 m (Figure 6.2). This suggests that there is a high rate of sediment transport due to fast (~ 1 m/s) tidal currents and wave action on the shallow parts of the bank. In some locations, superimposed on these dunes, ripples can be identified. Again, the asymmetry in the bedforms suggests that the sediment transport direction is

towards the north. However, the effects of storms on the dune migration direction and size will not necessarily be represented in the survey depending on the time elapsed since the most recent storm event before the survey.

Further to the south, flow related dunes are visible. Figure 6.3 shows the disturbance from the mean bed level, caused by the dunes. These dunes are 1.5 m to 2 m high, again suggesting high sediment transport rates. These bedforms are very irregular in size and shape, with longer bedforms to the west of the surveyed area and shorter ones to the east in shallower water. In between there are quite a lot of discontinuities in the pattern of bedforms. In general the orientation of the crests is slightly diagonal to the slope of the bank. This pattern suggests that the sediment transport is mostly along the slope, but with a significant component up the slope in the south-east corner of the plot. This is evidence that the residual transport pattern is maintaining the height of the sandbank in that there is a supply mechanism for sediment up the slope.

In general, the bedforms indicate that there is a high rate of sediment transport (indicated by the height of the dunes), with a residual transport towards the north up and over the sandbank.

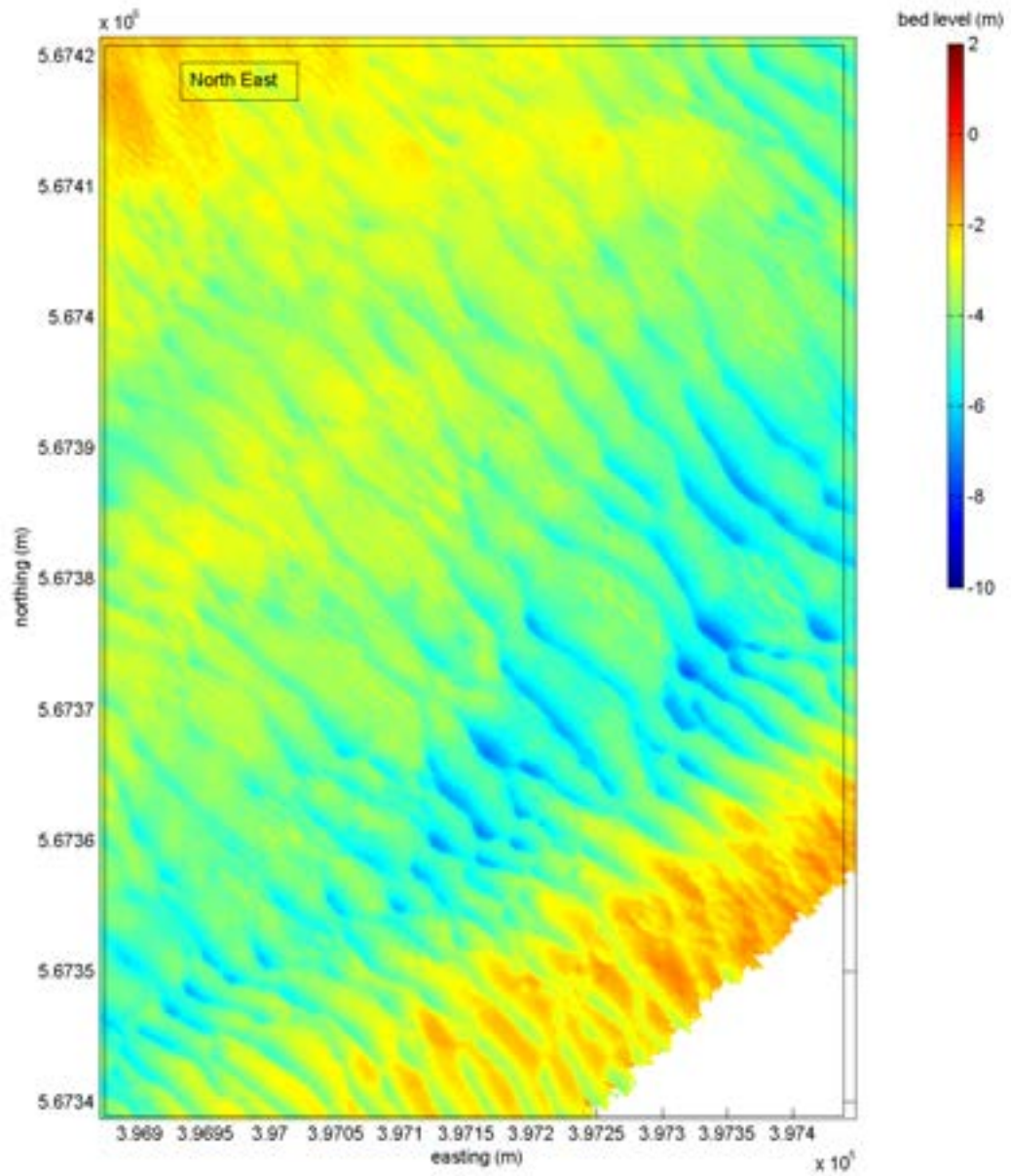


Figure 6.2: Large dunes visible on the shallow parts of South Goodwin Sands

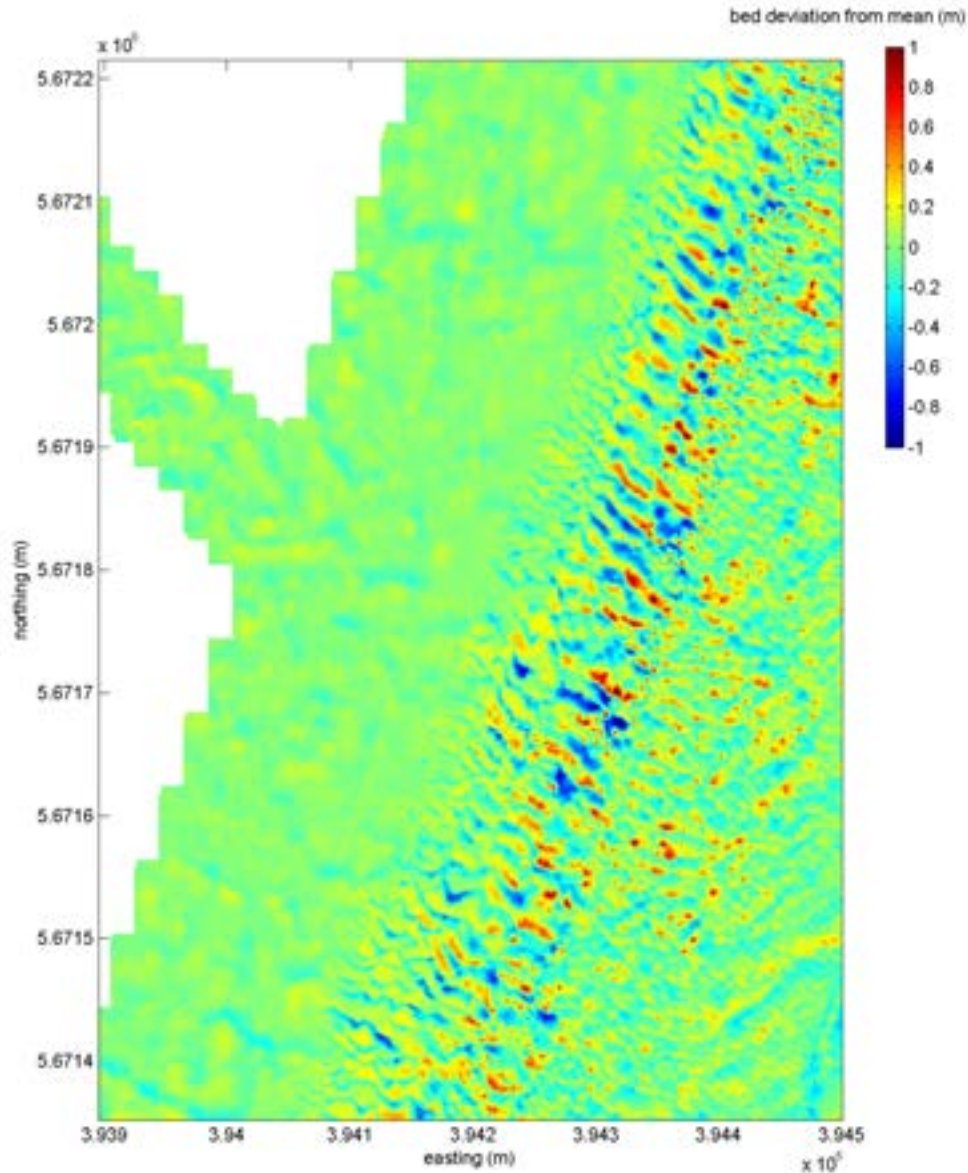


Figure 6.3: Flow related dunes on the slopes of South Goodwin Sands. The colours indicate the deviation from the mean bed level, caused by the dunes.

7. Discussion and conclusions

The sediment transport model SISYPHE has been used to calculate the sediment transport pattern around Goodwin Sands. The results from simulations with and without the proposed aggregate dredging have been compared to assess the impact of the dredging on the sediment transport and seabed changes.

The sediment transport results show a clockwise residual transport pattern around Goodwin Sands, with a northward drift to the west and a southward drift to the east of the banks. This recirculation cell maintains the presence of the sandbank system.

The model results also suggest that there is a small residual northward transport from the Straits of Dover, which feeds Goodwin Sands with additional material, although the amount of material available for transport there is considered to be small. Little or no sediment escapes from the banks to the north. This suggests that the volume of the banks is expected to be stable, perhaps even growing at a very slow rate. This finding provides some confirmation of earlier work (HR Wallingford, 2008) that concluded that the volume of the sandbanks is constant or gradually increasing.

The proposed aggregate dredging only causes minor and localised changes to the magnitude of the residual sediment transport rate and erosion/deposition pattern. The pattern of transport remains broadly unchanged with any slight changes predicted to be close to the proposed dredging. In most locations the changes are indicated by a reduction in predicted erosion rate within the dredging area, and a reduction of potential deposition rate in the deeper channel areas next to the proposed dredging area. No impact on the sediment transport processes which control the naturally changing form of the South Goodwin Sands, including the intertidal areas on the banks, is predicted.

8. References

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Appendices

A. Description of SISYPHE-HR

SISYPHE-HR is the state-of-the-art sediment transport model used at HR Wallingford. It combines the best of the SISYPHE sediment transport model, publicly available as part of the open source TELEMAC model suite (originally developed by the National Hydraulics Laboratory of the French Electricity Board – EDF-LNH), with additional formulations to incorporate HR Wallingford's extensive knowledge and experience of simulating sediment transport and bed evolution previously included in HR Wallingford's sediment transport model SANDFLOW-2D.

SISYPHE-HR can be applied as a stand-alone post-processor model, using input from flow (e.g. TELEMAC) and wave (e.g. TOMAWAC or SWAN) models. Alternatively, SISYPHE-HR can be run coupled to a TELEMAC flow model, whilst exchanging information on a time step level.

A.1. Theoretical background

SISYPHE-HR can model sedimentary systems containing very fine and fine sands (with median grain diameters d_{50} between 0.06 and 0.25 mm) which mainly move in suspension. The model can also be used to identify trends in the case of medium sand (d_{50} between 0.25 and 0.5 mm). If the sediment contains a high proportion of clay or silt particle sizes less than 0.06 mm, it would be more appropriate to use models capable of simulating mud transport, e.g. the DELWAQ mud transport model used at HR Wallingford.

The main factors controlling sand transport are:

- advection by currents;
- settlement under gravity;
- turbulent diffusion in all directions (but only the vertical component is of significance under most circumstances);
- exchange of sediment between the flow and the bed.

The study of sand transport generally is very complex but more so in the case of estuaries or coastal areas. This is because the water movements are continually changing, with the rise and fall of the tide, and there is usually a wide range of sediments on the bed and possibly areas without mobile sediment, leading to unsaturated and oversaturated loads in the water.

A.1.1. Sediment transport formulations

The evaluation of bed exchanges requires a formulation for the sediment transport rate. SISYPHE-HR offers the choice between a total load transport formula and a combination of a concentration equation with a bedload transport formula.

Within SISYPHE-HR, the preferred option is the SANDFLOW-2D approach for suspended load transport, which determines the concentration based on the suspended load formula of Soulsby-van Rijn combined with the bedload predictor of Soulsby-Van Rijn. Other available bedload transport predictors are the Meyer Peter-Muller and the Einstein Brown formula. Three alternative equations are available to prescribe the reference concentration: Zyserman and Fredsoe, Bijker, and Van Rijn. Alternatively, one can use one of the total load formulae: Soulsby-Van Rijn, Bijker, Bailard and Dibanjnia and Watanabe, Engelund-Hansen.

The choice of sand transport relation requires a careful consideration of the site conditions and the limitations of the transport formulae. It should be borne in mind that most relationships found in the literature are based on river or channel data where sediments are more narrowly graded than in estuaries. Usually, there is cohesive material present in estuary sediments and this may alter the transport properties. SISYPHE-HR has the capability to model such mixed sediment systems, however it is noted that the behaviour of mixed sediments is not well understood.

A.2. Model Application

The application of the model and interpretation of the results requires a good understanding of sand physics. Firstly it is important to choose representative values for the main parameters. Ideally these should be based on laboratory tests of actual sediment samples from the site.

This may be done using measured suspended sediment concentrations and/or measured transport rates. However, these concentrations and transport rates usually cover short periods and are prone to measurement uncertainty and randomness in the forcing conditions. Ideally, observed bathymetric changes are used as well, as these give a better indication of the long-term processes.

In addition, it should be appreciated that sand transport is not an exact science. Accordingly, whatever model is used, and whatever parameter values are chosen it is essential that results required an expert assessment. Provided this is done SISYPHE-HR provides a valuable engineering tool.

As with all models, it is preferable to calibrate and validate a model build with SISYPHE-HR. Even though SISYPHE-HR has been tested and validated against observations, each specific model application requires adaptation to the local conditions, by determining relevant sediment characteristics, choosing the best transport predictor and incorporating relevant hydrodynamics.

A.3. Model Inputs

SISYPHE-HR requires free surface elevation and flow velocities from a TELEMAC-2D flow model simulation (or depth-averaged values of from a TELEMAC-3D simulation), together with information describing the initial distribution of sand on the bed. If wave stirring is considered important, wave orbital velocities from an area wave model such as TOMAWAC or SWAN are required.

If available, a boundary data file specifying time-varying or constant sediment concentrations at the model open boundaries can be used, but often the preferred option is to use equilibrium conditions at the boundary whilst locating these boundaries sufficiently far away from the area of investigation. Other parameters required include the typical sediment grain size distribution, or a single median grain size. If available, other basic sediment properties, such as settling velocity and threshold shear stress for initiation of motion, can be used or alternatively these can be estimated using formulations included in the model.

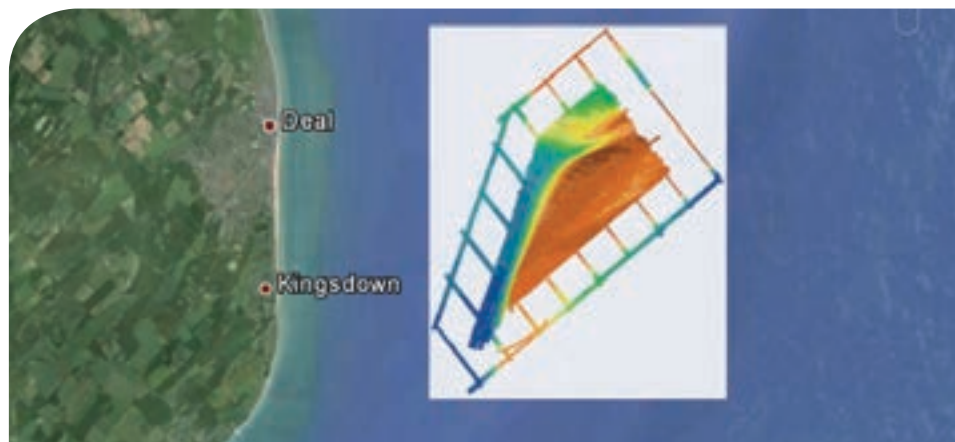
Data is input to SISYPHE-HR using ASCII data and steering files, and unformatted direct access results files from TELEMAC equivalent. The steering files are set up using the context sensitive editor included in the user interface. SISYPHE-HR can be applied as a stand-alone post-processor model, using input from flow (e.g. TELEMAC) and wave (e.g. TOMAWAC or SWAN) models. Alternatively, SISYPHE-HR can be run coupled to a TELEMAC flow model, whilst exchanging information on a time step level, including bed updating.

SISYPHE-HR is controlled using HR Wallingford's user interface PYXIS, which includes an extensive model logging system with error checking, version control and run description. This interface enhances quality control of the model set-up and simulations and guarantees that simulations can be reproduced in the future.

A.4. Model OUTPUTS

SISYPHE-HR produces a single binary output file containing relevant flow information, suspended concentrations for all grain size classes, the resulting bedload and suspended load transport rates, and the erosion-deposition patterns and instantaneous bed levels resulting from these transport rates at user selected intervals during the simulation.

The SISYPHE-HR model results can be presented graphically and where required analysed further using various plotting and post-processing tools available at HR Wallingford.



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Appendix 7.1

WFD Compliance Assessment

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1 Introduction

1.1 Introduction to the Water Framework Directive

The Water Framework Directive (Council Directive 2000/60/EC establishing a framework for community action in the field of water policy) (WFD) was adopted by the European Commission in December 2000.

The WFD requires that all EU Member States must prevent deterioration and protect and enhance the status of aquatic ecosystems. This means that Member States must ensure that all new projects do not adversely impact upon the status of aquatic ecosystems, and that historical modifications that are already impacting need to be addressed.

The Directive was transposed into law in England and Wales by the Water Environment WFD (England and Wales) Regulations 2003 and amended in 2015 to transpose elements of the Priority Substances Directive (2013/39/EU). As a result, the requirements of the WFD need to be considered at all stages of the planning and development process for all water bodies, including those that are man-made.

The consideration of the proposed Goodwin Sands aggregate dredging scheme under the WFD will, therefore, apply to all water bodies that have the potential to be impacted.

1.2 Implementation of the WFD

Classification schemes for both estuarine and coastal waters out to one nautical mile from the shore have been developed in response to the WFD. The scheme classifies the status of surface waters using information on the ecological, physico-chemical, chemical and hydromorphological quality of a body of water. For surface waters there are two separate classifications for water bodies; ecological and chemical. For a water body to be in overall 'good' status, both ecological and chemical status must be at least 'good'.

Ecological classification comprises:

- The condition of biological elements, for example fish;
- Concentrations of supporting physico-chemical elements, for example the oxygen or ammonia levels;
- Concentrations of specific pollutants, for example copper; and
- Largely undisturbed hydromorphology for high status.

Ecological status is recorded on a scale of high, good, moderate, poor or bad. 'High' denotes largely undisturbed conditions and the other classes represent increasing deviation from this natural condition, otherwise described as a 'reference condition'. The ecological status classification for the water body, and the confidence in this, is determined from the worst scoring quality element.

Chemical status is assessed by compliance with environmental standards for chemicals that are listed in the Priority Substances Directive (2013/39/EU). These chemicals include priority substances, priority hazardous substances, and eight other pollutants carried over from the Dangerous Substances and its Daughter Directives. Chemical status is recorded as 'good' or 'fail'. The chemical status classification for the water body is determined by the worst scoring chemical.

For water bodies that have been designated as heavily modified (HMWB) as a result of physical modifications, the Environment Agency classifies according to ecological potential rather than status. This requires application of the 'mitigation measures approach' for classifying HMWBs as recommended by UKTAG (2008). This approach first assesses whether actions to mitigate the impact of the physical modification are in place to the extent that could reasonably be expected. If this mitigation is in place, then the water body may be classified as achieving 'good' or 'better' ecological potential. If this level of mitigation is not in place, then the water body will be classed as 'moderate' or 'worse' ecological potential. Before an overall ecological potential classification is applied, the second step is for the results of the mitigation measures assessment to be cross-checked with data from biological and physico-chemical assessments.

The ecological potential will be changed where the Environment Agency has data for biological quality elements that show signs of damage from pressures other than hydromorphological alterations. For example, if the diatom or phytoplankton status is poor because of nutrient pressures,. To reflect this other pressure the water body will be labelled as 'Poor Ecological Potential'. This is also true where data are available for physico-chemical elements showing poor quality.

Some areas require special protection under European Directives, such as the revised Bathing Waters Directive (2006/7/EC) and the Habitats Directive (92/43/EEC). These Directives establish protected areas to manage water, nutrients and chemicals and ecologically significant habitats and species respectively – and where possible, have been brought in line with the planning timescales of WFD.

1.3 Purpose of this Appendix

This appendix has been produced to document the outcome of the WFD compliance assessment for the proposed Goodwin Sands aggregate dredging scheme. Within the document, the method used to undertake the assessment is presented in **Section 2**. Also included within this section is a short screening exercise undertaken to identify the WFD water bodies that need to be considered. The second stage of the assessment (Stage 2 Scoping) is presented in **Section 3**. This presents the results of the scoping assessment and summarises the WFD water body elements that require further consideration in **Section 4** (Stage 3 Detailed Assessment). **Section 5** summarises any mitigation or improvement measures that have been identified, either as part of scheme development or as a result of this assessment. **Section 5** then presents the outcome of the WFD compliance assessment and makes a statement as to whether the proposals are considered to be WFD compliant. References are presented in **Section 6**.

2 Method of Assessment

WFD compliance assessments require the assessment of whether a scheme (or element of a scheme) is compliant or non-compliant with the environmental objectives outlined in **Table 2.1**.

Table 2.1 *Environmental objectives in WFD for surface waters*

Objectives (taken from Article 4 of the WFD)	Reference Article
Surface waters	
Member States shall implement the necessary measures to prevent deterioration of the status of all bodies of surface water.	4.1(a)(i)

Objectives (taken from Article 4 of the WFD)	Reference Article
Member States shall protect, enhance and restore all bodies of surface water, subject to the application of subparagraph (iii) for artificial and heavily modified bodies of water, with the aim of achieving good surface water status by 2015 (updated to 2027).	4.1(a)(ii)
Heavily modified and artificial water bodies	
Member States shall protect and enhance all artificial and heavily modified bodies of water, with the aim of achieving good ecological potential and good surface water chemical status by 2015 (updated to 2027).	4.1(a)(iii)
Progressively reduce pollution from priority substances and cease or phase out emissions, discharges and losses of priority hazardous substances.	4.1(a)(iv)

As stated in **Table 2.1**, a default objective in all water bodies is to prevent deterioration in either the ecological and/or chemical status. For HMWBs/artificial water bodies, the prevention in deterioration relates to the ecological potential of the water body. Any activity which has the potential to have an impact (as defined by the biological, physico-chemical, chemical and hydromorphological quality elements listed in Annex V of the WFD) will need consideration in terms of whether it could cause deterioration in the ecological and/or chemical status or potential of a water body.

Where the assessment suggests that deterioration in water body status is likely to occur as a result of the scheme, measures to mitigate the likely impacts and therefore avoid deterioration are required. Where the assessment suggests that deterioration in class status could occur that cannot be mitigated, the requirement for an article 4.7 assessment will need to be considered.

2.1 Guidance used to inform the Assessment

The approach to the assessment will follow the requirements as set out in the 'Clearing the Waters' Guidance (Environment Agency, 2012) for schemes requiring dredging.

This guidance is separated into different parts in the early stages of the assessment depending on whether the project is new (i.e. the project started after 2009) or pre-existing (i.e. activities which started or were ongoing during the assessment periods 2006-2008 and to account for the latest round of River Basin Management Plans (RBMP), (2012-2014). As a result, the formal screening stage is only applicable to existing activities although a level of screening is also required for new activities. The guidance document recommends a four stage process which is outlined in more detail below.

2.1.1 Stage 1 Collation of baseline information

Stage 1 requires the collation of information regarding the water bodies that could be impacted by the proposed scheme and the baseline information that is available.

Identification of water bodies: Selection rationale

Water bodies that could potentially be affected by the scheme are identified using the Environment Agency's water body shapefiles and online WFD mapping system (Data Catchment Explorer, Environment Agency 2015). Water bodies are then selected for inclusion in the initial stages of the compliance assessment using the following criteria:

- All surface water bodies that could potentially be directly impacted by the scheme (i.e. those within the scheme footprint);
- Any surface water bodies further upstream that have direct connectivity and could potentially be affected by the proposed scheme; and
- Any surface water bodies downstream that have direct connectivity and could potentially be affected by the proposed scheme.

Baseline data

The information for this project is collated from the South East RBMPs (Environment Agency, 2009 and 2015).

2.1.2 Stage 2 Scoping

The scoping stage enables regulators and operators to determine the scope of the detailed assessment required to establish whether an activity could have an effect on one or more quality elements in a water body. Scoping therefore assists in defining which water bodies and quality elements could be affected. This assessment uses the scoping tables as prescribed in the 'Clearing the Waters' guidance (Environment Agency, 2012).

2.1.3 Stage 3 Detailed assessment

This stage of the assessment aims to assess whether the activity will have a significant non-temporary effect on one or more WFD quality elements scoped in at Stage 2, on a water body level. Additionally, the test is then to determine whether the activity is likely to affect a parameter sufficiently to lower its existing class status. For priority substances, the process requires the assessment to consider whether the activity is likely to prevent the parameter to achieve good chemical status.

The assessment will therefore establish whether the scheme will:

- Cause deterioration in a water body quality element.
- Cause deterioration in water body status.
- Prevent WFD status objectives being achieved.
- Prevent status objectives being achieved in any other water bodies.

Following the broad principles of the WFD, the scheme is considered to be non-compliant if any of the scheme components will cause WFD failure for any of the quality elements.

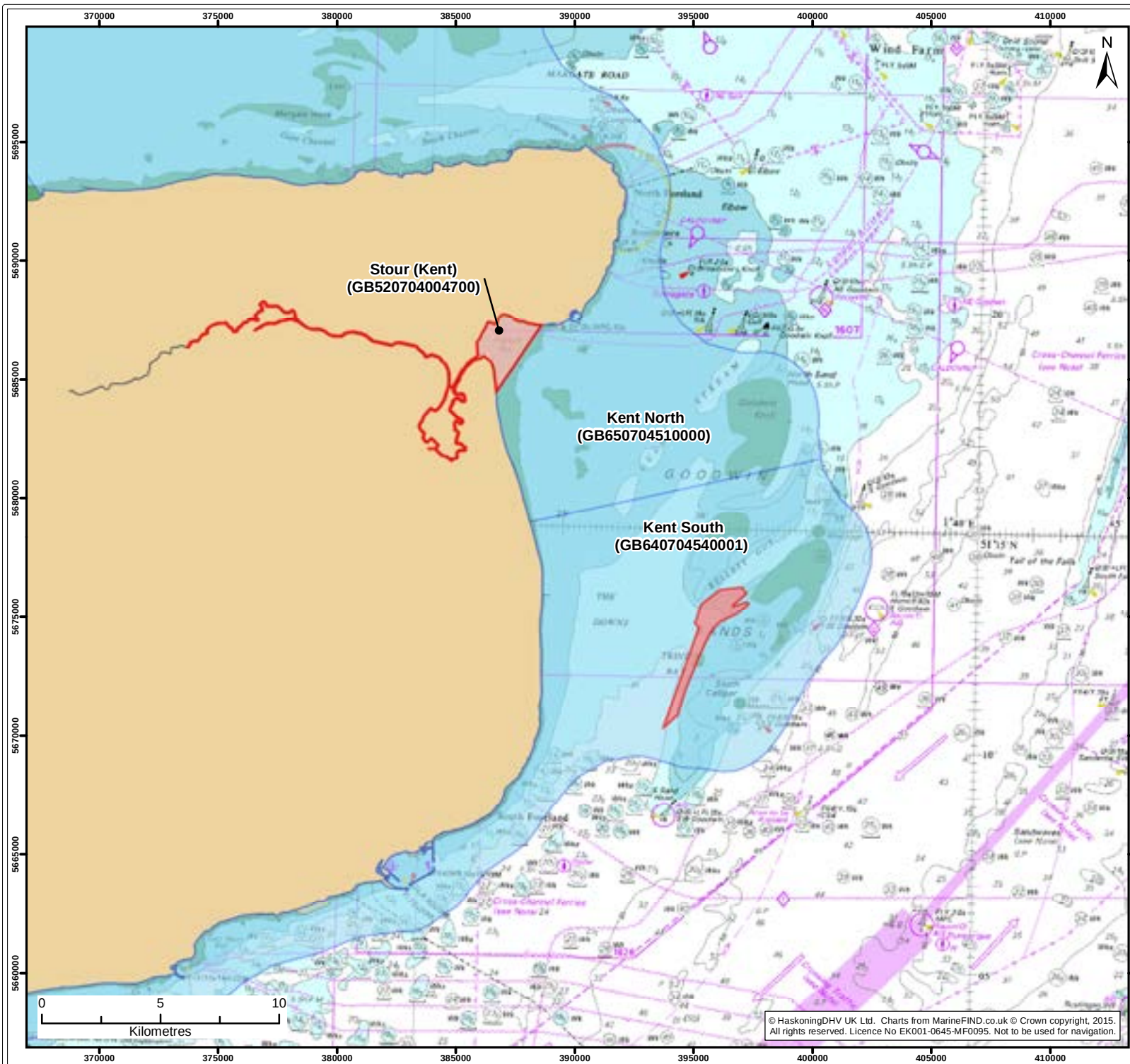
2.1.4 Stage 4 Identification and evaluation of measures

If it is established that an activity is likely to affect water status at water body level (that is, by causing deterioration or by preventing achievement of the WFD objective), or that an opportunity may exist to contribute to improving status at a water body level, potential measures to achieve either of these must be investigated. This stage considers these measures and, where necessary, evaluates the measures in terms of cost and whether that cost is disproportionate.

2.2 Water Bodies Screened in for Assessment

The Clearing the Waters guidance (Environment Agency, 2012) only requires scoping tables to be completed for those waterbodies in which dredging will occur. Where a pathway exists for an effect within the directly impacted water bodies, Stage 3 of the assessment will then need to consider water bodies in direct connectivity where an effect could occur. In order to determine which water bodies should be screened in for assessment, the extent of the proposed dredge area has been overlaid on the WFD water bodies. This is shown in **Figure 2.1**.

As a result, the Kent South coastal water body has been identified to take through the WFD compliance assessment process. Where information was not available in the recently updated RBMPs, data from the 2009 RBMPs (Environment Agency, 2009) have been used, and this is indicated by a '*'. **Table 2.1** summaries the information available for this water body.



Legend:

- Proposed Dredge Area
- WFD Estuarine waterbodies
- WFD Coastal waterbodies

Client:	Project:
Dover Harbour Board	Goodwin Sands Aggregate Dredging Environmental Statement

Title:
Water Framework Directive Water Bodies

Figure:	2.1	Drawing No:	PB2107/ES/021

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
01	11/12/2015	JE	DC	A4	1:225,000

Co-ordinate system: WGS 1984 UTM Zone 31N



Table 2.2 WFD water body scoped in for assessment alongside status classifications, whether designated as heavily modified, presence of protected areas and any mitigation measures that are in place.

Water body name and reference	Water body type	Area (km ²)	Current overall status	Record overall objective	If not at good status record all WFD parameters at moderate status or below or failing if contributing to chemical status	Is the water body designated as heavily modified or artificial? If so record reason*	Protected Areas*	Mitigation Measures in place*
Kent South (GB640704540001)	Coastal	248	Moderate	Good by 2027	Supporting elements (surface water)	Heavily Modified-Coastal Protection	Bathing Water Directive, Natura 2000 (Habitats and/or Birds Directive), Nitrates Directive	Manage disturbance, site selection (disposal of dredge material) (e.g. site selection), sediment management

2.2.1 Protected Areas

There are a number of Protected Areas listed within the WFD water body (see **Table 2.2** above). However not all require assessment. For example, the Nitrates Directive relates to actions associated with farming and land use and therefore are not considered further within this assessment. In terms of the Natura 2000 sites, a Discretionary Advice Service (DAS) request was submitted to Natural England in December 2015. This request set out the detailed information provided above to show that there would be no impact of the proposed aggregate extraction on the interest of the Outer Thames Special Protection Area (SPA) or birds attributed to the surrounding coastal SPAs (see **ES Section 11 – Ornithology** for further detail). A response was received on 21st January 2016 to confirm their agreement that a Habitats Regulation Assessment (HRA) was not required for the proposed scheme. Natural England's full response to the DAS request is provided in **Appendix 4.3 –Response to DAS Request**. As a result, no further consideration is provided here. The only Protected Areas to be considered further are therefore the designated bathing waters.

Figures showing the locations of the designated bathing waters are shown in **Figure 2.2**. **Table 2.3** summarises the information collated regarding these designations.

Bathing Waters

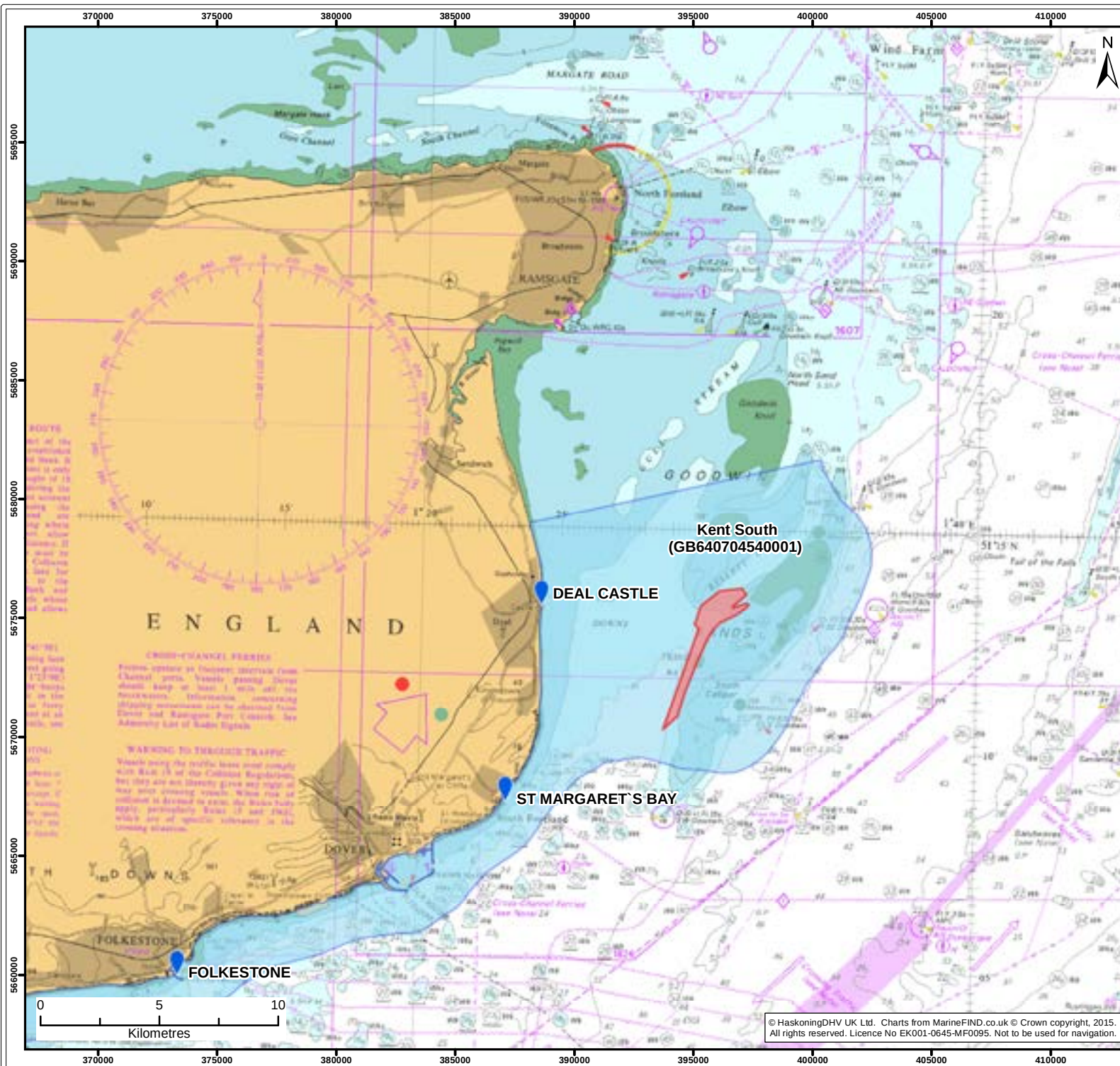
Although designated bathing waters come under the umbrella of protected areas they are still protected by their own legislation and the revised Bathing Waters Directive (2006/7/EC) categories (see below for details) were reported against for the first time in 2015. This new Directive set more stringent water quality standards and also put a stronger emphasis on beach management and public information. Parameters assessed comprise:

- *Escherichia coli*.
- Intestinal enterococci.

The revised directive put in place three new compliance categories – excellent, good and sufficient (the existing poor quality category remains). There is also a requirement to ensure that all bathing waters are of at least sufficient standard by 2015 and that appropriate measures have been taken to increase the number of bathing waters classified as excellent or good. It should be noted that classification is based on four years' worth of data and therefore monitoring for this directive commenced in 2012. Compliance information for the bathing waters in the study area is presented in **Table 2.3**. Since monitoring using the new parameters only commenced in 2012, classifications from before 2015 are listed as projected (information taken from Environment Agency website 'What's in your backyard', 2015).

Table 2.3 *List of bathing waters located within the WFD water bodies identified during screening.*

Protected Area	Type of protected area	Compliance information	Additional Information
Deal Castle	Bathing Water	2015 Excellent 2014 Excellent 2013 Good	The only natural water course is the Stour estuary which drains into Pegwell bay about 10 km to the north which can reach the beach. Within the Stour's catchment there are inputs from storm overflows that can occur when heavy rainfall overwhelms the sewerage system although improvements are in place to protect compliance. There are storm overflows in the vicinity of the bathing water which could impact on water quality during periods of heavy rain but all potential sewage related impacts have been designed not to impact on bathing water compliance. Bathing water potentially at risk from surface water run off during periods of heavy rain.
St Margaret's Bay	Bathing Water	2015 Excellent 2014 Excellent 2013 Excellent	There are storm overflows in the vicinity of the bathing water which could impact on water quality during periods of heavy rain but all potential sewage related impacts have been designed not to impact on bathing water compliance. Bathing water potentially at risk from surface water run off during periods of heavy rain.
Folkestone	Bathing Water	2015 Excellent 2014 Good 2013 Good	Pent Stream runs through the urban area of Folkestone and drains into Folkestone Bay to the west of the bathing water. This bathing water is therefore subject to short term pollution caused when heavy rainfall washes faecal material into the sea from livestock, sewage and urban drainage. All potential sewage inputs have been improved in order to protect compliance.



Legend:

- Proposed Dredge Area
- WFD Coastal waterbodies
- Designated Bathing Waters

Client:	Project:
Dover Harbour Board	Goodwin Sands Aggregate Dredging Environmental Statement

Title:
Designated Bathing Waters

Figure: 2.2	Drawing No: PB2107/ES/022

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
01	11/12/2015	JE	DC	A4	1:225,000

Co-ordinate system: WGS 1984 UTM Zone 31N



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3 WFD Compliance Assessment: Scoping

The aim of this section is to consider whether the screened in water body could be impacted upon by the proposed scheme and highlight the quality elements within the water body that could be impacted. This assessment therefore determines the scope for the detailed assessment (Stage 3) if required. The results of Stage 2 are presented in **Table 3.1**.

Table 3.1 Results of Stage 2 for dredging within the Kent South Coastal Water body using the Clearing the Waters Guidance (Environment Agency, 2012)

WFD parameter	Classification	Dredging triggers for potential effects on WFD parameters at water body level	
		Screening trigger	Include in detailed assessment?
Biological elements			
Phytoplankton	Composition, abundance and biomass	In guidance this element is screened out as dredging is generally considered to only have very transient effects on this parameter	No
Other aquatic flora (angiosperms, saltmarsh, seagrass, macroalgae, seaweed)		In guidance triggers are split into three categories: - Will the dredging directly remove intertidal area or is it within 10m of Mean Low Water Springs (MLWS) (if yes, further assessment is triggered)? Response: Dredging can only be undertaken in depths of water in which a Trailing Suction Hopper Dredge (TSHD) can work. This was considered during the site selection exercise undertaken to inform the optimum location (see Section 2 - Description of the Proposed Scheme). As a result of the selection process, dredging will not be undertaken within 10m of MLWS. - Proportion of water body impacted by dredging activity will be >5% (formula to be applied 1.5 x dredge footprint) – if yes, further assessment is triggered. Response: No, the percentage area over which the dredging will occur using the above formula is 2.4% - High level assessment (made up of a number of elements, need to score 2 or more to trigger scoping) - Is the dredging dispersive or non-dispersive? Response: The dredging is non-dispersive (Score 0). - When will the dredge occur (score 1 if March to October, score 0 if November to February). Response: The dredging will occur within March to October and therefore a score of 1 has been	No
Benthic invertebrate fauna			
Fish fauna (transitional only)			

WFD parameter	Classification	Dredging triggers for potential effects on WFD parameters at water body level	
		Screening trigger	Include in detailed assessment?
		allocated (Score 1) TOTAL SCORE: 1	
Hydromorphological elements			
Depth variation	-	The triggers in guidance refer to the proportion of water body impacted. If greater than 5% then further assessment is required. Response: No, the percentage area over which the dredging will occur is 2.4%	No
Bed	Quantity (transitional only), structure and substrate		
Inter-tidal zone structure		Will the dredging directly remove intertidal or is it within 10m of MLWS? Response: See response above – No.	No
Dominant Currents (coastal water bodies only)	Direction	Is the dredge a significant change to a maintenance dredge? Response: This is dredging for aggregate and therefore is not maintenance dredging.	Yes
Freshwater flow (transitional only)	-	In guidance this element is screened out as dredging is not generally considered to have an effect on this parameter. Additionally, this assessment considers coastal waters only.	No
Wave exposure	-	Will the dredge take place in shallow water? Response: No, see above regarding site selection exercise and optimisation of location for dredging in deeper areas therefore it is concluded that dredging will not be undertaken in shallow water.	No
Chemical and physical-chemical elements			
Transparency		Triggers relate to the percentage of water body to be impacted (i.e. is it >5%), time of year to be dredged and whether dredging is dispersive. Response: The percentage area over which the dredging will occur is 2.4% and the technique is non-dispersive. However the dredge will take place within March to October and therefore a score of 1 is allocated (Score 1) TOTAL SCORE: 1 (scoping is required if score is over 1.5).	No
Thermal conditions		Screened out in guidance as dredging will not impact on thermal conditions.	No
Oxygenation conditions		Triggers relate to the percentage of water body to be impacted (i.e. is it >5%), time of year to be dredged and whether dredging is dispersive. Response: The percentage area over which the dredging will occur is 2.4% and the technique is non-dispersive. However the dredge will occur within March to October and therefore a precautionary score of 1 is allocated (Score 1) Additional points should be allocated where sediment chemical oxygen demand is an issue, if dredging is near to raw sewage inputs and where oxygen issues have been identified within the water body. Further	No

WFD parameter	Classification	Dredging triggers for potential effects on WFD parameters at water body level	
		Screening trigger	Include in detailed assessment?
		assessment is required where 4 points or more are scored. Response: In relation to these additional issues, dredging will not occur in the vicinity of raw sewage discharges and oxygenation issues within this water body have not been recorded. Significant impacts on the dissolved oxygen concentrations on the water body associated with dredging are therefore not anticipated. TOTAL SCORE remains at 1.	
Salinity		Screened out in guidance	No
Nutrient conditions		Is the dredge a capital or new dredge? Response: the dredge is a new aggregate dredge however; the material to be dredged is coarse sand and is not located close to potential sources of significant nutrient inputs. As a result, this quality element is scoped out.	No
Specific pollutants			
Sediment quality	Cefas Action Levels	Sediment quality results are presented in Section 7 – Marine Water and Sediment Quality . There is only one Cefas Action Level 1 exceedance for arsenic at site 1 within the material to be dredged and no Cefas Action Level 2 exceedances.	No
Protected Areas			
Natura 2000 (Habitats and/or Birds Directive), Nitrates Directive/Bathing Waters Directive.	Relevant legislation associated with each protected area	There is the potential for any dredging plume to reach the designated bathing waters. In relation to Natura 2000 sites, Natural England confirmed that HRA was not required as a result of a DAS request. As a result, no further consideration of Natura 2000 sites is required as part of this WFD assessment.	Yes (Bathing Waters)
Mitigation Measures Assessment			
Manage Disturbance	Site selection (dredge material disposal) (e.g. avoid sensitive sites) Sediment management	The proposals to dredge the material are a one off event and therefore will not cause ongoing issues with the ability to achieve the mitigation measures in place as identified in this water body.	No
Site selection (dredge material disposal) (e.g. avoid sensitive sites)			
Sediment management			

Table 3.2 summarises the outcome of the scoping assessment as provided in **Table 3.1**. Where a cross (✖) is included, no impact on this quality element is anticipated and therefore the quality element is scoped out from requiring further assessment. Where the symbol is a tick (✓), this indicates that further assessment is required.

Table 3.2 Summary of outcome of Stage 2

Water Body	Biological elements	Hydromorphological elements	Physicochemical	Specific Pollutants	Protected Areas	Mitigation Measures assessment
Kent (south) water body	x	✓ (dominant currents)		x	✓ (Bathing Waters)	x

4 Stage 3: Detailed Assessment

4.1 Purpose of this section

This section presents the results of the detailed compliance assessment that has been undertaken for the coastal water body Kent South. It considers potential impacts on water body status in more detail, recommends measures to mitigate any predicted impacts where required, and makes a clear statement about whether deterioration in water body status would occur.

4.2 Kent South Water Body (GB640704540001)

4.2.1 Impacts on quality elements

The main risks to the WFD water body during the scheme for this water body have been identified as:

- Potential changes to hydromorphological supporting parameters associated with dredging (dominant currents); and
- Potential changes to Protected Areas (Bathing Waters).

4.2.2 Barriers to achieving good status/potential

In terms of dominant currents, changes in bathymetry as a result of dredging may alter the magnitude and direction of tidal currents both locally and potentially across a wider area. This could in turn alter natural processes which could have direct effects on biological quality elements. **ES Section 6 – Coastal Processes and Hydrodynamics** of the ES provides the evidence relevant to the assessment of this quality element. A short summary is therefore provided here with further detail available in both the ES Section and **Appendix 6.2 – Tidal Flow Modelling**.

To assess the potential changes to this parameter, hydrodynamic modelling was undertaken using an existing calibrated tidal flow model of the eastern English Channel and southern North Sea refined to provide enough resolution around Goodwin Sands. The model was run for pre-dredging and post-dredging bathymetries to predict the footprint of the effect on tidal currents over a 15-day spring-neap tidal cycle. The resulting output indicated that there were no directional changes and that the predicted changes in tidal current velocities are so small that they would still be within the range required for the current sediment habitats to remain unaffected. Closer to the coast, no changes are predicted. As a result, large permanent changes to the natural processes forming the existing habitats within the water body are not anticipated.

4.2.3 Impacts on other water bodies

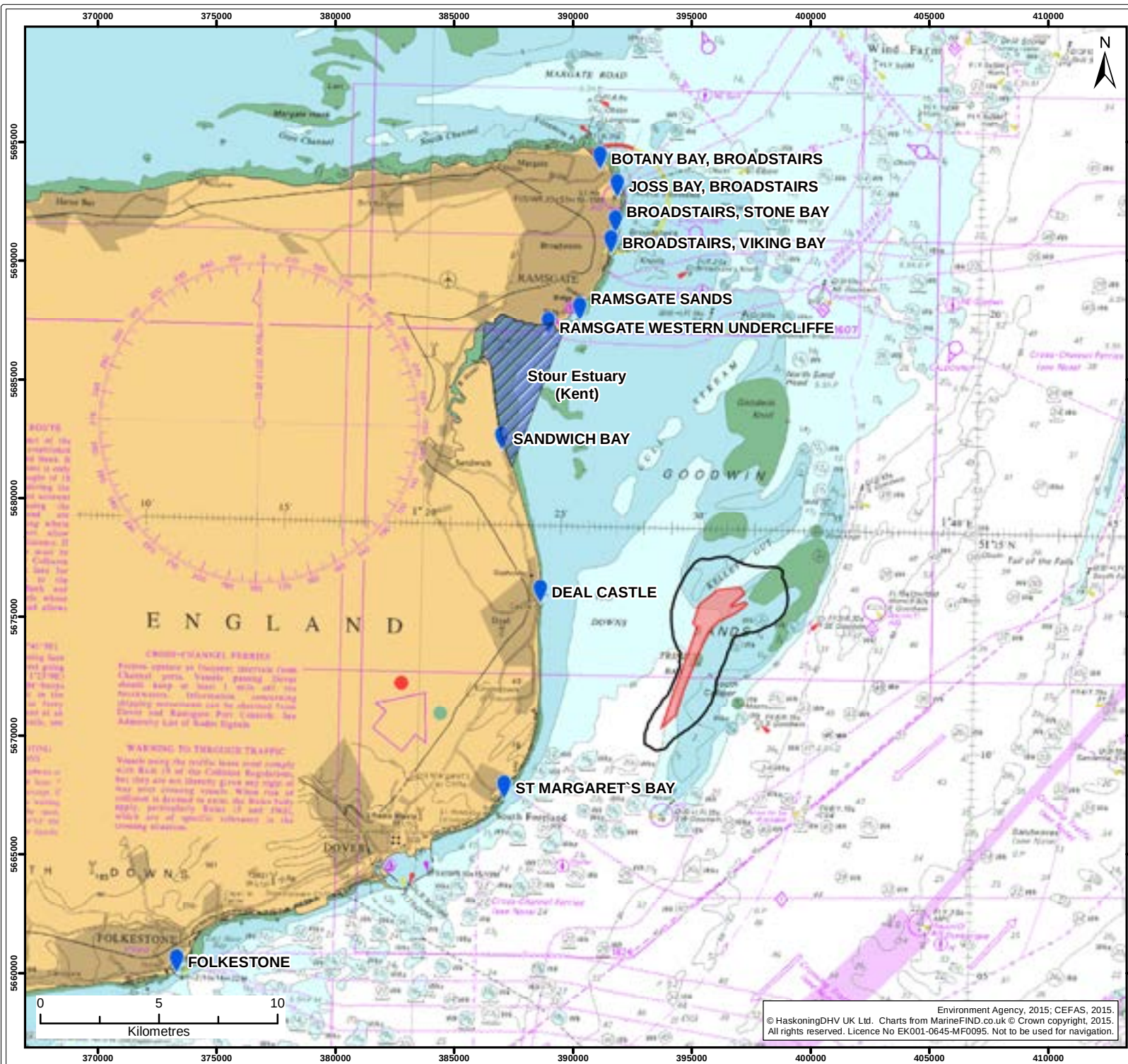
Because the risks to the water body are small in scale and entirely within the coastal water body, no impacts to other water bodies are anticipated.

4.2.4 Impacts on Protected Areas

To assess the potential extent of the sediment plume from the dredging, again hydrodynamic modelling was undertaken. This is relevant to assessing the potential effects on bathing waters since it is the sediment plume which could impact on bathing water compliance parameters.

The modelling uses a high level approach to identify the footprint of potential impact arising from dredging plumes over the entire dredging operation. Footprints of impact are established for the fine sediment ($D < 63 \mu\text{m}$) and fine sand ($63 \mu\text{m} < D < 250 \mu\text{m}$) fractions which are released in the dredging overflow. Further detail is provided in **ES Section 6 – Coastal Processes and Hydrodynamics** and **Appendix 6.4 – Sediment Dispersion Modelling**.

Figure 4 shows the peak concentration contour associated with the fine sediment and fine sand released by the dredging against the locations of the designated bathing waters. The results indicate that the plume does not extend to the coastline where the bathing waters are located. As a result, changes to bathing water quality are not anticipated and therefore the ability of the bathing waters to meet compliance targets will not be impacted by the proposed scheme.



Legend:

- Proposed Dredge Area / PIZ
- Secondary Impact Zone (SIZ)**
- 10mg/l
- Designated Shellfish Waters
- Designated Bathing Waters

Client:
Dover Harbour
Board

Project:
Goodwin Sands
Aggregate Dredging
Environmental Statement

Title:

Bathing and Shellfish Water Designations

Figure:

4

Drawing No:

PB2107/ES/029

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02	16/02/2016	JE	DC	A4	1:225,000
01	16/12/2015	JE	DC	A4	1:225,000

Co-ordinate system: WGS 1984 UTM Zone 31N



Environment Agency, 2015; CEFAS, 2015.
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5 Stage 4: Mitigation Measures and Monitoring

5.1.1 Mitigation/improvement measures

This assessment does not identify any further mitigation required. This is predominantly because mitigation has already been built into the proposals by ensuring the proposed dredge occurs in the least environmentally sensitive location. Specifically, GIS software was used to overlay datasets to identify a proposed dredge area with the following characteristics:

- Includes adequate resource (sand) thickness to supply the required volume of aggregate, including contingency for the event of new constraints becoming evident during the scheme;
- Avoids intertidal areas that could be used by seals as haul out sites;
- Avoids shallow water areas that are not accessible for TSHDs;
- Avoids protected and charted wrecks;
- Avoids areas where intensive fishing effort occurs; and
- Avoids Annex I biogenic reef habitats. Data sources used to inform this were the JNCC Potential Annex I reef habitat dataset (JNCC, 2015), Defra Goodwin Sands rMCZ Post-survey Site Report (Defra, 2015), the scheme specific ecological survey results (MESL, 2015) (see **ES Section 8-Benthic Ecology**) and a scheme specific review of the exploration survey sidescan data for reef habitat features (see **Section 8**).

The dredger will be equipped with a Global Positioning System (GPS) to enable accurate positioning and dredging within the licenced area. Dredgers are also fitted with an Electronic Monitoring System (EMS) which records the vessel's position every 30 seconds during dredging operations. The data from the EMS system is monitored by the contractor and the MMO to ensure dredging operations are undertaken accurately. In accordance with Marine Minerals Guidance 1 (ODPM, 2002) and established industry practice it is proposed that an average 50cm capping layer will be left in place following completion of dredging. This capping layer, which will match the pre-dredge seabed surface, facilitates the re-colonisation and recovery of benthic communities (JNCC and Natural England, 2011).

5.1.2 Alternatives

As part of scheme development, alternatives to dredging at Goodwin Sands were considered. **Table 5.1** summaries these options and the reasoning behind why they were not considered suitable. Further detail is provided in **ES Section 2 – Description of Proposed Scheme** and **Appendix 2.2 – Consideration of Alternatives**.

Table 5.1 Summary of options considered and reasons for not carrying the option forward

Option	Reason why not chosen	Summary
Use of material from licenced commercial aggregate dredging sites	Goodwin Sands is located in close proximity to the DWDR site at Dover Harbour (approximately 12km to the north east). As alternatives to Goodwin Sands, the closest marine aggregate extraction areas to Dover Harbour are situated at South Hastings to the south west (65km) and Longsand to the north (68km).. Therefore sourcing aggregate from a commercial marine aggregate site would require the transport of material over greater distances. This has environmental and economic implications for the scheme.	Ruled out due to distance to site and therefore environmental (air quality) and economic factors.
Use of material from land based	The use of land based sources of aggregate would require the transportation of material from the aggregate site to the DWDR	Ruled out due to road traffic, implications for air

Option	Reason why not chosen	Summary
sources	site by road. The local and regional road network in and around Dover already experiences high volumes of road traffic and the DWDR project is seeking, where possible, to minimise the road traffic movements as far as possible. This option will also have air quality and noise implications in addition to the increase in cost.	quality and noise in addition to significant economic implications.
Use of material from navigational dredging	Suitable schemes not identified – additionally material to be dredged as part of the DWDR scheme is not considered suitable for reclamation purposes due to physical characteristics of the material.	No suitable schemes and dredge arisings from DWDR are not suitable for reclamation.
Use of recycled and secondary aggregates	Secondary and recycled aggregates are the by-products of various works and operations and are derived from a wide range of sources not commonly used as fill material for land reclamation works. Additionally, consultation with both the Environment Agency and the local council indicates that there are no facilities close to Dover that would be able to supply the quantity of aggregates required. As a result, one or a combination of these recycled and secondary sources of aggregates will not be able to provide the necessary size and quantities of materials required for the DWDR scheme.	Unlikely to be a viable option due to quantities of material required.

5.1.3 Summary of assessment

The early stages of the WFD compliance assessment (screening and scoping) indicated that the proposed scheme has the potential to affect one surface water body in the area; the Kent South coastal water body. All quality elements were scoped out with the exception of Protected Areas (Bathing Waters) and dominant currents, which were considered in further detail in Stage 3. Detailed Assessment hydrodynamic modelling undertaken to inform the EIA provides evidence to confirm that for bathing waters, the predicted sediment plume remains offshore in close proximity to the dredge area and does not extend to the coastline where the bathing waters are located. As a result, aggregate dredging at Goodwin Sands will not threaten the ability of the bathing waters to achieve compliance under the Revised Bathing Waters Directive.

With respect to potential effects on dominant currents, the hydrodynamic modelling also predicts that there are no changes to overall current direction and that the change in current velocity is so small that it is unlikely to affect the formation of the existing bedforms, above the natural tidal processes. Additionally, closer to the coast, impacts on dominant currents are not predicted. As a result, large scale changes to bedforms and natural sediment transport processes are not anticipated.

Available mitigation measures and alternatives to the scheme have also been considered. To summarise, mitigation measures are possible and include a number of within scheme design elements, such as the avoidance of specific interest features within the agreed dredge area and a number of best practice mechanisms such as the sediment capping layer to leave viable habitat for marine ecological features. Alternatives to dredging aggregate from Goodwin Sands have been ruled out for a number of reasons relating to economic factors, availability of material and the potential for increased environmental impacts.

Overall, therefore, it is considered that the proposed scheme at Goodwin Sands will be compliant with the requirements of the WFD.

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Appendix 8.1

Goodwin Sands Exploration Area – Benthic and Epibenthic Characterisation Report

GOODWIN SANDS EXPLORATION AREA

Benthic and Epibenthic Characterisation Report

December 2015

Prepared for

Royal HaskoningDHV

On behalf of Dover Harbour Board

By

Marine Ecological Surveys Limited



Report Warranty

This report has been prepared with due care and diligence and with the skill reasonably expected of a reputable consultant experienced in the types of work carried out under the contract and as such the findings in this report are based on an interpretation of data which is a matter of opinion on which professionals may differ and unless clearly stated is not a recommendation of any course of action.

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Goodwin Sands Aggregate Extraction Characterisation Survey		
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Statement

Marine Ecological Surveys Limited (MESL) was commissioned by Royal HaskoningDHV to conduct a marine environmental characterisation study at Goodwin Sands, off the coast of Kent.

The primary objective of the survey was to characterise the benthic, epibenthic and sediment characteristics of an interest area being investigated for potential aggregate extraction. The outputs of the survey are intended to support an Environmental Impact Assessment (EIA) for aggregate extraction on South Goodwin Sands. Due to the short time period of time between the characterisation survey and the planned commencement of dredging, the data gathered during this survey also serves as the pre-dredge baseline.

The survey undertaken by MESL in August 2015 involved the acquisition of sediment samples using a 0.1m² mini-Hamon grab from 71 stations across the area and the deployment of 4 epibenthic beam trawls.

MESL is a member of the Institute of Environmental Management and Assessment (IEMA) and is a leading participant in the National Marine Biological Analytical Quality Control (NMBAQC) scheme.

Marine Ecological Surveys Limited
10 December 2015



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NON-TECHNICAL SUMMARY

At the instruction of Royal HaskoningDHV and on behalf of Dover Harbour Board (DHB), Marine Ecological Surveys Ltd (MESL) conducted a marine benthic and epibenthic characterisation and baseline study at Goodwin Sands in August 2015. The primary objective of the survey was to characterise the marine ecological environment across the area and to provide data to support an Environmental Impact Assessment (EIA) for aggregate extraction on South Goodwin Sands. This study also serves to establish the baseline environmental conditions as a pre-dredge survey.

The survey undertaken was in line with the Terms of Reference prepared by MESL and submitted to the Marine Management Organisation (MMO) for regulatory approval. The sampling array was designed by Cefas to follow the Regional Seabed Monitoring Programme (RSMP) methodologies, which are being applied to other aggregate extraction areas around the UK. A total of 71 benthic grab stations were sampled. A sediment particle size distribution (PSD) sample was taken from all recovered grabs, and 50 samples were preserved for macrofaunal analysis, as per the Terms of Reference. A sub-sample of sediment to be analysed for chemical contaminants was also taken from 70 samples. In addition, four epibenthic trawl samples were undertaken across the survey area.

The survey area was split into the Primary Impact Zone (PIZ; defined as the boundary of the exploration area), the Secondary Impact Zone (SIZ; defined as the immediate tidal footprint around the exploration area), the Context Zone (sampled to give supporting information on the surrounding benthic environment), and a Reference Zone (located outside the range

of any potential impacts, sampled to provide a comparison site against which future change can be measured).

A summary of the key results of this report are presented below:

1. Sediments throughout the survey area were generally characterised by sandy substrates, although relatively high proportions of gravel existed at some stations, particularly those in the secondary impact zone (SIZ) to the south-west of the exploration area. Within the exploration area, sediments were almost exclusively sandy, with very little silt content. There was some degree of variability between sediment composition in the exploration area, the SIZ, the context zone and the reference zone.
2. Chemical contaminants analysis indicated that almost the entire suite of contaminants tested were below Cefas Action Level 1. Arsenic was the only contaminant to exceed this level, and no contaminants were present in concentrations above Action Level 2. Arsenic concentrations within the exploration area were predominantly below the Action Level 1 limit.
3. Benthic community composition across the survey area was dominated by Annelida in terms of contribution to total abundance and species richness. Echinodermata dominated contribution to total biomass. A total of 301 taxa were sampled during the course of the benthic biological survey. The mean number of individuals per sample was 67.97, the mean number of taxa per sample was 22.18 and the mean biomass per sample was 0.28g ash-free dry weight (AFDW).

4. The most abundant species recorded was the annelid worm *Spirobranchus lamarcki* and the crustacean *Pisidia longicornis*. The mysid shrimp *Gastrosaccus spinifer* and the bryozoan *Electra pilosa* were the most frequently encountered taxa in the samples.
5. Greatest benthic abundance, species richness and biomass were typically concentrated in the SIZ to the south-west of the exploration area. Values for each index within the exploration area were comparatively low.
6. No Annex I reef habitats were observed during the benthic survey. Individuals of *Sabellaria spinulosa* and Mytilidae were recorded, however not in sufficient densities to reflect the presence of biogenic reef features.
7. Multivariate analysis identified the presence of seven distinct faunal groups across the survey area. The distribution of the faunal complement was found to be correlated with sediment type, with the variation in PSD accounting for some of the observed variance in fauna. The presence of sands (particularly fine grained sands) exerted the greatest influence on faunal distribution.
8. The exploration area was predominantly characterised by the biotope A5.231 – *Infralittoral mobile clean sand with sparse fauna*. Other major biotope types across the survey area included A5.13 – *Infralittoral coarse sediment* and A5.43 – *Infralittoral mixed sediment*. Biotopes assigned in this report were well correlated with those assigned during surveys of the Goodwin Sands rMCZ.
9. Epibenthic community structure was relatively diverse. A total of 1,760 individuals from 49 taxa were recorded from the four trawl samples undertaken. The presence of a dense brittlestar bed (*Ophiothrix fragilis*) at one station to the south-west of the exploration area had a large influence on overall abundance and biomass recorded. Common fauna sampled included bryozoans, hydroids, gobies and sandeels, in addition to brittlestars.
10. A number of sandeels were recorded during the epibenthic survey, including relatively high numbers within the exploration area. No other species of conservation importance were noted across the survey array.
11. The exploration area and associated SIZ overlaps with the Goodwin Sands rMCZ. Given that no biogenic reef features were noted during the benthic survey (for which the rMCZ is recommended to protect), it is unlikely that dredging in the exploration area will impact on the ecological features of this site.

A. INTRODUCTION

Marine Ecological Surveys Limited (MESL) was commissioned by Royal HaskoningDHV on behalf of Dover Harbour Board (DHB) to conduct a marine environmental characterisation survey at Goodwin Sands, off the coast of Kent. The outputs of the survey are intended to support an Environmental Impact Assessment (EIA) for aggregate extraction on South Goodwin Sands.

Goodwin Sands has never been licensed for regular aggregate extraction. However, extraction for specific infrastructure projects has been allowed in the past. Material has been taken off both North and South Goodwin sites, with extraction occurring in the late 1970s (670 thousand m³ of sand was dredged by DHB between 1976-77 to be used as in-filling during construction of the Dover Hoverpad), from 1984 to 1990, and in 1998 (DHB sourced material for use in construction of the Dover unaccompanied trailer park), which was the last time extraction occurred.

Table 1. The boundary co-ordinates of each vertex of the exploration area of Goodwin Sands (decimal degrees WGS84).

	Latitude	Longitude
A	51.23168 N	1.52071 E
B	51.21201 N	1.54464 E
C	51.17296 N	1.47676 E
D	51.22140 N	1.50072 E

The exploration area lies approximately 10km off the coast of Deal in Kent, and covers an area approximately 11.6km². The location of the exploration area is shown in Figure 1. Coordinates of each vertex of the exploration area are presented in Table 1.

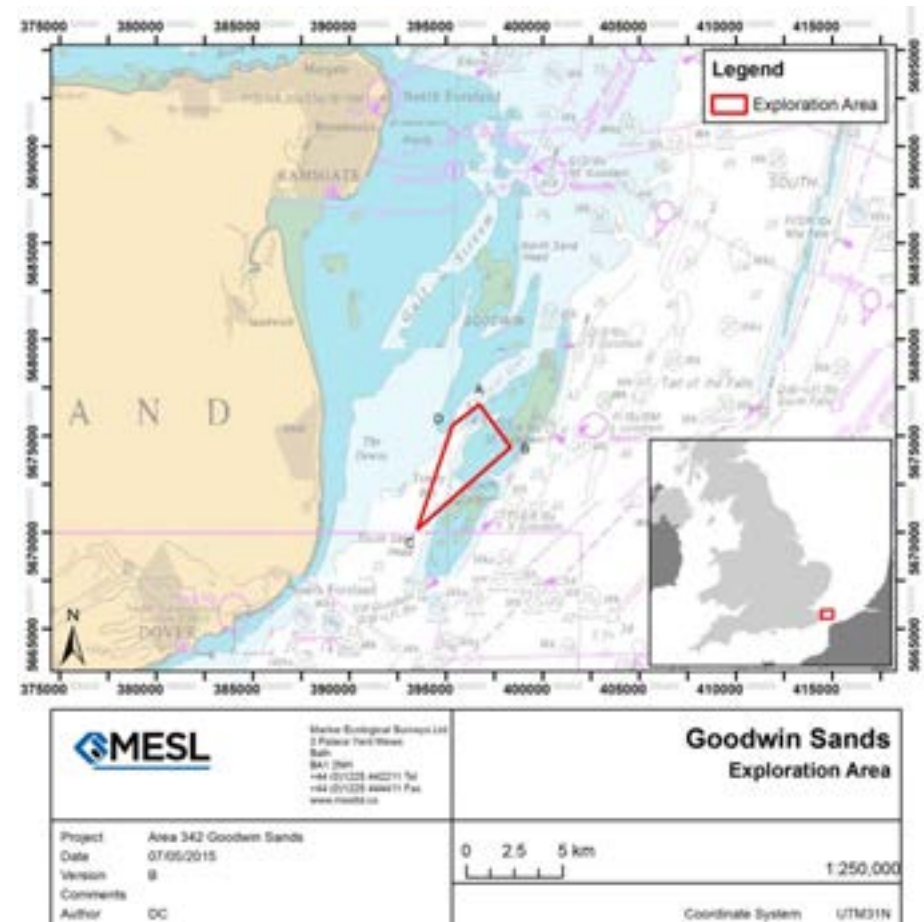


Figure 1. The location of Goodwin Sands and the interest area (shown in red). ARCS Chart 1406-0 used under licence from the UK Hydrographic Office.

A.1. Aims and Objectives

The primary objectives of the survey at Goodwin Sands were as follows:

1. To describe the distribution of sediment types in the survey area and their relation to biological community composition.
2. To describe the distribution and concentration of chemical contaminants contained within the sediments of the survey area.
3. To describe the biological nature of the seabed and the benthic biological communities that occur in the survey area, along with the characterising taxa for each community type, in order to provide reliable information for a subsequent impact assessment.
4. To identify the occurrence of species or communities of conservation significance.

In order to achieve these objectives a benthic and epibenthic survey was conducted at Goodwin Sands in August 2015 in line with the specification set out in the agreed Terms of Reference (ToR).

B. METHODOLOGY

B.1. Survey Rationale

The survey designed at Goodwin Sands complies with the methodology set up for the regional seabed monitoring programme (RSMP) by Cefas and the aggregates industry (Cooper, 2013; 2014). The RSMP approach was designed to develop a baseline characterisation for macrofauna and sediments in five aggregate extraction regions around the UK.

The ToR for the Goodwin Sands benthic survey were prepared by MESL and reviewed by Cefas prior to submission to the Marine Management Organisation (MMO) for approval prior to the start of the survey (MESL, 2015). Regulatory approval of the ToR was gained on 13/07/2015.

In order to ensure that a robust and comprehensive survey array was adopted that provides suitable data to fully inform the subsequent EIA, the exploration area (i.e. Primary Impact Zone, PIZ) and Secondary Impact Zone (SIZ) were taken into account during this survey. The PIZ and SIZ have been sampled alongside a Reference area, within the recommended Goodwin Sand rMCZ, as well as a Context area around the SIZ (Figure 2).

It is considered that in the PIZ, which for the purpose of this study has been assumed to be the entire exploration area, direct impacts from dredging will result in the removal of organisms from the area, changing the composition and structure of benthic marine communities.

The secondary impact zone (SIZ), where indirect impacts from dredging may result in marked changes in faunal composition as a result of the deposition of fines from the dredging process, has been estimated for the purposes of this study utilising information from local tidal information

from tidal diamonds. One hour of flow in each relevant vector for each hour of tide has been applied to the vertices of the exploration area boundary in order to estimate the maximum likely secondary impact zone. This follows the findings of Newell *et al.* (1998), which states that any sediments mobilised by the dredging process are likely to be deposited within a few hundred metres of the disturbance, and in line with tidal flow (Newell *et al.*, 1998). In Figure 2, the SIZ has been divided into bedform (0 – 2500m) and PSA change zones (2500m to limit of SIZ).

The benthic monitoring and characterisation survey included the acquisition of 71 sediment samples for particle size distribution (PSD) analysis, 50 benthic grab samples for faunal analysis and the deployment of four epibenthic trawls. The final array was designed by Keith Cooper at Cefas and approval for the survey specification was gained from the MMO on 13/07/2015.

A total of 21 stations were positioned inside the potential PIZ and a further 22 stations in the potential secondary impact zone, based on a 1km grid pattern. Fourteen stations were positioned in the reference area and 14 in the Context area around the SIZ.

Single grab samples were acquired from each station in the survey array, as per common practice and current industry guidelines. Grab samples acquired from each station were analysed for either sediment particle composition only, or sediment particle composition plus macrofaunal analysis as required. A separate sub-sample was also retained from each sample for chemical contaminants analysis.

In addition to the benthic grab sampling survey, a series of trawls were undertaken with a 2m scientific beam trawl, in order to investigate the epibenthic and demersal fish assemblages which occur across the survey area. A total of four epibenthic trawls were undertaken, two within the boundary of the PIZ, and two within the potential SIZ.

The location of each sampling station and the impact treatments for each station is shown in Figure 2.

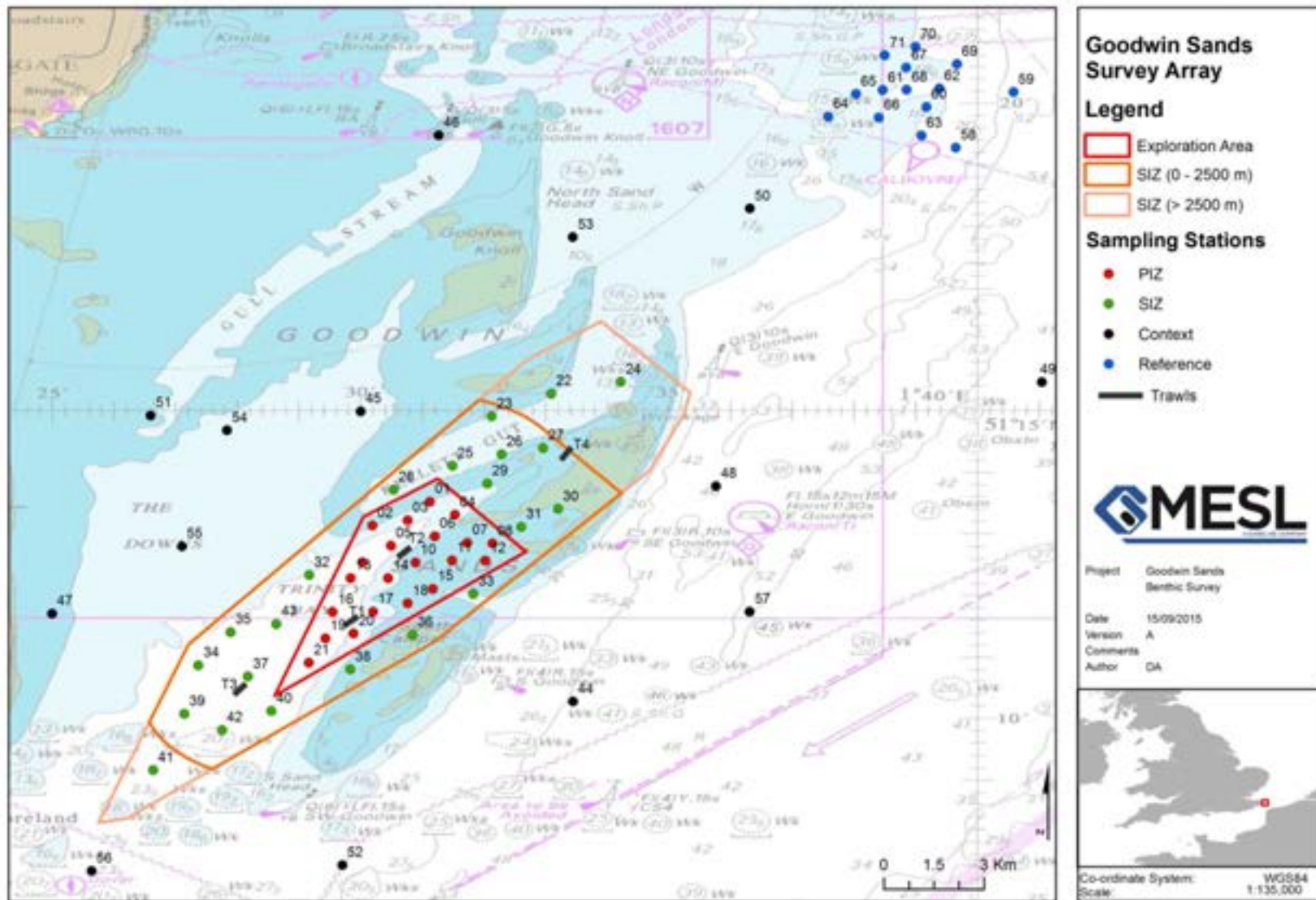


Figure 2. The location of stations sampled as part of the Goodwin Sands benthic monitoring and characterisation survey during August 2015. A breakdown of which samples were acquired from each station is presented in Appendix Table 1. Arcs Chart 1543-0 used under licence from the UK Hydrographic Office.

B.2. Benthic Survey

B.2.1. Benthic Grab Sampling

The survey was conducted on the survey vessel *Algier Rose* owned and operated by Dillingham & Associates. All survey work was completed in August 2015 working out of Dover and Ramsgate.

All samples were obtained using a standard 0.1m² mini-Hamon grab deployed from the survey vessel *Algier Rose*. Samples were obtained as close as possible to the target station coordinates, and within 50m of the target location. Up to four attempts were made to retrieve a sample of at least 5L in volume at each station. If this was not possible, the station was relocated within 100-200m radius of the original target location for the fifth attempt. When small samples of less than 5L in volume were recovered during the attempts, they were kept to one side and the largest of the small samples were processed if a suitably large sample could not be obtained.

Following deployment, the grab was brought aboard the survey vessel and the sample discharged into a plastic box. A photograph of each sample was taken (Appendix Plate 1). A note was made of the volume of sample obtained, along with supplementary information about the sediment (Appendix Table 1). Field notes include the grab coordinates, time of sampling, depth and weather conditions.

Subsamples of approximately 0.5L were taken for PSA from each sample. Each sediment subsample was placed in sealed and secure containers with appropriate internal and external labels. Separate sub-samples of

approximately 0.5L were also taken for chemical contaminants analysis and were stored in specially provided containers.

When faunal analysis was required, the remainder of the sample were placed on a 1mm mesh net supported on a 1mm mesh stainless steel sieve and gently washed with seawater to remove excess fine sand. After sieving, a photograph of each sample was taken. The residual sample were transferred into a labelled plastic bucket, preserved in buffered 4% formalin and sealed with a tight fitting lid. The samples were retained for subsequent analysis of the benthic infauna in the laboratory. If no faunal analysis was required the rest of the sample was discarded.

Samples were recovered from every station targeted, yielding a total of 71 PSA samples, 50 macrofaunal samples and 71 chemical contaminant samples. A breakdown of which stations required PSA samples only and which required PSA and macrofaunal sample analysis is shown in Appendix Table 1. One chemical contaminant sample could not be analysed due to its composition of mainly cobbly material. Two stations (52 and 57) produced only small macrofaunal samples after 5 attempts (3 and 2L respectively). These data have been included in the relevant analyses. The location of the stations sampled is presented in Figure 2.

B.2.2. Epibenthic Trawling

The epibenthic survey was conducted using a 2m scientific beam trawl with a 3mm cod-end. The trawl was towed for approximately 500m or 10 minutes into the prevailing tide at a slow constant speed, which ensured that the trawl remained in contact with the seabed for efficient sampling and minimised the sampling of larger fish. A total of four trawls were undertaken, the locations of which are shown in Figure 2.

Once brought onboard, the catch was emptied onto a sorting tray on the deck of the vessel where it was photographed, sorted and analysed *in situ*. All species (invertebrates and fish) were identified, enumerated and weighed (biomass wet weight).

Lengths of all commercially important species were recorded to the nearest 5mm (total length, rounded down), with the abundance of other species recorded. Following analysis, the catch was returned to the water as soon as practicable. Several specimens were retained for verification in the lab. Full field notes from the epibenthic survey are presented in Appendix Table 2. A photograph of each trawl sample is presented in Appendix Plate 2.

B.2.3. Separation & Analysis of the Fauna

On arrival at the MESL analytical laboratory, the samples were checked against the field notes in accordance with our standard operating procedures (Appendix 1) and signed against the list of samples collected. The excess formalin was poured through a 1mm mesh sieve and collected for licensed disposal. Each sample was gently eluted with tap water through a 1mm mesh sieve to extract the low-density components (crustaceans and polychaetes) and combined with the material initially separated from the formalin in the sample. The larger macrofauna were removed from the eluted material. This stage in the initial sorting process was carried out in the open air to reduce the effects of residual formalin used to preserve the sample on the survey vessel.

The sediments were sorted under a stereomicroscope with the aim of extracting the fauna. The entire sample of separated fauna was then preserved in industrial methyated spirit (IMS) for subsequent analysis.

Each of the extracted samples was subsequently sorted into major faunal groups before being analysed to species level by experienced taxonomists who sign a log sheet on completion of the analysis of each individual sample. Taxonomic identification is checked throughout the process by our senior analysts and against a reference collection held for ease of use in the analytical laboratory.

MESL is a leading participant in the National Marine Biological Analytical Quality Control (NMBAQC) scheme. Species identification was recorded in a standard format using species codes from Howson & Picton (1997).

B.2.4. Biomass Determination

The blotted wet weight of major groups recorded from the benthic grab samples was measured. These data were then used to estimate total biomass as ash-free dry weight (AFDW) in grams using conventional conversion factors for each of the faunal groups. The wet weight conversion factors are as follows in accordance with Eleftheriou & Basford (1989):

- Annelida x 0.155
- Crustacea x 0.225
- Mollusca x 0.085
- Echinodermata x 0.08
- Miscellaneous groups x 0.155

Miscellaneous groups were mostly accounted for by Bryozoa, Hydrozoa, Nemertea, Cnidaria, Actiniaria, and Pycnogonida.

B.2.5. Particle Size Distribution (PSD)

The sediment sub-samples were subjected to PSD analysis by Gardline Environmental Limited. The stations from which PSD samples were obtained are presented in Appendix Table 1 along with supplementary information obtained during the survey.

The sediments were sieved at ½ phi intervals over a particle size range 64mm-0.063mm, on the Wentworth scale. Where a sample was found to contain greater than 5% fine material (<63µm) by weight, the sample was subject to further analysis using laser diffraction to determine the particle size distribution down to <1µm. The results were expressed as cumulative percentage retained on each sieve size.

These values are summarised in Appendix Table 3 and 4, and further divided in Appendix Table 5 into higher groupings of % gravel, % sand and % silt for ease of broad scale substrate assessment.

B.2.6. Chemical Contaminants Analysis

Chemical contaminants analysis was undertaken by ALS Global. Sub-samples of sediments collected on board the survey vessel were stored in specially provided containers and stored according to ALS recommendations until ready for analysis. The range of contaminants proposed for testing is shown in Table 2. It was agreed with Cefas that testing for polychlorinated biphenyls (PCBs) was unnecessary due to the low likelihood of the presence of these contaminants at the offshore survey site.

Table 2. Suite of determinants to be analysed from contaminant samples acquired as part of the 2015 benthic survey at Goodwin Sands, together with method description (where available), accreditation of the testing lab and reporting limit.

Determinants	Method Description	Reporting Limit
Heavy Metals		
Mercury as Hg, dry weight	Hydrides ICP	0.2 mg/kg
Arsenic as As, dry weight	Metals ICP	1 mg/kg
Cadmium as Cd, dry weight	Metals ICP	0.2 mg/kg
Chromium as Cr, dry weight	Metals ICP	1 mg/kg
Copper as Cu, dry weight	Metals ICP	5 mg/kg
Lead as Pb, dry weight	Metals ICP	2 mg/kg
Nickel as Ni, dry weight	Metals ICP	1 mg/kg
Zinc as Zn, dry weight	Metals ICP	5 mg/kg
TBT		3.0 µg/L
PAHs		
Acenaphthene	PAH HPLC	0.1 mg/kg
Acenaphthylene	PAH HPLC	0.1 mg/kg
Anthracene	PAH HPLC	0.1 mg/kg
Benzo(a)anthracene	PAH HPLC	0.1 mg/kg
Benzo(a)pyrene	PAH HPLC	0.1 mg/kg
Benzo(b)fluoranthene	PAH HPLC	0.1 mg/kg
Benzo(g,h,i)perylene	PAH HPLC	0.1 mg/kg
Benzo(k)fluoranthene	PAH HPLC	0.1 mg/kg
Chrysene	PAH HPLC	0.1 mg/kg
Dibenz(a,h)anthracene	PAH HPLC	0.1 mg/kg
Fluoranthene	PAH HPLC	0.1 mg/kg
Fluorene	PAH HPLC	0.1 mg/kg
Indeno(1,2,3-c,d)pyrene	PAH HPLC	0.1 mg/kg
Naphthalene	PAH HPLC	0.1 mg/kg
PAH, Total of 16 EPA	PAH HPLC	1 mg/kg
Phenanthrene	PAH HPLC	0.1 mg/kg
Pyrene	PAH HPLC	0.1 mg/kg

B.3. Statistical Analysis of the Data

B.3.1. Univariate Analysis

Univariate statistical analyses were carried out by MESL using Microsoft Excel (2007). The data were analysed in a number of ways in order to extract information regarding the abundance of fauna, the number of taxa present (species richness) and the total major group biomass (gAFDW for benthic samples, gWW for epibenthic trawls) at each station. Additional summary data are presented where appropriate.

B.3.2. Multivariate Analysis

Various multivariate techniques were performed on the data using the PRIMER V6 software package. This included the following routines:

- Hierarchical Cluster Analysis
- SIMPROF
- Multidimensional Scaling Ordinations
- SIMPER
- Relate and BioENV

A full description of these techniques is provided in Appendix Table 2.

B.4. Thematic Maps (GIS)

All of the GIS maps used in MESL's report are generated using ArcGIS version 10.3.

C. RESULTS & DISCUSSION

C.1. The Nature of the Substrata

C.1.1. Particle Size Distribution (PSD)

The PSD samples were analysed in-line with the methodology presented in Section B.1.6. Sediment samples were acquired from all 71 target stations.

Appendix Tables 3 and 4 show the particle size distribution of the sediments at each of the sample sites from which benthic infauna were extracted. These data are expressed as the percentage of material retained on sieves ranging from 31.5mm down to <0.063mm and as laser diffraction results for finer material (>5% fines). Laser diffraction was undertaken at stations 35 (SIZ), 43 (SIZ), 47 (Context Zone), 55 (Context Zone) and 59 (Reference Zone) (Appendix Table 4). The sediment data have been summarised in Appendix Table 5 to show the percentage silt (<0.063mm), sand (0.063-<2mm) and gravel ($\geq$ 2mm) that comprised each sediment sample. The distribution of sand, silt and gravel across the site is illustrated in Figure 3.

Figure 3 shows that sediments were generally characterised by sandy substrates, although a high percentage of gravel existed at a number of stations, principally those to the north-east and south-west of the Goodwin Sandbanks. Mud or silt was present in very low percentages at most stations. Sediment within the exploration area itself comprised almost exclusively sands, with little to no gravel or silt present.

The average sediment composition across the survey area, split by impact zone, is shown in Table 3.

Table 3. Average sediment composition in the interest area as determined by the survey.

Zone	% Gravel	% Sand	% Silt
All stations	22.74	76.12	1.14
Primary Impact Zone	1.30	98.57	0.12
Secondary Impact Zone – Bedform Zone	25.42	73.13	1.45
Secondary Impact Zone – PSA Change Zone	33.97	65.75	0.28
Secondary Impact Zone All	26.59	72.12	1.29
Context Zone	40.19	58.11	1.69
Reference Zone	31.42	66.70	1.88

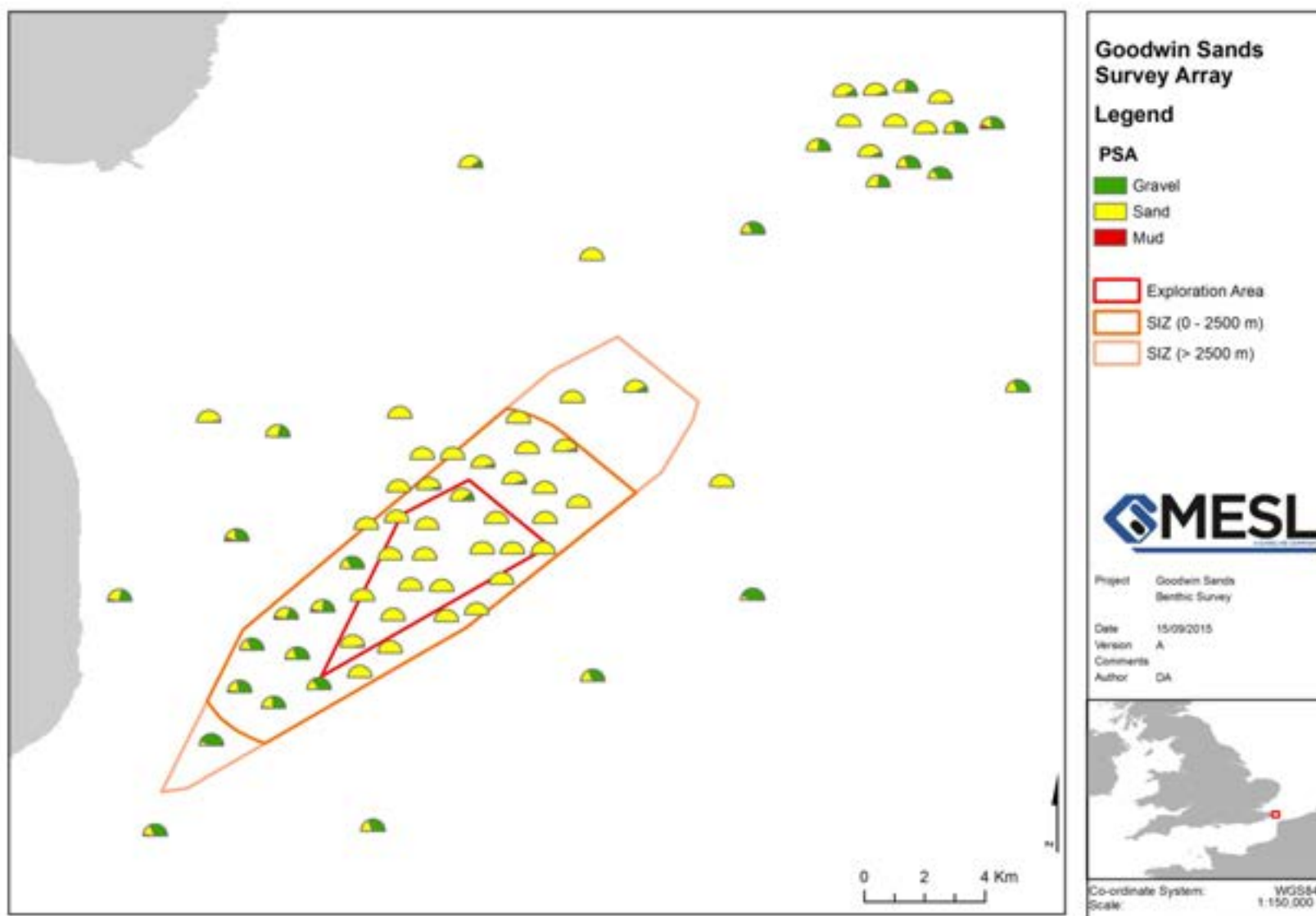


Figure 3. The relative proportions of gravel, sand and silt in the PSD samples obtained as part of the Goodwin Sands 2015 survey. The location of the pie diagrams represents approximate station positions.

C.1.2. Multivariate Statistical Analysis of Sediment Data

The results shown in the previous section present a good overview of sediment types across the region. A more sensitive comparison of sediment composition across the area can however be achieved by applying multivariate statistical techniques that utilise the complete size spectrum of particles recorded in each sample.

A variety of analytical techniques within the PRIMER v6 software package were utilised in order to facilitate a more detailed analysis of the data and to provide greater insight into the composition of the sea floor across the exploration area and the surrounding region. These techniques are described in detail within Appendix 2.

A group average sorting dendrogram (based on Euclidian Distance) and a corresponding multidimensional scaling (MDS) plot presented in two dimensional format were produced in PRIMER using the sediment data acquired from across the survey area. The outputs of these analyses are presented in Figures 4 and 5, which demonstrates the existence of 6 distinct sediment groups, determined at a Euclidean distance of 35. The low stress value of the MDS plot (0.08) indicates that this image presents a good spatial interpretation of the inter-relationships between the sediment samples acquired from across the survey area.

The mean proportions of gravel, sand and silt that account for these multivariate sediment groups are presented in Table 4.

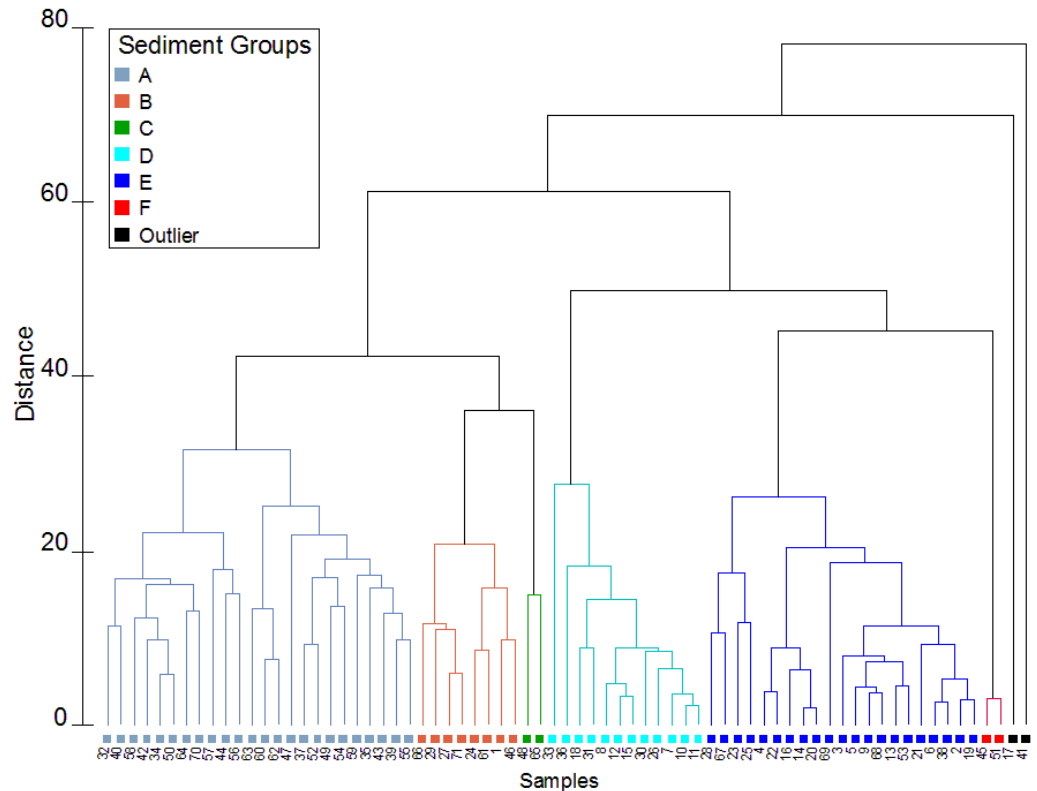


Figure 4. Group average sorting dendrogram based on Euclidean distance, for the particle size composition of the sediments sampled during the Goodwin Sands 2015 survey.

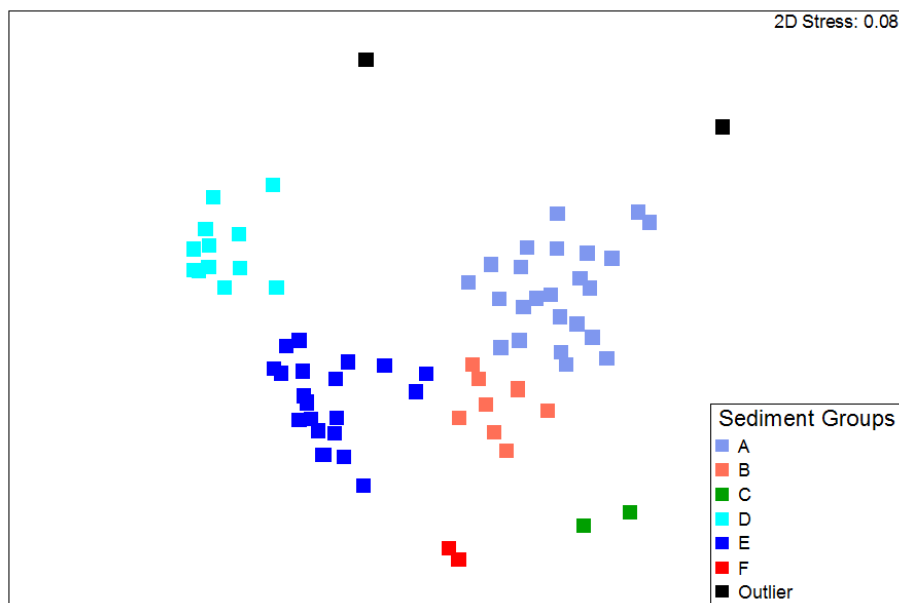


Figure 5. Multidimensional scaling plot (presented in 2D format), based on Euclidean distance, for the particle size composition of the sediments sampled during the Goodwin Sands 2015 survey.

Table 4. The mean proportions of gravel, sand and silt accounting for each of the Goodwin Sands multivariate sediment groups in 2015. Each group has been assigned a description based on a modified Folk (1954) scale of classification.

Sediment Group	Average % Gravel	Average % Sand	Average % Silt	Folk Classification
A	56.90	40.19	2.91	sG
B	15.49	84.23	0.27	gS
C	1.37	98.54	0.09	(g)S
D	0.01	99.92	0.07	S
E	1.51	98.18	0.31	(g)S
F	2.85	97.01	0.14	(g)S

A summary of each sediment group is presented below, with the distribution of each group mapped in Figure 6.

Sediment Group A

Sediment Group A comprised gravelly sandy Gravel (sG) and contained the highest gravel and slit proportions of all groups. This group was the most commonly occurring sediment group (24 samples) and was found throughout the area, with the exception of inside the boundary of the PIZ. This group dominates the bedform secondary impact zone to the south-west of the PIZ.

Sediment Group B

Sediment Group B comprised 8 stations in total and has been classified as gravelly Sand (gS). This group is located within all of the impact zones, including inside the PIZ.

Sediment Group C

Sediment Group C comprised 2 stations located at the east and north of the SIZ. This group was classified as slightly gravelly Sand, being mainly dominated by sandy substrates (98.5%).

Sediment Group D

Sediment Group D was classified as Sand and comprised 12 stations (17% of the total). The group contained almost exclusively sandy material, with a very minor gravel and silt content. Sediment Group D was located throughout the PIZ and the SIZ, aligning with the topography of sandbank features.

Sediment Group E

Sediment Group E, classified as slightly gravelly Sand, comprised 21 stations located mainly in the PIZ. Examples of this group were however found in all impact zones. The group composition was highly similar to Groups C and F, and contained a greater gravel and silt content than Group D.

Sediment Group F

Sediment Group F comprised only 2 stations, both located in the context zone. The group was classified as slightly gravelly Sand, containing a higher gravel proportion than Groups C and E.

In addition to the sediment groups identified, 2 samples (Stations 17 and 41) did not group with any other samples and have been labelled as Outliers in the analyses. Station 17 contained a very high proportion of fine sand (0.125mm) and Station 41 contained a very large amount of coarse gravel (31.5mm), differing from other stations.

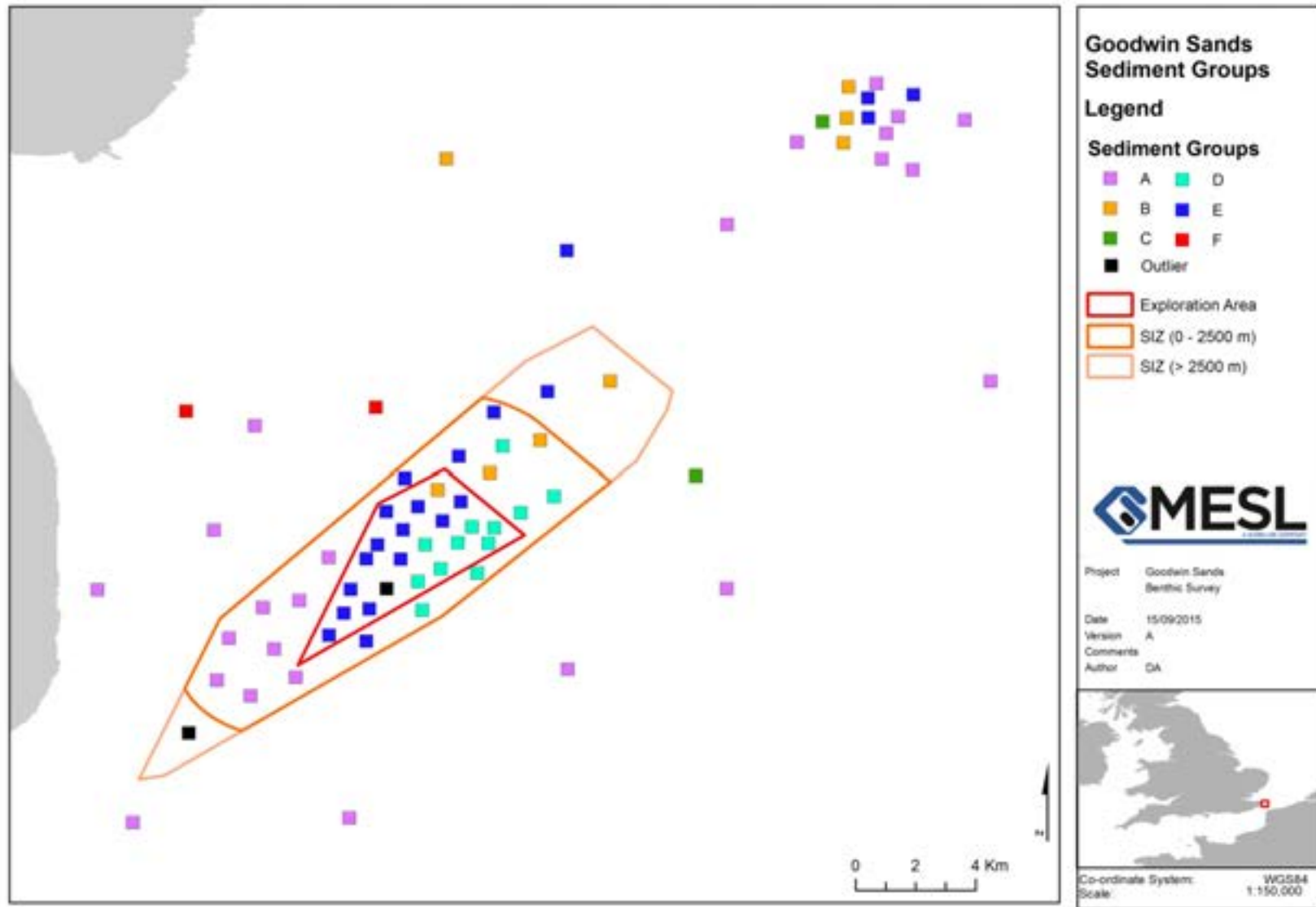


Figure 6. The distribution of sediment groups determined by multivariate analysis in the interest area.

Summary of Sediment Characteristics

- Sediments throughout the survey array were dominated by sand with gravel making an important contribution to the sediment character in places. Only a minor silt proportion was recorded during the survey.
- The sediment recorded within the exploration area is dominated by Sand and slightly gravelly Sand.
- Multivariate analysis identified six distinct sediment groups across the survey area, classified as sandy Gravel, Sandy, gravelly Sand and slightly gravelly Sand (three groups).

C.2. Chemical Contaminants

The results of the chemical contaminant testing undertaken on samples from Goodwin Sands are shown in Table 5. It should be noted that analysis on 1 sample could not be undertaken (Station 57) due to the cobbly nature of the sub-sample.

The data are presented with reference to Cefas Action Levels¹. It can be seen from Table 6 that the only contaminant which was recorded at greater levels than Action Level 1 was Arsenic. No contaminants were recorded at levels exceeding Action Level 2.

The distribution of Arsenic concentrations recorded across the survey area is mapped in Figure 7. It can be seen that concentrations of Arsenic within the exploration area are predominantly below Action Level 1, with only one station shown to exceed this limit. Full chemical contaminant data is presented in Appendix 12.

¹ <http://www.cefas.defra.gov.uk/media/562541/cefas%20action%20levels.pdf>

Table 5. Chemical contaminant concentrations recorded at Goodwin Sands in 2015. All concentrations are reported in mg/kg dry weight.

	Cefas Action Level 1	Cefas Action Level 2	Goodwin Sands Average	Goodwin Sands Maximum	Number of samples > Cefas Action Level 1
Arsenic	20	100	27.24	96	36
Mercury	0.3	3	0.002	0.037	0
Cadmium	0.4	5	0	0	0
Chromium	40	400	4.61	11	0
Copper	40	400	0.65	15	0
Nickel	20	200	5.05	18	0
Lead	50	500	1.37	12	0
Zinc	130	800	18.43	58	0
TBT	0.1	1	0	0	0
Benzo(a)pyrene	-	-	0.0005	0.022	-
Total PAH			0.005	0.24	-

Summary of Chemical Contaminant Data

- Chemical contaminant samples were acquired and analysed from 70 stations across the survey area.
- The suite of contaminants tested included heavy metals, polycyclic aromatic hydrocarbons and tributyl tin.
- When compared to Cefas Action Levels, only Arsenic was found to be greater than Cefas Action Level 1. No contaminants were recorded at greater concentrations than the Action Level 2 limits.
- Arsenic concentrations within the exploration area were relatively low, and only exceeded Action Level 1 at one station.

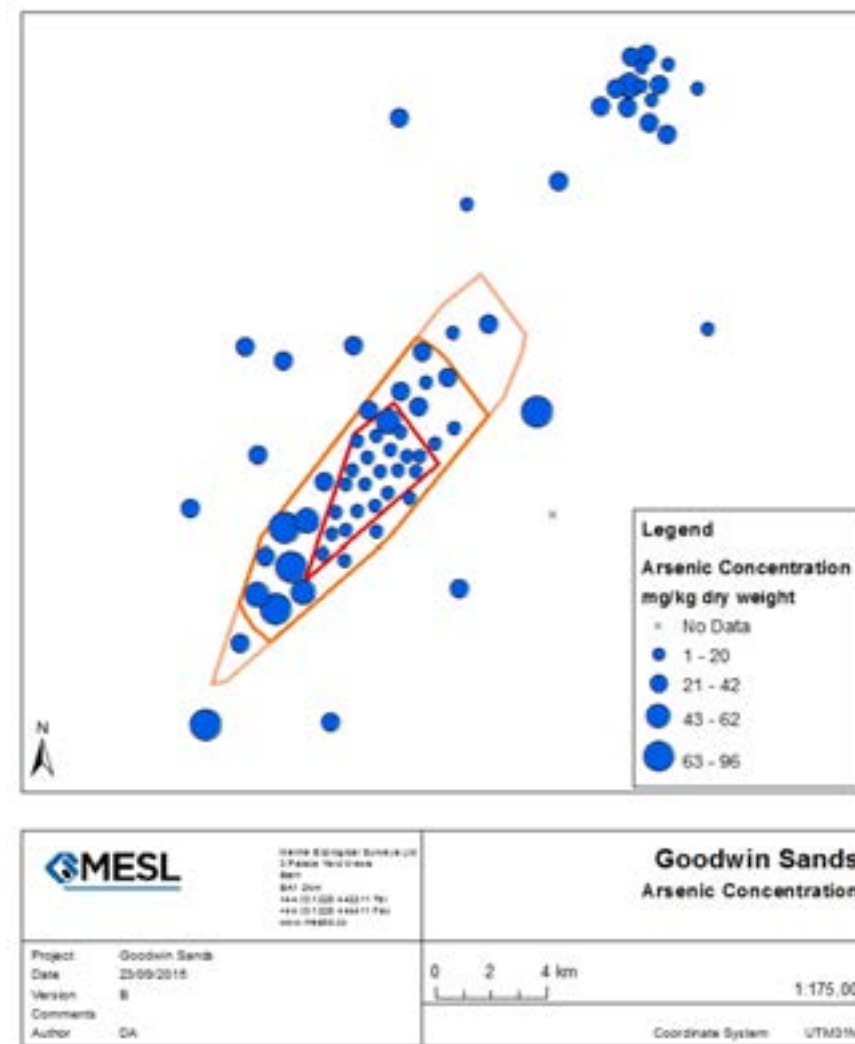


Figure 7. Concentrations of Arsenic recorded during the 2015 Goodwin Sands survey.

C.3. The Nature of the Benthic Fauna

C.3.1. Benthic Species Richness, Abundance and Biomass

A total of 301 taxa and 3,398 individuals were sampled from the 50 faunal stations surveyed, with a total biomass of 14.18g AFDW. The full taxonomic list, including the numerical abundance of each taxon by station, is provided in Appendix Table 6. The biomass of each major faunal group (by station) is presented in Appendix Table 7. A contact sheet of each grab sample is presented in Appendix Plate 1.

The mean number of taxa recorded per sample was 22.18. The mean number of organisms per sample was 67.96, and the mean biomass per sample was 0.28g AFDW. Although several stations contained a low abundance of individuals (commonly associated with infralittoral mobile sandy sediment habitats), only one station was afaunal (Station 1). A summary of the data is presented in Appendix Table 8. Images of some of the most abundant fauna identified from the samples obtained are presented in Plate 1.

Figure 8 indicates the percentage contribution of the major faunal groups to total abundance, species richness (diversity) and biomass. It can be seen that Annelida dominated the benthic community in terms of abundance and species richness. Despite contributing relatively low proportions to abundance and species richness, Echinodermata made the greatest contribution to biomass, reflective of the larger body size of echinoderm organisms, such as *Ophiothrix fragilis* and *Amphipholis squamata*. Crustacea made the second largest contribution to abundance and the third to species richness.



Plate 1. Examples of some of the most commonly occurring benthic taxa found within the samples acquired at Goodwin Sands in 2015. Clockwise from top left: brittlestar *Amphipholis squamata*; porcelain crab *Pisidia longicornis*; mysid *Gastrosaccus spinifer*; terebelid Polychaete *Caulleriella alata*; bryozoan *Electra pilosa*; and annelid *Nephtys cirrosa*.

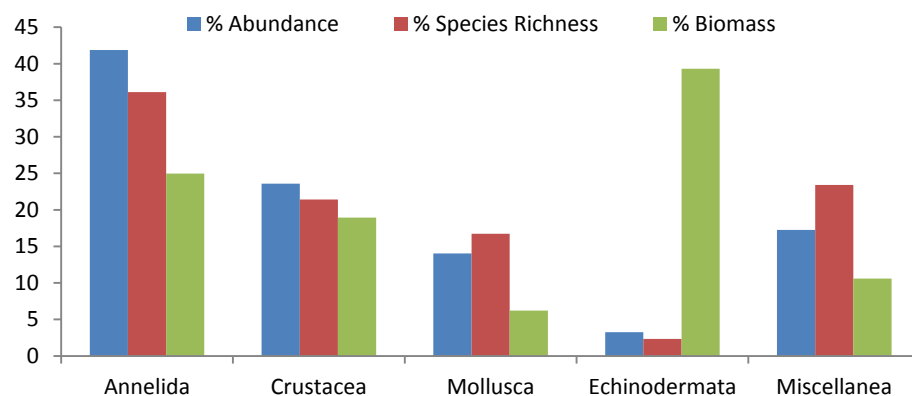


Figure 8. The relative contribution of the main faunal groups to the total abundance, species richness (diversity) and biomass sampled during the 2015 Goodwin Sands survey.

The contribution of the top ten organisms to overall abundance is illustrated in Figure 9. Together these taxa accounted for 47% of all sampled individuals. The highest contributors to overall abundance were the annelid worms *Spirobranchus lamarcki* and *Sabellaria spinulosa*, the crustacean *Pisidia longicornis*, the molluscs *Abra alba* and *Kurtiella bidentata* and the ascidian *Dendrodoa grossularia*. A total of 132 *S. spinulosa* individuals were recorded during the survey from 10 stations, although not in . The occurrence of *S. spinulosa* across the survey area is further discussed in Section D.2.

Figure 10 reveals the taxa that occurred in the highest proportion of samples collected during the survey. The crustacean *Gastrosaccus spinifer* (36% of samples) and the bryozoan *Electra pilosa* (34% of samples) occurred most frequently. The annelid *Spirobranchus lamarcki* and the hydrozoan *Sertularia* sp. were present in 32% of the samples. Five of the top ten most common taxa belong to the phylum Annelida.

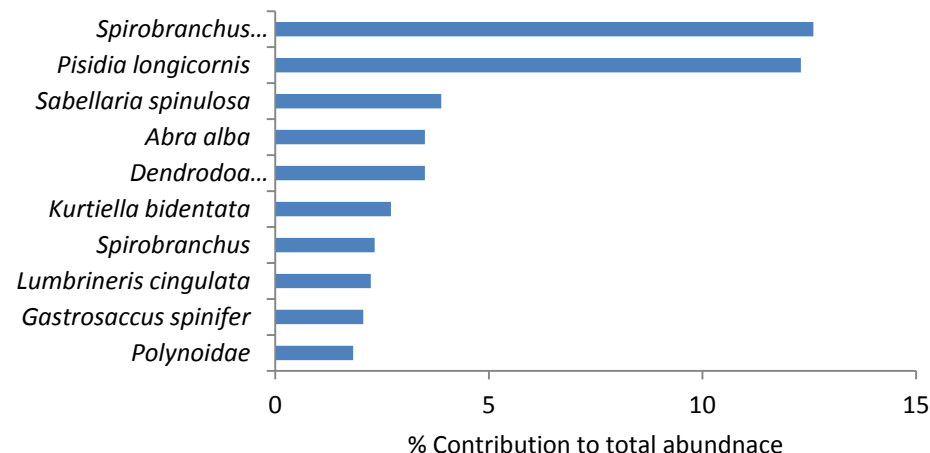


Figure 9. The 10 most abundant taxa sampled during the 2015 Goodwin Sands survey

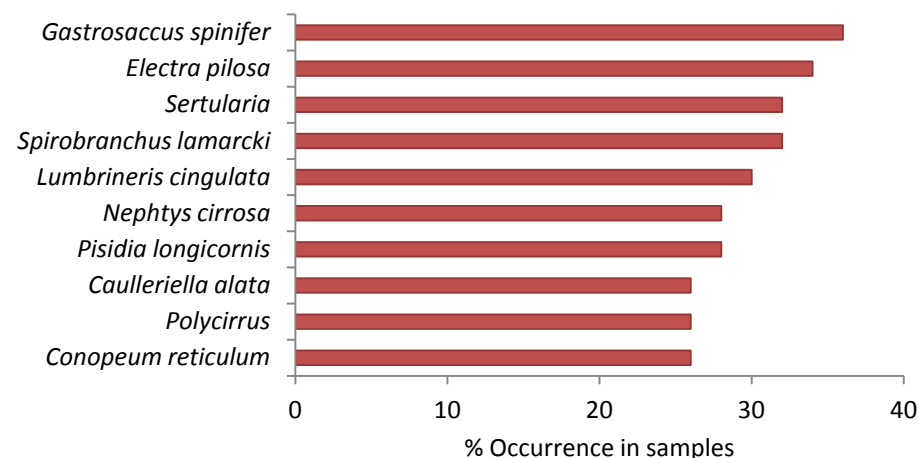


Figure 10. The 10 most commonly occurring taxa sampled across during the 2015 Goodwin Sands survey

C.3.2. The Distribution of Abundance, Species Richness and Biomass of Benthic Fauna across the Survey Area

Figure 11 (overleaf) shows the relative values of abundance (number of individuals), species richness (number of taxa) and biomass (g AFDW) of benthic infauna at each station in the survey area.

The figure demonstrates high spatial variability in abundance across the survey area. Abundance figures ranged from sites that were afaunal (no organisms recorded) to stations where in excess of 500 individuals were identified. Highest abundance was typically found to the south-west of the PIZ and in the SIZ. Abundance values within the boundary of the PIZ were relatively small compared to those outside the boundary. Lowest abundance can be loosely correlated with the shallowest bathymetry, on top of sandbank crests.

Species richness broadly followed the pattern indicated by abundance, with lowest diversity recorded within the boundary of the PIZ and greatest species richness observed to the south-west of the survey array. Species richness ranged from 0 individuals per station to 121 (recorded at Station 41 in the SIZ).

The distribution of biomass across the survey area likewise followed a similar pattern to that of species richness and abundance, although some variation was observed. The greatest biomass concentrations were observed to the south-west of the array, although some stations within the boundary of the PIZ did show considerable biomass. Station 39 in the SIZ recorded the greatest biomass across the array.

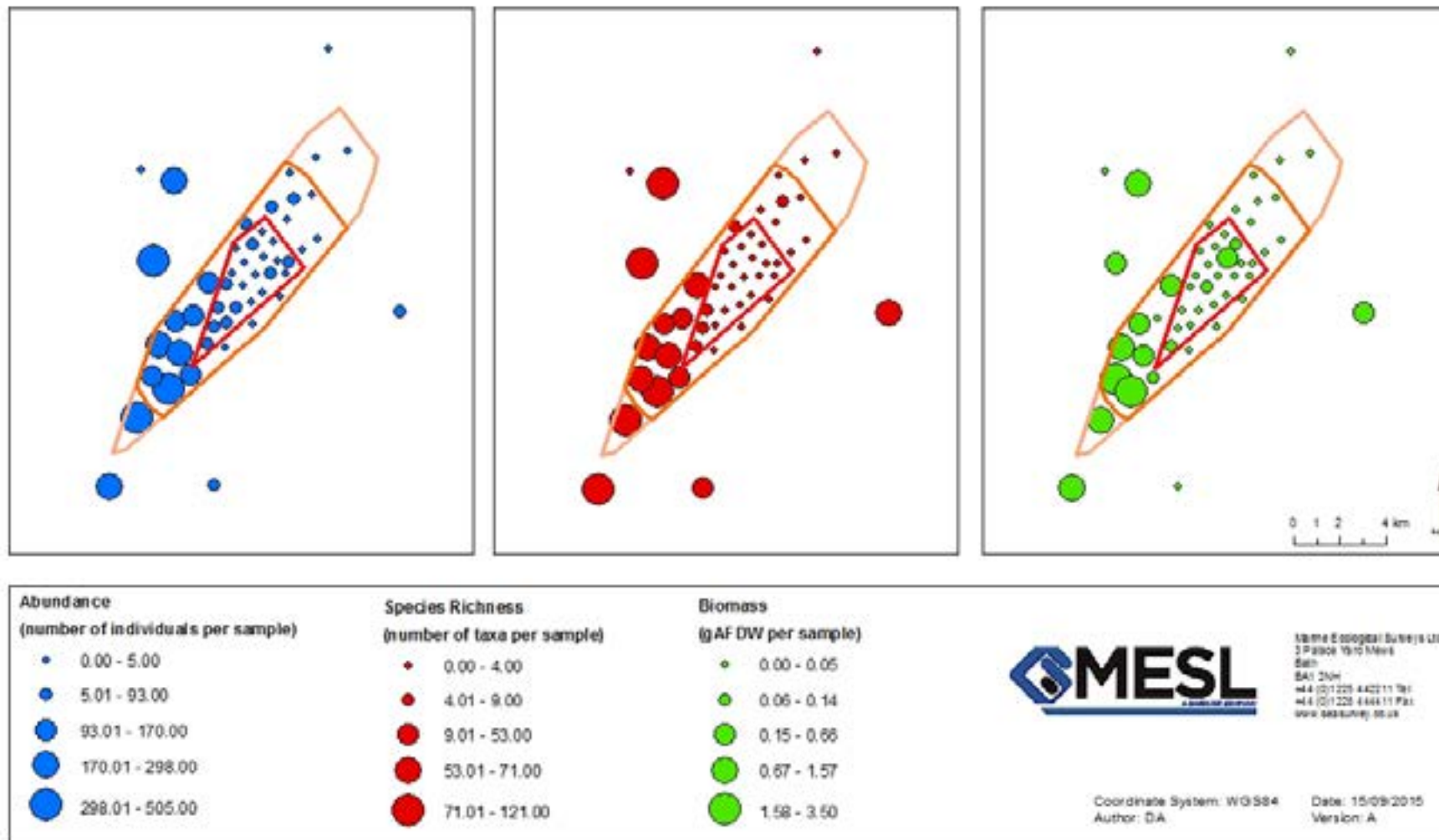


Figure 11. The population abundance (individuals per 0.1m²), species richness (number of species per 0.1m²) and biomass (gAFDW per 0.1m²) of benthic infauna recorded during the 2015 survey of Goodwin Sands.

C.3.3. Multivariate Statistical Analysis of Community Composition

The composition of the biological communities in the survey area is best analysed by multivariate methods. These take into account the species variety and the relative abundance of each taxon and allow inferences to be made on the characterising species that comprise the major communities in the survey area.

Figure 12 shows a group average sorting dendrogram (based on Bray-Curtis similarity of square-root transformed data) and the corresponding Multi-Dimensional Scaling (MDS) ordination, presented in two-dimensional format, for the benthic infauna recorded across the survey area. The 2D stress of the ordination is low (0.11) indicating that the two-dimensional representation provides a reasonable interpretation of the interrelationships that occur between the communities sampled at the different survey stations.

A total of seven distinct faunal groups were identified in the Goodwin Sands samples by using the SIMPROF routine in Primer V6 (See Appendix 2 for details). In addition to the seven groups identified, samples from 6 stations did not group with any other samples and have been labelled as Outliers. The output of the analysis used to define these groups is presented in Appendix Table 9. A summary of the group characteristics is presented in Table 6.

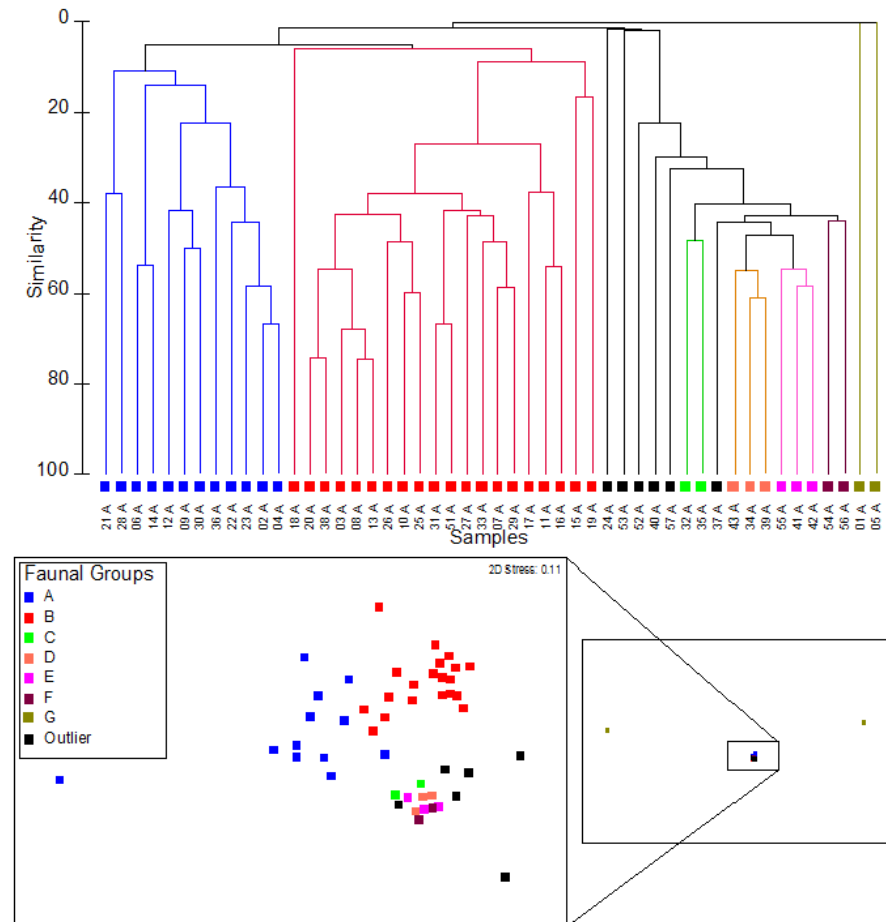


Figure 12. A group average sorting dendrogram based on the square root benthic abundance data (Bray-Curtis similarity) and the corresponding multidimensional scaling (MDS) ordination, presented in two-dimensional format, using data gathered from Goodwin Sands in 2015. Note that Group G is characterised by low similarity and is thus not shown on the MDS subset.

Table 6. Average abundance (number of individuals), species richness (number of taxa) and biomass (gAFDW) of each of the multivariate faunal groups identified across Goodwin Sands during the 2015 survey.

Faunal Group	Average Abundance	Average Number of Taxa	Average Biomass (gAFDW)
A	4.17	3.33	0.06
B	7.10	3.30	0.01
C	125.00	51.00	0.51
D	172.00	63.67	1.49
E	451.67	101.33	1.62
F	295.50	94.50	0.96
G	0.50	0.50	0.01

The geographical distribution of these faunal groups is shown in Figure 13. The relationship between the distribution of sediments and the distribution of infauna is further explored in Section C.2.4, where more sensitive statistical techniques have been applied.

Faunal Group A (average group similarity of 22%) was the second most commonly occurring group, recorded at 12 stations within the PIZ and SIZ. The group was not highly diverse and was dominated by the annelid *Nephtys cirrosa* and the amphipod *Pontocrates altamarinus*, both characteristic of mobile sandy habitats.

Faunal Group B (average group similarity of 29.35%) was the most commonly occurring group, characterising the 40% of all stations (20 stations), mainly located in the PIZ and the bedform SIZ. This Faunal Group contains the lowest average biomass recorded, and similar to Faunal Group A was not highly diverse; only 2 species contributed to over 90% of the group similarity. These characterising species were the mysid

crustacean *Gastrosaccus spinifer* and the amphipod *Urothoe brevicornis*, both indicative of mobile sandy habitats.

Faunal Group C (average group similarity of 48.14%) was recorded at two stations, both located within the bedform SIZ. Key characterising fauna of Group C were the annelid worms *Spirobranchus lamarcki*, *Lumbrineris cingulata* and the bivalve *Abra alba*.

Faunal Group D (average group similarity of 56.72%) was recorded at 3 stations to the south-west of the PIZ in the SIZ. The crustacean *Pisidia longicornis* made the greatest contribution to this group's similarity. Other key characterising fauna of this group included the annelid worms *S. lamarcki* and *L. cingulata*.

Faunal Group E (average group similarity of 55.70%) was recorded at 3 stations in the SIZ and Context zones. This group contained the highest average abundance, the greatest average number of taxa, and the greatest average biomass of all groups. Characteristic fauna included *Pisidia longicornis* and *S. lamarcki*, amongst other fauna commonly associated with aggregations of *Sabellaria spinulosa*, which made the third greatest contribution to the group similarity.

Faunal Group F (average group similarity of 43.81%) was recorded at 2 stations both in the context zone. This Faunal Group contained the second highest average abundance and number of taxa of all groups. The annelid *S. lamarcki* and the bivalve *Kurtiella bidentata* were characteristic species.

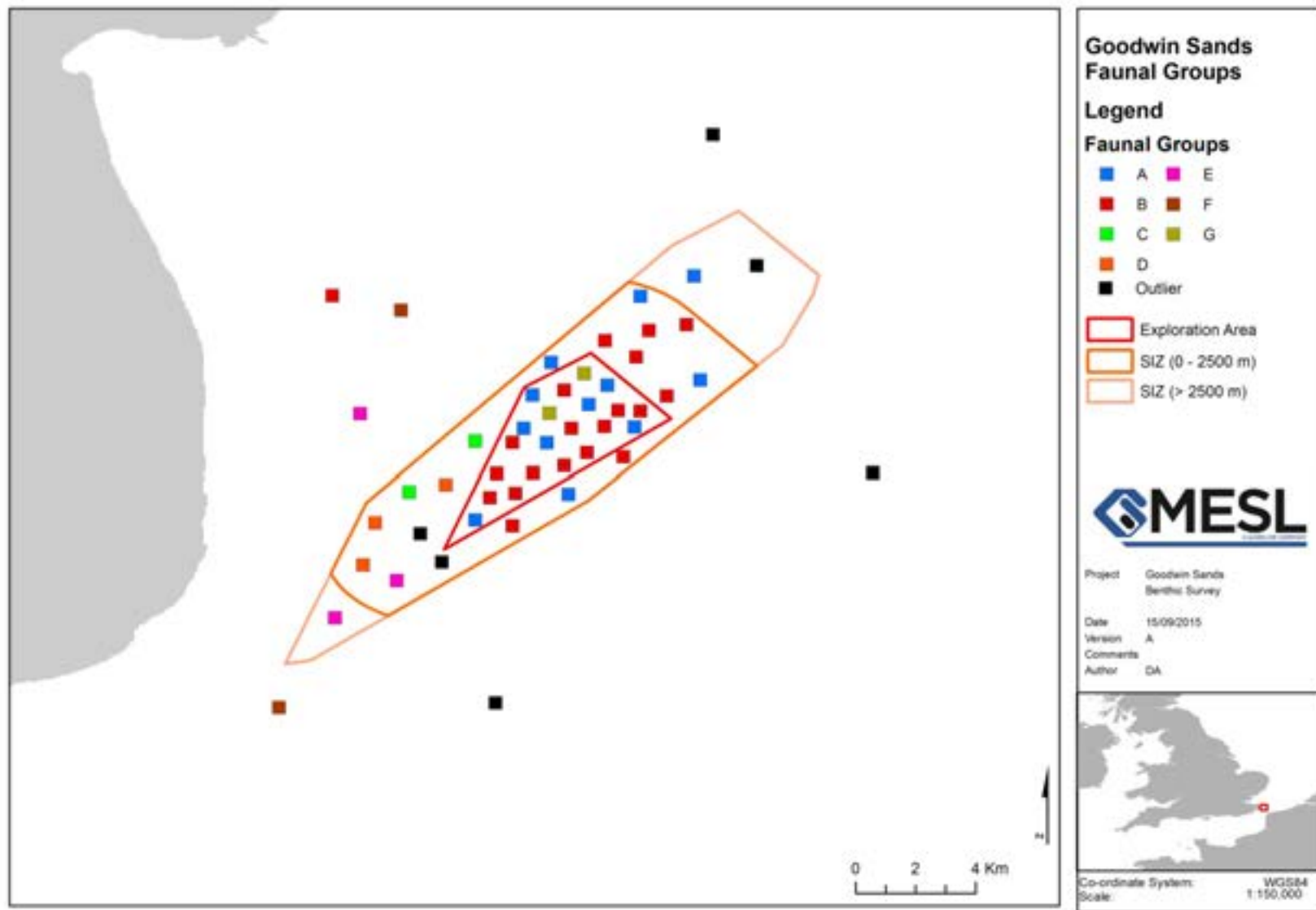


Figure 13. The spatial distribution of faunal groups identified from multivariate analysis of fauna recorded in the 2015 Goodwin Sands samples.

Faunal Group G (average group similarity is zero) was formed by two stations located within the PIZ. One of these stations was found to be afaunal, which explains the lowest values in abundance and number of taxa observed.

C.3.4. Linking Faunal Data to Environmental Variables

The data relating to sediment and faunal groupings, seen in Figures 3 to 13, suggest some correspondence between the benthic communities and the composition of the substrate. In particular, it was noted that within the PIZ the faunal groups that contained low average abundances, number of taxa and biomass (Groups A & B) predominantly corresponded with the less heterogeneous sediments that comprised Sediment Groups D and E.

It is well documented that sediment composition is an important factor for determining the distribution of infaunal communities (Cooper *et al.* 2011; Ellingsen, 2002). For example, the presence of coarse sediments provides attachment sites for a diverse assemblage of species including bryozoans and hydroids. Cooper *et al.* (2011) asserted that taxa characterising gravel dominated sediments were typically only found in association with these sediment fractions.

Research undertaken by MESL (2007) suggested that biodiversity (relating to the number of characterising taxa in marine deposits) can be directly related to sediment type. It was found that the wide range of habitats that occur within mixed sediment types such as mixed sands and gravel support a higher biodiversity of benthic infauna than well sorted sediments. Essentially, the more heterogeneous the sediments, the

greater the number of species they can support. A greater mix of sediment particle sizes increases the number of potential habitat types for benthic species.

In order to establish the robustness of this relationship, the faunal data were compared with the sediment data using the BIO-ENV and RELATE multivariate statistical routines within PRIMER v6 (fully described in Appendix 2).

The RELATE routine provides a means for testing correlations between two multivariate patterns, which in this case was a test for relationships between the distribution of biological communities and the distribution of sediment types. The results of this test demonstrates that there is a significant relationship ($Rho = 0.201$, Significance Level = 0.1%) between the multivariate patterns observed in the sediment data and in the faunal communities.

In order to establish which particle sizes correlate most strongly with the patterns observed within the faunal communities, the faunal and sediment data were tested using the ~~ENV~~ routine. The results indicate that the strongest correlation between the multivariate patterns in the sediment and faunal data correspond most strongly with the distribution of sand of particle size 2.8mm (correlation of 0.253), and fine sand of particle size 1.4mm to 0.18mm (correlation of 0.247).

C.4. Biotope Mapping

A biotope map of the sublittoral sediments of Goodwin Sands was produced based on the infaunal and PSA data collected across the site. Biotopes were assigned in accordance with Connor *et al.* (2004) based on the sediment, depth and faunal data collected in 2015. The point data was interpolated over the PIZ and SIZ of the site using Thiessen polygons to delineate the boundaries between different biotope complexes. The Goodwin Sands biotope map is presented in Figure 14.

Full coverage biotopes have only been mapped within the PIZ and SIZ as this is where the density of sampling points is greatest. Biotopes outside of the PIZ and SIZ are represented as points only as the paucity of sampling stations would likely lead to large error in the interpolation of biotopes between points outside of these areas.

It should be noted that the biotope map is based on data acquired from the sampling stations only, and is interpolated between points. There may thus be some degree of error in areas where no sampling points are present. It should also be noted that the biotope classification is based only on data collected in August 2015, and does not incorporate acoustic data.

Biotopes have been assigned at a minimum of EUNIS Level 4. Biotope matches for the coarse and mixed sediment habitats and the faunal data recorded were not accurate, so only sand habitats have been taken to EUNIS Level 5.

The biotopes recorded across the sampling are as follows:

- A5.13 – Infralittoral Coarse Sediment
- A5.14 – Circalittoral Coarse Sediment
- A5.23 – Infralittoral Fine Sand
- A5.25 – Circalittoral Fine Sand
- A5.43 – Infralittoral Mixed Sediment
- A5.44 – Circalittoral Mixed Sediment

In addition to the Level 4 biotopes described above, A5.23 has also been mapped at EUNIS Level 5 as A5.231 – Infralittoral mobile clean sand with sparse fauna.

It can be seen from Figure 14 that the PIZ is predominantly characterised by A5.231 ‘Infralittoral mobile clean sand with sparse fauna’. The SIZ is characterised by three infralittoral biotope complexes: A5.231, A5.13 and A5.43. Further examples of these biotopes are present in the reference and context areas, alongside deeper circalittoral biotopes to the south-east of the PIZ.

The biotopes based on data presented in this report have been overlain with those assigned as part of the Goodwin Sands rMCZ 2015 Post-Survey Site Report (Defra, 2015) in Figure 15. It can be seen there is a good level of agreement between the two biotope mapping exercises, with both studies describing habitats within the PIZ as subtidal sand. The MCZ data is further discussed in Section D.1.2.

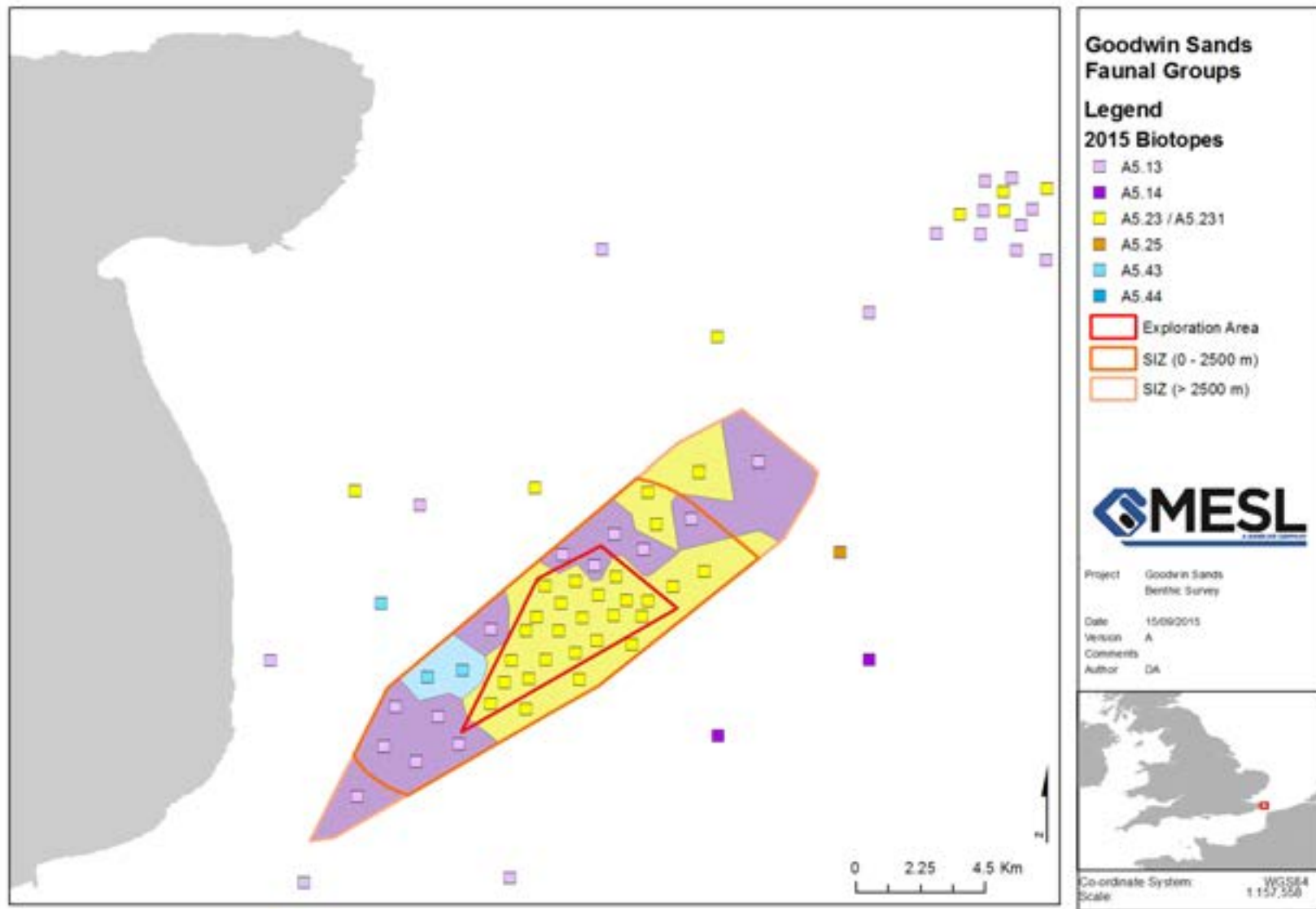


Figure 14. The spatial distribution of biotopes assigned to the benthic sampling stations at Goodwin Sands based on 2015 data.

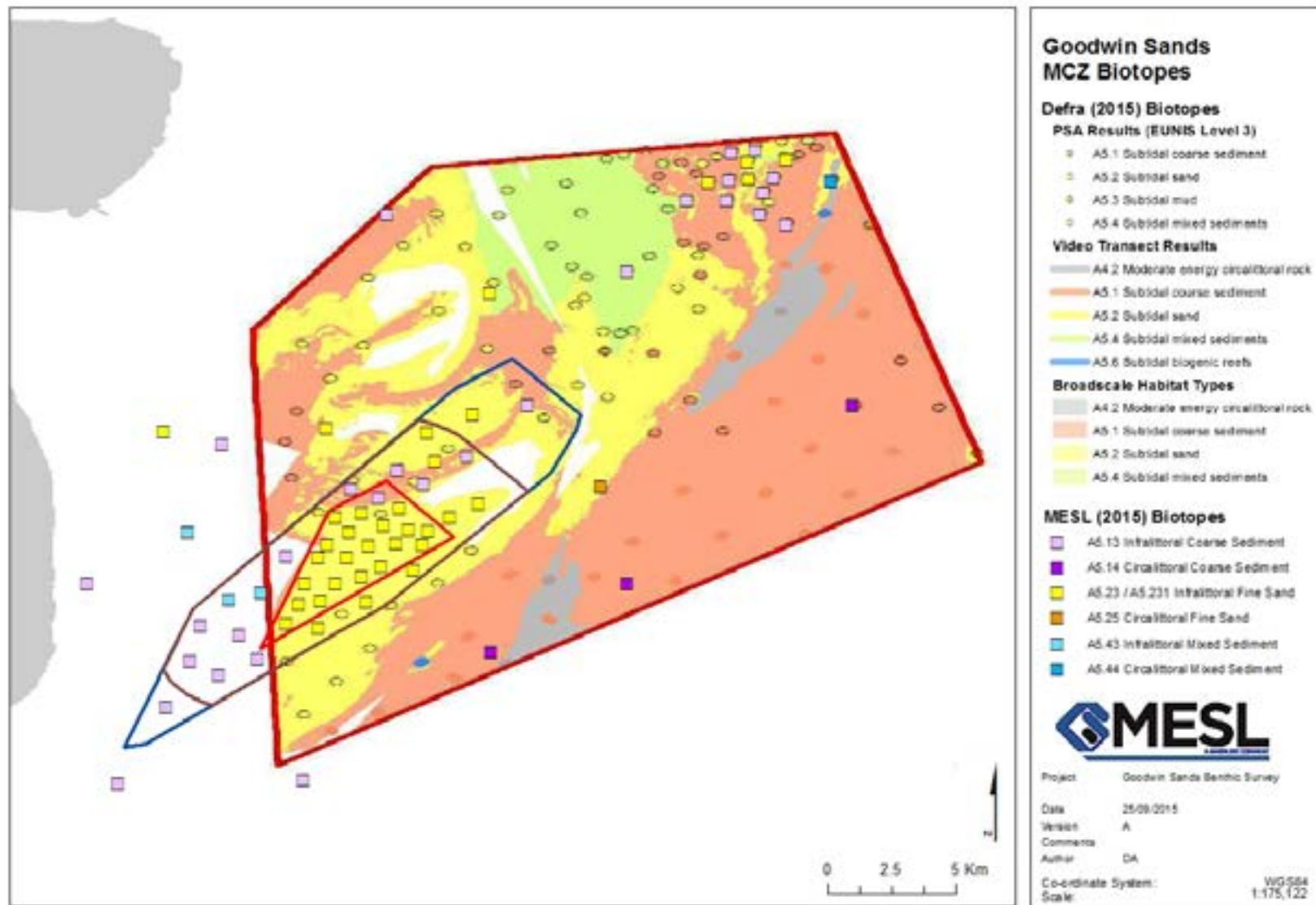


Figure 15. A comparison of the biotopes defined by Defra (2015) within the Goodwin Sands rMCZ and the MESL 2015 biotopes, defined by data presented in this report.

C.5. Cumulative Impacts on Benthic Fauna

Cumulative impacts are defined as ‘the combined effects of more than one dredging licence area within a region’; and in-combination effects are ‘the combined effects of dredging and different seabed users within a region’ (BMAPA & the Crown Estate, 2010).

As no other aggregate extraction areas or aggregate application areas lie in close proximity to the Goodwin Sands exploration area, it is considered that cumulative impacts are likely to be non-existent. Further data would need to be gathered to assess any likely in-combination effects at the exploration area.

Summary of Benthic Infauna

- A total of 3,398 individuals representing 301 taxa were recorded during the 2015 survey at Goodwin Sands.
- Average per station abundance was 67.96 individuals, average species diversity was 22.18, and average biomass was 0.28g AFDW.
- Annelida dominated the contribution to total abundance and species diversity, and made the second largest contribution to total biomass. The biomass was dominated by Echinodermata.
- The encrusting annelid worm *Spirobranchus lamarcki* and the porcelain crab *Pisidia longicornis* were the most abundant taxa recorded. The crustacean *Gastrosaccus spinifer* and the bryozoan *Electra pilosa* were the most frequently encountered taxa in the samples.
- Faunal abundance, diversity and biomass were typically greatest outside of the exploration area boundary to the south-west of the SIZ. Infaunal abundance, diversity and biomass were correlated to some extent with sediment type and the topography of sandbank features.
- Multivariate analysis identified the presence of seven distinct faunal groups which were subject to considerable variation across the survey array. The distribution of faunal complement was found to be loosely correlated with sediment type, with the variation in PSD accounting for approximately 20% of the observed variance in fauna.
- The exploration area was largely defined by the biotope A5.231 – Infralittoral mobile clean sand with sparse fauna.
- No other aggregate Licence Areas are found in close proximity to the interest area, therefore cumulative effects are not expected to occur.

C.6. The Nature of the Epibenthos

C.6.1. Epibenthic Species Richness, Abundance & Biomass

A total of 49 epibenthic taxa were recorded from the four trawls undertaken across the area of interest in August 2015. A total of 1,760 individuals were sampled from all trawl stations, with a total biomass of 7,916g wet weight (WW). The complete faunal inventory, which includes the numerical abundance of each taxon, is presented in Appendix Table 10. The biomass of each taxon is shown in Appendix Table 11.

The mean number of taxa recorded per sample was 22.25, the mean number of individuals per sample was 440, and the mean biomass was 1,979g WW. The total biomass was influenced by the relatively high abundance of the common brittlestar *Ophiothrix fragilis* encountered during the survey and large body size of several *Scyliorhinus canicula* which were recorded.

Images of some of the most abundant invertebrate and fish species recorded in the beam trawl samples are presented in Plate 2.

The distribution of sandeels across the survey area is discussed in Section D.3.1.



Plate 2. Examples of some of the most commonly occurring invertebrate and fish species recorded in the beam trawl samples acquired across Goodwin Sands in 2015. Clockwise from top left: the brittle star *Ophiothrix fragilis*; the pink shrimp *Crangon crangon*; the weaver fish *Echiichthys vipera*; the small-spotted catshark *Scyliorhinus canicula*; and the prawn *Pandalina brevirostris*.

C.6.2. Community Composition of the Epibenthos

The percentage contribution made by each major faunal group to the epibenthic abundance, species richness and biomass across all epibenthic trawl stations sampled in August 2015 is illustrated in Figure 16.

Epifaunal abundance in this area was dominated by Echinodermata, followed by Crustacea and Pisces. Pisces and Crustacea contributed the most to overall species richness, and Pisces the most to total biomass recorded, reflecting the large body size of fish species recorded, particularly *Scyliorhinus canicula*.

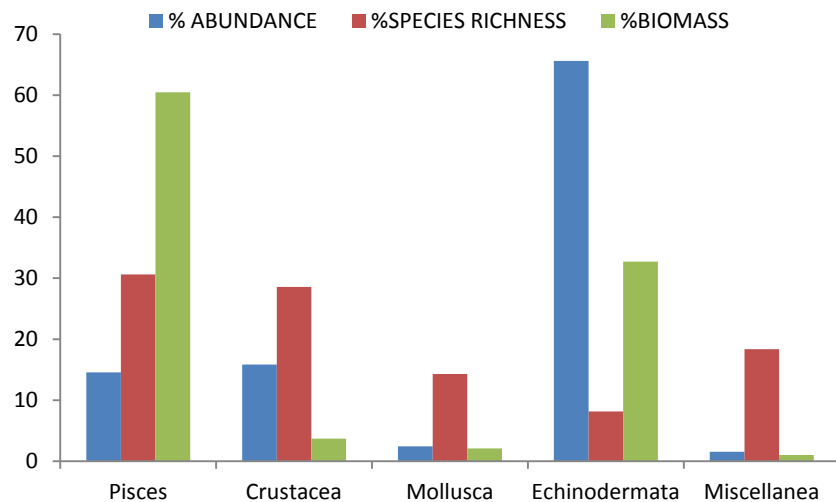


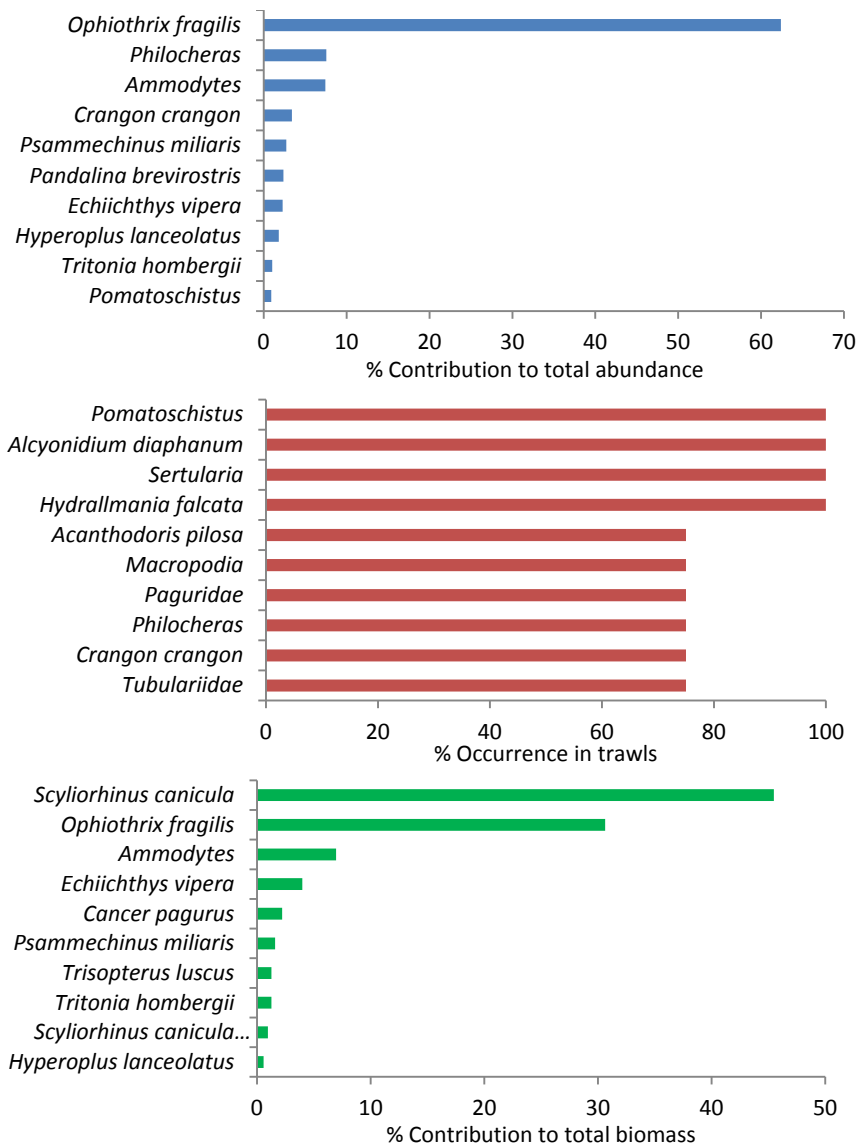
Figure 16. The relative contribution of each major faunal groups to abundance, species richness and biomass of the epibenthic fauna from the trawl stations sampled at Goodwin Sands in 2015.

The numerical abundance of individuals present in the catch, the percentage occurrence of the main taxa in the trawl samples and the highest contributors to overall biomass at the four stations sampled in August 2015 is summarised in Figures 17a-c.

It can be seen from Figure 17a that the brittlestar *Ophiothrix fragilis* was the most abundant species recorded, accounting for over 60% of all individuals encountered. This is likely due to the presence of a possible brittlestar bed at the station to the south-west of the PIZ. The crustacean *Philocheas* sp. was the next most abundant species encountered, followed by the sandeel *Ammodytes* sp.

Figure 17b shows the top 10 most commonly occurring species recorded during the survey. Of the top 10 most widely occurring species, four were found in every trawl sample: the goby *Pomatoschistus*, the bryozoan *Alcyonidium diaphanum* and the hydroids *Sertularia* sp. and *Hydrallmania falcata*. The ubiquitous occurrence of many species across the site indicates the relative uniformity of the area as an epibenthic habitat.

Figure 17c demonstrates that *Scyliorhinus canicula* found at trawl Station 3, dominated biomass, accounting for over 45% of the total recorded. The second largest contribution was *O. fragilis*, which was the most abundant taxon recorded. Six of the most significant species in terms of biomass are fish due to relatively large body size compared with other common fauna such as the hydrozoans *Hydrallmania falcata* and *Sertularia*.



C.6.3. Distribution in the Survey Area

The relative values for numerical abundance, species richness and biomass of fish and invertebrates recorded at the four trawl sites during the survey are summarised in Figure 18.

Some considerable variation was evident within the epibenthic dataset, with the greatest values for abundance and biomass being over an order of magnitude greater than the minimum values recorded for each index. Greatest abundance, species richness and biomass were recorded to the south-west of the PIZ in the SIZ. A large number of brittlestars (1,080) at Station T3 (south-west SIZ) is likely to account for the high abundance and biomass observed there. Values for each index recorded within the PIZ were typically mid-range.

Figure 17a-c. The 10 most important epibenthic species in terms of percentage abundance, occurrence and biomass during the 2015 Goodwin Sands survey.

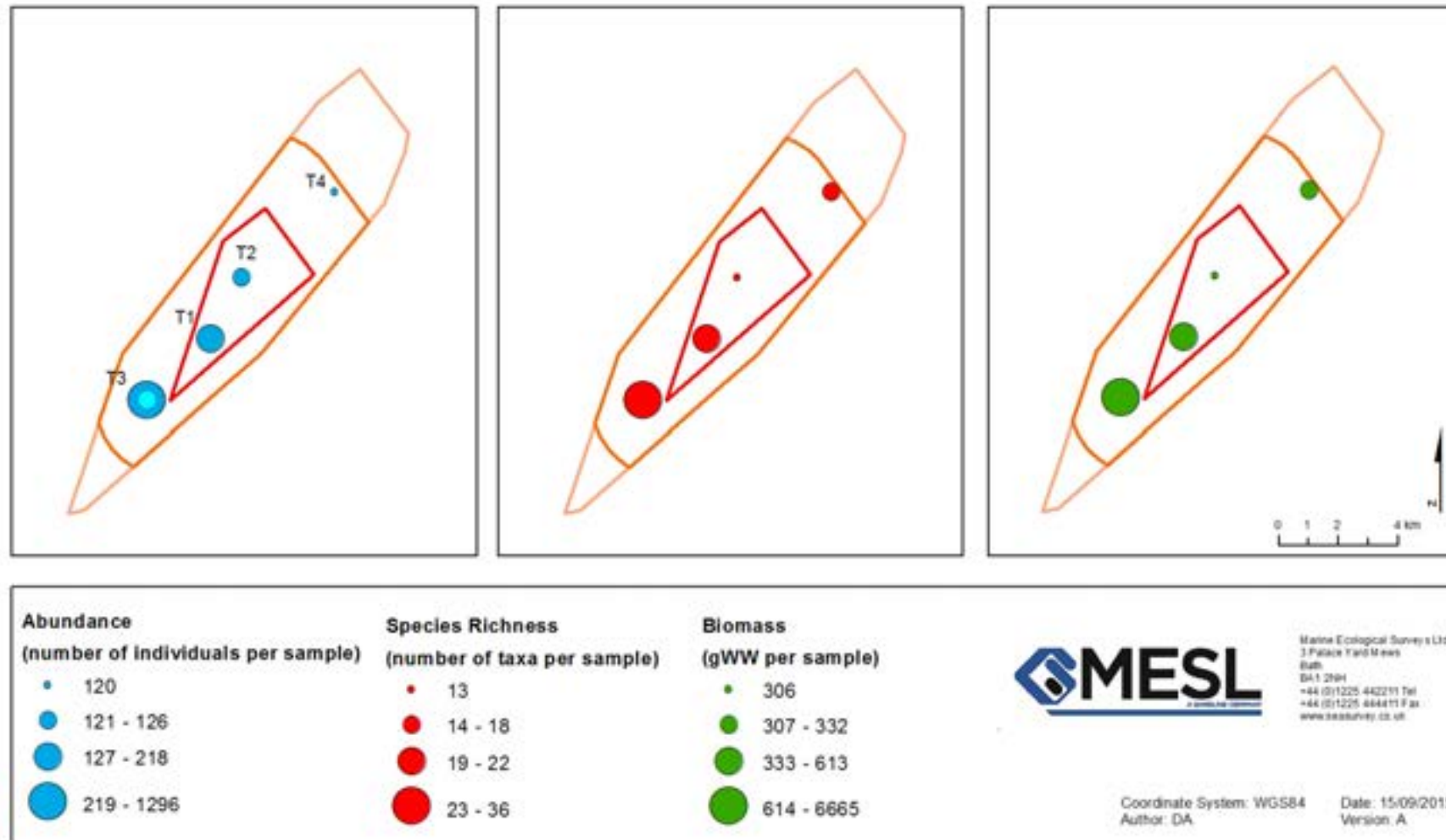


Figure 18. The abundance, species diversity and biomass found in the epibenthic trawls sampled across Goodwin Sands in 2015.

Summary of Epibenthic Fauna

- A total of 1,760 individuals representing 49 epibenthic taxa were recorded during the Goodwin Sands epibenthic survey in 2015. A total biomass of 7,916g WW was reported.
- The mean number of taxa recorded per sample was 22.25, the mean number of individuals per sample was 440, and the mean biomass was 1,979g WW.
- Epifaunal abundance was dominated by Crustacea and fish (Pisces), although the main contribution was made by the echinoderm *Ophiothrix fragilis*. Four taxa were found in all four trawl samples, including the gobies *Pomatoschistus* sp, the bryozoans *Alcyonidium diaphanum* and the hydroids *Sertularia* sp. and *Hydrallmania falcata*. Biomass was dominated by the small-spotted catshark *Scyliorhinus canicula* and the brittlestar *Ophiothrix fragilis*.
- A combined total of 163 sandeels were recorded at three of the trawl stations.
- The abundance, species richness and biomass of fish and epifauna were greatest outside of the exploration area, towards the south-

D. CONSERVATION REVIEW

D.1. Sites Protected Under UK and European Nature Conservation Legislation

Data for this section are taken in part from the Balanced Seas MCZ Regional Project Final Recommendations (Balanced Seas, 2011) and the Goodwin Sands rMCZ Post-Survey Site Report (Defra, 2015).

D.1.1. Natura 2000 Sites

Neither the exploration area nor the predicted SIZ overlap with any internationally recognised Natura 2000 conservation sites, such as Special Areas of Conservation (SACs) or Special Protection Areas (SPAs).

D.1.2. Marine Conservation Zones (MCZ)

In accordance with the Marine and Coastal Access Act. 2009, “the UK appropriate authority can designate Marine Conservation Zones (MCZ) based on the purpose of conserving species of marine flora and fauna, particularly if they are rare or threatened, or for conserving or protecting marine habitats or features of geological or geomorphological interest”.

Three recommended Marine Conservation Zones and a designated Marine Conservation Zone are in the vicinity of the interest area. A summary of these sites is presented below:

- Thanet Coast Marine Conservation Zone

The Thanet Coast MCZ has been designated due to multiple habitat types present in this area, including sublittoral and intertidal sand, chalk, rock, peat and clay and gravel. The

designation of this site is also intended to protect extensive *Sabellaria* reef and two species of stalked jellyfish found locally.

- **Goodwin Sands recommended Marine Conservation Zone**

The Goodwin Sands rMCZ is dominated by sandbanks which act as a shelter for a wide variety of marine species. The area is also recommended for conservation due to the presence of *Sabellaria spinulosa* reefs and blue mussel beds.

Dover to Deal recommended Marine Conservation Zone

The Dover to Deal site has been put forward for designation due to various intertidal and subtidal habitats. Of particular importance are the examples of chalk platform shores, subtidal chalk reefs and blue mussel beds. In addition, there are also extensive *Sabellaria* reefs known in the locality.

- **Offshore Foreland recommended Marine Conservation Zone**

This site is located along the channel between Kent and France and contains rocky habitats as well as sand wave features. The site is regarded as prime sandeel habitat and supports a large abundance of crustaceans.

The location of these conservation areas is shown in Figure 19.

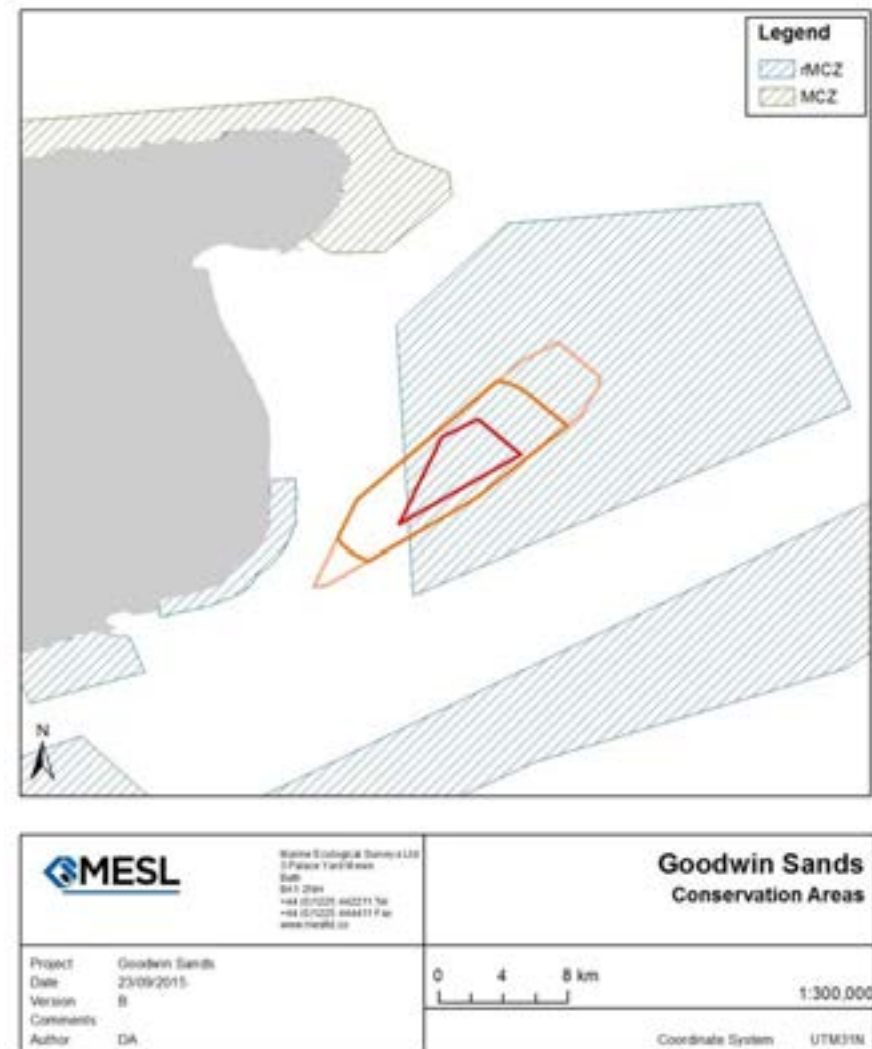


Figure 19. The position of the exploration area at Goodwin Sands and the proposed survey array in relation to established and recommended Marine Conservation Zones (rMCZs).

It can be seen from Figure 19 that both the exploration area and secondary impact zone in the area of interest overlaps with the Goodwin Sands rMCZ. It is understood that the Goodwin Sands rMCZ is not included within the second tranche of MCZs consulted upon for designation in early 2016. As such, the MMO has stated that the Marine Licence application for aggregate extraction within the exploration area does not need to include a full MCZ assessment. The site is however likely to be considered for designation in the future under Tranche 3 of Defra's MCZ designation programme, thus this report does consider possible impacts to MCZ features.

As described above, the Goodwin Sands rMCZ has been recommended for designation due to the presence of sandbank features, blue mussel beds and *Sabellaria* reef features. Several *Sabellaria spinulosa* individuals were recorded during the 2015 survey (discussed in Section D.2. below), although no evidence of any reef features were noted. Likewise, some juvenile *Mytilus* sp. individuals were recorded during the survey (18 individuals), however no adult *Mytilus edulis* individuals were recorded, and no numbers in large enough abundances to constitute a biogenic reef habitat, either within the exploration area, the SIz, or the context and reference zones.

The Goodwin Sands rMCZ 2015 Post-Survey Site Report indicates the presence of Blue mussel beds and *Sabellaria* reefs outside of the exploration area and SIz, to the south, east and north-east of the study area, as shown in Figure 20. Given the predominant direction of tidal movements in the area and the shape and extent of the likely SIz, it is highly unlikely that these areas will be affected by any dredging activity in the exploration area.

The Goodwin Sands rMCZ 2015 Post-Survey Site Report also indicated the presence of subtidal chalk habitats as a habitat of conservation interest, as shown in Figure 20. These sites are also located away from the PIZ and SIz, to the south, east and north-east. Additionally, widespread subtidal sands and gravels are present across much of the rMCZ, as shown in Figure 20, including within the PIZ and SIz.

Based on the data presented in this report and the location of the features of conservation interest as mapped in Defra (2015), it is therefore concluded that impacts resulting from aggregate extraction would be unlikely to have any impact on the ecological features of the Goodwin Sands rMCZ, especially considering the sparse nature of the fauna and the impoverished benthic communities documented within the PIZ boundary.

The next closest site to the exploration area is the Dover to Deal rMCZ which lies approximately 4km due east from the closest point of the area, and approximately 2km due east from the closest point of the SIz. It is highly unlikely that any impacts from activity in the exploration area would affect the ecological features of this site, given that this rMCZ is not within any of the predicted impact zones.

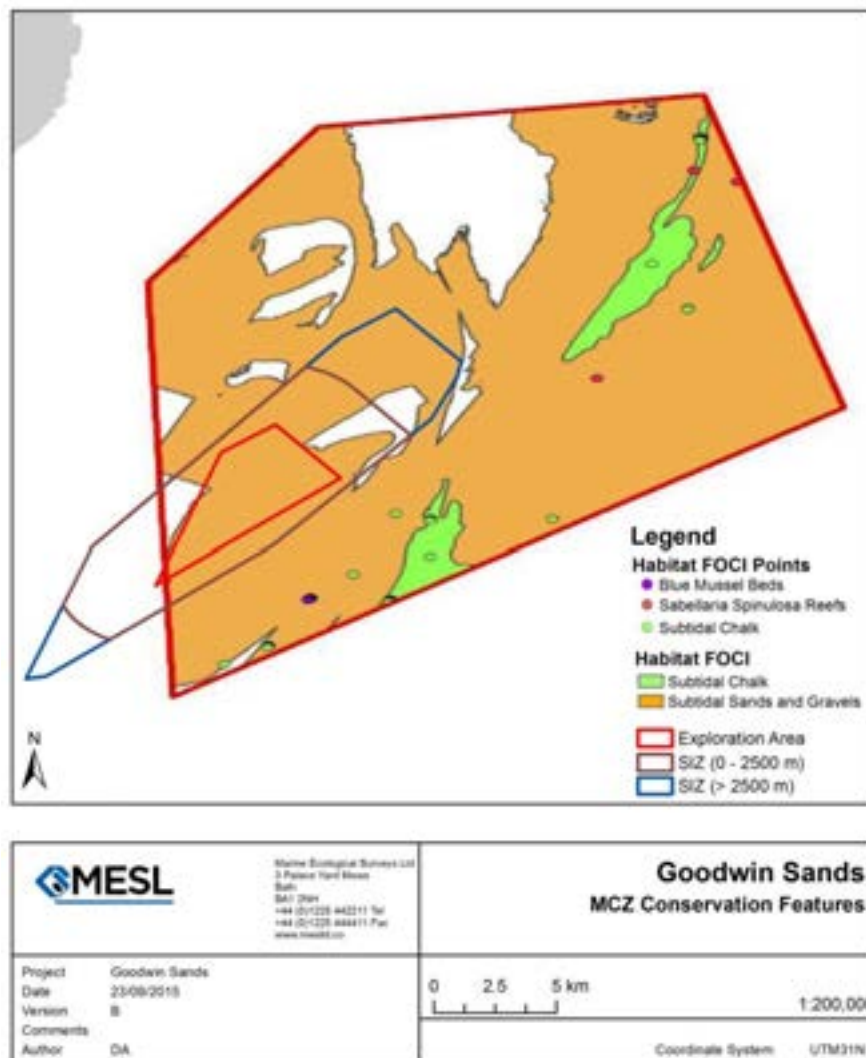


Figure 20. Goodwin Sands rMCZ features of conservation interest as mapped in Defra (2015), with respect to the Goodwin Sands exploration area. The rMCZ boundary is shown in dark red.

D.2. Habitats of Conservation Importance

In addition to the protected areas found across the area of interest, a number of habitats of potential conservation significance listed under Annex I of the EC Habitats Directive are suspected to occur in the vicinity of the exploration area. Annex I habitats are defined under the Council Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Fauna and Flora; more commonly referred to as the EC Habitats Directive (1992) as amended. Under these regulations, species and habitats that fall into designated categories are eligible for legal protection from activities which have the potential to damage them.

Potential habitats of conservation importance likely to occur in the region of the exploration area include the following:

- **Sandbanks** covered by seawater at all stages of the tide; and
- **Biogenic Reefs** which can include dense aggregations of the Ross worm *Sabellaria spinulosa*, the honeycomb worm *Sabellaria alveolata* or other organisms such as mussels (*Mytilus* sp. and *Modiolus* sp.).

The sandbank features at Goodwin Sands are well documented and are recommended for conservation as part of the Goodwin Sands rMCZ (as detailed in Section D.1 above).

The distribution of *Sabellaria spinulosa* reefs and blue mussel beds, as mapped as part of the MCZ designation process, is discussed in Section D.1.2 above and is presented in Figure 20. No evidence of any biogenic reef features was documented during the 2015 Goodwin Sands survey. Small abundances of *Sabellaria spinulosa* were recorded at 10 stations

during the survey, although not at densities thought sufficient to constitute reef features in line with guidance in Hendrick and Foster-Smith (2006) and Gubbay (2007), where densities of several thousand individuals per m² are quoted as constituting even moderate quality reef. It should be noted that *Sabellaria spinulosa* as a species is afforded no conservation protection, rather the reef features constructed by this species. The distribution of *Sabellaria spinulosa* recorded during the 2015 survey is presented in Figure 21.

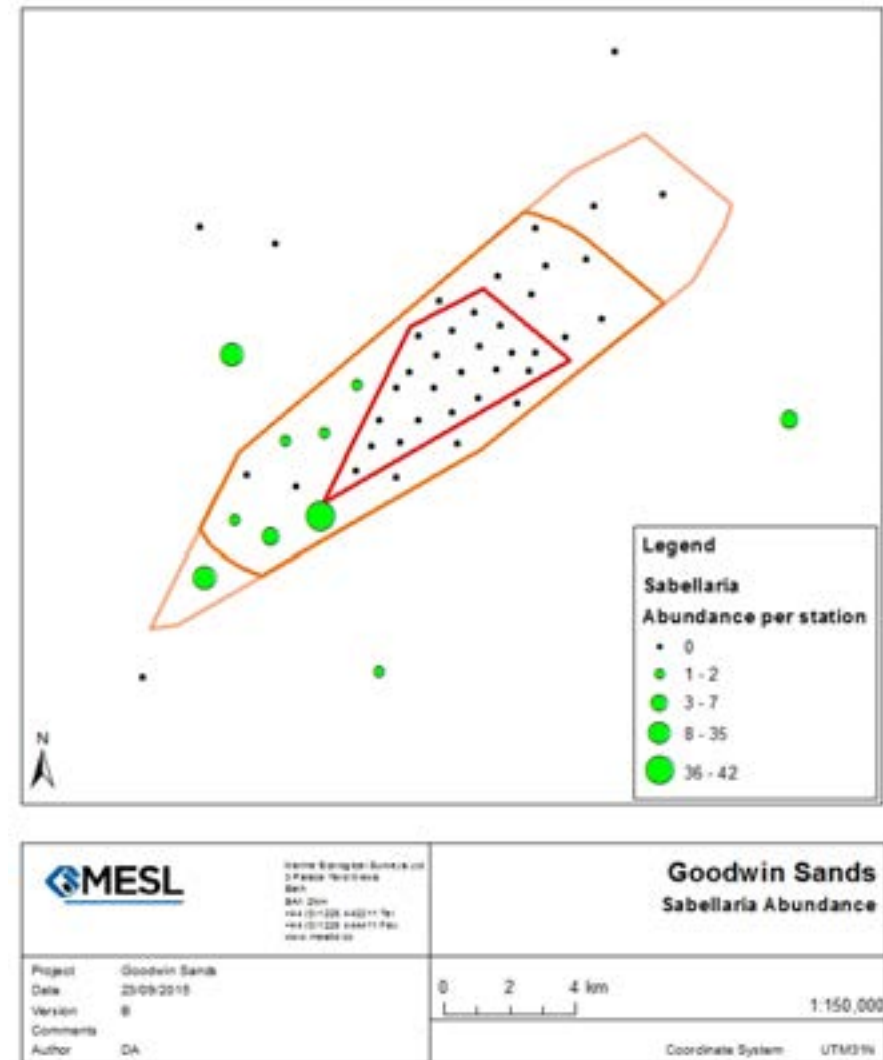


Figure 21. The distribution of *Sabellaria* abundance recorded during the 2015 Goodwin Sands survey.

D.3. Species of Conservation Importance

D.3.1. Sandeels

The Goodwin Sands survey area has been identified as a potentially important habitat for sandeels. Sandeels are listed as a priority conservation species under the UK Post-2010 Biodiversity Framework (formerly UK Biodiversity Action Plan). The species exhibits a high level of site fidelity and a preference for specific sediment types in which they can burrow and lay their eggs (Jensen *et al.* 2010).

A number of sandeels (both *Ammodytes* sp. and *Hyperoplus lanceolatus*) were recorded during the 2015 survey. The distribution of sandeels as recorded in the epibenthic survey is shown in Figure 22. In addition to the sandeels recorded in the trawl samples, four *Ammodytes marinus* individuals were recorded from two stations in the benthic grab sampling survey. These stations (06 and 14) were located within the north of the exploration area in close proximity to where the maximum abundance of sandeels from the trawl samples was recorded.

It can be seen from Figure 21 that sandeels were recorded at three of the four trawl sampling stations. The greatest abundance (66 individuals) was recorded within the PIZ.

Literature evidence suggests that sandeels reach maturity at approximately 14cm in length (Bergstad *et al.* 2001). The majority of sandeels recorded during the 2015 epibenthic survey (135, 83% of total) were under this length and were classed as juveniles. Sandeels are known to spawn at suitable habitats off the south-east coast of the UK (Coull *et*

al. 1998; Ellis *et al.* 2012), although the data collected as part of this survey is insufficient to determine whether spawning occurs at Goodwin Sands.

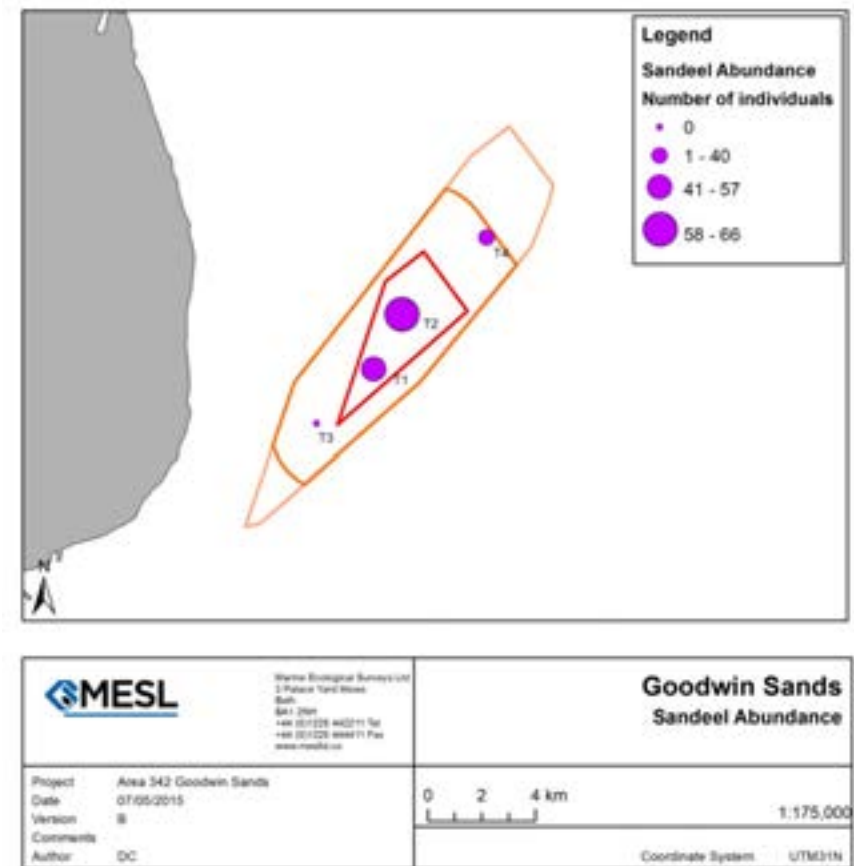


Figure 22. The distribution of sandeel (*Ammodytes* sp. and *Hyperoplus lanceolatus*) and abundance at Goodwin Sands as recorded in the 2015 survey.

D.3.2. Other Species of Conservation Interest

No other species of conservation interest were recorded during the survey.

D.3.3. Invasive/Alien Species

No invasive or alien species were recorded in high abundance during the 2015 Goodwin Sands survey, although lone individuals of *Crepidula fornicata* and *Monocorophium sextonae* were recorded.

Summary of Conservation Review

- No Natura 2000 conservation areas are present in the vicinity of the exploration area.
- Several recommended Marine Conservation zones are located in close proximity to or overlap with Goodwin Sands.
- The exploration area and associated SIZ overlaps with the Goodwin Sands rMCZ. This area is recommended for designation due to the presence of biogenic reefs and sandbank habitats, although no evidence of any biogenic reef features was observed during the benthic or epibenthic survey, and it is unlikely that dredging activity at the site would impact on the ecological interest features of the rMCZ based on the evidence in this report. No impacts from aggregate extraction at Goodwin Sands are expected to occur at any other rMCZ sites.
- *Sabellaria spinulosa* individuals were noted during the benthic survey, although not in densities sufficient enough to form reef habitats.
- Relatively high numbers of sandeels were recorded during the Goodwin Sands epibenthic survey, including at sites located within the exploration area.

E. CONCLUSIONS

1. Sediments throughout the survey area were generally characterised by sandy substrates. Relatively high proportions of gravel also existed at some stations, particularly those in the SIZ to the south-west of the PIZ. Within the exploration area, sediments were almost exclusively sandy, with very little silt content. There was some degree of variability between sediment composition in the PIZ, the SIZ, the context zone and the reference zone.
2. Chemical contaminants analysis indicated that almost the entire suite of contaminants tested were below Cefas Action Level 1. Arsenic was the only contaminant to exceed this level, and no contaminants were present in concentrations above Action Level 2. Arsenic concentrations within the exploration area were predominantly below the Action Level 1 limit.
3. Benthic community composition across the survey area was dominated by Annelida in terms of contribution to total abundance and species richness. Echinodermata dominated contribution to total biomass. A total of 301 taxa were sampled during the course of the benthic biological survey. The mean number of organisms per sample was 67.97, the mean number of taxa per sample was 22.18 and the mean biomass per sample was 0.28g AFDW.
4. The most abundant species were the annelid worm *Spirobranchus lamarcki* and the crustacean *Pisidia longicornis*. The mysid shrimp *Gastrosaccus spinifer* and the bryozoan *Electra pilosa* were the most frequently encountered taxa in the samples.
5. Greatest benthic abundance, species richness and biomass were typically concentrated in the SIZ to the south-west of the PIZ. Values for each index within the exploration area were comparatively low.
6. Multivariate analysis identified the presence of seven distinct faunal groups across the survey area. The distribution of faunal complement was found to be correlated with sediment type, with the variation in PSD accounting for approximately 20% of the observed variance in fauna. The presence of sands (particularly fine grained sands) exerted the greatest influence on faunal distribution.
7. The exploration area was predominantly characterised by the biotope A5.231 – *Infralittoral mobile clean sand with sparse fauna*. Other major biotope types across the survey area included A5.13 – *Infralittoral coarse sediment* and A5.43 – *Infralittoral mixed sediment*.
8. Epibenthic community structure was relatively diverse. A total of 1,760 individuals from 49 taxa were recorded from the four trawl samples undertaken. The presence of a dense brittlestar bed (*Ophiothrix fragilis*) at one station to the south-west of the exploration area had a large influence on overall abundance and biomass recorded. Common fauna sampled included bryozoans, hydroids, gobies and sandeels, in addition to brittlestars.
9. The exploration area and associated SIZ overlaps with the Goodwin Sands rMCZ. Given that no biogenic reef features were noted during the benthic survey (for which the rMCZ is recommended to protect), it is unlikely that dredging in the exploration area will have an impact on biogenic reef features.

10. No Annex I reef habitats were observed during the benthic survey. Individuals of *Sabellaria spinulosa* and Mytilidae were recorded, however not in sufficient densities to reflect the presence of biogenic reef features as per Hendrick and Foster-Smith (2006) and Gubbay (2007), where densities of several thousand individuals per m² are quoted as constituting even moderate quality reef.
11. A number of sandeels were recorded during the epibenthic survey, including relatively high numbers within the exploration area. No other species of conservation importance were noted across the survey array.

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G. APPENDICIES

Appendices

1. MESL SOPs & Quality Assurance Procedures
2. Multivariate Analysis Techniques - Methods Statement

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1. Benthic Grab Samples Contact Sheet
2. Epibenthic Samples Contact Sheet



Appendix 8.2

Goodwin Sands Exploration Area Sidescan Sonar Interpretative Report



GOODWIN SANDS GEOPHYSICAL SURVEY 2015

(EGS Job No. 5432)

INTERPRETIVE REPORT

REVISION 1 - FINAL

NOVEMBER 2015

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ISSUE AND APPROVAL CONTROL SHEET

5432 DHB – Goodwin Sands Geophysical Survey 2015

Interpretive Report – Rev 1 - Final

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Copies of this report will be issued to:

Dover Harbour Board	1 x Electronic

Document Revised By: **Tom Smethurst**
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Date: 30th October 2015

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Date: 05th November 2015

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Date: 06th November 2015



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ABBREVIATIONS

Abbreviation	Meaning
ADCP	Acoustic Doppler Current Profiler
BGS	British Geological Society
CD	Admiralty Chart Datum
DHB	Dover Harbour Board
EIA	Environmental Impact Assessment
km	Kilometre
m	Metre
MBES	Multibeam Echosounder
NU	North-up
SBP	Sub-Bottom Profiler
SSS	Side-scan Sonar
SVP	Sound Velocity Profiler
UKHO	United Kingdom Hydrographic Office
USBL	Ultra Short Baseline
WGS84	World Geodetic System 1984

EXECUTIVE SUMMARY

In July 2015, Dover Harbour Board (DHB) contracted EGS International Ltd (EGSi) to undertake a pre-dredging survey within the vicinity of the Goodwin Sands, off the East coast of the UK.

DHB is planning development of the Western Docks at the Port of Dover through a project called the Dover Western Docks Revival (DWDR). The works require approximately 2.5 million m³ of aggregates for new berth construction and reclamation. DHB intends to obtain aggregate by dredging material from the Goodwin Sands; a sandbank system located approximately 7km off the east Kent coast. The primary purpose of the survey was:

“To collect data to support the design of the proposed aggregate dredging scheme and to inform the EIA and consenting process. The surveys will provide information on the distribution, type and quantity of aggregate resources within the prospecting area, and help to identify areas and features of ecological and historic interest that need consideration as part of the EIA process.”

Geophysical operations were undertaken using a high-frequency multibeam system (MBES), side-scan sonar (SSS) system, two different sub-bottom profilers (SBP) and an Ultra Short Baseline (USBL) sub-surface positioning system. In addition, an Acoustic Doppler Current Profiler (ADCP) was deployed during survey operations in order to record local currents.

The survey was conducted on-board the FPV Morven, operating on a 24-hour basis.

Initial vessel mobilisation, equipment calibrations and verifications took place whilst the vessel was in Southampton. The vessel subsequently transited to the Port of Ramsgate, designated as the port of operations. Final equipment calibrations and verifications were carried out following the Onsite Kick-Off meeting on the 7th July.

Geophysical survey operations started on the 10th July and were completed on the 2nd August with the vessel demobilisation taking place in Ramsgate on the same day.

The ADCP seabed frame was initially deployed on 9th July. When recovered on 24th July the data collected by the ADCP unit was found to be invalid. The ADCP frame was therefore redeployed at a different location on 30th July and finally recovered after a series of unsuccessful attempts on the 24th September, with full data recovery.

This report is concerned with the Bathymetric and Geophysical Survey of the Goodwin Sands. Details regarding the ADCP operations and results are included in a separate, dedicated report (5432 DHB – Goodwin Sands Geophysical Survey 2015 - ADCP Static Deployment Report).

1. INTRODUCTION

1.1. PROJECT INFORMATION

Client:	Dover Harbour Board (DHB)
Project:	Goodwin Sands Geophysical Survey
Contractor:	EGS (International) Ltd (EGS)
Contractor Reference:	5432
Survey Area:	Goodwin Sands
Survey Type:	Bathymetric and Geophysical Survey
Survey Period	July/August 2015
Survey Vessel:	FPV Morven
Client Project Manager:	Alan Breck alan.breck@doverport.co.uk
Contractor Project Manager:	Dr Walter Colautti wcolautti@egssurvey.co.uk

1.2. PROJECT DESCRIPTION

Dover Harbour Board (DHB) is planning development of the Western Docks at the Port of Dover through a project called the Dover Western Docks Revival (DWDR). The works require approximately 2.5 million m³ of aggregates for new berth construction and reclamation. DHB intends to obtain aggregate by dredging material from the Goodwin Sands, a sandbank system, located approximately 7km off the East Kent coast.

The primary purpose of the survey was to collect data to support the design of the proposed aggregate dredging scheme and to inform the EIA and consenting process. The survey provides information on the distribution, type and quantity of aggregate resources within the prospecting area and will help to identify areas and features of ecological and historic interest that need consideration as part of the EIA process.

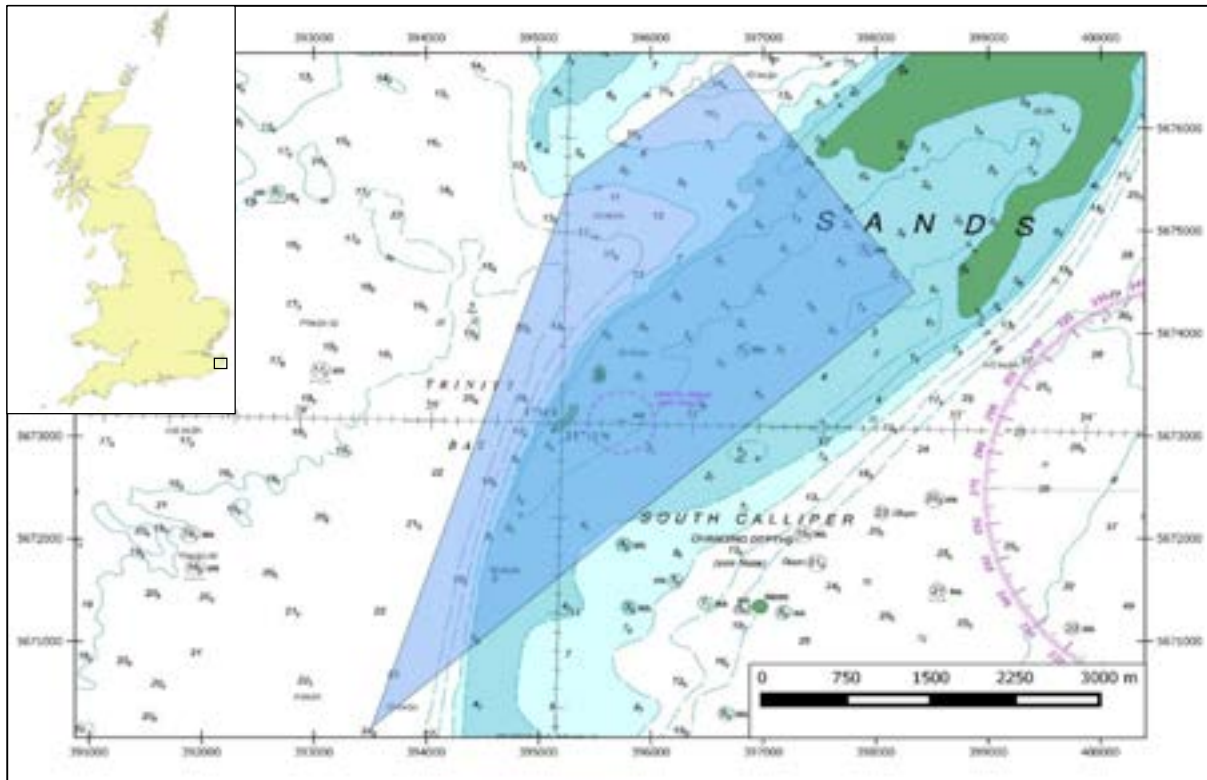


FIGURE 1: OVERVIEW OF MAIN GEOPHYSICAL SURVEY AREA

1.3. SCOPE OF WORK

The main aims of the survey were to:

- Survey the prospecting area using a Chirp, Boomer or equivalent system to generate high resolution images of the sub-bottom stratigraphy and structures within the area.
- Survey to check seabed elevation using a Multi Beam Echo Sounder (MBES) system.
- Provide high resolution SSS data on the nature and extent of seabed features within the prospecting area, including those of ecological, heritage and archaeological interest.

In addition to the bathymetric and geophysical survey, an Acoustic Doppler Current Profiler (ADCP) was to be deployed to obtain current data. Water turbidity measurements were also to be recorded.

DHB expanded the initial scope of work for the bathymetric and geophysical survey, requesting for crosslines to be extended for 1km outside the survey area boundary and for four perimeter lines to be surveyed as well at a 1km distance from the main survey area.

Where pertinent data and information such as locations of wrecks visible in the acoustic records from the extended crosslines and perimeter lines have been included in this report.

2. SURVEY OPERATIONS SUMMARY

The survey work was carried out using the vessel FPV Morven on a 24-hour basis. Initial vessel mobilisation, equipment calibrations and verifications took place whilst the vessel was in Southampton. The vessel subsequently transited to the Port of Ramsgate, designated as the port of operations. Final equipment calibrations and verifications were carried out following the Onsite Kick-Off meeting on the 7th July.

Geophysical survey operations were carried out between 10th July and 2nd August 2015 with the vessel demobilisation taking place in Ramsgate on the same day. Details of the survey operations and data acquisition can be found in the Operations Report (*5432 DHB - Goodwin Sands Geophysical 2015 - Operations Report*).

Table 1 below presents a summary of survey operations:

Date	Activity
07/07/2015	Start of Mobilisation. Onsite Kick-Off meeting on board the Morven in Ramsgate.
09/07/2015	MBES/SSS verifications carried out and ADCP frame deployed.
10/07/2015	Mobilisation complete. Begin geophysical survey operations.
18/07/2015	Deep water work completed.
25/07/2015	Survey team reduced to two as carrying out operations over high water only. ADCP frame recovered. No valid data recovered.
30/07/2015	ADCP frame deployed at new location.
02/08/2015	Geophysical survey operations complete.
24/09/2015	ADCP recovered. Full data recovery.

TABLE 1: SUMMARY OF SURVEY OPERATION

3. PERSONNEL

3.1. PROJECT MANAGEMENT

Name	Role
Stephen Hayes	Project Director
Dr Walter Colautti	Project Manager
Mark Lyden	HSE Manager
John Bartle	Technical Manager

TABLE 2: PROJECT MANAGEMENT PERSONNEL

3.2. REPORTING PERSONNEL

Name	Role
Peter Watchorn	QC Manager
Dr Elizabeth Andrews	Head of Geoscience
Paul Clement	Head of Hydrography
Tom Smethurst	Geophysicist
Emma Le Marchant	Geophysicist
Rob Arnold	Geophysicist
Damien Wall	Senior Hydrographic Surveyor
Will Gillman	CAD & GIS Analyst

TABLE 3: REPORTING PERSONNEL

4. SURVEY RESULTS

Significant survey results are presented as a series of 16 charts, with significant results being presented in this report.

4.1. SUMMARY OF CHARTS

Table 4 below presents a summary of the charts presented in associated with this report:

Chart Type	Scale	Chart Content	Chart File Title
North-up Bathymetric Image with Contours (x 2)	1:7,500	Bathymetry imagery Bathymetric contours	5432_NU_MBES
North-up Seabed Features (x 2)	1:7,500	Sediment boundaries Seabed features Sonar contacts	5432_NU_SBF
North-up SSS (x 2)	1:7,500	SSS mosaic (HF)	5432_NU_SSS
North-up Base of Recent Sediments (x 2)	1:7,500	Depth below seabed of Base of Recent Sediments	5432_NU_DBS_UNIT_1
North-up Top of Bedrock (x2)	1:7,500	Depth below seabed of Top of Bedrock	5432_NU_DBS_UNIT_3
North-up Vessel Trackplot (x 2)	1:7,500	Vessel (CRP) trackplot	5432_NU_CRP_TP
North-up SBP Trackplot (x 2)	1:7,500	SBP trackplot	5432_NU_SBP_TP
North-up SSS Trackplot (x 2)	1:7,500	SSS towfish trackplot	5432_NU_SSS_TP

TABLE 4: SUMMARY OF CHARTS PRESENTED WITH REPORT

4.2. ELECTRONIC DELIVERABLES

The table below presents a list of all the electronic deliverables submitted with this report:

Dataset	Deliverable	File Format	File Extension
MBES	Vessel Trackplot	AutoCAD	.dwg and .dxf
	Raw Bathymetry Data	QINSY Native	.qpd
	SVP Logs	Excel	.xlsx
	Gridded Bathymetry 0.5/1 m resolution	ASCII/Geotiff	.xyz and .tif/.tfw
	Bathymetric Contours (0.5m intervals)	AutoCAD	.dwg/.dxf
	SSS Trackplot	AutoCAD	.dwg/.dxf
SSS	Raw SSS Data with Corrected Navigation	XTF	.xtf
	SSS HF Mosaic – 0.25m Resolution (tiled if necessary)	Geotiff	.tif/.tfw
	Sonar Contacts List	AutoCAD	.dwg/.dxf
	Sonar Contacts List	ASCII	.docx/.csv
	Seabed Features	AutoCAD	.dwg/.dxf
SBP	SBP Trackplots	AutoCAD	.dwg/.dxf
	Raw SBP Data with Corrected Navigation (Petrel compatible)	SEGY	.sgy
	Levels (depth below seabed)	ASCII/Geotiff	.xyz and .tif/.tfw
	Navigator Logs	Excel	.xlsx
Logsheets			

TABLE 5: SUMMARY OF ELECTRONIC DELIVERABLES

4.3. LINE PLAN

Prior to the start of survey operations a line plan was developed in order to allow efficient survey planning and for use as a guide for helmsman and navigators.

Main line spacing was 50m, with 1km crosslines perpendicular to these throughout the site and extending for 1km outside the survey area boundary. Additional survey lines were added as infill where required in order to achieve the project data coverage requirements.

Perimeter lines were also planned, offset by 1km from the boundaries of the main survey area.

4.4. BATHYMETRY

Full bathymetric coverage was achieved across the Goodwin Sands survey site with the addition of extended crosslines and perimeter lines.

Figure 2 shows the bathymetric coverage obtained over the site.

The MBES data acquired during the survey shows the seabed water depth within the surveyed area ranges from approximately 1.67m above (drying height) CD VORF, on top of the South Calliper Sands, to 36.57m below CD VORF at the most eastern extent of the area surveyed.

As shown in

Figure 2, the MBES data has defined the south west extents of South Calliper Sands in agreement with the Admiralty Chart. The extended crosslines have delineated the shoals to the north and south of Kellet Gut, including the drying heights to the northeast of the survey area.

It is to be noted that strong tidal streams affect the survey area resulting in rapid sediment migration. As a consequence, numerous “tearing” artefacts can be seen in the bathymetric dataset. These do not affect the quality of the data, but simply reflect the changes in the seabed morphology in the period of time between when survey lines are run.

Figure 3 provides an example of the “tearing” effect in the bathymetric DTM caused by the highly dynamic nature of the seabed in the surveyed area.

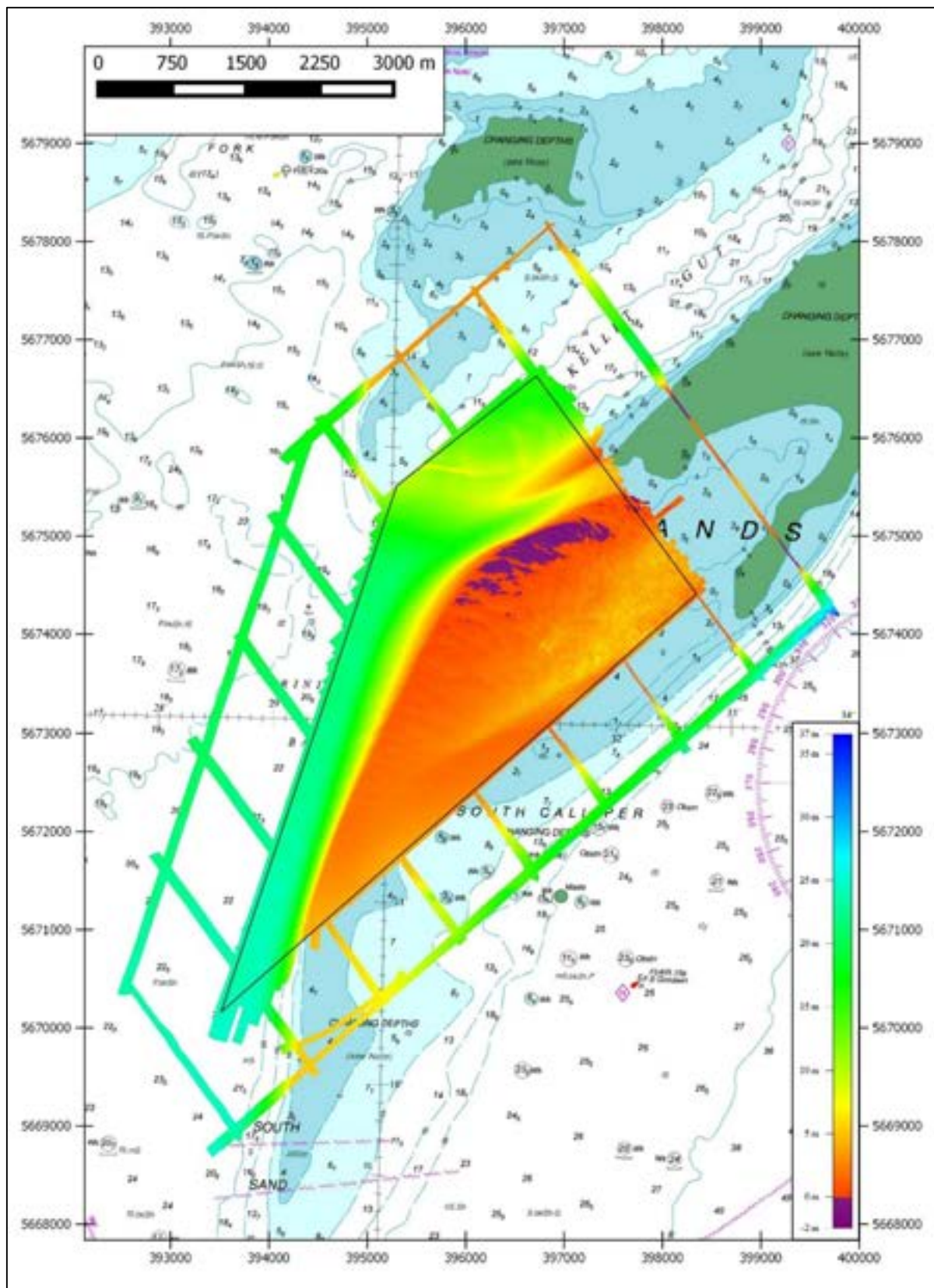


FIGURE 2: OVERVIEW OF BATHYMETRIC COVERAGE (DEPTHS RELATIVE TO CHART DATUM)
 ("DRYING HEIGHTS", I.E. NEGATIVE VALUES ABOVE CD VORF, ARE INDICATED BY THE COLOUR PURPLE)

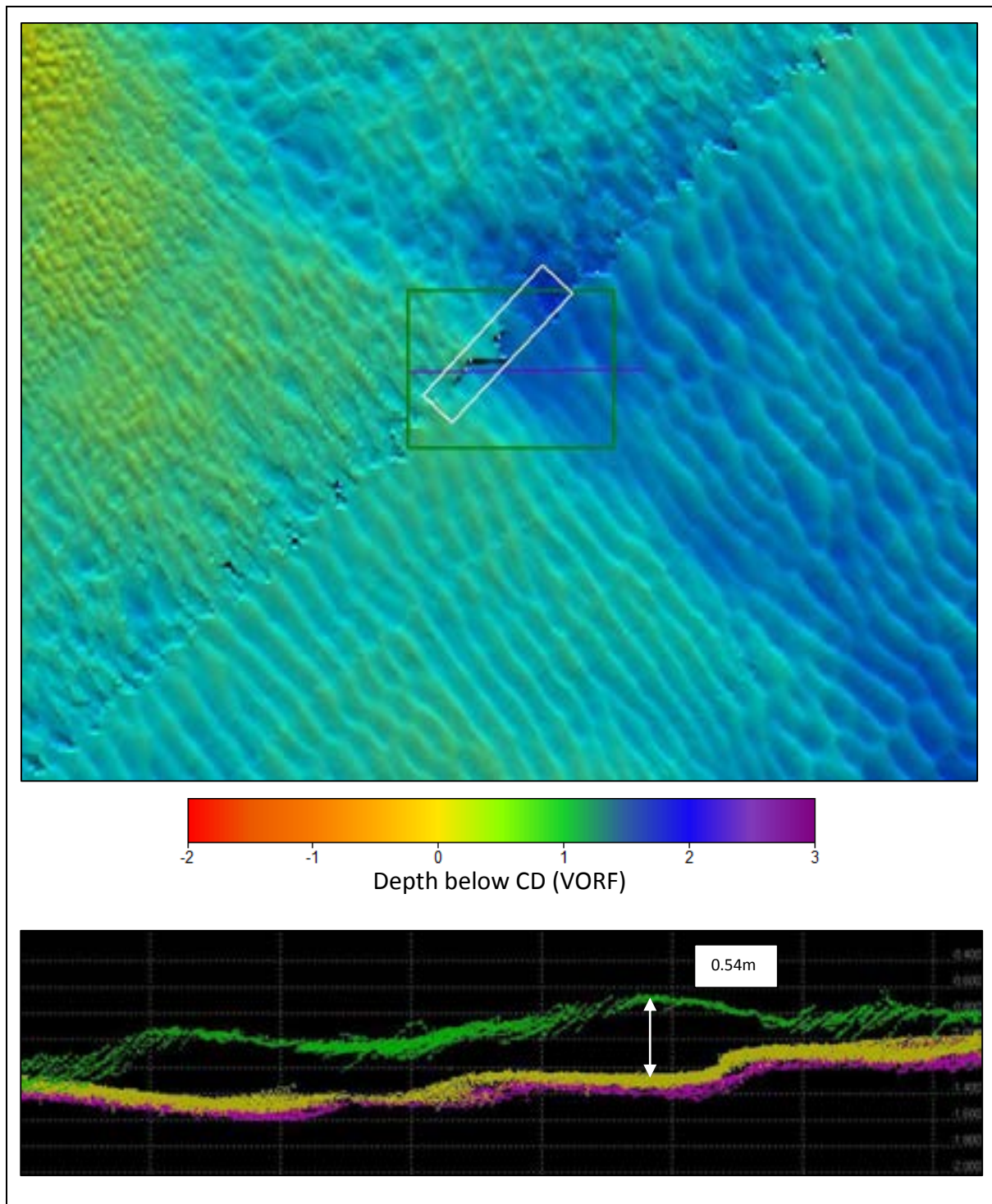


FIGURE 3: TEARING ARTEFACT CAUSED BY MOVEMENT OF SANDS BETWEEN SURVEY RUNS

Two charted wrecks were identified in the bathymetric and SSS datasets, locations of these wrecks relative to the boundary of the main survey area are shown in Figure 4.

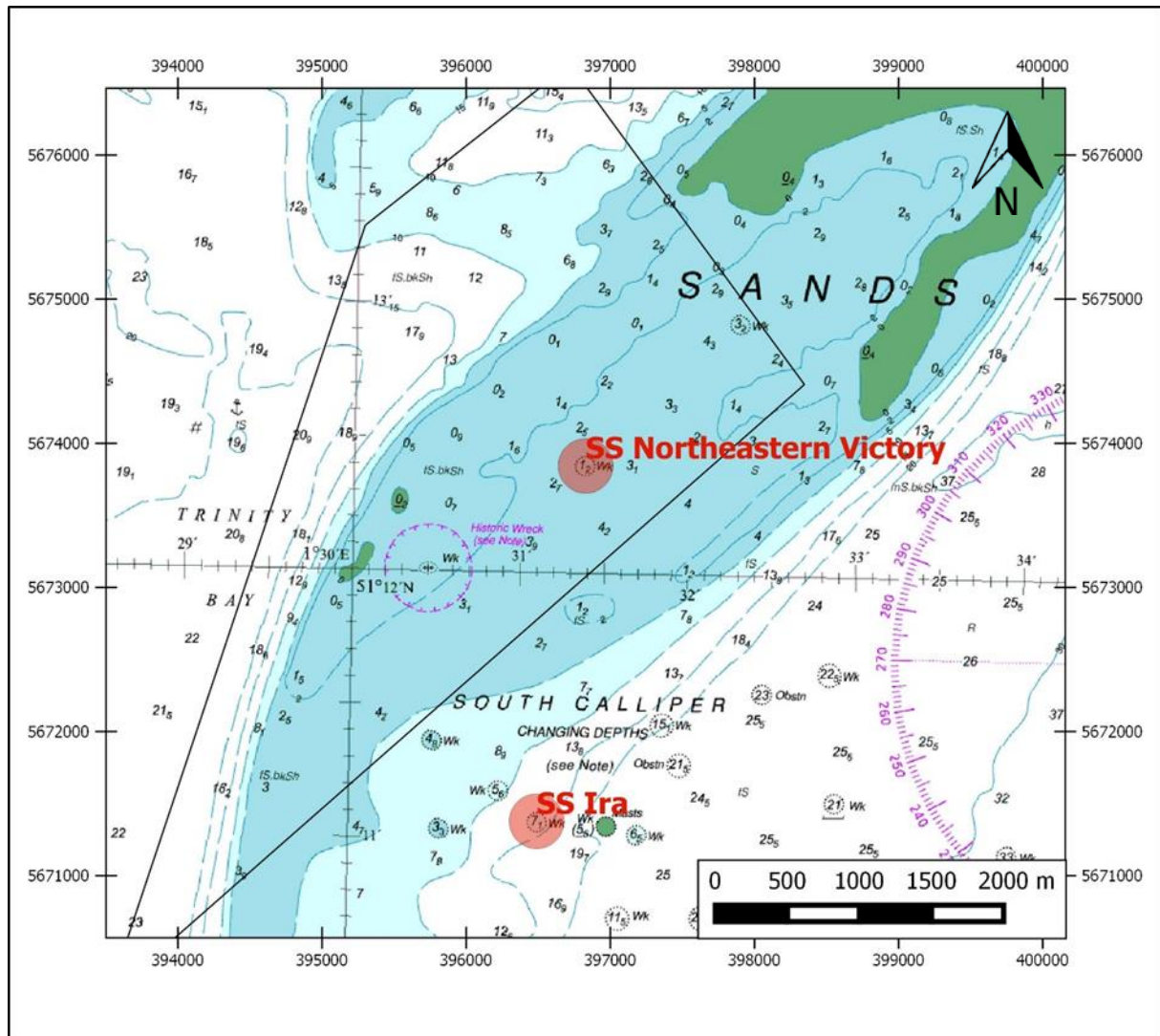


FIGURE 4: LOCATIONS OF WRECKS VISIBLE IN SURVEY DATA

The 'SS *Northeastern Victory*' (Figure 5), located at 51° 12.399'N, 001° 31.375'E, was identified in the bathymetric dataset within the main survey area. The wreck is found at a depth of approximately 2.8m (CD VORF) and stands 1.4m proud of the surrounding seabed. The shallowest reliable sounding over the wreck is 1.4m.

The 'SS *Ira*' (Figure 6), located at 51° 11.064'N, 001° 31.130'E, was identified to the southeast of the main survey area. The wreck is located at a depth of approximately 16.0m (CD VORF) and stands 3.7m proud of the surrounding seabed as calculated from the shallowest reliable sounding of 12.2m.

In the bathymetric dataset, scouring can be seen affecting the seabed around both wrecks.

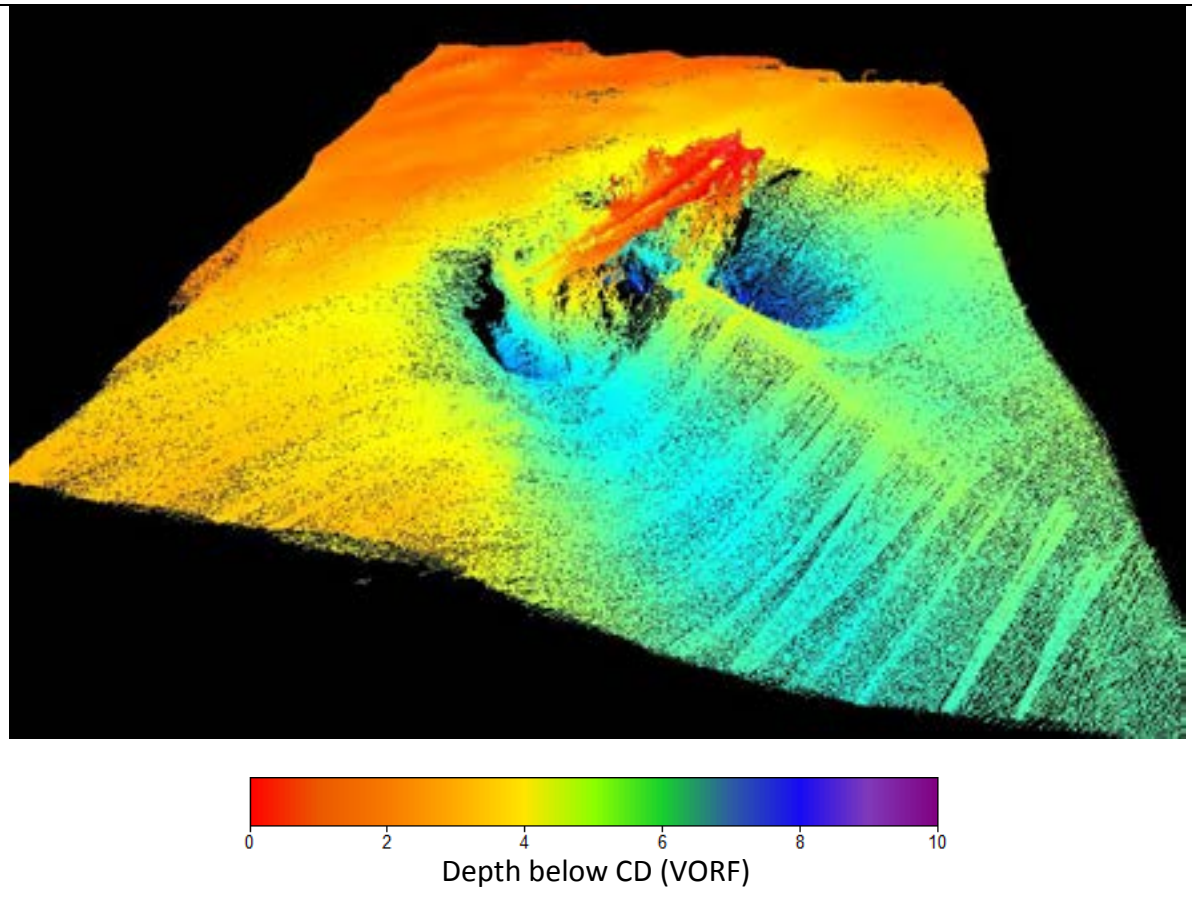


FIGURE 5: WRECK – ‘SS NORTHEASTERN VICTORY’

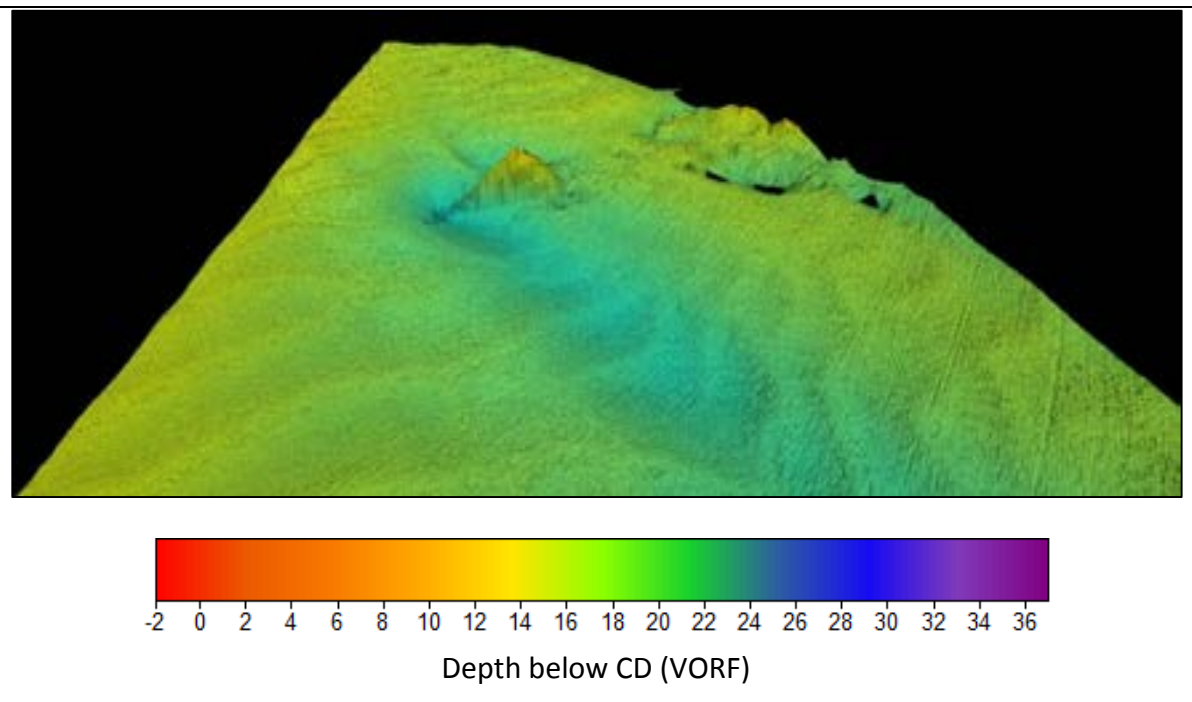


FIGURE 6: WRECK – ‘SS IRA’

The location of a further wreck at 51° 12.009'N, 001° 30.454'E, charted as an Historic Wreck on the Admiralty charts and reported as the '*Admiral Gardner*' (Wrecksite, 2015), was surveyed extensively during operations. However, no sign of the wreck or of any associated debris could be identified on the records over the area. It is to be noted that the wreck has reportedly been buried since 1997 (Wrecksite, 2015).

4.5. SIDE-SCAN SONAR DATA

A Klein 3000 Series dual frequency (100/500 kHz) side-scan sonar was used during the survey to acquire high resolution acoustic data for the interpretation of the seabed features, including sediment distribution and any natural or man-made sonar contacts.

SSS data across the whole site was susceptible to quality degradation from rough sea state and poor weather. This was primarily due to strong tidal currents present in the shallowest areas of the site causing increased wave height. Short cable towing lengths required in shallow water meant that the SSS data was increasingly effected in these shallow areas and this created heave, pitch and roll artefacts.

Due to the shallow water depth, the effective range over the sandbank area was decreased to approximately 50m either side of the transducers (100m swath); however, given the relatively tight line spacing chosen (50m), this did not present a problem in achieving the desired >100% coverage set out in the scope of work.

Figure 7 displays an overview of the SSS mosaic generated from the high frequency sonar data (500 kHz) at 0.25m resolution over the main survey area.

The following features were interpreted from the SSS records and are presented in the Seabed Features chart:

- Seabed sediment boundaries and seabed morphological features
- Sonar contacts
- Linear Debris

To produce the Seabed Features chart, the higher resolution 500 kHz SSS data was used and reviewed on a line-by-line basis together with the gridded bathymetry and bathymetric backscatter data.

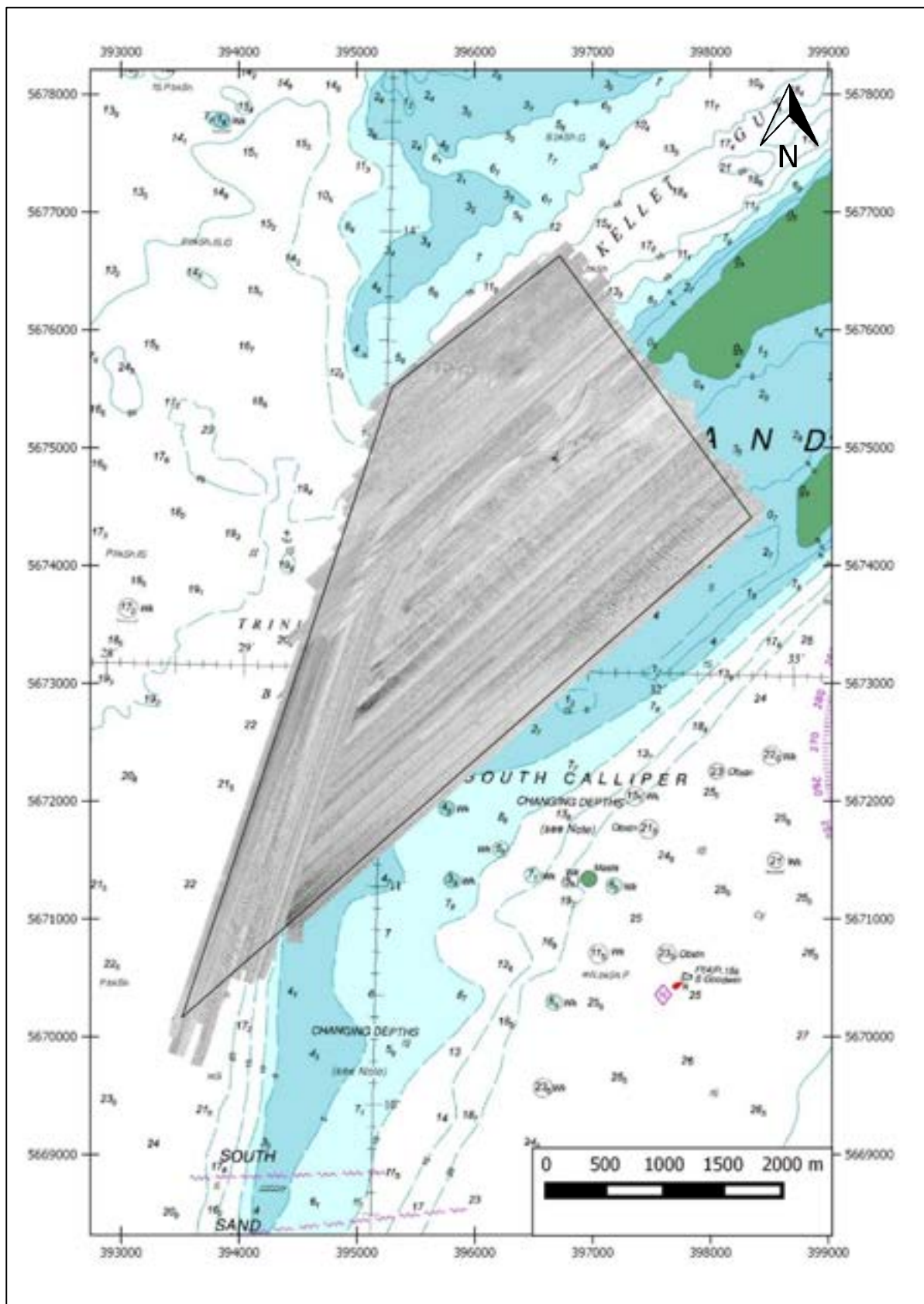


FIGURE 7: OVERVIEW OF SSS MOSAIC

4.6. BEDFORMS

The acoustic records show a highly dynamic seabed with active sandwaves and megaripples found over the majority of the main survey area. The highly mobile bedforms are formed due to the strong tidal currents affecting in the area causing a rapid migration of the sediments across the sandbank. These features vary in height and wavelength throughout the site, with the largest sandwaves reaching about 1.5m of height.

The crests alignment and profile of the features within the main survey area seem to indicate a local trend in migrations towards South-east. This trend is also confirmed by the comparison of the bathymetry collected during the survey with the contours on the UKHO charts which suggest a generalised migration of the sandbank in a similar direction.

It is to be noted that individual features have not been marked on the charts due to their transient nature. However, general orientation and the range of wavelength and height found over the different sections of the survey area have been reported.

4.7. SEABED CLASSIFICATION

The seabed has been classified based primarily on the seabed reflectivity and texture as seen on the acoustic records, integrated with the background information available from the BGS.

Table 6 below presents a list of the different seabed types interpreted within the survey area along with an associated data example from the SSS mosaic.

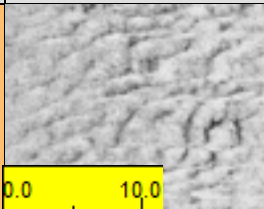
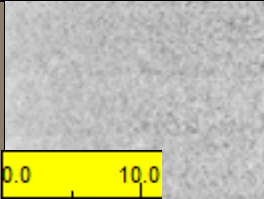
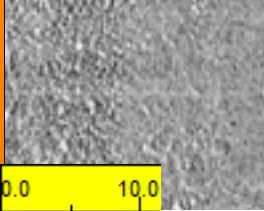
Interpreted Seabed Type	Acoustic Characteristics	Colour on SBF Chart	SSS Data Example
SAND with sandwaves and megaripples	Medium acoustic reflectivity, slight grainy texture due to bedforms		
Veneer of SAND over ROCK	Low acoustic reflectivity, no texture		
Intermittent exposure of ROCK	High acoustic reflectivity, grainy texture		

TABLE 6: SUMMARY OF SEABED SEDIMENT CLASSIFICATION (SCALE IN METRES)

Figure 8 displays an overview of the different seabed type distribution as derived from the interpretation of the SSS records. An example of SSS record showing of the different seabed types found in the area is also presented in Figure 23.

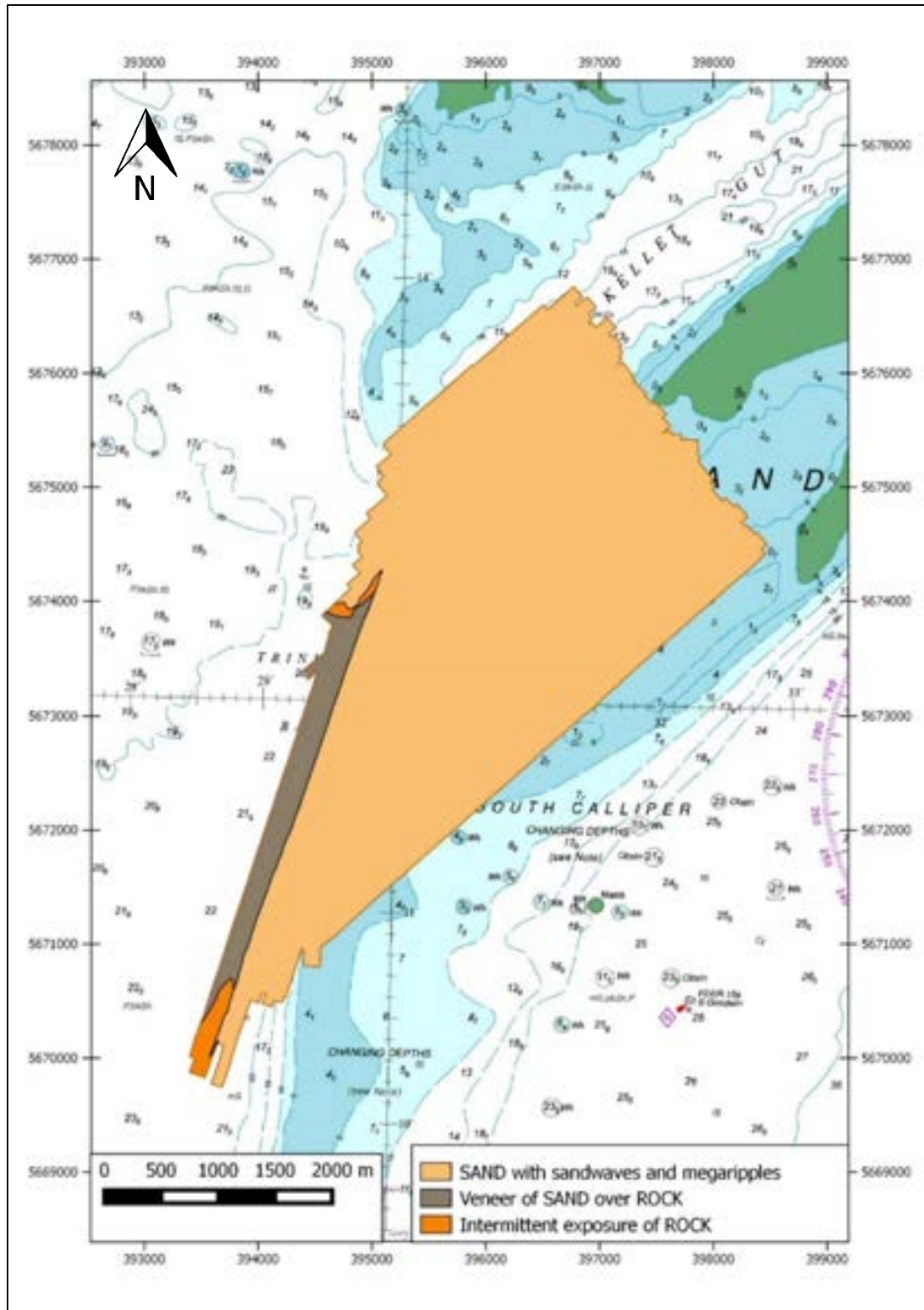


FIGURE 8: OVERVIEW OF SEABED CLASSIFICATION

4.8. SONAR CONTACTS

Sonar contacts were interpreted from the SSS data on a line-by-line basis using a minimum threshold of 0.5m x 0.5m in length and width.

All sonar contacts identified within the main survey area have been interpreted as either boulders or items of debris, with a single sonar contact interpreted as a wreck.

Contacts have been identified as “Debris” if showing a distinctly linear shape or shadow or clearly appeared to be of man-made origin, otherwise they have been classified as “Boulder”.

A total of 24 sonar contacts were identified within the main survey area, including the wreck of the ‘SS *Northeastern Victory*’ (UKHO Wreck No: 13479) (Figure 14 and Figure 15), 18 items of debris 10 of which related to the debris field associated with the wreck) and 5 boulders. Details of all identified sonar contacts within the main survey area are presented in Appendix A.

It is to be noted, that the wreck of the ‘SS *Ira*’ (UKHO Wreck No: 13719) was also identified in the SSS records (Figure 16). This has not been included in the list as found outside of the main survey area.

4.8.1. LINEAR DEBRIS

Three linear items of debris were identified in the SSS records towards the southern limit of the surveyed area; all of these features were greater than 100m in length and appeared to be partially buried within the sandwave/megaripples area. It is therefore unclear if the features seen on the SSS records, interpreted to be some sort of cable, refer to individual items or are the exposed sections of a more extensive feature.

Figure 9 below provides an overview of the location of these contacts and examples of the SSS records for these features are presented in Figure 10, Figure 11 and Figure 12.

The only cabling reported on the Admiralty charts for the area is a disused cable located to the south of the main survey area (Figure 8). However, these features could be related to another uncharted cable, e.g. an old disused telecom cable.

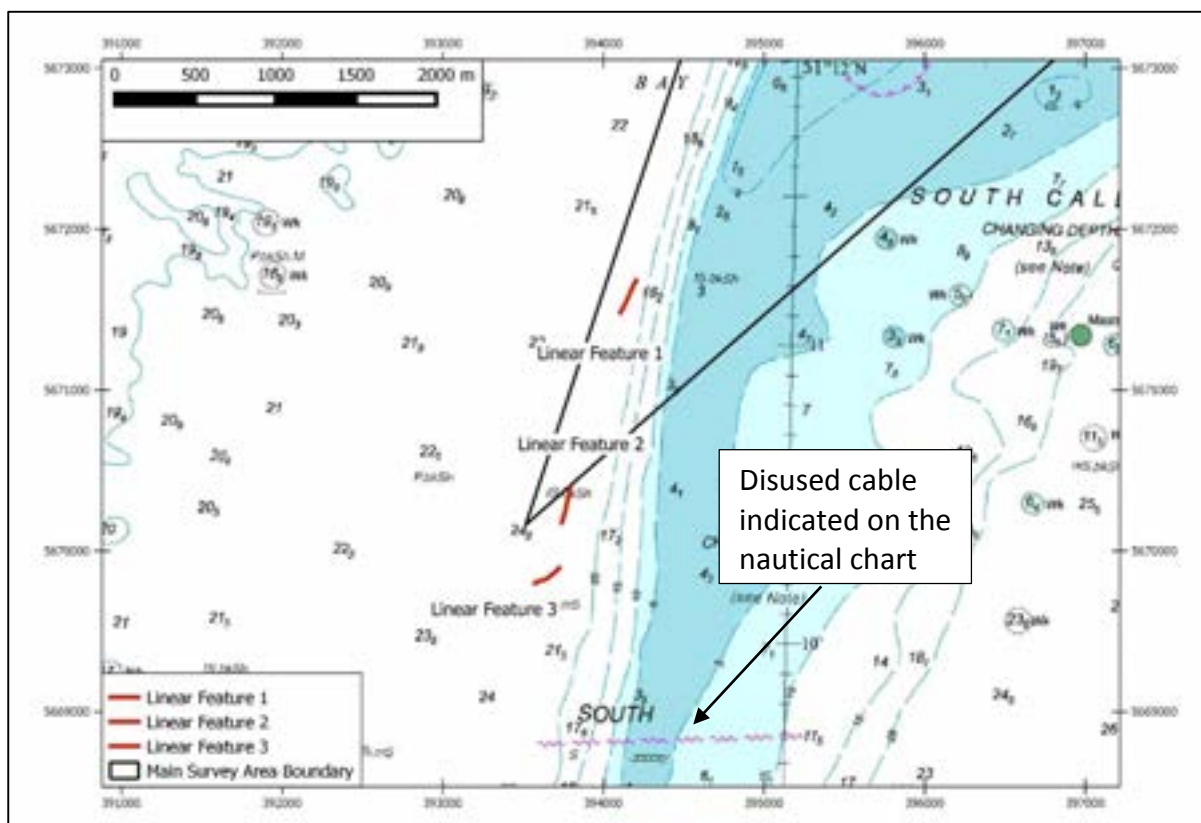


FIGURE 9: LOCATION OF LINEAR FEATURES IDENTIFIED IN SSS RECORDS

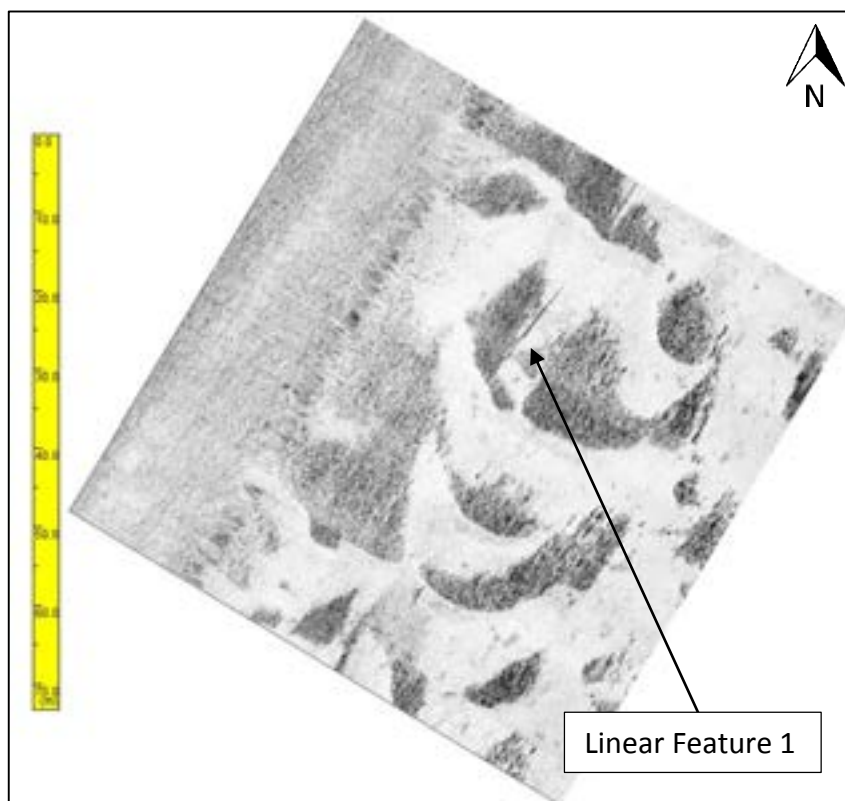


FIGURE 10: SECTION OF LINEAR FEATURE 1 FROM SSS RECORDS

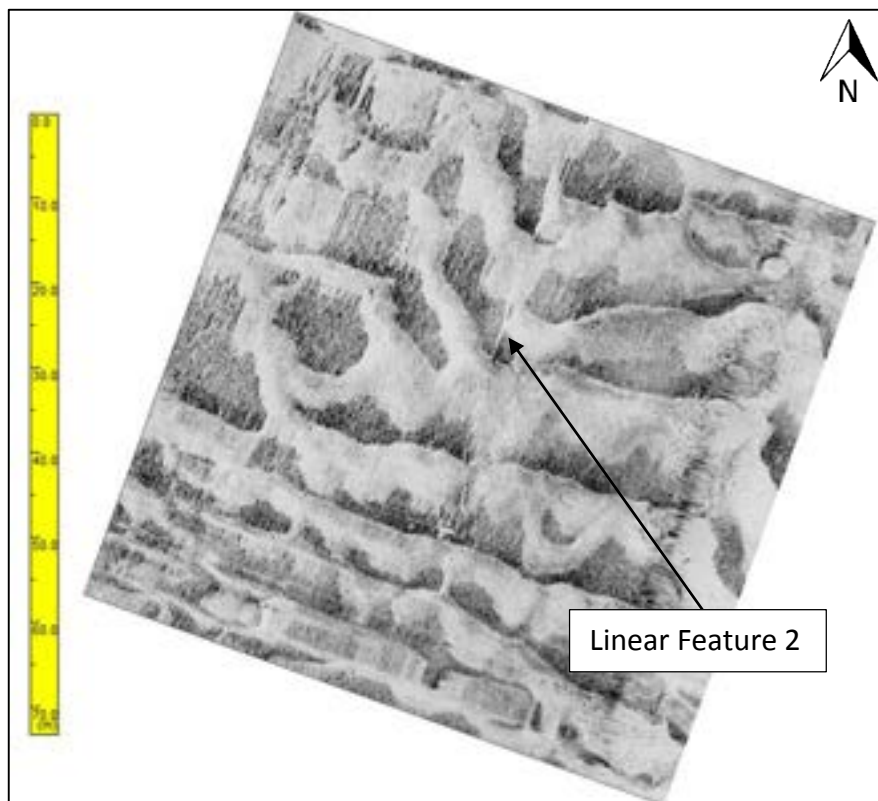


FIGURE 11: SECTION OF LINEAR FEATURE 2 FROM SSS RECORDS

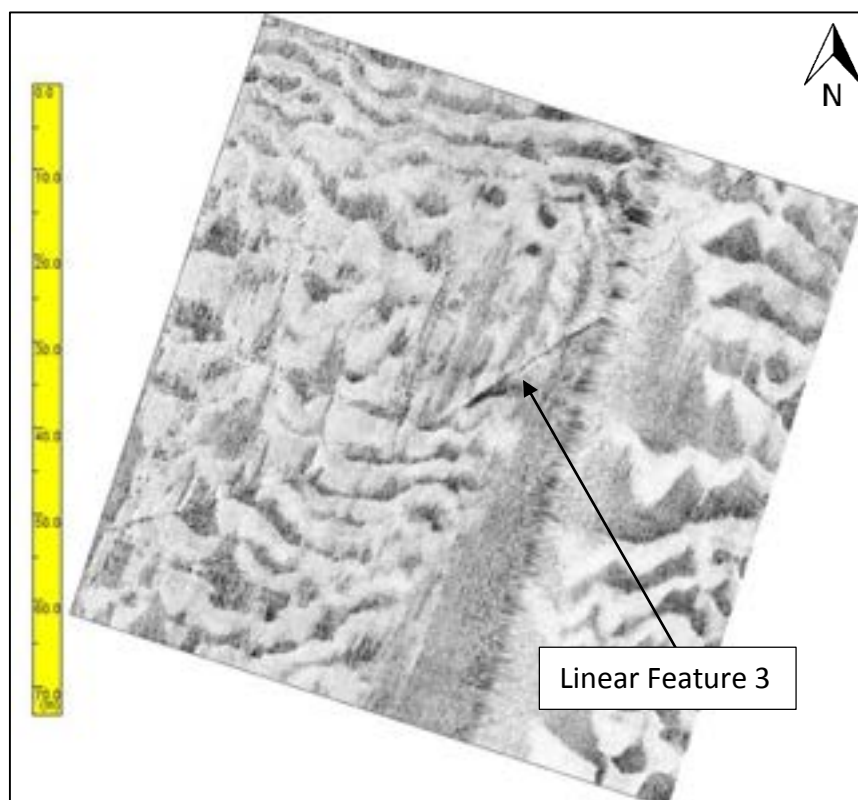


FIGURE 12: SECTION OF LINEAR FEATURE 3 FROM SSS RECORDS

4.8.2. WRECKS

The large stern section and the area of debris associated with the aft section of the wreck of the '*SS Northeastern Victory*' (UKHO ID: 13749) could be clearly identified in the SSS records (Figure 14 and Figure 15).

An historic image of the '*SS Northeastern Victory*' being broken up in two section on the Goodwin Sands is provided below.

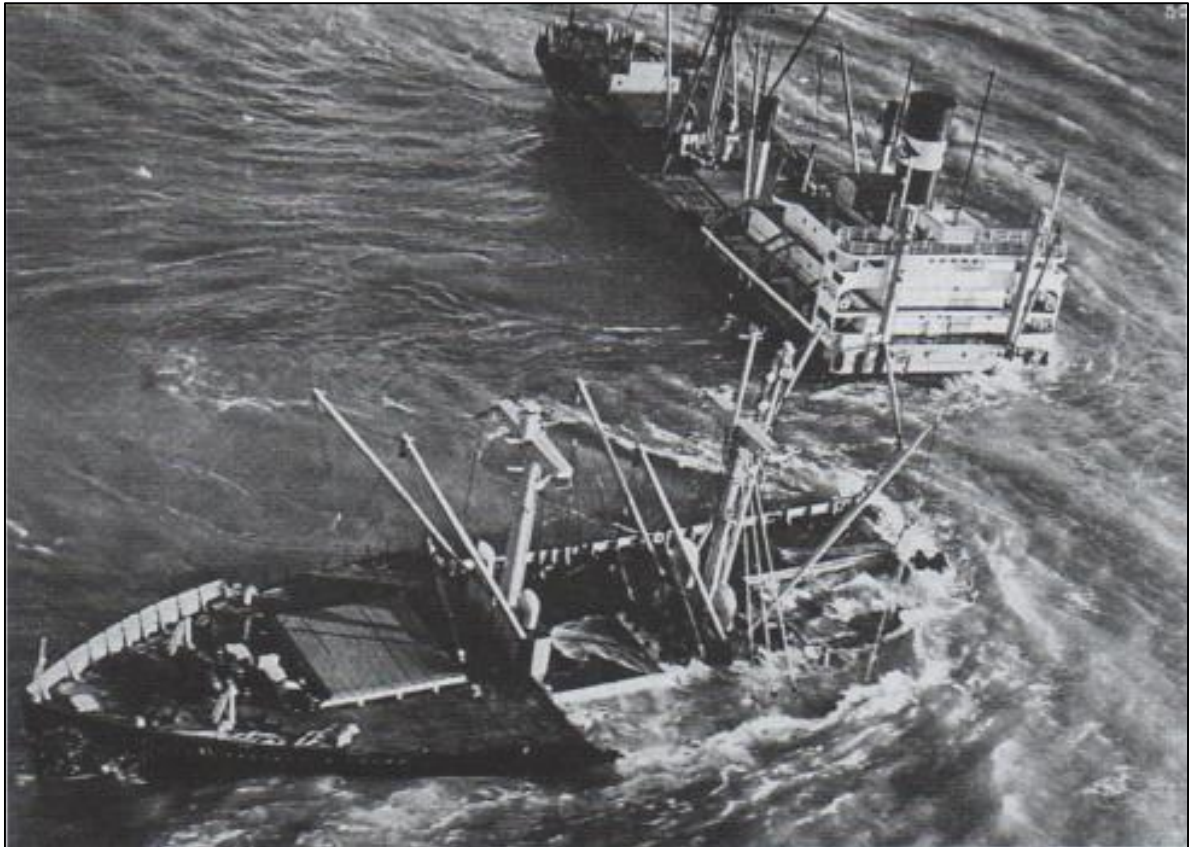


FIGURE 13: IMAGE OF THE '*SS NORTHEASTERN VICTORY*' WRECK ON GOODWIN SANDS (WRECKSITE 2015)



FIGURE 14: SSS IMAGE – REMNANTS OF THE STERN SECTION OF THE ‘SS NORTHEASTERN VICTORY’ WRECK

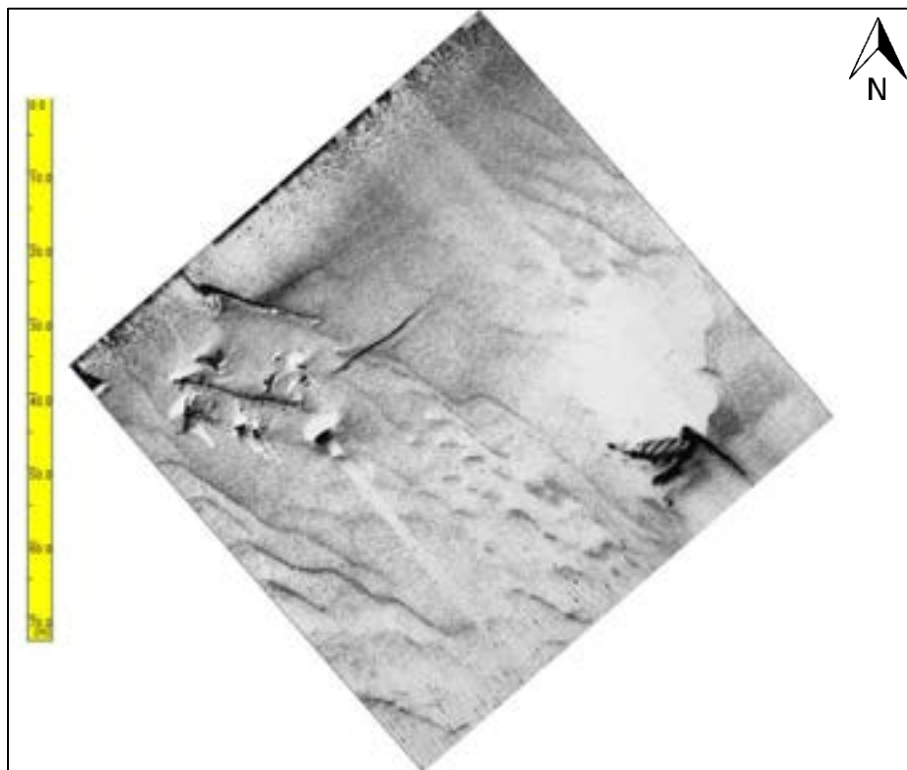


FIGURE 15: SSS IMAGE – DEBRIS FIELD ASSOCIATED TO THE ‘SS NORTHEASTERN VICTORY’ AFT SECTION

A further wreck, the 'SS *Ira*' (UKHO Wreck No: 13719) has also clearly been identified on one of the extended crosslines run to the southeast of the main survey area. An image of the wreck as seen on the SSS records is provided in Figure 16.

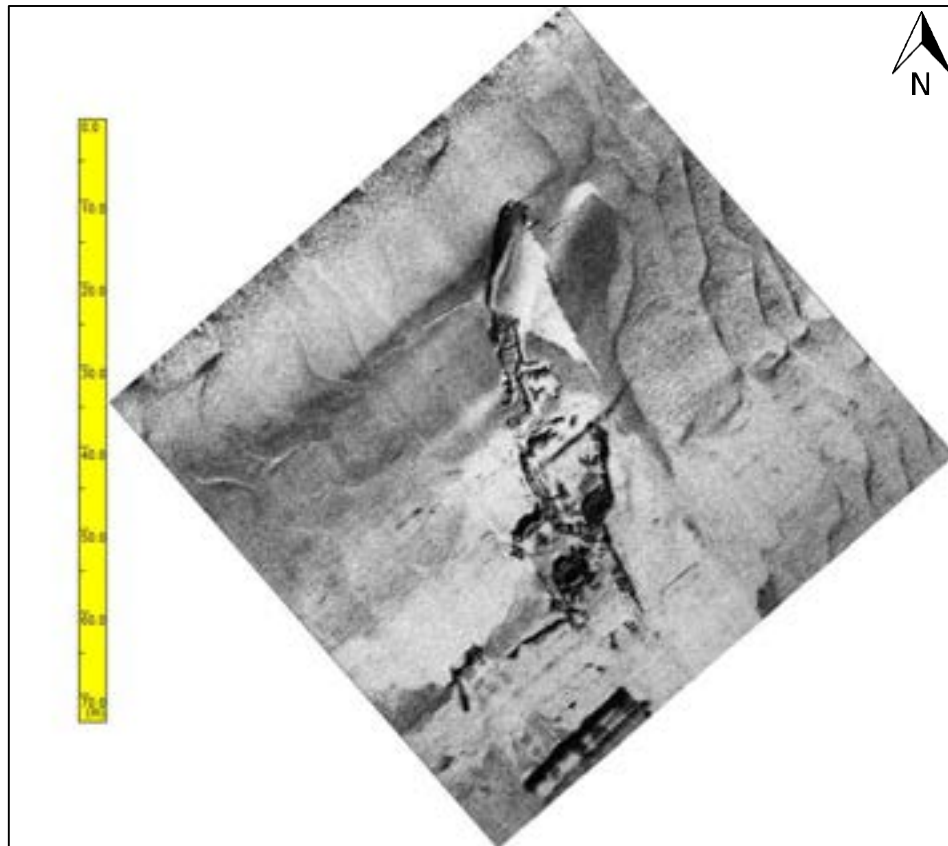


FIGURE 16: SSS IMAGE - 'SS *Ira*' WRECK

4.9. SEISMIC DATA

Two different seismic system, a Knudsen 3260 CHIRP system and C-Products C-Boom Boomer system, were used during acquisition to form the basis for interpretation of the shallow geology over the site.

It was determined during the initial phase of the acquisition that there was no significant benefit in recording the CHIRP in the shallowest areas of site. In these areas the boomer provided the deeper penetration required to map the interface between the upper unconsolidated sediments and the underlying bedrock.

Boomer data was therefore recorded along all planned survey lines, whilst the CHIRP was used only in the deeper sections of the site in order to better resolve sub-surface units where the thickness of the sediment cover was reduced.

A trackplot showing where the CHIRP data was used in order to aid interpretation is presented in Figure 17.

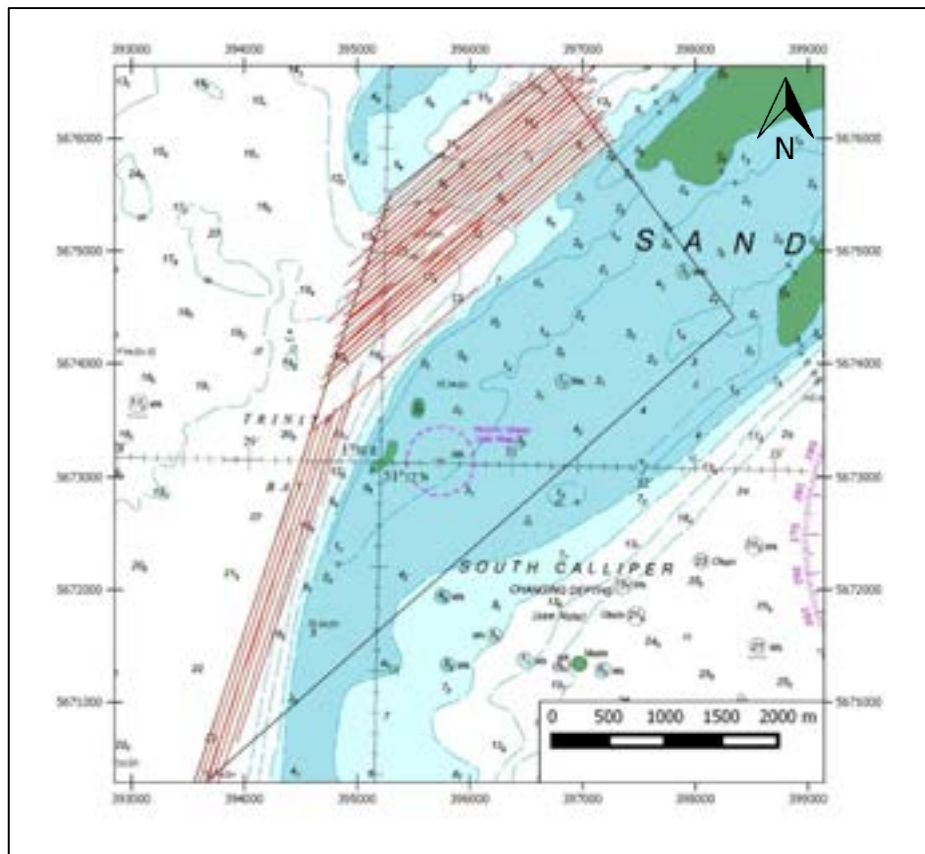


FIGURE 17: TRACKPLOT SHOWING CHIRP LINES USED IN THE INTERPRETATION.

4.10. SHALLOW GEOLOGY

Seismic data were interpreted and the main seismo-stratigraphic units were identified based on their characteristics in the seismic records and used, together with the available background information (e.g. BGS charts) to establish a geological model over the survey area.

Three seismo-stratigraphic units were identified in the records during interpretation (Figure 18) and are presented in Table 7 below.

Seismic Unit	Seismic Characteristics	Unit Thickness (m)	Interpreted Sediment/Rock Type
Unit 1 Recent Sediments	Base defined by high amplitude, continuous sub-horizontal reflector	0 - 28m	Unconsolidated sandy sediments
Unit 2 Infilled Palaeochannel	Densely packed internal reflectors, with scattered hyperbolae	0 - 19m	Possibly finer riverine/estuarine sediments with scattered boulders
Unit 3 Bedrock	Top of unit identified by high amplitude continuous reflector	-	Upper Cretaceous Chalk

TABLE 7: SUMMARY OF INTERPRETED SEDIMENT UNITS

Note. A single speed of 1650ms^{-1} was used for the time-depth conversion of all the reflectors picked and for the creation of the sub-surface charts (levels and isopach).

The seismic records over the main survey area show two main units, Unit 1 and Unit 3, interpreted to represent respectively the recent unconsolidated sandy sediments forming the Goodwin Sands sandbank and the underlying bedrock. The two units are separated by high amplitude, continuous, sub-horizontal reflector, interpreted to be associated with the top of the Cretaceous Chalk reported in the BGS chart of the area, which can clearly be seen in all the seismic records (see Appendix B).

The isopach of Unit 1 (Figure 19) shows that the variation in the thickness of the top unconsolidated sandy sediments reflects the general morphology of the sandbank. Thickness ranges from 0m where the underlying rock outcrops in the Southwest to a maximum of about 28m where the palaeochannel (Unit 2) is seen affecting the base level of the sandy sediments.

The third unit, Unit 2, is associated with what appears to be an infilled palaeochannel locally affecting the Chalk (Figure 18). On the seismic records the channel infill shows densely packed internal reflectors, possibly representing different infill events, along with hyperbolae which may indicate the presence of scattered boulders. The extents of the palaeochannel and the palaeochannel sediment thickness are shown in Figure 20

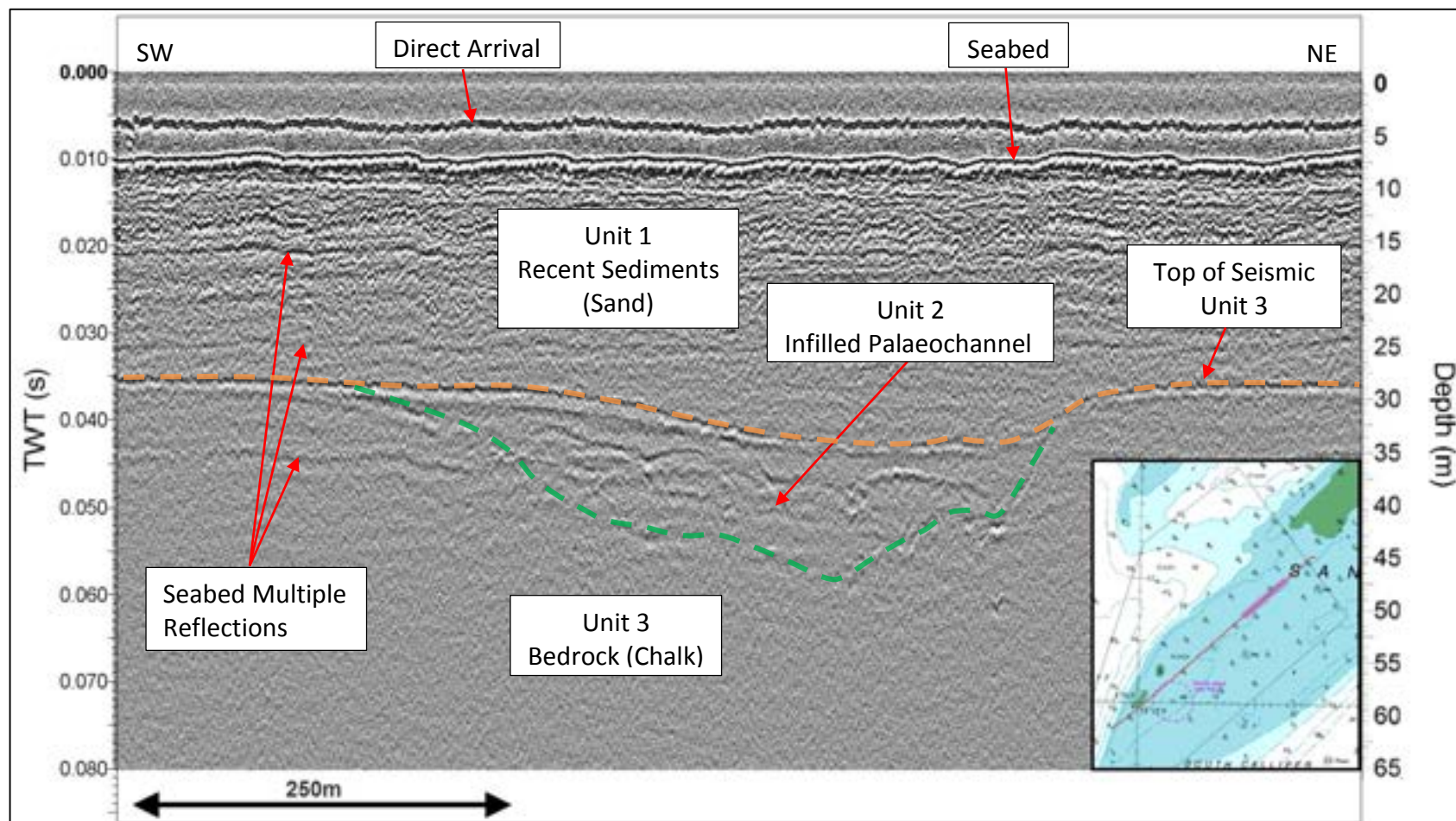


FIGURE 18: SEISMIC RECORD SHOWING THE INTERPRETED SHALLOW GEOLOGY OF THE SURVEY AREA

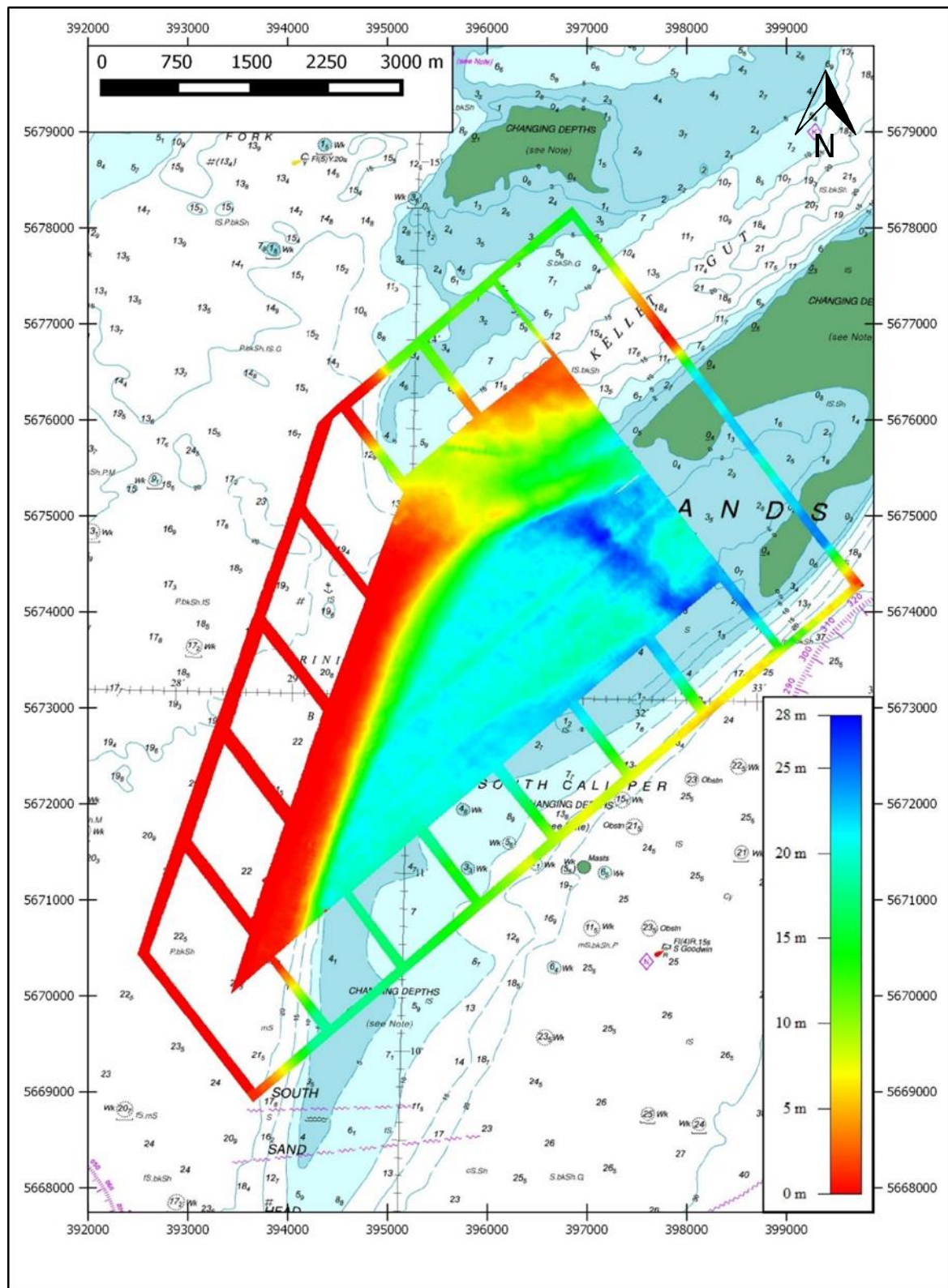
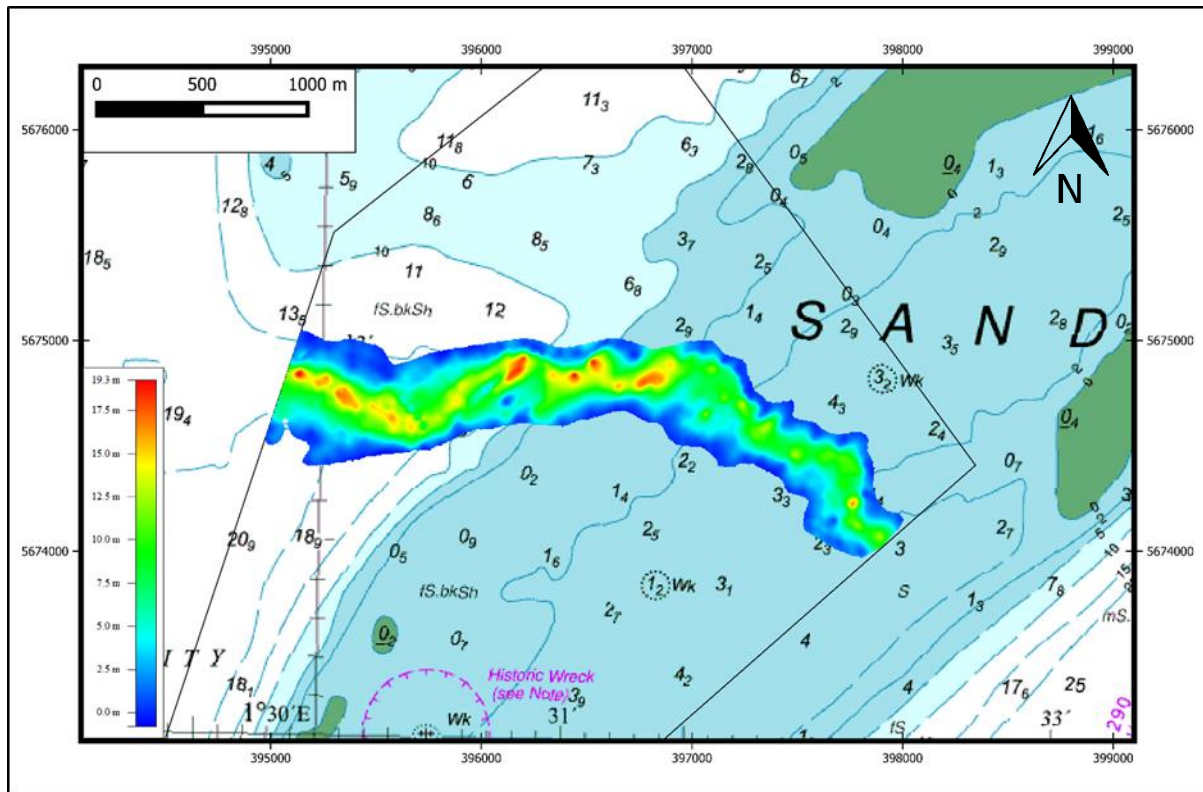


FIGURE 19: UNIT 1 - RECENT SEDIMENTS (SAND) ISOPACH
(COLOUR BAR INDICATES THICKNESS IN METRES)



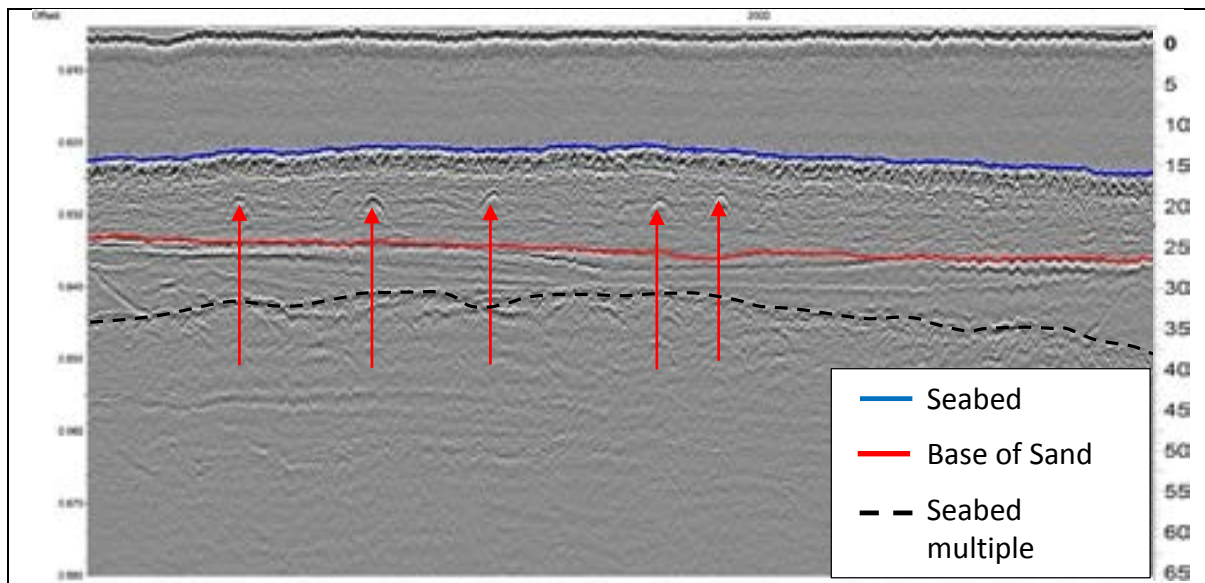


FIGURE 21: BOOMER RECORD SHOWING SUBSEA HYPERBOLAE
(APPROX. DEPTH IN METERS ON THE RIGHT)

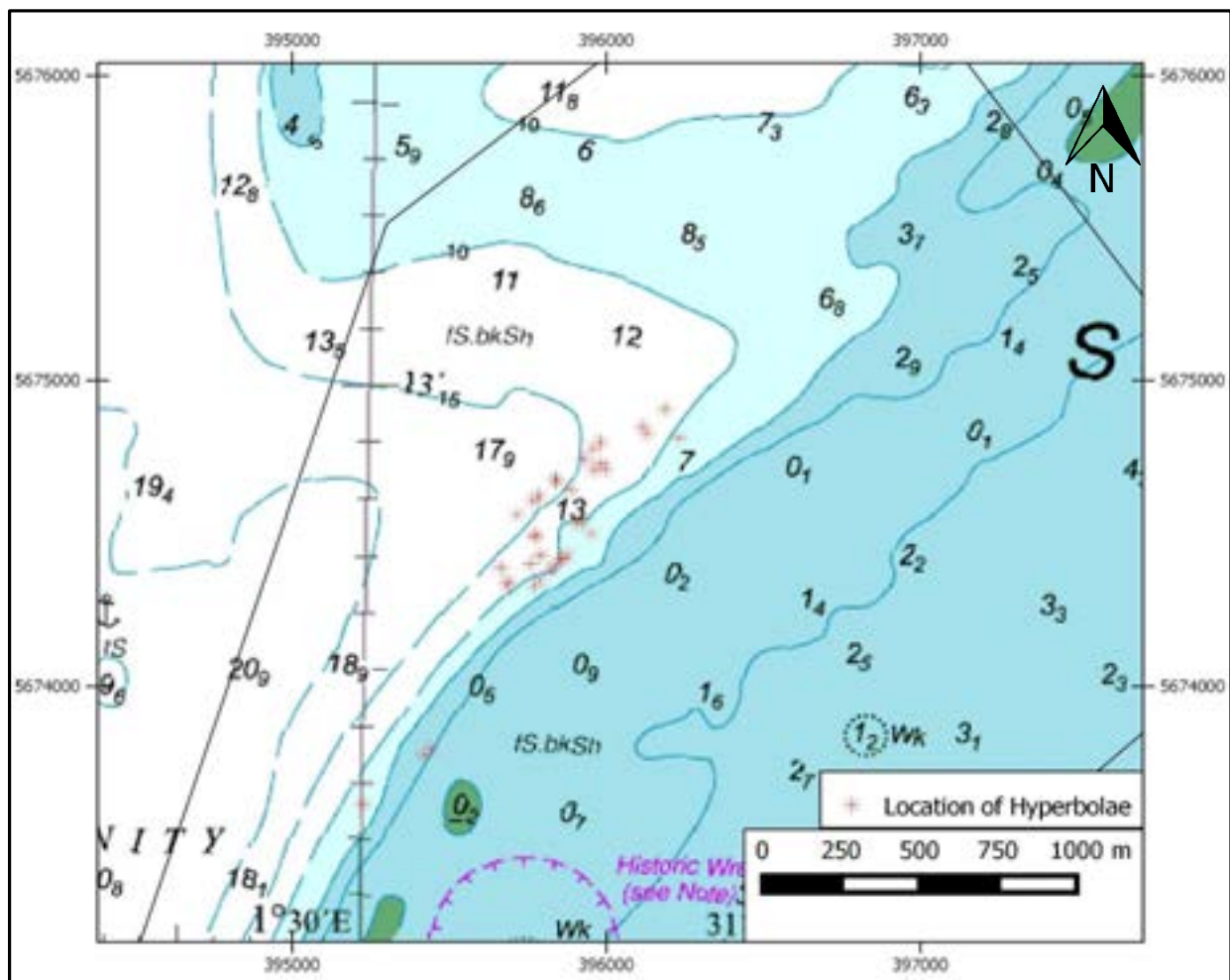


FIGURE 22: HYPERBOLAE DISTRIBUTION

4.11. CHIRP DATA

As previously mentioned the higher frequency of the Chirp system allowed for a better resolution especially in areas where sediment cover was less than 2m. The section towards the southwest boundary of the survey area provide a prime example of this, as seen in the SSS and SBP records shown in Figure 23.

An abrupt change in the seabed characteristics is visible in the SSS record and has been used to define the surficial boundary between the areas classified as 'SAND with sandwaves and megaripples' with the areas of 'Veneer of SAND over ROCK' and "Intermittent ROCK Exposure". The sharp boundary is likely due to the combination of the reducing thickness of the sediments cover towards the outer edges of the bank and higher velocities of the tidal current operating in the deeper sections of the area.

The Chirp line 1 record in Figure 23 shows a relatively flat seabed with the Chirp profiler system achieving little penetration into the harder sub-surface material. This, combined with the SSS record of the corresponding area, indicates that the underlying bedrock (interpreted as Chalk) is outcropping in this area, with only an intermittent coarse sediment cover at some locations. Chirp line 2, positioned approximately 50m East of Chirp Line 1, shows an increased thickness of the sedimentary cover with sandwaves and megaripples visible on top of the bedrock and seen also in the SSS record.

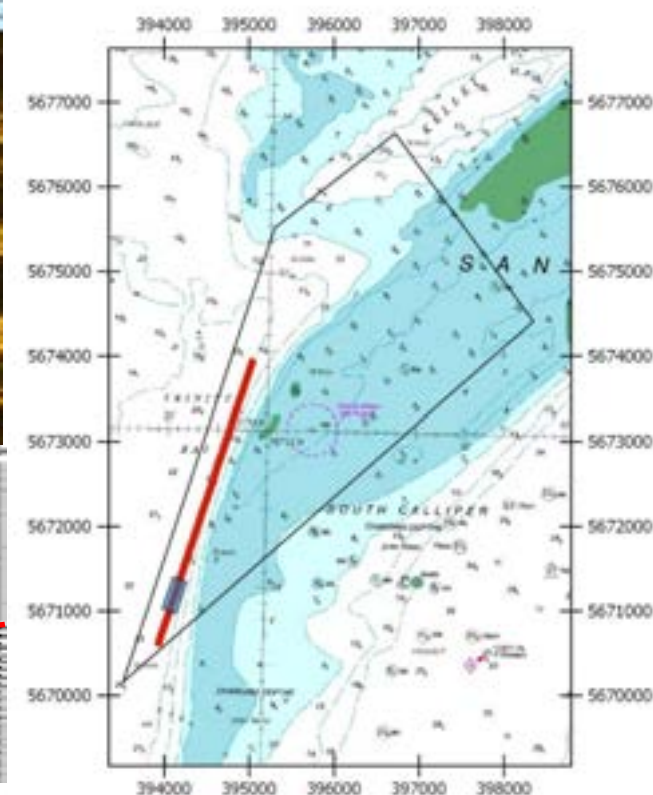
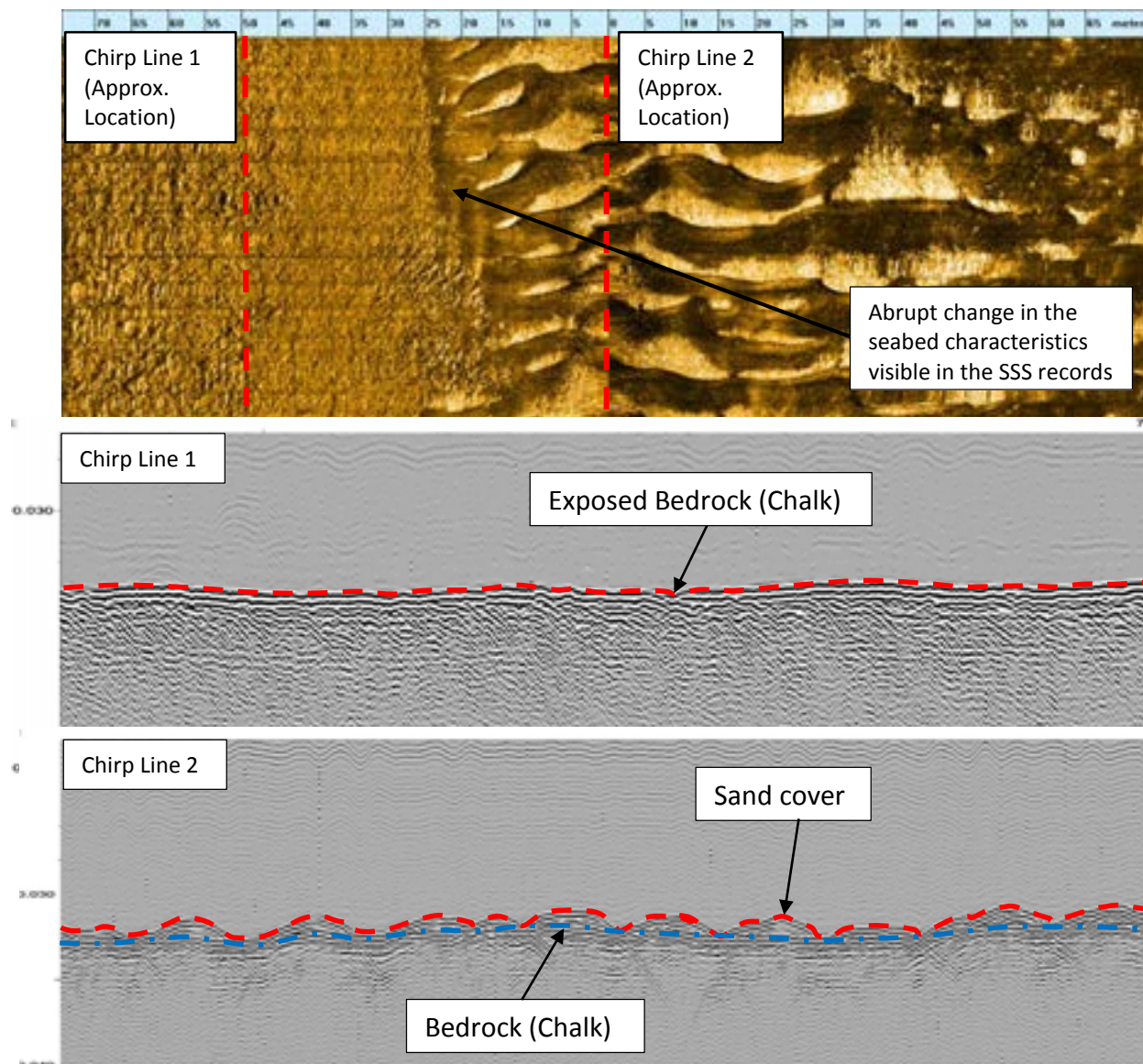


FIGURE 23: SSS AND CHIRP DATA EXAMPLES

The reduction in the sediment cover thickness when moving off the sandbank towards the western boundary of the survey area can be clearly seen in both the SSS and CHIRP records.

5. CONCLUSIONS

MBES data acquired during survey operations has been examined and the depth of the seabed within the surveyed area was found to vary from approximately 1.7m above (drying height) CD on top of South Calliper Sands to 36.6m below CD at the most eastern point of the survey area.

Based on the acoustic records the seabed of the area surveyed has been divided in three main types:

- SAND with sandwaves and megaripples
- Veneer of SAND over ROCK
- Intermittent exposure of ROCK

Mobile sandy sediments characterised by the presence of active bedforms (sandwaves and megaripples) are found over the entire area surveyed with exception of the deeper section towards the edges of the bank to the Southwest, where the underlying bedrock can be seen intermittently exposed.

The highly mobile seabed features vary in height and wavelength throughout the site, with the largest sandwaves reaching about 1.5m of height.

Two chartered wrecks have been identified on the in the bathymetric dataset and on the SSS records during the survey work: The '*SS Northeastern Victory*', is located within the main survey area at an approximate water depth of 2.8m (CD), whilst the '*SS Ira*', has been identified to the south of the main survey area on one of the extended crosslines, at an approximate depth of 16m (CD).

It is to be noted, that no evidence were found in the records of a further wreck, the '*Admiral Gardner*', reported within the main survey area and charted as a Historic Wreck.

A total of 24 sonar contacts were identified within the main survey area, including the '*SS Northeastern Victory*' wreck, 18 items of debris (10 of which are associated with the wreck) and 5 boulders.

In addition, three linear items of debris were identified in the SSS records towards the southern limit of the surveyed area; all of these features were greater than 100m in length and appeared to be partially buried within the sandwave/megaripples area. It is therefore unclear if the features seen on the SSS records, interpreted to be some sort of cable, refer to individual items or are the exposed sections of a more extensive feature.

Based on the seismic records the shallow geology of the area has been interpreted as comprising three units:

- Unit 1 - Recent unconsolidated sediments (Sand)
- Unit 2 - Infilled palaeochannel
- Unit 3 - Bedrock (Chalk)

The upper unconsolidated sandy sediments associated to Unit 1 and the underlying rock represented by Unit 3, interpreted as Upper Cretaceous Chalk, are separated by one continuous sub-horizontal reflector well visible on all the seismic records throughout the surveyed area.

The thickness of the top unconsolidated sediments vary from 0m where the underlying rock outcrops in the Southwest of the surveyed area to a maximum of about 28m where the palaeochannel associated to Unit 2 is seen affecting the base of Unit 1.

The interpreted infilled palaeochannel (Unit 2), locally affects the bedrock cutting across the survey site in an East - West direction. The palaeochannel infill shows densely packed internal reflectors, with a thickness of up to 19m in its deeper sections.

A small number of hyperbolae were observed in the seismic records data. These are caused by point diffractors, which could potentially represented buried objects such as boulders or debris. No hyperbolae were observed in the shallower sections of the site. However, this could be due to the presence of a number of seabed 'multiples' in the seismic records masking the signature of these features.

6. REFERENCES

- BGS (1989), Thames Estuary, Solid Geology. 1:250,000 Series (Sheet 51°N-00°)
- BGS (1990), Thames Estuary, Sea Bed Sediments and Quaternary. 1:250,000 Series (Sheet 51°N-00°).
- Wrecksite, 2015 (<http://www.wrecksite.eu/chartDetails.aspx?444>)

Appendix 8.3

Survey Terms of Reference

GOODWIN SANDS PROSPECTING AREA

Proposed Terms of Reference for a Benthic Characterisation Survey

July 2015

Prepared for

Royal Haskoning DHV

On behalf of Dover Harbour Board

By

Marine Ecological Surveys Limited



Report Warranty

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A. Introduction

Marine Ecological Surveys Limited (MESL) has been commissioned by Royal Haskoning DHV on behalf of Dover Harbour Board (DHB) to prepare the Terms of Reference for a characterisation survey at Goodwin Sands, off the coast of Kent. The outputs of the survey are intended to support an Environmental Impact Assessment (EIA) for aggregate extraction on South Goodwin Sands. This document sets out the Terms of Reference for a benthic, epibenthic and sediment survey to be conducted at the site in summer 2015. Due to the short time period between the characterisation survey and the planned commencement of dredging, this study will also serve as the pre-dredge survey.

Goodwin Sands has never been licensed for regular aggregate extraction. However extraction for specific infrastructure projects has been allowed in the past. Material has been taken off both the North and South Goodwin sites and extraction occurred in the late 1970s, from 1984 to 1990 and in 1998, which was the last time extraction occurred.

The prospecting area lies approximately 10 km off the coast of Deal in Kent, and covers an area of approximately 11.6 km². The location of the prospecting area is shown in Figure 1. Coordinates of each vertex of the area are presented in Table 1.

It should be noted that the survey area is located within the boundary of the Goodwin Sands recommended Marine Conservation Zone (rMCZ),

populated by *Mytilus* (blue mussel) beds and *Sabellaria spinulosa* (Rossworm) reefs¹. This is further discussed in Section E.

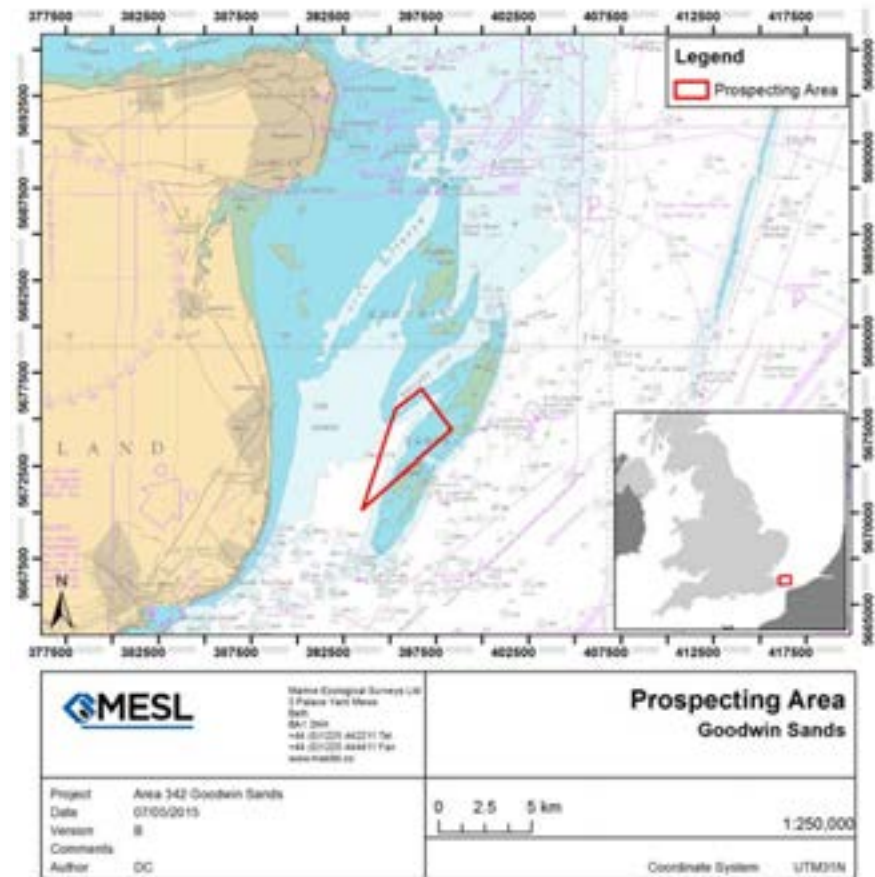


Figure 1. The location of Goodwin Sands and the prospecting area (Red). ARCS Chart 1406-0 used under license from the UK Hydrographic office.

¹ The Wildlife Trusts (2014). <http://www.wildlifetrusts.org/MCZ/goodwin-sands>. Accessed 07 May 2015.

Table 1. The boundary co-ordinates of each vertex of the prospecting area of Goodwin Sands (decimal degrees WGS84).

	Latitude	Longitude
A	51.23168 N	1.52071 E
B	51.21201 N	1.54464 E
C	51.17296 N	1.47676 E
D	51.22140 N	1.50072 E

A.1 Aims and objectives

The principal objectives of the proposed survey at Goodwin Sands are as follows:

1. To describe the biological nature of the seabed and the benthic biological communities that occur in the survey area, along with the characterising taxa for each community type, in order to provide reliable information for a subsequent impact assessment
2. To describe the distribution of sediment types in the survey area and their relation to biological community composition
3. To describe the distribution and concentrations of chemical contaminants contained within the sediments of the survey area
4. To identify and document the occurrence of species or communities of conservation significance

In order to achieve these objectives, appropriate methodologies for benthic and sediment surveys of the prospecting area and the surrounding vicinity are detailed over the following sections.

B. Survey Design

The survey design at Goodwin Sands will comply with the methodology set up for the regional seabed monitoring programme (RSMP) by Cefas and the aggregates industry²³. The RSMP approach was designed to develop a baseline characterisation for macrofauna and sediments in five aggregate extraction regions around the UK.

In order to ensure that a robust and comprehensive survey array is adopted which will provide suitable data to fully inform the subsequent EIA, it is proposed that both the prospecting area (Primary Impact Zone, PIZ) and secondary impact zone (SIZ) are taken into account during this survey. The PIZ and SIZ will be sampled alongside a Reference area, within the proposed Goodwin Sand rMCZ, and a Context area around the SIZ (Figure 2).

It is considered that in the PIZ, which for the purpose of this study has been assumed to be the entire prospecting license area, direct impacts from dredging will result in the removal of organisms from the area, changing the composition and structure of benthic marine communities.

The secondary impact zone (SIZ), where indirect impacts from dredging may result in marked changes in faunal composition as a result of the deposition of fines from the dredging process, has been estimated for the purposes of this study utilising information from local tidal information from tidal diamonds. One hour of flow in each relevant vector for each

hour of tide has been applied to the vertices of the prospecting area boundary in order to estimate the maximum likely secondary impact zone. This follows the findings of Newell et al. (1998)⁴ which states that any sediments mobilised by the dredging process are likely to be deposited within a few hundred metres of the disturbance, and in line with tidal flow (Newell *et al.*, 1998). In Figure 2, the SIZ has been divided into bedform (0 – 2500 m) and PSA change zones (2500 m to limit of SIZ).

It is proposed that an array of 71 grab sampling stations will be targeted in the Goodwin Sands area. Of these, 21 stations require sediment particle size analysis (PSA) only and 50 stations require both faunal and sediment PSA (Table 2). The primary factor controlling the biological resources will be sediment composition, therefore it is important that the sediment composition from the actual samples from which the fauna were extracted is known. A separate sub-sample will also be retained for chemical contaminants analysis.

21 stations are to be positioned inside the potential PIZ and a further 22 stations have been placed in the potential secondary impact zone, based on a 1 km grid pattern. 14 stations are positioned in the reference area and 14 in the Context area around the SIZ. Existing sampling stations within the Reference and Context areas only need to be sampled for PSA (Table 2).

² Cooper, K.M. 2013. Marine aggregate dredging: a new regional approach to environmental monitoring. PhD Thesis. University of East Anglia.

³ Keith Cooper and Clair Mason (CEFAS). Regional Seabed Monitoring Plan (RSMP). Protocol for Sample Collection and Processing. Version 4.0.

⁴ Newell, R.C., Seiderer, L.J., Hitchcock, D.R. (1998). The impact of dredging works in coastal waters: A review of the sensitivity to disturbance and subsequent recovery of biological resources on the sea bed. *Oceanography and Marine Biology: an Annual Review* 36, 127-178.

It is proposed that one single grab sample will be acquired from each station in the survey array, as per common practice and current industry guidelines.

In addition to the benthic grab sampling survey, it is also proposed that a series of trawls will be undertaken with a 2 m scientific beam trawl, in order to investigate the epibenthic and demersal fish assemblages which occur across the survey area. A total of four epibenthic trawls will be undertaken, two within the boundary of the PIZ, and two within the potential SIZ.

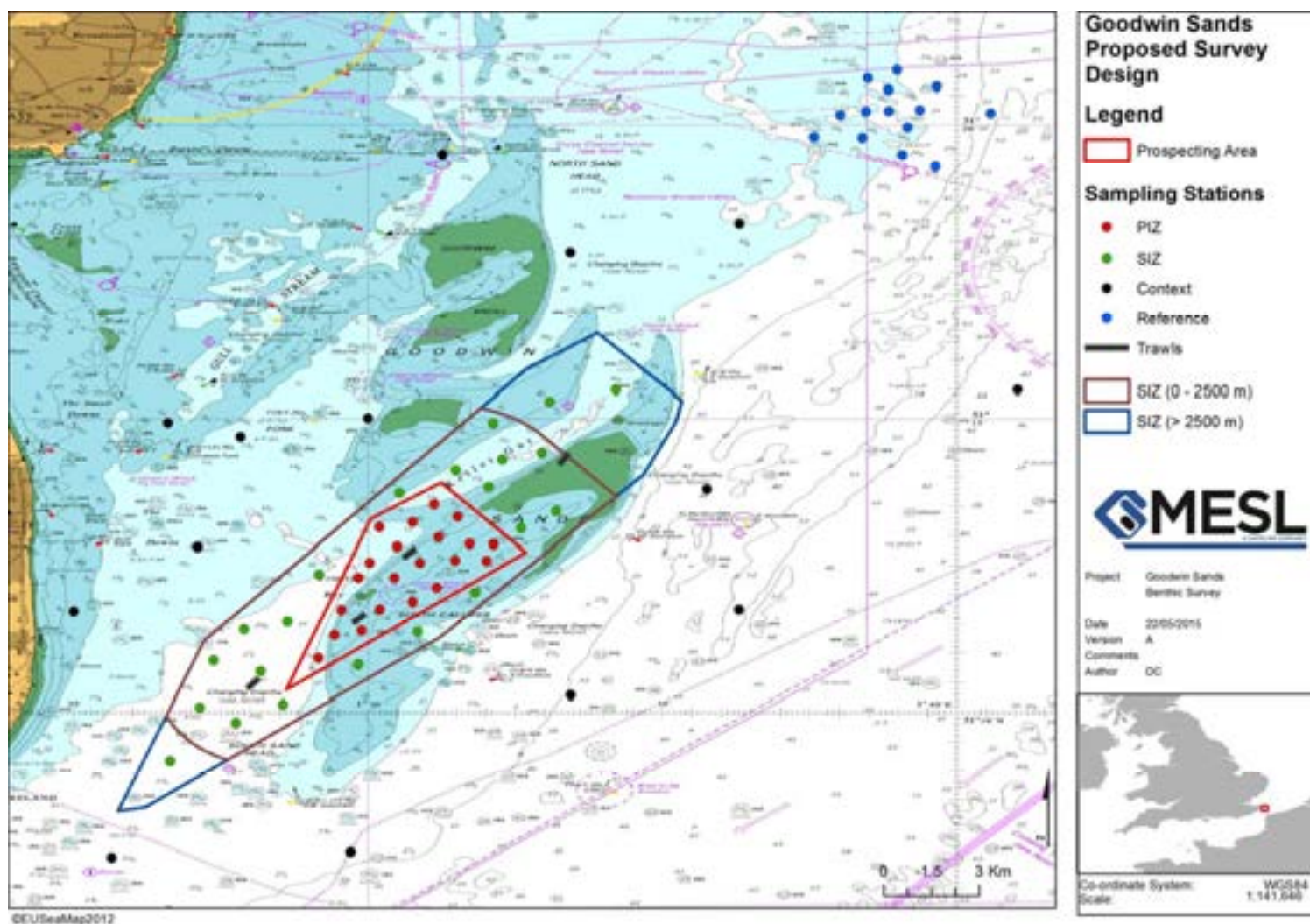


Figure 2. The location of proposed stations for the 2015 benthic survey in the prospecting area of Goodwin Sands. Stations within the prospecting area (primary impact zone, PIZ) are shown in red, and stations in the predicted secondary impact zone (SIZ) in green (1 hour of tide in all directions using local tidal diamonds). Sampling stations in the Reference and Context area are respectively shown in blue and black. The proposed epibenthic trawl locations are shown as black dashes. ARCS Chart 323-0 used under Licence from the UK Hydrographic Office.

C. Sampling Protocol

C.1 Proposed Survey Station Locations

The location of the proposed benthic grab and epibenthic trawl samples to be taken for the 2015 survey of Goodwin Sands are shown in Figure 2. These are taken from the survey array designed by Keith Cooper at Cefas in accordance with the RSMP survey design protocols. A summary table with station information and coordinates is presented in Table 2. The epibenthic trawl start coordinates are presented in Table 3.

Table 2. Benthic grab sample coordinates for the 2015 survey at Goodwin Sands.

Label	Latitude	Longitude	Zone	Required sample
GWS_001	51.22550000	1.51870000	Primary	PSA & MACRO
GWS_002	51.21900000	1.50315000	Primary	PSA & MACRO
GWS_003	51.22046667	1.51270000	Primary	PSA & MACRO
GWS_004	51.22193333	1.52548333	Primary	PSA & MACRO
GWS_005	51.21353333	1.50821667	Primary	PSA & MACRO
GWS_006	51.21615000	1.52003333	Primary	PSA & MACRO
GWS_007	51.21438333	1.52881667	Primary	PSA & MACRO
GWS_008	51.21416667	1.53561667	Primary	PSA & MACRO
GWS_009	51.20906667	1.50048333	Primary	PSA & MACRO
GWS_010	51.20901667	1.51478333	Primary	PSA & MACRO
GWS_011	51.20963333	1.52471667	Primary	PSA & MACRO
GWS_012	51.20948333	1.53368333	Primary	PSA & MACRO
GWS_013	51.20476667	1.49726667	Primary	PSA & MACRO
GWS_014	51.20475000	1.50745000	Primary	PSA & MACRO

GWS_015	51.20185000	1.51946667	Primary	PSA & MACRO
GWS_016	51.19558333	1.49248333	Primary	PSA & MACRO
GWS_017	51.19571667	1.50335000	Primary	PSA & MACRO
GWS_018	51.19795000	1.51270000	Primary	PSA & MACRO
GWS_019	51.18845000	1.49046667	Primary	PSA & MACRO
GWS_020	51.18973333	1.49810000	Primary	PSA & MACRO
GWS_021	51.18185000	1.48601667	Primary	PSA & MACRO
GWS_022	51.25475000	1.55145000	Secondary	PSA & MACRO
GWS_023	51.24860000	1.53540000	Secondary	PSA & MACRO
GWS_024	51.25795000	1.57023333	Secondary	PSA & MACRO
GWS_025	51.23523333	1.52480000	Secondary	PSA & MACRO
GWS_026	51.23830000	1.53806667	Secondary	PSA & MACRO
GWS_027	51.24003333	1.54930000	Secondary	PSA & MACRO
GWS_028	51.22873333	1.50893333	Secondary	PSA & MACRO
GWS_029	51.23040000	1.53418333	Secondary	PSA & MACRO
GWS_030	51.22348333	1.55331667	Secondary	PSA & MACRO
GWS_031	51.21870000	1.54333333	Secondary	PSA & MACRO
GWS_032	51.20561667	1.48608333	Secondary	PSA & MACRO
GWS_033	51.20051667	1.53045000	Secondary	PSA & MACRO
GWS_034	51.18116667	1.45616667	Secondary	PSA & MACRO
GWS_035	51.19013333	1.46485000	Secondary	PSA & MACRO
GWS_036	51.18941667	1.51401667	Secondary	PSA & MACRO
GWS_037	51.17810000	1.46955000	Secondary	PSA & MACRO
GWS_038	51.18005000	1.49720000	Secondary	PSA & MACRO
GWS_039	51.16798333	1.45236667	Secondary	PSA & MACRO
GWS_040	51.16876667	1.47590000	Secondary	PSA & MACRO
GWS_041	51.15271667	1.44395000	Secondary	PSA & MACRO
GWS_042	51.16360000	1.46253333	Secondary	PSA & MACRO

GWS_043	51.19233333	1.47723333	Secondary	PSA & MACRO
GWS_044	51.17133333	1.55738333	Context	PSA ONLY
GWS_045	51.25000000	1.50000000	Context	PSA ONLY
GWS_046	51.32478333	1.52108333	Context	PSA ONLY
GWS_047	51.19516667	1.41663333	Context	PSA ONLY
GWS_048	51.22970000	1.59596667	Context	PSA ONLY
GWS_049	51.25791667	1.68405000	Context	PSA ONLY
GWS_050	51.30493333	1.60516667	Context	PSA ONLY
GWS_051	51.24881667	1.44330000	Context	PSA & MACRO
GWS_052	51.12698333	1.49508333	Context	PSA & MACRO
GWS_053	51.29716667	1.55733333	Context	PSA & MACRO
GWS_054	51.24481667	1.46386667	Context	PSA & MACRO
GWS_055	51.21340000	1.45168333	Context	PSA & MACRO
GWS_056	51.12546667	1.42731667	Context	PSA & MACRO
GWS_057	51.19570000	1.60510000	Context	PSA & MACRO
GWS_058	51.32141667	1.66076667	Reference	PSA ONLY
GWS_059	51.33646667	1.67635000	Reference	PSA ONLY
GWS_060	51.33245000	1.65283333	Reference	PSA ONLY
GWS_061	51.33700000	1.64105000	Reference	PSA ONLY
GWS_062	51.33745000	1.65633333	Reference	PSA ONLY
GWS_063	51.32468333	1.65146667	Reference	PSA ONLY
GWS_064	51.32981667	1.62626667	Reference	PSA ONLY
GWS_065	51.33595000	1.63375000	Reference	PSA ONLY
GWS_066	51.32956667	1.64000000	Reference	PSA ONLY
GWS_067	51.34308333	1.64740000	Reference	PSA ONLY
GWS_068	51.33711667	1.64748333	Reference	PSA ONLY
GWS_069	51.34406667	1.66108333	Reference	PSA ONLY
GWS_070	51.34871667	1.64990000	Reference	PSA ONLY

GWS_071	51.34641667	1.64156667	Reference	PSA ONLY

Table 3. Epibenthic trawl start coordinates for the 2015 survey at Goodwin Sands.

Station	Latitude	Longitude	Impact Zone
T1	51.191927	1.495537	Primary
T2	51.210405	1.509974	Primary
T3	51.173214	1.465702	Secondary
T4	51.236810	1.554067	Secondary

C.2 Proposed Survey Vessel

The survey vessel *Algier Rose* owned and operated by Dillingham & Associates is proposed for the benthic characterisation survey. Goodwin Sands is fully within the scope of *Algier Rose* working out of Ramsgate.

Algier Rose is a Workboat Coded MCA Category2 rated 12.2 m vessel. The vessel is fully rigged to carry out benthic and epibenthic sampling.



Figure 3. Proposed survey vessel *Algier Rose* owned and operated by Dillingham & Associates.

C.3 Benthic Sample Collection

Collection of the benthic grab samples and the analysis of fauna will be conducted in-line with the RSMP Protocol for Sample Collection and Processing specification⁵ and the current Guidelines for the Conduct of Benthic Studies at Aggregates Extraction Sites⁶.

Single seabed samples will be taken with a standard 0.1 m² Hamon grab deployed from the survey vessel. Samples will be obtained as close as possible to the target station coordinates, and within 50 m of the target location. Four attempts will be made to retrieve a sample of at least 5L in volume at each station. If this is not possible, the station will be relocated within a 100-200 m radius of the original target location for the fifth attempt. When small samples of less than 5L in volume are recovered during the attempts, they will be kept to one side and the largest of the small samples will be processed if a suitably large sample cannot be obtained.

Following deployment, the grab will be brought aboard the survey vessel and the sample discharged into a plastic box below the grab stand. A photograph of each sample will be taken and included as an appendix to the report as evidence of collection.

⁵ Keith Cooper and Clair Mason (CEFAS). Regional Seabed Monitoring Plan (RSMP). Protocol for Sample Collection and Processing. Version 4.0.

⁶ Ware, S.J., & Kenny, A.J., (2011) Guidelines for the Conduct of Benthic Studies at Marine Aggregate Extraction Sites (2nd Edition). Marine Aggregate Levy Sustainability Fund. MALSF project: MEPF 08/P75. 80pp.

Detailed field notes will be taken including as a minimum the grab coordinates, time of sampling (in UTC), depth, sample volume, sediment type, weather conditions and any notes on the fauna present within the grab. This information will be recorded as an appendix to the report.

Subsamples of approximately 0.5L will be taken for PSA from each sample. Each sediment subsample will be placed in sealed and secure containers with appropriate internal and external labels. Separate subsamples of approximately 0.5L will also be taken for chemical contaminants analysis and will be stored in specially provided containers.

When faunal analysis is required, the remainder of the sample will be placed on a 1 mm mesh net supported on a 1 mm mesh stainless steel sieve and gently washed with seawater to remove excess fine sand. After sieving, a photograph of each sample will be taken. The residual sample will be transferred into a labelled plastic bucket, preserved in buffered 4% formalin and sealed with a tight fitting lid. The sample will be retained for subsequent analysis of the benthic infauna in the laboratory. If no faunal analysis is required the rest of the sample will be discarded.

C.4 Macrobenthic Separation & Analysis of the Fauna

On arrival at the MESL analytical laboratory, the samples will be checked against the field notes in accordance with the MESL standard operating procedures (included as an appendix to the report) and signed against the list of samples collected. The excess formalin will be sieved through a 1mm mesh sieve and collected for licensed disposal whilst the fauna are retained. Each sample will then be gently eluted with tap water through a 1mm mesh sieve to extract the low-density components (Crustacea and

polychaetes). This stage in the initial sorting process will be carried out in open air to reduce the effects of residual formalin.

Following this, the sediments will be sorted in white trays under a magnifier to remove small higher density macrofauna (small echinoderms, molluscs etc.) and subsequently under a stereomicroscope to extract all remaining fauna. The entire mixed sample of separated fauna will then be preserved in industrial methylated spirits for later analysis. Each of the extracted samples will be sorted into major faunal groups before being analysed to species level by our analysts who sign a log sheet on completion of the analysis of a particular sample. Taxonomic identification will be checked throughout the process both by our senior analysts and against a reference collection held for ease of use in the analytical laboratory.

Marine Ecological Surveys Limited is a leading participant in the National Marine Biological Analytical Quality Control (NMBAQC) scheme. Species identification will be recorded in a standard format using species codes in Howson & Picton (1997)⁷. The analysed material is retained for a period of three months for audit purposes if required as standard.

C.5 Macrobenthic Biomass Determination

The blotted wet weight of the major phyla recorded from the benthic grab samples will be measured using precision balances. The data will

⁷ Howson C.M. & Picton B.E.(1997). The Species Directory of the Marine Fauna and Flora of the British Isles & Surrounding Seas. Ulster Museum & The Marine Conservation Society, Belfast & Ross-on-Wye. Ulster Museum Publication No. 276. ISBN 0 948150 06 8.

then be used to estimate total biomass as ash-free dry weight (AFDW) in grams using conventional conversion factors for each of the faunal groups. These wet weight conversion factors are as follows according with Eleftheriou & Basford (1989)⁸:

- Annelida = x 0.155
- Crustacea = x 0.225
- Mollusca = x 0.085
- Echinodermata = x 0.08
- Miscellaneous groups including Porifera & Bryozoa = x 0.155

C.6 Trawl Sample Acquisition

Trawl sampling will be undertaken during daylight hours due to health and safety considerations. Trawling during daylight hours is considered to be suitable to sample the full range of epibenthic species which inhabit the survey area. Goodwin Sands is known to be a potentially dangerous survey location, and several of the trawls are located in shallow waters. Night time sampling is thus deemed to be a potential safety risk, and is considered unnecessary.

At each trawl station a 2 m scientific beam trawl with a 3 mm cod-end will be deployed. The trawl will be towed for approximately 500 m or 10 minutes into the prevailing tide at a slow constant speed. The time and co-ordinates will be recorded in the survey field notes when the trawl reaches the seabed and commences “fishing”. Upon retrieval of the net

⁸ Eleftheriou, A. & Basford, D.J. (1989) The Macrobenthic Fauna of the Offshore Northern North Sea. *J. Mar. Biol.* 69, 123-143.

the catch will be released into a trawl sorting tray and will be photographed before processing and identification.

All processing of the catches will be undertaken on board the survey vessel where possible. All fish, shellfish and motile invertebrates will be identified to the highest practicable level and enumerated by taxon. Biomass values will be recorded at taxon level for fish and commercially targeted species. The catch will be returned to the sea alive where possible.

Any organisms which are not readily identifiable in the field will be preserved and stored in labelled site-specific buckets for subsequent identification at MESL’s benthic laboratory. The methods for sample analysis in the laboratory will conform to those employed for grab samples.

Following identification, enumeration and biomassing, the resultant data will be subjected to a variety of statistical analyses as specified below.

C.7 Sediment Particle Size Analysis

Each PSA sample acquired from the survey will be sent to Gardline Environmental Limited (GEL) for analysis. The sediments will be air dried and sieved over the range 64 mm down to 0.063 mm on the Wentworth scale. The results will be expressed as cumulative percentage passing and converted by MESL to absolute percentage retained on each sieve size. Gardline Environmental is a participant in the National Marine Biological Analytical Quality Control Scheme (NMBAQC) for PSA.

C.8 Chemical Contaminants Analysis

Chemical contaminants analysis will be undertaken by ALS Environmental Ltd, based in Coventry. ALS is highly experienced in conducting chemical analysis of marine sediment samples and has a range of accreditations including UKAS, MCERTS and ISO:9001. Sub-samples of sediments collected on board the survey vessel will be stored in specially provided containers and stored according to ALS recommendations until ready for analysis. The range of contaminants proposed for testing is shown in Table 4. Details of each contaminant methodology can be supplied on request.

Table 4. Suite of determinants to be analysed from contaminant samples acquired as part of the 2015 benthic survey at Goodwin Sands, together with method description (where available), accreditation of the testing lab and reporting limit.

Determinants	Method Description	Accreditation	Reporting Limit
Heavy Metals			
Mercury as Hg, dry weight	Hydrides ICP	UKAS	0.2 mg/kg
Arsenic as As, dry weight	Metals ICP	UKAS	1 mg/kg
Cadmium as Cd, dry weight	Metals ICP	UKAS	0.2 mg/kg
Chromium as Cr, dry weight	Metals ICP	UKAS	1 mg/kg
Copper as Cu, dry weight	Metals ICP	UKAS	5 mg/kg
Lead as Pb, dry weight	Metals ICP	UKAS	2 mg/kg
Nickel as Ni, dry weight	Metals ICP	UKAS	1 mg/kg
Zinc as Zn, dry weight	Metals ICP	UKAS	5 mg/kg
PCBs			
PCB 101	PCB GC-ECD	UKAS	1.0 µg/kg
PCB 118	PCB GC-ECD	UKAS	1.0 µg/kg
PCB 138	PCB GC-ECD	UKAS	1.0 µg/kg
PCB 153	PCB GC-ECD	UKAS	1.0 µg/kg

PCB 180	PCB GC-ECD	UKAS	1.0 µg/kg
PCB 28	PCB GC-ECD	UKAS	1.0 µg/kg
PCB 52	PCB GC-ECD	UKAS	1.0 µg/kg
TBT		UKAS	3.0 µg/L
PAHs			
Acenaphthene	PAH HPLC	UKAS	0.1 mg/kg
Acenaphthylene	PAH HPLC	UKAS	0.1 mg/kg
Anthracene	PAH HPLC	UKAS	0.1 mg/kg
Benzo(a)anthracene	PAH HPLC	UKAS	0.1 mg/kg
Benzo(a)pyrene	PAH HPLC	UKAS	0.1 mg/kg
Benzo(b)fluoranthene	PAH HPLC	UKAS	0.1 mg/kg
Benzo(g,h,i)perylene	PAH HPLC	UKAS	0.1 mg/kg
Benzo(k)fluoranthene	PAH HPLC	UKAS	0.1 mg/kg
Chrysene	PAH HPLC	UKAS	0.1 mg/kg
Dibenz(a,h)anthracene	PAH HPLC	UKAS	0.1 mg/kg
Fluoranthene	PAH HPLC	UKAS	0.1 mg/kg
Fluorene	PAH HPLC	UKAS	0.1 mg/kg
Indeno(1,2,3-c,d)pyrene	PAH HPLC	UKAS	0.1 mg/kg
Naphthalene	PAH HPLC	UKAS	0.1 mg/kg
PAH, Total of 16 EPA	PAH HPLC	UKAS	1 mg/kg
Phenanthrene	PAH HPLC	UKAS	0.1 mg/kg
Pyrene	PAH HPLC	UKAS	0.1 mg/kg

D. Data Analysing and Reporting

D.1 Statistical Data Analysis

All data generated throughout the survey and analysis will be entered into an appropriate database for secure long term storage.

Statistical analysis follows the procedures recommended in the *Guidelines for the Conduct of Benthic Studies at Marine Aggregate Sites* (Ware & Kenny 2011). Multivariate analysis will be carried out using the PRIMER V6 software package^{9,10}. All data will be analysed using appropriate methods by highly experienced and fully trained marine ecologists.

In accordance with the guidelines, benthic, epibenthic, sediment and chemical data will be analysed using both univariate and multivariate testing. Samples may be split into *a priori* groups classified by impact treatment to allow hypothesis testing to be undertaken. Patterns and groupings within the data will be investigated using the multivariate techniques identified below:

Hierarchical Cluster Analysis

Cluster analysis aims to find “natural groupings” such that samples within a group are more similar to each other than samples in different groups. The most commonly used clustering techniques are the hierarchical agglomerative methods. These start with a similarity matrix and “fuse”

the samples into groups and the groups into larger clusters, starting with the highest mutual similarities then gradually lowering the similarity level at which groups are formed until all of the samples are contained in a single cluster. The results of hierarchical clustering are represented by a tree diagram or dendrogram, with the x axis representing the full set of samples and the y axis representing the similarity level at which the groups are considered to have fused.

Multidimensional Scaling (MDS) Ordination

This technique allows the construction of a “map” or configuration of the samples in multidimensional space. This configuration attempts to position the samples as accurately as possible to reflect the similarity between the samples. For example, if sample 1 has a greater similarity to sample 2 than it does to sample 3 then sample 1 will be positioned more closely to sample 2 than it is to sample 3. This “map” of the relative similarities between samples is then plotted in two dimensions. It is important to remember that this two-dimensional plot is a representation of a multidimensional picture.

The SIMPER routine

The SIMPER routine allows the comparison between groups of samples from one site to another to be made. Species (or particle size fractions) responsible for the dissimilarity between sites are listed in decreasing order of importance in the discrimination of the two sample groups. This routine also provides information on which species are responsible for the within-site similarities and their contribution to the internal similarity of the group.

⁹ Clarke, K. R and Warwick, R. M. (2001) *Change in Marine Communities: An Approach to Statistical Analysis and Interpretation*. Second Edition. PRIMER-E: Plymouth.

¹⁰ Clarke, K. R & Gorley, R. N. (2006) *PRIMER v6: User Manual/Tutorial*. PRIMER-E: Plymouth.

ANOSIM

This will be used to test the null hypothesis (H_0) that there are no differences in community (or sediment) composition between the pooled sample categories featured in the investigation.

Due to the inherent difficulties in quantification, colonial taxa are typically excluded from multivariate analyses.

D.2 Reporting

Upon completion of the data analysis, a full benthic technical report will be produced. The Report will include details of the survey and data processing as well as interpretation of the ecological data.

In the report, chemical contaminant data will be compared against the Cefas guideline Action levels which assess dredged material and its suitability for disposal at sea¹¹.

It is proposed that the data for biodiversity, the number of individuals and the biomass of the benthic fauna will be principally plotted in GIS format. Similarly the major communities will be related to sediment composition through multidimensional scaling (MDS) techniques, and will be plotted in GIS format for comparison with the distribution of sediment types in the survey area prior to dredging.

¹¹ Cefas Guideline Action Levels for the disposal of dredged material. <http://www.cefas.defra.gov.uk/media/562541/cefas%20action%20levels.pdf>. Accessed 27th May 2015.

The Reports for the survey will be fully illustrated and will include details of relevant methodology, interpretation of the results and appendices with the complete data upon which the report is based. We propose that the report will include the identification of the limits of acceptable change in sediment particle size composition¹² for the biological assemblages in the prospecting area at Goodwin Sands. This will result in a decrease of efforts during future monitoring surveys as samples from the PIZ and SIZ may only require sediment PSA samples to be acquired.

The report will be provided as both hard-copy and as CD versions, the latter containing the appendices and data.

D.3 Thematic Maps (GIS)

All of the GIS maps used in our report are generated using ArcGIS version 10.3.

¹² Cooper, K.M. (2013) Setting limits for acceptable change in sediment particle size composition: Testing a new approach to managing marine aggregate dredging. Marine Pollution Bulletin 73, 86-97.

E. Resources of Conservation Importance

The prospecting area is located partially within the boundary of the Goodwin Sands rMCZ which is known to be populated by *Mytilus edulis* (blue mussel) beds and *Sabellaria spinulosa* (Rossworm) reefs¹³. The proposed survey array is shown in relation to these conservation areas in Figure 4.

Sabellaria spinulosa is a tubiculous worm, which can cause significant alteration to the seafloor by turning large volumes of sand into intricate tube structures. In their most prolific forms these structures are classified as biogenic reefs and are protected under Annex I of the EU Habitats Directive. Mussel beds, such as those formed by the edible mussel *Mytilus edulis*, also fall under the protection of Annex I of the EU Habitat Directive.

The 2015 Goodwin Sands benthic survey will take note of any resources of conservation importance which are observed during the survey. Descriptions of any potential Annex I habitats made during the survey will take into consideration the methods discussed in Gubbay (2007¹⁴) and Hendrick & Foster-Smith (2006¹⁵).

¹³ The Wildlife Trusts (2014). <http://www.wildlifetrusts.org/MCZ/goodwin-sands>. Accessed 7th May 2015.

¹⁴ Gubbay, S. 2007. Defining and managing *Sabellaria spinulosa* reefs: Report of an inter-agency workshop. 1-2 May, 2007. JNCC Report No. 405. Joint Nature Conservation Committee (JNCC). 22 pp.

¹⁵ Hendrick, V.J. & Foster-Smith, R.L. 2006. *Sabellaria spinulosa* reef: a scoring system for evaluating 'reefiness' in the context of the Habitats Directive. *Journal of the Marine Biological Association of the United Kingdom*. **86** 655-677.

It is not anticipated that the Goodwin Sands benthic survey will impact upon any of the features of the rMCZ or the recommended Reference Area (rRA) in any significant manner, given the small footprint of the sampling gear, and the position of the survey stations along the Goodwin sand bank. Furthermore, the prospecting area has been designed to avoid reef habitat locations which have been mapped and identified in the JNCC Potential Annex I reef habitat data set¹⁶.

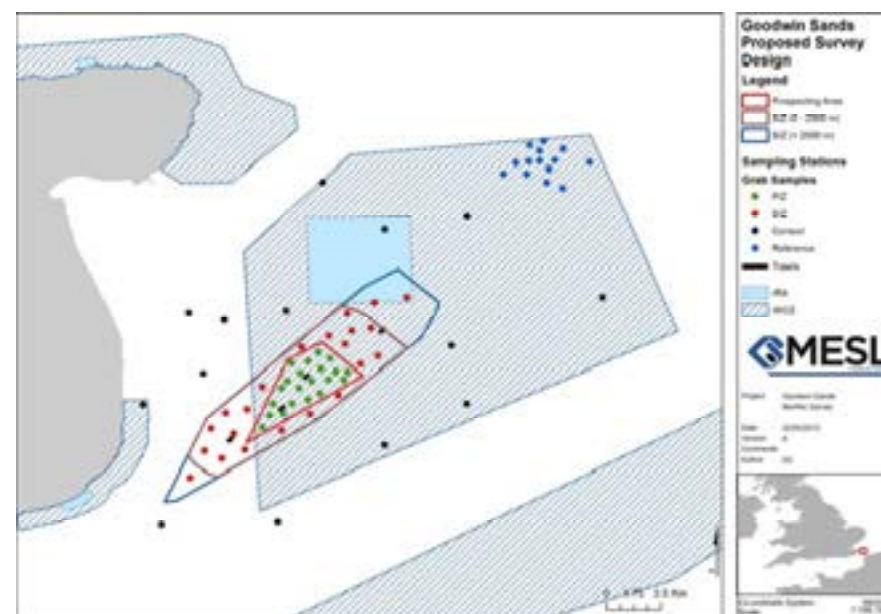


Figure 4. The position of the prospecting area and the proposed survey array in relation to the boundary the boundary of the Goodwin Sands recommended Marine Conservation Zone (rMCZ) (hashed area) and the recommended Reference Area (rRA).

¹⁶ <http://jncc.defra.gov.uk/page-3054>. Accessed 27th May 2015.

F. Survey Planning

F.1 Permits and Consents

MESL will ensure that all relevant consents and permits necessary for the survey are secured ahead of mobilisation. This includes providing a notice for an exempt activity (grab sampling) to the MMO, submitting an application to the Crown Estate for a Small Works Consent and associated seabed users conflict check, and gaining dispensation from Kent and Essex IFCA to conduct a beam trawl survey using undersized nets. As the proposed survey vessel is not a registered fishing vessel, it is understood that no fisheries exemptions from the MMO needs to be applied for.

F.2 Timing of the Surveys

It is anticipated that the survey at Goodwin Sands will be conducted during the summer of 2015, ideally in early July. However, due to the shallow nature of Goodwin Sands, bad weather is a potential factor which may delay survey operations. The survey will also have to be timed to coincide with peak spring tides, which may factor in delays to the survey programme.

Following the acquisition of seabed samples, it is anticipated that sample analysis will be complete with 8-10 weeks. A draft of the final report will be delivered within 4-6 weeks following the completion of sample analysis. This will be provided to the MMO for regulatory approval.

It is recommended that any subsequent baseline or monitoring surveys are undertaken at a similar time of year to the 2015 characterisation

survey, and should adopt the same sampling protocol, in order to produce temporally comparable data.

Appendix 13.1

MEP Full Characterisation of Commercial Fishing and Charter Angling Activity at and Around the Goodwin Sands



Full Characterisation of Commercial Fishing and Charter Angling Activity at and Around the Goodwin Sands

Report prepared by MacAlister Elliott and Partners Ltd.

18th March 2016



Project Number:	2990 UK
QA Number:	2990R0B
Report Title:	Full Characterisation of Commercial Fishing and Charter Angling Activity At and Around the Goodwin Sands
Author	Frances James
Date:	18 th March 2016

SUMMARY OF WORK UNDERTAKEN

This report presents the results of a baseline study to ascertain the amount of fishing activity taking place on the Goodwin Sands and surrounding area, herein referred to as 'the study area'. It will inform the Environmental Impact Assessment (EIA) relating to the extraction of aggregate from the Sands for fill material for the Dover Western Docks Revival (DWDR) scheme.

MacAlister Elliott & Partners (MEP) initially undertook discrete meetings with the Kent and Essex Inshore Fisheries Conservation Authority (KEIFCA) and the Thanet Fishermen's Association (TFA) in Ramsgate to obtain insights into fishing patterns and activity levels in the area of interest. Discussions were also held with ex Balanced Seas/Natural England staff who had previous experience in characterising activity in the area, during the recommendation of the Goodwin Sands as a potential future Marine Conservation Zone (MCZ). Fisheries effort and landings data were obtained from the Marine Management Organisation (MMO) and the KEIFCA to further characterise fishing activity patterns in the study area. There was a focus on the most proximal and relevant ports to the study area, including Herne Bay, Whitstable, Broadstairs, Margate, Ramsgate, Deal, Dover and Folkestone. These meetings, in conjunction with knowledge held by MEP and the FLO, led to the identification of fishers known to have a reliance on fishing grounds in and around the study area.

Interviews were then held with 41 fishers (9 of these charter anglers) from Ramsgate, Deal, Folkestone, Dover and Whitstable to discuss their fishing operations and opinions relating to the proposed scheme. Meetings were either conducted by the TFA (mainly for the Ramsgate fishers) or were held in person by MEP where possible to permit MEP to observe fishing vessels, business locations and to facilitate a discussion about where fishing occurs and to mark this activity on a chart. Interviews followed a semi-structured format to enable analysis of comparable information. The methodology is discussed in greater detail in Section 2.

The characteristics of the fisheries and fishing businesses were also identified during a brief telephone interview survey and site visits.

Following the completion of interviews, charts of fishing grounds obtained during interviews were digitised and entered into a Geographical Information System (GIS). Compilation of the polygons enabled the identification of overlapping fishing grounds to determine areas of higher and lower fishing intensity, by port, gear type and species. In conjunction with information on fishing value and methods of operating, maps of relative value of fishing grounds were developed.

The analysis of the outputs from the above activities provides the foundation for the characterisation of fishing presented in this report and will inform the Environmental Impact Assessment (EIA).

SUMMARY OF FISHING IN AND AROUND THE DREDGE SITE

Fishing occurs in and around the study area by three categories of fishing vessels; commercial fishing vessels, charter angling vessels and recreational angling vessels (defined in the Glossary). Fishing occurs using a variety of gears, but gear diversity is a characteristic found only within the commercial fishing category. Here, pots, traps and netting gears are the most important gears used in the local commercial fleets, which mainly fall into the under 10m overall length category. In the ports listed above, there are 67 fishing vessels registered by the MMO. Not all of these are thought to active¹.

Commercial fishing in the area is dominated by fishing for demersal species such as sole, bass, cod, smoothound and thornback ray, caught mainly by drift and static netting gear. Fisheries for shellfish are equally important, particularly those for whelk, lobster and crab, caught by baited pots and laid on the seabed and hauled after a period of soaking. Trawling is not a prevalent activity within the study area. Fisheries are seasonal, with lobster, crab and bass targeted during the summer, sole, bass, ray and smoothound targeted during the spring, and cod during the winter. Seasonality arises due to the biological movements of species for migration or spawning in different regions of the study area, but also to an extent from market demand and price variation.

Sole generates the greatest landed value into ports of the study area (£2.6 million from 2010-2014; ICES Rectangle 31F1), followed by whelks and bass. However, lobster has the greatest landed value per kilo than any other species landed (~£12/kg). Most catch is landed into Ramsgate, Folkestone and Whitstable, where landed values totalled £10 million from 2010-2014. In terms of contribution to annual earnings, fishers also reported that whelk, bass, sole and lobster, as well as skate, cod and crab, were the most important. Few individuals revealed their annual earnings but those that were reported fell within the range of Seafish's 2014 economic fleet segment estimates.

Recreational and charter angling vessels use rod and lines (and occasionally drift nets) to target varied and seasonal species, similar to those targeted by the commercial fleet. Fish may be retained or released by the angler but exchange of cash for caught fish is prohibited. Charter angling vessels generally have quite a limited range but carry customers to well-known angling spots and work between 14-150 days a year. Recreational vessels are much more diverse in terms of seagoing capabilities, powered by both inboard and outboard engines. Recreational and charter angling activity appears to be more intense on the edges of the Sands, over wreck sites and in channels.

Suitable fishing ground is found through much of the study area for the commercial fisheries (the study area is defined in Section 2.1), but there are hotspots of productivity that are likely to be of significant financial importance to specific fishing vessels that target specific species. Many fishermen are now moving towards targeting a mixed catch to remain viable, so fishing grounds are often wide ranging.

¹ Consultation with Kent and Essex IFCA

SENSITIVITY TO DISTURBANCE

Commercial fishing is arguably the most sensitive to disturbance of the three fishing vessel categories, as inshore commercial fishing vessels typically fish at specific fishing grounds. Fishing grounds accessible to a given vessel are restricted by competition with other fishing vessels, suitable habitat for target species, and the capacities of the vessel fishing. Commercial fishing vessels are also subject to a strict regulatory regime that limits what can be fished, where and by which vessel. Together with the specificity of fishing gear, these factors combine to restrict where and when commercial fishing can occur. As charter angling and recreational angling are less limited in terms of what they fish for and where, and because using a rod and line is not limited by benthic habitat, these two categories are less sensitive to localised disturbance or limited access to a given area.

Analysis of fishing activity data suggest that in general there are low levels of large vessel commercial fishing activity in the study area (vessels more than 10 metres in overall length) but that some activity of the small inshore-ranging commercial fleets (vessels 10 metres and under in overall length) will be disrupted. High levels of fishing activity are seen out of Ramsgate and to the west of this region, in the Thames Estuary, along the 6 nautical mile limit and out of Dover and Folkestone. It is estimated that vessels from Ramsgate will be the most greatly affected.

The longevity of the impacts resulting from reduced access, displacement and possible loss of fish resource will depend upon length of the dredging phase. Communication will be important in minimising the impacts to the local fishing fleet, including advance warning and accurate details of dredging operations, ongoing liaison with the fishing community to minimise disruption to fishing activities where practicable. This way, static gear vessels (such as those that make up the majority of the local fleet) that have historically fished in the area can continue whenever it is safe to do so.

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ABBREVIATIONS AND GLOSSARY

AIS	Automatic Identification System
CEFAS	Centre for Environment, Fisheries and Aquaculture Science
CFP	Common Fisheries Policy
Charter angling	Fishing by vessels licensed to carry passengers for angling trips and which declare taxable profit from charter fees
Commercial fishing	Fishing by licensed fishing vessels for declared taxable profit derived from the sale of fish
DEFRA	Department for Environment, Food and Rural Affairs
Demersals	Species that live on or near the seabed and feed on bottom-living organisms
DHB	Dover Harbour Board
DWDR	Dover Western Docks Revival Scheme
EC	European Community
EIA	Environmental Impact Assessment
Elasmobranchs	A biological subclass of Chondrichthyes or cartilaginous fish, that includes the sharks and the rays, skates, and sawfish
EU	European Union
FLO	Fisheries Liaison Officer
FQAs	Fixed Quota Allocation Units, the units held by the individual vessels in each group, or by a group collectively, that establishes what proportion of the EU fish quota for certain fish species is allocated to each group.
ICES	International Council for the Exploration of the Sea
JNCC	Joint Nature Conservation Committee
KEIFCA	Kent and Essex Inshore Fisheries Conservation Authority
MCA	Maritime and Coastguard Agency
MCZ	Marine Conservation Zone
MEP	MacAlister Elliott and Partners Limited
MMO	Marine Management Organisation
Pelagics	Fish that live neither close to the bottom nor near the shore
PO	Producer Organisations, bodies set up by fishery or aquaculture producers. They are in charge of the day-to-day management of fisheries and play an essential role in running the Common Fisheries Policy and the Common Organisation of the Markets
RBS data	Registered Buyers and Sellers Data
Recreational angling	In context of this report, recreational angling is a leisure activity undertaken by recreational anglers operating from small private angling vessels
TAC	Total Allowable Catch, a catch limit set for a particular fishery, generally for a year or a fishing season. TACs are usually expressed in tonnes of live-weight equivalent, but are

	sometimes set in terms of numbers of fish
TFA	Thanet Fishermen's Association
Trailer Suction Hopper Dredgers	Vessels that are mostly used for dredging loose material such as sand, clay or gravel. To this end, one or two suction tubes equipped with a drag head that is trailed over the ground are lowered.
VMS	Vessel Monitoring System

Dover Harbour Board (DHB) plan a Dover Western Docks Revival (DWDR) scheme which will include a reclamation element to create new port operational land. The expansion requires aggregate for fill material and DHB's preferred source of aggregate is dredging from the South Goodwin Sands. An area on South Goodwin Sands has been selected for dredging (Figure 1). DHB plan to dredge approximately 2.5 million m³ of material, using Trailer Suction Hopper Dredgers. Activity is estimated to comprise three dredging periods of four months' duration, commencing in September 2016 and ending in 2019.



This report presents the results of a baseline study to ascertain the amount of commercial and charter fishing taking place on the South Goodwin Sands and surrounding area, commissioned to inform the EIA. The proposed dredging is expected to exclude fishing operations from Active Dredging Zones (ADZs), so it is essential to quantify the level of activity currently occurring within the study area.

2 METHODOLOGY

2.1 Study area

The nature of fishing activity on the Goodwin Sands, permits the study area to be compact, as vessels with a demonstrated reliance on fishing grounds in this study area are limited in terms of range and are moored at nearby harbours and landing sites. The study area which surrounds the proposed dredge area includes proximal landing ports of commercial significance, which have been highlighted in Figure 2 below.

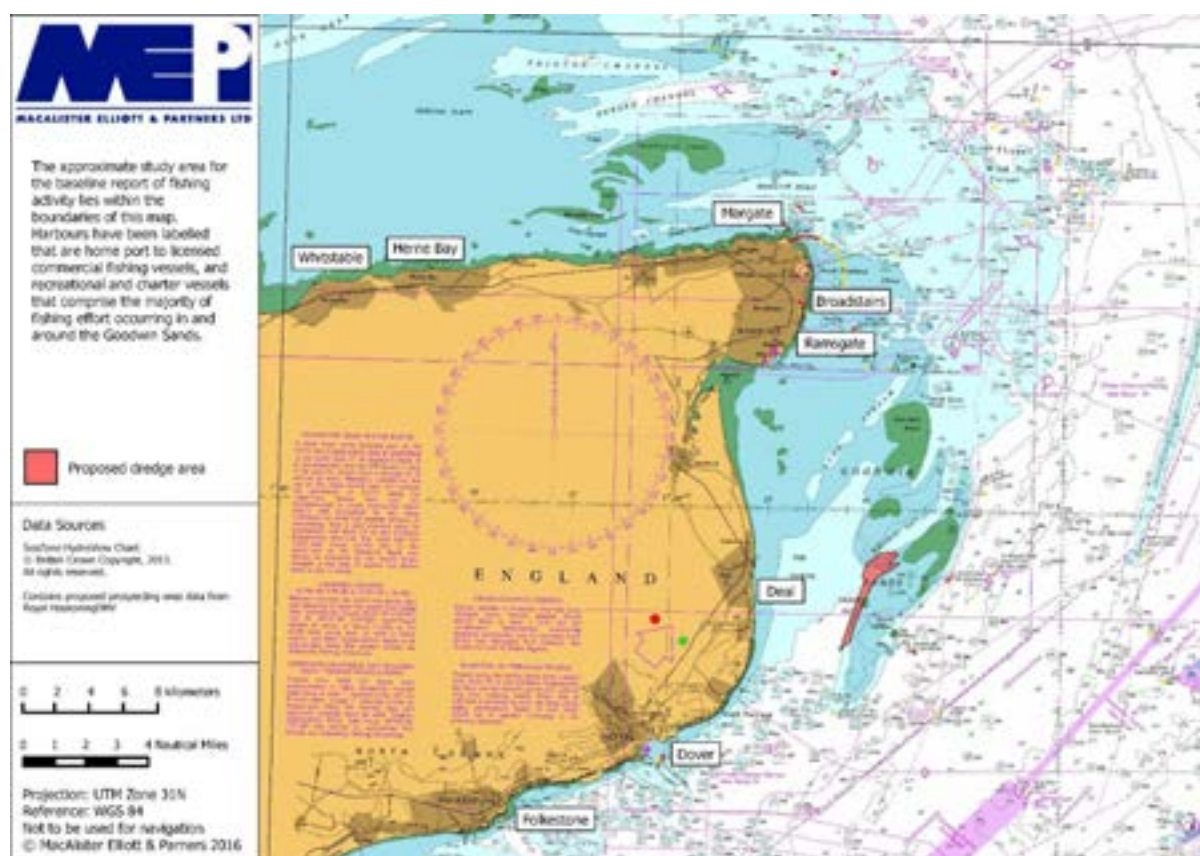


Figure 2: Chart of the approximate study area. Harbours with licensed commercial fishing vessels that comprise the significant majority of commercial fishing effort occurring in and around the Goodwin Sands site have been labelled.

The main commercial fishing harbours in the study area, in terms of volume and value of landings, are Ramsgate, Whitstable and Folkestone (see Section 3.1.4 for more details), yet harbours in close proximity to the proposed extraction site, such as Margate, Broadstairs, Deal and Dover are equally important in context of this study due to the local nature of the fishery.

2.2 Approach to characterisation

Characterising fishing activity is challenging, as the nature of fishing in a given area changes from year-to-year in response to the many variables that influence operating patterns and the abundance of fish. Fuel costs, legislative changes, the variability inherent in natural resources and a host of other factors cause fishers to modify their activities to maximise returns. This report therefore presents a characterisation of fishing activity occurring in the study area at the current time.

There is no single source of data or information that can be accessed to accurately characterise fishing activity in the UK, and what data are available are subject to significant constraints (see Section 2.3.1), therefore when working with the inshore fishing fleet, charter and recreational angling sectors, direct consultation with representatives of these sectors and of the fisheries management bodies operating in the local area are essential. To address these constraints, a strongly consultative approach is required, as detailed in Section 2.3.4.

2.3 Sources of information

2.3.1 UK fishery statistics

The main sources of data used in the compilation of UK sea fisheries statistics are derived from i) the European Union fisheries legislation on keeping and submitting logbooks and providing landings declarations and sales notes, primarily Council Regulation (EU) 1224/2009; and ii) general powers under the Sea Fisheries (Conservation) Act 1967.

Fishers working from vessels over 10 metres in length are required by law to complete logbooks of fishing activity that are submitted to the Marine Management Organisation (MMO), after each fishing trip. These logbooks are supplemented with information from landings declarations and sales notes. Confidence in landings data for the over-10 metre fleet is good, although a proportion of fishing activity is believed to remain unreported.

Historically, information on landings by vessels 10 metres and less in length was collected via voluntary declarations from the industry and via estimates of landings and fishing effort determined by fisheries officers working for the regulatory body tasked with management of commercial fisheries. It is generally accepted that this system grossly underestimated actual landings. At the time of writing this report, there remains no statutory requirement under either EU or national legislation for fishers to declare their catches if caught by a vessel 10-metres and under in length.

The introduction of the Registration of Fish Buyers and Sellers (RBS) and Designation of Fish Auction Sites Regulations 2005 (England) requires that all buyers and sellers of first sale fish are registered, and that buyers who buy fish direct from a vessel or agent submit buyer's sales notes to the local fisheries office within 48 hours of a sale taking place. These sales notes are the primary source of information for statistics relating to landings by under-10 metre vessels. This system has improved the monitoring and control of landings of fish

by this fleet segment, as sales notes are required to include information on the vessel and port of landing relating to fish being marketed. However, the completeness of the statistics is uncertain, as landings are only reported when the fish are sold or data have been provided voluntarily. Low volume sales are not necessarily reported. Data reliability is also dependent on the information provided by fishers and buyers. While inspectors carry out manual and automatic checks on information provided by vessel operators, supplemented by Monitoring, Control and Surveillance information, the MMO reports that a proportion of fishing activity remains unreported².

Information about shellfish catches is obtained via the shellfish restrictive licensing scheme, introduced in 2004. All fishing vessels with an overall length of 10 metres or less fishing for crabs and lobsters were required to fill in monthly activity forms. Vessels over 10 metres in length continued to fill in EU logbooks.

In 2009 the recording procedures were streamlined and have since relied on RBS information for the 10 metres and under fleet. Due to changes in reporting procedures, the MMO advises that trends in reported landings from 2005 to 2006, and from 2009 to 2010 should be considered with care. In addition to considerations about the effect of changes in reporting procedures, the completeness of the shellfish data set is uncertain.

2.3.2 Fisheries statistics requested and obtained to date

Information requests were submitted to the MMO Statistics and Analysis Team in May and June 2015 for preliminary characterisation and in December 2015 for full characterisation. Most data were not provided in time for full characterisation but average fishing patterns and landings values are not likely to have significantly changed in the time period between requests. Moreover, full characterisation has focused on consultation. The data requested were as follows:

- Vessel Monitoring System data for the past 5 (2010-2015) years for ICES statistical rectangle 31F13;
- Overflight aerial surveillance data for the past 5 years for all ICES statistical rectangles;
- Value of total landings for the past 5 years for home ports in ICES statistical rectangle 31F1, by species;
- Volume of total landings for the past 5 years for home ports in ICES statistical rectangle 31F1, by species;
- Fishing effort data for the past 5 years in ICES statistical rectangle 31F1, by home port for local ports Whitstable, Margate, Ramsgate, Sandwich, Deal, Dover, Folkestone, Hythe and Rye.
- Local fishing vessel sightings data from KEIFCA patrols

² Marine Management Organisation – MMO (2015). Fishing data collection, coverage, processing and revisions [Online]. Available: <https://www.gov.uk/fishing-activity-and-landings-data-collection-and-processing> [Accessed 21.06.2015].

³ See Figure 3: ICES statistical rectangles 31F1



Figure 3: ICES statistical rectangles 31F1. Source: http://geo.ices.dk/viewer.php?add_layers=ices_ref:ices_rectangles

Other UK fishery data obtained from the MMO (available online, without request) are statistics on local fleet characteristics, including the registered and licensed fishing vessel lists for the over 10m and under 10m fishing vessels. These lists contain information such as vessel name length, power, tonnage and age. Lists are updated monthly and are available on the MMO website⁴.

The level of detail that can be obtained from the RBS data is limited due to the MMO having a responsibility to protect data provided to them by the fishing industry. This leads to aggregation and suppression of data, whereby a “rule of 5” is applied as best practise. This rule leads to data being suppressed where a record relates to less than 5 vessels. The characteristics of the commercial fleet operating in the study area results in data suppression which will reduce the usefulness of the RBS data for this baseline report.

Data suppression has a significant impact on the ability to inquire into fishing effort, as it is not possible to determine the effort applied by vessels that are fishing in the study area. Effort data is compressed to provide, for example, the number of days fished in a given month for a specific gear type, but it is not possible to determine how many vessels contribute to the recorded effort or where the effort was expended.

2.3.3 AIS, VMS and Surveillance data

UK and European fishing vessels over 15 metres in length are legally required to carry and operate Automatic Identification System (AIS) units and UK registered commercial fishing vessels over 12 metres in length should operate Vessel Monitoring System (VMS) units.

⁴ Marine Management Organisation – MMO (2015). UK Vessel Lists. [Online]. Available: <https://www.gov.uk/government/collections/uk-vessel-lists> [Accessed 28.01.2016].

These units send a regular report of a vessel's location to the MMO and other organisations via satellite. This information is useful to inform fisheries authorities of days at sea, adherence to closed areas and sectoral regulations.

Aerial surveillance data are collected by the MMO as part of its obligation to monitor, record and enforce fishing activity within the MMO's area of jurisdiction. This information provides an insight into the activities of vessels not required to carry VMS systems, notably the under-10 metre fleet. The data collection is irregular and infrequent. This precludes the data from being used in quantitative assessments of fishing effort, but it does provide an insight into types of vessel activity and relative spatial distribution of effort. The data are owned by the MMO and information about the activities of non-UK vessels is therefore available.

Statistical data on observations of fishing vessels made by fishery patrol vessels and aircraft fill in some gaps in terms of spatial understanding, but the frequency of data recording is low and not standardised. The lack of standardisation is positive from an enforcement perspective, but limits the confidence in drawing conclusions from plots of available data. VMS data which can provide a good spatial understanding of fishing activity is currently only available for the 12 metre and over commercial fishing fleet⁵. Of the 67 commercial vessels registered to local ports (Herne Bay, Whitstable, Broadstairs, Margate, Ramsgate, Deal and Dover) only one UK vessel was registered to be over 15m in length and the VMS data are therefore not relevant to this study beyond identifying whether large fishing vessels are accessing the Goodwin Sands.

AIS data for this study are available to MEP in real-time and the tracks of fishing vessels (up to 90 days) identified in the study area (Figure 4) are available for download every few hours. Vessel details were recorded in a spreadsheet and the 90-day tracks of these vessels downloaded and plotted on Google Earth.

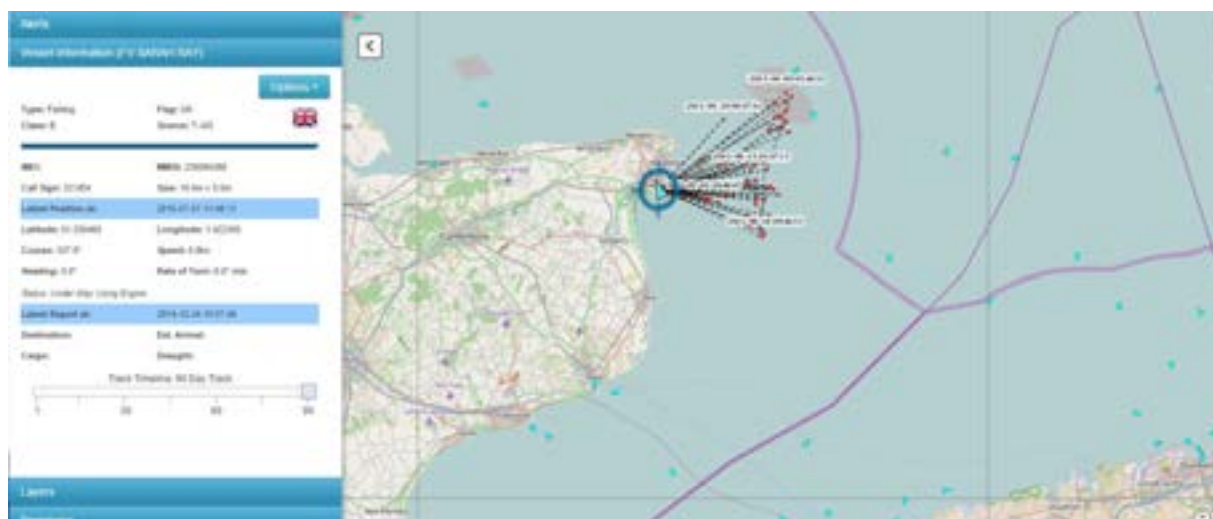


Figure 4: AIS viewer and study area. Image shows a selected fishing vessel where vessel details and the downloadable 90-day track is displayed.

⁵ Vessels 12 metres and over in length will soon be required to operate a VMS unit and to allow position data to be transmitted to fishing authorities. The majority of the commercial fleet, particularly in inshore waters are 10 metres and under.

2.3.4 Consultations

As outlined previously, publically available data on the commercial fishing fleet is subject to limitations when being used to develop a baseline of fishing activity at the scale required for this project. Also, data on the charter and recreational angling fleets is virtually non-existent. For these reasons, consultation with representatives of the fishing industry, anglers and regulators was essential to accurately characterise fishing activity in the footprint of the extraction site and surrounding waters.

MEP consultations commenced with discrete meetings with the KEIFCA at their office in Ramsgate to obtain insights into fishing patterns and activity levels in the area of interest. Discussions were also held with ex Balanced Seas/Natural England staff who had previous experience in characterising activity in the area, during the recommendation of the Goodwin Sands as a potential future Marine Conservation Zone (MCZ).

Following the meetings with regulators, using information obtained from the MMO, KEIFCA and local knowledge held by MEP, an initial list of vessel owners was drafted. The interview list initially focussed on the fishermen's associations present in the study area, as these organisations will have the best knowledge of vessels known to be active on a regular basis. The associations and their contacts are provided in Appendix 1.

Given the relatively small area that would be occupied by the dredge site, the number of commercial vessels operating in the area is relatively low, which supported comprehensive consultations with commercial and charter fishing vessel owners from relevant harbours. Given Ramsgate is the most significant harbour in terms of fishing activity (see Section 3.1.2.2), 75% of consultations occurred with vessel owners from here. Other harbours included were Deal, Dover, Folkestone and Whitstable.

Owners of commercial fishing vessels and charter angling vessels were contacted by telephone to arrange a meeting to complete the interview and to discuss their views of the dredging development. Prior to the meetings a data collection sheet was developed to guide interviews (see Appendix 2), providing comparable information across interviews.

In total 41 interviews were completed, comprising 31 commercial fishing vessel owners, 9 charter angling vessel owners and 1 interview held with a key representative of the recreational angling sector⁶. Interviews were conducted by Frances James and David Elliott of MEP but for most of the Ramsgate vessels owners, interviews were conducted by the Thanet Fishermen's Association (TFA). During initial meetings at the KEIFCA, the TFA had expressed that commercial fishers would only provide information during TFA meetings, without MEP's presence. The interviews typically took place at a location suggested by the interviewee and lasted between 30 and 90 minutes. Information about the vessel, method of operation and business was gathered using the data sheet, and a series of questions relating to perceptions about the dredging project asked. Information about spatial activity

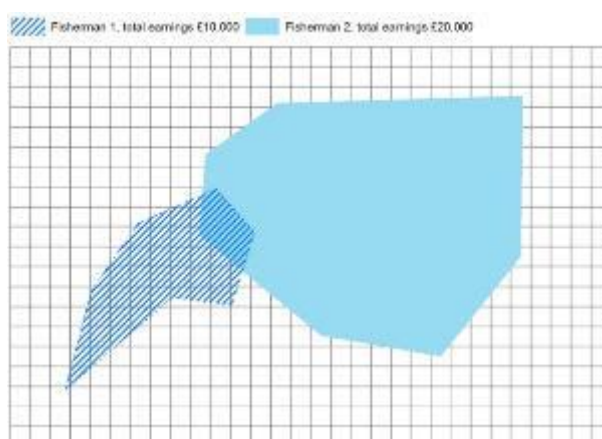
⁶ The semi-structured interview format was not followed at this meeting, which was conducted with a representative of the recreational angling fleet, rather than a vessel or business operator.

was gathered by asking interviewees to mark their fishing grounds onto a nautical chart marked with latitude and longitude. In MEP interviews, the chart did not identify where the dredge site was proposed to prevent undue bias, although many respondents were broadly aware of the project and its approximate location. At the interviews people were also asked if there were other vessel owners who should be consulted by MEP.

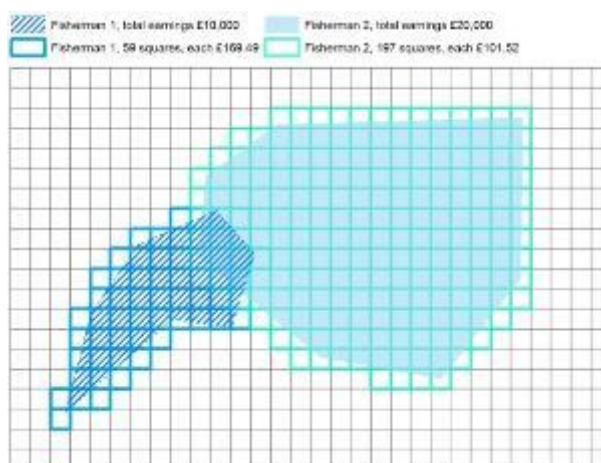
The TFA had previously been made aware of the approximate location of the dredge site by DHB so during TFA interviews, the dredge area had been marked. The TFA provided confidence that the responses received are broadly accurate in terms of defining key fishing grounds for vessel owners identified. However, as some bias may have occurred, data on inshore small vessel (<10m) fishing grounds was cross-checked with data held by the IFCA. The confidence of accuracy in each dataset is discussed in Section 3.1.1.7.

Consultation responses were analysed in Excel and spatial patterns of fishing activity on charts analysed using Geographical Information Systems (GIS). Each polygon created from digitising the responses received from fishing vessel owners about the location of fishing grounds, is overlaid to produce digitised maps. The methodology for estimating the value of fishing grounds is as follows:

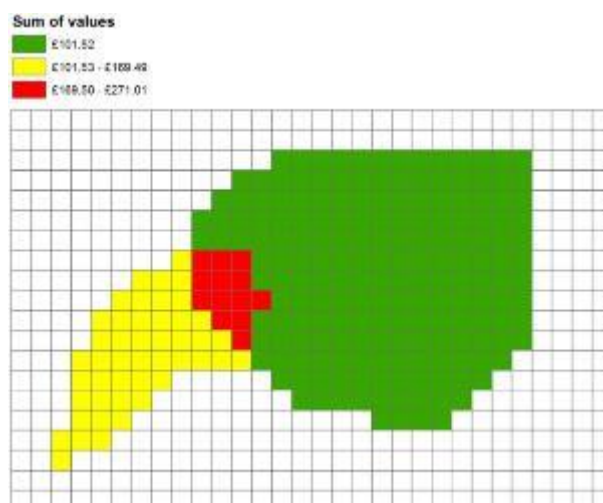
- 1) In this example, there are two fishermen who each fish a single area that overlap slightly with each other.



- 2) Convert the fishermen's polygons to a grid (note: the grid size used here is particular large to highlight how this methodology slightly overestimates a fisherman's working area). Divide each fishermen's per species earnings by the number of grid squares and assign that value to each square.



3) Overlay the grid squares and sum each stack.



3 ESTIMATIONS OF FISHING ACTIVITY

3.1 COMMERCIAL

The Goodwin Sands site lies within ICES rectangle 31F1, close to the southern end of ICES Area IVc, southern North Sea, near the border with ICES area VIId, eastern English Channel. Data on commercial fishing activity in the study area have been obtained from several sources, including the MMO, KEIFCA, AIS software providers and through consultation with fishing industry representatives (see Section 2.3 for full details).

These data aim to estimate the number and frequency of commercial fishing vessels exploiting the Goodwin Sands, the seasonality of this activity, the species targeted and the estimated value of landings. Commercial fishing activity is subsequently characterised below.

3.1.1 Fishing effort and fishing grounds

3.1.1.1 VMS and Aerial Surveillance Data

Fisheries VMS (Figure 7 & 8) and aerial sightings data (Figure 5 & 6) data (provided by the MMO) are presented here for the 2010-2014 period (aerial sightings data) for the 2010-2015 period (VMS data). Together, these datasets aim to provide a good spatial understanding of recent fishing activity in the commercial fleets operating over the Goodwin Sands and surrounding area. The limitations associated with both data sets are discussed in Section 2.3.3.



Figure 5: Results of aerial surveillance (aerial sightings data) for years 2010 to 2014 in ICES Rectangle 31F1 and the study area (data source: MMO).

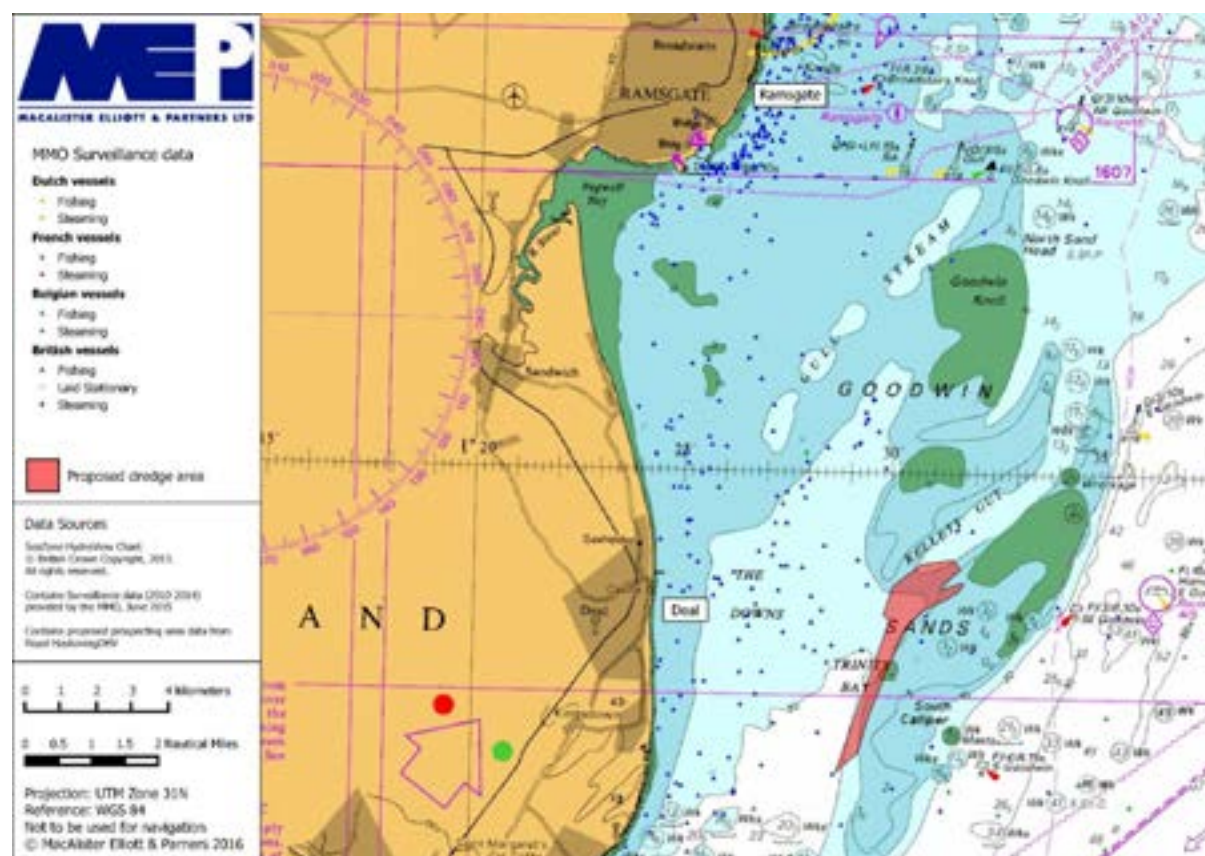


Figure 6: Results of surveillance (aerial sightings data) for years 2010 to 2014 in ICES Rectangle 31F1, zoomed to the Goodwin Sands area and planned exploration area (data source: MMO).

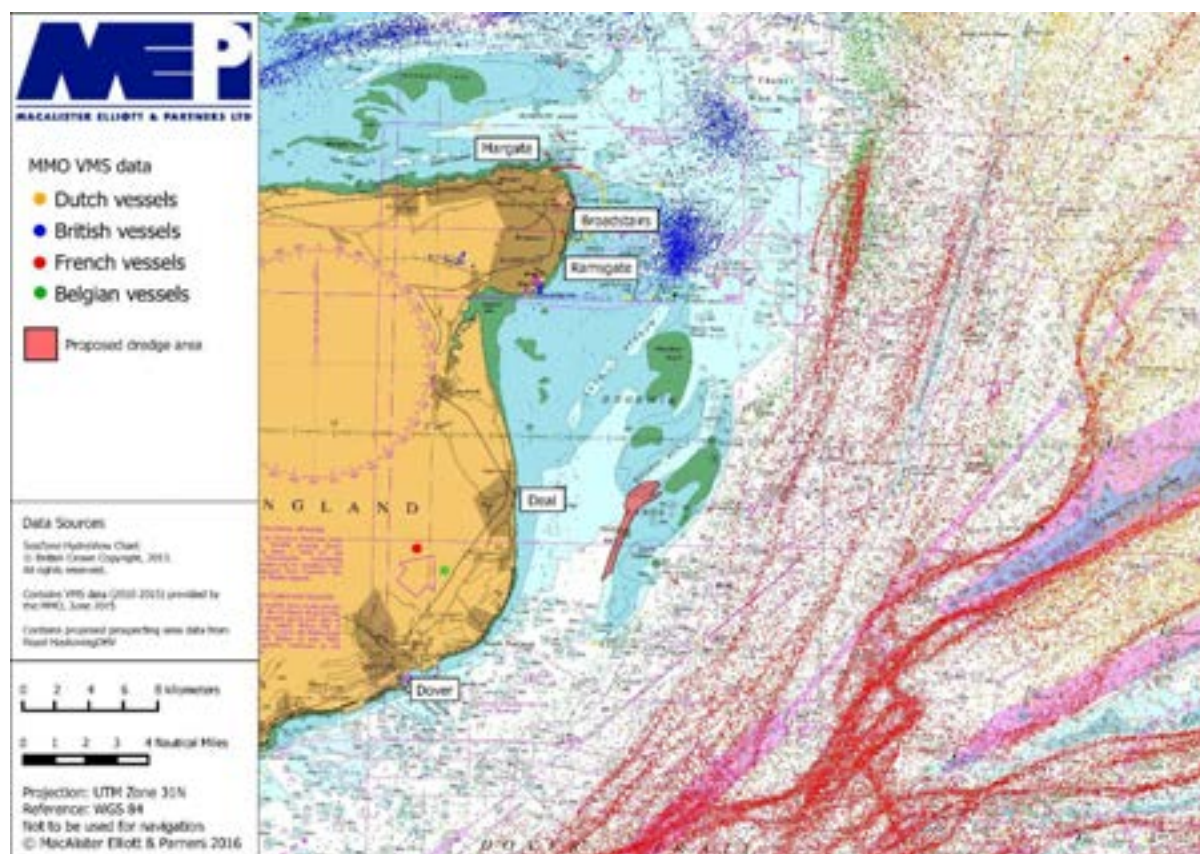


Figure 7: Results of VMS data for years 2010 to 2015 in ICES Rectangle 31F1 and the study area (data source: MMO).

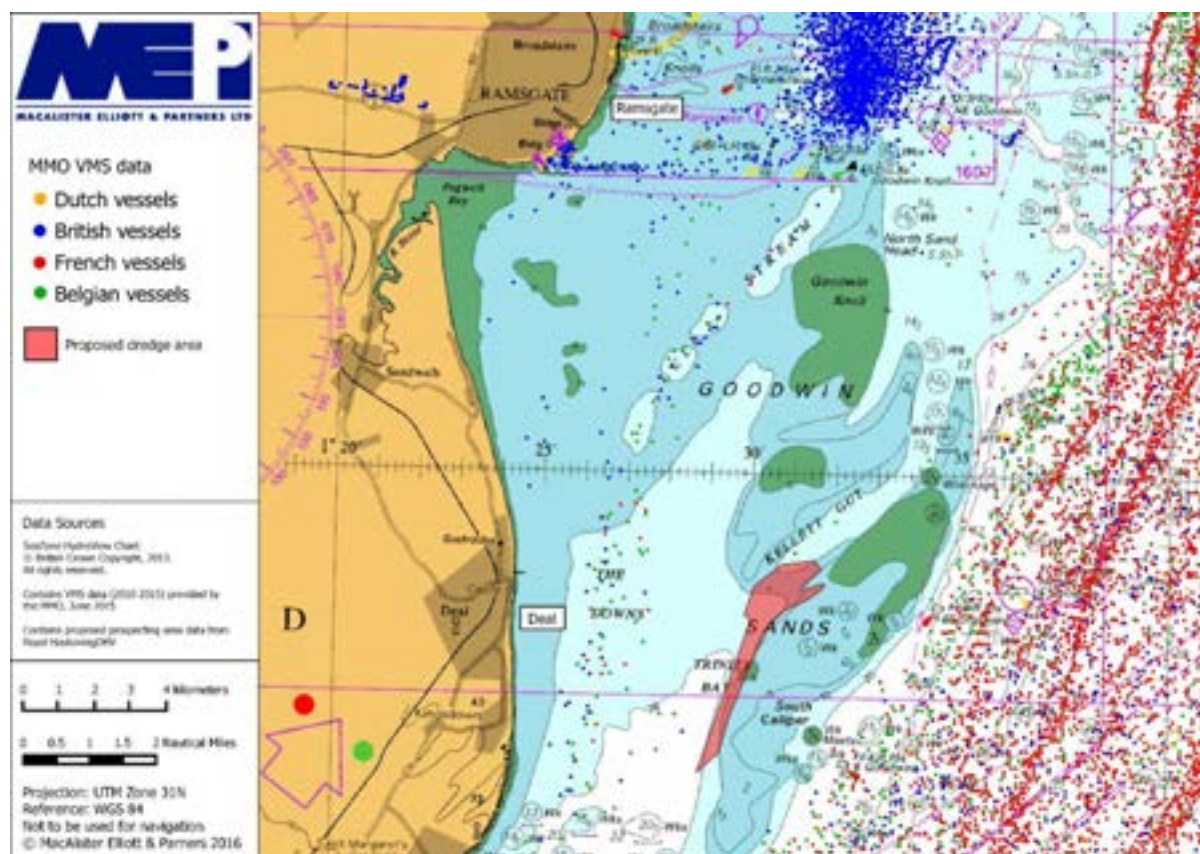


Figure 8: Results of VMS data for years 2010 to 2015 in ICES Rectangle 31F1 zoomed to the Goodwin Sands area and planned exploration area (data source: MMO).

In summary, Figures 5 to 8 show very low levels of fishing effort on the Goodwin Sands, and higher levels of fishing effort to the east of Ramsgate, over the Thanet wind farm area, in the outer Thames Estuary and east of the 6nm limit.

Observed fishing activity directly within the proposed dredge area is limited to one Belgian vessel. VMS data suggest that vessels over 15m do not regularly frequent the area (Figures 7 and 8). Surveillance data suggest that smaller vessels, such as the under 10m potters and netters, do not fish in the proposed dredge area as Figure 6 does not show data here. The activity of these vessels appears to be concentrated to the west of the proposed dredge area, on The Downs.

In many areas of the UK, local fishing grounds are frequented by vessels that enter local fishing grounds in conjunction with periods of time when fished resources are either seasonally abundant, or access to areas of high abundance is permitted. These vessels are called 'nomadic' vessels.

In addition to UK registered nomadic vessels, fishing grounds may be visited by non-UK registered fishing vessels from European Union member-flagged vessels. In general there are regulations restricting access to waters between 0nm-6nm of the UK coastline, which prevents the majority of larger and non-UK vessels from accessing nearshore waters. There are exceptions to the provisions that permit certain vessels access through 'historic access rights' or 'grandfather rights'. Figure 7 and 8 show high levels of foreign vessel activity to the

east of the Goodwin Sands. Foreign vessels fishing within the 6nm limit are likely to be fishing under these grandfather rights.

3.1.1.2 AIS Data

The results presented in this section represent fishing vessel Automatic Identification System (AIS) data covering a month-long period identifying vessels present in the area from the 2nd June 2015 to 1st of July 2015 and 90 days of track records either side of these dates, covering a window of 210 days. This presents an up-to-date 'snapshot' of fishing vessel movements in the area. However, AIS is only required on vessels of over 15m in length, so the under 15m fleet will not always be detected on the AIS viewer platform.

Figure 9 below displays the 90-day tracks of all fishing vessels (UK and foreign) identified in the study area, identified over the month-long sampling period (data are included in Appendix 4).



Figure 9: AIS data plotted on Google Earth displaying the 90-day tracks of all fishing vessels identified in the study area from the 2nd June 2015 to the 1st July 2015. Source: ExactEarth AIS data. Red circles represented the start/end of a fishing track. Fishing tracks are orange.

Over the period of sampling, fishing vessels over 15m in length have not travelled or fished over the proposed dredge area. Intense fishing effort appears to be concentrated to the northeast of Ramsgate, north of Whitstable and along the 6-12nm limit in the Channel.

In addition to the collection of 90-day tracks, information about fishing vessels was also collected, such as size, flag, status (i.e. 'fishing' or 'under way using engine') and speed.

Of the 25 different vessels identified in the sampling period, 13 were UK flagged, 7 were French and 5 were Belgian.

All French and Belgian flagged vessels recorded were between 21 and 24 m in length. Belgian vessels were always recorded as ‘fishing’ and the long term (90 day) track data show that this was sometimes within 6nm of the UK coastline, suggesting that this particular vessel has historic, or ‘grandfather’ fishing rights (i.e. registered before 1995).

UK vessels were between 10 and 22m in length but most vessels were 10m in length. UK vessels tended to fish east of Ramsgate harbour or north of Whitstable harbour. A few vessels were identified as fishing within the Thanet and Kentish Flats offshore wind farm areas.

Therefore the single point sightings of fishing vessels (of all size ranges) recorded over a month, did not show vessels utilising the area proposed for extraction.

3.1.1.3 MMO fishing effort data

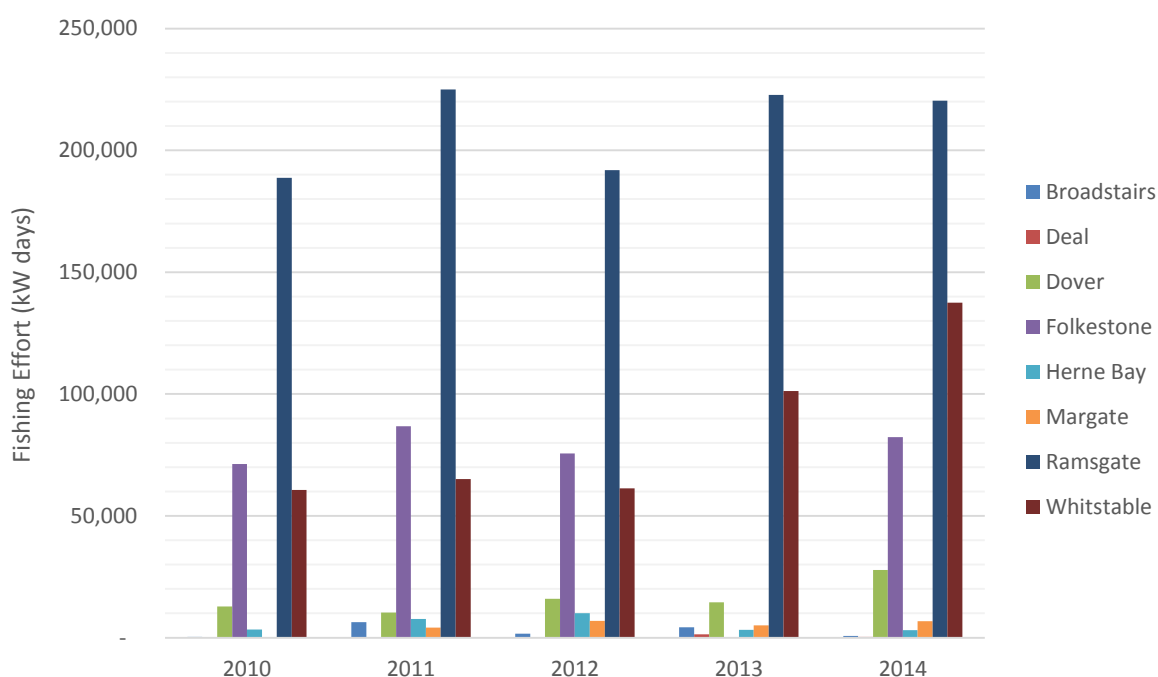


Figure 10: Total fishing effort (in kW days) for fishing vessels landing catches from ICES Rectangle 31F1 into proximal ports to the Goodwin Sands, from 2010-2014. Source: MMO.

Figure 10 shows that the vessels landing catches to Ramsgate have the greatest fishing effort of the ports proximal to the Goodwin Sands, totalling between ~188,000 – 225,000 kW days per year. Vessels landing catches in Whitstable and Folkestone also show high fishing effort (~60,000 – 130,000 kW days per year). The other landing ports in the area (such as Deal).

Fishing effort data (in total minutes) provided by the MMO has also been mapped onto the study area for the years 2011-2013 (Figures 11-13). In this time period, there has been no fishing effort, recorded by the MMO, over the proposed prospecting site. In 2012, some, low levels of fishing effort are recorded on the western Goodwin Sands area. The patchy data is also indicative of low fishing effort.

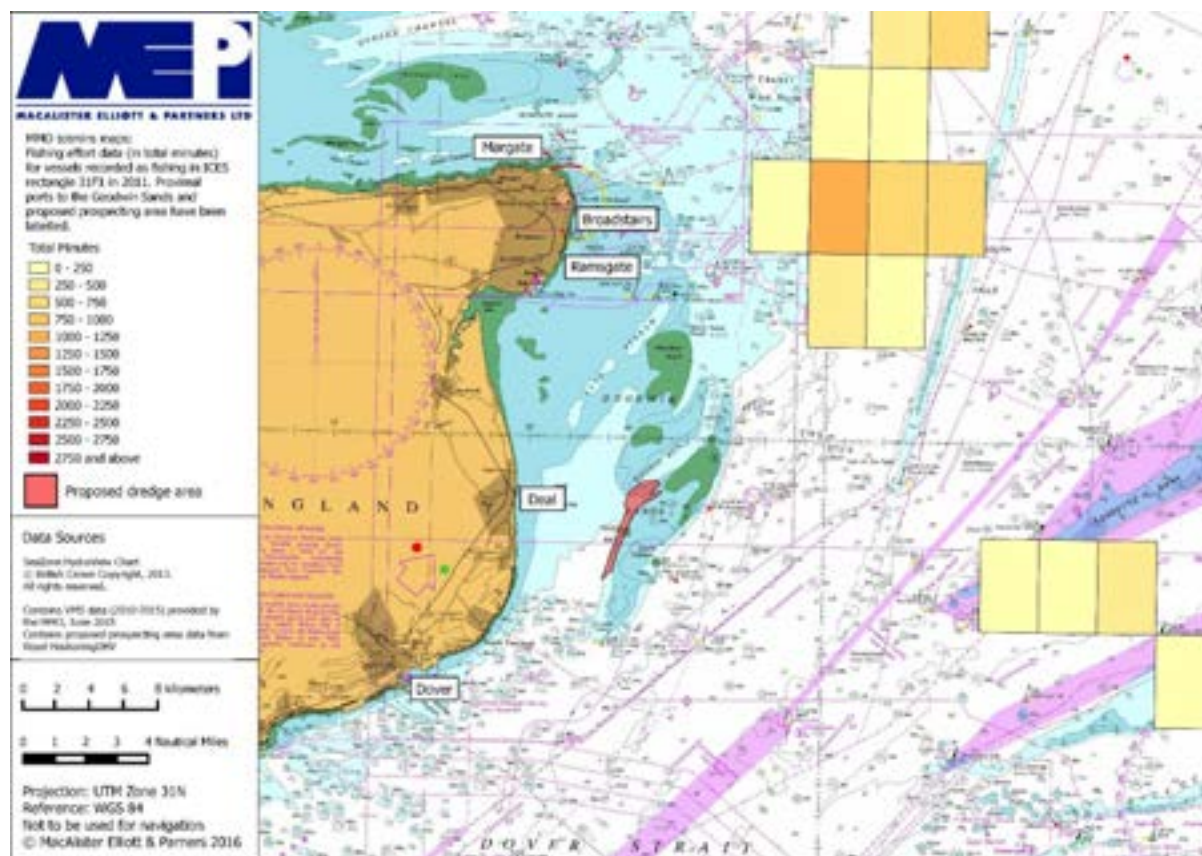


Figure 11: Fishing effort data (in total minutes) for vessels recorded as fishing in ICES rectangle 31F1 in 2011. Source: MMO.

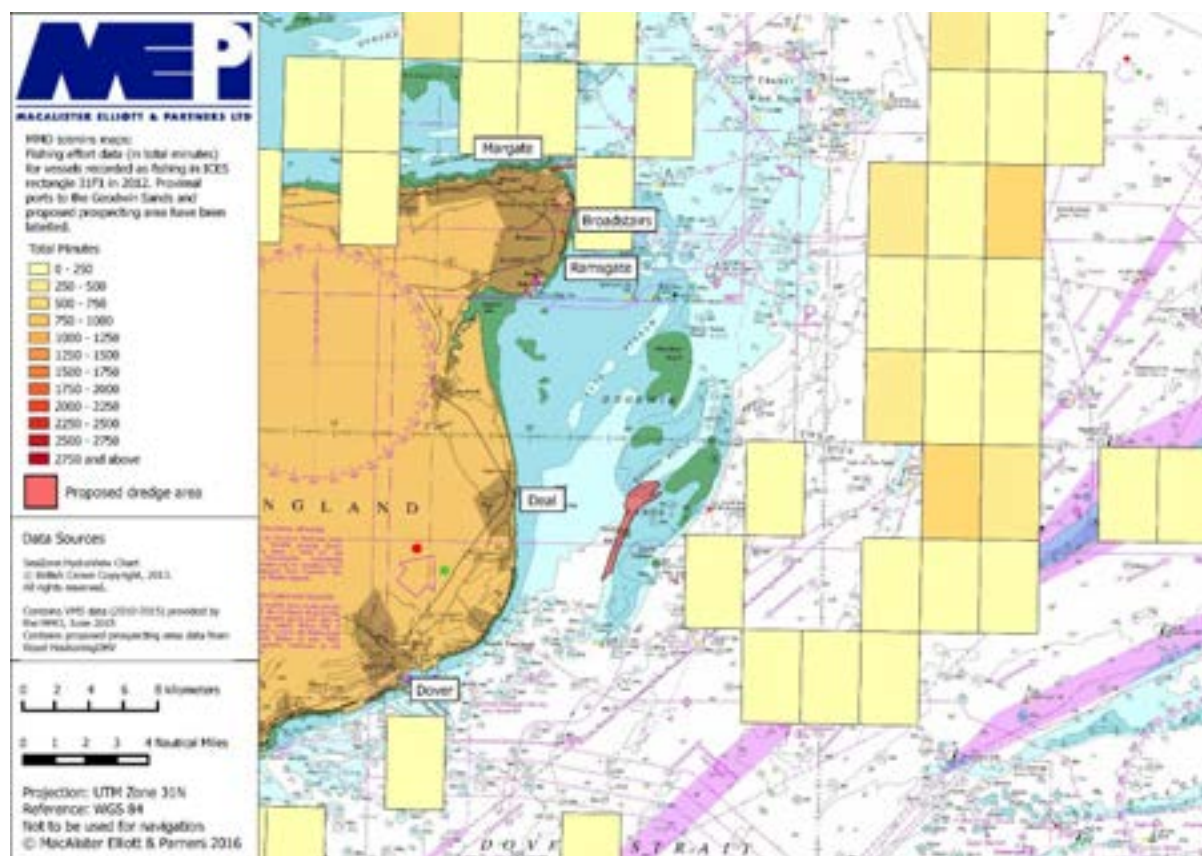


Figure 12: Fishing effort data (in total minutes) for vessels recorded as fishing in ICES rectangle 31F1 in 2012. Source: MMO.

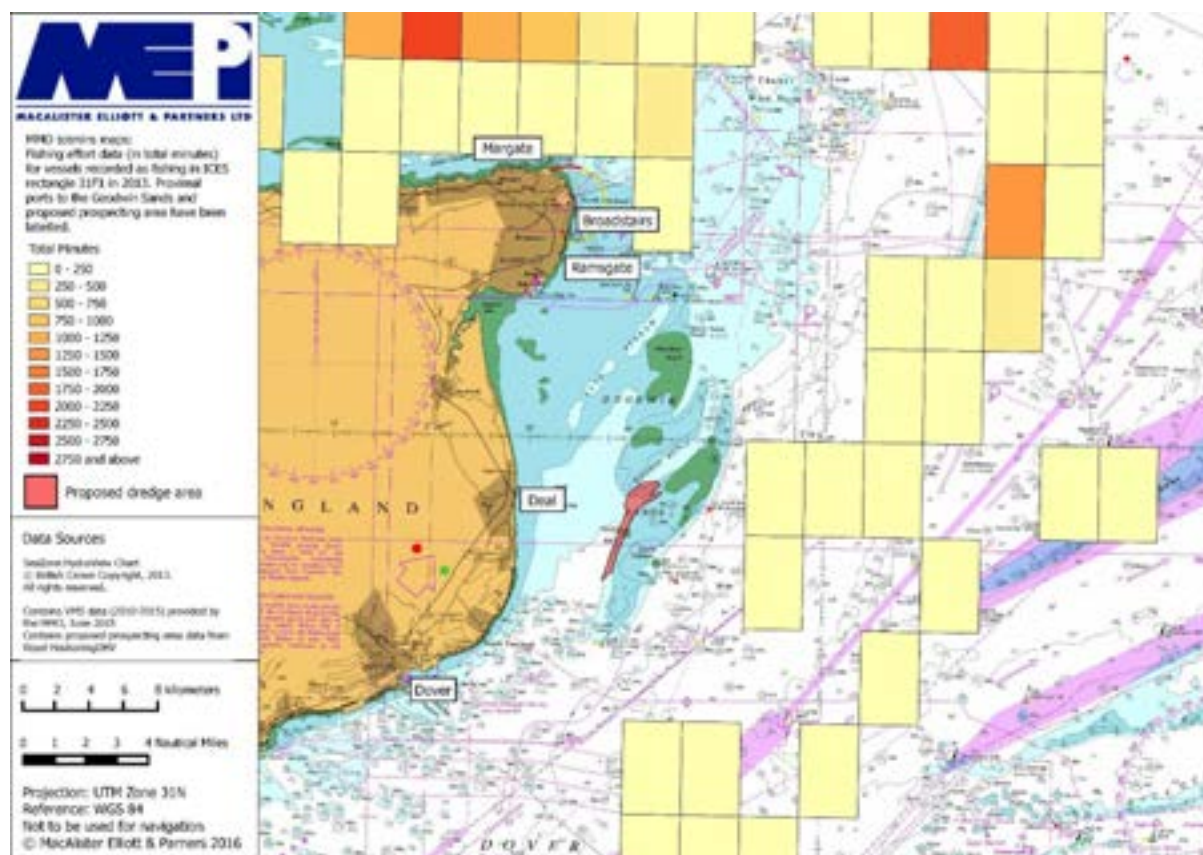


Figure 13: Fishing effort data (in total minutes) for vessels recorded as fishing in ICES rectangle 31F1 in 2013. Source: MMO.

3.1.1.4 Defra data

In a partnership between Defra, Natural England and the Joint Nature Conservation Committee (JNCC), four Regional MCZ Organisations were created to provide advice during the designation of various UK MCZs. As part of the final recommendations process, the south-east Balanced Seas regional MCZ project undertook stakeholder activity mapping to characterise commercial fishing activity in the area. The results, from 280 interviews with the commercial fishing sector showed that relative fishing activity was at low levels over the Goodwin Sands area, with areas of medium activity near Ramsgate harbour, in the Thames Estuary and the North Foreland area, and areas of high relative activity south of Folkestone and north of Margate⁷ (Figure 14).

⁷ 2010 Balanced Seas MCZ Project Stakeholder Interview Data, Recreation Whole Project Interviews and Home Port: http://portal.oceannet.org/search/full/catalogue/dassh.ac.uk__MEDIN_2.3__0039c5b06b74e8d1dcc5cb15dfe4cbb1.xml [Accessed 04.08.2015].

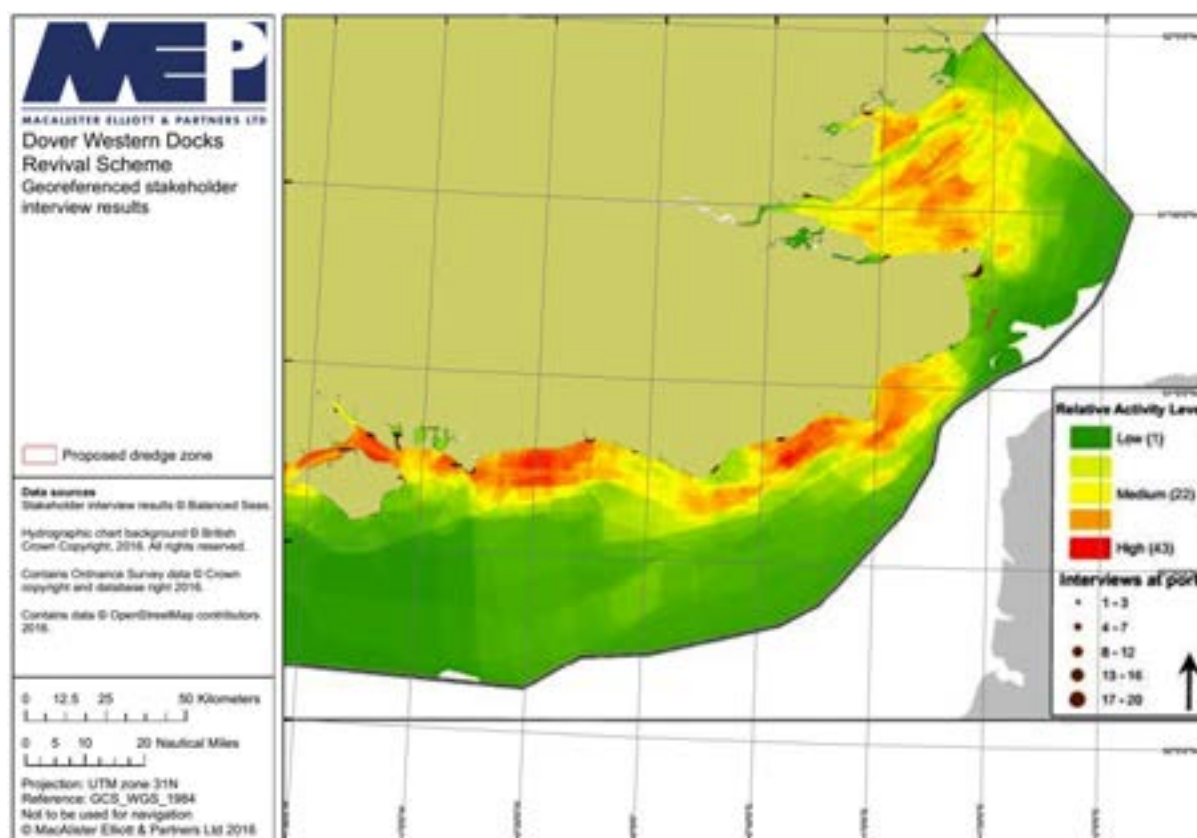


Figure 14: Relative commercial fishing activity levels in the study area and wider region. Map shows results from individual stakeholder interviews conducted in 2010, combined and overlaid onto a 500m grid. Source: Jules Martin.

3.1.1.5 Kent and Essex IFCA inshore patrol vessel sightings data

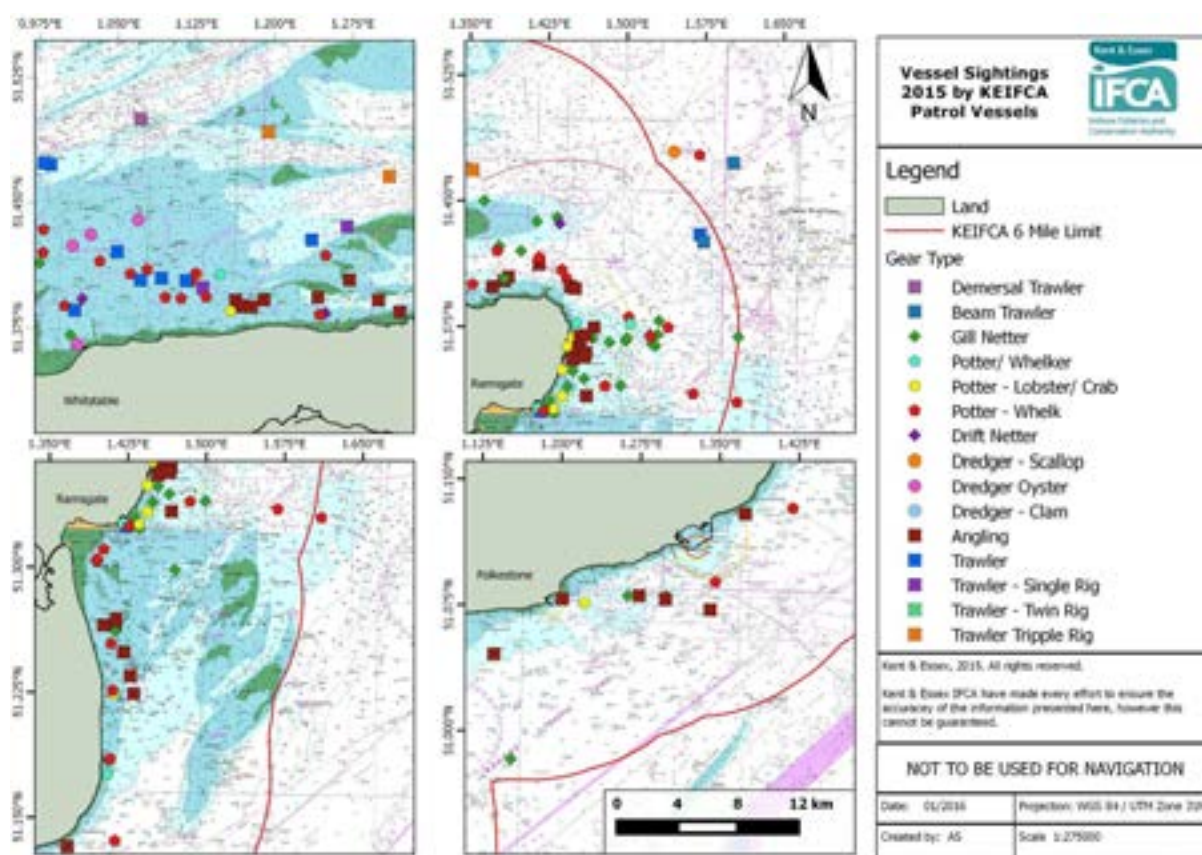


Figure 15: KEIFCA inshore patrol fishing vessel sightings data 2015. Source: KEIFCA.

The Kent and Essex IFCA regularly patrol the inshore waters of their district, enforcing fisheries law and monitoring fishing activity. Figure 15 shows the latest sightings of fishing vessels within the 6nm limit. Apart from consultation and MMO aerial sightings data, this dataset is another method of estimating the activity of the 10m and under fleet that do not carry AIS or VMS. Most activity appears to be concentrated out of Margate, Ramsgate and in the Thames Estuary. No vessels were sighted over the Goodwin Sands in the 119 patrols that took place in 2015.

3.1.1.6 Consultations

Figure 16 below is a composite image that is created by layering reported fishing grounds over a baseline map. The colours on the map of consultation responses change from yellow to brown to indicate increasing overlaps between reported fishing areas. The majority of responses from consultation were from vessels 10m and under in length so this dataset is representative of this vessel class.

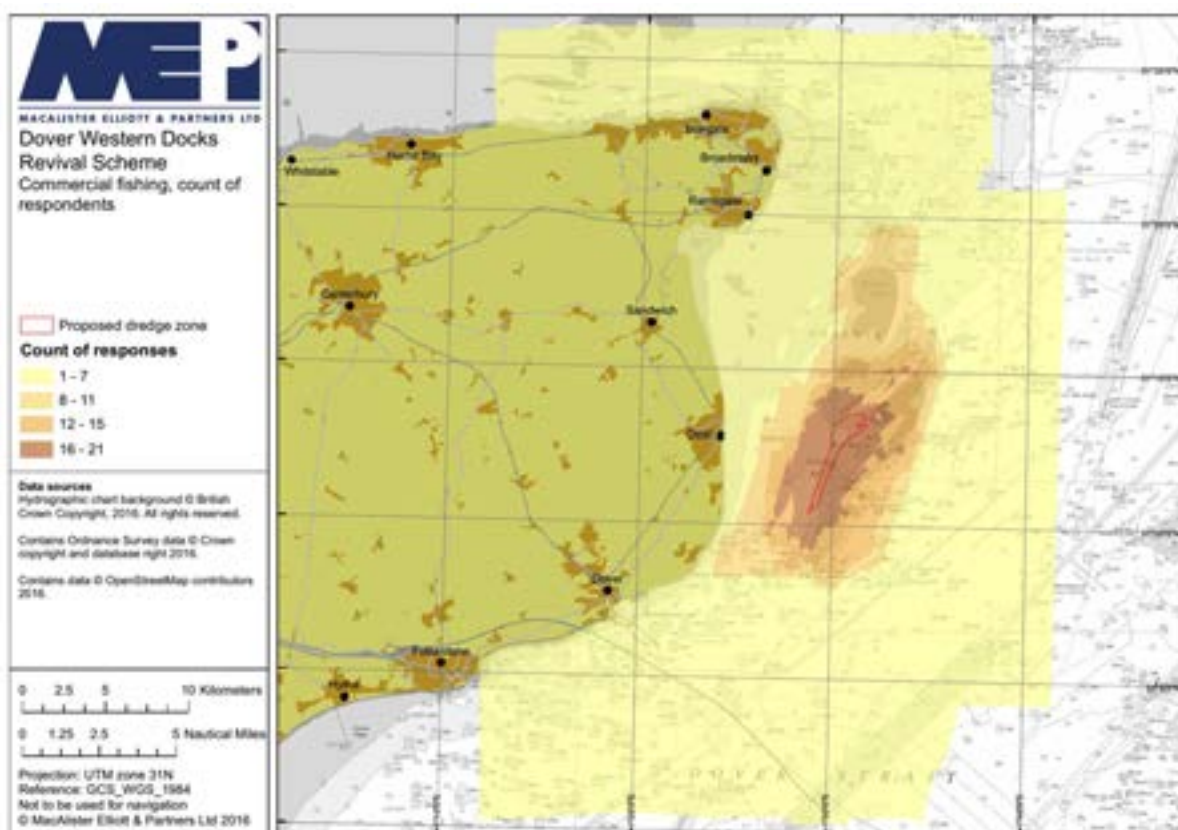


Figure 16: Heat map of overlapping fishing grounds (polygons obtained from digitised images of fishing grounds provided by interviewed vessel owners). Source: KEIFCA.

Figure 16 suggests that there is a significant concentration of activity over and in close proximity to the dredge site. There is a risk that vessel owners would seek to emphasise the relative importance of grounds in and immediately around the dredge site, this being an artefact of fishers being shown the approximate dredge zone prior to MEP consultation (Section 2.3.4 for explanation). Figure 15 (KEIFCA vessel sightings data) did not verify this reported level of inshore fishing activity. Figure 17 below maps the extent of fishing activity by port.

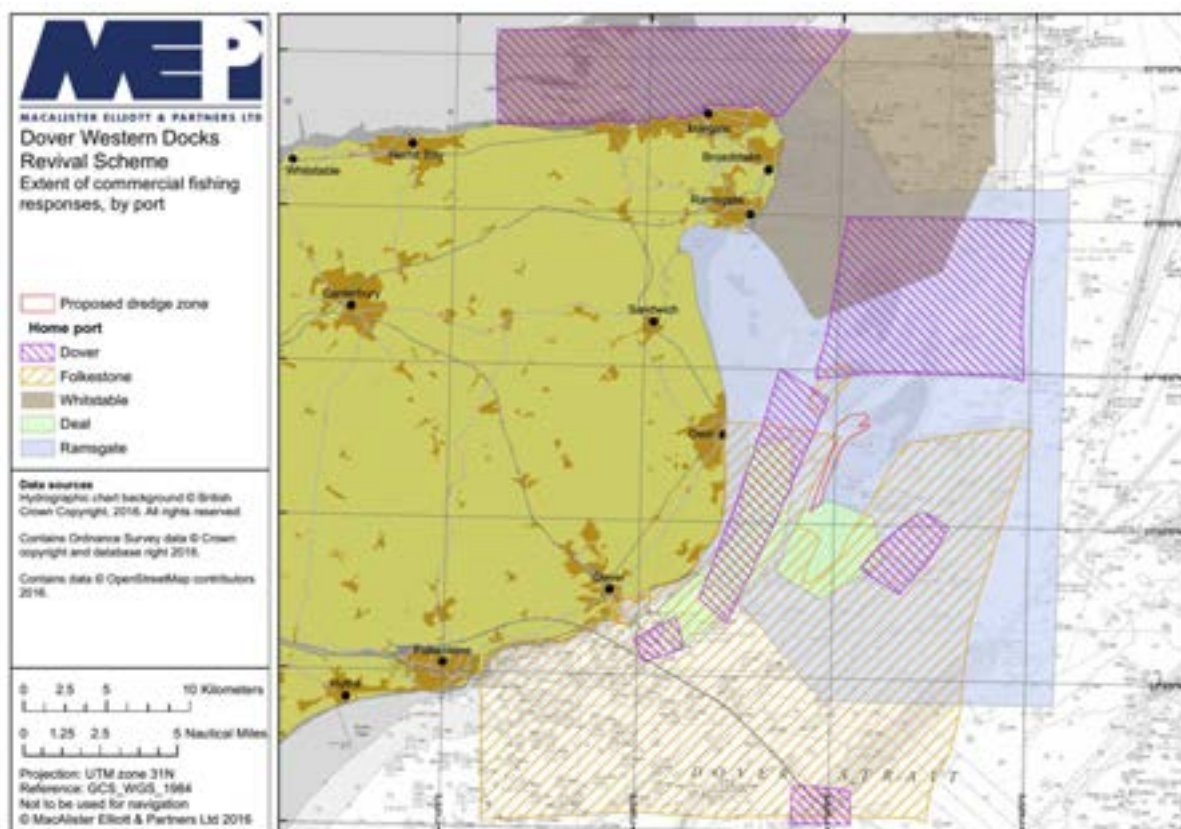


Figure 17: Extent of fishing grounds by port (polygons obtained from digitised images of fishing grounds provided by interviewed vessel owners).

Ramsgate, Deal and Folkestone fishers reported to fish within the area of dredge site. Other ports, such as Dover may utilise the area but this may not have been captured in the maps presented here, which only present the extent of grounds fished by interviewed people. Dover vessels were the most wide-ranging, followed by Ramsgate and Folkestone. Whitstable vessels have reported to have fishing grounds north of the dredge site (as expected due to their reliance on estuary-based fisheries).

Figure 16 represents the focus of suggested fishing activity, which can be used as a proxy for value, however further steps were taken to analyse the relative value of fishing grounds in the study area. Estimating the relative value of grounds fished can be achieved by assigning reported value of a fishing business to the demarcated fishing grounds associated with that fishing business. Figure 17 below (see Section 2.3.4) provides a high level estimate of value by area within the study area. What the map does not indicate is relative importance by individual vessel or fishing business, i.e. an area of yellow is as important as an area of brown to an individual fishing business. However, the method does provide an indication of the cumulative importance to the local fishing fleet of particular fishing grounds.

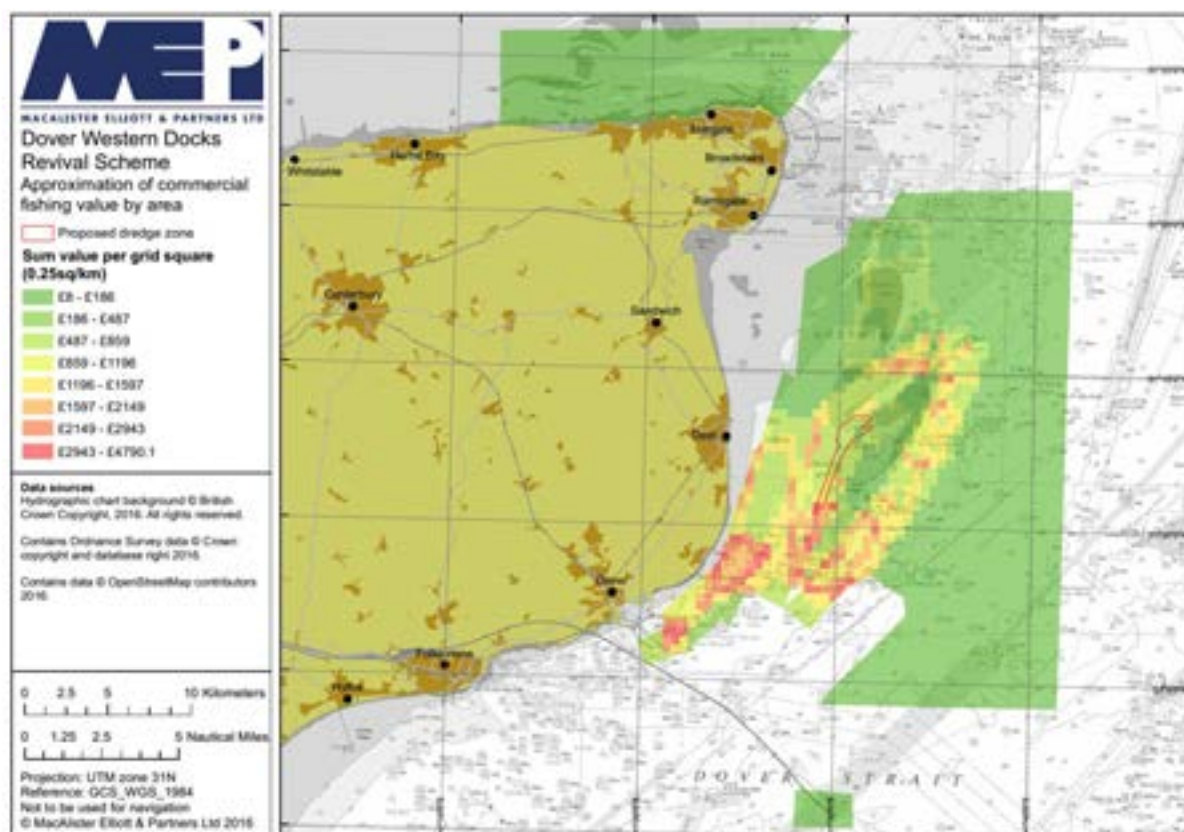


Figure 18: estimate of value obtained from fishing grounds in the study area

Whilst there have been obvious assumptions made here (only 9 commercial fishermen provided turnover values), some rough areas of value can be obtained. The areas of highest value appear close inshore off the South Foreland coast between Dover and Deal and around the edges of the Goodwin Sands, also particularly at the southern tip of the Sands. The southern tip of the dredge area appears to overlap with areas of fishing grounds of high value. Looking at fishing grounds in terms of gear and species (Figure 29, page 36, Figure 33, page 39 and Figure 25, page 40) and the species that generate the most earnings for local fishers (Figure 37, page 42), we can estimate that these valuable fishing grounds may be for potters targeting whelk, and to a lesser extent for potters targeting lobster and crab, and liners and netters targeting bass and cod.

3.1.1.7 Commercial fishing effort summary

The data indicate that for the larger commercial fleets (>10m in length) there are low levels of commercial fishing activity on the proposed dredge area and surrounding Goodwin Sands. High levels of fishing activity in general are seen out of Ramsgate and to the west of this region, in the Thames Estuary, along the 6nm limit and out of Dover and Folkestone. The activity of these vessels can be easily monitored and analysed through VMS, AIS and aerial surveillance data so there is good confidence in the trends these data show.

For the small, inshore fleets that are generally 10 m and under in length, the majority of the datasets suggest there to be low levels of fishing activity over the proposed dredge area.

The only evidence of high fishing effort over this area is that of the latest consultation, which suggests it is used by a large number of fishers (Figure 16). However, the latest mapped consultation responses must be interpreted with great caution due to many interviewed fishers having been shown the approximate dredge area prior to and during interview.

This consultation dataset was subsequently cross-checked with those also representing the activity of the small inshore fleet and in contrast, low activity levels are strongly suggested by previous consultations (Figure 14), no sightings of vessels in the area for the last year (Figure 15) and the fact that the area is of relatively low value (which can also suggest low usage) (Figure 18).

The activity of inshore fleets is notoriously difficult to estimate as they do not carry AIS or VMS, so reliance is placed on the results from all available datasets.

The majority of evidence suggests that there are low levels of commercial fishing activity over the dredge area but potential disruption to some activity of the 10m and under inshore fleet cannot be completely ruled out.

3.1.2 Fleet characteristics

This section presents fleet profile data obtained from the MMO and KEIFCA which will be used to estimate the capacity and size of the registered and licensed commercial fishing fleets utilising the local area. These data are supplemented by fleet characteristics from consultations. A detailed analysis of gear type use is also presented.

3.1.2.1 Harbours

Seven (7) harbours are registered by the MMO as 'home ports' (Figure 26 e), although we also include Deal in this section here due to its proximity to the Sands. Other vessels may travel from other harbours occasionally, but interviews suggest that the principle vessels with a significant dependency on fishing grounds within or adjacent to the dredge site (based on frequency of fishing trips into the study area) have been captured in the consultation process.

Ramsgate is the most significant fishing harbour in the study area, having the largest fleet of drift netting boats on the Kent and Essex coast (Figure 19). It has the most appropriate fishery quayside facilities, including large mooring and landings areas, fuel services (TFA) and gear storage (TFA). Vessels are greatly affected by the weather, with few boats being able to fish regularly in certain periods of poor weather¹⁰.



Figure 19: Fishing boats moored in Ramsgate Harbour (source: www.captainsvoyage-forum.com)

During winter, the main fishing is for cod and whiting and for scallops from Rye when the fishing is poor on local grounds. Gill and trammel nets are set close inshore by several boats during the winter for cod and whiting. In spring, most of the full-time static gear boats and many part-time boats turn to sole, using trammel nets and also gill nets which are both fixed and drifted, and landing rays using 220 mm nets until late autumn. During the summer, bass are caught in drift nets, cod nets are used over wrecks, and pots are set off this rocky coast for lobsters, crabs and whelks. Some vessels have also used nets for cuttlefish during the warmer months, though there has recently been less activity in this fishery. There are

several specialist charter and private angling vessels that fish wrecks and banks principally for cod and bass⁸.

Broadstairs is a very small drying harbour, with just 1 vessel currently registered to it. Vessels focus on netting but have come to use a combination of fishing methods due to fishing pressures. Vessels use pots from spring onwards to take lobsters and brown crabs. The lobster season usually ends around November. Several vessels moved from here to work full time at Ramsgate (which is also the case at Margate), and only small landings are now made at Broadstairs throughout the year. A few trailed angling and semi-commercial rod and line boats may launch at Broadstairs during the summer⁸.



Figure 20: Broadstairs harbour (source: www.thanet.go.uk)

Deal has no harbour and vessels land their catch on the exposed landing site shingle beach and are hauled ashore using static winches. Vessels use nets and pots from spring to autumn. Gill and trammel nets take cod and whiting in autumn and winter and mackerel in spring. Between spring and autumn, tangle and trammel nets are used for sole, plaice, ray, dogfish and, to a lesser extent, turbot and brill, often on Goodwin Sands. Bass are caught in drift nets and provide the main earnings in summer. Pots are set for brown crabs, lobsters and whelks between Walmer and Dover and fishing effort peaks in summer. Some fishers move to other ports when fishing off this coast is poor, and charter angling trips are becoming a popular alternative to commercial fisheries⁸.



Figure 21: Deal harbour (source: MEP)

Dover Port's main function however is as Europe's busiest ferry port, both for passengers and trade, the port is not a major fishing harbour, with 7 vessels currently registered to it. Nearshore chalk reefs provide good potting grounds for both brown crabs and lobsters and bass and flatfish are caught in drift and fixed nets during the warmer months. Fishing vessels have used Dover as a midway point this quarter due to poor weather conditions. A number of fishing vessels from other ports have been sighted at Dover undergoing maintenance work over the winter season⁸.



Figure 22: Dover port (source: www.a2btravelextras.com)

Folkestone is a small fishing harbour with 10 registered vessels. Vessels are mainly trawlers (cod, sole) but there are also whelk potters and scallop dredgers.



Figure 23: Folkestone harbour (source: MEP)

Margate is a small drying harbour which is base to 3 registered vessels, 1 of which is active¹⁰. For most of the period between April and late November, vessels set trammel nets from the low water mark out to as far as 15–20 miles offshore to take sole, mixed flatfish, rays and bass. Wreck netting in summer yields the occasional good catches of cod, pollack, bass and conger eel. During the winter, gill nets are used to take cod. Herring are occasionally fished with drift nets⁸.



Figure 24: Margate harbour (source: telegraph.co.uk)

Whitstable has a sheltered drying stone harbour, which protects a very active diverse fleet of trawlers, netters, potters and dredgers. Multi-rigged otter trawls operate most of the year, targeting sole, cod and whiting, with rays and bass targeted for short periods. A few vessels regularly dredge for native oysters in autumn and winter, pair trawling takes place seasonally for bass and a few vessels dredge for cockles, mainly on the Maplin Sands off the Essex coast, and only fish local grounds during periods of bad weather. They also use various trawling methods when the cockle beds are closed. Harvesting of seed mussels has taken place in recent years. The remainder of the fleet relies on static gear, mainly whelk pots throughout the year, along with set (and drift) nets for sole, bass and mullet, and pots for lobsters and brown crabs. Several vessels move to Rye to fish for scallops during the winter when fishing on local grounds has become too poor for them to make a living. Local private

grounds may only be fished by arrangement with the owners. Shellfish processors situated around the harbour deal with cockles, lobsters, oysters and whelks⁸.



Figure 25: Whitstable harbour (source: kent.co.uk)

3.1.2.2 Fleet Profile

The full data set of over 10m and under 10m vessels is provided in Appendix 3. The fleet profile of these vessels are presented on the following page in Figures 26 a-e.

Ramsgate and Whitstable are larger ports and the majority of registered vessels are registered to these (Figure 26 e). Of these 66 vessels, 53 are UK vessels. Others are French, Dutch and Irish. The other 2 are unknown but are also likely to be UK vessels.

The majority of the local fleet are under 10m overall length (56/66 vessels) with an average overall length of 7.93m (Figure 26 a). They range up to about 15nm offshore and tend to operate one or more gear types (see Section 3.1.2.3). The seasonality in abundance of target species usually means some vessels are part-time but consultations revealed that all commercial vessel owners interviewed were full-time, fishing 12 months of the year with no other occupation. The average vessel tonnage is 7.38 GT and the average power is 77.08 Kw (Figures 26 c and d, respectively).

The age of vessels ranges from 4 – 49 years, with average of 27 years (Figure 26 b). There is ongoing reinvestment in the fleet through extensive refits, but few new boats are being purchased. Fishers are keen to use the vessels for as long as they are fit for purpose, choosing to re-fit existing vessels over the significant capital investment in a new one, despite the lost fishing time that results. An estimated replacement cost for an inshore vessel is typically around £150,000⁹.

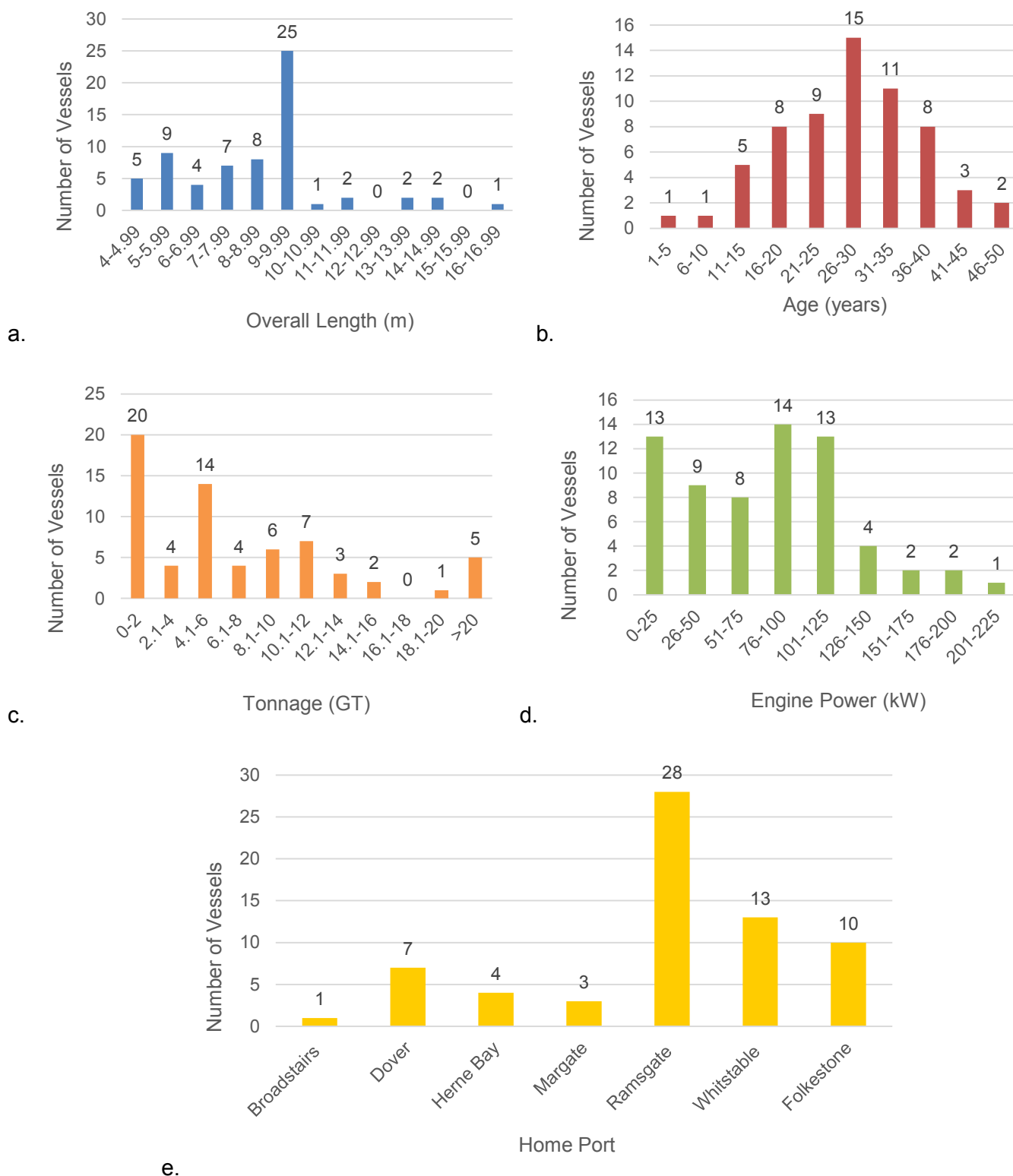


Figure 26: Profile of local commercial vessels utilising ports proximal to the Goodwin Sands as home port. Graphs show the structure of the fleet in terms of a) size, b) age, c) tonnage, d) power and e) home port.

According to the MMO statistics (up to January 2016), 67 vessels are registered to home ports of Herne Bay, Whitstable, Margate, Broadstairs, Ramsgate, Dover and Folkestone yet not all of these vessels are active. The KEIFCA recently reported¹⁰ on the number of vessels actively fishing from these harbours (Table 1). In Whitstable, more vessels appear to be active than registered but for all other harbours, fleets are not fully active.

Table 1: Number of registered vessels vs number of active vessels by fishing harbour

Harbour	Registered vessels (MMO)	Active vessels (KEIFCA)
Broadstairs, Margate, Ramsgate	32	30
Herne Bay	4	2
Dover	7	4
Folkestone and Hythe	13	13
Whitstable	13	15
Deal and Walmer	Not MMO 'home ports'	5

Of the 31 commercial fishing vessel owners interviewed, only 4 operated vessels over 10 metres in length. These were trawlers based at Ramsgate. The majority of vessels active in the study area are 10 metres and under in length (from 4.4 m to 10 m), with implications for range and seagoing capacity.

The number of crew carried approximately correlated with vessel size, e.g. single-handed vessels correlate with the smaller vessels in the local fleet. Single-handed vessels are generally restricted in terms of range and operations, partly reflecting the generally smaller size of these vessels and the nature of the local marine environment, but also due to the difficulties of operating longer trips without crew to assist with pilotage and operating fishing gear. Most owners consulted worked with 2 crew (Table 2). The number of crew also correlated with gear type diversity. Where boats were operated single-handed, only nets tended to be used. Boats with more crew usually indicated use of mixed gear, such as drift and static nets, pots and dredges.

Table 2: Number of vessels operating single-handed, with 2 crew or with 3 crew

Crew	1	2	3
Count	10	24	6

3.1.2.3 Gears in use

The majority of the local commercial fleet are small, under 10m vessels that range approximately 20-25nm from port⁹. Several factors will influence the gear type used, which include species targeted, type of seabed being worked and physical water conditions. Some fishing vessels will have a degree of flexibility when operating gear, such as netters, that may alternate between fixed/anchored nets and drift nets depending on tides. Potters may also deploy nets to increase diversity in catch⁹. This flexibility depends on conditions, target species abundance and market prices.

MMO landings data from ICES rectangle 31F1, from proximal ports to the Goodwin Sands (Whitstable, Herne Bay, Margate, Broadstairs, Ramsgate, Deal and Dover) (Section 3.1.3) indicate that important species caught in the local area are demersals such as sole, bass, cod, thornback ray and smoothound, and shellfish such as whelk, lobster and crab. Many of these fisheries show distinct seasonality (Section 3.1.3. and 3.1.4.).

Landings data (Figure 27) and aerial surveillance data (Figure 28) indicate that these species are mainly targeted by trapping and netting, operated from small, specialised vessels. Ramsgate and Whitstable are home ports to larger fishing fleets so show a greater diversity in the gear types operated, including a few trawlers (Figure 27).

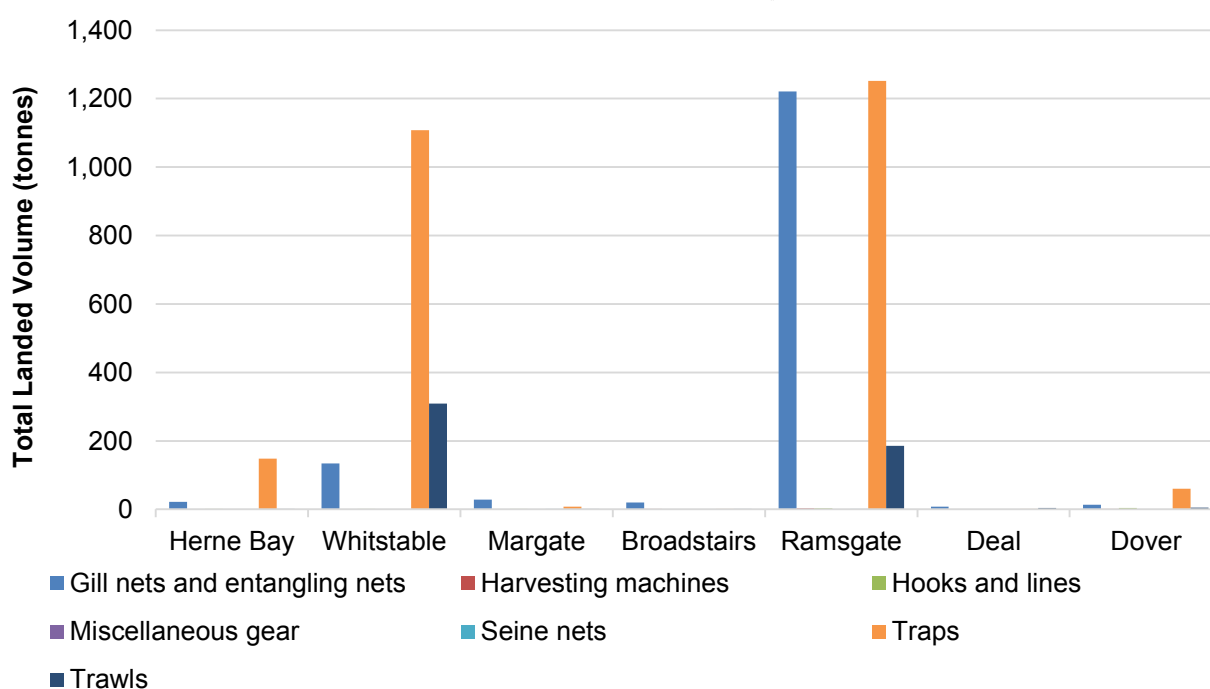


Figure 27: a-e: Total volume of catch recorded as landed by various gear types (2010-2014) to proximal ports to the Goodwin Sands¹¹.

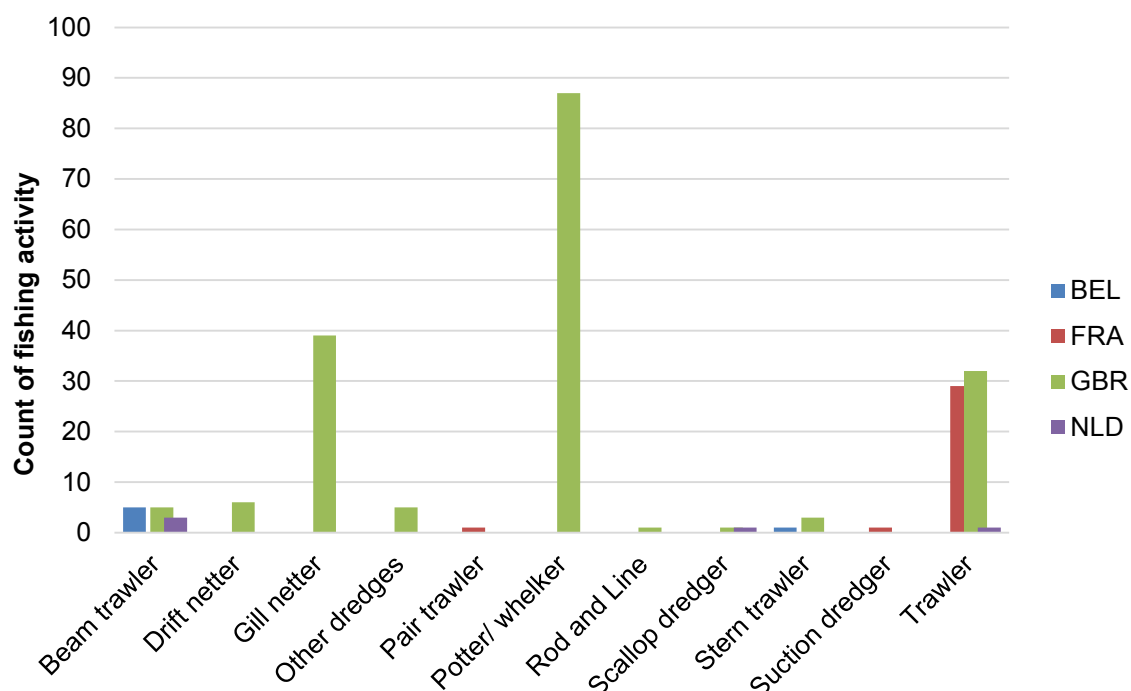


Figure 28: MMO aerial sightings data of fishing activity in ICES Rectangle 31F1 for 2012-2013, by vessel type. BEL = Belgium, FRA = France, GBR = UK, NLD = Netherlands.

During consultation, fishers were asked which gears they used. Of the 31 commercial fishers consulted, most operated nets and pots (Table 3). Reported net types were static (anchored) or drifting gillnets and trammel nets. 58% of commercial fishers reported also operated more than one type of gear, sometime up to 4 types (Table 4).

Table 3: Fishing gear deployed by those consulted

Nets	Pots	Rod and Line	Trawl	Dredge
27	13	6	5	1

Table 4: Number of gear types operated by those consulted

Number of gear types	1	2	3	4
Count	12	13	4	1

Figure 29 shows the extent of this reported fishing activity by gear type.

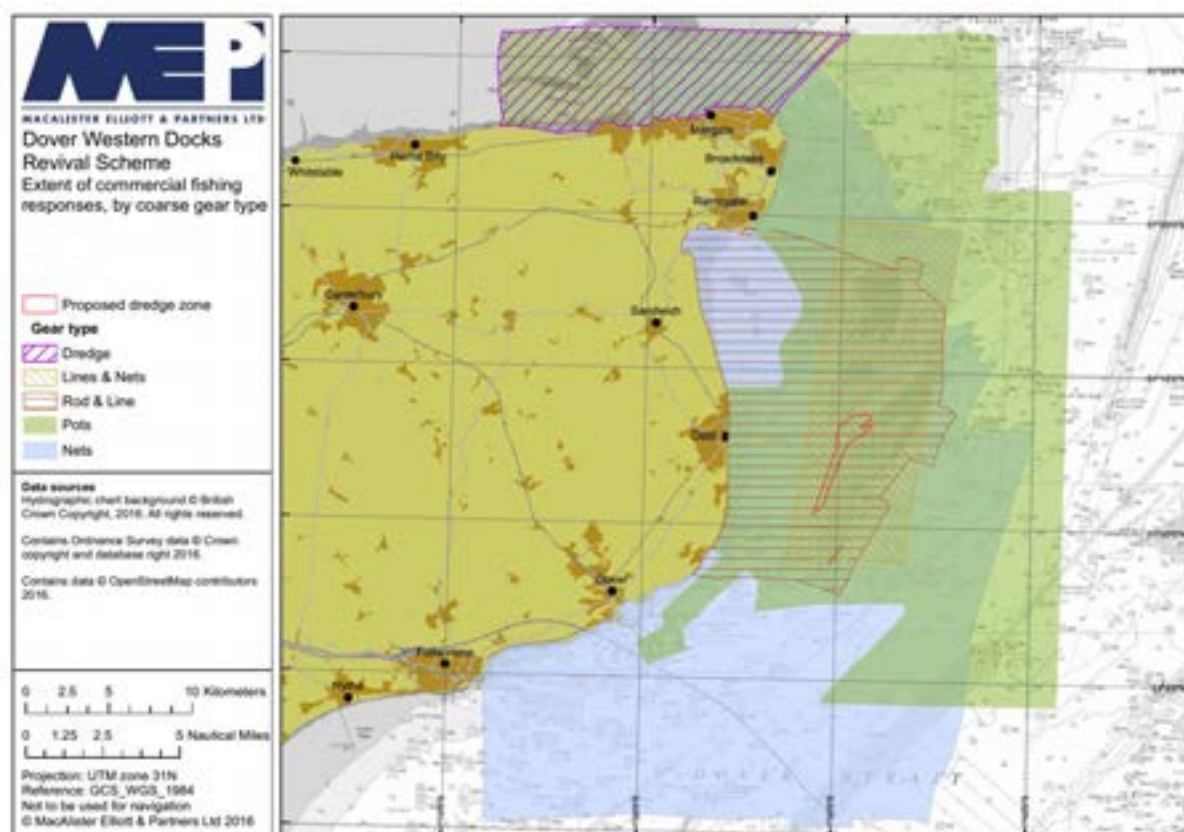


Figure 29: Extent of fishing grounds by coarse gear type (polygons obtained from digitised images of fishing grounds provided by interviewed vessel owners).

All gear types reported (apart from oyster dredges) utilise the dredge area but fishing grounds are generally wide-ranging. Lines and nets, and rod and lines appear to have the greatest concentration of activity over the dredge area. Grounds for potting and netting are clearly diverse and tend to relate to the habitat of the target species. During consultation, trawling activity was only reported in 4 cases, so this activity has not been mapped separately. Levels of potting, netting and trawling activity are low in comparison to the wider region however¹³. (Figures 30, 31 and 32).

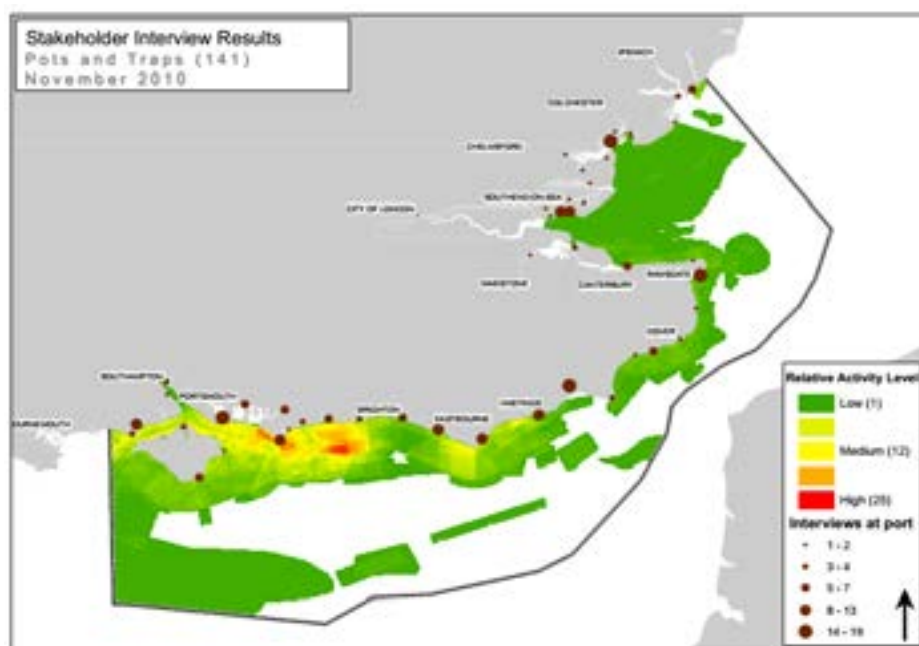


Figure 30: Commercial pot and trap fishing activity levels in the study area and wider region. Map shows results from individual interviews conducted in 2010, combined and overlaid onto a 500m grid. Source: Jules Martin.

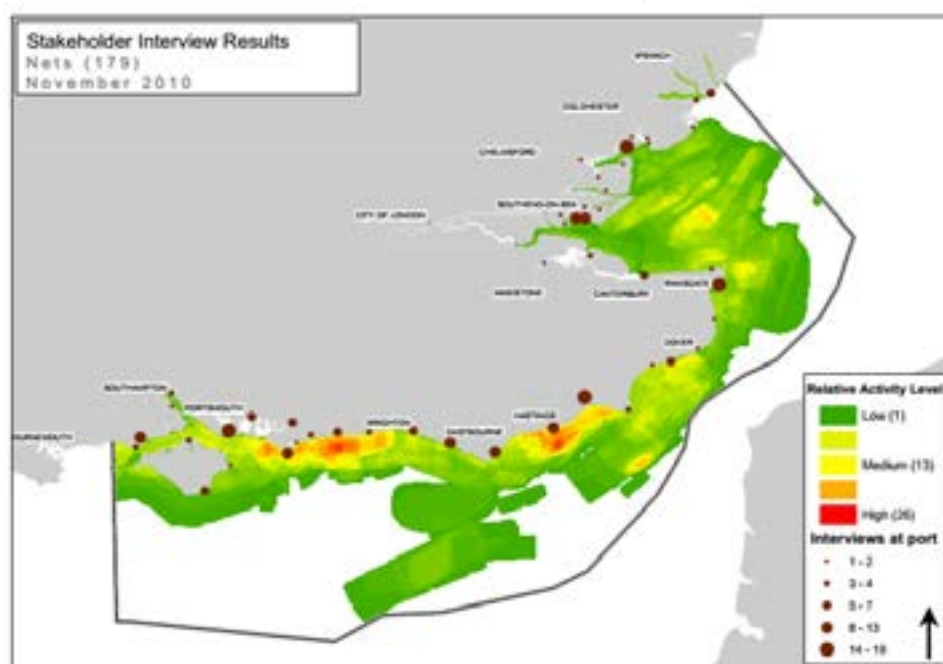


Figure 31: Commercial net fishing activity levels in the study area and wider region. Map shows results from individual interviews conducted in 2010, combined and overlaid onto a 500m grid. Source: Jules Martin.

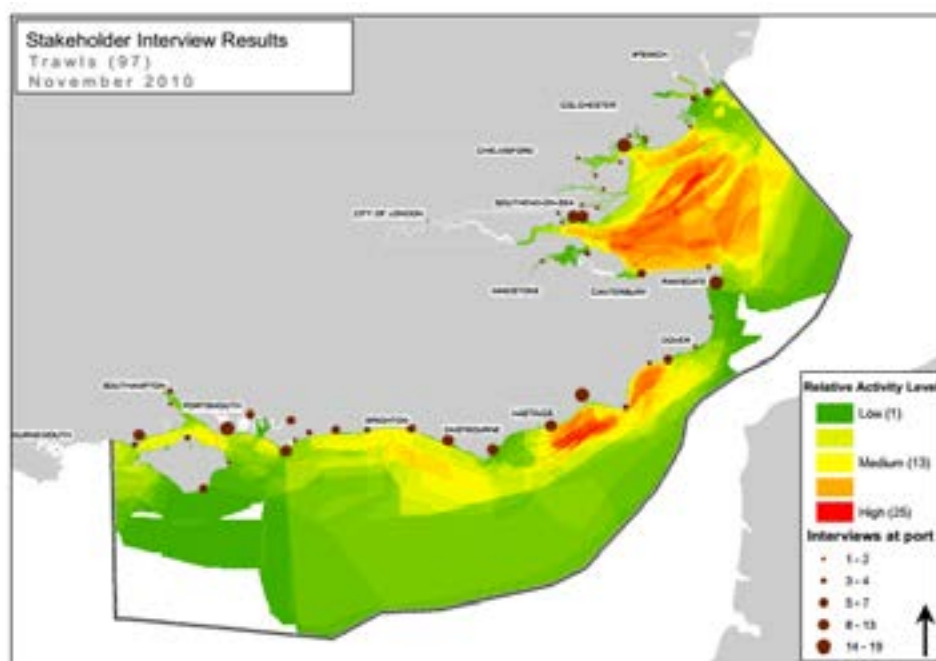


Figure 32: Commercial trawl fishing activity levels in the study area and wider region. Map shows results from individual interviews conducted in 2010, combined and overlaid onto a 500m grid. Source: Jules Martin.

Reports of the KEIFCA¹⁰ and consultations revealed that commercial fisheries in the area have now moved towards targeting a mixed catch whereas previously, vessels would have been more specialist single-gear vessels, targeting a specific species or species groups. Reasons for this are numerous but fishers have reported quota restrictions, stock changes, civil works and renewable energy development disturbance, and changing weather conditions to be cumulative factors causing a shift away from reliance on specific species, and a reduction in fleet activity (see Table 1).

Trapping and potting are typical fisheries operating on and around the Goodwin Sands, primarily targeting whelk, lobster and crab. Figure 33 shows the extent of fishing grounds for these species, mapped from consultations.

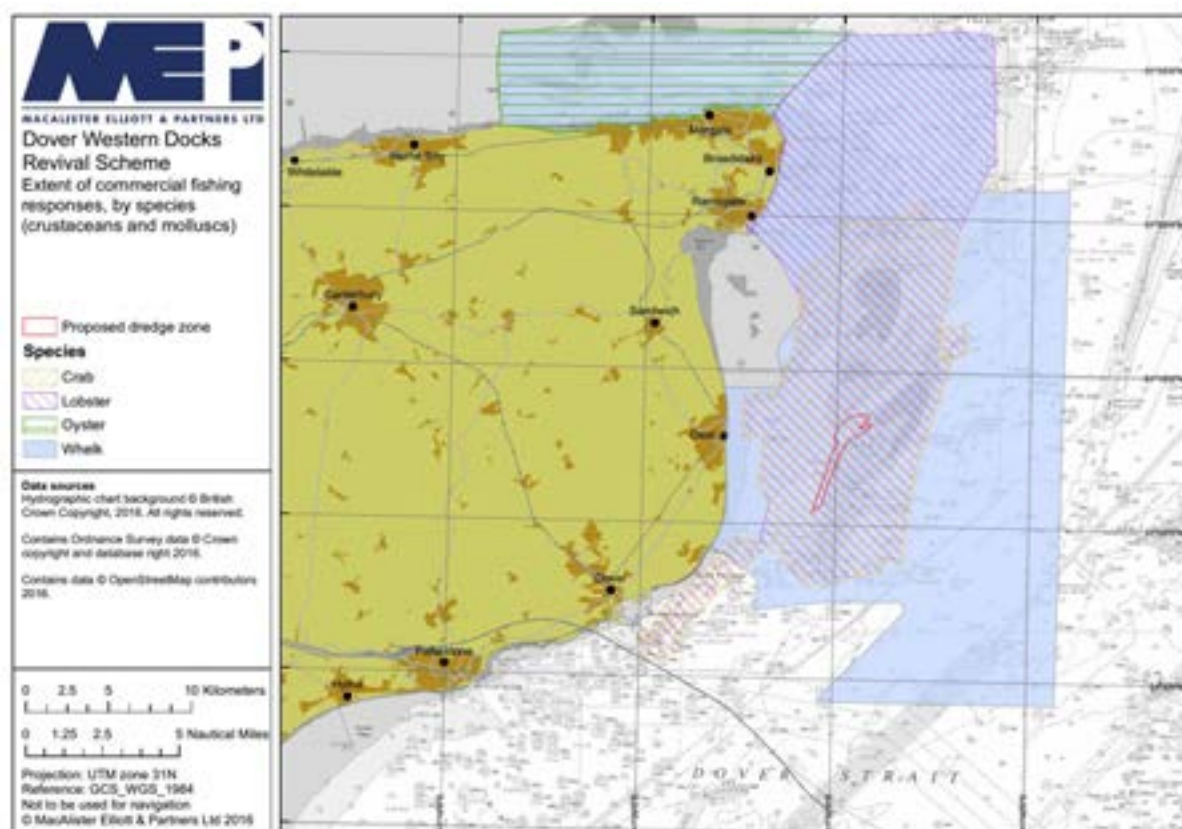


Figure 33: Extent of fishing grounds by mollusc and crustacean species (polygons obtained from digitised images of fishing grounds provided by interviewed vessel owners).

Whelk are caught all year round on diverse fishing grounds, whereas lobster and crab tend to be summer fisheries on more specific grounds that are likely to correlate with and reflect habitat preferences of crab and lobster for grounds that enable burying (crab) or refuge (lobster).

All grounds overlap with the dredge area. Pots (Figure 34) for these species are usually set in 5-35m of water, baited (usually using flounder), and strung together on a lead line of up to 20 pots. Depending on the species, the number of individuals in the pot (lobster and crab may fight) and weather conditions, pots are allowed to soak for 12 to 48 hours and then retrieved. Management and restrictions that apply to these gears in the area are listed in Section 3.1.5.



Figure 34: Whelk pots. Image: KEIFCA.

Drift netting and static gill netting have been adapted to target a variety of species since the 1970s, including bass, cod, sole and various species of elasmobranchs. As the seasonality of each species differs (cod - a winter fishery, sole - a spring/summer fishery, and thornback ray - a spring fishery), netting takes place all year round over diverse grounds, which include the Goodwin Sands. Figure 35 shows the extent of fishing grounds for these species, mapped from consultations.

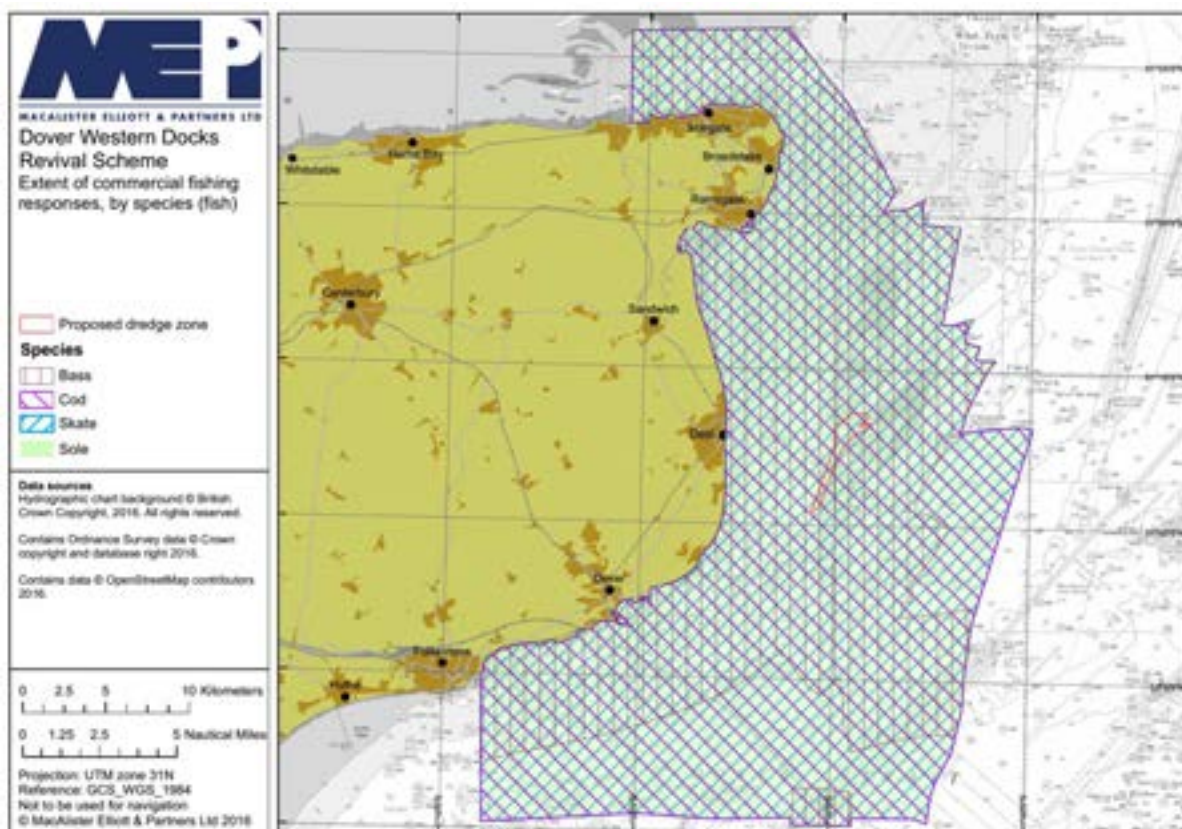


Figure 35: Extent of fishing grounds by fish species (polygons obtained from digitised images of fishing grounds provided by interviewed vessel owners).

The nets are typically 500m long, single-wall construction of 80–100mm monofilament mesh. Fishers set the gear strategically to drift with the tide and may fish either daylight or night time hours⁹ (Figure 36).



Figure 36: A typical drift net. Source: NFFO

Trawling as a fishing method in this area is not particularly pertinent due to restrictions in quota for certain species and the higher fuel costs associated with the fishing method. As such, there are only a few active trawlers based in Ramsgate and Whitstable. French, Belgian, Dutch and German fleets do also have historic rights to trawl in the eastern area of the Goodwin Sands, beyond the 6nm limit. In this area, all trawls are generally towed, the primary forms being pair trawls, beam trawls and single or multi-rig otter trawls targeting demersal species. Foreign fleets such as the Belgians, operate pulse trawling technology.

Under KEIFCA byelaws¹², within the 6nm limit, there is a maximum size restriction of 17m overall length for UK trawlers (except the few with 'Grandfather rights') and it has been reported that the UK over 10m fleet do not utilize the Sands as their main fishing area, however they use the area outside the 6nm limit as a track to fish through to link with other adjacent fishing grounds¹³.



3.1.3 Species, value and seasonality: consultations

3.1.3.1 Species and value

Markets for landed species range from local, national and export markets depending on seasonal demand, consumer preference and entrepreneurial activity. Market demand is strong in domestic (including local and national)¹⁴ markets for crab, lobster and most finfish species, whereas export markets dominate for whelk (China and Korea). Demand in continental European markets for crab, lobster and Dover sole is also strong, providing sellers with options. Entrepreneurial activity by fishers or sellers is an important driver of improved returns, for example processing crab and selling directly to the public, or establishing supplier agreements with top end restaurants to deliver high quality fresh fish.

Looking at the target species reported by commercial fishers, whelk contributed most significantly to earnings¹⁵, followed by bass, skate, crab, cod and sole (Figure 37). All fishers consulted targeted a mixed catch (at least 4 different species), fishing for most months in the year.

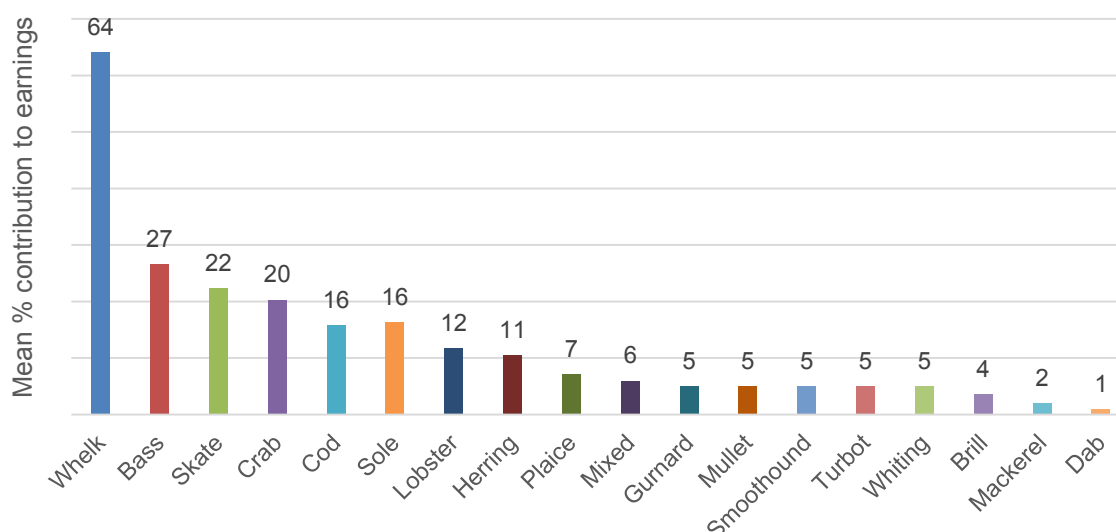


Figure 37. Reported percentage contribution of target species to annual turnover. Number of commercial fishers consulted that provided information = 23/31.

Based on reported earnings (details of which must remain confidential), an estimate of the value of annual landed catch by commercial fishing vessels interviewed was calculated.

The calculation is based on reported turnover from 7 commercial fishing vessels. These are the only cases where interviewees were willing to provide information on both a) annual turnover and b) percentage contribution of target species to annual turnover.

Value of annual catch is derived from expressing the percentage contribution of target species as a percentage of reported turnover (Table 5).

Table 5: estimate of annual value of landed catch by 7 commercial fishing vessels active in the study area.

Target species	Annual landed value of 7 vessels
Bass	£223,200
Whelk	£165,000
Sole	£135,000
Lobster	£133,500
Cod	£98,900
Crab	£44,500
Skate	£42,300
Smoothound	£6000
Pouting	£4000
Turbot	£1200
Pollack	£400
Plaice	£400
Total	£835,000

Using this method, the annual value of landed bass from the 7 vessels is estimated at about £223,200 per year (first sale value). Whelk is estimated to contribute in the region of £165,000, and sole and lobster just over £130,000 per annum. The total value of landings attributable to the 7 commercial fishing vessels is thus estimated at £835,000 per annum, taking the first point of sale value.

As details on turnover were provided by only 11 commercial fishers of 31 interviewed, it is not accurate to extrapolate to the wider fleet and it is more appropriate to look at MMO landings statistics and the Seafish fleet economic performance datasets for more accurate estimations of value.

Using the Seafish fleet economic performance dataset (2014¹⁶), the national average fishing income for fleet segments 'UK pots and traps under 10 metres', 'UK pots and traps 10-12 metres', 'UK drift and fixed nets under 10m' and 'South West beamers under 250Kw' is £54,200, £113,500, £45,900 and £564,400 per annum, respectively.

Applying these average earnings to the vessels consulted, expected turnover for those 7 vessels would be £730,044. Given the variation in vessel types in the local fleet observed that fall within the fleet segment 'UK pots and traps under 10 metres' there are in reality substantial deviations from the average, and the total reported earnings for the 7 fishing vessels in the area of interest do not appear unreasonable (Table 6).

Table 6: comparisons between reported annual earnings and Seafish reported average incomes per vessel for various types of UK vessel.

Vessel type	Reported annual income	2014 estimates average vessel	Seafish per
UK pot & trap 10-12m	£60,000	£113,500	
UK pots and traps under 10m	£30,000, £120,000, £80,000, £60,000	£54,200	
Beam trawlers (under 250Kw)	£500,000	£564,400	
UK drift-fixed nets under 10m	£20,000, £150,000	£45,900	

What remains clear from all the data is the significance of bass, whelk, sole, cod, skate and crustaceans (crab and lobster) to local earnings. This is supported by MMO landings data (see Section 3.1.4).

3.1.3.2 Seasonality

The top 8 targeted species (Table 5 above) were analysed for seasonality and are presented in Figure 38 below. Most vessels targeted bass, cod, skate and sole.

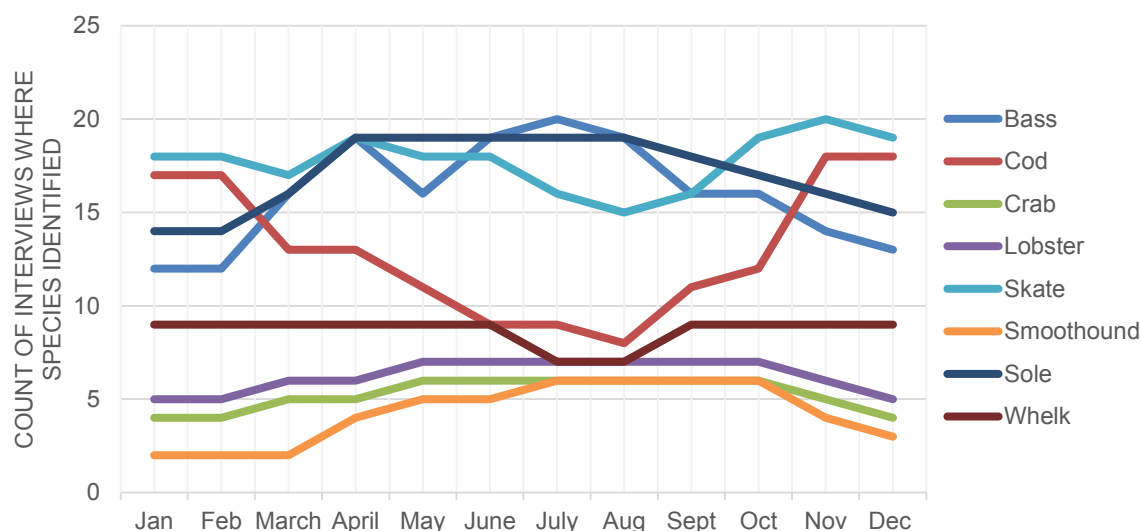


Figure 38: The seasonality of the top 8 targeted species reported in consultation with commercial fishers.

Bass was generally reported to be targeted in the spring and summer months although MMO landings data show more pronounced seasonality in the spring and autumn (Section 3.1.4.4.4.6). Cod is a winter fishery, as shown by both datasets (Section 3.1.4.4.5). Sole is generally targeted in spring and summer, although MMO landings show more pronounced peaks in seasonality (Section 3.1.4.4.4). Few responses were collected for crab and lobster but most activity appears to be in the summer as supported by MMO statistics (Sections 3.1.4.4.3 and 4). All data indicate that skate and whelk are caught all year round (Sections 3.1.4.4.1 and 3.1.4.4.8.). Smoothound is shown here to be a summer fishery, although MMO landings indicate higher catches in spring (Section 3.1.4.4.9).

3.1.4 Species, value and seasonality: MMO landings data

This section presents the estimated high-level value of the commercial fishery, the key commercial species targeted and the seasonality of activity, from vessels landing catches to fishing ports proximal to the Goodwin Sands. Estimations are based on landing statistics provided by the MMO for the 5 year period 2010-2014 and for ICES rectangle 31F1.

3.1.4.1 Volume and value of regional landed catch

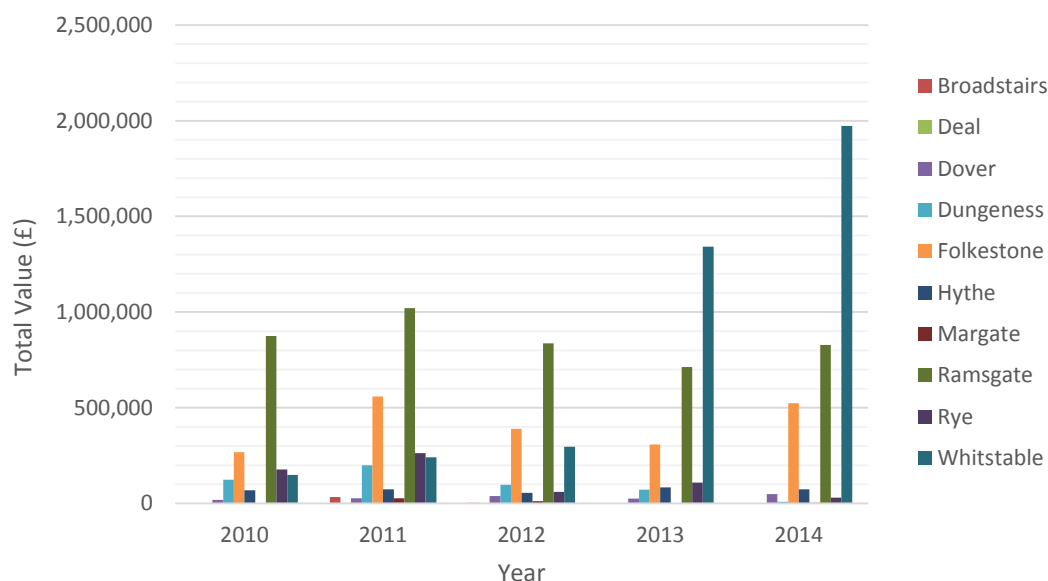


Figure 39: Value of fished species (GBP) caught in ICES rectangle 31F1 and landed at proximal fishing ports to the Goodwin Sands, 2010 to 2014.

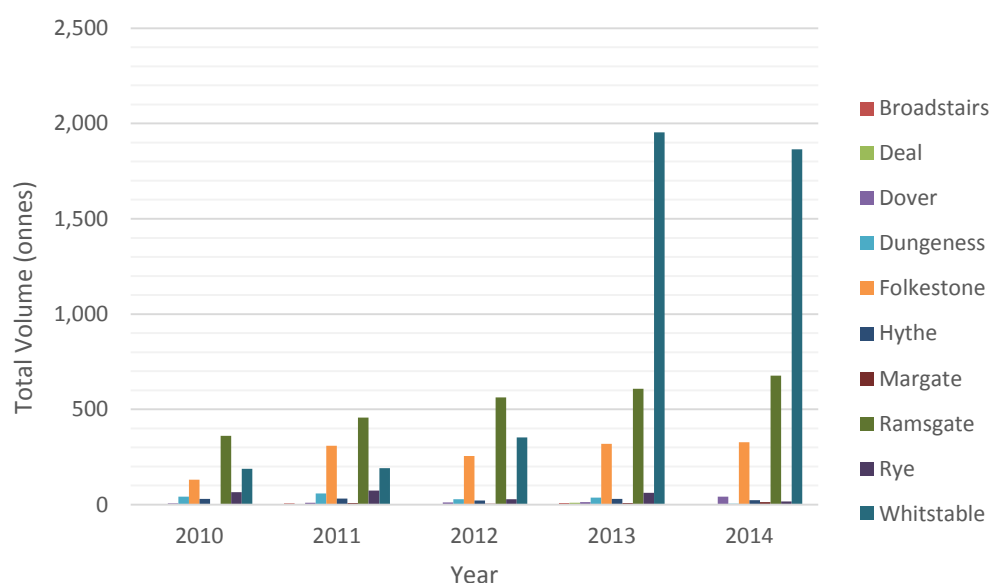


Figure 40: Volume of fished species (GBP) caught in ICES rectangle 31F1 and landed at proximal fishing ports to the Goodwin Sands, 2010 to 2014.

Figure 39 provides a general synopsis of activity in recent years at proximal ports (years 2010-2014) to the study site. The value (and volume, Figure 40) fluctuates year-on-year, but the patterns between ports each year is relatively consistent, with Ramsgate, Folkestone and Whitstable dominating landings. In 2013 and 2014, landings for Whitstable are elevated due to significant landings of cockles (over 1000 tonnes in each year – see Figures 44 & 45).

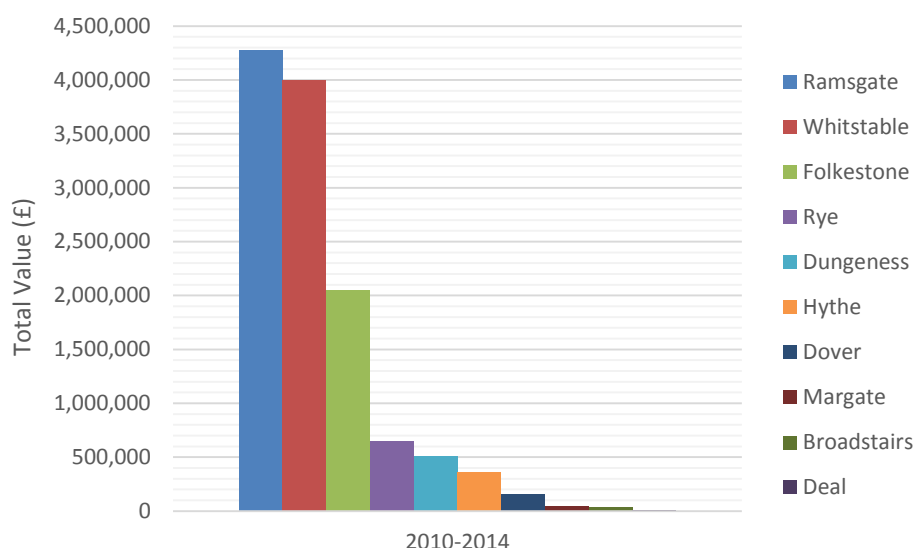


Figure 41: Total value of landed catch over 5 years at significant local and regional fishing harbours proximal to the Goodwin Sands.

Figure 41 further highlights the significance of Ramsgate, Folkestone and Whitstable as ports of commercial significance in the study area. From 2010-2014, landing values from these three ports totalled over £10 million. As a yearly average, landings from all proximal ports are around £2.4 million.

Bringing the data to a more local level, Figure 42 presents the landings (in terms of value) of the 5 closest harbours to the proposed extraction site. Ramsgate is the most significant port in terms of landings in the commercial fishery, it having the most fishing vessels utilizing it as home port in the local area (see Section 3.1.2.2). No landings were recorded for Deal in 2010 and 2011, which may be due to Deal being a small landing beach and catches being landed elsewhere, or due to possible undeclared catches.



Figure 42: Value of fished species (GBP) caught in ICES rectangle 31F1 and landed the ports closest to the Goodwin Sands, 2010-2014.

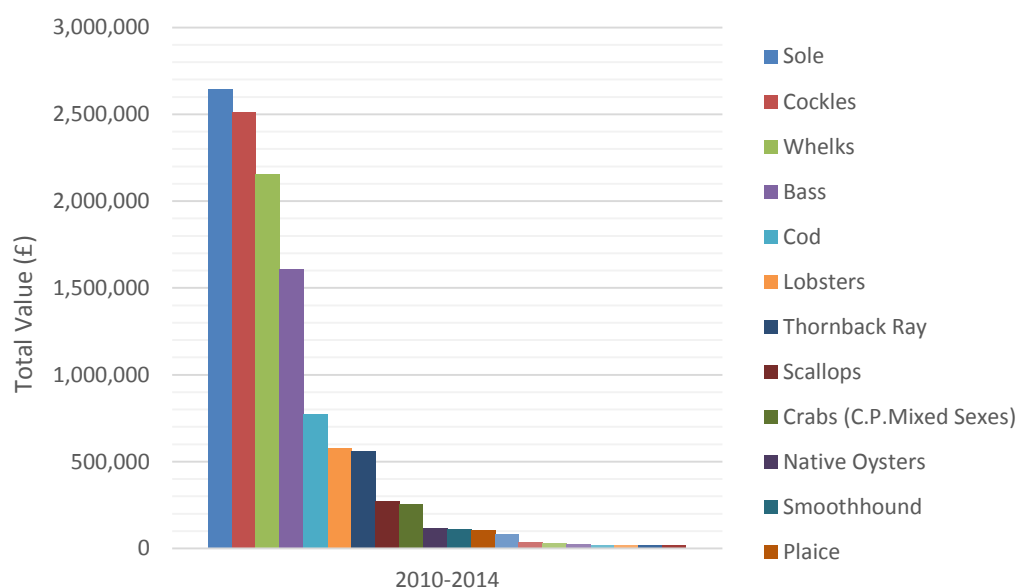


Figure 43: Landed value (GBP) of commercially important species caught in ICES rectangle 31F1 and landed to ports proximal to the Goodwin Sands, 2010-2014.

In terms of species, sole has generated the greatest landed value from 2010-2014 (£2.6 million). Shellfish such as cockles and whelks and demersals such as bass are also valuable species. Figure 43 presents total value but the relative value of each species (i.e. £/kg) is given in the following section for each local port. Lobster has the greatest value per kilo than any other species landed in the area.

3.1.4.2 Catch compositions of key ports

The following sections consider each of the key ports relevant to this characterisation in more detail, including key commercial species comprising landings. Folkestone is not considered to be local to the proposed extraction site so is not included in this section. Catch compositions are averages, based on 4 years of data from the MMO (2010-2014).

3.1.4.2.1 Whitstable

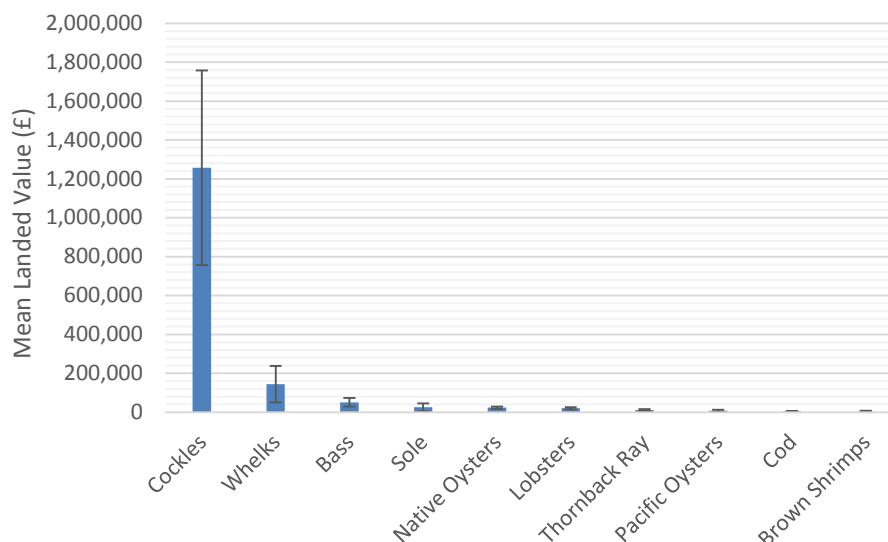


Figure 44: Average value of the top ten landings into Whitstable caught in 31F1 from 2010-2014. Bars indicate standard deviation from the mean.

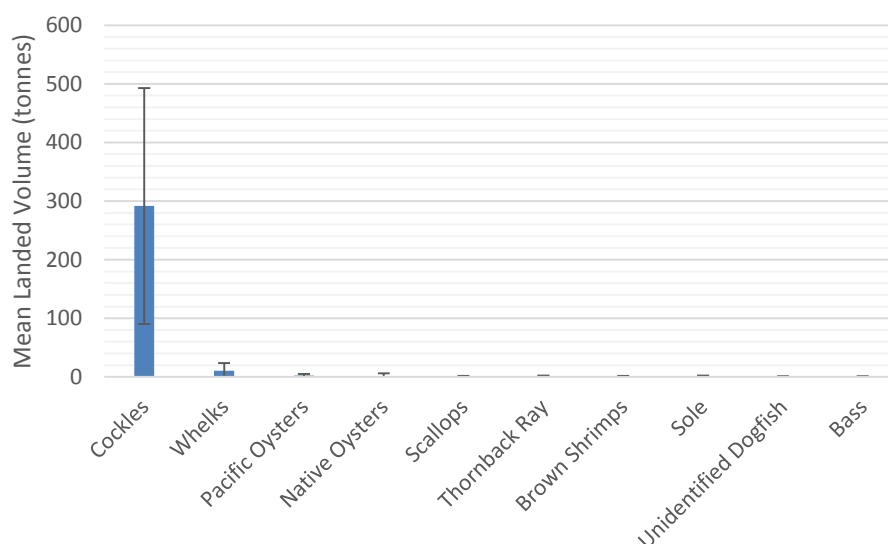


Figure 45: Average volume of the top ten landings into Whitstable caught in 31F1 from 2010-2014. Bars indicate standard deviation from the mean.

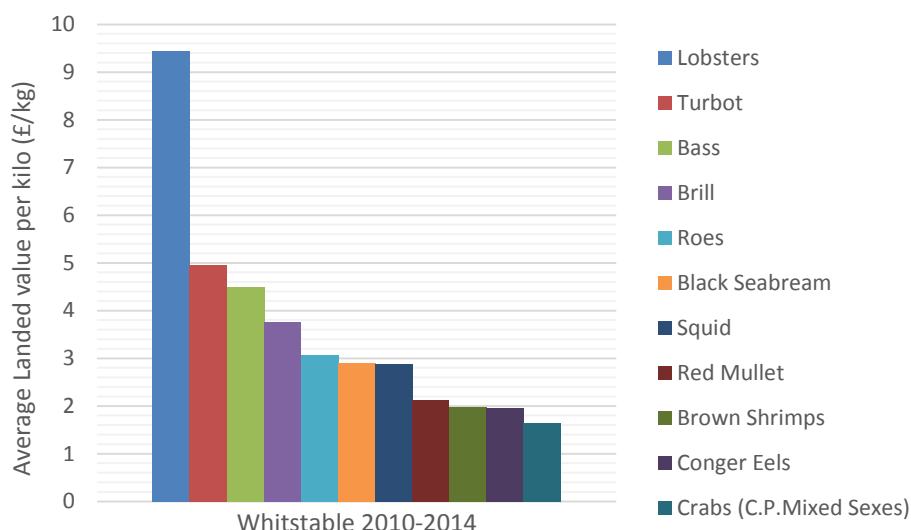


Figure 46: Average landed value per kilo of various species landed into Whitstable caught in 31F1 from 2010-2014.

Figure 45 indicates a dominance in fisheries for cockles (*Cerastoderma edule*). However, the variability in the data set is large which misrepresents the true catch composition for Whitstable. For example, from 2010-2012 there were no landings of cockles, yet in 2013 and 2014, over 1000 tonnes of cockles were landed in each year.

It is also important to state here that cockles are fished locally from grounds proximal to Whitstable harbour and the Maplin Sands, and not on the Goodwin Sands, so this species can be discounted from further analysis. In terms of other important fisheries operating from Whitstable, the landings data show whelk (*Buccinum undatum*) to be an important catch, which are caught using static whelk potting gear.

It is important to consider the volume and value of landings in conjunction with each other, as some species will be more valuable. Figure 46 shows average landed values per kilo of species caught and landed into Whitstable. Lobster (*Hommarus gammarus*) is by far the most valuable landed species (achieving in excess of £14,000 total landed value in 2014, on average ~£9/kg), followed by demersal species such as turbot (*Scophthalmus maximus*), bass (*Dicentrarchus labrax*) and brill (*Scophthalmus rhombus*).

3.1.4.2.2 Herne Bay

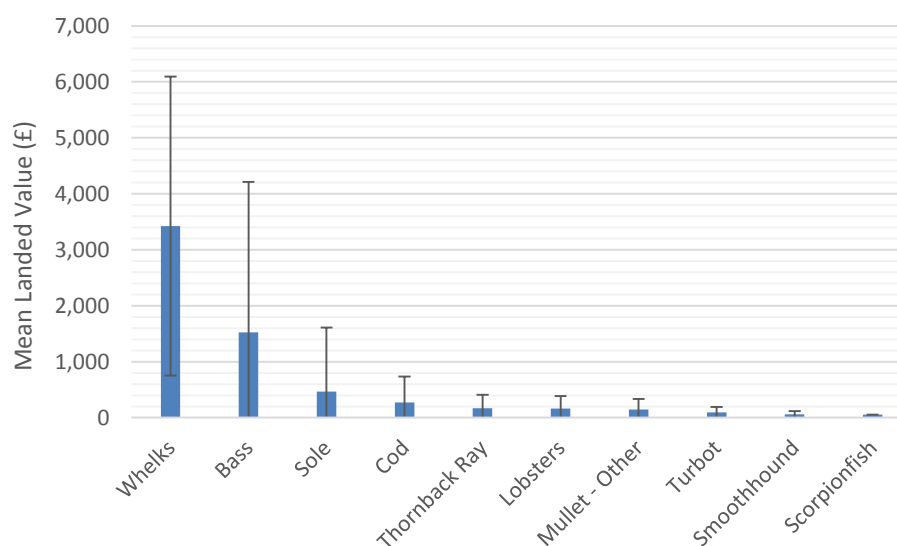


Figure 47: Average value of the top ten landings into Herne Bay caught in 31F1 from 2010-2014. Bars indicate standard deviation from the mean.

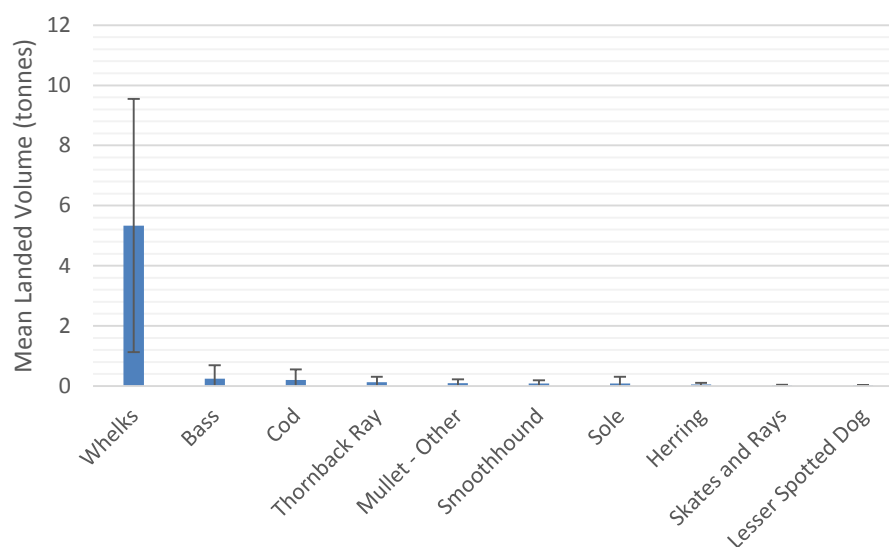


Figure 48: Average volume of the top ten landings into Herne Bay caught in 31F1 from 2010-2014. Bars indicate standard deviation from the mean.

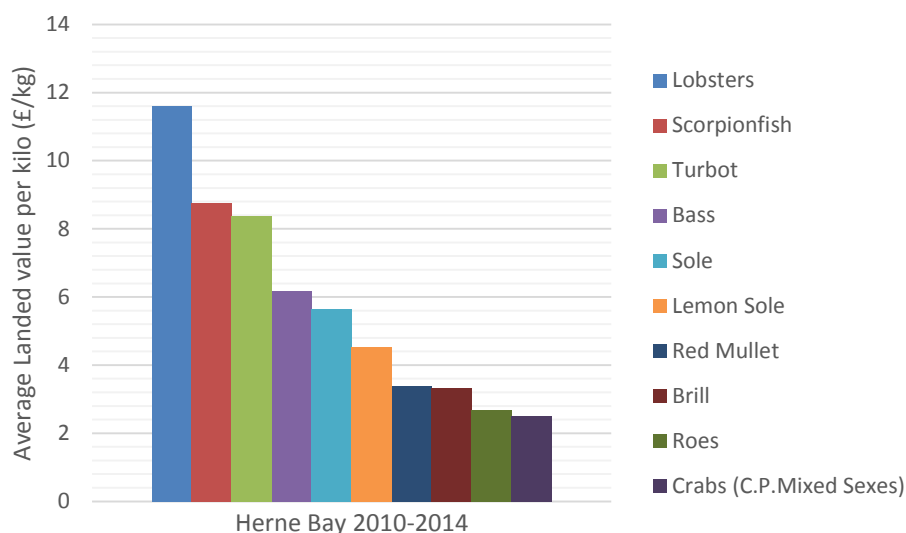


Figure 49: Average landed value per kilo of various species landed into Herne Bay caught in 31F1 from 2010-2014.

The landings data show whelk to be an important catch for vessels operating out of Herne Bay; landings in 2014 were valued at £30,000. Catches do not appear to be seasonal, varying in volume and value between months (see seasonality - Section 3.1.4.4), which may explain the large variability in the data. For example, in 2011, around 1 tonne of whelks were landed, but in 2012, 70 tonnes were landed.

Demersal species such as bass, sole (*Solea solea*) and cod (*Gadus morhua*), caught mainly by netting gear, are also important species. The data are very variable, however.

Figure 32 shows a more varied range of high value species landed into Herne Bay than into Whitstable. Although lobsters are again the most valuable species in terms of landed value per kilogram (~£12/kg), Scorpionfish (*Scorpaenidae spp.*) and turbot show similar average landed values (~£8/kg). Average values of lobsters varies between harbours, Herne Bay lobster fetching a higher landed value, on average, than Whitstable lobster.

3.1.4.2.3 Ramsgate

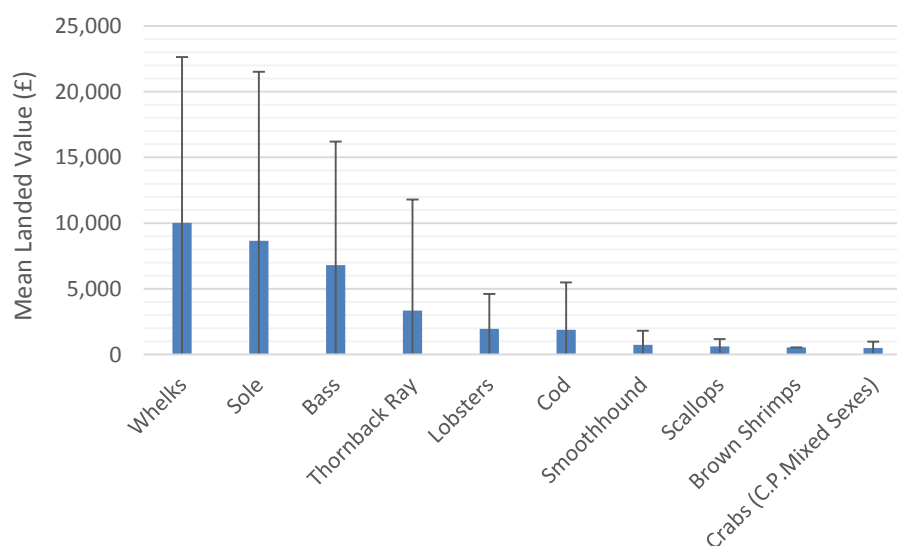


Figure 50: Average value of the top ten landings into Ramsgate caught in 31F1 from 2010-2014. Bars indicate standard deviation from the mean.

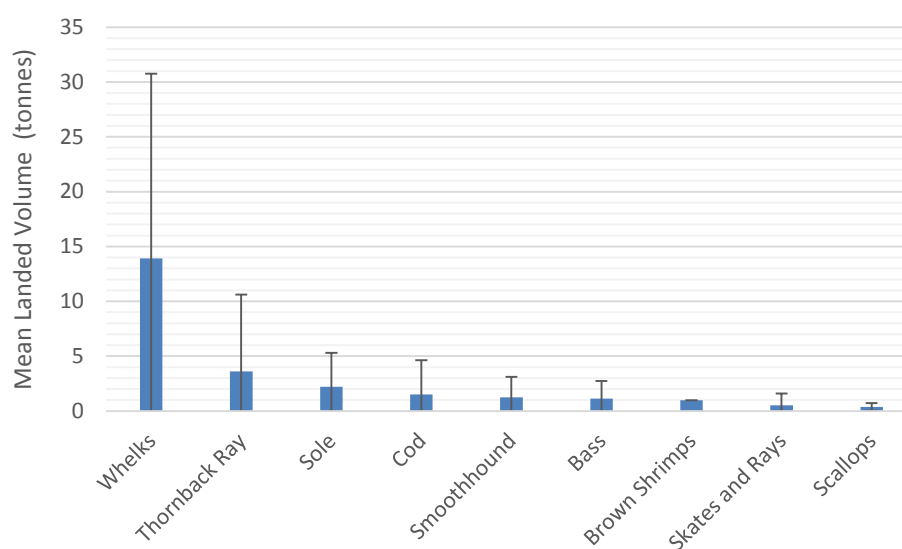


Figure 51: Average volume of the top ten landings into Ramsgate caught in 31F1 from 2010-2014. Bars indicate standard deviation from the mean.

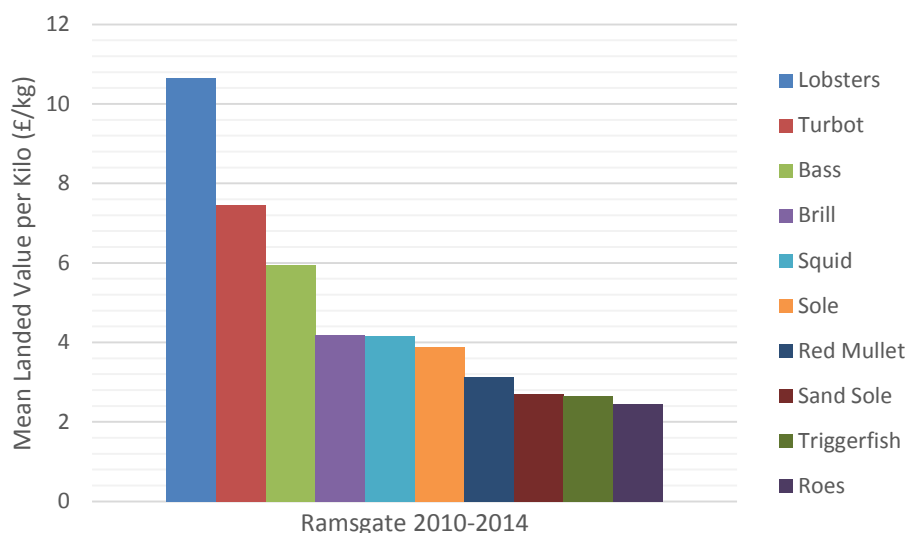


Figure 52: Average landed value of the top ten species landed into Ramsgate caught in 31F1 from 2010-2014.

Ramsgate landings are dominated by whelk, which are caught all year round. In 2014, around 408 tonnes of whelk were landed into Ramsgate, valued at approximately £323,000. This is around ten times the value landed at Herne Bay, highlighting Ramsgate's significance as one of the key commercial harbours in the area. Demersal species such as thornback ray (*Raja clavata*), sole, bass and cod comprise a smaller, but still significant, proportion of overall landings into Ramsgate.

Again, lobster is shown to be the most valuable catch (~10/kg) (Figure 52), as well as other demersal such as turbot and bass.

3.1.4.2.4 Margate

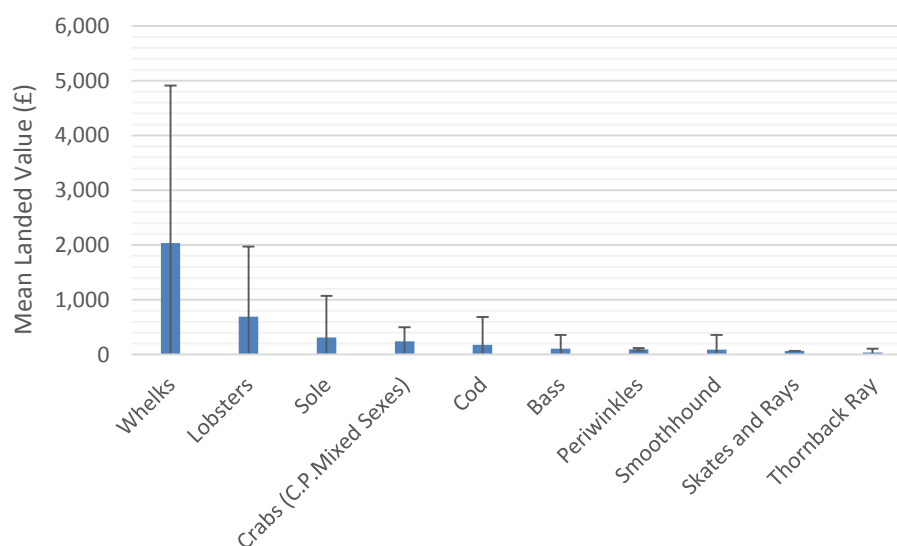


Figure 53: Average value of the top ten landings into Margate caught in 31F1 from 2010-2014. Bars indicate standard deviation from the mean.

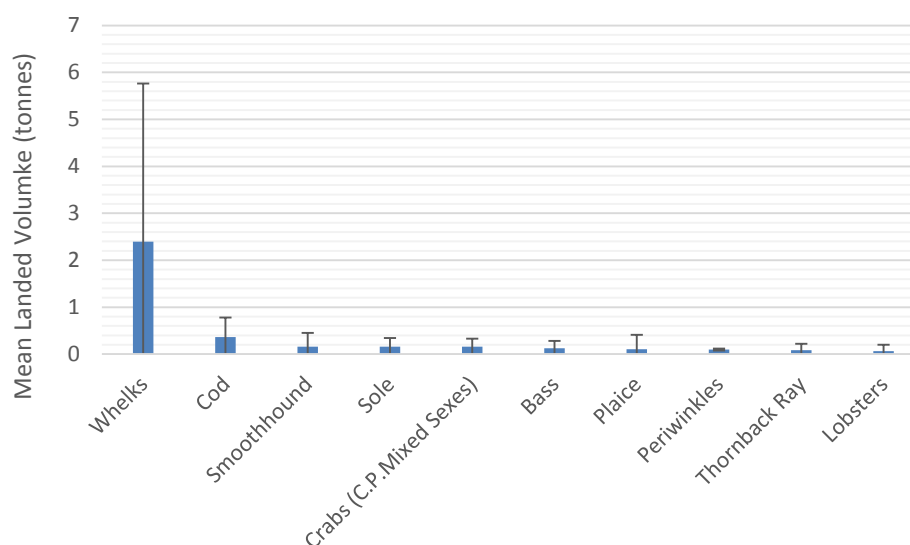


Figure 54: Average volume of the top ten landings into Margate caught in 31F1 from 2010-2014. Bars indicate standard deviation from the mean.

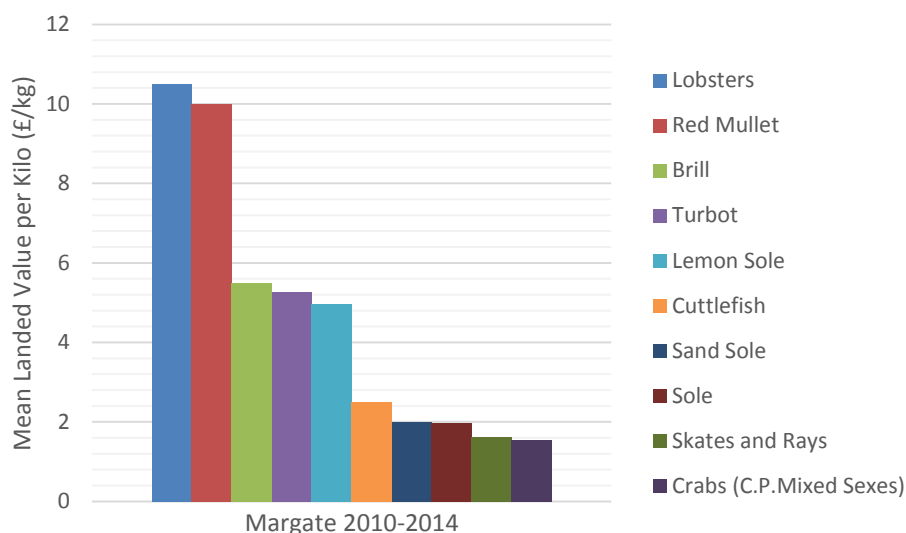


Figure 55: Average landed value per kilo of the top ten species landed into Margate caught in 31F1 from 2010-2014.

As seen in other harbours on the Isle of Thanet (Herne Bay, Ramsgate and Whitstable), landings are dominated by whelk, although the volume landed are much less significant than at Ramsgate. Cod, lobster and sole are also important species. Lobsters are the most valuable species landed at Margate with landed values of ~£10/kg (Figure 55). The high values seen for red mullet (*Mullus spp.*) relate to one year (2011) of landings – 0.5kg for £5, so species such as brill, turbot and sole are more valuable in general to Margate.

3.1.4.2.5 Broadstairs

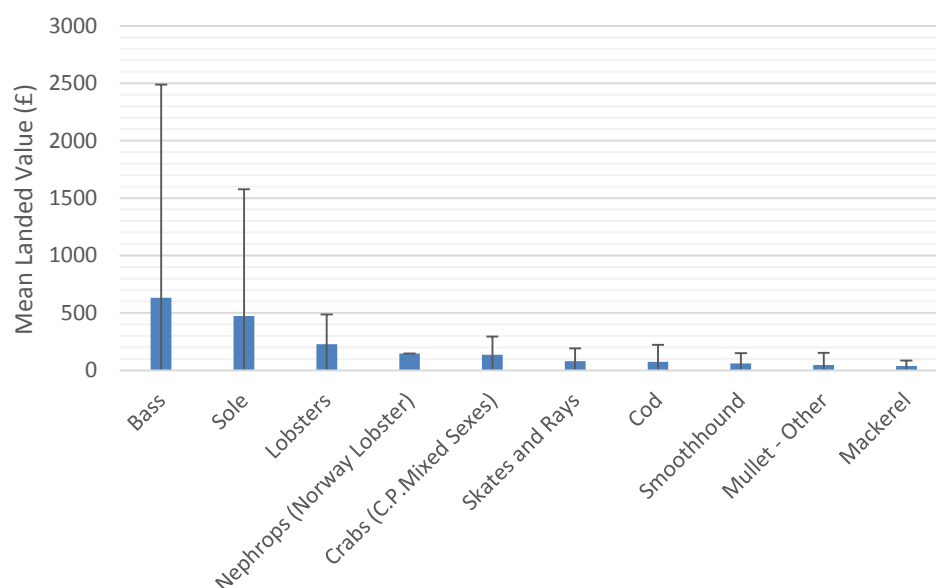


Figure 56: Average value of the top ten landings into Broadstairs caught in 31F1 from 2010-2014. Bars indicate standard deviation from the mean.

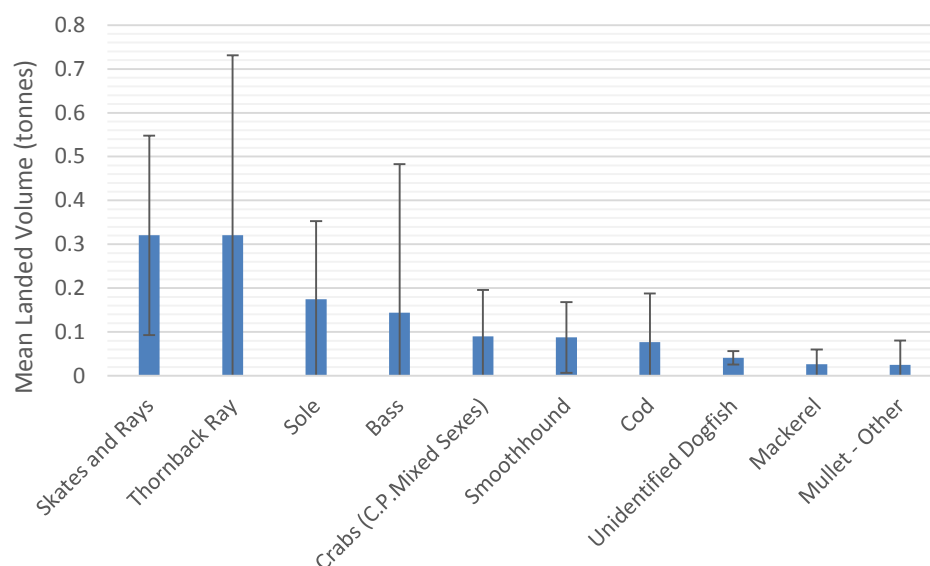


Figure 57: Average volume of the top ten landings into Broadstairs caught in 31F1 from 2010-2014. Bars indicate standard deviation from the mean.

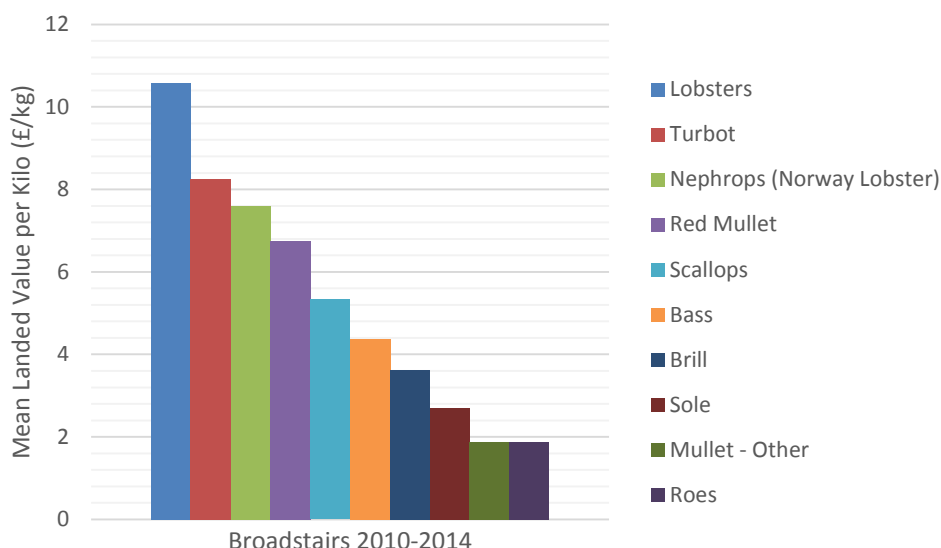


Figure 58: Average landed value per kilo of the top ten species landed into Broadstairs caught in 31F1 from 2010-2014.

In contrast the other harbours on the Isle of Thanet, the fisheries operating out of Broadstairs do not include those for whelk. Demersal finfish and elasmobranch species are the main species landed at this harbour but the volumes are much less significant than those at Ramsgate and other harbours on the Isle of Thanet. In total 25 different species have been landed at Broadstairs in the 5 year period analysed, whereas 52 species have been landed at Ramsgate.

The catch composition of the most valuable species landed at Broadstairs varies slightly to other harbours; with nephrops (*Nephrops norvegicus*) and scallops (*Pectens maximus*) occasionally making up some of the landed catch in single years. Lobsters still remain the most valuable catch (Figure 58).

Note that for 2013 and 2014, the landed volume of some species was reported, but without a value so results for Broadstairs for bass, cod, dab, ray, tope, whiting, shad and cuttlefish should be treated with caution.

3.1.4.2.6 Deal

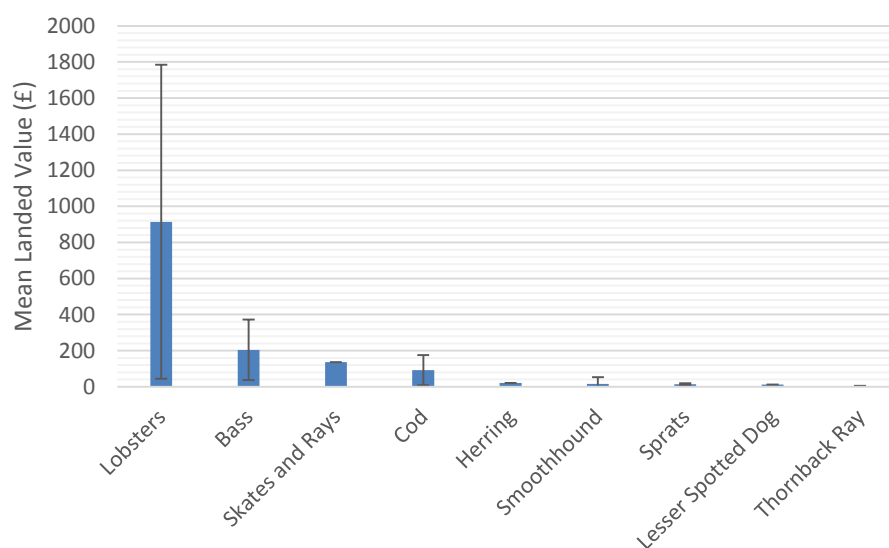


Figure 59: Average value of the top ten landings into Deal caught in 31F1 from 2010-2014. Bars indicate standard deviation from the mean.

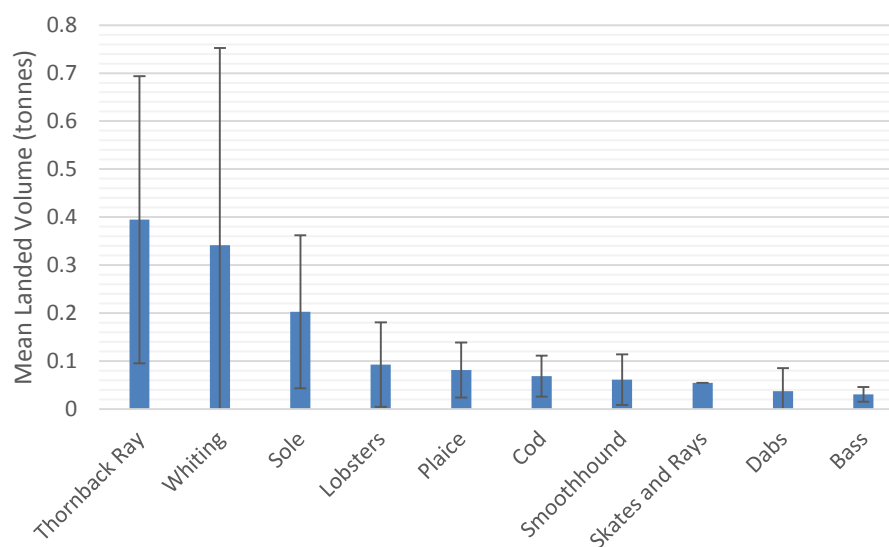


Figure 60: Average volume of the top ten landings into Deal caught in 31F1 from 2010-2014. Bars indicate standard deviation from the mean.

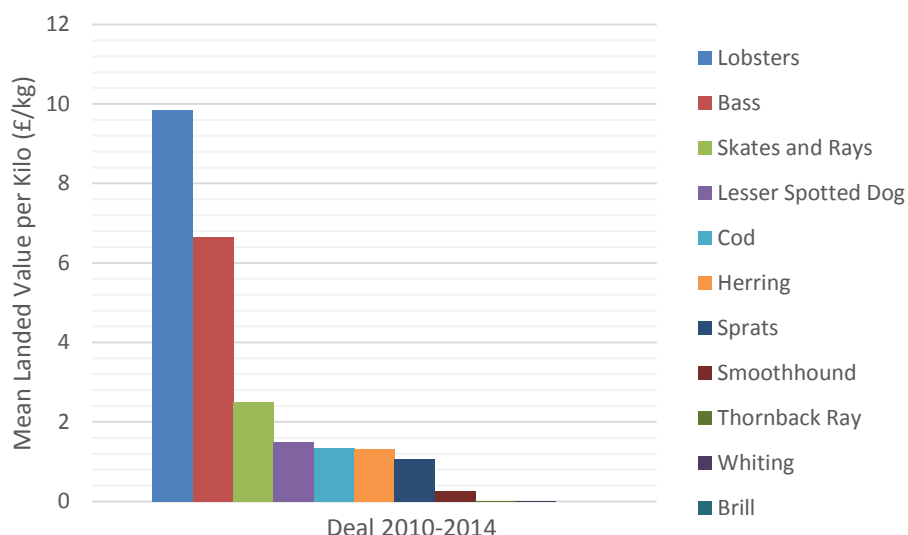


Figure 61: Average landed value per kilo of the top ten species landed into Deal caught in 31F1 from 2010-2014.

The fisheries operating out of Deal are on a much smaller scale than at other ports in the study area; only 8 different species are landed. Deal does not have a harbour so all boats are beach launched which restricts the size and range of vessels. Lobster are an important catch and are the most valuable of the species landed here. Demersal species such as thornback ray, whiting and sole are also important species. After lobster, bass is considered to be one of the most valuable species landed (~£7/kg) on the beaches at Deal (Figure 61).

3.1.4.2.7 Dover

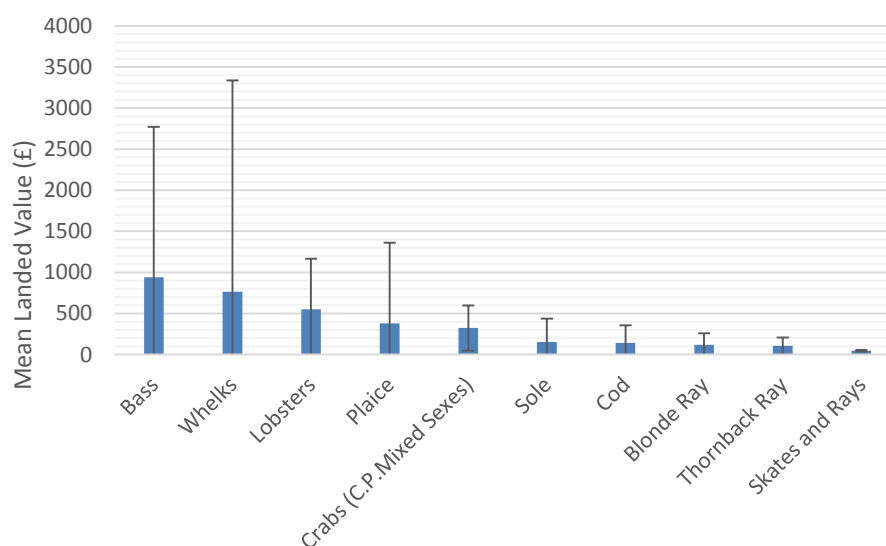


Figure 62: Average value of the top ten landings into Dover caught in 31F1 from 2010-2014. Bars indicate standard deviation from the mean.

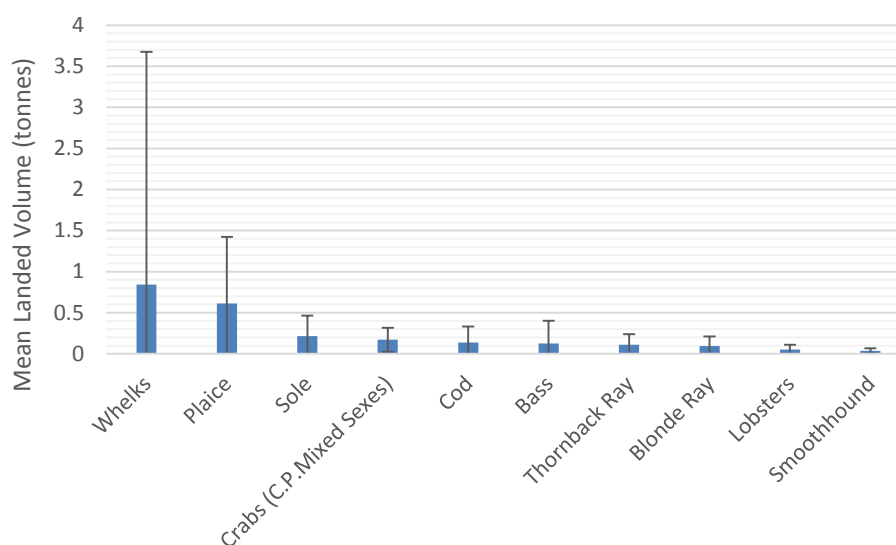


Figure 63: Average volume of the top ten landings into Dover caught in 31F1 from 2010-2014. Bars indicate standard deviation from the mean.

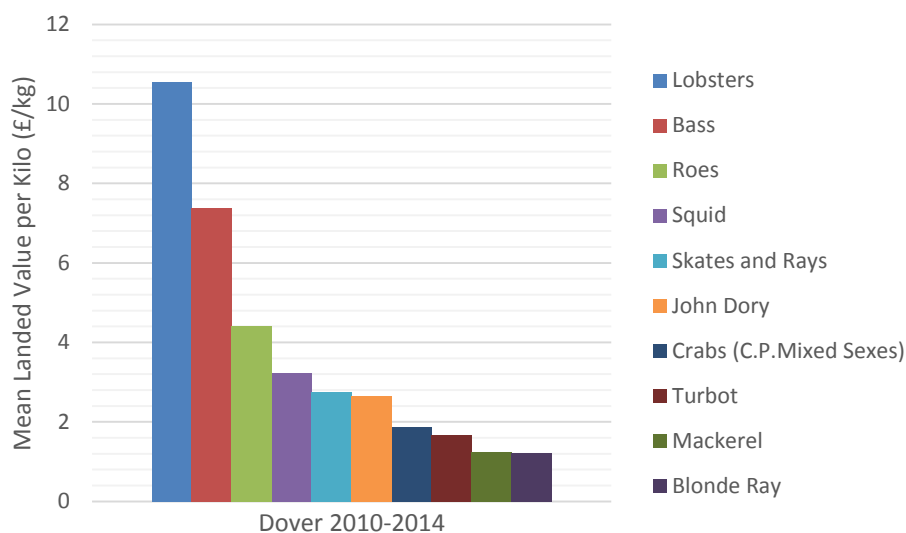


Figure 64: Average landed value per kilo of the top ten species landed into Dover caught in 31F1 from 2010-2014.

The fisheries operating out of Dover mainly target whelk and demersal fish such as plaice, bass and sole, although landings are not as significant as those into other ports in the area, such as Ramsgate. Valuable species landed at Dover are lobster and bass, both fetching over £7/kg.

3.1.4.3 Landings trends over time

Having looked at each local landing site in terms of catch composition, it is also important to look at the changes in the value of volume of commercially important species over time. The data below present the landings of the closest harbours to the proposed extraction site.

3.1.4.3.1 Ramsgate

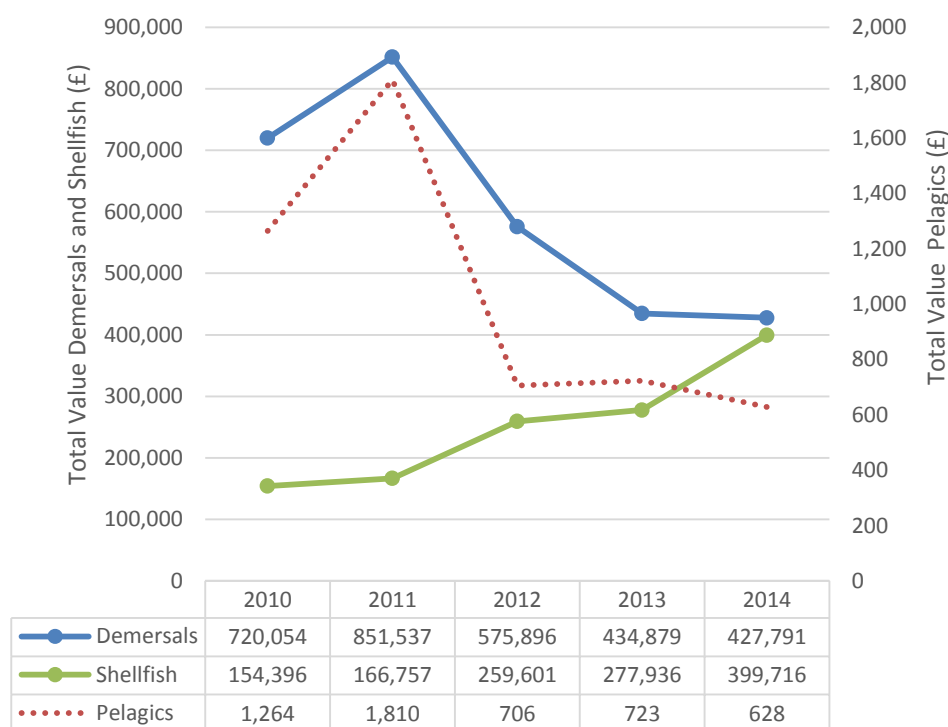


Figure 65: Value of landings of principal target species categories for Ramsgate between 2010 and 2014, caught in 31F1. Pelagic landings are less significant, so have been plotted to a secondary axis.

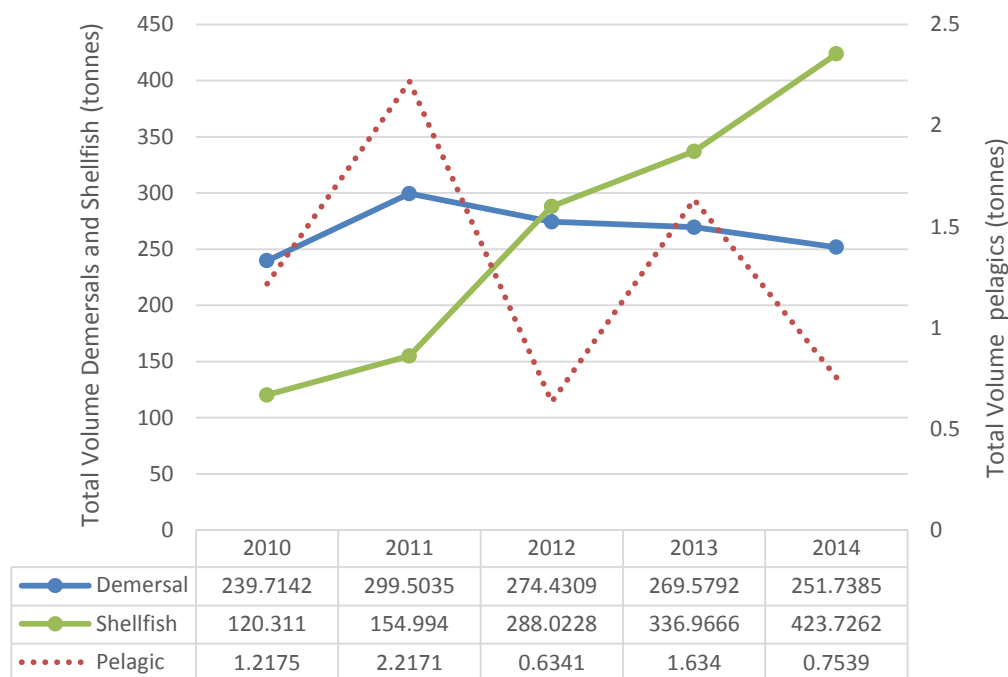


Figure 66: Value of landings of principal target species categories for Ramsgate between 2010 and 2014, caught in 31F1. Pelagic landings are less significant, so have been plotted to a secondary axis.

As seen in the catch composition, landings into Ramsgate are dominated by demersals and shellfish (namely sole, bass, ray and whelk). Fisheries for pelagics are less significant, where in any year, no more than 2.5 tonnes of pelagics have been landed.

Over time the value of demersal species landings into Ramsgate has decreased, although the landed volume has not fluctuated significantly. The value of shellfish species landed has gradually increased in line with increases in volume landed, indicating an increase in catches over the years, but with a stable value.

3.1.4.3.2 Margate

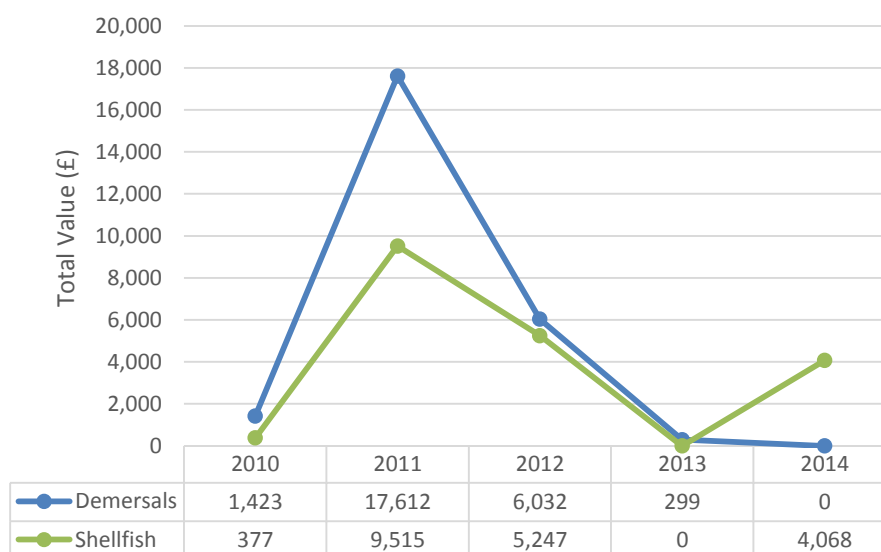


Figure 67: Value of landings of principal target species categories for Margate between 2010 and 2014, caught in 31F1.

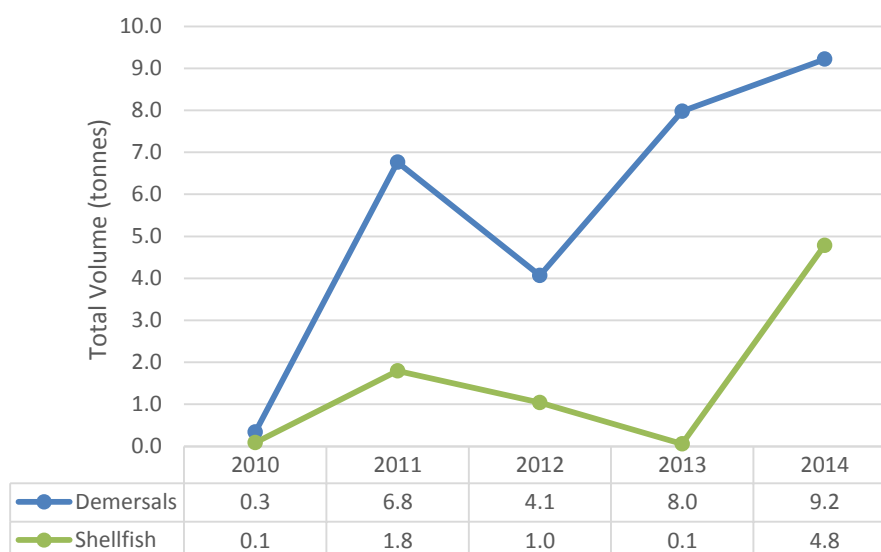


Figure 68: Volume of landings of principal target species categories for Margate between 2010 and 2014, caught in 31F1.

As landings of pelagics only totalled £3, they have not been included in these graphs. Fisheries for demersals (namely sole, bass and cod) and shellfish (lobster, whelk and crab) dominate.

Over time the value of demersal species landings into Margate has decreased, although landings have increased which may be indicative of changes in price in species such as sole, bass and cod over the 5 year period. The value of shellfish species landed has

gradually changed in line with changes in volume landed, indicating again that shellfish have a more stable landed value and/or unit price than demersal fish.

3.1.4.3.3 Broadstairs

In 2013 and 2014, the landed volume of some species was reported, but without a value so results for Broadstairs have only been presented in terms of volume.

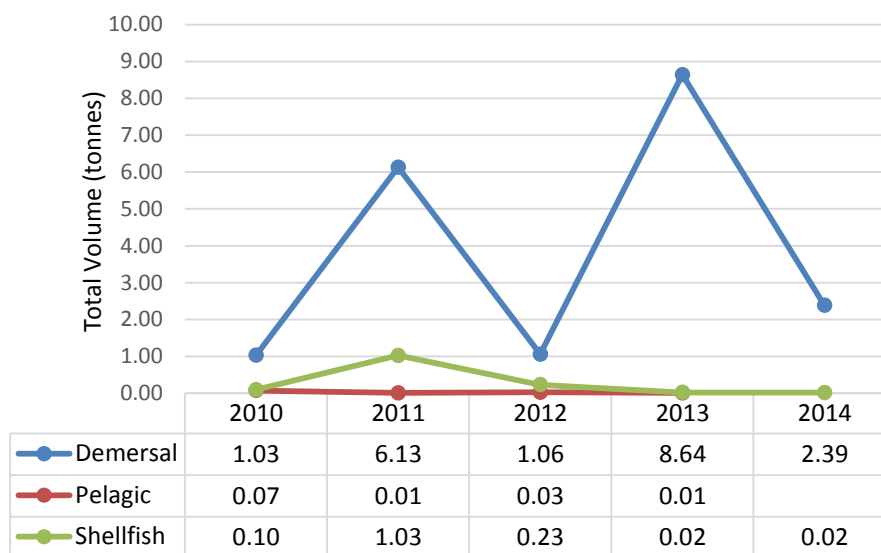


Figure 69: Volume of landings of principal target species categories for Broadstairs between 2010 and 2014, caught in 31F1.

Demersals (namely elasmobranchs, sole, cod and bass) dominate landings at Broadstairs. The volume landed fluctuates year on year. Landed volumes of species into Broadstairs is much less significant than those at Margate and Ramsgate.

3.1.4.3.4 Dover

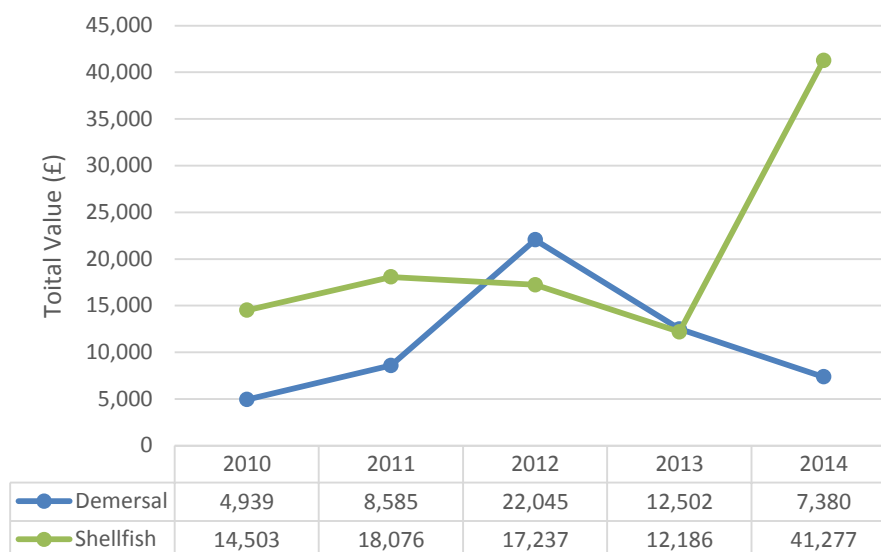


Figure 70: Value of landings of principal target species categories for Dover between 2010 and 2014, caught in 31F1.

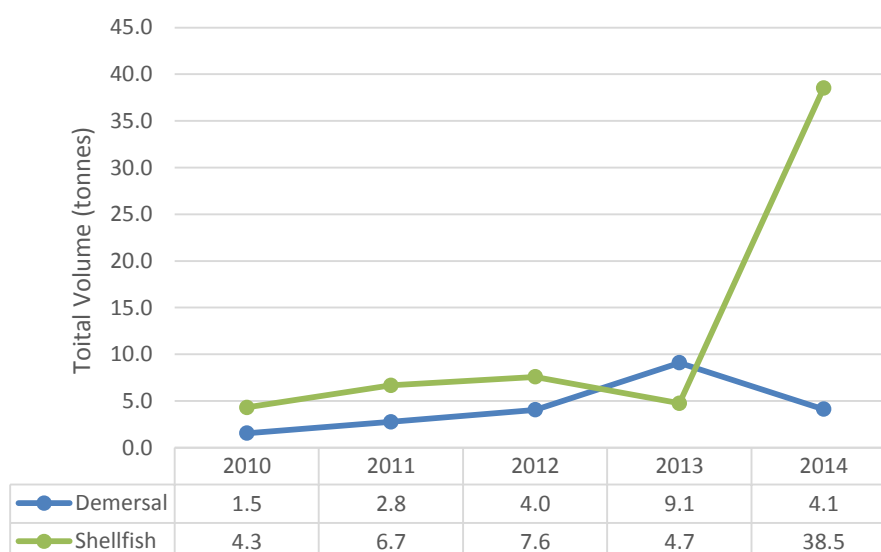


Figure 71: Volume of landings of principal target species categories for Dover between 2010 and 2014, caught in 31F1.

As landings of pelagics only totalled £12, they have not been included. Fisheries for demersals (namely bass, thornback ray and cod) and shellfish (lobster, whelk and crab) dominate, although are not as significant in terms of landings when compared to Ramsgate.

Over the 5 year period, trends in landings have remained relatively stable, except in 2014 where a significant amount of whelk was landed into Dover.

3.1.4.3.5 Deal

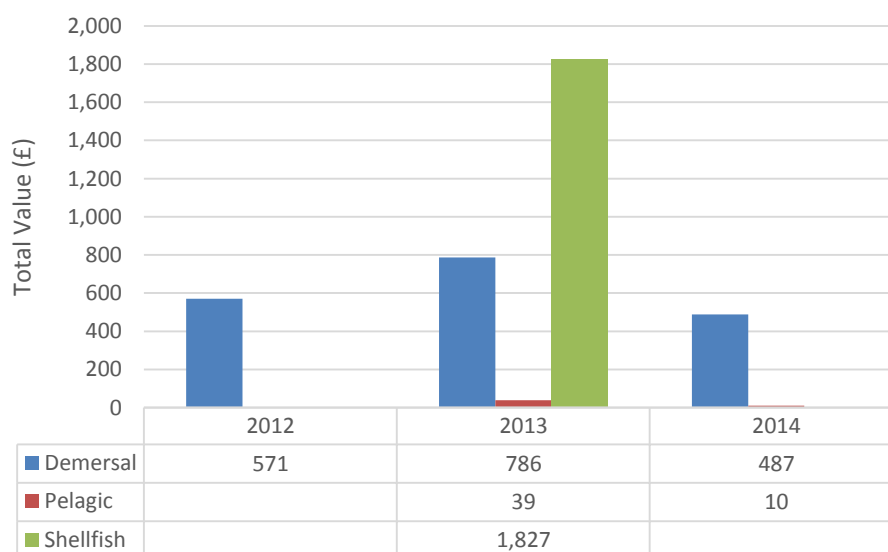


Figure 72: Value of landings of principal target species categories for Broadstairs between 2012 and 2014, caught in 31F1.



Figure 73: Volume of landings of principal target species categories for Broadstairs between 2012 and 2014, caught in 31F1.

Deal is also a relatively small landing site in terms of landed volume of demersals, due to the nature of the beach landings site. The peak in value in 2013 (without corresponding peak in volume) was due to a large landing of valuable lobster. The peak in volume in 2013 (without corresponding peak in value) was due to the landings of less valuable thornback ray, sole and whiting. No Landings were seen at Deal in 2010-201 which as previously mentioned, which may be due to Deal being a small landing beach and catches being landed elsewhere, or due to possible undeclared catches.

3.1.4.3.6 All sites demersals

The following graphs summarise the general year on year changes in the volumes and values of landed species to the harbours and beaches proximal to the Goodwin Sands. Fisheries for demersals and shellfish dominate activity in the area, so pelagics have not been included.

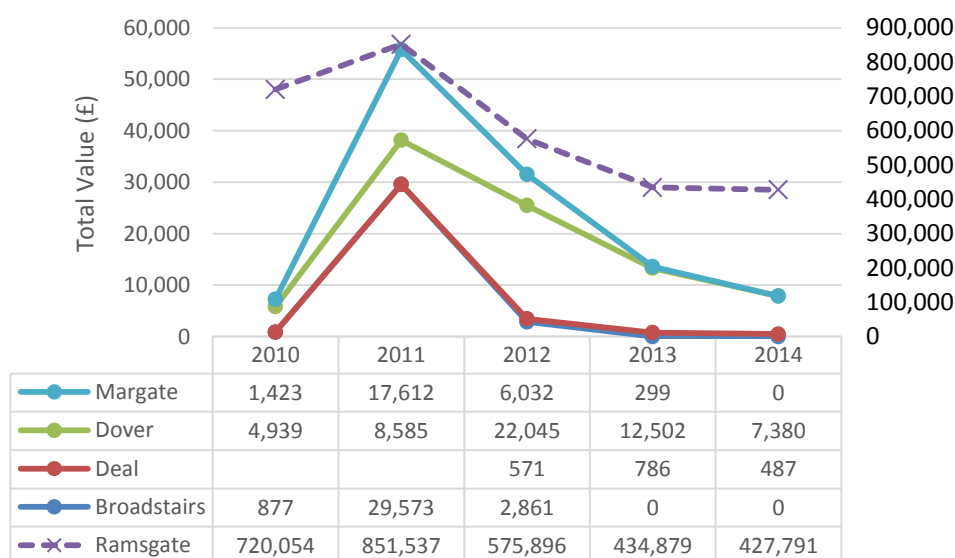


Figure 74: Total value of demersal landings for all landing sites between 2010 and 2014, caught in 31F1. Ramsgate has been plotted to a secondary axis due to the difference in scale of landings.

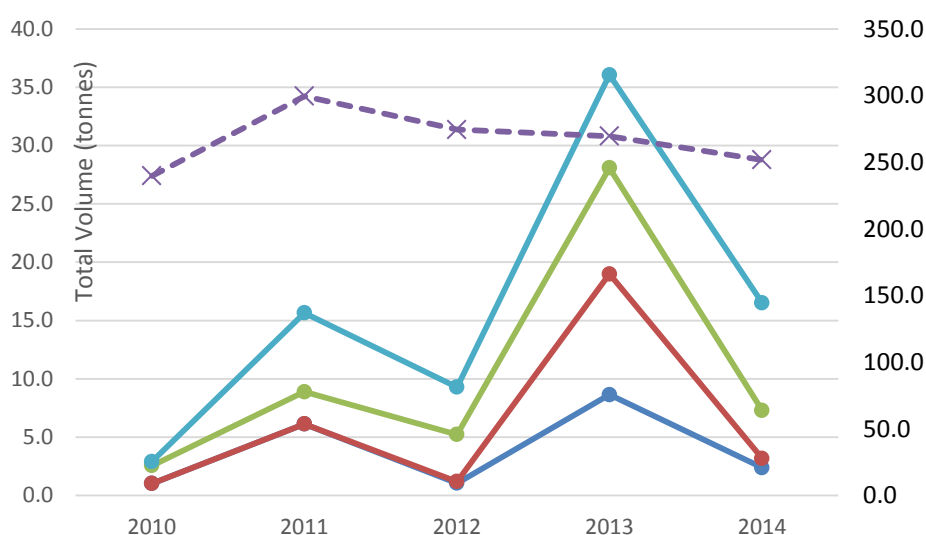


Figure 75: Total volume of demersal landings for all landing sites between 2010 and 2014, caught in 31F1. Ramsgate has been plotted to a secondary axis due to the difference in scale of landings.

The value of demersal fish landings in the area appear to have decreased from 2011-2014 whereas the volume of landings fluctuates more over the same time period. In 2013, the volume of demersals landed into most ports increased, while value drops, indicating price changes in the market.

3.1.4.3.7 All sites shellfish

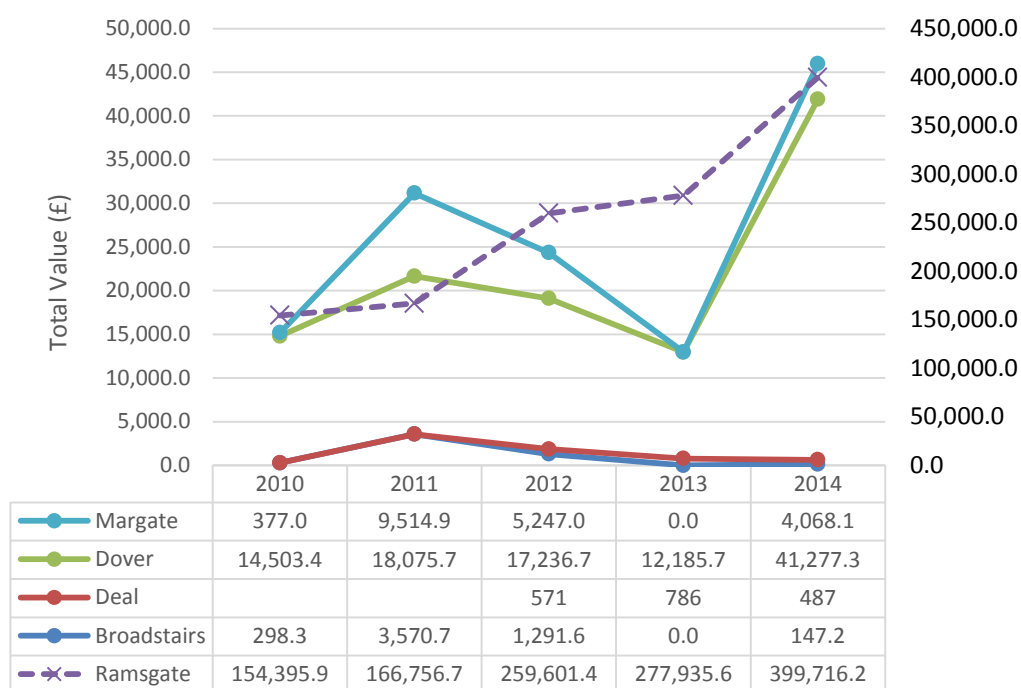


Figure 76: Total value of shellfish landings for all landing sites between 2010 and 2014, caught in 31F1. Ramsgate has been plotted to a secondary axis due to the difference in scale of landings.

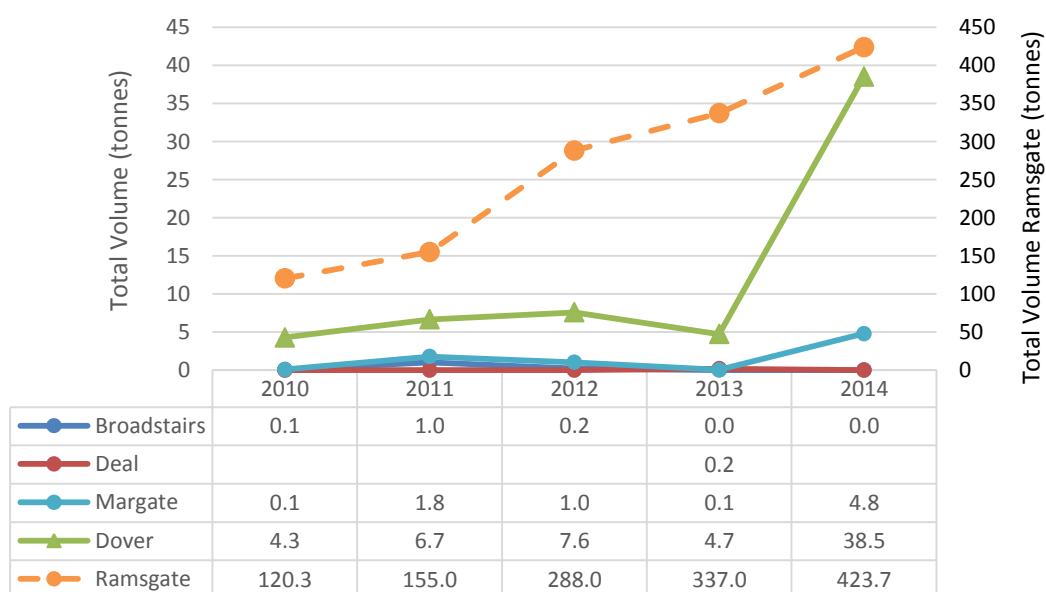


Figure 77: Total volume of shellfish landings for all landing sites between 2010 and 2014, caught in 31F1. Ramsgate has been plotted to a secondary axis due to the difference in scale of landings.

Landings of shellfish at Deal and Broadstairs have remained relatively constant from 2010-2014. Few boats operate out of these small landing sites. At Ramsgate, shellfish landings have increased steadily over the 5 year period. As described in Section 3.1.4.3.4, the trends seen at Dover are due to the landings of whelk in one year.

3.1.4.4 Seasonality of target species

The seasonality of the key target species is examined in subheadings within this section of the report. The data analysed relates to landings reported to have been caught in ICES statistical rectangle 31F1 the harbours and beaches proximal to the Goodwin Sands and surrounding area. Key target species were selected where over 20 tonnes in total was landed from 2010-2014. Cockles and oysters have been discounted as these fisheries do not take place on the Goodwin Sands.

3.1.4.4.1 Whelk

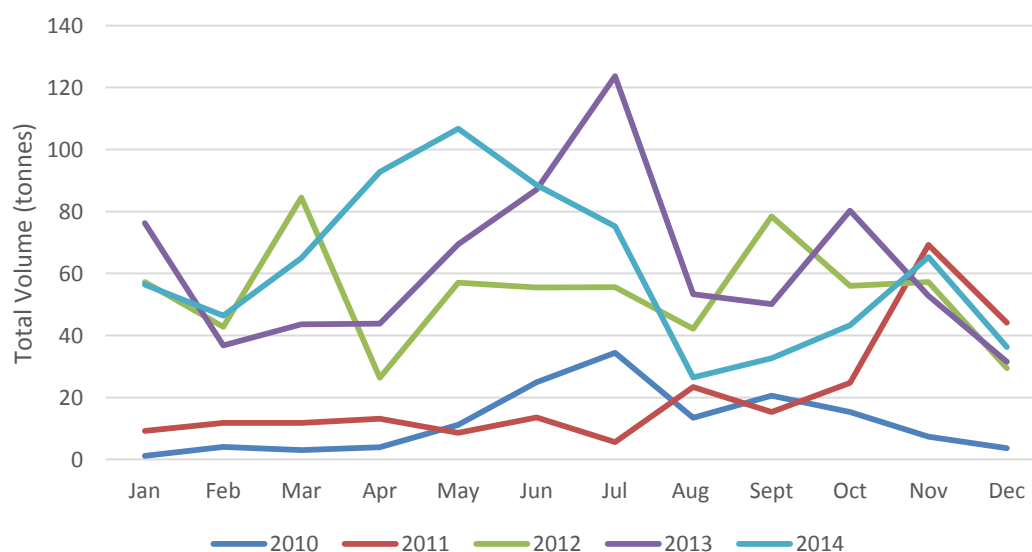


Figure 78: Volume of whelk caught in 31F1 and recorded as landed in Whitstable, Herne Bay, Margate, Ramsgate and Dover.

The whelk fishery operates throughout the year and does not appear to have a specific seasonality.

3.1.4.4.2 Lobster

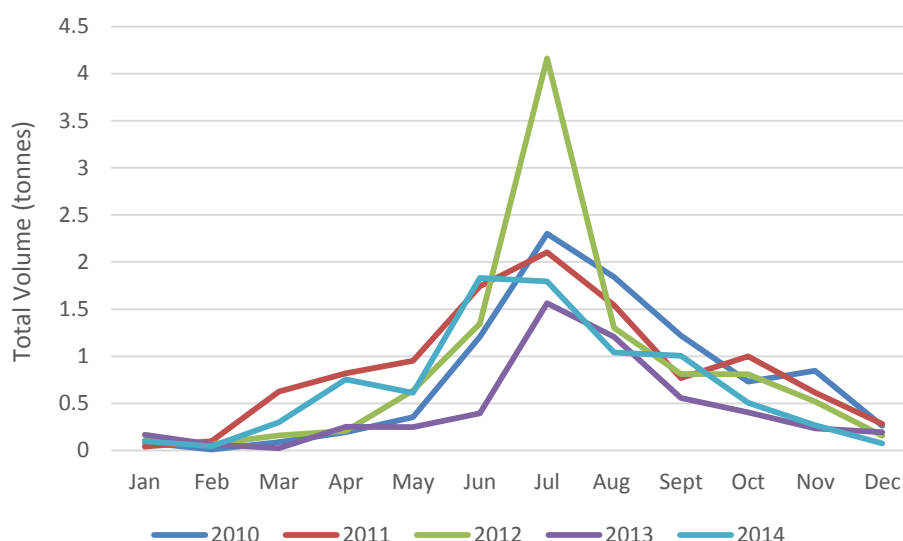


Figure 79: Volume of lobster (*H. gammarus*) caught in 31F1 and recorded as landed in Whitstable, Herne Bay, Margate, Broadstairs, Ramsgate, Deal and Dover.

The lobster fishery continues throughout the year but landings generally peak in summer (Figure 79), coinciding with increased water temperatures. Landings then decrease substantially as lobster activity levels decrease around August. Lower activity levels result in lobster reducing their hunting and foraging activity, which results in reduced catches for fishers. Local demand for crab in restaurants and pubs peaks in summer in conjunction with the holiday season.

3.1.4.4.3 Crab

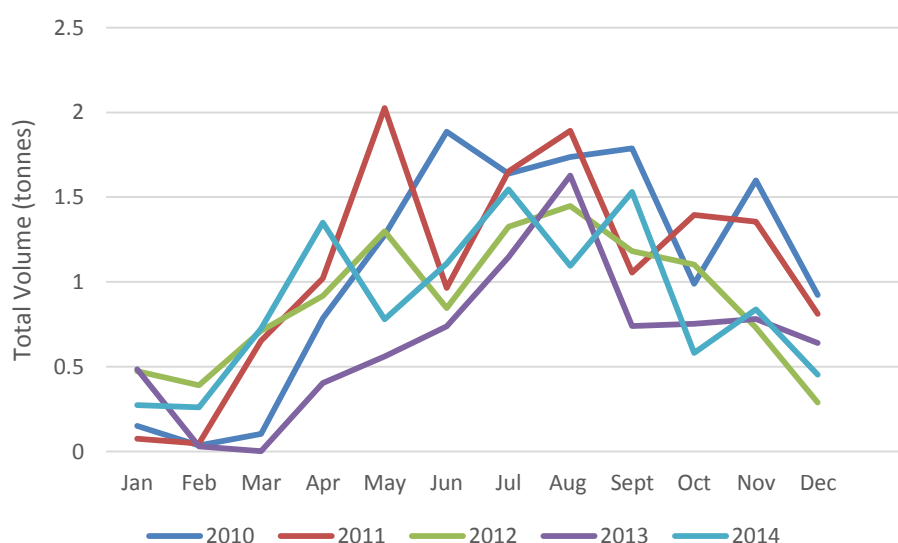


Figure 80: Volume of crab (*C. pagarus*) caught in 31F1 and recorded as landed in Whitstable, Margate, Broadstairs, Ramsgate and Dover.

The landings data show the brown crab fishery to operate throughout the year, with higher catches beginning in spring and continuing through to autumn. Landings are low in the winter months. Prices are generally linked to supply in crab fisheries. Local demand for crab in restaurants and pubs peaks in summer in conjunction with the holiday season. Out of season many lobster/crab fishers also fish for whelks and consequently during the winter it is fairly common for such fishers to move their parlour pots further offshore and haul them less frequently (once or twice a week) whilst working whelk gear too.

3.1.4.4.4 Sole

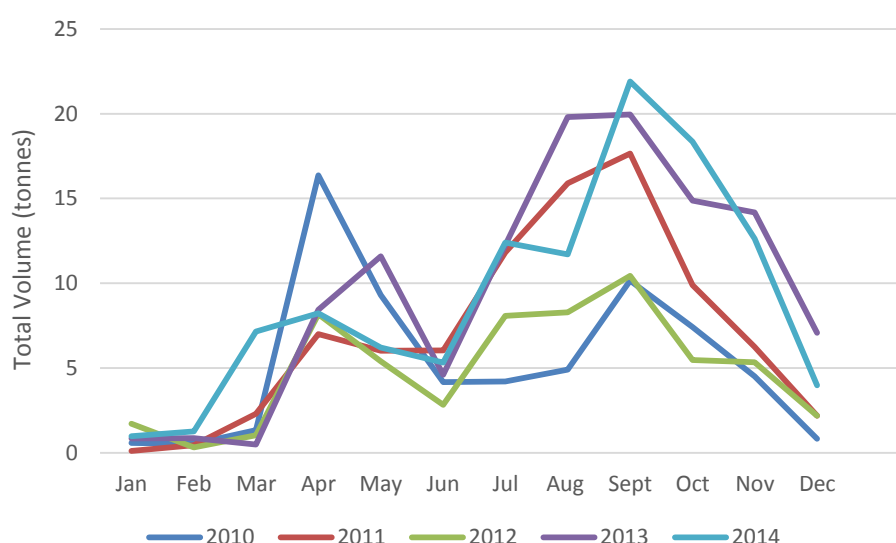


Figure 81: Volume of sole (*S. solea*) caught in 31F1 and recorded as landed in Whitstable, Herne Bay, Margate, Broadstairs, Ramsgate, Deal and Dover.

Landings data show peaks in landings of sole from April-May and then August-September. The peak in spring is likely to be related to the fisheries operating out of the Thames Estuary which target fish that migrate into the estuary to spawn as water temperatures increase. In the autumn, adults move offshore again, hence increased landings at this time.

3.1.4.4.5 Cod

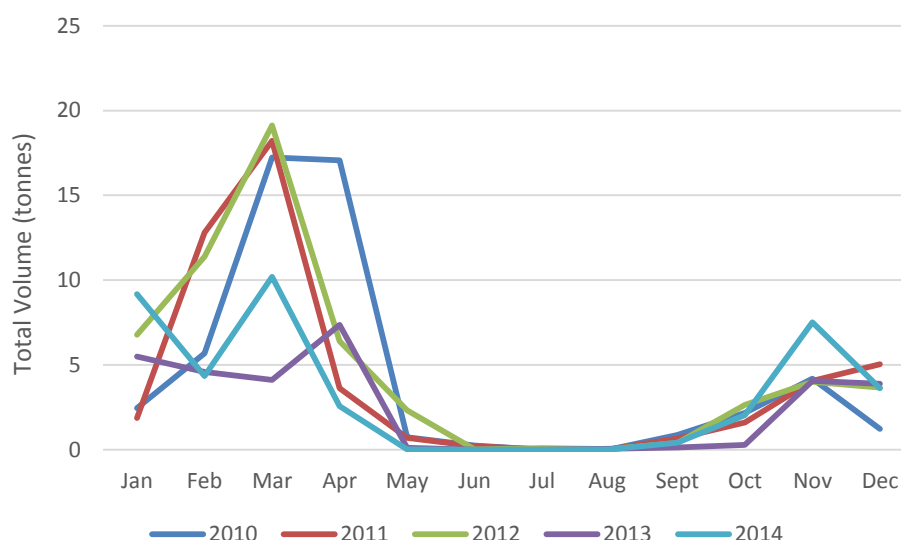


Figure 82: Volume of cod (*G. morhua*) caught in 31F1 and recorded as landed in Whitstable, Herne Bay, Margate, Broadstairs, Ramsgate, Deal and Dover.

Landings data show cod to be a very seasonal fishery in the study area. Cod landings show a distinct correlation with the colder months; they drop off sharply in March. Larger mature cod migrate down from the colder Scandinavian waters to join the smaller immature cod which have remained around the UK all year long. They leave again to colder waters in the spring.

3.1.4.4.6 Bass

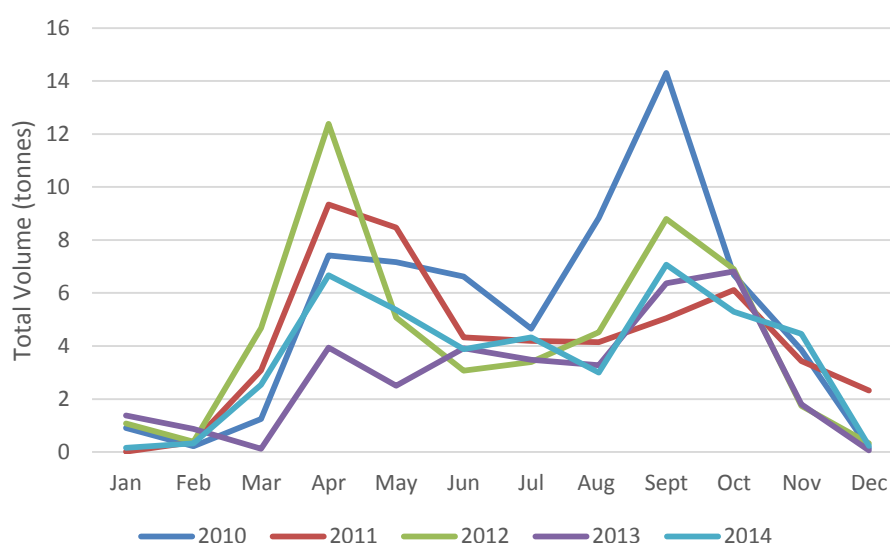


Figure 83: Volume of bass (*D. labrax*) caught in 31F1 and recorded as landed in Whitstable, Herne Bay, Margate, Broadstairs, Ramsgate, Deal and Dover.

Bass displays a peak in landings from March-April and from August-October. This may relate to increased fishing effort, changes in the abundance of bass, which are migratory, from year-to-year. Bass spend the colder months in deeper water which explains the low volume of landings in the winter months here seen in Figure 83. Bass is reported to be as a summer drift net fishery for many of the ports considered in this study²⁶.

3.1.4.4.7 Thornback ray

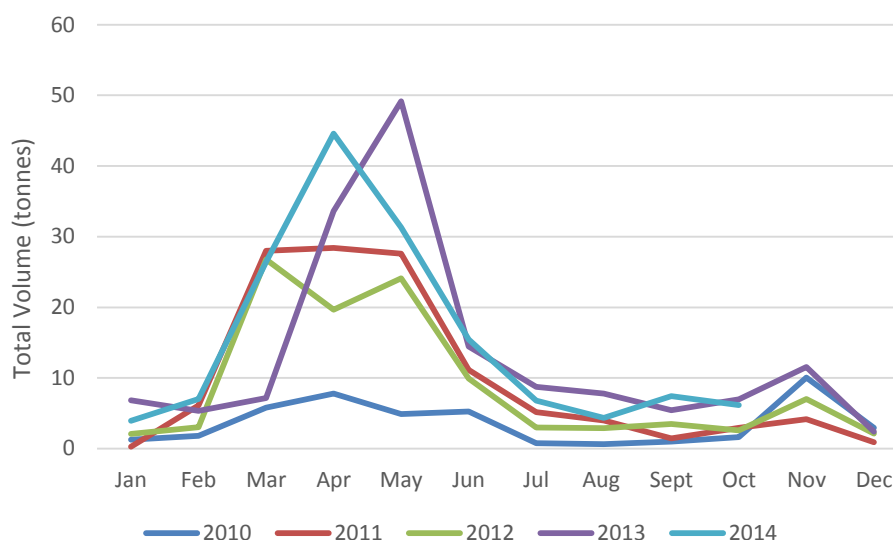


Figure 84: Volume of thornback ray (*R. clavata*) caught in 31F1 and recorded as landed in Whitstable, Herne Bay, Margate, Broadstairs, Ramsgate, Deal and Dover.

The commercial fishery for thornback ray shows distinct seasonality, with a peak in landings from March-May. Aside from lower landings in 2010, there is not significant variation between years. Adults undertake seasonal migrations, moving into shallower water during summer, and offshore in the winter¹⁷. Fishing reports from recreational and charter anglers also report 'spring runs of thornbacks'¹⁸, explaining the spring peak in Figure 84.

3.1.4.4.8 Skate and ray

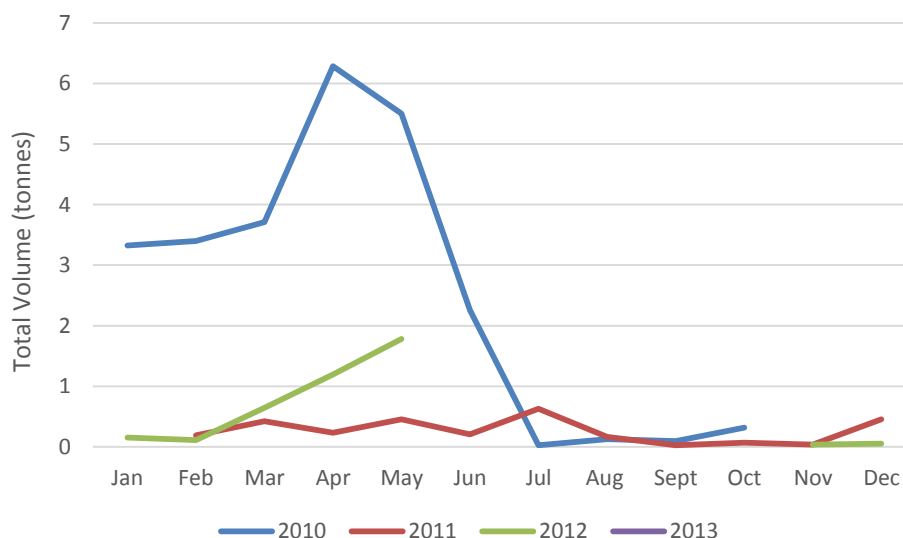


Figure 85: Volume of skate and ray caught in 31F1 and recorded as landed in Whitstable, Herne Bay, Broadstairs, Ramsgate and Deal.

There is significant annual variation in the landings of skate and ray to ports in the area. The variation may be due to a number of reasons including: sporadic fishing effort, skates and rays being taken as marketable by-catch species in demersal net and trawl fisheries and therefore having no specified target season, changes in data collection procedures, and multiple species being caught under the grouping 'skates and rays' also not having a specified season.

3.1.4.4.9 Smoothhound

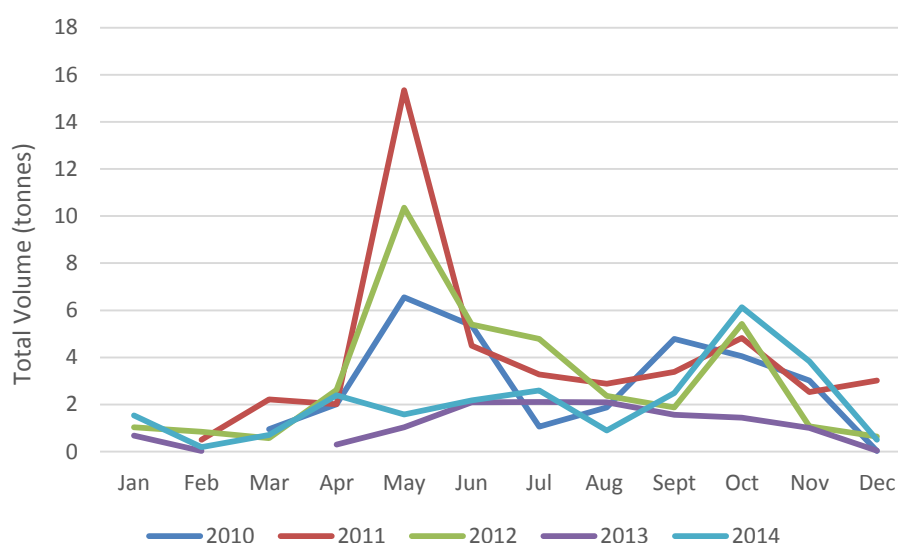


Figure 86: Volume of smoothhound (*Mustelus spp.*) caught in 31F1 and recorded as landed in Whitstable, Herne Bay, Margate, Broadstairs, Ramsgate, Deal and Dover.

Landings of smooth hound show peaks in May and to a lesser extent in October. The species moves inshore looking for peeler crabs as the weather warms and the crabs start to moult. Boat fishing on sand banks throughout the district produces good numbers of smoothhound in late April to late June, especially before the weed builds up. Most of these fish are large visiting pregnant females¹⁹.

Although some seasonality is seen, there is also annual variation in landings. 2013 does not show peak landing periods and other years show variation in the volume of landings in peak months. KEIFCA report an 'all year' season for smoothhound.



3.1.5 Management

The European Community (EC) is the legislative institution of the EU and administers fisheries management in all EU waters through its Common Fisheries Policy (CFP), in force since 1983. European legislation and the CFP apply within the respective member states' national waters, including within the 6nm limit. Through the CFP, the EC sets statutory measures for a variety of species, in partnership with ICES, which provides scientific advice on the state of stocks. These measures apply throughout the EU and create binding requirements for all EU Member States. The cornerstone of the CFP's regulatory approach is the system of Total Allowable Catches (TACs) and catch quotas, supported by technical conservation measures (gear restrictions, minimum landing sizes and closed areas), as well as decommissioning schemes to reduce fishing capacity.

The CFP sets quotas for each Member State that has fishing rights in the European Union waters. Each Member State is given a quota based on the total available (TAC) and the traditional share the Member State has received in previous years. After the quota are fixed by the Council of Ministers, each EU Member State is responsible for policing its own quota. Basic regulations stipulate that each Member State can use different management approaches, including licensing, limited entry to a fishery, individual vessel quotas and so on. Catches and landings must be recorded and regulations govern what fishing gear can be used in shared waters.

The MMO, is an executive non-departmental public body, established on the 1st April 2010 given powers under the Marine and Coastal Access Act 2009. The MMO is charged with quota management responsibilities in England and divides up England's fishing quotas across the 3 fishing industry groups:

- Sector – fish Producer Organisations (POs) that manage quota for their members
- 10-metres-and-under pool – vessels 10 metres or under that are not members of a producer organisation
- Non-sector – vessels over 10 metres that are not members of a POs

The number of fixed quota allocation (FQA) units held by the individual vessels in each group, or by a group collectively, establishes what proportion of the EU quota is allocated to each group.

The quota assigned to the non-sector and 10-metre-and-under pools may be adjusted in line with underpinning arrangements – this is where there are guaranteed minimum levels of allocated quota. The minimum level for each stock will be a percentage of the UK quota equal to the average percentage share of initial allocations made to the 10-metres-and-under fleet from 1991 to 1993.

For vessels over 10 metres, FQA units are associated with the licence of the vessel. For vessels 10 metres and under, FQA units are held centrally by MMO.

The study area lies within ICES rectangle 31F1, close to the southern end of ICES Area IVc, southern North Sea, near the border with ICES area VIId, eastern English Channel. The TAC for 2015, for the species of commercial importance caught in these ICES areas are provided below in Table 8.

Table 7: 2015 Total Allowable Catches (TAC). Source: EC.

Stock	2015 TAC
Cod (VIId)	1701
Cod (IV)	29,189
Plaice Channel (VIId,e)	4787
Sole Eastern Channel (VIId)	3483
Sole (IV)	11,900
Skates & Rays (VIId)	798
Skates & Rays (IIa & IV)	1256
Haddock (IV)	40,711
Whiting (IV)	13,678
Saithe (IV)	66,036
Plaice (IV)	128,376
Mmo Turbot and Brill (IV)	4642
Lemon Sole and Witch (IV)	6391
Dab & Flounder (IV)	18,434
Sandeel (IV)	0
Spiny dogfish (IV) (VII)	0

Although bass is currently not subject to a TAC, new regulations have come into force²⁰.

Permanently closed areas: you must not catch, retain (keep), tranship (transfer fish from one vessel to another while at sea) or land bass from the following areas: ICES VIIb, VIIc, VIIj and VIIk, and outside the 12 nautical mile limit of ICES VIIg and VIIa. This is not likely to affect fishermen in the study area.

Commercial fishing restrictions:

From the 1st January 2016 to the 30th of June 2016 in the North Sea and Channel demersal trawls and seines can retain up to 1% bass as by-catch. Fixed nets, hooks and lines can have up to 1300kg of bass per vessel per month except February and March. All other gear types, including drift nets are excluded. This will affect fishermen in the study area.

From the 1st of July 2016 to the 31st of December 2016 in the same area, demersal trawls and seines can retain up to 1000kg of bass per vessel per month. Fixed nets, hooks and lines can retain up to 1300kg of bass per vessel per month. All other gear types can retain up to 1000kg of bass per vessel per month.

Landing obligation:

This currently only applies to pelagic fisheries (the demersal landing obligation will not apply to bass in 2016). If a fisher targets pelagic fisheries with pelagic gear then they must land all the bass caught unless they are operating in an area where commercial fishing for bass is prohibited, in which case you may not keep any bass caught; it must be discarded.

The quota system in England is complex, as the distribution, availability over the course of the year, variable popularity across different stocks and role as part of a mixed fishery, make it difficult for the various fleets operated to the quota system to fully exploit the value of the

quota available to each licensed vessel. As a result, proportions of quota are often not fully used, which has led to a system of quota swaps between POs and the 10-metre and under fleet to redistribute or lease quota to areas where it can be utilised.

Partly as a result of the complexity of the quota system, non-quota species, i.e. those species that are not subject to a TAC, are increasingly important to fishers, particularly those operating in nearshore waters where the diversity of catch contributes to remaining economically viable. Non-quota species of importance in the study area include shellfish (notably whelk, lobster and crab) and smoothhound, which are subject to management control via minimum landing sizes and for bass, bag limits.

Within territorial waters (from the baseline to the 12nm limit) the member state is entitled to develop its own management regime for inshore fisheries. In England, the Fisheries Directorate of the Department for Environment, Food and Rural Affairs (DEFRA) is responsible for managing sea fisheries and the marine environment and ensures that all relevant EC and national fisheries regulations are enforced.

DEFRA is supported in its fisheries management role by the MMO which is charged with quota management responsibilities in England. The MMO co-ordinates an enforcement programme for monitoring, control and surveillance of all sea fishing activity within British fishery limits around the coast of England, and UK vessels operating outside those waters. As defined in the Marine and Coastal Access Act 2009, MMO activities include marine planning, marine licensing, marine nature conservation, fisheries management, enforcement and response to marine emergencies.

Within fisheries management, the MMO has a range of functions which includes:

- managing European funding schemes,
- licensing of English fishing vessels in the inshore and offshore fleets,
- managing fleet capacity,
- managing fisheries quota allocations (to Producer Organisations and the non-sector fleet) and monitoring quota uptake,
- enforcing fisheries rules to ensure compliance with CFP regulations, and
- collecting, coordinating and providing information on the UK's fishing fleet capacity, effort and economic data, based on catches and fishing activity from fish markets, merchants, fishing logbooks, landing declarations and sales notes.

In English inshore waters, the MMO works closely with the respective Inshore Fisheries and Conservation Authorities (IFCAs), which replaced the Sea Fisheries Committees in April 2011. In context of the proposed dredging operations, the study area falls within the Kent and Essex IFCA (KEIFCA) jurisdiction, which includes an office in Ramsgate.

IFCAs are funded through central government and local authorities, and their duties and powers are set out in sections 153 to 158 of the Marine and Coastal Access Act 2009. Each IFCA provides the regulatory framework for fishing activities within a district that covers part of the English coast going out to 6 nautical miles with its inland boundaries aligning with those of its constituent local authorities. Each IFCA is granted powers under the Sea Fisheries Regulation Act (1966) and subsequent amendments to make byelaws to conserve fish stocks, regulate fishing activities, and ensure marine environmental protection in

connection with fishing activities within their District. These regulations are made by a Committee made up of representatives from the relevant local authorities, representatives from the MMO, Environment Agency and Natural England, and local people with experience and expertise in the inshore marine area, such as commercial fishers and recreational anglers, and marine environmental experts.

KEIFCA's jurisdiction covers an area of over 3,412 km², and extends from the east end of Rye Bay in Kent to the northern boundary of Essex on the River Stour. The seaward boundary follows the 6 mile nautical limit measured from the 1983 baseline, which, due to drying sand banks, extends up to 15 miles offshore in some places. The up-river KEIFCA boundary in the Thames includes the waters adjacent to Kent County Council and Thurrock Council, with the district boundary running from Dartford creek (River Darent) on the south shore to Mar Dyke on the North Shore. The other district limits for the rest of the rivers located within the boundaries of Kent and Essex extend to their tidal limit (including, the Medway, the Blackwater and the Colne).

The KEIFCA ensures that the local byelaws, stipulating vessel length restrictions, fishing instrument regulations and various other input controls are complied with. Examples of KEIFCA byelaws²¹ include the following:

- Gear alterations, such as escape gaps on parlour pots,
- Restrictions on the mesh sizes of mesh trawl nets,
- Minimum landing sizes for several fish and shellfish species.

3.2 CHARTER

Chartered sea angling is a popular hobby in UK and the urban conurbations of South East England provide a large market for the Kent and Essex ports. Preliminary investigations were carried out in July 2015 including a brief telephone survey of charter angling vessel skippers from Ramsgate, Deal, Dover and Folkestone. A series of further, constructive interviews with members of the charter fishing industry were conducted in January 2016 following the same format as commercial fishing interviews (see Appendix 2). 9 charter skippers were interviewed, providing data from which to estimate the seasonality of this activity and the species targeted. Chartered fishing activity is subsequently characterised below.

3.2.1 Fishing effort and fleet characteristics

Charter fishing vessels ranged in size from 9-17m but most fall within the 10-12m category. All vessels operated rod and line gear using bait, lure or fly fishing techniques and the majority of vessels have a single skipper as crew. Skippers are experienced fishers, reporting to have fished for 9-49 years.

Typical charter fees are £35-40 per person per day depending on whether trips are on a weekend or a weekday. For a group (of 10-12) people skippers charge around £400-450 for an 8h day trip. Trips can be for fishing but skippers also reported to take customers out on seal watching trips. Average reported turnover from charter angling was £30,000 per annum, within a range of £20,000 to £60,000.



Figure 87: typical charter boat. Image is of Skerry Belle moored in Ramsgate harbour²²

Days worked are heavily dependent on weather with anglers unenthusiastic to go out in high winds and rough seas. A successful charter vessel might work between 100 and 150 days a year, over all months but with a reduced activity in the winter. Vessels generally come from Ramsgate, Sandwich, Deal, Dover and Folkestone¹³. Skippers interviewed were from

²² Image from: <https://www.charterboats-uk.co.uk/skerrybelle-ramsgate/> [Accessed 01.07.2015].

Ramsgate and Dover. Figure 20 on the next page maps the extent of fishing activity by port as reported in consultations. The colours change from yellow to brown to indicate increasing overlaps between reported fishing areas.

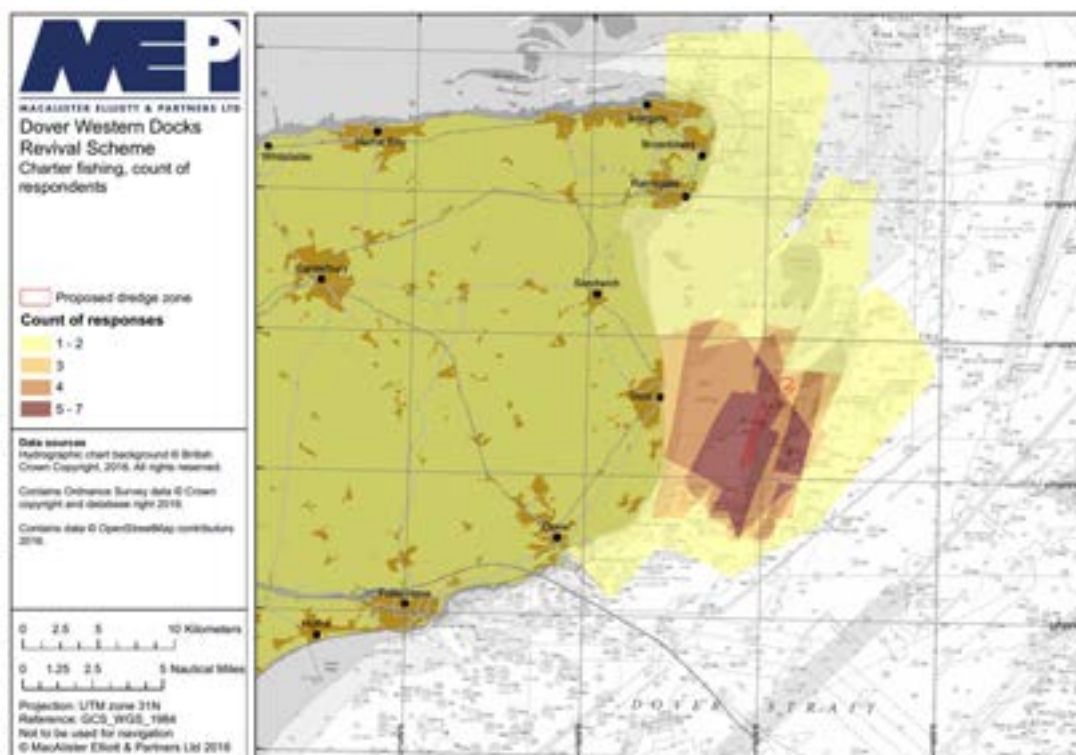


Figure 88: Heat map of overlapping charter fishing grounds (polygons obtained from digitised images of fishing grounds provided by interviewed vessel owners).

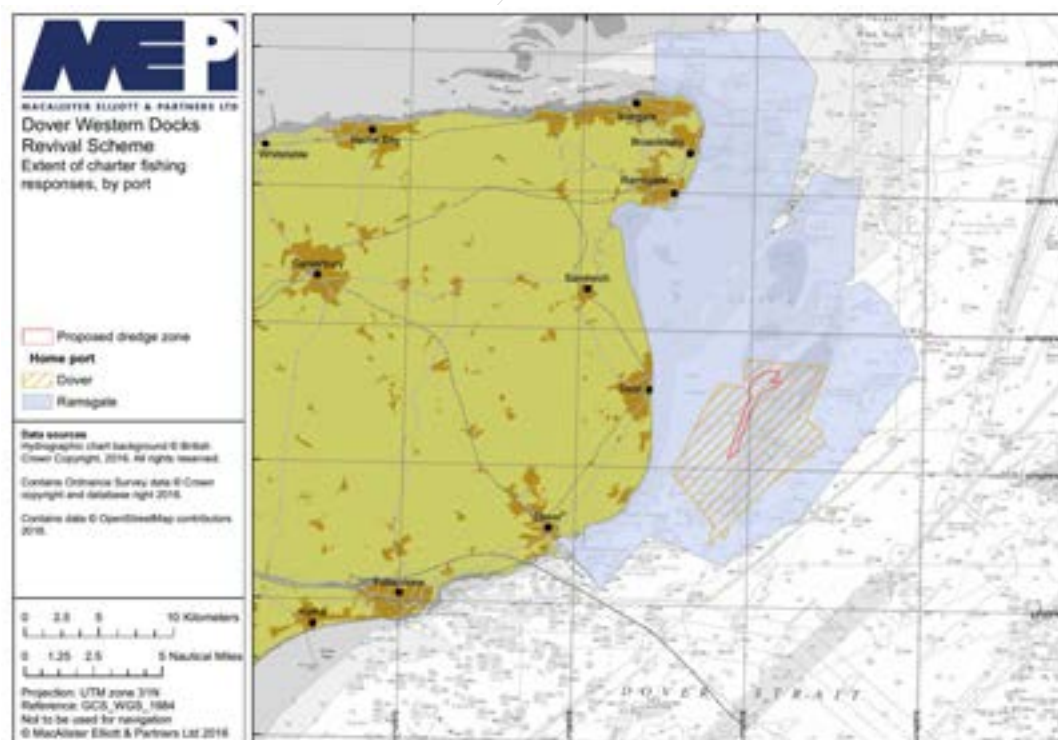


Figure 89: Heat map of overlapping charter fishing grounds (polygons obtained from digitised images of fishing grounds provided by interviewed vessel owners).

Charter angling grounds are wide ranging due to the diverse target catch, particularly shown by vessels from Ramsgate. Ramsgate anglers are reported to concentrate mainly on the edges of the Goodwin Sands, the Banks themselves being described by commercial, charter and recreational fishers as suggests otherwise. Activity on the edges of the Sands has been described as ‘very intense’, particularly around wrecks²⁵. Here, drift net fishing takes place as well as rod and line angling. Skippers commented that they visited the Goodwin Sands on around 30% of their trips.

Trinity Bay in the south west has been reported to be the most popular for charter boat fishing and also north-east to south of Goodwin Buoy. Many of the Dover and Folkestone vessels fish the waters off Dungeness and off the wrecks in the Channel.

3.2.2 Species and seasonality

Interviewed charter fishers were asked which species made up the greatest proportions of their catch. On average, skate made up 36% of a charter vessel’s annual catch, cod 24%, plaice 22% and bass 19% (Figure 22).

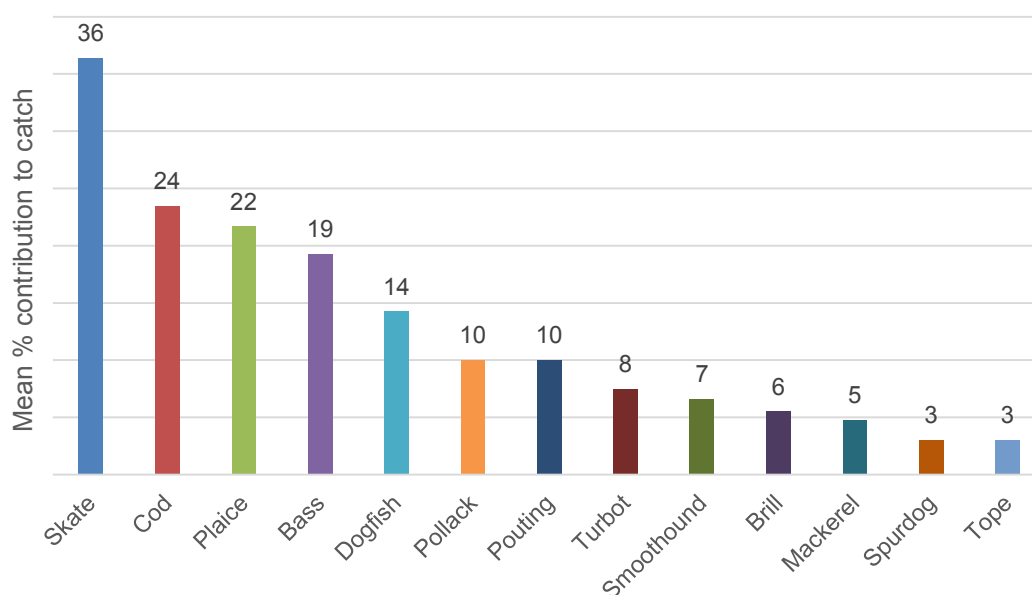


Figure 90: Mean % contribution of target species to annual charter angling catch. Number of fishers interviewed = 9.

The main species caught on the grounds around the Goodwin Sands include skate, smooth hound, bass, thornback ray, dogfish, herring, mackerel, cod, whiting and grey mullet. Most of these were recorded during interview.

Skates and rays: these species generally stay in water under 100m deep and in summer they will come into shallower inshore water and within the range of the sea angler. Generally though, they are present all year round.

Cod: being a cold-water species cod are much more common around the UK in autumn and winter, although some remain around the UK all year, especially the smaller specimens.

Bass: this species spends the colder months in deeper water and the summer sees them coming within range of the shore angler as they feed on sprats, sand eels and smaller mackerel.

Dogfish: present all year round

Smoothound: present all year round.

Herring: present all year round

Mackerel: this species are migratory and come to the UK in spring and early summer, when they will feed actively and then migrate to warmer seas in the autumn months to spawn, during which time they will feed little

Whiting: this species move within range of the shore angler in autumn and generally stay until late winter. Bigger whiting of 1-2lb become more common in inshore waters closer to Christmas, and by late March the whiting have begun to move out to sea again to spawn again. Smaller whiting may stay in coastal waters all year round.

Grey mullet: Mullet are usually found in schools inshore often in estuaries or in marinas and harbours feeding on algae, small invertebrates and detritus during the warmer summer months but reducing feeding effort during colder winter month.

Charter fishers reported that most species are caught all year round, with bass being targeted more in the summer months and cod in the winter months (Figure 23).

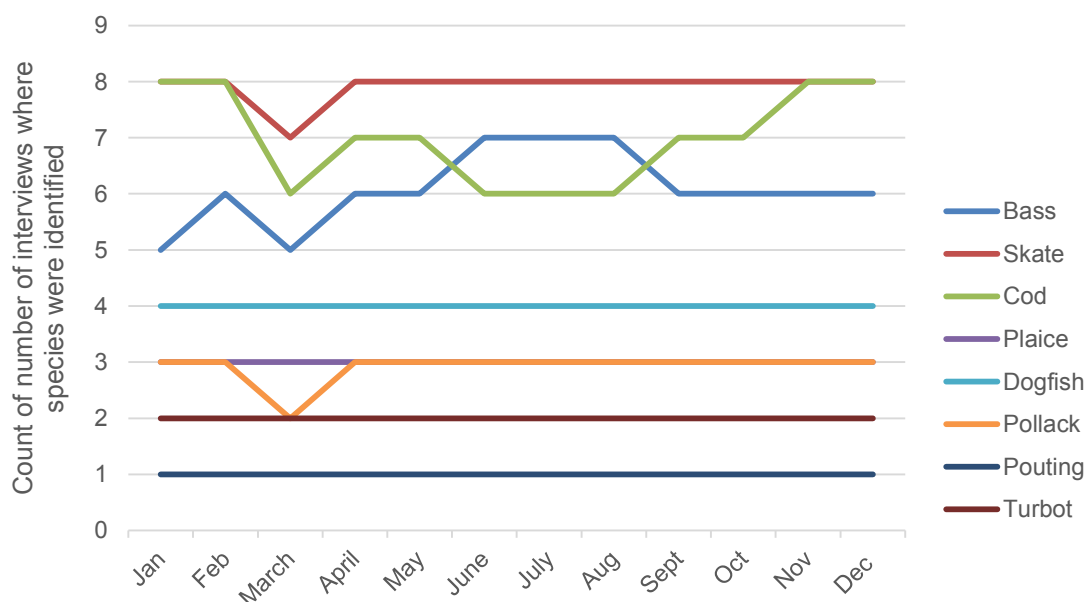


Figure 91: The seasonality of the top 8 targeted species reported in consultation with charter fishers. The values derived represent the count of times species were noted as present in fishers catch compositions during interviews.

3.2.3 Management

Charter angling vessels are regulated for safety by the MCA and fish landed are prohibited from being sold commercially. Minimum landings sizes²³ do apply and all fish caught below these sizes must immediately be returned to the sea:

Smoothound: 51cm

Bass: 42cm

Additional management measures apply to bass. In areas IVc and VIId, from the 1st of January 2016 to the 30th of June 2016, recreational fishers must catch and release only. From the 1st of July 2016 to the 31st of December 2016, recreational fishers are allowed 1 bass per fisher per day. This applies to vessel or shore fishing²⁰.

Dogfish: 38cm

Herring: 20cm

Mackerel: 30cm (North Sea) 20cm (other areas)

Cod: 35cm

Whiting: 27cm

Grey Mullet: 30cm

Plaice: 27cm

Sole: 24cm

²³ Numbers obtained from KEIFCA and British Sea Fishing.

3.3 RECREATIONAL

One recreational fisher was interviewed and a local KEIFCA board member representing this sector was asked questions similar to those asked to charter anglers. Information has also been gathered from previous Natural England consultations during the recommendation of the Goodwin Sands as a potential future MCZ.

3.3.1 Fishing effort and fleet characteristics

Recreational sea fishing in the study area takes place from the beach, piers and some privately owned vessels over the entire study area. This is an unregulated activity and it is therefore difficult to estimate the number of people or vessels participating in this sector.

There are a large number of sea angling clubs in the district, many of them organising shore-based competitions, and with large areas of sheltered water and plentiful marinas and slipways, the area also attracts many privately owned angling boats.

The recreational sea fisheries within the district are a valuable asset to the economy of the region, encouraging spending on tourism and leisure as well as providing a useful recreational activity for many people, bringing them into contact with the marine environment.

There is no licence required to fish in the sea recreationally and anyone can do so in accordance with local bylaws or restrictions. There are over 150 fishing and tackle shops in Kent and Essex.

In terms of the numbers of vessels, observations have revealed that at least 30 private angling vessels operate from Folkestone, and at least 5 from Dover. There are a similar number of vessels in Ramsgate. In Herne Bay, a small fleet of trailer-launched boats use rod and line mainly in summer for bass and rays for recreation or semi-commercially²⁶.

Recreational fishing vessels are generally less than 11m overall length, and many are significantly smaller, which limits their range. The gears used are similar to those mentioned for charter angling (Section 3.2.1).

Fishing effort is extremely variable and is dependent on weather, tide, employment and spare time, thus the number of days fished could vary greatly. Recreational fishers will sometimes pay around £35-45 for a day's angling on a boat, and sometimes £1.50 to fish off a pier or jetty, or from a beach or their own boats. It is illegal to sell their catch, although there are reports of some fishers selling lucrative catches of bass.

Consultations indicate that recreational vessels do not generally fish on the Goodwin Sands, except on very calm days due to their limited range. It is reported that vessels from Ramsgate are more likely to visit the Goodwin Sands than those from Folkestone and Dover. Recreational anglers are reported however, to heavily fish the wrecks on the edges of the Sands and will anchor up current and drift the bait down current over the wreck²⁵. Note that

recreational fishers are likely to be a main client base for chartered skippers and therefore fishing areas important to skippers will be important to recreational fishers.

3.3.2 Species targeted

Recreational anglers target similar species to the commercial angling (line gear) vessels. Preferred species include table fish such as mackerel (*Scomber scombrus*), herring (*Clupea harengus*), cod (*Gadus morhua*) and bass (*Dicentrarchus labrax*). In addition smooth hound (*Mustelus spp.*), skate and rays²⁴, grey mullet (*Chelon labrosus*) and Dover sole (*Solea solea*) are sought after.

Recreational anglers are reported to catch undersized or juvenile mackerel for to use as bait for bass fishing²⁵.

Seasonality:

See Section 3.2.2.

Dover sole: these species tend to live in deeper water in the winter but come into shallower water to feed and spawn when the weather warms up in spring.

3.3.3 Management

Existing regulation includes minimum landings sizes (see Section 3.2.3), the bass limits²⁰ and the prohibition on selling catches.

²⁴ See: <http://britishseafishing.co.uk/fish-species/skates-and-rays/> for skate and ray species caught.

²⁵ Balanced Seas Essex/Thames/ North Kent Local Group Third Meeting (2010): http://www.thamesweb.com/component/docman/doc_download/105-local-group3-meeting-report?Itemid=61. [Accessed 07.07.2015].

4 SOCIO-ECONOMICS

4.1.1 Numbers of people directly and indirectly employed by the industry

As the numbers of people employed indirectly and directly by the fishing industry in such a large study area are great, a full socio-economic profile is not possible as part of this EIA. However, estimates have been based on consultation with the Kent and Essex IFCA and previous analyses by Royal HaskoningDHV⁹ and CEFAS²⁶.

In summary, it is estimated that there are around 40-65 vessels from the adjacent ports fishing on and around the Goodwin Sands²⁷ on either a full or part time basis, with around 1-3 fishers per vessel. These estimates are based on the information provided below.

Ramsgate is the most significant port in terms of proximity to the study area and in terms of volume and value of landings when compared to other local ports. Ramsgate has the largest fleet of netting boats on the Kent and Essex coast, comprising 28 (mostly full time²⁶) vessels. The fishers on these vessels are generally owner/operators⁹, and land in the region of £1.9m per annum (2014 MMO data). Crew are paid as share fishers, receiving around 25% to 27% of gross vessel earnings. This arrangement has altered in recent years in favour of the crew, as previously various operating costs were removed before shares were calculated⁹. As seen in the wider UK fishing industry, this reflects a growing demand for experienced crew that are properly qualified in first aid, sea survival etc., as well as competition with other marine and non-marine sectors⁹.

There are reported to be combination of full and part-time fishermen operating out of each port²⁶, but it appears that many are now moving to full-time activity due to pressures to move towards targeting several species to remain viable. See Section 3.1.2.2 for the numbers of estimated active vessels in all ports.

Ancillary industries associated with commercial fishing businesses extend upstream and downstream of fishing activity. Upstream activities include vessel and fishing gear manufacturers, boat yards, specialist marine engineers, marine electricians, joiners and others. Downstream activities include marketing, transport and trade, and processing and retailing. As a general rule of thumb it is generally accepted that for every fisher or worker at sea there are four jobs created on land.

Although landings to Ramsgate have not declined in recent years overall fishing in the south-east has reduced in scale. Consequently, some ancillary services have been lost, as has been seen in the wider UK fishing industry⁹. There has been very little investment in new vessels in recent years and any such purchases are likely to be direct from manufacturers throughout Europe, rather than through local companies. Other major expenditure, such as gear, is also likely to be direct from manufacturers. Smaller items may be purchased locally from chandlers, whose main business is from the recreational and charter angling sector⁹.

Fuel is purchased on a collective basis by the Thanet Fishers Association (TFA) and purchased individually from a fuel pump facility administered by the TFA. The Ramsgate vessels still require mechanical and electrical engineering expertise which may support several full time positions⁹.

There is no local auction market for fish landed at Ramsgate and no nearby auction market where the fish can be sold. Similarly, there is no local processing capacity, as most landings comprise whole prime fish, which is sold unprocessed, shellfish, which is sold live, or roundfish and dogfish, which is gutted at sea before sale. Much (90%) of fish landed is destined for the continent and the remainder is sent to London. 6 vessels have formed a company, Foreland Fish, to jointly market their fish which better ensures sufficient volume to supply customer demands and reduces transport costs⁹.

Overall, while the Ramsgate fleet itself does not support many additional full time positions in ancillary industries, it is an important part of the fisheries sector in the South East, which in turn supports a number of ancillary services.

4.1.2 The benefits of the industry on heritage and tourism

In the case of many English inshore fishing communities²⁸, tourism has become a major source of income and the most immediate route for improving their economic fortunes. This reality is often based on a community development approach of starting from the ‘assets’ that the area has – a seaside location, a harbour and the heritage to appeal to visitors. Fishing industry representatives are generally proud of their communities, viewing them as generally supportive, with a unique culture and ambience. A working port holds considerable attraction for residents and tourists, a fishing port particularly so. It is worth remembering that capture fisheries are the last hunting activity left in the mainstream human food chain and fishing boats are generally considered picturesque, which immediately presents the fishing industry as a tourist attraction.

Inshore fishing has a particularly important role because it is possible for people to gain closer access to the sights and sounds of fishing activity working from harbours that the public do not necessarily have to be excluded from. Tourism managers often describe fishing as being ‘iconic’ of an area – featuring in publicity for a resort - and adding to its attraction whilst people are visiting, a role that is crucial in many communities.

Ramsgate is a large port with vessel slipping and repair facilities so fish landings are not immediately visible to the passer by. It appears from scoping visits that most of the catch is sold to traders and wholesalers. Despite this, some of the local restaurants do offer “catch of the day” and there are pavement cafes and waterfront bars. During consultation, charter fishermen also highlighted the importance of the charter industry in supporting local businesses. For example, in the summer, charter fishing companies will often collaborate

with local pubs where customers are taken out on 8 hour day trips and return to a meal on the waterfront.

There are also trawler races, mock battles and seafood competitions that take place here to entertain residents and visitors in the summer months which help to promote the fishing heritage of these coastal towns. Boat trips also operate from Ramsgate harbour offering full or half day fishing activities or seal and wildlife watching tours. These boats are often skippered by fishers.

Deal's fishing vessels are clearly visible to residents and visitors alike, pulled ashore on the narrow cobble beach adjacent to the centre of town. Beach and pier fishing are also popular in Deal and several advertisements for fishing trips were seen on scoping visits (Figure 73).



Figure 92: Fishing trip advertising in Deal. Image: MEP.

At Folkestone, part of the harbour is dedicated to fishing and has several buildings related to the industry, including cold stores, retail outlets and processing plants for the Folkestone Trawler Company. Restaurants, pubs and fish and chip shops are all in close proximity to this area of the harbour which forms the centre piece of an attractive area of docks which has been refurbished in recent years. This has directly benefitted from the local presence of the fishing industry. The adjacent area of the port contains charter and private angling vessels.

Being close to the dense populations of London and the South East, the district's recreational sea fisheries also attract visitors from further afield supporting businesses and livelihoods comprised of the many angling charter boats, bait-diggers, tackle shops and angling guides. There is a large number of sea angling clubs in the district and many of them organise shore-based competitions. With large areas of sheltered water and plentiful marinas and slipways, the area also attracts many privately owned angling boats. The recreational sea fisheries within the district are a valuable asset to the economy of the region, encouraging spending on tourism and leisure as well as providing a useful recreational activity for many people, bringing them into intimate contact with the marine environment.

In terms of a local market for the landed catch, much (90%) of fish landed is destined for the continent and Korea and the remainder is sent to London, so there is potential for more local

added value, for both fishers, tourism and local heritage. This could be in the form of more local fish markets, or seafood festivals, such as that held at Whitstable.

Appendix 1

Fisherman's associations consulted in the local area:

- Deal and Walmer Fishers's Association;
- Folkestone Fishers's Association;
- Hythe Fishers's Association;
- Margate Fishers's Association;
- Southern North Sea Inshore Fishers's Association;
- Thanet Fishers's Association; and
- Whitstable Fishers's Association.

Appendix 2

Appendix 2: Example of interview form

DWDR fisheries consultations (1)

Date:

Interviewer:

Number of Years fishing		Other occupations	
How many months a year fished?		Fishing grounds	Please note corresponding chart number:

Vessel length (LOA)		Gears operated	
Home port		VMS/AIS	
Number of crew			
If two vessels are owned please provide information for both vessels.			
Vessel length (LOA)		Gears operated	
Home port		VMS/AIS	
Number of crew			

Business turnover (estimated average over 3 years):

Associated businesses:

Buyers (i.e. French, English, local market names, buyers names):

Species targeted		Estimated % of annual turnover	Gear	Months fished
a				
b				
c				
d				
e				
f				
g				
h				
i				
j				

DWDR fisheries consultations (2)

Do you know about the proposed dredging activities?

Do you think it will directly interfere with your fishing activity?

Do you think it will indirectly interfere with your fishing activity?
Do you think maintenance traffic would interfere with your fishing activity?
Do you think the species you target would be affected by the dredging activities?
Do you think your earnings will be affected by the dredging activities?
If yes, what percentage of earnings do you estimate would be affected?
Do you have any other concerns about the dredging activities?



Appendix 3

Appendix 1: Registered and licensed vessels of 10 metres and under overall length listed in proximal ports to the study area

Home port	Port letters and number	Vessel name	Fish producer organisation	Length (m)	Tonnage	Engine Power (kw)	Year Built	Shellfish Licence (Y/N)
BROADSTAIRS	R4	RAINBOW CHASER	NON-SECTOR	7.3	1.97	32	1978	Y
DOVER	DR174	MISTRESS	NON-SECTOR	4.56	0.63	19	1991	N
DOVER	FE371	DENISE	NON-SECTOR	5.06	1.31	10	1966	N
DOVER	DR170	MARINER III	NON-SECTOR	7.4	4.3	119.36	1989	Y
DOVER	DR161	SAPPHIRE	NON-SECTOR	7.5	4.7	30	1991	Y
DOVER	HH32	BOY LUKE B	NON-SECTOR	7.87	4.86	80	1979	Y
DOVER	DR110	MOSS ROSE	NON-SECTOR	8.2	5.54	67	1980	Y
HERNE BAY	FE25	TEDDIE BOY	NON-SECTOR	5.9	1.1	16.5	1983	N
HERNE BAY	R97	UPTIDE 4	NON-SECTOR	5.9	0.89	29	2004	N
HERNE BAY	WH20	ALANDA	NON-SECTOR	8.7	4.24	170.6	2011	Y
HERNE BAY	RX43	SIMON ISAAC	NON-SECTOR	9.3	5.47	55	1989	N
MARGATE	R77	LINDY	NON-SECTOR	5.64	1.63	8		Y
MARGATE	R94	RAZORBILL	NON-SECTOR	8.5	5.99	131	1989	Y
MARGATE	R80	ENDURANCE	NON-SECTOR	9.32	9.85	82	1982	N
RAMSGATE	R19	KEZZA	NON-SECTOR	4.4	0.82	22.1	1991	N
RAMSGATE	R491	OZ 5	NON-SECTOR	4.65	0.74	6.7	2000	N
RAMSGATE	R53	SALLY	NON-SECTOR	4.92	0.82	11	2000	N
RAMSGATE	R492	LITTLE RED	NON-SECTOR	5.2	0.91	9	1973	N
RAMSGATE	DR179	SEABREEZE	NON-SECTOR	5.39	0.97	8.95	1975	N
RAMSGATE	R264	CHIPS	NON-SECTOR	6.07	0.84	7	1982	N
RAMSGATE	R5	JO-ANN	NON-SECTOR	6.1	1.36	13.42	1988	N
RAMSGATE	R1	BUMBLE	NON-SECTOR	6.5	1.09	36	1991	Y
RAMSGATE	DR173	NEW VENTURE	NON-SECTOR	6.77	1.19	124	1997	Y
RAMSGATE	R489	SUNTAN	NON-SECTOR	7.6	2.23	96	1985	N
RAMSGATE	WY223	SOLITAIRE	NON-SECTOR	7.96	3.08	36	1982	Y
RAMSGATE	R488	ROSEANNE	NON-SECTOR	8	1.82	36	1985	Y
RAMSGATE	DR104	DAWN DIVER	NON-SECTOR	8.1	5.26	27	1985	Y
RAMSGATE	DR165	OUR KATE	NON-SECTOR	8.7	4.98	67	1991	N
RAMSGATE	R11	FAIRWIND	NON-SECTOR	8.83	3.74	59	1983	Y
RAMSGATE	R467	DEFIANT	NON-SECTOR	9.8	7.91	111.9	1997	Y
RAMSGATE	R8	HOLLADAYS	NON-SECTOR	9.85	4.84	89	1977	Y
RAMSGATE	R490	SARAH RAY	NON-SECTOR	9.95	9.54	91.2	2009	N
RAMSGATE	FE69	PROGRESS	NON-SECTOR	9.95	11.35	127	1989	Y
RAMSGATE	R480	BOY JOSHUA	NON-SECTOR	9.96	14.47	111	1982	Y
RAMSGATE	SM47	KATY B	NON-SECTOR	9.96	9.43	112	1987	Y
RAMSGATE	DR167	STELLA MARIS	NON-SECTOR	9.98	12.1	117	1981	Y
RAMSGATE	R31	DELTA STAR	NON-SECTOR	9.98	8.8	201	1999	Y
RAMSGATE	F38	JACKO-IV	NON-SECTOR	1.41	18.6	19.37	1992	N

RAMSGATE	YH481	SOLAR STAR	NON-SECTOR	9.98	10.23	120	1980	Y
RAMSGATE	R471	PREDATOR	NON-SECTOR	9.99	6.73	160	1999	Y
RAMSGATE	RX447	OUR RUBY	NON-SECTOR	4.9	0.68	7.3		N
RAMSGATE	RX53	EVIE ROSE	NON-SECTOR	9.99	14.95	102	1995	N
WHITSTABLE	R61	CHRISDIAN R	NON-SECTOR	5.06	0.83	29.4	2000	Y
WHITSTABLE	RX71	HOPE	NON-SECTOR	5.2	0.83	29	1988	N
WHITSTABLE	DR122	BOY LUKE	NON-SECTOR	7.54	2.16	54	1990	Y
WHITSTABLE	PW458	ORIENT	NON-SECTOR	8.4	5.75	96	1988	Y
WHITSTABLE	R3	MISTY	NON-SECTOR	9.5	4.45	59	1979	Y
WHITSTABLE	HL1054	SUVERA	NON-SECTOR	9.8	11.35	101	1992	Y
WHITSTABLE	BM479	LISA K	NON-SECTOR	9.82	7.97	80	1973	N
WHITSTABLE	LI114	LISA MARIE OF ARUN	NON-SECTOR	9.87	5.61	84	1978	Y
WHITSTABLE	FE60	BOY BEAU	NON-SECTOR	9.95	12.48	122	1995	N
FOLKESTONE	FE381	CATCH 22	NON-SECTOR	5.1	0.73	6	1999	N
FOLKESTONE	FE63	JACQUELINE	NON-SECTOR	9	4.66	89	1983	Y
FOLKESTONE	P40	SAMALLEN	NON-SECTOR	9.26	8.52	89	1975	N
FOLKESTONE	FE137	VIKING PRINCESS	NON-SECTOR	9.86	11.67	103	1995	Y
FOLKESTONE	FE20	VALENTINE	NON-SECTOR	9.9	11.82	100	1999	N
FOLKESTONE	FE74	PETER PAUL	NON-SECTOR	9.9	7.64	89	1989	Y
FOLKESTONE	HL16	LADY PATRICIA	NON-SECTOR	9.94	8.41	89	1984	N
FOLKESTONE	WO4	BOY CALLUM	NON-SECTOR	9.98	13.66	110.5	1989	Y

Appendix 3: Registered and licensed vessels of over 10 metres overall length listed in proximal ports to the study area

Home port	Port letters and number	Vessel name	Fish producer organisation	Length (m)	Tonnage	Engine Power (kw)	Year Built	Shellfish Licence (Y/N)	Scallop Licence (Y/N)
DOVER	FE50	ROYAL CHARLOTTE	NON-SECTOR	11.24	10.63	65	1976	N	N
WHITSTABLE	F165	CARDIUM II	NON-SECTOR	13.95	23.28	112	1993	N	Y
WHITSTABLE	F52	OLY-RAY	NON-SECTOR	13.95	18.76	69.37	2002	N	N
WHITSTABLE	BM116	OUR SARAH JAYNE	NON-SECTOR	14.02	28.24	143	1973	N	Y
WHITSTABLE	BM114	SEIONT A	NON-SECTOR	16.99	38	145	1968	N	Y
FOLKESTONE	FE75	ROWENA	NON-SECTOR	10.64	11.68	94	1989	Y	N
FOLKESTONE	FE385	CHARLES EDWARD	SOUTH WESTERN FPO LTD	14.95	23.4	180		N	Y
FOLKESTONE	KY279	WINAWAY	THE FIFE FPO LTD	11.4	20.99	179	1988	N	N

Appendix 4

Appendix 2: AIS data mapped for the study

Date	Name	Name	Length (m)	Width (m)	MMSI	Lat	Long	Location	Status	Speed
02/06/2015	FV St Jaques 2	France	22	7	227138700	51.204445	1.674438	10nm east of deal	at anchor	5.6
02/06/2015	FV Sarah Ray	UK	10	5	235094386	51.330477	1.4223	ramsgate	Under way using engine	0.1
02/06/2015	Seiont A GUARD	UK	17	5	235001428	51.362770	1.02668	whitstable harbour	Under way using engine	0
02/06/2015	Wash Pilgrim	UK	12	4	235050574	51.363203	1.026772	whitstable harbour	Under way using engine	0
02/06/2015	Z56 Pieter	Belgium	24	6	205336000	51.476347	1.602180	north of thanet wind farm	Engaged in fishing	4.5
03/06/2015	FV Sarah Ray	UK	10	5	235094386	51.32791	1.421863	Ramsgate harbour	Under way using engine	7.9
03/06/2015	FV St Jaques 2	France	22	7	227138700	51.173978	1.639032	10nm east of deal	at anchor	9.5
03/06/2015	Seiont A GUARD	UK	17	5	235001428	51.49965	1.027418	8nm north of whitstable	Under way using engine	2.2
03/06/2015	Our Sarah Jayne	UK	15	5	235032001	51.504057	1.017727	8nm north of whitstable	Under way using engine	2.2
03/06/2015	Z56 Pieter	Belgium	24	6	205336000	51.391107	1.692682	just south of thanet windfarm	Engaged in fishing	5.5
04/06/2015	Emulate	UK	12	6	235007100	51.11346	1.47573	6nm east of Dover	Under way using engine	9.9
04/06/2015	FV Ludovic Geoffray	France	21	8	228227700	51.323615	1.713158	10nm east of Ramsgate	Engaged in fishing	8.8
04/06/2015	FV Mercator	France	23	7	227117600	51.172052	1.563987	6nm east of coastline	not defined	10.3
04/06/2015	FV Pascal	France	23	7	227141900	51.300122	1.68369	10 nm east of Ramsgate	Under way using engine	10.7
04/06/2015	FV Sarah Ray	UK	10	5	235094386	51.327525	1.42179	Ramsgate harbour	Under way using engine	8
04/06/2015	Wash Pilgrim	UK	12	4	235050574	51.377493	1.008883	anm north of whitstable harbour	Under way using engine	6.7
04/06/2015	Seiont A GUARD	UK	17	5	235001428	51.362783	1.02664	Whitstable harbour	Under way using engine	0
04/06/2015	Our Sarah Jayne	UK	15	5	235032001	51.36276	1.026725	Whitstable harbour	Under way using engine	0
04/06/2015	Z56 Pieter	Belgium	24	6	205336000	51.412283	1.702115	just east of thanet wind farm	Engaged in fishing	5.3
05/06/2015	Sam Allen	UK	10	4	235064152	51.071563	1.19043	just south of folkestone harbour	Under way using engine	6.4
05/06/2015	FV Sarah Ray	UK	10	5	235094386	51.327525	1.42179	Ramsgate harbour	Under way using engine	6.1
05/06/2015	Seiont A guard	UK	17	5	235001428	51.362783	1.02664	Whitstable harbour	Under way using engine	0
05/06/2015	Wash Pilgrim	UK	12	4	235050574	51.363173	1.0268	Whitstable harbour	Under way using engine	0
05/06/2015	Viking Princess	UK	10	4	235018274	51.118488	1.308385	Dover harbour	Under way using engine	0
09/06/2015	FV Sarah Ray	UK	10	5	235094386	51.33048	1.422305	Ramsgate harbour	Under way using engine	0
12/06/2015	VISION BF191	UK	22	7	235103134	51.130803	1.721175	15nm east of dover	Not defined	9.4
12/06/2015	FV LA SOUVERAINE	France	24	6	227104700	51.0961	1.56215	9nm east of Dover	Not defined	7.7

12/06/2015	FV Sarah Ray	UK	10	5	235094386	51.328152	1.421722	Ramsgate harbour	Under way using engine	7.8
12/06/2015	SEIONT-A GUARD	UK	17	5	235001428	51.442203	1.097012	just south of kentish flats offshore windfarm	Under way using engine	0.6
12/06/2015	WASH PILGRIM	UK	12	4	235050574	51.363173	1.0268	Whitstable harbour	Under way using engine	0
16/06/2015	FV Sarah Ray	UK	10	5	235094386	51.325787	1.432923	0.6 nm south east of ramsgate harbour	Under way using engine	7.1
16/06/2015	Viking Princess	UK	10	4	235018274	51.063643	1.199718	1nm southeast of Folkestone harbour	Under way using engine	6.7
16/06/2015	n79 warrior	belgium	24	6	205291000	50.762642	0.640493	6nm south east of hastings	fishing	10.4
16/06/2015	Seiont A GUARD	UK	17	5	235001428	51.442033	1.109502	Just south of kentish flats offshore wind farm	Under way using engine	2.5
16/06/2015	Z56 Pieter	Belgium	24	6	205336000	50.775243	0.732737	7nm south east of hastings	fishing	5.2
17/06/2015	FV Paxdei	France	24	6	227106400	51.040245	1.423773	6.4 nm southeast of dover	not defined	11.2
17/06/2015	FV Sarah Ray	UK	10	5	235094386	51.325512	1.430895	just east of ramsgate harbour	under way using engine	7.1
17/06/2015	SEIONT-A GUARD	UK	17	5	235001428	51.446263	1.099022	just south of kentish flats offshore farm	not defined	1.4
17/06/2015	Our Sarah Jayne	UK	15	5	235032001	51.363283	1.027588	Whitstable harbour	under way using engine	0
18/06/2015	FV Job Senior	Belgium	24	6	205191000	51.408003	1.762098	12nm northeast of broadstairs	fishing	5.4
18/06/2015	FV Mercator	France	23	7	227117600	51.235175	1.634300	12nm east of Deal	not defined	7.8
18/06/2015	FV Sarah Ray	UK	10	5	235094386	51.325198	1.42984	0.5 nm southeast of ramsgate harbour	under way using engine	7.7
18/06/2015	SEIONT-A GUARD	UK	17	5	235001428	51.41477	1.079262	3nm northeast of whitstable harbour	under way using engine	6.4
18/06/2015	FV Van Maerlant	Belgium	23	6	205261000	51.45407	1.734672	2nm north east of thanet windfarm	not defined	6.7
18/06/2015	Our Sarah Jayne	UK	15	5	235032001	51.362773	1.026735	whitstable harbour	under way using engine	0
18/06/2015	Z56 Pieter	Belgium	24	6	205336000	51.475462	1.598517	1nm north of thanet windfarm	fishing	6.2
19/06/2015	FV Sarah Ray	UK	10	5	235094386	51.32604	1.421615	ramsgate harbour	under way using engine	7.9
19/06/2015	Sam Allen	UK	10	4	235064152	51.07291	1.191218	1nm south of folkestone	under way using engine	3.2
19/06/2015	Viking Princess	UK	10	4	235018274	51.07037	1.410125	4.9 nm southeast of dover	under way using engine	1.7
19/06/2015	SEIONT-A GUARD	UK	17	5	235001428	51.3628	1.026667	whitstable harbour	under way using engine	0
22/06/2015	FV Le Marmouset 2	France	23	6	228108900	51.188958	1.716138	11nm east of deal	not defined	10
22/06/2015	Progress	UK	10	4	235079307	51.46076	1.666798	just north east of thanet wind farm	under way using engine	6.4
22/06/2015	FV Sarah Ray	UK	10	5	235094386	51.301003	1.615767	7nm east of ramsgate	under way using engine	3.9
22/06/2015	Christabel	UK	10	4	235069888	51.330142	1.421292	Ramsgate harbour	under way using engine	0
01/07/2015	Portia	UK	11	5	235102141	51.11266	1.336767	just south of dover harbour	under way using engine	18.4
01/07/2015	Louise Jane	UK	12	4	235040701	51.031492	1.438755	10nm southeast of folkestone	under way using engine	8.9
01/07/2015	Rowena	UK	10	4	235080623	51.069483	1.221788	1.4nm southeast of folkestone	under way using engine	8
01/07/2015	FV Sarah Ray	UK	10	5	235094386	51.329412	1.420585	ramsgate harbour	under way using engine	6.4
01/07/2015	Progress	UK	10	4	235079307	51.46076	1.666798	east of thanet wind farm	under way using engine	6.4

01/07/2015	Christabel	UK	10	4	235069888	51.329412	1.420585	ramsgate harbour	under way using engine	5.2
01/07/2015	Sam Allen	UK	10	4	235064152	51.07754	1.192922	0.5 nm southeast of folkestone	under way using engine	5
01/07/2015	Viking Princess	UK	10	4	235018274	51.117287	1.309773	Dover harbour	under way using engine	0.2

Appendix 14.1

Archaeological Desk Based Assessment

Executive Summary

Dover Harbour Board is proposing to dredge up to 2.5 million m³ of fine to coarse sand from Goodwin Sands to provide aggregate for land reclamation and berth construction required for the Dover Western Docks Revival scheme in the Port of Dover. Geophysical and ecological surveys were carried out in 2015 within an exploration area on the South Goodwin Sands. A proposed dredge area was refined with consideration to the avoidance of sensitive locations, including consideration of protected and charted wrecks.

This report details the results of a desk based archaeological baseline and impact assessment undertaken to inform the Environmental Impact Assessment (EIA) and resulting Environment Statement (ES) for the proposed scheme. The ES is submitted in support of Dover Harbour Board's application for a Marine Licence from the Marine Management Organisation (MMO).

The desk based assessment, including the assessment of geophysical data by Wessex Archaeology and consultation with key stakeholders, demonstrates the potential for archaeological material of high value to be present within the proposed dredge area.

Geophysical data indicates an east to west trending fluvial palaeochannel in the north of the proposed dredge area, cutting into the chalk bedrock. This palaeochannel has the potential to contain *in situ* prehistoric archaeological and palaeoenvironmental material. However, there will be **no impact** during dredging and a capping layer of an average 50cm of sand will be left overlying the chalk bedrock, including the palaeochannel.

Reworked prehistoric artefacts may be present within the overlying marine sand and potential impacts to these artefacts are judged to be of **moderate adverse significance**. If finds are brought to the surface via the dredging process they will be addressed through the marine aggregate industry archaeological reporting protocol. The application of the protocol, together with a programme of archaeological monitoring, will ensure that all identified prehistoric finds are recorded and provided with appropriate conservation, therefore reducing the impact to **minor adverse**.

Geophysical data demonstrates the presence of two wrecks and 20 further anomalies of uncertain origin and possible archaeological interest. In addition, there are four historic records of wrecks of possible archaeological interest with no corresponding geophysical anomalies, including the location of the designated *Admiral Gardner*. Due to the mobility of the sands it is assumed that these previously recorded wrecks are now buried. All identified wrecks and anomalies within the proposed dredge area will be avoided during dredging and therefore there will be **no impact**.

Outside the exploration area there are five further designated historic wrecks on Goodwin Sands (*Stirling Castle*, *Restoration*, *Northumberland*, *Roosjwick* and GAD 8) plus an additional wreck currently being considered for designation (GAD 23). The potential impact of dredging upon the stability of these sites was assessed using physical processes modelling undertaken by HR Wallingford. The results of modelling indicate that there will be **no impact**.

Goodwin Sands represents a major hazard to marine navigation and, as such, has perhaps the highest density of recorded shipping losses in the UK. As such there is high potential for the presence of further maritime archaeological sites and finds to be present buried within the sand, previously undiscovered. Similarly, although there are no known aircraft crash sites or findspots within the proposed dredge area, there is high potential for the previously undiscovered remains of crashed aircraft.

Impacts to previously undiscovered, *in situ* maritime and aviation sites are judged to be of possible **major adverse significance**. The impact to isolated artefacts that may be brought to the surface via the drag head is judged to be of **moderate adverse significance**. Further assessment of pre-dredge multibeam bathymetry data may help to identify any further wrecks that may be present. If impacts occur, however, the application of the protocol, together with a programme of archaeological monitoring, will ensure that further impacts are minimised and that all identified maritime and aviation finds are recorded and provided with appropriate conservation, therefore reducing the impact to **minor adverse**.

The historic seascape character of Goodwin Sands has been assessed as high value, primarily due to the perception of the sands as a major shipping hazard associated with numerous historic accounts of losses. The character also comprises submerged prehistoric landscape features, aircraft crash sites, commercial shipping, historic wreck sites, commercial fisheries, recreational activities, subsea cables and aggregate extraction. As this area has been subject to historic dredging activity there will be **no change** to this character from the proposed scheme.

The proposed dredge area is located between c. 5 and 6.5km offshore from the stretch of the Kent coast between Deal and Kingsdown. There are two scheduled monuments along this stretch of coast, the artillery castles at Deal and Walmer, and large numbers of listed buildings and undesignated heritage assets. Impacts to the setting of these heritage assets, and to the Goodwin Sands themselves, will be temporary and reversible and are assessed as being of no more than **minor adverse significance**.

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1 Introduction

Dover Harbour Board (DHB) is proposing to dredge up to 2.5 million m³ of fine to coarse sand and gravels from the sandbanks known as South Goodwin Sands, which are located offshore, approximately 12km north east of the Port of Dover. The proposed Goodwin Sands aggregate dredging scheme is a component of the wider Dover Western Docks Revival (DWDR) development, which will create a two berth cargo handling facility and new port-centric distribution facility at the Port of Dover.

In 2012, DHB gained consent for Terminal 2 (T2), a major proposal for a new second ferry terminal and marina development in the Western Docks, via the Dover Harbour Revision Order 2012 (the HRO). The DWDR scheme lies within the consented development for T2.

The proposed Goodwin Sands aggregate dredging scheme (hereafter referred to as 'the proposed scheme') will provide aggregate for land reclamation and berth construction required for the DWDR development. A full description of the proposed scheme is provided in **Section 2** of the Environmental Statement (ES).

This report details the results of a desk based archaeological baseline and impact assessment undertaken to inform the Environmental Impact Assessment (EIA) process and the resulting ES for the proposed scheme. The ES will be submitted in support of DHB's application for a Marine Licence from the Marine Management Organisation (MMO), which would authorise the proposed aggregate dredging, subject to minerals extraction permission being granted by The Crown Estate (TCE).

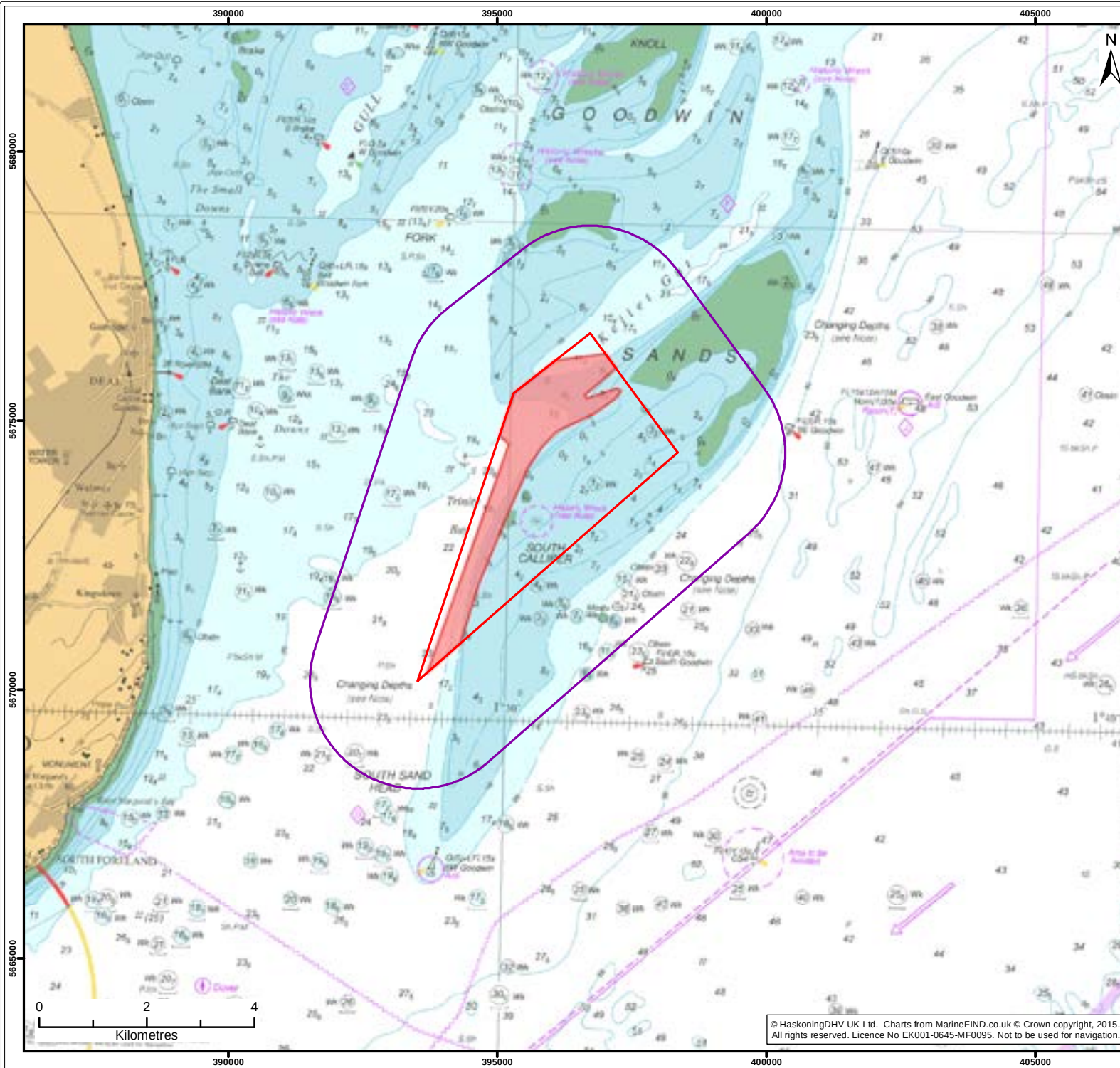
The desk based assessment considers the baseline historic environment (see **Section 6**) with regard to:

- Seabed prehistory (i.e. archaeological remains on the seabed corresponding to the activities of prehistoric populations that may have inhabited what is now the seabed when sea levels were lower);
- Maritime archaeology (i.e. the remains of boats and ships and archaeological material associated with prehistoric and historic maritime activities);
- Aviation archaeology (i.e. the remains of crashed aircraft and archaeological material associated with historic aviation activities);
- Historic seascape character (i.e. the attributes that contribute to the formation of the historic character of the seascape); and
- Coastal heritage (i.e. archaeological sites and historic buildings along the Kent coast that may be affected by the proposed scheme).

In addition, this desk based assessment examines the potential impacts to the baseline historic environment and proposes mitigation measures to avoid or reduce impacts (see **Section 7**).

2 Study Area

The proposed dredge area is located on the western side of South Goodwin Sands (**Figure 2.1**). It covers an area of 3.9km² and extends from the Kellet Gut channel south west along the western side of the South Calliper sandbank. Based on multibeam echosounder data collected in July 2015 (EGS International Ltd (EGS), 2015), the depth range within the proposed dredge area ranges from -4.3mCD to -25mCD.



Legend:

- Proposed Dredge Area
- Exploration Area
- NRHE and Kent HER Search Area

Client:	Project:
Dover Harbour Board	Goodwin Sands Aggregate Dredging Environmental Statement

Title:

Study Area

Figure: 2.1	Drawing No: PB2107/ES/035

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
01	12/01/2016	JS	DC	A4	1:100,000

Co-ordinate system: WGS 1984 UTM Zone 31N



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Geophysical and ecological surveys were undertaken in summer 2015 within an exploration area on the South Goodwin Sands (**Figure 2.1**). The proposed dredge area was refined based upon the results of these surveys and the following information sources:

- Geographic Information System (GIS) mapping of constraints including physical, ecological and socio-economic datasets;
- GIS mapping of available commercial fisheries data (e.g. data from vessel monitoring systems (VMS), automatic identification systems (AIS), aerial surveillance and Kent and Essex Inshore Fisheries Conservation Authority patrol records);
- Dredger operational constraints (e.g. vessel draught and water depth restrictions);
- The location of previous DHB dredging campaigns at South Goodwin Sands (see **Section 6.4**);
- Feedback from pre-scoping consultation with Natural England and Historic England; and
- EIA scoping responses.

The proposed dredge area was selected with consideration to the avoidance of sensitive locations identified by the above sources, including consideration of protected and charted wrecks.

In addition, a search for documented losses of wrecks and aircraft recorded by the National Record for the Historic Environment (NRHE) and the Kent Historic Environment Record (HER) was undertaken within a search area comprising the exploration area plus a 2km buffer.

The proposed dredge area, exploration area and NRHE and HER search area constitute the study area for this desk based assessment (**Figure 2.1**).

Additional consideration is given to heritage assets outside the study area including:

- Protected wrecks sites on Goodwin Sands, beyond the study area with respect to the assessment of potential changes to hydrodynamic and sedimentary process regimes, both locally and regionally; and
- Heritage assets on the Kent coast between Deal and Kingsdown with respect to the assessment of potential impacts to the setting of heritage assets.

3 Legislation, Policy and Guidance

The legislation, planning and policy context and EIA process relevant to the proposed dredging scheme is detailed in **Section 3** of the ES. Additional legislation, policy and guidance relevant to archaeology and the historic environment within the study area is presented below.

Legislation relevant to the protection and preservation of archaeological and historical remains within the study area is summarised in **Table 3.1**.

Table 3.1 *Legislation relevant to archaeology and the historic environment within the study area*

Legislation	Summary	Sites for consideration
Protection of Wrecks Act 1973: Section One	Wrecks and wreckage assessed to be of historical, archaeological or artistic importance can be protected by way of site specific designation. It is an offence to carry out certain activities within a defined area surrounding a designated wreck, unless a licence for those activities has been obtained through Historic England.	Six
Protection of Wrecks Act (1973): Section Two	This provides protection for wrecks that are designated as dangerous due to their contents and is administered by the Maritime and Coastguard Agency through the Receiver of Wreck.	None
Ancient Monuments and Archaeological Areas Act 1979 (as amended)	This Act is primarily used to protect terrestrial sites, but has also been used to protect underwater sites. Scheduled Monuments and Areas of Archaeological Importance are afforded statutory protection by the Secretary of State, and consent is required for any major works. The law is administered by Historic England and the Department of Culture, Media and Sport.	None
Protection of Military Remains Act 1986	Under the Protection of Military Remains Act 1986 the MoD can designate wrecks lost within the last 200 years, whose position is known, as 'controlled sites', and can designate named vessels lost on or after 4th August 1914 (Britain's entry into World War I), whose location is unknown, as 'protected places'. It is not necessary to demonstrate the presence of human remains for wrecks to be designated as either 'controlled sites' or 'protected places'.	Two aircraft, one protected place
Merchant Shipping Act (1995)	This Act sets out the procedures for determining the ownership of underwater finds that turn out to be 'wreck', defined as any flotsam, jetsam, derelict and lagan found in or on the shores of the sea or any tidal water. It includes ship, aircraft, hovercraft, parts of these, their cargo or equipment. If any such finds are brought ashore, the salvor is required to give notice to the Receiver of Wreck that he/she has found or taken possession of them and, as directed by the Receiver, either hold them pending the Receiver's order or deliver them to the Receiver. The act is administered by the Maritime and Coastguard Agency.	N/A

Although there are no protected wrecks within the proposed dredge area, there are six protected wrecks within 10km of the dredge area that are included in this assessment. Details of these wrecks are provided in **Section 6.2.1** of this report.

Heritage assets on the Kent coast are located outside the study area but are included in this assessment with respect to their setting (**Section 6.5**), and are subject to specific heritage legislation including:

- Ancient Monuments and Archaeological Areas Act 1979 (as amended): There are two Scheduled Monuments between Deal and Kingsdown, the artillery castle at Deal (List entry Number: 1013380) and the artillery castle at Walmer (List entry Number: 1013381); and
- Planning (Listed Buildings and Conservation Areas) Act 1990: Works affecting Listed Buildings or structures and Conservation Areas are subject to additional planning controls administered by Local Planning Authorities. There are a large number of Listed Buildings within this coastal stretch and Conservation Areas at Deal, Walmer and Kingsdown.

This assessment also takes account of current government policy, comprising the *Marine Policy Statement* (HMSO 2011) and the *National Planning Policy Framework* (NPPF) (2012).

The NPPF was published by the Department for Communities and Local Government (DCLG) in March 2012. Section 12 of the NPPF (Conserving and enhancing the historic environment) sets out the principal national guidance on the importance, management and safeguarding of heritage assets within the planning process. Although the study area lies wholly below low water (and is therefore covered by the Marine Policy Statement) key principles from the NPPF are still relevant to this assessment. These are presented in **Table 3.2**.

Table 3.2 Key principles from Section 12 of the NPPF relevant to this assessment.

Paragraph Number	Policy Text	Addressed in this Document
128	In determining applications, local planning authorities should require an applicant to describe the significance of any heritage assets affected, including any contribution made by their setting. The level of detail should be proportionate to the assets' importance and no more than is sufficient to understand the potential impact of the proposal on their significance. As a minimum the relevant historic environment record should have been consulted and the heritage assets assessed using appropriate expertise where necessary. Where a site on which development is proposed, includes or has the potential to include heritage assets with archaeological interest, local planning authorities should require developers to submit an appropriate desk-based assessment and, where necessary, a field evaluation.	Section 6
129	Local planning authorities should identify and assess the particular significance of any heritage asset that may be affected by a proposal (including by development affecting the setting of a heritage asset) taking account of the available evidence and any necessary expertise. They should take this assessment into account when considering the impact of a proposal on a heritage asset, to avoid or minimise conflict between the heritage asset's conservation and any aspect of the proposal.	Sections 6.1.3, 6.2.3, 6.3.3, 6.4, 6.5
132	When considering the impact of a proposed development on the significance of a designated heritage asset, great weight should be given to the asset's conservation. The more important the asset, the greater the weight should be. Significance can be harmed or lost through alteration or destruction of the heritage asset or development within its setting.	Section 7.2
135	The effect of an application on the significance of a non-designated heritage asset should be taken into account in determining the application. In weighing applications that affect directly or indirectly non designated heritage assets, a balanced judgement will be required having regard to the scale of any harm or loss and the significance of the heritage asset.	Sections 6.1.3, 6.2.3, 6.3.3, 6.4, 6.5
139	Non-designated heritage assets of archaeological interest that are demonstrably of equivalent significance to scheduled monuments, should be considered subject to the policies for designated heritage assets.	e.g. <i>Britannia</i> Section 6.2.1
141	Local planning authorities should make information about the significance of the historic environment gathered as part of plan-making or development management publicly accessible. They should also require developers to record and advance understanding of the significance of any heritage assets to be lost (wholly or in part) in a manner proportionate to their importance and the impact, and to make this evidence (and any archive generated) publicly accessible.	Section 7.4

With respect to the historic environment, the *Marine Policy Statement* (2011: 21) also reflects the principles set out in the NPPF and states that:

'The view shared by the UK Administrations is that heritage assets should be enjoyed for the quality of life they bring to this and future generations, and that they should be conserved through marine planning in a manner appropriate and proportionate to their significance.'

Key principles from the Marine Policy Statement relevant to this assessment are presented in **Table 3.3**.

Table 3.3 Key principles from the Marine Policy Statement relevant to this assessment.

Paragraph Number	Policy Text	Addressed in this Document
2.6.6.3	Opportunities should be taken to contribute to our knowledge and understanding of our past by capturing evidence from the historic environment and making this publicly available, particularly if a heritage asset is to be lost.	Section 7.4
2.6.6.5	Many heritage assets with archaeological interest in these areas are not currently designated as scheduled monuments or protected wreck sites but are demonstrably of equivalent significance. The absence of designation for such assets does not necessarily indicate lower significance and the marine plan authority should consider them subject to the same policy principles as designated heritage assets (including those outlined) based on information and advice from the relevant regulator and advisors.	e.g. <i>Britannia</i> Section 6.2.1
2.6.6.7	In considering the significance of heritage assets and their setting, the marine plan authority should take into account the particular nature of the interest in the assets and the value they hold for this and future generations. This understanding should be applied to avoid or minimise conflict between conservation of that significance and any proposals for development.	Sections 6.1.3, 6.2.3, 6.3.3, 6.4, 6.5
2.6.6.8	The marine plan authority, working with the relevant regulator and advisors, should take account of the desirability of sustaining and enhancing the significance of heritage assets and should adopt a general presumption in favour of the conservation of designated heritage assets within an appropriate setting. The more significant the asset, the greater should be the presumption in favour of its conservation. Substantial loss or harm to designated assets should be exceptional, and should not be permitted unless it can be demonstrated that the harm or loss is necessary in order to deliver social, economic or environmental benefits that outweigh the harm or loss.	Sections 7.2
2.6.6.9	Where the loss of the whole or a material part of a heritage asset's significance is justified, the marine plan authority should identify and require suitable mitigating actions to record and advance understanding of the significance of the heritage asset before it is lost. Requirements should be based on advice from the relevant regulator and advisors.	Section 7.4

In addition to the consideration of legislation and policy as outlined above, this desk based assessment also takes account of available guidance including:

- The Setting of Heritage Assets Historic Environment Good Practice Advice in Planning: 3 (Historic England, 2015);
- Chartered Institute for Archaeologists' Standard and Guidance for Historic Environment Desk-Based Assessments (2014) and Code of Conduct (2014);

- Marine Geophysics Data Acquisition, Processing and Interpretation Guidance Notes (English Heritage and Bates, R., Dix, J. K., Plets, R., 2013);
- Conservation Principles, Policies and Guidance for the Sustainable Management of the Historic Environment (English Heritage, 2008);
- JNAPC Code of Practice for Seabed Development (Joint Nautical Archaeology Policy Committee and TCE, 2006); and
- Marine Aggregate Dredging and the Historic Environment; Guidance note (BMAPA and English Heritage, 2003).

4 Methodology

4.1 Data Sources

The baseline environment within the study area has been identified and described with reference to the following sources:

- Geophysical survey data (sidescan sonar, sub-bottom profiler and multibeam echosounder) acquired within the exploration area by EGS in 2015 and assessed by Wessex Archaeology (2015);
- Multibeam echosounder data from Goodwin Sands acquired on behalf of the Marine and Coastguard Agency (MCA) as part of the Civil Hydrography Programme and provided to Wessex Archaeology by the United Kingdom Hydrographic office (UKHO) via the Infrastructure for Spatial Information in Europe (INSPIRE) portal (accessed 11/2015);
- Previous archaeological survey work undertaken by Wessex Archaeology within the Goodwin Sands and surrounding areas (Wessex Archaeology, 2015);
- UKHO records of wrecks and obstructions;
- Records of sites and finds from the Kent HER;
- Records of sites and finds from the NRHE;
- Records of Protected Wreck Sites from the National Heritage List online;
- Background British Geological Survey (BGS) geological information (BGS, 1990; Cameron et al., 1992), and relevant Admiralty Charts for the study area;
- Site assessments for the Goodwin Sands wrecks designated under the Protection of Wrecks Act 1973; and
- Secondary sources including maps, journal articles and online web resources.

4.2 Geophysical Assessment

The geophysical data were acquired by EGS' on board survey vessel FPV *Morven*, between 10th July and 2nd August 2015. The data set comprised sidescan sonar, multibeam echosounder and sub-bottom profiler (chirp and boomer) data. The data was provided to Wessex Archaeology in raw format and the data was processed using specialist software. The technical specifications for the survey, and the processing of the data by Wessex Archaeology, are detailed, along with the results of the assessment, in a technical report included as **Appendix 14.2** to the ES (Wessex Archaeology, 2015).

The sidescan sonar data was rated as being of 'variable' data quality, including some data of good quality (Wessex Archaeology, 2015). Many files exhibited noise interference due to cable snatching as a result of strong tides and currents and inevitable noise caused by shallow water depths. Overall, however, the data quality was found to be suitable for the identification of standing and partially buried wrecks.

The multibeam echosounder data was found to be of a high standard, with resolution of 0.5m, and suitable for the archaeological assessment of seabed objects and debris (Wessex Archaeology, 2015). The 2009 multibeam echosounder data (acquired on behalf of the MCA as part of the Civil Hydrography Programme and provided to Wessex Archaeology by the UKHO via the INSPIRE portal) did not cover the whole exploration area. The data was, however, also rated as 'good' and was used to assess site conditions of existing wrecks and broad depth changes to the bank area over the time series available.

The sub-bottom profiler (boomer) data was generally of 'good' quality, although some lines exhibited noise due to weather conditions experienced during the survey and the shallow water depths resulted in seabed multiples appearing in the data (Wessex Archaeology, 2015). However, these did not detrimentally affect the data to a significant degree and it was deemed suitable for archaeological interpretation.

Geophysical anomalies seen in the data were grouped, compared to UKHO wrecks and obstructions data, and classified in accordance with the definitions in **Table 4.1**.

Table 4.1 Criteria discriminating relevance of seabed features to the proposed scheme (Wessex Archaeology, 2015)

Non-Archaeological	U1	Not of anthropogenic origin
	U2	Known non-archaeological feature
	U3	Non-archaeological hazard
Archaeological	A1	Anthropogenic origin of archaeological interest
	A2	Uncertain origin of possible archaeological interest
	A3	Historic record of possible archaeological interest with no corresponding geophysical anomaly

Similarly, criteria applied to shallow geological features of possible archaeological potential are presented in **Table 4.2**.

Table 4.2 Criteria discriminating relevance of shallow geological features to the proposed scheme (Wessex Archaeology, 2015)

Non-Archaeological	U2	Known non-archaeological feature
Archaeological	P1	Feature of probable archaeological interest, either because of its palaeogeography or likelihood for producing palaeoenvironmental material
	P2	Feature of possible archaeological interest

All the anomalies of archaeological potential that have been identified within the proposed dredge area and wider exploration area are presented in **Appendix A** and further discussed in this report.

4.3 Impact Assessment

A detailed methodology for impact assessment is presented in **Section 3** of the ES.

In summary, assessing the significance of an impact is made by combining the predicted magnitude of the effect with the value and/or sensitivity of the receptor, and is subject to expert judgement. This assessment method considers the following elements:

- The sensitivity of a receptor to an effect;
- The value of a receptor;
- The magnitude of the effect;
- The probability that an effect-receptor interaction will occur; and
- The determination and (where possible) qualification of the level of impact on a receptor, considering the probability that the effect-receptor interaction will occur, the spatial and temporal extents of the interaction and the significance of the resulting impact.

An outline of how the assessment method presented in **Section 3** of the ES is applied to archaeological receptors is provided below.

The sensitivity of a receptor is a function of its capacity to accommodate change and reflects its ability to recover if it is affected. The guidelines used in the determination of receptor sensitivity for the assessment presented in **Section 7** of this report are set out in **Table 4.3**.

Table 4.3 Generic guidelines used in the determination of receptor sensitivity

Sensitivity	Description
High	Receptor has a limited capacity or no capacity to accommodate physical or chemical changes or influences and limited or low capacity to recover from effects.
Medium	Receptor has a limited capacity to accommodate physical or chemical changes or influences but moderate potential to recover from effects.
Low	Receptor has a moderate capacity to accommodate physical or chemical changes or influences and good recoverability potential
Negligible	Receptor is generally tolerant of and can accommodate physical or chemical changes or influences. Receptor has a high potential to recover from effects.

Impacts to a heritage asset's setting or character can be temporary. For example, the additional presence of vessels associated with a scheme or project can affect the setting of an asset through the introduction of additional noise, fuel fumes or through disturbance of the view from that asset. The setting (i.e. the way in which people experience the heritage asset) can recover, however, once those vessels are no longer present.

Impacts which result in damage or destruction of the assets themselves, or their relationship with their wider environment and context, are permanent. Once destroyed an asset cannot recover. For this reason, the assessment of impacts is defined solely by their archaeological value.

The value of a receptor is a function of a range of factors. The Marine Policy Statement (Department for Environment, Food and Rural Affairs (Defra), 2011: 21) states that the value of heritage assets (receptors)

to this and future generations lies in their heritage interest, which may be archaeological, architectural, artistic or historic.

In accordance with this definition, the value of archaeological receptors are assessed by examining the receptor's age, type, rarity, survival and condition, fragility and vulnerability, group value, documentation, associations, scientific potential and outreach potential. These factors help to characterise a receptor and to assess how representative it is in comparison to other similar archaeological, architectural, artistic or historic heritage assets. In the majority of cases, statutory protection is only provided to a site or feature judged to be an above average example in regard to these factors.

The value of archaeological receptors is discussed as part of the baseline set out in **Section 6** of this report. The criteria used for assessing the value of archaeological receptors are specified in **Table 4.4**.

The overall measure (negligible/low/medium/high) assigned to sensitivity and / or value which is carried forward to define the significance of an impact (see **Table 4.6**), necessitates the application of professional judgement, and will require explanatory text in support of any conclusion.

Table 4.4 Criteria used in the determination of the value of archaeological receptors

Value	Criteria
High	Receptor possesses key characteristics which contribute significantly to the distinctiveness, rarity and character of the resource, is of high importance and rarity that is national and / or international in scale. Includes designated receptors such as protected wreck sites or aircraft crash sites and undesignated assets of the quality and importance to be designated under the legislation as set out in Table 3.1 .
Medium	Receptor possesses key characteristics which contribute to the distinctiveness and character of the resource, is of medium importance and rarity that is regional in scale.
Low	Receptor possesses characteristics which are locally distinctive only, are of low to medium importance and rarity that is local in scale.
Negligible	Receptor characteristics do not make a significant contribution to local character or distinctiveness, and are of very low importance and rarity.

The magnitude of an effect is defined by consideration of the extent, duration, frequency and severity of the effect. To help define the magnitude of effect, the criteria presented in **Table 4.5** have been adopted for the purposes of this impact assessment.

Table 4.5: Guidelines used in the determination of the magnitude of effect

Magnitude	Description
High	Loss of resource and / or integrity of the resource. Partial loss of or damage to key characteristics, features or elements (Adverse). Improvement to, or addition of, key characteristics, features or elements of the resource. Improvement of attribute quality (Beneficial). Permanent change, which is likely to occur.
Medium	Minor loss of, or alteration to, one (maybe more) key characteristics, features or elements. Measurable change in attributes, quality or vulnerability (Adverse). Minor improvement to, or addition of, one (maybe more) key characteristics, features or elements of the resource. Minor improvement to attribute quality (Beneficial). Long-term though reversible change, which is likely to occur.

Magnitude	Description
Low	Very minor loss of, or alteration to, one (maybe more) key characteristics, features or elements. Noticeable change in attributes, quality or vulnerability (Adverse). Very minor improvement to, or addition of, one (maybe more) key characteristic, feature or element. Very minor improvement to attribute quality (Beneficial). Short- to medium-term though reversible change, which could possibly occur.
Negligible	Temporary or intermittent very minor loss of, or alteration to, one (maybe more) characteristic, feature or element; possible change in attributes, quality or vulnerability (Adverse). Possible very minor improvement to, or addition of, one (maybe more) characteristic, feature or element; possible improvement to attribute quality (Beneficial). Short-term, intermittent and reversible change, which is unlikely to occur.

The probability of an impact occurring is also captured within this assessment; including both the probability that the effect will occur and the probability that a receptor will be present.

The determination and qualification of impact significance is based upon a degree of expert judgement with consideration to the nature of the effect / receptor interaction and based upon the data presented in **Section 6** of this report. Using the significance matrix in **Table 4.6** as a guide, each significance judgement is qualified in the text of **Section 7.3** of this report.

Table 4.6 Significance matrix used as a guide in the determination of impact significance

Magnitude	Value and / or Sensitivity of Receptor			
	Negligible	Low	Medium	High
Negligible	Negligible	Negligible	Minor	Minor
Low	Negligible	Minor	Minor	Moderate
Medium	Minor	Minor	Moderate	Major
High	Minor	Moderate	Major	Major

The different levels of impact significance are minor, moderate or major and can be adverse or beneficial. Where it has been determined through expert judgement that there would be no change to a receptor as a result of the proposed dredging, the impact is assessed as no impact. Where it is difficult to discern any change in comparison to existing conditions the impact is assessed as negligible. Generic terminology for classifying and determining impact significance is presented in **Section 3** of the ES.

5 Consultation

The following consultation was undertaken and used to inform EIA scoping, this desk based assessment and the ES in relation to archaeology and the historic environment:

- A meeting was held between RHDHV, DHB, HR Wallingford, the MMO, the Environment Agency, Natural England and Historic England on 18th May 2015 to discuss the proposed aggregate dredging scheme at Goodwin Sands;

- The *Goodwin Sands Aggregate Dredging EIA Scoping Report* (RHDHV, 2015) was submitted to the MMO on 31st July 2015 and a scoping response was sent to the MMO by Historic England dated 10th September 2015;
- Nominated Archaeologists for the protected wrecks *Stirling Castle*, *Restoration* and *Gad 8* (Douglas McElvogue) and *Rooswijk* (Alex Hildred) were contacted on 24th August 2015 to request feedback on the EIA Scoping Report. Responses were received 14th September and 15th September respectively;
- Historic England were contacted on 6th November 2015 to request a telephone conference to discuss the value of the magnetometer survey as an appropriate means of assessment. A telephone conference between the MMO, Historic England, DHB and RHDHV took place 19th November 2015 and it was agreed that magnetometer survey would not be required for archaeological purposes only (subject to further mitigation requirements);
- The following Licensees and Nominated Archaeologists were contacted via email on 8th December to inform them of the proposed dredging scheme and to request any specific requirements with regard to the protected wrecks outside the proposed dredge area and within the wider area of Goodwin Sands:
 - Brian Neave Licensee *Stirling Castle*;
 - Bob Peacock Licensee *Stirling Castle* and previously *Restoration* and *Northumberland*;
 - Dan Pascoe Nominated Archaeologist *Northumberland*;
 - Ken Welling Licensee *Rooswijk*; and
 - Rex Cowan *Rooswijk*.
- No responses were received and a follow up email was sent on 11th January 2016. Responses were received from Ken Welling and Daniel Pascoe on 12th January 2016;
- An email outlining the proposed scheme was sent to the Trust for Thanet Archaeology on 20th January 2016. No response was received and a follow up email was sent 16th February 2016. A response was received from Ges Moody (Deputy Director) on the same day;
- Following a request for information, an email outlining the proposed scheme was sent to Margaret Symonds, Chair of the Isle of Thanet Archaeological Society, on 19th January 2016. A response was received the same day;
- An email outlining the proposed scheme was sent to the Commonwealth War Graves Commission on 19th February 2016 with regard to sites designated under the Protection of Military Remains Act 1986 outside yet in proximity to the proposed dredging area. At time of writing no response had been received; and
- A working group meeting was held between RHDHV, DHB, HR Wallingford, the MMO and Historic England on 2nd March 2016 to present the results of the desk based assessment.
- A site visit by the RHDHV Senior Marine Heritage Consultant, DHB's Environmental Officer and Historic England was undertaken on 18th April to view works being undertaken by Van Oord in Bournemouth. The Bournemouth beach recharge scheme reflects the proposed approach to dredging and reclamation for DWDR comprising dredging from Licence Area 137 (south west of the Isle of Wight) and discharge of sand from the dredger via a floating pipeline to the beach. The site visit allowed for a further consultation with Historic England and a fuller understanding of what may be considered appropriate and proportionate archaeological mitigation for the proposed Goodwin Sands dredging scheme.

Account has been taken of the results of consultation within the assessment presented in this report. A detailed consultation log (including the consultation responses, details of how they have been addressed and cross-referenced to project documentation) is presented in **Section 4** of the ES.

6 Baseline Environment

6.1 Seabed Prehistory

6.1.1 Known

There are no known prehistoric sites or findspots within the proposed dredge area.

6.1.2 Potential

Goodwin Sands is an extensive area of sand banks comprising highly mobile sands overlying an Upper Chalk platform. The banks are exposed at low tides with permanently submerged areas immediately surrounding the banks, and a deeper channel extending into the English Channel along the seaward side. The basement geology of the region is the Chalk Group, which was originally deposited in a shallow marine environment during the Upper Cretaceous period (Cameron et al. 1992). This chalk deposit is widespread across the southern North Sea, and outcrops to form the distinctive white cliffs at places such as Dover and the Alabaster Coast in France.

The earliest direct evidence for Hominin activity in the UK has been identified at the Lower Palaeolithic sites of Happisburgh, on the Norfolk coast, and Pakefield, on the Suffolk coast, dating from (up to) c. 970,000 years before present (BP) and c. 700,000 BP respectively (Parfitt et al, 2005; Parfitt et al, 2010). Since then, repeated glacial/interglacial cycles and the associated rise and fall of sea level has seen the study area exposed as a terrestrial landscape at times during the Pleistocene and early Holocene. When this exposure coincided with phases of warmer climate, human inhabitation would have been possible. Following the last ice age, during the Late Pleistocene, a terrestrial environment is likely to have existed within the region into the Early Holocene and it is possible that this landscape was occupied up until the final marine transgression between 8,900 and 5,000 BP.

During the 19th century, Charles Lyell wrote that Goodwin Sands were a “remnant of land” and not a “mere accumulation of sea sand” (Lyell, 1835: 408-409). His theory was based upon the results of borings associated with the erection of a lighthouse by the Trinity Board in 1817 which showed that the bank comprised, “fifteen feet of sand, resting on blue clay”. Goodwin Sands were subsequently equated with the island known to the Romans as *Infera Insula* (Low Island) and in 1098 there are historic accounts that an island named *Lomea* was ‘overflowed’, resulting in the formation of the sands (Holmes, 1907: 526-527).

It has subsequently been demonstrated that this island did not exist and that the evidence presented by Lyell is unreliable (Cloet, 1954). The composition of Goodwin Sands, comprising an accumulation of marine sand on chalk, and a lack of evidence for a clay island, suggests limited potential for the survival of any former dry-land surfaces that may have existed during times of lowered sea level in the past and, consequently, limited potential for submerged prehistoric archaeology.

The assessment of sub-bottom profiler data by Wessex Archaeology (2015), however, revealed a distinct east to west trending channel feature crossing the north of the study area (**Figure 6.1**). This channel is a complex feature, with at least two (possibly three) separate episodes of cut and fill visible. This may indicate a braided channel system (a channel that consists of a network of small channels separated by small and often temporary islands), or a single feature reactivated at different periods of time. It may also

indicate a combination of both. Additionally, very small mound features have been identified overlying the channel, both around the edges and in the centre. Again, these are relatively intermittent, and could represent associated small fluvial bank/terraces or could be ridges created by sediment reworking during the Holocene marine transgression.

The fill is generally unstructured and appears chaotic on some data lines, but the different phases of fill appear relatively similar (Wessex Archaeology, 2015). A strong reflector was observed intermittently between lines of data within the channel that may represent a particularly strong basal reflector of one of the phases of cut and fill, or may represent pockets of shallow gas indicative of the presence of preserved organic material within the fill sediment. The channel is directly overlain by the marine sands that form the Goodwin Sands, generally around 20m thick with a mobile upper surface characterised by sand ripples and occasional small sand waves.

Previous work undertaken within the Outer Thames Estuary (EMU, 2009) and within the English Channel (Hamblin et al., 1992), have identified extensive palaeochannel complexes. Closer to the study area, to the northeast of the Goodwin Sands, a number of small, palaeochannels and possible associated palaeolandscapes features have been observed (Wessex Archaeology, 2011a). Some of these large channel systems, such as the Thames/Medway system in the Outer Thames Estuary and the Northern Palaeovalley/Lobourg Channel system in the English Channel, are thought to have been particularly long lived, potentially being originally created in pre-Anglian (Cromerian, c. 760,000 – 478,000 BP) times and 'reactivated' during subsequent sea level lowstands into the Early Holocene (EMU, 2009).

The feature seen in the data by Wessex Archaeology (2015) is interpreted as a fluvial palaeochannel similar to those described above and could date from a range of periods between the Cromerian and the Early Holocene. As such, the sediments associated with this feature are considered to be of high archaeological potential, and could contain both *in situ* and derived anthropogenic artefacts and preserved palaeoenvironmental material.

The overlying modern, marine sand is not considered to have high prehistoric potential, although it may contain reworked older sediments and associated archaeological material, particularly at the margins of the Goodwin Sands bank where the thickness of the deposit is relatively thin. Off the edge of the bank to the west the sand reduces rapidly in thickness to a thin veneer and is less than 1m thick in places.

Eight resource assessment vibrocores, acquired for DHB by Fugro Ltd to between 4.65m and 5.7m depth, additionally demonstrate the make-up of the bank within the proposed dredge area (**Figure 6.1**). Marine sands directly overlie chalk in two of the cores (VC02 and VC03) while marine sands are observed throughout the core in five of the vibrocores where the deposit is thicker (VC04, VC07, VC08, VC09 and VC10). One core (VC01) revealed a 1.1m clay deposit in between the marine sands and the underlying chalk. This soft grey, slightly sandy clay deposit, recorded with much chalk gravel and cobble content, was seen underlying 1.45m of marine sand within the south of proposed dredge area and off the edge of the bank where the resource is thinnest.

6.1.3 Value of Archaeological Receptors

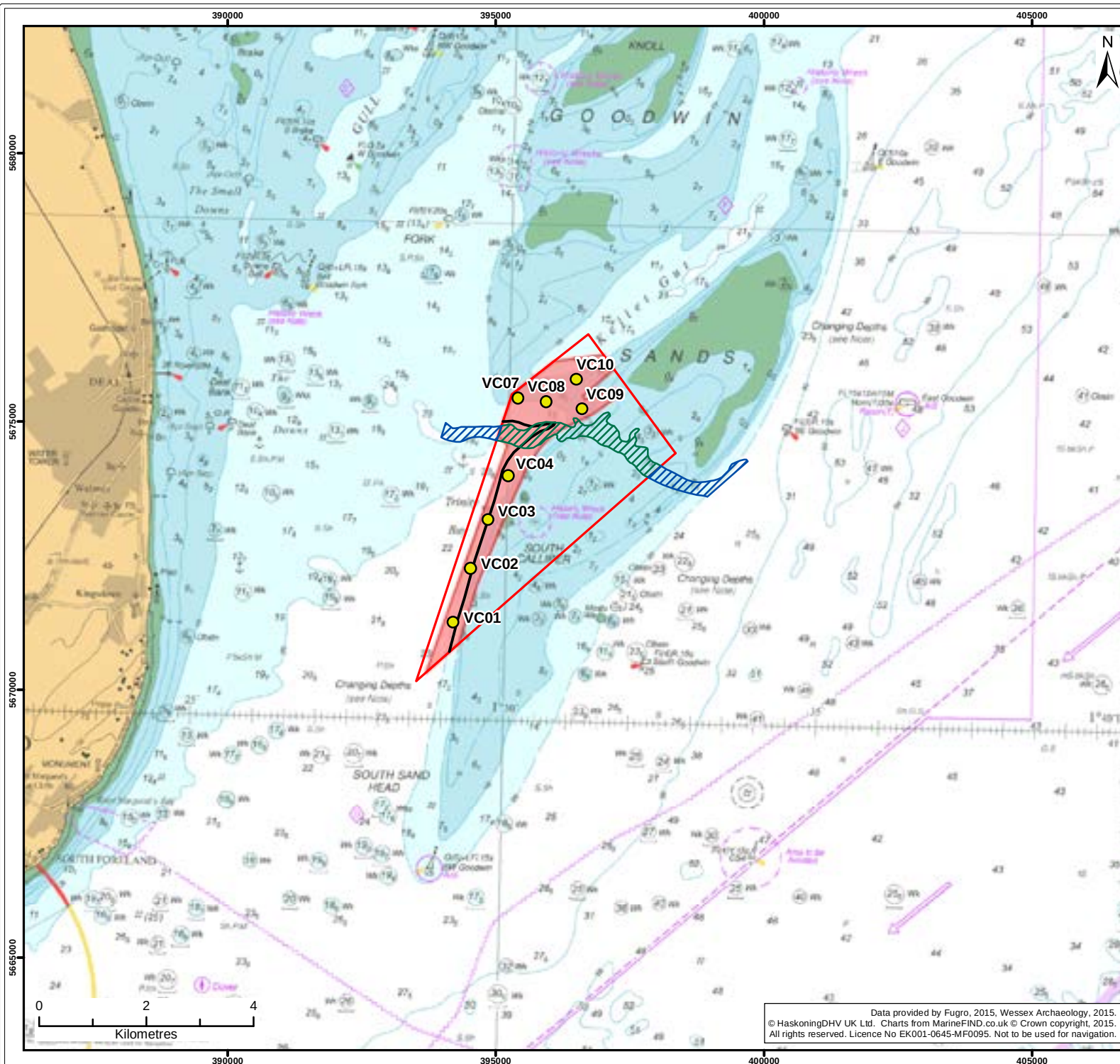
Discoveries of *in situ* archaeological and palaeoenvironmental material are rare within the marine environment. Consequently any such discoveries will be of **high** value.

The archaeological research value of material from secondary, derived contexts is lower than that of *in situ* material, but as there is potential for remains of high value to be present, it is necessary to take a precautionary approach and, as such, any such discoveries will also be considered to be of **high** value.

Open



This precautionary approach represents good practice in archaeological impact assessment and reduces the potential for impacts to be under assessed.



Legend:

- Proposed Dredge Area
- Exploration Area
- Approximate Edge of Bank

Palaeochannel Events

- Inferred by Wessex Archaeology
- Observed by Wessex Archaeology in the Sub-bottom Profiler Data
- Vibrocore Locations (Fugro, 2015)

Client:
Dover Harbour
Board

Project:
Goodwin Sands
Aggregate Dredging
Environmental Statement

Title:
Seabed Prehistory

Figure: 6.1 Drawing No: PB2107/ES/036

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
02	25/02/2016	JE	DC	A4	1:100,000
01	12/01/2016	JS	DC	A4	1:100,000

Co-ordinate system: WGS 1984 UTM Zone 31N



Data provided by Fugro, 2015, Wessex Archaeology, 2015.
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All rights reserved. Licence No EK001-0645-MF0095. Not to be used for navigation.

6.2 Maritime

6.2.1 Known

Wrecks within the proposed dredge area and exploration area

Full details of previously identified wrecks and geophysical anomalies observed by Wessex Archaeology (2015) are provided in **Appendix A**.

Within the exploration area there are two previously recorded wrecks observed in the geophysical data (**7018** and **7024**) and classified as A1 (anthropogenic origin of archaeological interest) (**Figure 6.2**). Both are located outside the proposed dredge area.

Anomaly **7018** was interpreted as a partially buried wreck measuring 81.2m x 37.3m x 4.7m, located at approximately 3m LAT depth of water, identified as two distinct areas of debris aligned north west to south east and approximately 34m apart (Wessex Archaeology, 2015). The location corresponds to the US steam ship *North Eastern Victory* (UKHO 13749) which sank 24th December 1946 after running aground in thick fog, recorded as breaking in two pieces before it sank.

Anomaly **7024** was not seen within the 2015 data but is visible within the Civil Hydrography Program data as a large piece of debris (Wessex Archaeology, 2015). It has previously been recorded as the possible stern of a vessel, and is completely buried at present.

There are four wrecks classified as A3 (historic records of possible archaeological interest with no corresponding geophysical anomalies) within the exploration area (**7006**, **7014**, **7023** and **7027**) (**Figure 6.2**). One of these lies within the proposed dredge area (**7006**):

- **7006**: small geophysical contact recorded by the UKHO in 1996, not seen since and currently classed as 'dead' (not detected by repeated surveys, therefore considered not to exist and classed as 'dead' by the UKHO);
- **7014**: the recorded position of the *Admiral Gardner* (a protected wreck discussed in further detail below);
- **7023**: a disturbed area (foul ground) last observed by the UKHO in 1981 and current classed as 'dead'; and
- **7027**: magnetic anomaly recorded in 1997 and currently classed as 'dead'.

Although these anomalies were not seen in the geophysical data it is considered likely that they may still be present, albeit buried.

In addition to these four A3 records, a further recorded wreck was identified in the assessment by RHDHV for further consideration. The *Britannia* was an East Indiaman which stranded on the west side of the South Sand Head in 1809 while outward-bound from London and Gravesend for Madras and China. Laden with cloth, lead, and copper, *Britannia* was a wooden sailing vessel and was lost in the same storm as the *Admiral Gardner* (**7014**).

There is some uncertainty as to the location and identity of the remains of *Britannia* with multiple record entries from the available sources. One of the wrecks that has previously been identified as possibly the remains of *Britannia* is located c. 15 metres outside and to the south of the proposed dredge area and exploration area (NRHE 904848, UKHO 14869) (**Figure 6.2**). There are no specific details of the remains

recorded at this location and they are assumed buried. The UKHO record (14869) also classifies this site as 'dead'.

The anomaly **7027** is located at the same position as an unidentified wreck recorded by the NRHE (831712) and the Kent HER (MKE9774) and reported by a local trawlerman in 1980, known as 'East Indiaman' and also possibly referring to the *Britannia* (**Figure 6.2**). The NRHE record describes the wreckage of a wooden craft, which lies below the sand but that covers and uncovers.

The *Admiral Gardner* (**7014**) (designated 1985, National Heritage List number. 1000062) is located within the Goodwin Sands exploration area (**Figure 6.2**). The ship was an English East Indiaman, built in 1797, which stranded in Trinity Bay during a gale in 1809. The wreck was discovered in 1976 after East India Company tokens appeared in sand dredged from the Goodwin Sands for use as fill for construction in Dover Harbour. The wreck was subject to salvage work between 1980 and 1985 and was identified as the *Admiral Gardner* from the barrels of copper coins from the site, in comparison to the silver coins carried by *Britannia*. The site is subject to a 300m (radius) exclusion zone prohibiting unlicensed activities within the boundary. All dredging and associated activities will be strictly prohibited within the protected area.

The site of the *Admiral Gardner* is subject to a cycle of exposure and burial. Geophysical survey in 2012 showed that the site was buried (Wessex Archaeology, 2012a, 2013a). A site plan dated to July 1985 shows a substantially coherent shipwreck site, dominated by the presence of large features including seven large anchors, concreted iron bar and sections of framing and planking visible around the edges of the wreck mound. By the 1990s, however, salvage operations had resulted in considerable damage to the wreck mound. The last time the wreck was observed was in 2002 and a diver assessment in 2003 showed that the site was completely covered by sand. The site assessment for the wreck suggests that the South Sand Head (the southern sandbank of the Goodwin Sands) has shifted to the west over the last decade, covering the wrecks on the western edge of the sandbank including that of the *Admiral Gardner* (Wessex Archaeology, 2013a).

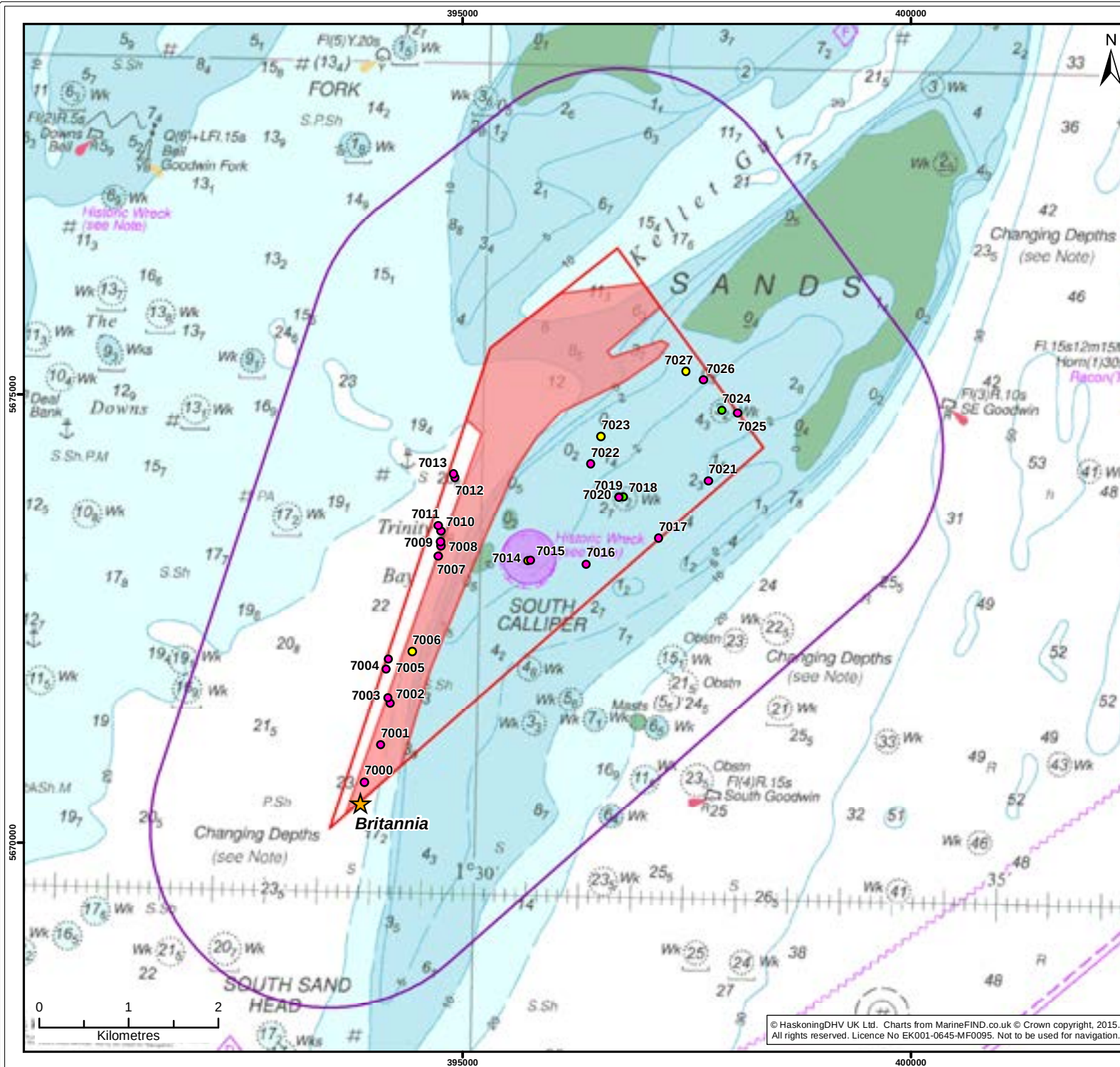
This burial accords with the current data that indicate the burial of previously exposed wrecks and anomalies (Wessex Archaeology, 2015). One anomaly (**7015**), classified as A2 and described as a dark reflector, was identified approximately 30m northwest of the recorded position of the *Admiral Gardner* measuring 7m x 1.3m with no discernible height. Wessex Archaeology suggest that this could be a natural feature, but retained the anomaly of potential archaeological interest due to its proximity to the recorded wreck position.

Goodwin Sands designated wrecks

There are five further wrecks located on Goodwin sands that are designated under the Protection of Wrecks Act 1973 (**Figure 6.3**).

The *Stirling Castle* (designated 1980, National Heritage List number. 1000056) is located c. 6km to the north of the exploration area. The site is subject to a 300m (radius) exclusion zone prohibiting unlicensed activities within the boundary.

The ship was built at Deptford in 1678 as part of the Thirty Ships programme and sank on the Goodwin Sands during the Great Storm in 1703, alongside the *Northumberland*, the *Mary* and the *Restoration*. The wreck was found in 1979 by divers from Thanet, whilst investigating a fisherman's net fastening as part of a survey of the Goodwin Sands.



Legend:

- Proposed Dredge Area
- Exploration Area
- NRHE and Kent HER Search Area
- Admiral Gardner: Protected Wreck Exclusion Zone

Wessex Archaeology Gazetteer

- A1
- A2
- A3
- ★ Recorded Position of Britannia

Client:	Project:
Dover Harbour Board	Goodwin Sands Aggregate Dredging Environmental Statement

Title:
Recorded Wrecks and Geophysical Anomalies

Figure: 6.2	Drawing No: PB2107/ES/037

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An archaeological assessment carried out in August 2008, comprising geophysical and diver survey, demonstrated significant degradation of the site as a probable result of storms in 2007, structural weakening of the timbers as a results of biological and mechanical damage, and possible commercial fishing damage (Wessex Archaeology, 2009). During the inspection of the site it was observed that all of the exposed timber structures seen were heavily eroded and subject to extensive biological attack.

The *Northumberland* (designated 1981, National Heritage List number. 1000058) is located c. 4.6km to the north of the exploration area. The site is subject to a 300m (radius) exclusion zone prohibiting unlicensed activities within the boundary.

The ship was the first 'third rate' to be built under the Thirty Ships programme, and was launched in 1679. The *Northumberland* was lost in the Great Storm of 1703 along with the *Stirling Castle*, *Restoration* and *Mary*. The wreck was found in 1979 after investigation of a net fastener by local divers.

An archaeological assessment carried out in 2009 comprising, diver and sidescan sonar survey, demonstrated increased sediment cover at the site in comparison to previous years (Wessex Archaeology, 2010a). The main threats to the site, however, have previously been identified as localised seabed erosion, mechanical degradation and biological decay with sediment levels observed to be particularly variable on the site and archaeological features subject to repeated covering and uncovering throughout the year. In response to a consultation request, the Nominated Archaeologist for *Northumberland*, Daniel Pascoe, reported that the wreck has been buried under several meters of sand since at least 2011.

The *Restoration* (designated 1981, National Heritage List number. 1000057) is located c. 4.8km to the north of the exploration area. The site is subject to a 300m (radius) exclusion zone prohibiting unlicensed activities within the boundary.

The ship was built at Harwich in 1678 as part of the Thirty Ships programme and also sank on the Goodwin Sands during the Great Storm in 1703. The site was discovered in 1980 during a survey programme, by local divers, of fishermen's net fastenings on the Goodwin Sands.

An archaeological assessment carried out in 2006, comprising diver assessment, multibeam survey and limited desk based assessment, indicated that the site comprised two mounds c. 100m apart, with scattered partly buried wreckage apparent on each mound (Wessex Archaeology, 2006). It has previously been suggested that the two mounds may represent the remains of both *Restoration* and the *Mary*, although there is no definitive evidence for this. The assessment concluded that changing sediment levels were likely to be having a detrimental effect upon the condition and survival of exposed features of the wreck, with a variation of 1.5m in burial depth between 2003 and 2006.

The *Rooswijk* (designated 2007, National Heritage List number. 1000085) is located c. 6.1km to the north east of the exploration area. The site is subject to a 150m (radius) exclusion zone prohibiting unlicensed activities within the boundary.

The ship was a Dutch East Indiaman, built in 1737, which foundered towards the north eastern end of the Kellet Gut, after grounding on the Goodwin Sands in 1739. A sport diver found the remains of the *Rooswijk* after extensive documentary research and magnetometer survey and over 1000 artefacts are thought to have been salvaged from the vessel prior to designation in 2007.

The site is currently known to consist of at least two main concentrations of 18th century wreck material, termed the East and West Sites (Wessex Archaeology, 2012b). A further concentration of wreck material

has subsequently been identified to the north. Survey work in 2008, 2009 and 2011 has suggested increasing levels of exposure at the site, possibly associated with the erosion of the sand bank immediately south-east of the site.

GAD8 (previously known as the 'Goodwins Cannon Site') (designated 2012, National Heritage List number. 1401982) is located c. 4.9km to the north west of the exploration area. Diving investigations in 2010 revealed that the site consists of a scatter of at least seven pieces of cast iron ordnance, a central concretion mound and a section of previously unseen coherent timber structure (Wessex Archaeology, 2011b). A local diver has suggested that the wreck may be the remains of the *Carlisle*, a Fourth Rate ship of the line which exploded in 1700. The site is subject to a 50m (radius) exclusion zone prohibiting unlicensed activities within the boundary.

A further wreck (GAD23, also known as the 'Bowsprit Wreck') has also been recommended for designation (**Figure 6.3**). First surveyed during geophysical investigation of the nearby Stirling Castle in 2005, diving fieldwork and assessments in 2010 and 2011 have indicated that the site is under constant threat from degradation due to the strong tides and mobile sands on Goodwin Sands, as well as damage from commercial fishing. The wreck was a mid to late 19th century merchant sailing ship operating in the coal trade, one of few such ships that survive.

There is a single vessel designated under the Protection of Military Remains Act 1986. The German submarine U-12, lost near Dover in the English Channel in 1939 after being struck by a mine, is designated as a protected place under this Act (**Figure 6.3**). The vessel was designated after being nominated by the German government as representative of all German submarines lost within UK jurisdiction. As a protected place, this is a record of loss only. Due to the proximity of the location of loss off Dover, it is possible that the wreck of this submarine may be located within the area of Goodwin Sands. However, there is no evidence to suggest that this submarine is located within the study area and the presence of a previously undiscovered, intact vessel of this size buried within the proposed dredge area is considered very unlikely.

Anomalies of possible archaeological interest

Twenty two anomalies seen in the geophysical data have been classified as A2 (uncertain origin of possible archaeological interest) (Wessex Archaeology, 2015) (**Figure 6.2**). Full details are provided in **Appendix A**.

Anomaly **7019** has been interpreted as isolated piece of debris in the vicinity of the wreck of the *North Eastern Victory*. The feature was identified in the sidescan sonar data as a dark reflector measuring 1.8m x 0.8m x 0.6m and observed as a mound within a depression in the multi-beam data. It is located 48m from the centre of the wreck outside the proposed dredge area.

Anomaly **7021** is a distinct anomalous area of dark reflectors representing a seafloor disturbance, measuring 15m x 2.9m with no discernible height. This anomaly is located outside the proposed dredge area.

Anomaly **7003** has been classified as a possible rope or chain located along the western extents of the proposed dredge area. The location of this anomaly suggests that it corresponds to a linear feature (Linear 1) seen in the data by EGS (2015, 23-24, Figure 9). EGS describe three separate linear features towards the southern limit of the exploration area, all greater than 100m in length and partially buried within an area of sandwaves/megaripples. The only cabling reported on the Admiralty charts for the area is a disused cable located to the south of the exploration area. However, EGS conclude that these features could be related to another uncharted cable, such as an old disused telecom cable. Wessex

Archaeology record a length of 250m for this anomaly, which would also be consistent with a disused cable.

Anomaly **7011** has been interpreted as a bright reflector, identified in the sidescan sonar data only, measuring 3.7m x 0.1m with no discernible height. A bright reflector can indicate material that absorbs acoustic waves instead of reflecting them, such as saturated wood or synthetic material. This anomaly is located outside the proposed dredge area.

Fifteen anomalies (**7000**, **7001**, **7002**, **7004**, **7005**, **7007** to **7010**, **7012**, **7013**, **7015**, **7017**, **7020** and **7022**) have been classified as dark reflectors and vary in size from 1m x 0.6m x 0.3m (**7007**) to 14.4m x 2m x 0.2m (**7009**). Wessex Archaeology (2015) conclude that these could either be individual pieces of debris or possible natural features. Five of the fifteen anomalies were identified in the proposed dredge area (**7000**, **7001**, **7002**, **7007** and **7008**).

Three anomalies were identified as mounds in the multibeam data only (**7016**, **7025** and **7026**). All three are located outside the proposed dredge area. These range in size from anomaly **7026** (5m x 3.5m x 0.5m) to anomaly **7016** (5m x 4.2m x 1.3m) surrounded by several smaller objects in a total area of 11m x 8m. These could be natural features or indicate areas of currently buried debris.

6.2.2 Potential

Goodwin Sands represents a major hazard to marine navigation and, as such, has perhaps the highest density of recorded shipping losses in the UK (Wessex Archaeology, 2014). Many of the most important trade routes of northern Europe pass close to Goodwin Sands, which are located offshore of the Downs, formerly one of the most important commercial and naval anchorages off the English coast. It has been estimated that over 800 shipwrecks have documented on Goodwin Sands (Cant, 2013). This coupled with the difficulties of marking the position of wrecks, and consequently identifying and monitoring archaeological sites, means that the potential for the presence of previously unrecorded wrecks on Goodwin Sands is very high.

To quantify this potential, a search for documented losses recorded by the NRHE and Kent HER was undertaken within a search area comprising the exploration area plus a 2km buffer. Documented losses are those for which a historical account of their loss at a given location is recorded, but for which the wrecks have never been found. These are grouped by the NRHE at named locations, arbitrary positions on the seabed where documentary sources suggest that wreck events took place. Named locations do not, except by chance, represent the presence of physical remains on the seabed. There are two named locations within 2km of the exploration area (**Figure 6.3**). The Kent HER data included records that correspond to those from the NRHE, many recorded at different locations, and also records of losses that the NRHE have grouped at named locations outside the study area (**Figure 6.3**). This is indicative of the uncertainty surrounding the location of many of these documented losses.

Documented losses may correspond to previously recorded, yet unidentified wrecks on the seabed (for example, the two unidentified wrecks described above that have both been tentatively identified as the remains of *Britannia*). They may also represent remains on the seabed, possibly buried, that are yet to be discovered.

There are 55 documented losses recorded by the NRHE and/or Kent HER within 2km of the exploration area. The year of loss varies from 1616 to 1980 with the highest density of losses in the 19th century (**Table 6.**).

Table 6.1 *Distribution of year of loss for Documented Losses*

Date Range	Number of Losses
1600-1649	1
1650-1699	2
1700-1749	1
1750-1799	6
1800-1849	8
1850-1899	18
1900-1913	2
First World War	5
1919 to 1938	3
Second World War	5
1946 to present	4

The majority of the losses were cargo vessels lost during the later 19th century, which may be indicative of increased trade activity during this period. During the 19th century technological advances, including steam power and the use of iron and steel construction, allowed for greater speed and durability that facilitated the growth of long distance trade. Where the nationality of the vessel is recorded, British or English vessels predominate, although American, Belgian, Danish, Dutch, German, Irish, Italian, Norwegian, Swedish and Welsh vessels are also represented. Most of the vessels represented in the data are wooden sailing vessels.

The NRHE also records the location of a major naval battle c. 1km to the north west of the proposed dredge area (NRHE 1582748). The Battle of the Downs took place in The Downs anchorage in 1639 as part of the Eighty Years' War in which the Dutch sought to win independence from Spanish rule. The Dutch convincingly beat the Spanish, forcing a number of Spanish ships ashore and between 23 and 25 Spanish vessels stranded, some of which were recovered, and others lost in action or on the Goodwin Sands. Three Dutch fireships were also lost, as well as six German vessels that were inadvertently caught up in the battle.

A study assessing pre-1730 shipping activity in England showed that many of the maritime battles that occurred around the UK were concentrated in the English Channel and along the East coast (Wessex Archaeology, 2004). The English, Dutch, French, Spanish and Flemish fleets periodically went to war from the 15th century in the fight for control of the English Channel and incoming trade from the Mediterranean and the Caribbean. Several battles are recorded around the Downs and off the east coast of Kent, including some of the major engagements of the Anglo-Dutch wars. This suggests that there is high potential for the presence of naval, as well as commercial, wrecks within the study area, as well as isolated finds such as cannonballs, indicative of these battle locations.

A recent study of Goodwin Sands wrecks reports that most of the wrecks present are of wooden ships that have not remained intact, battered to pieces by the gales that stranded them and now lying in dispersed debris fields (Wessex Archaeology, 2014). Geophysical survey in the Kellet Gut to the north east of the study area identified 132 anomalies with at least two wrecks across a 4km spread of debris. Some wrecks, however, have been very well preserved substantially intact, such as *Stirling Castle* and GAD 23 (the 'bowsprit wreck') to the north of the study area.

Fifteen of the 55 documented losses are recorded by the NRHE as possibly or potentially corresponding to remains of vessels that have been discovered outside the proposed dredge area. All but one were lost during the 20th century, the other lost in 1899.

The five 20th century losses which have not been correlated to remains on the seabed elsewhere include two that were lost in 1972 and 1980 and are of no archaeological interest. The remaining three are a steel steam ship (*Carlotta* lost 1900), a steel sailing vessel (*Bertha* lost 1906) and a schooner, presumably wooden (*Lina* lost 1918).

It is possible that these vessels (and the 35 losses from the 17th, 18th and 19th centuries that also have not been correlated to remains elsewhere) could correspond to UKHO records of wrecks and obstructions that were not seen within the geophysical data and classified by A3 by Wessex archaeology (2015) (historic record of possible archaeological interest with no corresponding geophysical anomaly) (**7006**, **7023** and **7027**). It is also possible that these may correspond to previously recorded, yet unidentified wrecks outside the study area, or that remains associated with these may not yet have been located, within or beyond the study area.

The potential for preservation within the study area is highest where the sand is deepest. Within the proposed dredge area the geophysics data has shown that the depth of sediment is thickest in the north of the area and along the eastern edge. The isopach map shown in (**Figure 6.4**) shows that sediment in these areas, along the edge of the bank is approximately 10 to 15m with isolated pockets of 15-20m depth. The thickness rapidly decreases towards the bank margins with only 0-2m of sand overlying the chalk along the western edge.

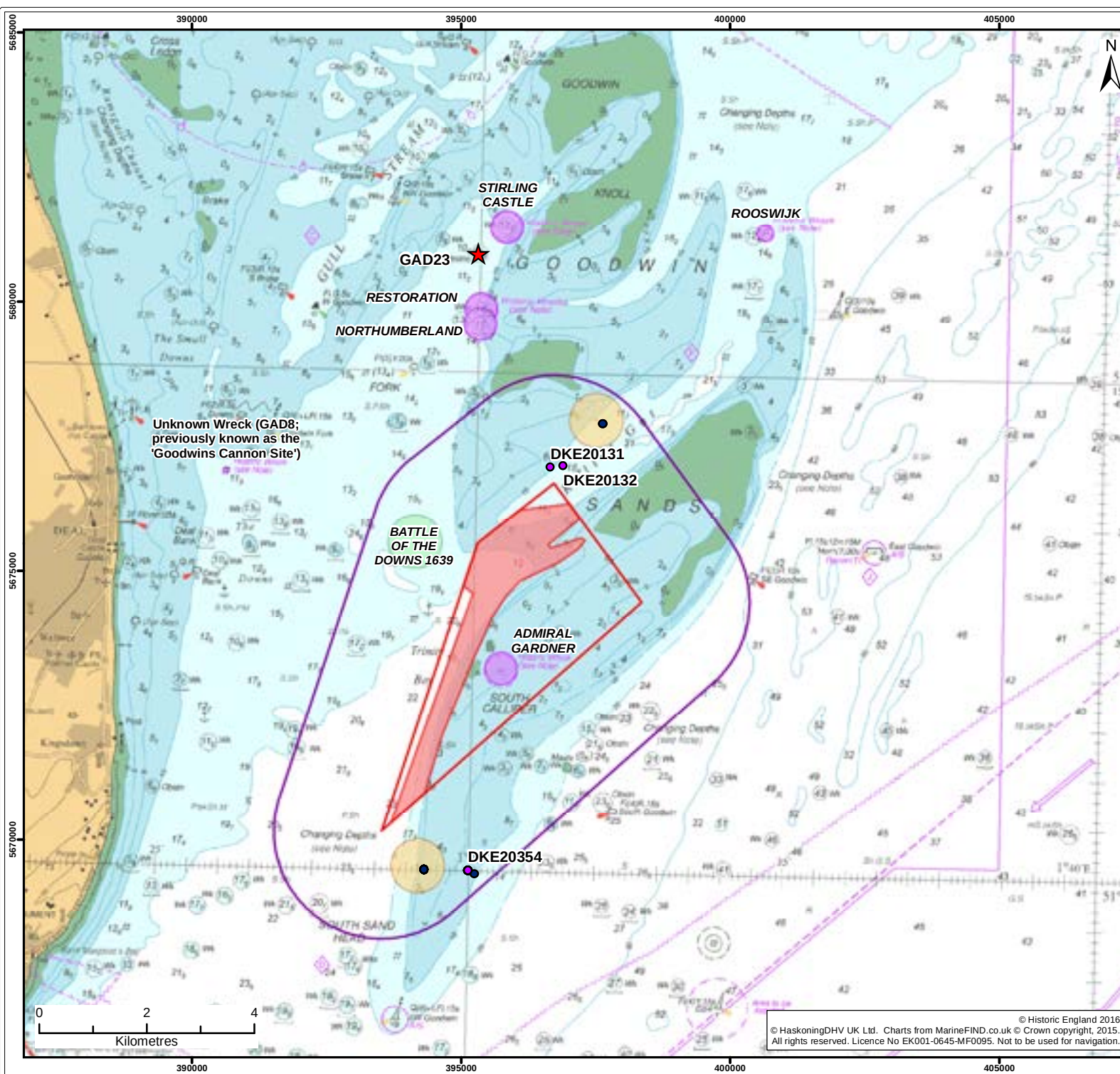
The two as yet undiscovered 20th century steel ships, for example, were both lost on the south sands head to the south of the proposed dredge area. The sediment cover is lowest at this southern end of the area. This, together with the low number of iron/steel vessels recorded as lost indicates that the potential for the substantial remains of intact metal wrecks within the proposed dredge area is low. Most of the wrecks on Goodwin Sands are of wooden vessels that have not remained intact (Wessex Archaeology, 2014). The potential for wooden wrecks, or parts of them, which account for the majority of documented losses is considered to be high.

6.2.3 Value of Archaeological Receptors

By virtue of their national importance and protected status, all designated vessels are of **high** archaeological value.

The wreck possibly identified as the early 19th century East Indiaman *Britannia*, lost in the same storm as the designated *Admiral Gardner*, should be considered as a potential candidate for designation, if the identity can be confirmed. As such, this wreck should be considered of **high** archaeological value.

The *North Eastern Victory* sank in December 1946, after running aground in thick fog and breaking in two pieces before it sank, seen as two distinct areas on the sidescan sonar data and partially buried. The vessel was an armed cargo vessel, an American Victory-type ex-Liberty ship carrying grapefruit, flour and rice from New Orleans to Antwerp. Between 1941 and 1945, 2,710 liberty ships were built which makes them one of the largest number of vessel types mass-produced to a single design (National Park Service, 2015). In terms of age and rarity, therefore, this wreck is of low archaeological value.



Legend:

- Proposed Dredge Area
- Exploration Area
- NRHE and Kent HER Search Area
- Protected Wreck Exclusion Zones
- NHRE Named Locations
- Battle of the Downs 1639
- GAD 23 Proposed for Designation (Protection of Wrecks Act 2973)
- Kent HER Documented Losses
- Kent HER Protected Place/Aircraft (Protection of Military Remains Act 1986)

Client:	Project:
Dover Harbour Board	Goodwin Sands Aggregate Dredging Environmental Statement

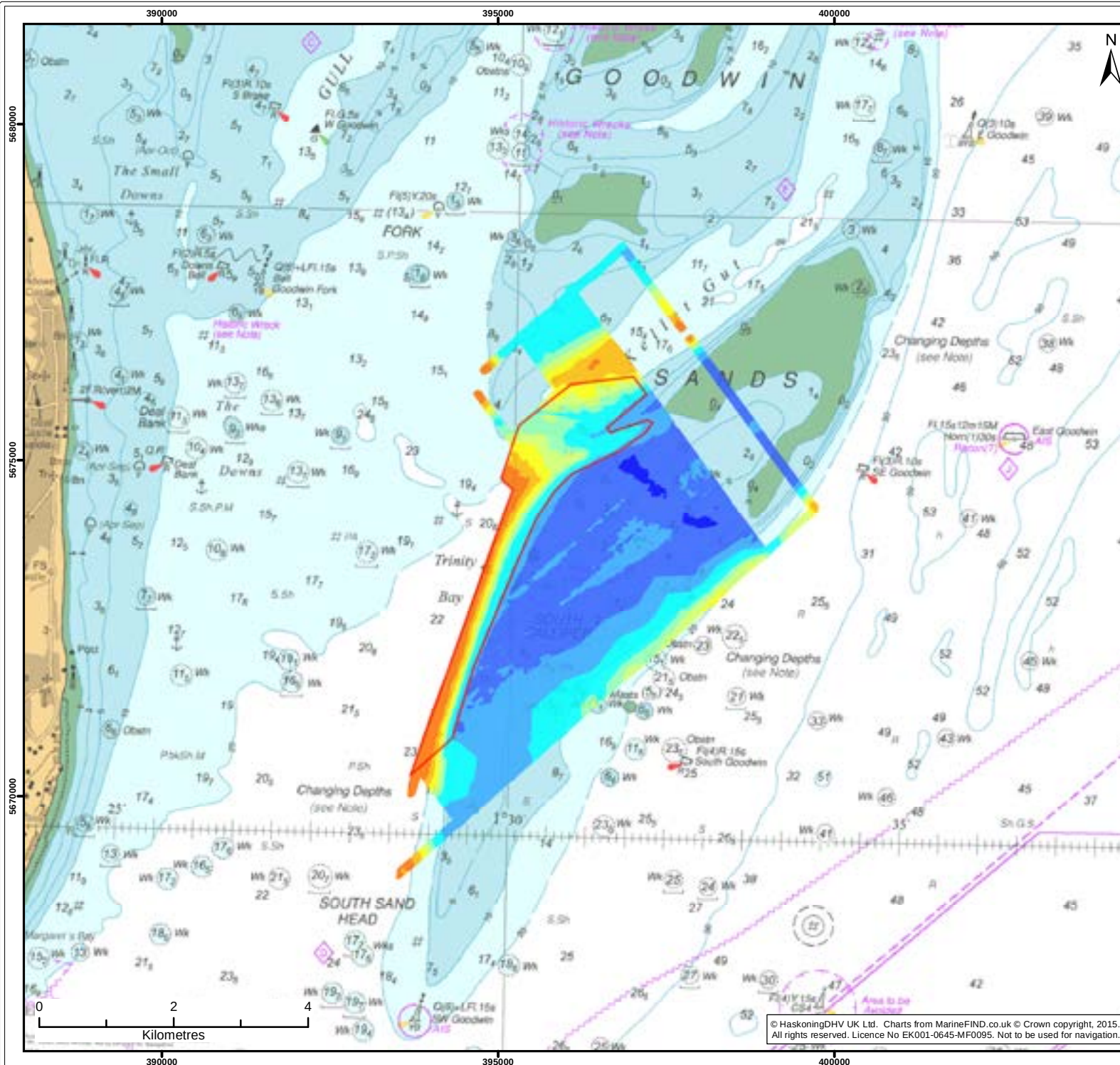
Title:
Protected Wrecks and Documented Losses

Figure: 6.3	Drawing No: PB2107/ES/038

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Legend:

Proposed dredge area

Base of Sand Isopach Thickness (m)

- 25 - 30
- 20 - 25
- 15 - 20
- 10 - 15
- 8 - 10
- 6 - 8
- 4 - 6
- 2 - 4
- 0 - 2
- 2 - 0

Client:
Dover Harbour
Board

Project:
Goodwin Sands
Aggregate Dredging
Environmental Statement

Title:
Proposed dredge area with isopach thickness

Figure: 6.4 Drawing No: PB2107/ES/005

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The NRHE records that in 1976, three masts were visible from the shore and by 1991 there were only two. In the early 1990s divers reported that the deck seemed to be shearing away and could collapse. The geophysics data shows, however, that substantial remains do survive, albeit in two parts, and with associated debris. In terms of survival and condition, therefore, the wreck is of medium archaeological value.

The vessel was lost after running aground in thick fog, with no loss of life. The NRHE record suggests that, 'as with the other US ships lost on this part of the Goodwin's around the same time, the basic cause was a directive issued in January 1946 by an Administrator for Ship Operations. This stated that the employment of pilots around the Thames Estuary was disapproved. US charts often neglected to show the Goodwin's as a navigational hazard, and omitted to show the Goodwin lightships.' The documentary value of the loss is considered to be medium.

In terms of group value, Liberty Ships were seen as, 'America's Lifeline in War', and are a significant national mnemonic for America's involvement in the Second World War. However, at time of loss the vessel was operating as part of America's trade fleet and was not lost as part of the war. Therefore, the vessel is considered to be of medium value.

With respect to the above, *North Eastern Victory* is assessed as being of **medium** archaeological value.

The unidentified anomalies and wrecks recorded by the UKHO (**7006**, **7023**, **7024** and **7027**), not seen in the 2015 geophysical data by Wessex Archaeology (2015) and probably buried, are of potential archaeological interest. Due to the uncertainty surrounding the identity, nature and extent of these recorded sites it is necessary to take a precautionary approach to impact assessment and, as such, each is considered to be of potentially **high** archaeological value. Similarly, 21 of the 22 anomalies seen in the geophysical data and classified as A2 (uncertain origin of possible archaeological interest) should also be considered to be of **high** value.

The remaining anomaly, **7003**, is considered to be of **low** archaeological value as a rope, chain or probable cable.

6.3 Aviation

6.3.1 Known

There are no known aircraft crash sites or findspots within the proposed dredge area.

6.3.2 Potential

There is high potential for the remains of crashed aircraft on Goodwin Sands.

For example, an intact, Dornier 17 German bomber was found on Goodwin Sands by a local diver in 2008, subsequently revealed to be the world's only surviving example of this type of aircraft. Shot down during the Battle of Britain in 1940, the remains of the Dornier were raised and are currently undergoing conservation at the RAF museum in Cosford.

There are two records of aircraft located c. 700m to the north of the proposed dredge area. The first is recorded by the NRHE (831719) and the UKHO (15048) as a wreck thought to be the remains of a Second World War American bomber, located in the Gull Stream among the Goodwin Sands. The second is an NRHE record (1398705) of a B26 Marauder (an American bomber) reported by divers lying on top of

an old shipwreck in Kellett Gut. Given that these two records are c. 250m apart it is likely that they represent the same wreck.

There are no further losses of aircraft recorded within the area searched. This is unlikely, however, to be a realistic reflection of the potential for aircraft to be present.

Following the advent of powered flight in the early 20th century, a large number of aircraft have been lost offshore, particularly during the Second World War (Wessex Archaeology, 2008). During the First World War balloons and airships were used in large numbers, with German Zeppelins being used to attack the UK and provide reconnaissance for the German fleet. The Royal Naval Air Service was responsible for the defence of Britain and airfields are recorded at Swingate (KENT MKE17130) and Walmer (NRHE 1413679) in Kent (Wessex Archaeology, 2013).

Aircraft at this time were fragile, made of wood and fabric and making long-distance cross-channel raids an unrealistic tactic and there was comparatively little aviation over the sea. A total of 28 fixed wing aircraft and 15 airships were lost by the German Imperial Air Service and Navy during raids on the UK mainland during the First World War. During this period 34 aircrew from British Home Defence Squadrons were recorded as lost, while significant numbers of aircraft were also lost in the UK through training accidents. The fragility of the aircraft structure, however, means that the remains of these early crashed aircraft rarely survive.

In comparison, it has been estimated that between 1939 and 1945 RAF Bomber Command lost 1,380 aircraft within the UK on operational flights and, a further 3,986 aircraft in non-operational accidents (Wessex Archaeology, 2008). It has also been estimated that Luftwaffe losses in and around the UK numbered c. 1,500. The Second World War saw the mass production of reliable and more durable metal aircraft which made cross-channel raids feasible and increased their capacity of defensive and offensive weapons.

In Kent, Manston was an important navigational point for allied aircraft returning from night raids during this period and the increase in traffic, and construction of anti-aircraft batteries along the coast, indicates the high potential for losses to have occurred over the study area (Wessex Archaeology, 2013b). Numbers of aircraft lost at sea are also indicated by records of Air/Sea Rescue services. Maps of Second World War RAF Air/Sea Rescue records indicate a high concentration of losses, particularly off the east and south coasts of Kent throughout the War (Wessex Archaeology 2008).

Prior to the Second World War both civil, and to some extent military flights, over the sea were uncommon (Wessex Archaeology, 2008). After 1945, however, the number of civil aviation services increased rapidly, accompanied by the introduction of the jet engine in the 1950s. The Air Accident Investigation Branch, the body charged with investigating civil air accidents in the UK, has records for 150 civil aircraft losses at sea since 1920.

Despite the low number of documented losses from the study area, the potential for aircraft remains to be present should be considered to be high. The locations of many of the aircraft losses may not have been recorded accurately, particularly during wartime, while many others may have been lost without record. As for maritime remains (**Section 6.2.2**), geophysical survey, the geomorphology of the proposed dredging area and historic dredging activities suggest that, while the survival of an intact aircraft within the study area is possible, discoveries of disarticulated aircraft remains are more likely to occur.

6.3.3 Value of Archaeological Receptors

All aircraft that have crashed whilst in military service are automatically protected under the Protection of Military Remains Act 1986. As such, all military aircraft should be considered to be of **high** value.

Due to the high potential for associated loss of life associated with aircraft crashes, and due to the potential for remains of high archaeological value to be present, all non-military aircraft should also be regarded as **high** value as a precautionary measure.

6.4 Historic Seascape Character

The Historic Seascape Character (HSC) of coastal and marine areas around England has been mapped through a series of projects funded by Historic England. The programme uses GIS to map data that can be queried to identify the key cultural processes that have shaped the historic seascape within a given area.

The Goodwin Sands are located within the HSC for the Thames Estuary and Kent (Cotswold Archaeology, forthcoming). At the time of writing the results of this study are not yet available for analysis, although the baseline assessment above indicates that all three of the subject areas (submerged prehistory, maritime and aviation) are represented within the study area and thereby contribute to the historic character. In particular, the perception of Goodwin Sands as a major hazard to shipping forms a key part of this character. The large number of wrecks in the 45-55m depth range are popular with scuba divers, and visibility is typically good (RHDHV, 2015). Local recreational diving organisations Dive125 (Dive125, 2015), Canterbury Divers (Canterbury Divers, 2015) and Mutiny Diving (Mutiny Diving, 2015) are all known to visit Goodwin Sands.

There are also several important fishing grounds within the area of the Goodwin Sands. The exploration area, wider Goodwin Sands and surrounding waters are located within the Kent and Essex Inshore Fisheries and Conservation Authority (KEIFCA) District (RHDHV, 2015). A variety of static and mobile gears are used including trawling, pair trawling, drift/fixed netting, potting, scallop and oyster dredging and cockle dredging.

A range of recreational vessels use the waters surrounding Goodwin Sands. The two main recreational activities in the study area are fishing and sailing although a number of recreational boat tour companies also operate in and around Goodwin Sands.

There are subsea cables in the vicinity of the exploration area, although there are no offshore disposal sites, military practice and exercise areas, oil and gas pipelines or installations (RHDHV, 2015). Thanet offshore wind farm is located c. 20km to the north east of the exploration area. There are no offshore wave or tidal installations within the study area. The nearest licensed aggregate extraction site is located 57km to the north of the exploration area at Longsand, although the study area partially overlaps with South Sand Head, the Historic Area 342 previously dredged by the DHB. Goodwin Sands has been dredged previously to provide aggregate for infrastructure projects at the Port of Dover and the Port of Ramsgate, with five licences being issued covering the North Goodwin and South Goodwin areas (293/1, 304, 342, 352 and 365) with over 9.5 million tonnes extracted between 1976 and 1998.

In summary, the historic character of the study area comprises the following:

- Submerged prehistoric landscape features;
- Aircraft crash sites;
- Commercial shipping;

- Historic wreck sites;
- Commercial fisheries;
- Recreational activities including scuba diving, recreational fishing, sailing and boat tours;
- Subsea cables; and
- Aggregate extraction.

The historic character of Goodwin Sands is of **high** value, primarily due to the perception of the sands as a major shipping hazard associated with numerous historic accounts of losses.

6.5 Heritage Assets on the Kent Coast

The proposed dredge area is located between c. 5 and 6.5km offshore from the stretch of the Kent coast between Deal and Kingsdown.

There are two scheduled monuments along this stretch of coast, the artillery castle at Deal (List entry Number: 1013380) and the artillery castle at Walmer (List entry Number: 1013381). These castles are part of a group of three constructed between 1539 and 1540, with the artillery castle and Sandown to the north (List entry Number: 1005147), constructed by Henry VIII to protect the Downs anchorage. The castles were financed from the proceeds raised by the Dissolution of the Monasteries and were built in response to the political crisis and consequent fear of invasion occasioned by the king's divorce of Catherine of Aragon in 1533. The gardens of Walmer Castle are also designated as a Grade II registered Park and Garden. Both Deal Castle and Walmer Castle are popular heritage, tourist attractions with their views to the sea forming part of their intrinsic historic context and setting.

There are a large number of listed buildings within this coastal stretch, largely centred on Deal and Walmer, such as the Grade II Listed early 19th century Georgian, Royal Hotel on the seafront at Deal. Also on the seafront is the Timeball Tower. This Grade II Listed Building was built as one of 10 royal signal towers used to semaphore messages to the Admiralty from the fleet at the Downs during the Napoleonic Wars. In 1855 the tower was adapted to include a 'time-ball', a means of signalling the time to enable ships to check their chronometers. At 12:55 every day a time-ball mounted on a 14ft mast would be raised halfway, at 12.58 pm it was raised to the top of the shaft and at 1 pm it was brought down by electric current direct from Greenwich and was thus able to give Greenwich Mean Time to ships on the Downs. The historic character and setting of both of these Grade II Listed structures, as well as others along the seafront, is strongly influenced by their proximity to the sea.

There are also three Conservation Areas: Middle Street Deal; Walmer Sea Front; and Kingsdown. These are areas designated for their special architectural and historic interest. The Walmer Seafront Conservation Area in particular comprises many buildings of maritime interest including Admiralty Mews, the former Naval Hospital and later the Royal Marines' School of Music, most of Archery Square and many other seafront properties.

The South East Rapid Coastal Zone Assessment Survey (SE RCZAS) also identifies large numbers of undesignated heritage assets along the coast between Deal and Kingsdown (Wessex Archaeology, 2013). Recorded assets include large numbers of Second World War coastal installations, including pillboxes, beach scaffolding, anti-aircraft batteries and a fougasse system along the beach from Kingsdown to Sandwich Bay (a system of pipes leading into the beach that could set the whole beach alight).

There is archaeological evidence for human activities from Deal to Kingsdown from the Prehistoric period onwards (Wessex Archaeology, 2013b). Prehistoric findspots along this stretch include Neolithic pottery,

found during the laying of a water main between Deal and Kingsdown (**MKE 6637**), and pottery found in a Brickearth pit in Deal (**MKE7347**, **NRHE 468483**). A large Late Neolithic or Early Bronze Age assemblage of over 620 flint artefacts were discovered in Deal (**MKE 17851**) and settlement evidence for the Bronze Age is known from Mill Hill, Deal. Three Bronze Age cremations were located in Deal (**MKE 7327**, **MKE 17797** and **NRHE 468435**) and a Late Bronze Age cremation within a bucket urn was recorded around 27m from the cliff edge beside the Kingsdown Golf Links (**MKE 6640**, **NRHE 467398**). Iron Age Field systems are also seen at Deal (**MKE 17769**) and a Middle Iron Age burial. Burials throughout the Iron Age in Deal showed a transition from inhumation (**MKE 5597**), first crouched (**MKE 19966**), then extended supine, to cremation (**MKE5594**).

There were Roman ports at Dover and Walmer and, during the medieval period, ports in Kent became increasingly significant for both overseas and coastal trade around Britain (Wessex Archaeology, 2013b). The Cinque Ports in Kent and East Sussex (of Hastings, New Romney, Hythe, Dover and Sandwich) and their member ports were particularly significant in the earlier and later medieval periods. By the 16th century Sandwich was the 'head port', but the port at Dover was the largest in Kent and the most maintained, due to its naval and cross-channel importance. By the mid-19th century the port at Deal had silted up and with the advent of steam, ships no longer needed to take shelter at Deal. The town subsequently emerged as a tourist resort with the first pier built in 1857.

Deal and Walmer castles and listed structures, such as the Timeball Tower, are of **high** heritage value. Undesignated heritage assets are numerous and vary in character and extent. For the purposes of this assessment, the value of undesignated assets is considered to be of **low** to **medium** heritage value.

6.6 Baseline Summary

The heritage assets, and their value, identified in the baseline assessment above are summarised in **Table 6.1** below.

Table 6.1 Summary of Known and Potential Assets and Value Judgements

Parameter	Receptor	Value	Reason for value judgment
Seabed Prehistory	Potential discoveries of <i>in situ</i> prehistoric archaeological and palaeoenvironmental material	High	Discoveries are rare within the marine environment.
	Potential discoveries of derived prehistoric artefacts.	High	Precautionary. Potential for artefacts of high value to be discovered.
Maritime	<i>Admiral Gardner, Stirling Castle, Northumberland, Restoration, Rooswijk, GAD8.</i>	High	Designated under the Protection of Wrecks Act 1973 as wrecks of national importance.
	GAD23.	High	Recommended for designation under the Protection of Wrecks Act 1973 as a wreck of national importance.
	Potential for discoveries of material associated with the submarine U12.	High	Protected under the Protection of Military Remains Act 1986.
	<i>Britannia</i> (Kent HER MKE13467, NRHE 904848, UKHO14869).	High	If possibly identified as the <i>Britannia</i> the wreck would be of national importance.
	<i>North Eastern Victory</i> (7018).	Medium	Potentially substantial remains of a mass produced American Liberty Ship.
	Unidentified possible wreck (7024).	High	Precautionary. Potential for artefacts of high value to be discovered.

Parameter	Receptor	Value	Reason for value judgment
	Unidentified (A2) geophysical anomalies and (A3) recorded wreck sites.	High	Precautionary. Potential for artefacts of high value to be discovered.
	Anomaly 7003.	Low	Rope, chain or probable cable.
	Potential discoveries of material associated with maritime activities.	High	Precautionary. Potential for artefacts of high value to be discovered.
Aviation	Potential discoveries of material associated with military aviation.	High	Automatically protected under the Protection of Military Remains Act 1986.
	Potential discoveries of material associated with civil aviation.	High	Precautionary. Potential for loss of life and for artefacts of high value to be discovered.
Historic Character	Historic seascape character of the Goodwin Sands.	High	Widespread public perception of Goodwin Sands as a major shipping hazard.
Coastal Heritage	Deal and Walmer Castle and Listed Buildings along the coast.	High	Designated as assets of national importance.
	Undesignated heritage assets.	Low/Medium	Numerous assets of varying character and extent.

7 Impact Assessment

7.1 Dredging Methodology

DHB is proposing to dredge up to 2.5 million m³ of fine to coarse sand and gravels from South Goodwin Sands, located approximately 19km north east of the Port of Dover. The aggregate dredging will be undertaken using one or two trailing suction hopper dredgers (TSHDs). During dredging the TSHD will move slowly across the dredging zone with its drag head deployed. As it does so, it removes, by suction, approximately 30-50cm of the uppermost layer of seabed sediment. Trailer dredging results in shallow depressions in the seabed that are 2-3m in width and up to 0.5m in depth (TCE, 2013).

The dredger will be equipped with a Global Positioning System (GPS) to enable accurate positioning and dredging within the licence area. Dredgers are also fitted with an Electronic Monitoring System (EMS) which records the vessel's position every 30 seconds during dredging operations. The data from the EMS system is monitored by TCE and the MMO to ensure dredging operations are undertaken within licensed areas.

Sediments will not be dredged down to underlying bedrock. In accordance with Marine Minerals Guidance 1 (ODPM, 2002) and established industry practice it is proposed that an average 50cm capping layer will be left in place following completion of dredging.

Once loaded into the hopper, the dredged aggregate will be transported by the dredger(s) to the DWDR site in the Western Docks, Dover for use as fill material for land reclamation and potentially berth construction works. Material will be mixed with seawater within the hopper and discharged to the reclaim area via a floating pipeline. The saturated sand will then be manoeuvred into position by excavators and bulldozers.

7.2 Mitigation through Design

Archaeological Exclusion Zones (AEZs) will be implemented around known heritage assets within the proposed dredge area, within which no dredging or anchoring of vessels will take place.

A single AEZ has been recommended by Wessex Archaeology (2015) following the geophysical assessment. The recorded wreck **7006** has not been observed since 1996 and the UKHO record has been amended to “Dead”. It is, however, recommended that a 50m radius AEZ should be implemented around this location (Centre point 394438, 5672133 UTMz31N) as it is possible that material may be buried at this position (**Figure 7.1**).

A further AEZ is also recommended around the recorded location of *Britannia* c. 15m outside and to the south of the proposed dredge area (**Figure 7.1**). A 100m AEZ is recommended to ensure that any wreck material in the vicinity of the location is avoided during dredging.

Six unidentified anomalies are located within the proposed dredge zone (**7000, 7001, 7002, 7003, 7007** and **7008**) (**Figure 7.1**). Following the assessment of geophysical data, Wessex Archaeology (2015) recommended that these be avoided but that AEZs, incorporating a buffer around the recorded positions, were not required.

The point locations to be avoided are listed in **Table 7.1**.

Table 7.1 Recorded locations of A2 anomalies to be avoided during dredging

WA ID	Classification	Easting	Northing	Length (m)	Width (m)	Height (m)
7000	Dark Reflector	393907	5670673	2	0.7	0.5
7001	Dark Reflector	394087	5671088	14.9	0.4	0.2
7002	Dark Reflector	394197	5671550	4.2	1.8	0.7
7003	Rope/Chain	394169	5671610	250	0.8	0.3
7007	Dark Reflector	394728	5673194	1	0.6	0.3
7008	Dark Reflector	394760	5673309	3.6	0.6	0.3

If it is not possible to avoid these recorded positions then further mitigation will be required (see **Section 7.4**). The prehistoric fill of the palaeochannel will also be avoided during dredging. The target aggregate comprises the sands overlying the palaeochannel which cuts into the Cretaceous chalk bedrock. As stated above (**Section 7.1**) these sands will not be dredged down to the underlying bedrock and an average 50cm capping layer will be left in place following completion of dredging. This will prevent impact to any prehistoric archaeological or palaeoenvironmental remains that may be present within the palaeochannel.

7.3 Assessment of Effects and Determination of Impact Significance

7.3.1 Direct Impacts to Heritage Assets

Direct impacts to heritage assets, either present on the seafloor or buried within seabed deposits, may result in damage to, or total destruction of, archaeological material or the relationships between that material and the wider environment (stratigraphic context or setting). These relationships can often be crucial to developing a full understanding of an asset.

Direct impacts to archaeological material may occur if they are present within the dredge footprint. Activities that interact with the seabed or the seabed deposits will not be undertaken beyond the proposed dredge area and impacts will, therefore, not occur beyond this boundary. There will be no direct impact to the Goodwin Sands designated wreck sites, which all lie outside the proposed dredge area.

Direct impacts to known heritage assets (recorded wreck **7006** and unidentified anomalies **7000**, **7001**, **7002**, **7003**, **7007** and **7008**) within the proposed dredge area will not occur as the positions of these known receptors will be avoided during dredging (see **Section 7.2**, mitigation through design).

Direct impacts to *in situ* archaeological and palaeoenvironmental material and derived artefacts within the palaeochannel will not occur due to the retention of a capping layer of an average 50cm of sand overlying the chalk bedrock and the palaeochannel infill (see **Section 7.2**, mitigation through design).

Direct impacts to potential archaeological material may occur if previously undiscovered heritage assets are buried within the target aggregate and if they are impacted by the drag head during dredging. As set out in **Section 6** above, the archaeological value of potential archaeological material is considered to be **high**.

The sensitivity of *in situ* maritime or aviation material to impacts from the dredger's drag head should also be considered to be **high**. All damage to archaeological receptors will be permanent and cannot be reversed. It will not be possible to assess the capacity of an impacted receptor to accommodate change until impacts have occurred and the receptor has been identified. A precautionary (worst case) approach is recommended which assumes that impacted receptors will have no capacity to accommodate change.

Similarly, the magnitude of the effect cannot be fully assessed until an impact to *in situ* maritime or aviation material has occurred. It is possible that the impact may result in the total loss of an archaeological receptor, or partial loss of, or damage to, key characteristics, features or elements. If present within the path of the dredger's drag head, damage is likely to occur and this change will be permanent. The potential magnitude of effect is, therefore, also judged to be **high**.

In accordance with the matrix in **Table 4.6**, direct impacts to potential *in situ* maritime and aviation heritage assets are assessed as being of possible **major adverse significance**.

Isolated artefacts, either of prehistoric, maritime or aviation origin, within reworked deposits may be considered less sensitive to change than *in situ* material as their relationship with their context or physical setting is less relevant to understanding their significance. Artefacts brought to the surface via the drag head and retained for further assessment, for example, have moderate potential to recover from the effect of this removal, particularly if provided with appropriate assessment and conservation. Removal from the marine context, however, will still result in the destruction of that contextual relationship, albeit a secondary context, and isolated artefacts are, therefore, judged to have limited capacity to accommodate physical changes or influences. Isolated, derived artefacts are thus considered to be of **medium** sensitivity to removal from the seafloor. If present within the path of the drag head the probability of the impact occurring is high, although possibly resulting in only a minor loss of, or alteration to, one (maybe more) key characteristics, features or elements. The magnitude of effect is also judged to be **medium**.

Direct impacts to derived, isolated artefacts that may potentially be present within the target aggregate are assessed as being of possible **moderate adverse significance** in accordance with the matrix in **Table 4.6**.

7.3.2 Indirect Impacts Associated with Coastal Processes and Hydrodynamics

The proposed dredging of aggregate from Goodwin Sands has the potential to directly and indirectly change the hydrodynamic and sedimentary process regimes, both locally and regionally. These impacts have been assessed and the results are presented in **Section 6** of the ES.

Changes in coastal processes can lead to re-distribution of erosion and accretion patterns while changes in tidal currents, for example, may affect the stability of nearby morphological and archaeological features. Indirect impacts to heritage assets may occur if buried heritage assets become exposed to marine processes, due to increased wave/tidal action for example, as these will deteriorate faster than those protected by sediment cover. Conversely, if increased sedimentation results in an exposed site becoming buried this may be considered a beneficial impact.

Numerical modelling has been undertaken by HR Wallingford (2015a, 2015b, 2015c, 2015d) to compare the existing environmental conditions with the conditions created by the dredging. Four models have been run to inform the EIA process; these models simulate waves, tidal currents, sediment plume dispersion and sediment transport.

The proposed dredging will predominantly release a mixture of fine and medium sand from the overflow, with a very small amount of mud. The mud will be released into the water column to form a plume which will disperse into the background. The sand will fall to the seabed and become part of the background sediment transport regime and will not change the bed substrate to any significant extent. The thickness of deposited mud from the plume will be of the order of a fraction of a millimetre and will likely be re-suspended on the following tide. Therefore, there will be **no impact** to archaeological receptors from increased sediment deposition.

The predicted maximum change in wave height is between 0.02m and 0.1m. The geographic distribution of these changes in wave height is always greater than 4.5km from the coastline beyond which (i.e. closer to the coast) there is no change. The results show that natural movement of the sand banks would cause significantly more variation in significant wave height than was predicted for the post-dredging bathymetries. Overall, the changes predicted to be caused by dredging are negligible and are unlikely to affect the form of recent sediments. Similarly, the predicted change in tidal current velocities is so small that it is unlikely to affect the form of recent sediments over and above the natural tidal processes. Therefore, there will be **no impact** to archaeological receptors from increased wave heights and tidal velocities.

The data also shows, therefore, that there will be no indirect impact to the designated wreck sites on the wider Goodwin Sands described in **Section 6.2.1**. The effects described above are limited to the locality of the proposed dredge area (<5km radius as a worst case) and any changes within this boundary will be negligible. The volume of material being taken is low relative to the scale of the sandbank system, the proposed dredge area has deliberately been located on the sheltered side of the bank to minimise any potential for effects on the hydrodynamic and sedimentary process regimes and the sediment plume is very limited due to the low percentage of fine grained silts and mud in the target aggregate. In addition, bathymetric changes from the proposed dredging are sufficiently low to minimise any changes to waves and tidal flow.

7.3.3 Historic Seascape Character

The historic seascape character of Goodwin Sands has been assessed as **high** value, primarily due to the perception of the sands as a major shipping hazard associated with numerous historic accounts of losses. The character also comprises submerged prehistoric landscape features, aircraft crash sites, commercial shipping, historic wreck sites, commercial fisheries, recreational activities, subsea cables and aggregate extraction.

As this area has been subject to historic dredging activity there will be **no change** to this character from the proposed scheme.

7.3.4 Setting

The setting of a heritage asset is the surroundings in which a heritage asset is experienced (Historic England, 2015). Elements of a setting may make a positive or negative contribution to the significance of an asset, may affect the ability to appreciate that significance or may be neutral.

The setting of historic wrecks on, and within, Goodwin Sands makes a positive contribution to the significance of those wrecks. The setting of the Goodwin Sands themselves should also be considered. The exposure of parts of the sands at low tide, with accounts of cricket matches played upon the sands in the past, and the visibility of some wrecks above the surface, mean that historic wrecks and the Goodwin Sands are experienced both above and below the surface of the water. The way in which individual wrecks are experienced is, therefore, influenced by the setting of the Goodwin Sands above water, from recreational boat tours for example, and below water by scuba divers.

During dredging the physical presence of the vessel will impact the setting of the Goodwin Sands, but the effects will be temporary. Once the vessel leaves the area the setting will recover from the effect. The sensitivity is, therefore, assessed as **low**. The magnitude of the effect is also assessed as **low**. There would be a noticeable change to the setting associated with the presence of the dredger although this would vary according to distance from the dredger with respect to noise and visual disturbance. This change would, however, only be short-to medium term and is entirely reversible.

In accordance with the matrix in **Table 4.6**, impacts to the setting of historic wrecks on the Goodwin Sands, and the Goodwin Sands themselves, are assessed as being of **minor adverse significance**.

The setting of assets along the Kent coast may also be impacted by the transit of the dredger. As outlined in **Section 6.5**, the setting of these coastal assets and their relationship with the sea forms a key component of their value, such as Deal and Walmer Castles the Timeball Tower. However, as above, the impact from the presence of the dredger will be temporary and short term. In addition, dredging activities will be undertaken a significant distance from the shore, between c. 5 and 6.5km from the Kent coast, and within a region already subject to significant numbers of daily vessel movements. The impact upon setting is thus assessed to be of **negligible adverse significance**.

In summary, the impact assessment has concluded that:

- Direct impacts to known heritage assets within the proposed dredge area **will not occur**;
- Direct impact to *in situ* prehistoric deposits associated with the palaeochannel **will not occur**;
- Direct impacts to previously undiscovered *in situ* maritime and aviation material within the proposed dredge area will be of possible **major adverse significance**;
- Direct impacts to isolated, derived artefacts brought to the surface via the drag head will be of possible **moderate adverse significance**;
- Indirect impacts as a result of changes to coastal processes and hydrodynamics **will not occur**;
- There will be **no change** to the historic character of the seascape;
- Impacts to the setting of Goodwin Sands and historic wrecks will be of **minor adverse significance**; and
- Impacts to the setting of coastal heritage assets will be of **negligible adverse significance**.

Therefore, based upon the EIA principle of moderate adverse impact significance and above being considered 'significant' in EIA terms, mitigation is only required to address the possible impact to

previously undiscovered *in situ* maritime and aviation material and to isolated discoveries of prehistoric, maritime and aviation derived artefacts.

7.4 Mitigation and Residual Impacts

7.4.1 Summary of Mitigation

In order to reduce the significance of adverse impacts the following mitigation measures are proposed:

- Archaeological assessment of pre-dredge and post-dredge geophysical survey;
- On board archaeological monitoring during dredging;
- Archaeological monitoring during discharge of dredged material;
- Implementation of an archaeological protocol for reporting discoveries of archaeological interest; and
- Additional mitigation in the event that anomalies of possible archaeological interest cannot be avoided

The methodology for these mitigation measures will be set out in an archaeological Written Scheme of Investigation (WSI) to be agreed by DHB with Historic England and the MMO prior to the commencement of dredging.

Following the application of mitigation the residual impact of dredging will be reduced to **minor adverse significance**.

7.4.2 Geophysical Assessment

Data acquired during pre-dredge and post-dredge geophysical surveys will be assessed by an appropriately qualified and experienced geophysical specialist. Data is expected to comprise multibeam bathymetry survey. This desk based assessment has confirmed that the mobility of the sands is high and that many heritage assets cover and uncover over time.

A pre-dredge assessment will facilitate the identification of any additional heritage assets that may have been uncovered between the acquisition of the 2015 data and the pre-dredge survey. If new heritage assets are revealed they will be avoided through the application of AEZs (new wrecks or aircraft crash sites), or through the avoidance of point locations (anomalies of potential archaeological interest). Newly acquired data may also help to clarify the nature and extent of the assets identified in this report that can inform the avoidance strategy for such assets.

A post-dredge assessment will inform understanding of the nature and extent of heritage assets following dredging, confirming the effectiveness of AEZs and avoidance and demonstrating the presence of any new assets that may have been uncovered.

7.4.3 On Board Archaeological Monitoring

The presence of an archaeologist on board during dredging can facilitate the application of the reporting protocol (see below) and allow for monitoring of the dredging process to ensure that significant impacts to heritage assets do not occur or, for buried archaeological material, impacts can be reduced by the effective and timely application of measures to record any finds and prevent further impacts.

A strategy for on board monitoring, including agreement on the duration of monitoring requirements, will be agreed by DHB with Historic England and the MMO prior to the commencement of dredging.

7.4.4 Archaeological Monitoring During Discharge

Archaeological monitoring during discharge of the dredged material at the Western Docks may be of benefit dependent upon the methodology for discharge. Following discharge via a floating pipeline the dredge material will be manoeuvred into position by excavators and bulldozers. The potential for observing material of archaeological interest during this process is expected to be low.

However, a series of archaeological monitoring visits during this process will facilitate the application of the reporting protocol (see below) and allow for monitoring of the discharge to minimise the potential for archaeological material to be lost during reclamation.

A strategy for discharge monitoring, including agreement on the duration of monitoring requirements, will be agreed by DHB with Historic England and the MMO prior to the commencement of dredging.

7.4.5 Reporting Protocol

To reduce potential archaeological impacts, dredging operators observe a code of practice for marine aggregate dredging and the historic environment, developed jointly by the British Marine Aggregates Producers Association (BMAPA) and Historic England (BMAPA and English Heritage, 2003). The industry also adheres to an archaeological reporting protocol, which ensures that discoveries of archaeological interest are reported and addressed in a timely and effective manner conducive to the day to day work of dredging company staff (BMAPA and English Heritage, 2005). Discoveries are reported by staff to an implementation service which advises on the necessary measures to address discoveries, such as first aid conservation, recording and temporary exclusion zones, if required. The protocol is accompanied by an awareness programme which offers training to staff in the identification of archaeological material and application of the protocol.

The marine aggregates industry protocol will apply throughout the dredging and discharge process of the proposed scheme.

7.4.6 Additional Mitigation

As stated in **Section 7.2**, if it is not possible to avoid the recorded positions of anomalies of possible archaeological interest (**Table 7.1**) then additional mitigation will be required.

Prior to agreeing any mitigation measures, further investigation may be necessary in order to clarify the nature, extent and archaeological interest of the anomaly. This may include the assessment of additional geophysical data or the use of drop down cameras, divers and/or Remotely Operated Vehicles (ROV) to ground-truth the anomaly.

If additional information demonstrates that the anomaly is non-archaeological or of low archaeological interest then it may be possible to remove the anomaly following prior agreement with Historic England and the MMO.

If further investigation confirms that the anomaly is of moderate or high archaeological interest then an AEZ may be recommended. If avoidance of an AEZ is not possible then measures to record the anomaly and monitor its removal will be agreed with Historic England and the MMO.

If required, the methodology for these measures will be set out in the archaeological WSI to be agreed by DHB with Historic England and the MMO prior to the commencement of dredging.

7.4.7 Residual Impacts

The application of the above mitigation will help to reduce the significance of impacts to buried archaeological material. The assessment of pre-dredge geophysical data will help to further clarify the historic environment resource and conditions and facilitate the identification of new sites, which can then be avoided. Archaeological monitoring and the application of the protocol will not prevent impacts from occurring, but represent appropriate and proportionate measures to ensure that once an impact has been identified/occurred, measures are put in place to prevent further impacts from occurring and to record any archaeological material that is encountered.

Although it is not possible to prevent impacts to all heritage assets from occurring, the application of the above measures is judged to be sufficient to reduce the significance of these impacts to **minor adverse** (i.e. an acceptable level).

8 Conclusions

This desk based assessment has identified potential for high value archaeological remains to be present within the proposed Goodwin Sands dredging area.

All known heritage assets will be avoided during dredging and there will be **no impact** to these assets from the proposed scheme

Potential impacts to coastal and hydrodynamic processes have been modelled and the results indicate that there will be **no indirect impact** upon heritage assets from possible destabilisation of sites. Predicted changes are of insufficient magnitude to result in changes to the sediment cover outside the proposed dredge area.

As the area has previously been subject to aggregate dredging activities there will be **no change** to the historic seascape character from the proposed scheme. Impacts to the setting of the Goodwin Sands and heritage assets along the coast will be temporary and reversible and are assessed as being no more than **minor adverse significance**.

Potential impacts to buried archaeological material may occur if previously unidentified sites or artefacts are present within the path of the drag head. Impacts to *in situ* sites are judged to be of potentially **major adverse significance** while impacts to isolated artefacts that may be brought to the surface are judged to be of **moderate adverse significance**.

With the application of mitigation comprising the further assessment of geophysical survey data, archaeological monitoring and the application of the marine aggregate industry archaeological reporting protocol, the significance of these impacts is judged to be reduced to **minor adverse**.

The methodology for these mitigation measures will be set out in an archaeological WSI to be agreed by DHB with Historic England and the MMO prior to the commencement of dredging.

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Appendix A: Seabed Features of Archaeological Potential

Table A0.1 Seabed features within the proposed dredge area

WA ID	Classification	Easting	Northing	Archaeological Discrimination	Length (m)	Width (m)	Height (m)	Description	External Reference
7000	Dark Reflector	393907	5670673	A2	2	0.7	0.5	Small straight object, which may be bigger at one end. Looks like has corresponding height shadow and appears to be in a depression. Observed as a small mound within a depression in the echosounder data.	-
7001	Dark Reflector	394087	5671088	A2	14.9	0.4	0.2	Dark curvilinear reflector, which appears thicker in the centre. Some bright shadow visible. Seems partially obscured by sandwave. Not observed in the echosounder data.	-
7002	Dark Reflector	394197	5671550	A2	4.2	1.8	0.7	Small irregularly shaped object with slight corresponding shadow. Looks rounded at one end, straight with the other end also curved. On the edge of the sandwave. Observed as a small object in the echosounder data also.	-
7003	Rope/Chain	394169	5671610	A2	250	0.8	0.3	Long thin object, which looks like it lies in both dark and bright sections of seabed, though intermittent. Possible rope/chain. Extends to NNE and SSW with southern tip extending SW. Is distinguishable in the echosounder data.	-
7006	Recorded Wreck	394438	5672133	A3	-	-	-	Recorded UKHO position of an unidentified wreck. Not observed in the sidescan sonar or echosounder data. Previously seen as a small contact in 1996. Not observed since; presumed buried. Has been amended to "Dead."	UKHO 15170
7007	Dark Reflector	394728	5673194	A2	1	0.6	0.3	Sub rounded object with corresponding shadow in the middle of a sand wave formation. Not observed in the echosounder data.	-
7008	Dark Reflector	394760	5673309	A2	3.6	0.6	0.3	Small straight dark edge with thin bright shadow rounded at one end. Looks odd. Not observed in the echosounder data.	-



Table A0.2 Seabed features outside the proposed dredge area but within the exploration area

WA ID	Classification	Easting	Northing	Archaeological Discrimination	Length (m)	Width (m)	Height (m)	Description	External Reference
7004	Dark Reflector	394150	5671933	A2	2.6	0.6	0.5	Small oval object with bright shadow - looks like it may be stretched. Observed in the echosounder data as an elongated mound with flared scour to the north west.	-
7005	Dark Reflector	394177	5672046	A2	0.8	0.5	0.3	Rounded dark edge of object with corresponding shadow with some possible scour to the side. Observed as a small object with some scouring in the echosounder data. Could be natural.	-
7009	Dark Reflector	394752	5673356	A2	14.4	2	0.2	Irregular dark edge of an object with bright shadow, second smaller object just to the east. Very near sandwave. Seen in the echosounder data also.	-
7010	Dark Reflector	394757	5673471	A2	3	1	0.2	Observed as a small round object in a depression. Appears as a small object with a flare of scour to the north in the echosounder data. Could be natural.	-
7011	Bright Reflector	394731	5673535	A2	3.7	0.1	0	Small straight bright object, could be stretched, no dark reflector discernible. Not observed in the echosounder data.	-
7012	Dark Reflector	394915	5674069	A2	1.5	0.8	0.4	Sub-rounded object with scour and rounded bright shadow. Could be in a depression. Small object within a depression observed in the echosounder data.	-
7013	Dark Reflector	394903	5674111	A2	5.9	1.3	0.8	Long angular object with irregular bright shadow. Could be stretched at narrower end. Looks like sediment build up with some scour and possible surrounding dark reflectors to SE side. Looks like small angular object within scour in the echosounder data.	-



WA ID	Classification	Easting	Northing	Archaeological Discrimination	Length (m)	Width (m)	Height (m)	Description	External Reference
7014	Recorded Wreck	395730	5673141	A3	-	-	-	Recorded UKHO position of British sailing vessel <i>Admiral Gardner</i> which sunk 24/01/1809. Last seen in 1997 30m x 10m x 2m. Noted as intact and almost entirely buried. Given protected designation and 300m exclusion zone. Not observed in sidescan sonar or echosounder data.	UKHO 14868 NRHE 1082122 HER MKE17338
7015	Dark Reflector	395760	5673145	A2	7	1.3	0	Irregular array of straight dark lines with no obvious shadow. Looks anomalous to the surrounding seabed. Could be natural but located 30m NE of position of <i>Admiral Gardner</i> .	-
7016	Mound	396380	5673103	A2	5	4.2	1.3	Seen in the multibeam echosounder data only as a mound with some surrounding smaller objects in a total area of 11m x 8m.	-
7017	Dark Reflector	397186	5673394	A2	3.9	3.5	0	Small angular object, possibly two inside each other, though it seems incomplete so possibly partly buried. No bright shadow visible. Not observed in the echosounder data.	-
7018	Wreck	396794	5673853	A1	81.2	37.3	4.7	Two distinct areas identified in the sidescan sonar and echosounder data, approximately 34m apart on NW - SE alignment. Centre of the two areas used for location position. The area to south east is observed as a distinct elliptical mound with a depression in the centre, appearing partially buried in the sediment and measuring 18.9m x 6.5m x 4.7m. Section to north west appears as a large but regular scatter of objects measuring 37m x 28m x 3.5m. Associated with UKHO recorded position of the US steam ship <i>North Eastern Victory</i> , which is recorded as being in two pieces with the middle section buried. Sunk 24/12/1946. The north west section appears as a distinct array of straight objects with structure in the CHP data, which implies area is being slowly buried.	UKHO 13749 NRHE 1523927 HER MKE76172
7019	Debris	396746	5673853	A2	1.8	0.8	0.6	Angular dark object with some bright shadow. Observed within depression in echosounder. Interpreted as debris from nearby wreck of <i>North Eastern Victory</i> .	-



WA ID	Classification	Easting	Northing	Archaeological Discrimination	Length (m)	Width (m)	Height (m)	Description	External Reference
7020	Dark Reflector	396743	5673847	A2	2.8	3.2	0.2	Small object with bright shadow, possible debris from wreck of North Eastern Victory. Smaller than 7019 and not observed in echosounder data.	-
7021	Seafloor disturbance	397742	5674033	A2	15	2.9	0	Distinct angular area of dark reflectors in the sidescan sonar data. Not observed in the echosounder data.	-
7022	Dark Reflector	396433	5674221	A2	1.1	1.9	0	Irregular object with no discernible height. Seems to be at end of a long bright linear, which could be a scar measuring 8.2m x 0.5m. This feature was not observed in the echosounder data.	-
7023	Recorded Wreck	396545	5674531	A3	-	-	-	Recorded UKHO foul ground position. Not observed in sidescan sonar or echosounder data. Last observed in 1981 by sonar as an area of rocks or wreck 25mx20m. Has been amended to "Dead".	UKHO 14780 NRHE 831709 HER MKE9771
7024	Wreck	397896	5674820	A1	13.5	8.2	0.9	Recorded UKHO position of an unidentified wreck, recorded as possible debris or vessel stern. Not observed in the current data set, but observed in the 2009 CHP data as a small but distinct irregular object within a depression, with some structure and surrounding scour.	UKHO 75211
7025	Mound	398067	5674787	A2	5.5	4	0.5	Observed as an object measuring 2m x 1m x 0.5m. Object in a large depression visible in the echosounder data only.	-
7026	Mound	397686	5675160	A2	5	3.5	0.5	Small mound visible in the echosounder data only.	-
7027	Recorded Wreck	397491	5675253	A3	-	-	-	Recorded UKHO foul ground position. Not observed in sidescan sonar or echosounder data. Recorded as a magnetometer anomaly only; presumed buried. Has been amended to "Dead".	UKHO 14749 NRHE 831712 HER MKE9774

Appendix 14.2

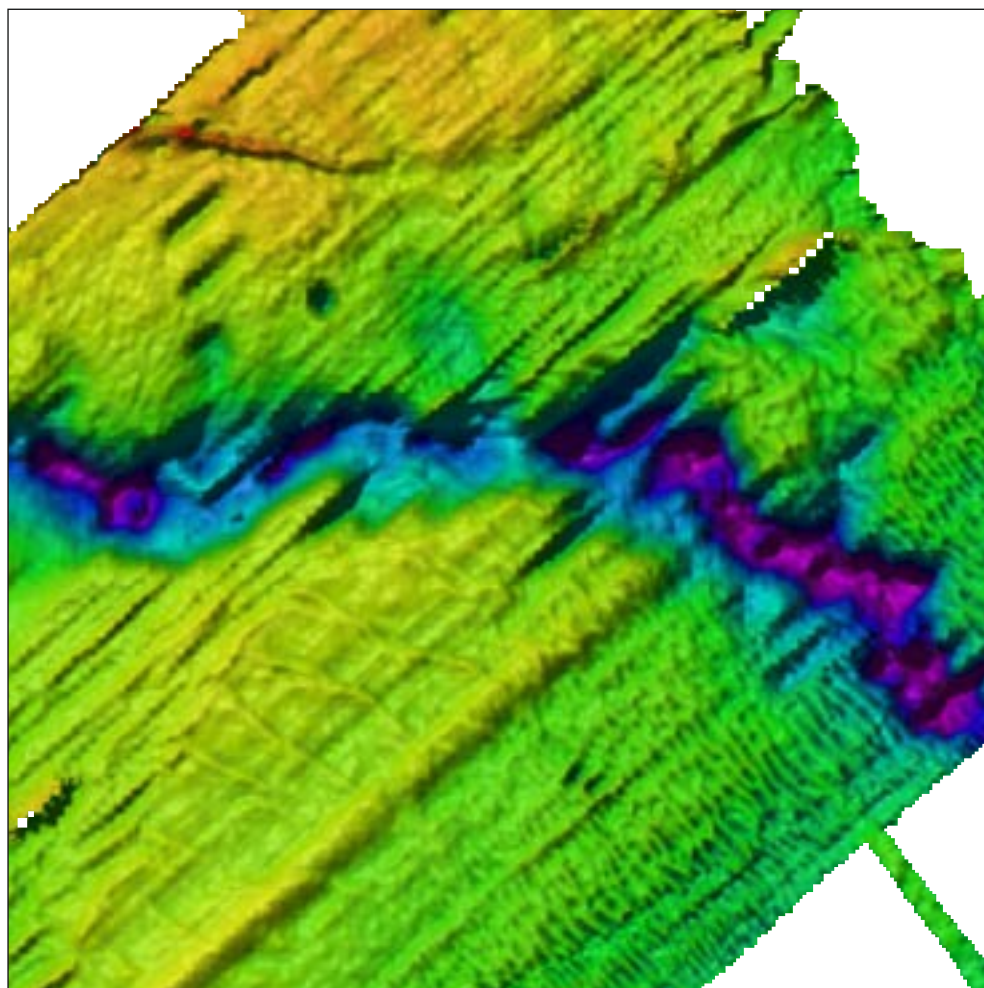
Wessex Archaeology – Goodwin Sands Archaeological Review of
Geophysical Data



making sense of heritage

Goodwin Sands

Archaeological Review of Geophysical Data



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Goodwin Sands

Archaeological Review of Geophysical Data

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Archaeological Review of Geophysical Data

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Goodwin Sands

Archaeological Review of Geophysical Data

Summary

Wessex Archaeology was commissioned by the Dover Harbour Board (DHB) to undertake an archaeological review of geophysical survey data obtained for the proposed Goodwin Sands aggregate dredging scheme. This review will inform the dredging scheme design and Environmental Impact Assessment being undertaken to support a Marine Licence application for the proposed aggregate dredging scheme. The data consisted of sidescan sonar, multibeam echosounder and sub-bottom profiler data acquired in 2015 by EGS (International) Limited.

The principal aim of this report is to provide an archaeological review of the geophysical data to assess the area for any anomalies of potential archaeological interest within the survey area, alongside a review of any known archaeological sites, and to identify any evidence for palaeolandscape features of archaeological potential within the survey area.

The survey area comprises three separate areas: an outer survey area, an exploration area, and a proposed dredge area. The proposed dredge area lies completely within the exploration area, and is DHB's proposed area of aggregate extraction.

This review has identified a total of 28 sites of potential archaeological interest within the exploration area and the proposed dredge area.

Two sites have been classified as A1 - Anthropogenic origin of archaeological interest, both within the exploration area only (**7018** and **7024**). Anomaly **7018** has been interpreted as a wreck site in two distinct pieces measuring 81.2 m x 37.3 m x 4.7 m in total, and located at the recorded position of the *North Eastern Victory*, an American steam ship sunk in 1946. Anomaly **7024** was not identified within the current data set but is visible within the Civil Hydrography Program data as a large piece of debris. It has previously been recorded as the possible stern of a vessel, and is completely buried at present.

As these sites are located outside of the proposed dredge area, no Archaeological Exclusion Zones have been recommended at this time. However, if the dredging location should change to cover these locations, then Wessex Archaeology would recommend a 50 m Archaeological Exclusion Zone be placed around the extents of each wreck site.

Four sites have been classified as A3 - Historic record of possible archaeological interest with no corresponding geophysical anomaly. Anomaly **7014** represents the recorded position of the protected wreck, *Admiral Gardner* (Statutory Instrument 2004/2395), which has an enforced exclusion zone of 300m around this position in the exploration area. A further two of the A3 anomalies are also located within the exploration area. These have all been amended to "Dead" in the United Kingdom Hydrographic Office record, defined as a wreck that has not been detected by repeated surveys and is therefore considered not to exist. This definition, however, is from a navigational hazard perspective and does not mean that low-lying or buried debris does not exist at this location. Due to their location outside of the proposed dredging area, and their "Dead"

recorded status, no exclusion zones have been recommended at this time. However, should the position of the proposed dredge area change, these recommendations would require revision.

The final A3 anomaly, **7006**, is located within the proposed dredge area. However, the wreck has not been observed since 1996 and the United Kingdom Hydrographic Office record has also been amended to "Dead". However, due to its position within the proposed dredge area, is recommended that a 50 m Archaeological Exclusion Zone should be considered around this location as it is possible there is buried material associated with this location.

A further twenty anomalies have been classified as A2 - Uncertain origin of possible archaeological interest, of which six are located within the proposed dredge area (**7000, 7001, 7002, 7003, 7007** and **7008**). It is recommended by Wessex Archaeology that an avoidance strategy be adhered to with respect to these anomalies within the dredge area; however no Archaeological Exclusion Zones are recommended..

A single, distinct palaeochannel has been identified within the sub-bottom profiler data trending approximately east to west across the entire survey area. This feature is interpreted as being a multi-phase fluvial channel created during times of low relative sea level, and potentially contains deposits dating from a range of periods from the Cromerian to the Early Holocene. As such, there is the potential for archaeological material from the Middle Palaeolithic to the Early Mesolithic to be present within these sediments.

In the east, this channel is protected by the significant thickness of sand of the Goodwin Sand, although in the west, and within the proposed dredge area, this sediment cover is negligible and the deposits are at direct risk from dredging activities.

It is recommended that any artefacts recovered during dredging activities, both related to the Prehistoric identified palaeochannel or more recent maritime-related activities, are reported using a suitable protocol, such as the Marine Aggregate Industry *Protocol for Reporting Finds of Archaeological Interest*.



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Laura Andrews and David Howell carried out the review and compiled the report, with quality control provided by Dr Louise Tizzard. Kitty Foster prepared the illustrations and the project was managed for Wessex Archaeology by Dr Louise Tizzard.

Goodwin Sands

Archaeological Review of Geophysical Data

1 INTRODUCTION

1.1 Project Background

1.1.1 Wessex Archaeology was commissioned by the Dover Harbour Board (DHB) to undertake an archaeological review of geophysical survey data obtained for the proposed Goodwin Sands aggregate dredging scheme. This review will inform the dredging scheme design and Environmental Impact Assessment being undertaken to support a Marine Licence application for the proposed aggregate dredging scheme. The proposed aggregate dredging scheme would form a component of the Dover Western Docks Revival (DWDR) development, and would involve the removal of aggregate material from the seabed within the survey area.

1.1.2 The survey area is located on the southern section of the Goodwin Sands banks, approximately 12 km north-east of Dover and 15 km south-east of Ramsgate, Kent (**Figure 1**). The survey area comprises three separate areas: an outer survey area, an exploration area (surveyed by DHB for aggregate dredging potential), and a proposed dredge area. The proposed dredge area lies completely within the exploration area, and is DHB's proposed area of aggregate extraction.

1.1.3 The assessment consists of a review of sidescan sonar (SSS), multibeam echo sounder (MBES) and sub-bottom profiler (SBP) data acquired by EGS (International) Limited (EGS) in 2015 from within the survey area. A United Kingdom Hydrographic Office (UKHO) data search was also undertaken for this assessment to acquire all information relating to any recorded wrecks and obstructions within the survey area.

1.2 Aims and Objectives

1.2.1 The aim of this study is to provide the DHB with an archaeological review of the survey area, including the condition of known archaeological sites. The report also aims to identify any new sites of potential archaeological interest that may have been previously buried and subsequently exposed within this area. This is to be undertaken through the following objectives:

- Assess the geophysical data acquired by EGS to identify whether any material of archaeological potential is present on the seabed within the exploration area;
- Identify any evidence for palaeolandscape features of archaeological potential within the survey area;
- Compare the results with past investigations directly associated with the survey area, known archaeological sites or records, and previous work undertaken in the wider region;
- Recommend mitigation for any identified material or archaeological potential likely to be directly impacted by future dredging.

- 1.2.2 For the purposes of this assessment, the SSS and MBES data were interpreted from within the exploration area only, whilst the SBP data were interpreted from within the exploration area and the outer survey area. This was to provide a wider context for any identified, large-scale palaeolandscape features.

2 METHODOLOGY

2.1 Data Sources

- 2.1.1 A number of data sources were consulted during this assessment, including:
- Geophysical survey datasets (SSS, SBP and MBES) from within the survey area, as acquired by EGS, and the associated survey operations and interpretive reports (EGS 2015a; 2015b);
 - MBES data acquired in 2009, covering part of the survey area and surrounding region, provided to WA by the UKHO via the INSPIRE portal. The data were acquired on behalf of the Marine and Coastguard Agency (MCA) as part of the Civil Hydrography Programme (CHP);
 - UKHO records of wrecks and obstructions within the exploration area;
 - The EIA Scoping Report for the proposed scheme prepared by Royal HaskoningDHV (RHDHV 2015);
 - Previous archaeological survey work undertaken by WA within the Goodwin Sands and surrounding areas (e.g. WA 2003, 2009, 2010; 2011; 2012);
 - Background British Geological Survey (BGS) geological information (BGS 1990, Cameron *et al.* 1992), and relevant Admiralty Charts for the survey area.

2.2 Geophysical Data – Technical Specifications

- 2.2.1 The geophysical data were acquired by EGS; the survey was undertaken on board survey vessel FPV *Morven*, between 10th July and 2nd August 2015. The data set comprised SSS, MBES and SBP (chirp and boomer) data.
- 2.2.2 The outer survey area was only partially covered by geophysical survey, and comprises a set of lines running around the perimeter of the survey area boundary and a series of north-west to south-east trending lines approximately 1 km apart. The exploration area (including the proposed dredge area) was fully surveyed (where possible due to water depths), with main lines generally running north-east to south-west (although some along the western edge were run north-north-east to south-south-west) at a spacing of 50 m.
- 2.2.3 The SSS deployed for the survey was a Klein 3000 dual frequency SSS towfish operating at high (500 kHz) and low (100 kHz) frequencies with a 75 m range. The SSS data were digitally logged using Klein's SonarPro software, and provided to WA as .*xtf* files.
- 2.2.4 A Sonardyne Scout Ultra Short Base Line (USBL) system was used on board to track the position of the sidescan sonar towfish, and the sonar data files were provided with corrected navigation applied.
- 2.2.5 The MBES data were acquired using a Kongsberg EM2040C system, operating at high (400 kHz) frequency. The MBES data were digitally logged using Kongsberg's SIS

acquisition software, and provided to WA as a tidally-reduced, gridded, .XYZ file. Data were gridded using a cell size of 0.5 m.

- 2.2.6 The SBP data were acquired using a Knudsen Chirp 3260 system on a Neptune Transducer (pole mounted) array, and a C-Products C-Boom low-voltage Boomer with C-Phone 8-element hydrophone. The data were digitally recorded using Knudsen's Sounder Suite (Chirp) and C-Product's C-View SDMP software, and provided to WA as navigation corrected .sgy files. Only the boomer data were used for the archaeological assessment, as the boomer data provided greater penetration into the sediments than the chirp data.
- 2.2.7 Primary positioning for the survey was provided by an Applanix POS MV 320 system (which also served as the MBES motion reference unit), with secondary positioning provided by a C&C Technologies C-NAV 3050 DGPS. All positions for the survey were recorded and expressed as WGS 1984 UTM Zone 31N coordinates.
- 2.2.8 As agreed through consultation with Historic England and the Marine Management Organisation, magnetometer data were not acquired for this project. Due to the mobile nature of the seabed sediments within the Goodwin Sands, it is possible that buried material exists within the survey area that has not been identified.
- 2.2.9 The 2009 CHP data were acquired by WA from the INSPIRE Portal and MEDIN Bathymetry Data Archive Centre (UKHO 2014) as raw, ungridded .gsf files in WGS 84 geographic coordinates. These files were then gridded using a cell size of 0.5m and re-projected to UTM31N coordinates.

2.3 Geophysical Data – Data Quality

- 2.3.1 The geophysical data sets used for this report were individually assessed for quality and their suitability for archaeological purposes, and rated using the following criteria (**Table 1**):

Data Quality	Description
Good	Data which are clear and unaffected by weather conditions or sea state. The dataset is suitable for the interpretation of standing and partially buried metal wrecks and their character and associated debris field. These data also provide the highest chance of identifying wooden wrecks and debris.
Average	Data which are affected by weather conditions and sea state to a slight or moderate degree. The dataset is suitable for the identification and partial interpretation of standing and partially buried metal wrecks, and the larger elements of their debris fields. Wooden wrecks may be visible in the data, but their identification as such is likely to be difficult.
Variable	This category contains datasets with the quality of individual lines ranging from good to average to below average. The dataset is suitable for the identification of standing and some partially buried metal wrecks. Detailed interpretation of the wrecks and debris field is likely to be problematic. Wooden wrecks are unlikely to be identified.

Table 1: Criteria for assigning data quality rating

- 2.3.2 The SSS data have been rated as 'Variable' using the above criteria table with a majority of files displaying significant noise interference from cable snatching due to strong tides and currents within the area, in addition to noise caused by shallow water depths. Some files were of good quality. Overall the data quality was found to be suitable for the identification of standing and partially buried wrecks; however detailed interpretation was

not possible. The positioning of the data was generally found to be good, as the majority of the files were provided to WA with corrected navigation included.

- 2.3.3 The MBES data have been rated as 'Good' using the above criteria. The data quality and resolution of 0.5m was found to be of a high standard and suitable for the archaeological assessment of seabed objects and debris.
- 2.3.4 The SBP (boomer) data have been rated as 'Average' using the above criteria. In general the data were of good quality, although some lines exhibited noise such as large amounts of swell due to weather conditions experienced during survey. The shallow water depths also proved detrimental to the data, as it resulted in the sea bed multiples being present at very shallow depth in some areas making interpretation difficult. However, these did not detrimentally affect the data to a significant degree and it was deemed suitable for archaeological interpretation.
- 2.3.5 The 2009 CHP INSPIRE MBES data were rated "Good" using the above criteria. The data quality and resolution of 0.5m was found to be of high standard and suitable for the archaeological assessment of seabed objects and debris. However, this dataset did not cover the entire exploration area and has only been used to assess site conditions of existing wrecks and broad depth changes to the bank area over the time series available.

2.4 Geophysical Data – Processing

- 2.4.1 The high frequency .xtf SSS data files were processed by WA using Coda Geosurvey software. This allowed the data to be replayed with various gain settings in order to optimise the quality of the images. The data were interpreted for any objects of possible anthropogenic origin. This involves creating a database of anomalies within Coda by tagging individual features of possible archaeological potential, recording their positions and dimensions, and acquiring an image of each anomaly for future reference.
- 2.4.2 A mosaic of the SSS data is produced during this process to assess the quality of the sonar towfish positioning. This process allows the position of anomalies to be checked between different survey lines and for the positioning to be further refined if necessary.
- 2.4.3 The form, size and/or extent of an anomaly is a guide to its potential to be an anthropogenic feature and therefore of archaeological interest. A single small but prominent anomaly may be part of a much more extensive feature that is largely buried. Similarly, a scatter of minor anomalies may define the edges of a buried but intact feature, or it may be all that remains as a result of past impacts from, for example, dredging or fishing.
- 2.4.4 The MBES data were analysed to identify any unusual seabed structures that could be shipwrecks or other anthropogenic debris. The data were gridded at 0.5m and analysed using Fledermaus software, which enables a 3-D visualisation of the acquired data and geo-picking of seabed anomalies.
- 2.4.5 The SBP data were processed by WA using Coda Seismic+ software. This software allows the data to be visualised with user selected filters and gain settings in order to optimise the appearance of the data for interpretation. The software then allows an interpretation to be applied to the data by identifying and selecting sedimentary boundaries and shallow geological features that might be of archaeological interest.

- 2.4.6 The SBP data were interpreted with a two-way travel time (TWTT) along the z-axis. In order to convert from TWTT to depth, the velocity of the seismic waves was estimated to be $1,600\text{ms}^{-1}$. This is a standard estimate for shallow, unconsolidated sediments.
- 2.4.7 Any small reflectors which appear to be buried material such as a wreck site covered by sediment were also recorded, the position and dimensions of any such objects noted in a gazetteer, and an image of each anomaly acquired. It should be noted that anomalies of this type are rare, as the sensors must pass directly over such an object in order to produce an anomaly.
- 2.4.8 Due to the relative small line spacing within the main survey area, the xyz results of the SBP assessment were also exported as a .txt file and loaded into Fledermaus. This enabled a 3-D visualisation of the interpreted surfaces to be created and, when combined with the MBES data, the depths of surfaces could be reduced down to a particular datum (in this case Chart Datum (CD)).

2.5 Geophysical Data – Anomaly Grouping and Discrimination

- 2.5.1 The previous section describes the initial interpretation of all available geophysical datasets which were conducted independently of one another. This inevitably leads to the possibility of any one object being the cause of numerous anomalies in different datasets and apparently overstating the number of archaeological features in the exploration area.
- 2.5.2 To address this fact the anomalies were grouped together; allowing one ID number to be assigned to a single object for which there may be, for example, a UKHO record and multiple SSS anomalies.
- 2.5.3 Once all the geophysical anomalies and desk-based information have been grouped, a discrimination flag is added to the record in order to discriminate against those which are not thought to be of an archaeological concern. For anomalies located on the seabed, these flags are ascribed as follows (**Table 2**):

Non-Archaeological	U1	Not of anthropogenic origin
	U2	Known non-archaeological feature
	U3	Non-archaeological hazard
Archaeological	A1	Anthropogenic origin of archaeological interest
	A2	Uncertain origin of possible archaeological interest
	A3	Historic record of possible archaeological interest with no corresponding geophysical anomaly

Table 2: Criteria discriminating relevance of seabed features to proposed scheme

- 2.5.4 All the anomalies of archaeological potential that have been identified within the exploration area are presented in **Appendix I** and discussed in this report.
- 2.5.5 Similarly, the discrimination flags applied to shallow geological features of possible archaeological potential are ascribed as follows (**Table 3**):

Non-Archaeological	U2	Feature of non-archaeological interest
Archaeological	P1	Feature of probable archaeological interest, either because of its palaeogeography or likelihood for producing palaeoenvironmental material
	P2	Feature of possible archaeological interest

Table 3: Criteria discriminating relevance of palaeogeographic features to proposed scheme

- 2.5.6 The grouping and discrimination of information at this stage is based on all available information and is not definitive. It allows for all features of potential archaeological interest to be highlighted, while retaining all the information produced during the course of the geophysical interpretation and desk-based assessment for further evaluation should more information become available.

3 PALAEOGEOGRAPHIC ASSESSMENT

3.1 Geological and Prehistoric Baseline

- 3.1.1 The exploration area is located on the western side of the South Goodwin Sands, an area of sand banks east of the Kent coast, within the southern North Sea basin. Although the exploration area is fully submerged at present, this has not always been the case.
- 3.1.2 The basement geology of the region is the Chalk Group, which was originally deposited in a shallow marine environment during the Upper Cretaceous period (Cameron *et al.* 1992). This chalk deposit is widespread across the southern North Sea, and outcrops to form the distinctive white cliffs at places such as Dover in the UK and the Alabaster Coast in France.
- 3.1.3 Regional uplift at the end of the Cretaceous and into the Early Tertiary resulted in a cessation of carbonate deposition and the study area being exposed as a terrestrial environment. Subsequent to this uplift, a limited amount of Tertiary and Pleistocene deposition occurred within the study area relative to other areas in the southern North Sea (Cameron *et al.* 1992).
- 3.1.4 The Pleistocene history of the southern North Sea is dominated by repeated glacial/interglacial cycles and the effects of the associated rises and falls in relative sea level (**Figure 2**). This is also represented in the geological record, with distinct terrestrial landscape features being present in some areas of the southern North Sea along with deposits of marine sediment.
- 3.1.5 Previous work undertaken within the Outer Thames Estuary (EMU 2009) and within the English Channel (Hamblin *et al.* 1992) have identified extensive palaeochannel complexes, both buried and underfilled, dating from periods of time within the Pleistocene and Early Holocene when the shallow shelf area surrounding the UK was exposed as a terrestrial environment.
- 3.1.6 Closer to the exploration area, previous survey work undertaken to the north-east of the Goodwin Sands (WA 2011) identified a number of small, underfilled palaeochannels and possible associated palaeolandscapes within multibeam bathymetry data, in

addition to the modern remains of the Lobourgh channel which trends approximately NNE – SSW to the east of the Goodwin Sands (BGS 1990).

- 3.1.7 Evidence from the wider region indicated a high potential for similar palaeochannels to be present within the exploration area, albeit likely covered by the modern sediment of the Goodwin Sands.
- 3.1.8 Some of these large channel systems, such as the Thames – Medway system in the Outer Thames Estuary and the Northern Palaeovalley - Lobourgh Channel system in the English Channel, are thought to have been particularly long lived, potentially being originally created in pre-Anglian (Cromerian, c. 760,000 – 478,000 BP) times and 'reactivated' during subsequent sea level lowstands into the Early Holocene (EMU 2009).
- 3.1.9 The earliest evidence for hominin activity in the UK dates to c. 970,000 years BP from Happisburgh, Norfolk (Parfitt *et al.* 2010), and therefore there is the potential for evidence of Palaeolithic hominin activity to exist within Late Pleistocene deposits and features dating from this period and younger, such as the described channel systems. Even where there is no direct evidence of anthropogenic activity, there may be preserved palaeoenvironmental material which can elucidate aspects of the former landscape and environment.
- 3.1.10 After warming of the climate and retreat of the ice sheet at the end of the Pleistocene, a terrestrial environment likely still existed within the region around the study area into the Early Holocene. It is possible that the now submerged environment of which the study area was a part was occupied up until the final marine transgression between 8,900 and 5,000 BP.
- 3.1.11 The current environment within the exploration area is generally marine, and as such is dominated by marine sediments and processes. The large sand banks of the Goodwin Sands are major bathymetric features which are known to shift over relatively short time periods whilst remaining within the same general area.
- 3.1.12 The banks are relatively steep, and Admiralty Chart data indicates they can rise >20 m above the surrounding seabed within a relatively short distance. The banks themselves are primarily sand and gravelly sand deposited directly on top of the Chalk Group basement, or on any Pleistocene/Early Holocene sediments should they be present. Away from the banks themselves, the superficial seabed sediment is represented by only a thin veneer on overlying the chalk bedrock (BGS 1990).

3.2 Palaeogeographic Assessment Results

- 3.2.1 Assessment of the SBP data has revealed the shallow geology within the exploration area comprises three separate units.
- 3.2.2 The lower (oldest) unit (**Unit 1**) forms the basement geology of the exploration area and has been interpreted as being the Cretaceous Chalk Group. This unit appears relatively unstructured in the SBP data, but has a consistently very strong, sub-horizontal upper reflector. This reflector, known as 'Top Chalk', is a distinctive, characteristic feature of the upper boundary of the Chalk Group within the southern North Sea. In some areas there is tentative evidence for an upper weathered layer within the chalk, although this is difficult to determine from the data.
- 3.2.3 As a Cretaceous deposit, the Chalk Group is considered too old to be of archaeological potential in itself, although the history of subaerial exposure of the unit suggests that its

upper layer may once have provided a land surface upon which archaeological material may have been deposited.

- 3.2.4 Cutting into this Cretaceous chalk bedrock, a distinct, approximately east to west trending channel feature has been identified crossing the study area (**Figure 3**). This feature has been tentatively identified on almost all survey lines, although confidence in interpretation is lower towards the east, where the overlying sand is thickest (due to reduced data penetration), and highest in the west, where there is very little sediment coverage and the feature is very clearly observed. A small bathymetric low, visible in the Admiralty Chart to the east and west of the survey area, potentially represents a continuation of this feature as an underfilled channel on the seabed.
- 3.2.5 This channel is a complex feature, with at least two (possibly three) separate episodes of cut and fill visible, suggesting either a braided channel system or a single feature reactivated at different periods of time, or a combination of both. The fill (**Unit 2**) is generally relatively unstructured and appears chaotic on some lines, but the different phases of fill appear relatively similar (**Figure 4**).
- 3.2.6 A strong reflector identified intermittently between lines within the channel could be a particularly strong basal reflector of one of the phases of cut and fill, or represent scattered pockets of shallow gas within the fill sediment. This indicates the possible presence of preserved organic material. Additionally, very small mound features have been identified overlying the channel, both around the edges and in the centre. Again, these are relatively intermittent, and could represent associated small fluvial bank/terraces or be ridges created by sediment reworking during the Holocene marine transgression.
- 3.2.7 This feature is interpreted as being a fluvial palaeochannel similar to those identified elsewhere in the southern North Sea (**Section 3.1**), and could date from a range of periods between the Cromerian and the Early Holocene. As such, the sediments associated with this feature are deemed to be of high archaeological potential, and could contain both *in-situ* or derived anthropogenic artefacts and preserved palaeoenvironmental material.
- 3.2.8 The shallowest unit (**Unit 3**) is the modern seabed sediment that forms the Goodwin Sands themselves. Across the majority of the study area this comprises a sand deposit generally around 20 m thick, the upper surface of which is mobile and characterised by sand ripples and occasional small sand waves.
- 3.2.9 Off the edge of the bank to the west, however, **Unit 3** reduces rapidly in thickness to a thin veneer overlying **Unit 1** and **Unit 2**, and can be <1 m thick in places. The interpreted edge of the bank is illustrated in **Figure 3**.
- 3.2.10 As modern marine sediment, **Unit 3** is not generally considered to be of high prehistoric archaeological potential. However, since the sands in this area are known to be mobile, they have the potential to cover previously unknown sites of archaeological interest such as shipwrecks. The bank also has the potential to protect older deposits of archaeological potential, such as **Unit 2**, and also to contain reworked older sediment and associated archaeological material, particularly around identified palaeogeographic features and where the **Unit 3** is relatively thin.

4 SEABED FEATURES ASSESSMENT

4.1 Archaeological Baseline

- 4.1.1 The survey area is located within the Goodwin Sands, an area of highly mobile sandbanks, which extend about ten miles north to south and are up to several miles wide off the east Kent coast. Due to rapidly shifting sediment the Goodwin Sands have proved difficult to mark or chart effectively, impeding the identification and monitoring of archaeological sites.
- 4.1.2 As an area of shallow, rapidly shifting sediment, the Goodwin Sands have historically proven to be a major hazard to marine navigation. Because of this, they have perhaps the highest density of wrecks, and therefore marine heritage assets, in the UK (WA 2014). As such, there have been many archaeological investigations undertaken in the vicinity of the Goodwin Sands.
- 4.1.3 WA has undertaken a number of surveys in the vicinity of the survey area including work on the known protected wreck *Admiral Gardner* (WA 2003, 2009, 2012). This wreck has previously been recorded as a magnetic anomaly only, but has been presumed buried since it was last observed in 1997 (SI 2004/2395; UKHO 14868).
- 4.1.4 Further wrecks identified within the wider region of the Goodwin Sands are outlined in the EIA Scoping Report (RHDHV 2015). Due to the nature of this region and the shifting sands that form the banks, there is high potential for the identification of previously undiscovered wrecks within the survey area, whilst those previously recorded wrecks have the potential to become buried or uncovered periodically.

4.2 Seabed Features Assessment Results

- 4.2.1 The results of this assessment are collated in gazetteer format and detailed in **Appendix I**. Below is a summary of the number and types of features identified in the exploration area for Goodwin Sands. The anomalies have then been divided into their classifications and described accordingly.
- 4.2.2 The archaeological review of geophysical data identified a total of 120 anomalies within the SSS data and 24 anomalies within the MBES data. In addition, 14 UKHO positions were identified within the outer survey area. Following the grouping and discrimination procedure outlined in **Section 2.5**, these were grouped to produce a list of 28 sites of potential archaeological interest within the exploration area (**Figure 5**). Of these, seven sites are located within the proposed dredge area. These were characterised as follows:

Archaeological Discrimination	Quantity		Interpretation
	Exploration area	Proposed dredge area	
A1	2	0	Anthropogenic origin of archaeological interest
A2	16	6	Uncertain origin of possible archaeological Interest
A3	3	1	Historic record of possible archaeological interest with no corresponding geophysical anomaly
Total	21	7	

Table 4: Anomalies of archaeological potential within the survey area

- 4.2.3 Furthermore, these anomalies can be classified by probable type, which can further aid in assigning archaeological potential and importance:

Anomaly Classification	Number of Anomalies	
	Exploration area	Proposed dredge area
Wreck	2	0
Debris	1	0
Seafloor Disturbance	1	0
Rope/chain	0	1
Bright Reflector	1	0
Dark Reflector	10	5
Mound	3	0
Recorded Wreck/ Obstruction	3	1
Total	21	7

Table 5: Types of anomaly identified

- 4.2.4 From this dataset two anomalies (**7018** and **7024**) have been classified as A1 – Anthropogenic origin of archaeological interest.
- 4.2.5 Anomaly **7018 (Sheet 1)** was interpreted as a partially buried wreck measuring 81.2 m x 37.3 m x 4.7 m, located at approximately 3 m LAT depth of water, identified as two distinct areas of debris aligned north-west to south-east and approximately 34 m apart. It has been identified at the UKHO recorded position of the US steam ship *North Eastern Victory* (UKHO 13749) which sank 24th December 1946 after running aground in thick fog, recorded as breaking in two pieces before it sank. The middle section has been previously presumed buried. The area to south-east is observed as a distinct elliptical dark reflector with possible sediment build up to one side measuring 18.9 m x 6.5 m x 4.7 m. The section to the north-west appears as a large area of scattered small objects measuring 37 m x 28 m in total, which appears mostly buried. It comprises a segmented strip along one side measuring 10.8m x 1.8m with pairs of small reflectors on the opposite side. The largest object was observed as angular and measuring 6.9 m x 1.8 m x 3.5 m.
- 4.2.6 In comparison with the 2009 CHP MBES data the north-west section appears as a distinct array of straight objects with apparent structure. This implies that the wreck has become increasingly buried by up to 2.8 m of sediment since 2009. The surrounding sediment will therefore obscure the identification of any further debris surrounding the main structure. This anomaly is located in the east of the exploration area.
- 4.2.7 Anomaly **7024** is the location of a previously recorded but unidentified wreck located within the exploration area. The record (UKHO 75211) relates to piece of debris

measuring 7 m x 6 m x 2.7 m identified in 2010, and described as the possible stern of a vessel. No geophysical anomalies were identified at this location within the current 2015 dataset. However, assessment of the 2009 CHP MBES data revealed an irregular mound measuring 13.5 m x 8.2 m x 0.9 m situated at this location. The feature is located within a depression and has an associated surrounding scour. It is likely that this feature is associated with the UKHO record and is currently buried. Even in the 2009 CHP data set the wreck appears fairly well buried and so further information is difficult to determine. However, due to the mobile nature of the surrounding sediment, it is likely that the given dimensions represent a minimum size of the wreck or wreckage.

- 4.2.8 Twenty anomalies have been classified as A2 – Uncertain origin of possible archaeological interest (see **Appendix I** for full list of anomalies).
- 4.2.9 One of these anomalies (**7019**) has been interpreted as isolated piece of debris in the vicinity of the wreck of the *North Eastern Victory*. The feature was identified in the SSS data as a dark reflector measuring 1.8 m x 0.8 m x 0.6 m and observed as a mound within a depression in the MBES data. It is located 48 m from the centre of the wreck in the exploration area.
- 4.2.10 Anomaly **7021** has been interpreted as a seafloor disturbance; classified as a distinct anomalous area of dark reflectors, measuring 15 m x 2.9 m with no discernible height. It has not been identified as debris due to the lack of coherent structure, size and form. This anomaly is located within the exploration area.
- 4.2.11 One anomaly has been classified as a possible rope or chain (**7003**). It was identified in the SSS data as a long curvilinear measuring 250 m x 0.8 m x 0.3 m, aligned approximately north to south with the southern end extending south-west. This anomaly is distinguishable as a long linear in the MBES data and is located along the western extents of the proposed dredge area.
- 4.2.12 Anomaly **7011** has been interpreted as a bright reflector, identified in the SSS data only, measuring 3.7 m x 0.1 m with no discernible height. A bright reflector can indicate material that absorbs acoustic waves instead of reflecting them (e.g. saturated wood or synthetic material). This anomaly is located in the exploration area.
- 4.2.13 Fifteen anomalies (**7000, 7001, 7002, 7004, 7005, 7007 - 7010, 7012, 7013, 7015, 7017, 7020** and **7022**) have been classified as dark reflectors; objects of uncertain origin of possible archaeological interest. These vary in size from 1 m x 0.6 m x 0.3 m (**7007**) to 14.4 m x 2 m x 0.2 m (**7009**). These could either be individual pieces of debris or could, on visual inspection, prove to be natural features.
- 4.2.14 Five of the fifteen anomalies were identified in the proposed dredge area (**7000, 7001, 7002, 7007** and **7008**); the remaining ten were identified within the exploration area.
- 4.2.15 Three anomalies were identified as mounds in the MBES data only (**7016, 7025** and **7026**). All three are located within the exploration area. These range in size from anomaly **7026**, measuring 5 m x 3.5 m x 0.5 m, to anomaly **7016**, measuring 5 m x 4.2 m x 1.3 m, surrounded by several smaller objects in a total area of 11 m x 8 m. These could be natural features or indicate areas of currently buried debris.
- 4.2.16 The remaining four anomalies (**7006, 7014, 7023**, and **7027**) have been classified as A3 – Historic records of possible archaeological interest with no corresponding geophysical anomalies.

- 4.2.17 Anomaly **7006** is located within the proposed dredge area and represents the recorded UKHO position of an unidentified wreck (UKHO 15170). A small contact was observed in this position in 1996 and the record has since been amended to “Dead”. A ‘Dead’ wreck is defined by the UKHO as a wreck “Not detected by repeated surveys, therefore considered not to exist” (UKHO 2008). However, this definition is from a navigational hazard perspective, and does not mean no low lying or buried wreck material or other debris is present at this location.
- 4.2.18 No geophysical anomalies were observed in the SSS or MBES data or within the 2009 CHP MBES data at the location of **7006**, and therefore the feature is likely to be buried. The seabed depth in 1996 was recorded as 23 m LAT, compared to 21 m LAT in the 2015 dataset indicating approximately 2 m sediment burial.
- 4.2.19 Anomaly **7014** is located within the exploration area and represents the recorded UKHO position of the *Admiral Gardner* (UKHO 14868). The wreck was last observed on the surface in geophysical data in 1997 as an intact, mostly buried, wreck measuring 30 m x 10 m x 2 m according to the UKHO record. Diving on the site in 2003 confirmed that the wreck was buried at this point (WA 2003). A further geophysical survey undertaken in 2008 confirmed that a magnetometer anomaly was associated with the location, but no anomalies were observed on the seabed (WA 2009). However no geophysical anomalies were identified within this dataset or within the 2009 CHP MBES data, indicating the wreck is likely buried for significant periods of time by the mobile sediments of the Goodwin Sands. One anomaly (**7015**), classified as a dark reflector, was identified approximately 30 m north-west of the recorded position of the *Admiral Gardner* measuring 7 m x 1.3 m with no discernible height. This feature could be a natural feature but has been retained due to its proximity to the recorded wreck position.
- 4.2.20 The wreck of the *Admiral Gardner* had been designated under Section 1 of the Protection of Wrecks Act 1973, first in 1985 (SI 1985/699), and then redesignated in 2004 (SI 2004/2395) to extend the designated area to 300m radius around the position of the wreck (**Figure 5**).
- 4.2.21 Anomaly **7023** is a record of a foul ground (UKHO 14780) and was last observed in 1981 as a disturbed area measuring 25 m x 20 m and has since been amended to “Dead” by the UKHO. No geophysical anomalies were identified at this location within this dataset or within the 2009 CHP MBES data, and the associated feature could either be buried or be located elsewhere. This position is located within the exploration area.
- 4.2.22 Anomaly **7027** represents the record of a foul ground position (UKHO 14749) and is located within the exploration area. It was recorded as a magnetometer anomaly only in 1997 and had previously been amended to “Dead” By the UKHO. No geophysical anomalies were identified at this location from within the dataset, or within the 2009 CHP MBES data. The associated anomaly could potentially be buried or be located elsewhere.

5 ARCHAEOLOGICAL RECOMMENDATIONS

- 5.1.1 With regards to mitigation of archaeology, the marine planning authority, working with the relevant regulator and advisors, takes account of the desirability of sustaining and enhancing the significance of heritage assets and adopts a general presumption in favour of the conservation of designated heritage assets within an appropriate setting (HM Government 2011; DCALG 2012).

- 5.1.2 The proposed activities within the proposed dredge area involve the direct removal of material from the seabed, which is potentially destructive to any shallow or surficial archaeological deposits. As such, steps must be taken to mitigate the potential impact upon such deposits wherever feasible.
- 5.1.3 One distinct palaeogeographic feature of archaeological potential (the channel cut and associated **Unit 2** infill) has been identified within the SBP data. This identified channel feature represents part of a preserved prehistoric landscape, further evidence of which has previously been identified from other areas of the southern North Sea in the form of palaeochannels and associated deposits. These deposits have the potential to contain *in-situ* and derived archaeological and palaeoenvironmental material, potentially dating from a period of time spanning from the pre-Anglian (Cromerian) to the Early Holocene.
- 5.1.4 Across the majority of the survey area the overlying seabed sediments are relatively thick (around 20 m), and as such would protect the identified feature from any proposed dredging activities. However, in the west of the survey area, including within the proposed dredge area, the overlying seabed sediments are relatively thin and so this protection does not exist. It is estimated that **Unit 2** is at direct risk from the proposed dredging activities in the area to the west of the Goodwin Sands bank as illustrated in **Figure 3**.
- 5.1.5 Wherever the seabed sediments are relatively thin, such as the area west of the edge of the bank (**Figure 3**), they also have the potential to include reworked sediment originating from **Unit 2**. As such, there is also the possibility for archaeological material to be present within the sediment targeted for dredging, indicating the potential impact upon such archaeological deposits in this area is relatively high.
- 5.1.6 It is not recommended that the area be avoided but, should any objects of possible archaeological interest be recovered during dredging operations, they should be reported using established protocol such as the Marine Aggregate Industry *Protocol For Reporting Finds of Archaeological Interest* (BMAPA and English Heritage 2005). For the area around **Unit 2**, this should also include any remains of palaeoenvironmental potential, such as any recovered samples of peat.
- 5.1.7 Within the proposed dredge area, six seabed anomalies have been classified as A2 – Uncertain origin of archaeological interest. Although no Archaeological Exclusion Zones are recommended by WA at this time, it is recommended that an avoidance strategy is implemented where possible with respect to these anomalies.
- 5.1.8 One UKHO record has been identified in the proposed dredge area (**7006**). A small contact was last observed in this position in 1996. The seabed depth in 1996 was recorded as 23 m LAT, compared to 21 m LAT in the 2015 dataset indicating approximately 2 m sediment burial. It is recommended that a 50 m Archaeological Exclusion Zone should be considered around this location as it is possible there is buried material associated with this location.
- 5.1.9 As the remainder of the 19 sites are situated in the exploration area lying outside the current proposed dredge area, and as such will not be impacted, no Archaeological Exclusion Zones have been recommended. Further consideration would be required if the location of the proposed dredge area was amended in the future.
- 5.1.10 Anomaly **7014** is the UKHO position of the protected wreck, the *Admiral Gardner*, which already has an exclusion zone of 300 m (radius) from this position in accordance with SI 2395 (2004).



- 5.1.11 It is recommended that if any objects of possible archaeological interest are recovered during dredging operations from the Goodwin Sands, that they should continue to be reported using established protocol such as the Marine Aggregate Industry *Protocol For Reporting Finds of Archaeological Interest* (BMAPA and English Heritage 2005).
- 5.1.12 It should be noted that, since the Goodwin Sands is an area of highly mobile seabed sediment, there is the potential for features of archaeological potential (such as wrecks and associated debris) to be buried within the area. An example of this is the *Admiral Gardner* which, although designated, appears to have been buried since 2003.

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APPENDIX I – SEABED FEATURES OF ARCHAEOLOGICAL POTENTIAL

WA ID	Classification	Easting	Northing	Archaeological Discrimination	Length (m)	Width (m)	Height (m)	Description	External References	Area
7000	Dark Reflector	393907	5670673	A2	2	0.7	0.5	Small straight object, which may be bigger at one end. Looks like has corresponding height shadow and appears to be in a depression. Observed as a small mound within a depression in the echosounder data	-	Proposed dredge area
7001	Dark Reflector	394087	5671088	A2	14.9	0.4	0.2	Dark curvilinear reflector which appears thicker in the centre. Some bright shadow visible. Seems partially obscured by sandwave. Not observed in the echosounder data.	-	Proposed dredge area
7002	Dark Reflector	394197	5671550	A2	4.2	1.8	0.7	Small irregularly shaped object with slight corresponding shadow. Looks rounded at one end, straight with the other end also curved. On the edge of the sandwave. Observed as a small object in the echosounder data also.	-	Proposed dredge area
7003	Rope/Chain	394169	5671610	A2	250	0.8	0.3	Long thin object, which looks like it lies in both dark and bright sections of seabed, though intermittent. Possible rope/chain. Extends to NNE and SSW with southern tip extending SW. Is distinguishable in the echosounder data	-	Proposed dredge area



WA ID	Classification	Easting	Northing	Archaeological Discrimination	Length (m)	Width (m)	Height (m)	Description	External References	Area
7004	Dark Reflector	394150	5671933	A2	2.6	0.6	0.5	Small oval object with bright shadow - looks like it may be stretched. Observed in the echosounder data as an elongated mound with flared scour to the north-west.	-	Exploration area
7005	Dark Reflector	394177	5672046	A2	0.8	0.5	0.3	Rounded dark edge of object with corresponding shadow with some possible scour to the side. Observed as a small object with some scouring in the echosounder data. Could be natural.	-	Exploration area
7006	Recorded Wreck	394438	5672133	A3	-	-	-	Recorded UKHO position of an unidentified wreck. Not observed in the sidescan sonar or echosounder data. Previously seen as a small contact in 1996. Not observed since; presumed buried. Has been amended to "Dead."	UKHO 15170	Proposed dredge area
7007	Dark Reflector	394728	5673194	A2	1	0.6	0.3	Sub rounded object with corresponding shadow in the middle of a sand wave formation. Not observed in the echosounder data	-	Proposed dredge area
7008	Dark Reflector	394760	5673309	A2	3.6	0.6	0.3	Small straight dark edge with thin bright shadow rounded at one end. Looks odd. Not observed in the echosounder data	-	Proposed dredge area
7009	Dark Reflector	394752	5673356	A2	14.4	2	0.2	Irregular dark edge of an object with bright shadow, second smaller object just to the east. Very near sandwave. Seen in the echosounder data also.	-	Exploration area



WA ID	Classification	Easting	Northing	Archaeological Discrimination	Length (m)	Width (m)	Height (m)	Description	External References	Area
7010	Dark Reflector	394757	5673471	A2	3	1	0.2	Observed as a small round object in a depression. Appears as a small object with a flare of scour to the north in the echosounder data. Could be natural.	-	Exploration area
7011	Bright Reflector	394731	5673535	A2	3.7	0.1	0	Small straight bright object, could be stretched, no dark reflector discernible. Not observed in the echosounder data.	-	Exploration area
7012	Dark Reflector	394915	5674069	A2	1.5	0.8	0.4	Sub-rounded object with scour and rounded bright shadow. Could be in a depression. Small object within a depression observed in the echosounder data.	-	Exploration area
7013	Dark Reflector	394903	5674111	A2	5.9	1.3	0.8	Long angular object with irregular bright shadow. Could be stretched at narrower end. Looks like sediment build up with some scour and possible surrounding dark reflectors to SE side. Looks like small angular object within scour in the echosounder data	-	Exploration area
7014	Recorded Wreck	395730	5673141	A3	-	-	-	Recorded UKHO position of British sailing vessel Admiral Gardner which sunk 24/01/1809. Last seen in 1997 30m x 10m x 2m. Noted as intact and almost entirely buried. Given protected designation and 300m exclusion zone. Not observed in sidescan sonar or echosounder data.	UKHO 14868	Exploration area



WA ID	Classification	Easting	Northing	Archaeological Discrimination	Length (m)	Width (m)	Height (m)	Description	External References	Area
7015	Dark Reflector	395760	5673145	A2	7	1.3	0	Irregular array of straight dark lines with no obvious shadow. Looks anomalous to the surrounding seabed. Could be natural but located 30m NE of position of Admiral Gardner.	-	Exploration area
7016	Mound	396380	5673103	A2	5	4.2	1.3	Seen in the multibeam echosounder data only as a mound with some surrounding smaller objects in a total area of 11m x 8m.	-	Exploration area
7017	Dark Reflector	397186	5673394	A2	3.9	3.5	0	Small angular object, possibly two inside each other, though it seems incomplete so possibly partly buried. No bright shadow visible. Not observed in the echosounder data.	-	Exploration area



WA ID	Classification	Easting	Northing	Archaeological Discrimination	Length (m)	Width (m)	Height (m)	Description	External References	Area
7018	Wreck	396794	5673853	A1	81.2	37.3	4.7	Two distinct areas identified in the sidescan sonar and echosounder data, approximately 34m apart on NW - SE alignment. Centre of the two area used for location position. The area to south-east is observed as a distinct elliptical mound with a depression in the centre, appearing partially buried in the sediment and measuring 18.9m x 6.5m x 4.7m. Section to north- west appears as a large but regular scatter of objects measuring 37m x 28m x 3.5m. Associated with UKHO recorded position of the US steam ship <i>North Eastern Victory</i> which is recorded as being in two pieces with the middle section buried. Sunk 24/12/1946. The north-west section appears as a distinct array of straight objects with structure in the CHP data which implies area is being slowly buried.	UKHO 13749	Exploration area
7019	Debris	396746	5673853	A2	1.8	0.8	0.6	Angular dark object with some bright shadow. Observed within depression in echosounder. Interpreted as debris from nearby wreck of <i>North Eastern Victory</i> .	-	Exploration area
7020	Dark Reflector	396743	5673847	A2	2.8	3.2	0.2	Small object with bright shadow, possible debris from wreck of <i>North Eastern Victory</i> . Smaller than 7019 and not observed in echosounder data.	-	Exploration area

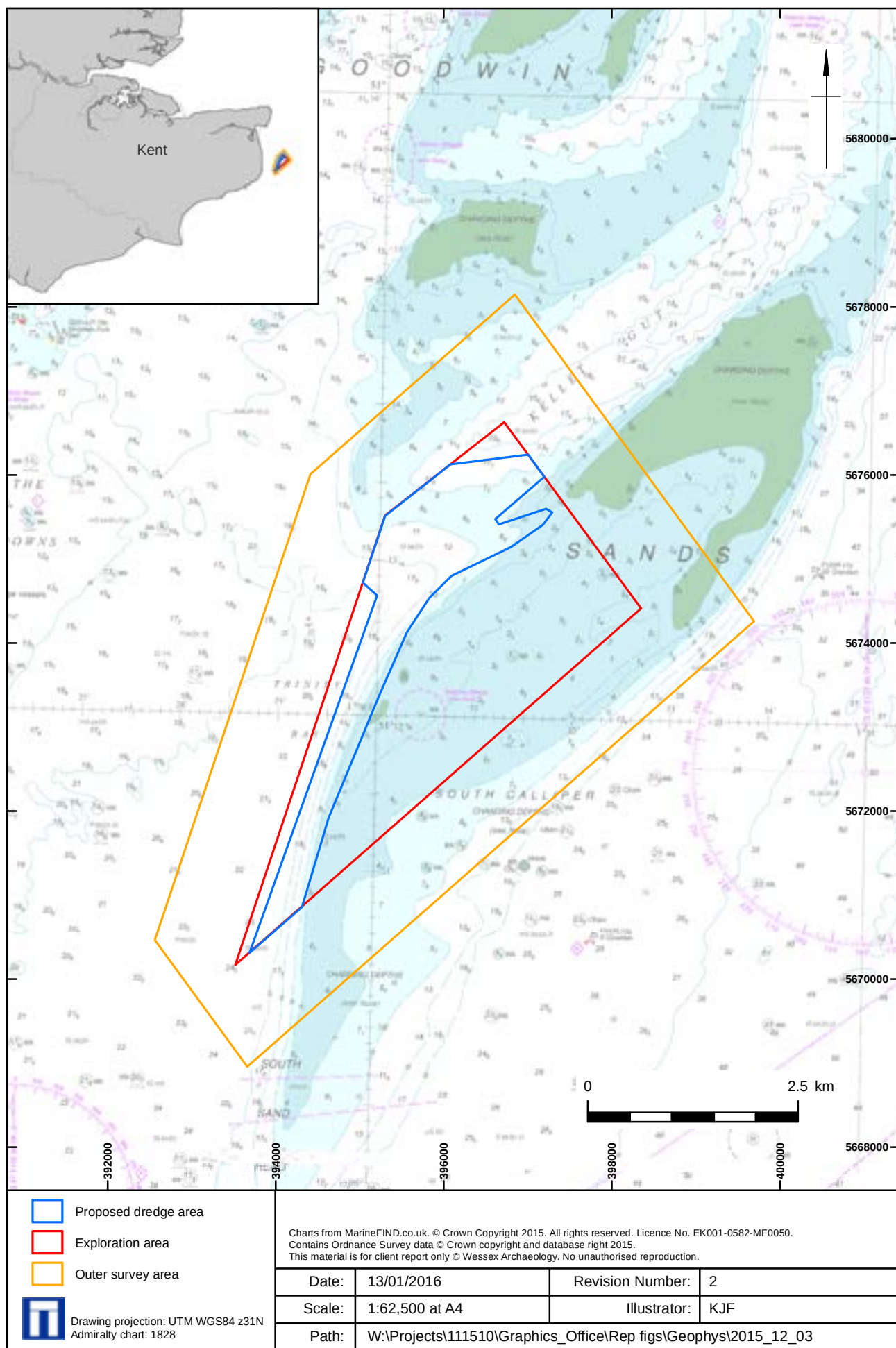


WA ID	Classification	Easting	Northing	Archaeological Discrimination	Length (m)	Width (m)	Height (m)	Description	External References	Area
7021	Seafloor disturbance	397742	5674033	A2	15	2.9	0	Distinct angular area of dark reflectors in the sidescan sonar data. Not observed in the echosounder data	-	Exploration area
7022	Dark Reflector	396433	5674221	A2	1.1	1.9	0	Irregular object with no discernible height. Seems to be at end of a long bright linear, which could be a scar measuring 8.2m x 0.5m. This feature was not observed in the echosounder data	-	Exploration area
7023	Recorded Wreck	396545	5674531	A3	-	-	-	Recorded UKHO foul ground position. Not observed in sidescan sonar or echosounder data. Last observed in 1981 by sonar as an area of rocks or wreck 25mx20m. Has been amended to "Dead".	UKHO 14780	Exploration area
7024	Wreck	397896	5674820	A1	-	-	-	Recorded UKHO position of an unidentified wreck, recorded as possible debris or vessel stern. Not observed in the current data set data, set but observed in the 2009 CHP data as a small but distinct irregular object within a depression, with some structure and surrounding scour.	UKHO 75211	Exploration area
7025	Mound	398067	5674787	A2	5.5	4	0.5	Observed as an object measuring 2m x 1m x 0.5m object in a large depression visible in the echosounder data only.	-	Exploration area
7026	Mound	397686	5675160	A2	5	3.5	0.5	Small mound visible in the echosounder data only.	-	Exploration area



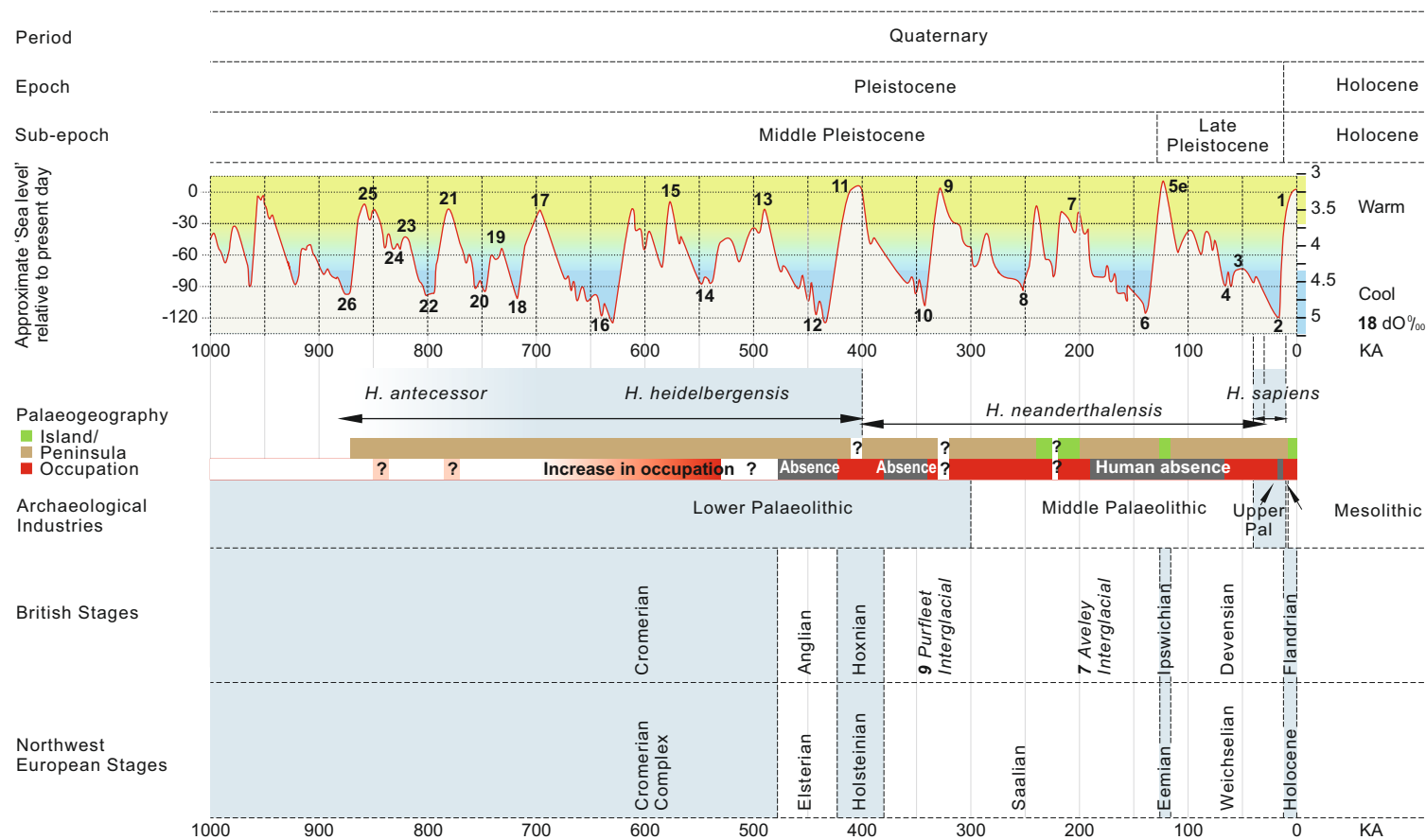
WA ID	Classification	Easting	Northing	Archaeological Discrimination	Length (m)	Width (m)	Height (m)	Description	External References	Area
7027	Recorded Wreck	397491	5675253	A3	-	-	-	Recorded UKHO foul ground position. Not observed in sidescan sonar or echosounder data. Recorded as a magnetometer anomaly only; presumed buried. Has been amended to "Dead".	UKHO 14749	Exploration area

1. Co-ordinates are in WGS84 UTM31N
2. Positional accuracy estimated $\pm 10\text{m}$



Survey Area Location

Figure 1



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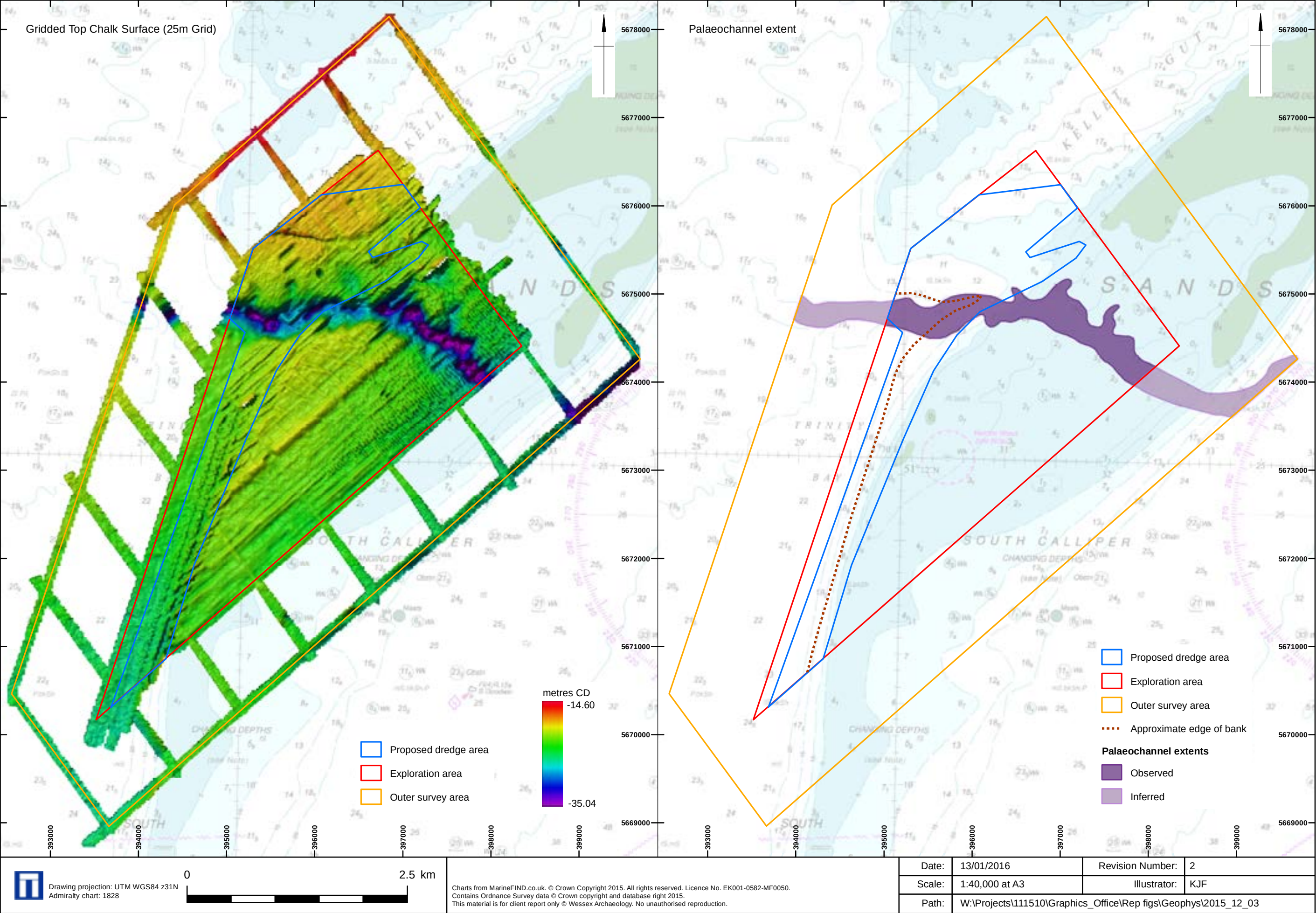
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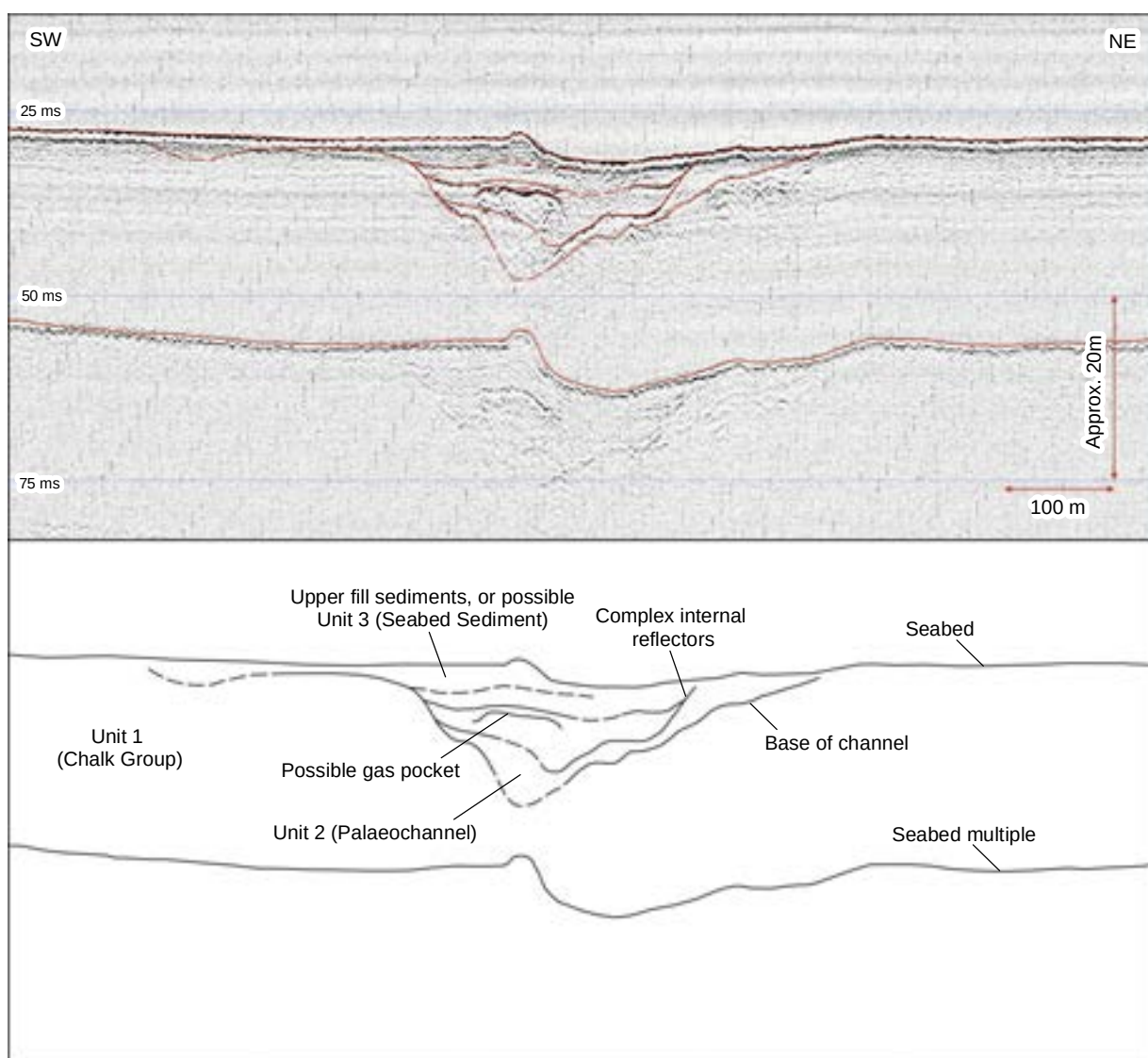
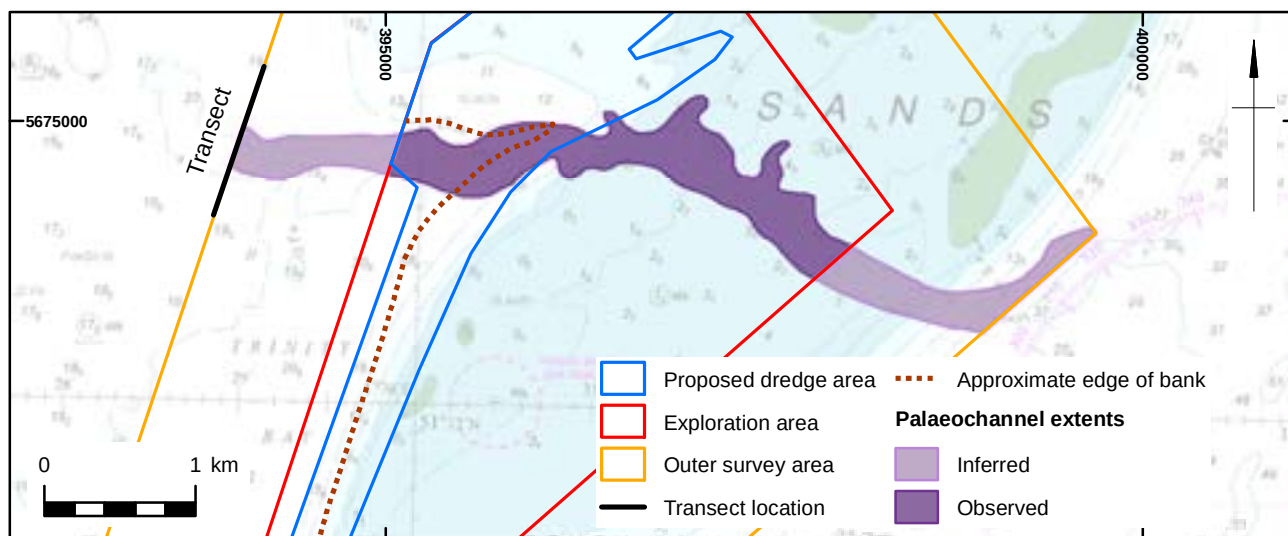
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Extent of Identified Palaeochannel

Figure 3



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Drawing projection: UTM WGS84 z31N
Admiralty chart: 1828

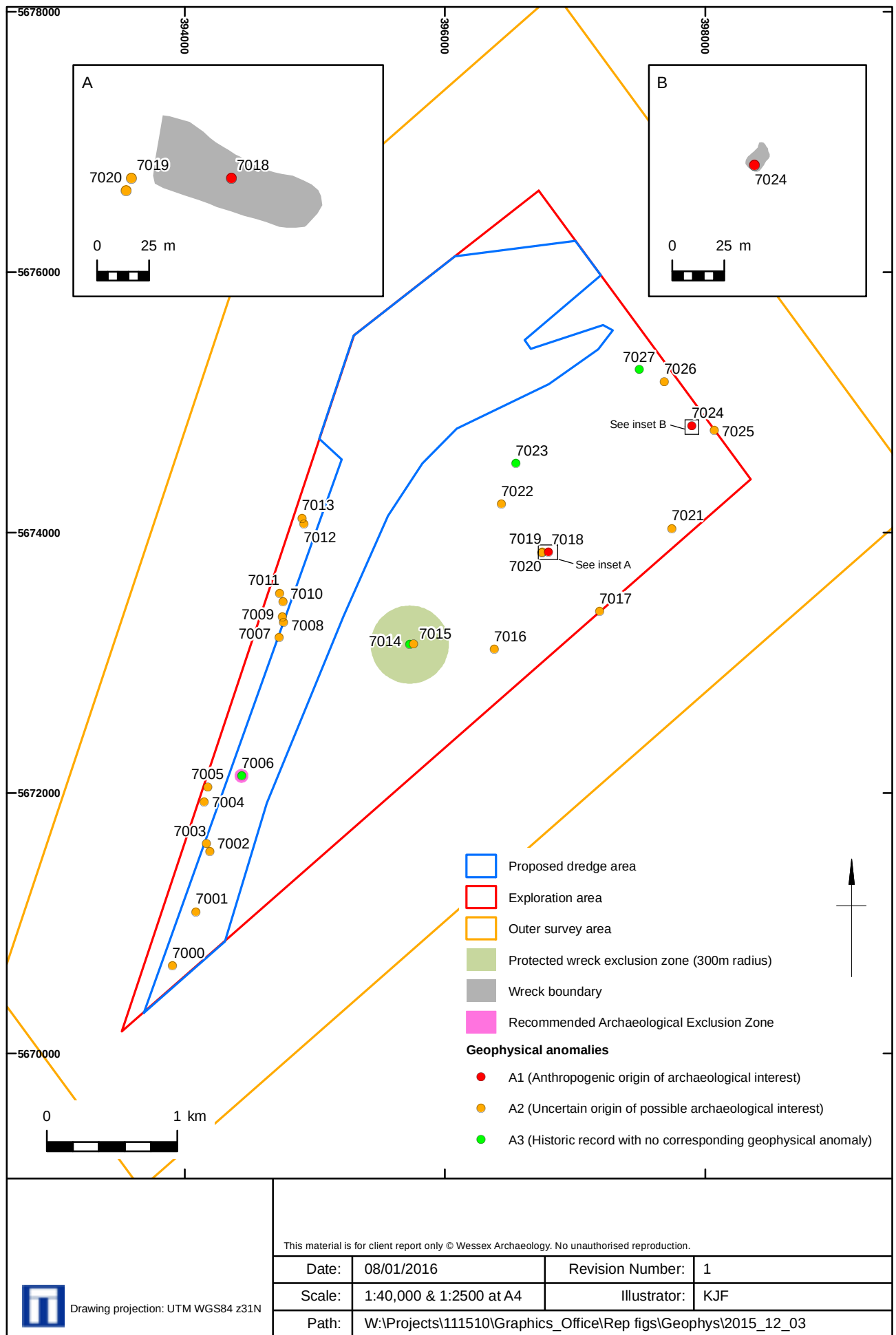
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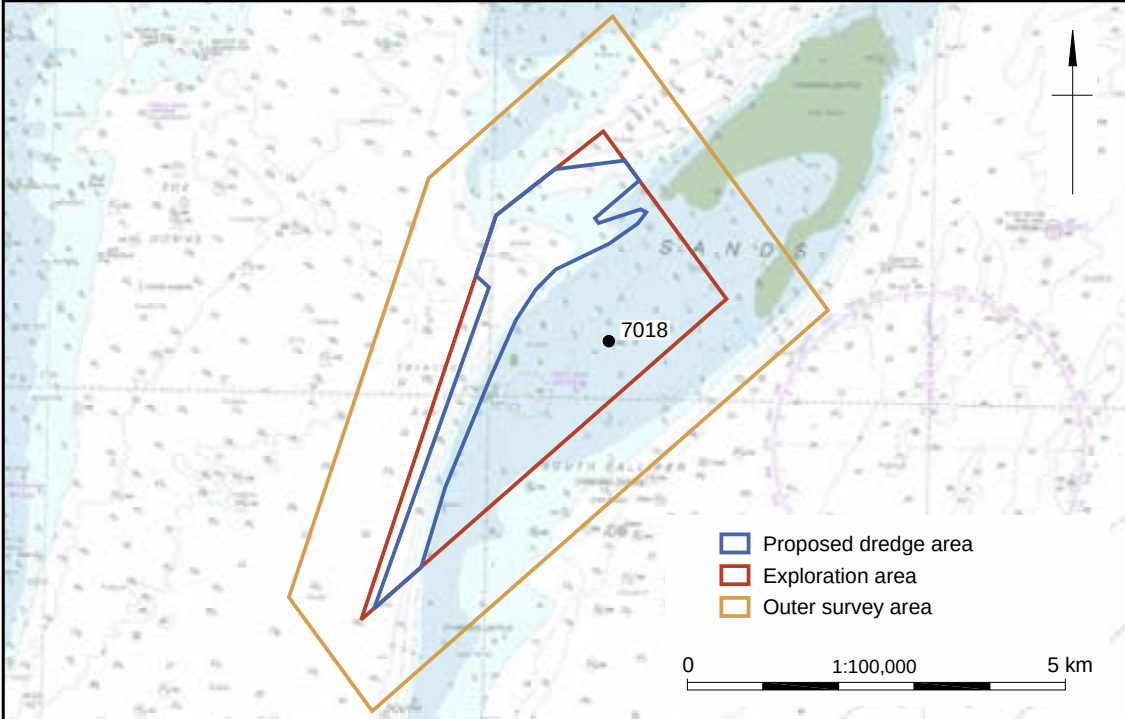
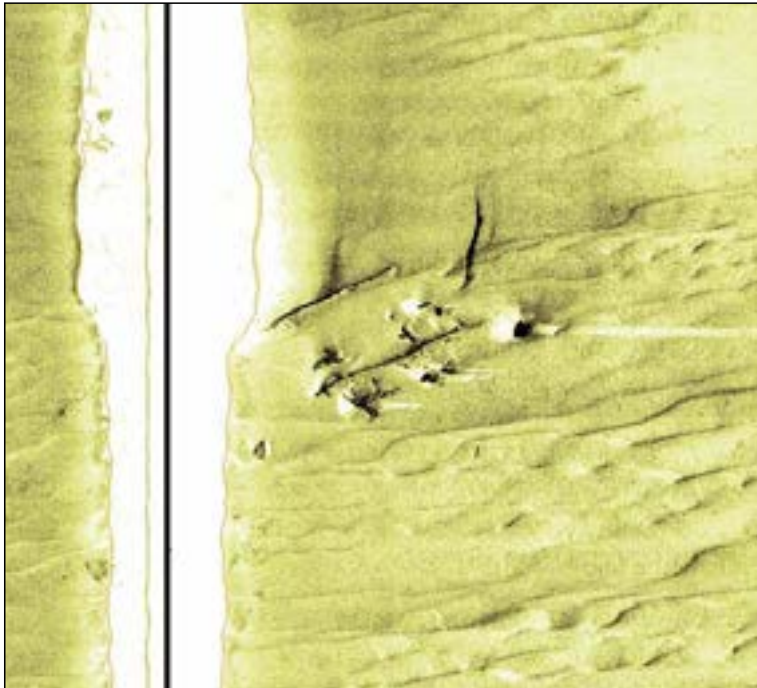
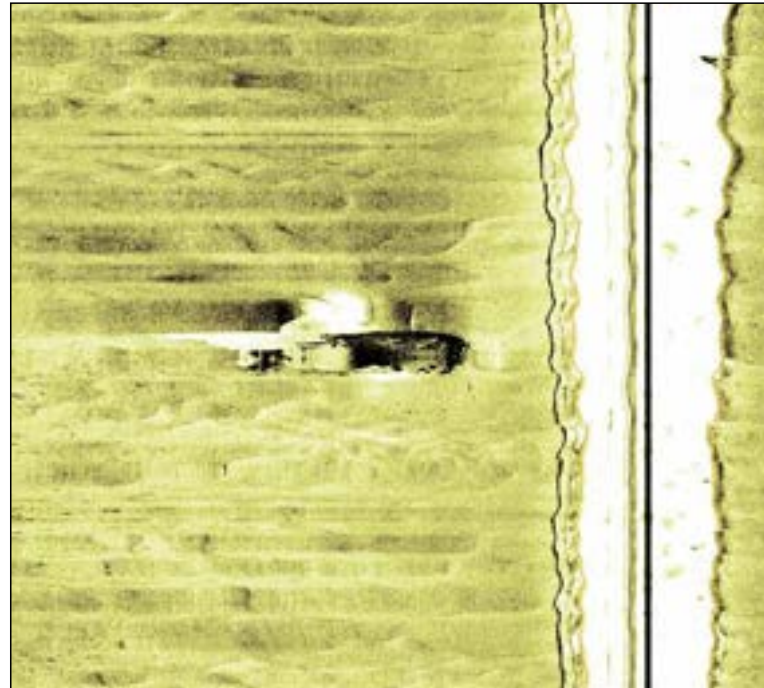
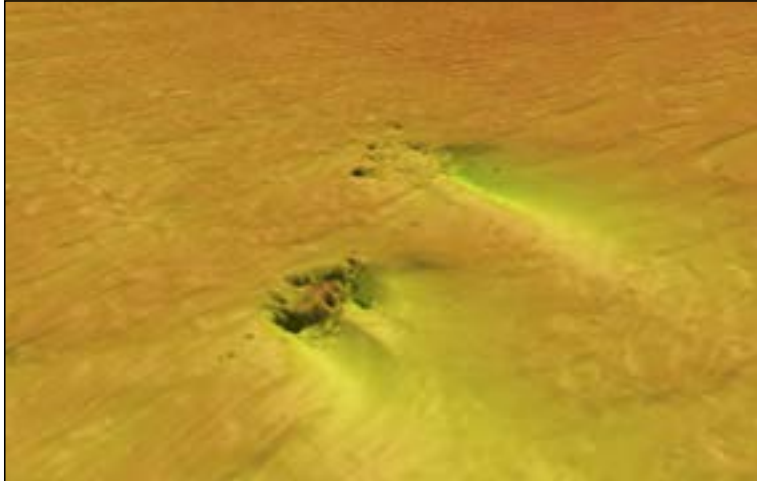
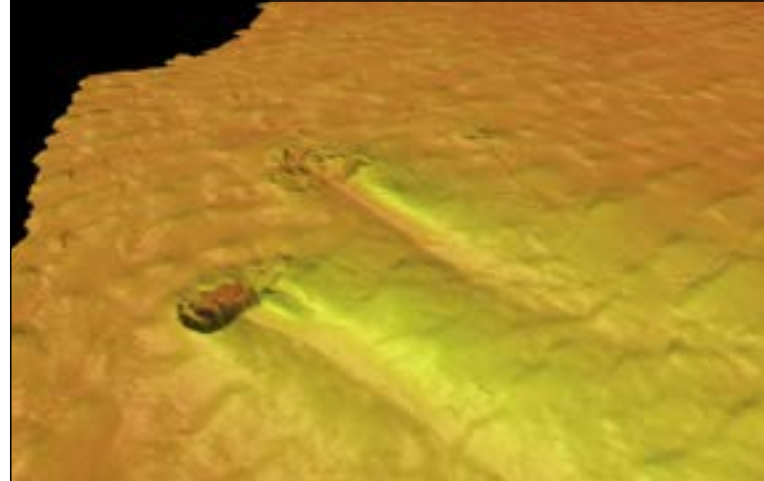
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Geophysical Anomalies

Figure 5

WA ID 7018			North Eastern Victory		(UKHO 13749)	
Location		396794 E, 5673853 N (UTM31N)				
Archaeological Importance		High				
Geophysical survey dimensions and notes		Dimensions: 81.2m x 37.3m x 4.7m. Observed as two distinct areas within large scour in the sidescan sonar data and multibeam bathymetry data at a slight NW - SE orientation. This anomaly has been interpreted as a wreck. Observed in the south east as a large elliptical mound appearing partially buried in sediment with a depression in the centre, measuring 18.9m x 6.5m x 4.7m. The second area lies approximately 34m to north west as is observed as a large but regular scatter of small objects measuring 37m x 28m x 3.5m. Possibly surrounding debris has also been identified.				
Build	Type	US steam ship				
	Construction	Two boilers, steam turbine engine of 600BHP, single shaft.				
	Dimensions	138.7m x 18.9m x 8.5m				
	Shipyard	Built 1945 by Permanente Metals Corporation, California				
Loss	Cause	Ran aground at speed in thick fog, broke in two and sank 24th December 1946				
Extent of Survival		Recorded as the wreck of the American steam ship <i>North Eastern Victory</i>. Distinct outline of a wreck site exhibiting significant height, clearly identified as two pieces each within an area of scour. From the UKHO record the wreck broke in two upon impact and therefore difficult to tell if midships are buried or if wreck pieces are becoming more broken up over time. From 2009 CHP multibeam echosounder data the area to north west is identifiable as a distinct irregular array of straight objects, rather than a surface scatter. From this it can be inferred that the site is likely being further buried in sediment.				
						
						
A sidescan sonar waterfall image of the North Eastern Victory (north west section), view facing east, 37m x 28m x 3.5m						
						
A sidescan sonar waterfall image of the North Eastern Victory (south east section), view facing east, 18.9m x 6.5m x 4.7m						
						
A multibeam echosounder image of <i>North Eastern Victory</i> , from 2015 dataset, facing west, x1 vertical exaggeration						
						
A multibeam echosounder image of <i>North Eastern Victory</i> , from 2009 CHP data, facing west, x1 vertical exaggeration						
 Drawing projection: UTM WGS84 z31N Admiralty chart: 1828 Contains public sector information, licensed under the Open Government Licence v2.0, from Maritime and Coastguard Agency. Charts from MarineFIND.co.uk. © Crown Copyright 2015. All rights reserved. Licence No. EK001-0582-MF0050. Contains Ordnance Survey data © Crown copyright and database right 2015. This material is for client report only © Wessex Archaeology. No unauthorised reproduction.						
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Appendix 16.1

Goodwin Sands Aggregate Dredging Coastal Impact Study
and EIA – Coastal Impact Study Report

Goodwin Sands Aggregate Dredging Coastal Impact Study and EIA

Coastal Impact Study Report



DDR5472-RT005-R02-00

March 2016

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Prepared



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Executive Summary

Dover Harbour Board (DHB) is proposing to dredge sand and gravel from the South Goodwin Sands off the coast of Kent for use as fill material for the Dover Western Docks Revival development at the Port. DHB is proposing to dredge up to 2.5 million m³ of sand and gravel from the subtidal parts of the South Calliper sandbank at the South Goodwin Sands, located approximately 12 km north east of the Port of Dover (Figure 1.1). Marine aggregate dredging requires a Marine Licence from the Marine Management Organisation (MMO). Royal HaskoningDHV, on behalf of the DHB, is undertaking an Environmental Impact Assessment (EIA) to support the application for a Marine Licence for consent to dredge.

HR Wallingford is supporting the EIA by a series of modelling studies and by preparation of a Coastal Impact Study report (this report). This study has been carried out to predict possible effects of dredging in a proposed new marine aggregate extraction area on the western flank of the South Goodwin Sands. More specifically, particular attention has been paid to the possibility of this dredging adversely affecting the coastline of eastern Kent.

The scope and methodology of this Coastal Impact Study assessment have been selected in order to apply a set of well-established criteria that address the concerns that such dredging might have one or more of the following effects along any coast or close inshore:

- Changing wave conditions, as a result of alterations in the patterns of wave refraction over the dredged area;
- Increasing wave heights by the removal of sandbanks or similar features within the dredging areas, if these are sufficiently high to dissipate wave energy by friction or wave breaking;
- Altering the tidal currents close inshore, thus disrupting the sediment transport in the nearshore zone or over the lower part of the foreshore;
- Altering or interrupting the natural sediment supply from offshore to the coastline by trapping of sediment within the dredged areas, or by reducing a potential sediment supply;
- Causing beach “draw down”, i.e. when storm waves erode sediment from the upper part of beaches and deposit it into dredged depressions, where it remains.

Having completed our consideration of all of the standard concerns regarding the possible impacts of the proposed aggregate dredging, we have concluded that there will be no effects along the eastern Kent shoreline, and therefore no significant coastal impacts. However, as is standard best practice for marine aggregate licences, we recommend monitoring of the dredging area before, during and after the extraction.

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1. Introduction

Dover Harbour Board (DHB) is proposing to dredge sand and gravel from the South Goodwin Sands off the coast of Kent for use as fill material for the Dover Western Docks Revival development at the Port. DHB is proposing to dredge up to 2.5 million m³ of sand and gravel from the subtidal parts of the South Calliper sandbank at the South Goodwin Sands, located approximately 12 km north east of the Port of Dover (Figure 1.1). Marine aggregate dredging requires a Marine Licence from the Marine Management Organisation (MMO). Royal HaskoningDHV, on behalf of the DHB, is undertaking an Environmental Impact Assessment (EIA) to support the application for a Marine Licence for consent to dredge.

In the past, sand and gravel obtained from several licensed aggregate dredging areas on the Goodwin Sands, off the eastern coast of Kent, has been used for various construction projects including reclamation works at the Port of Dover.

Marine mineral dredging in English waters is controlled under the Marine and Coastal Access Act 2009. An EIA Screening Opinion from the MMO has confirmed that the scheme will require an Environmental Impact Assessment under the Marine Works (Environmental Impact Assessment) Regulations 2007 (as amended). In addition to an Environmental Statement, a Coastal Impact Study (CIS) is also required to support the consent application.

HR Wallingford is supporting the EIA by a series of modelling studies and by preparation of a Coastal Impact Study report (this report). This CIS report describes our investigation of how the proposed dredging at South Goodwin Sands may affect the hydrodynamic and sedimentary environments in and around the dredging area and whether changes to waves, tidal flow and sediment transport could affect any part of the coastline.

1.1. Report layout

The remainder of this report is arranged as follows:

- Section 2 reviews the coastline nearest to the proposed dredging area, commenting on its morphology, beaches and sediment transport processes.
- Section 3 presents our understanding of the formation, changes and morphological processes of the Goodwin Sands.
- Section 4 sets out the background, requirements and scope of this Coastal Impact Study (CIS) which is to be submitted as part of the application to the MMO for the marine aggregate dredging scheme.
- Sections 5 and 6 respectively summarise the findings of computer modelling of wave propagation and tidal flows that has been undertaken to inform our assessment of the effects of the proposed dredging.
- Section 7 considers how the changes in waves and tidal flows caused by the proposed dredging, when combined, will alter sediment transport processes both local to the dredging area itself and further afield.
- Section 8 sets out the conclusions reached during this study and recommendations for monitoring the dredging and its effects.

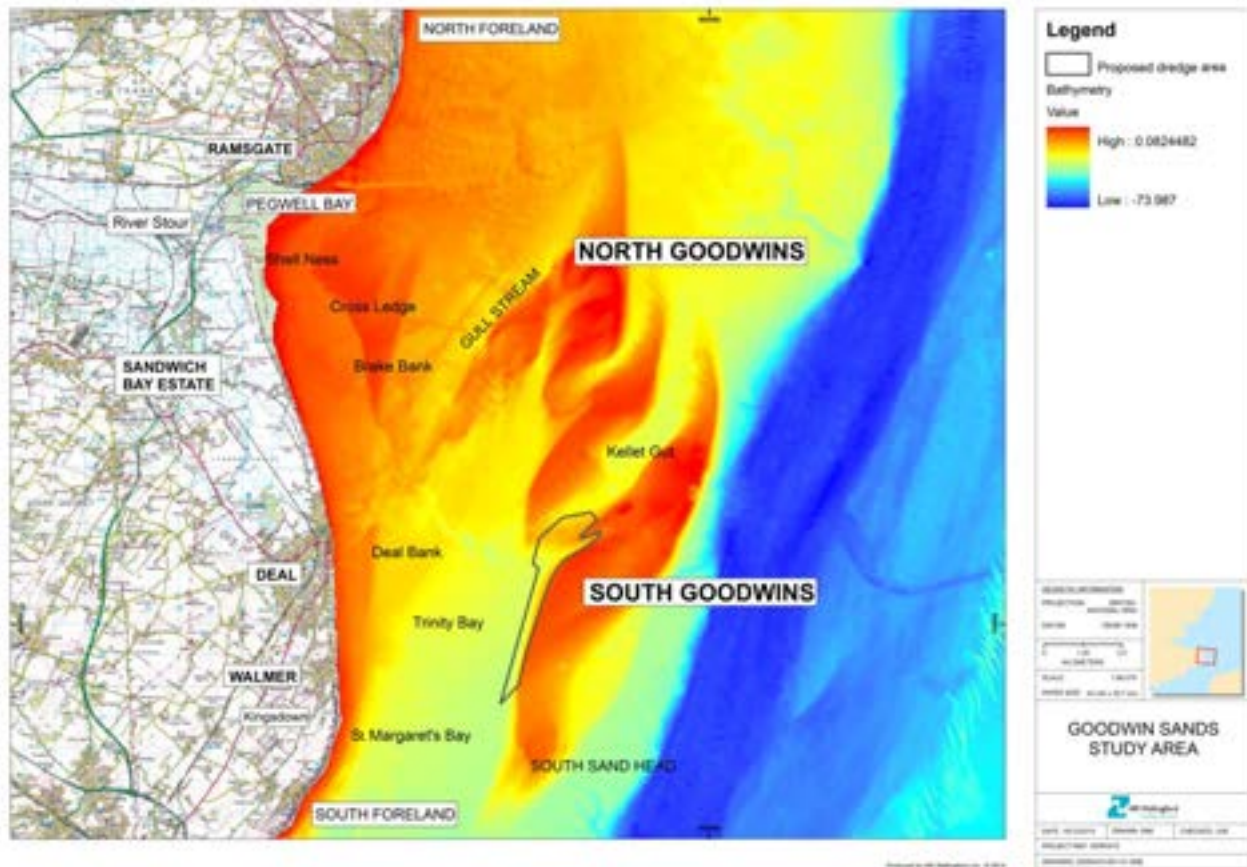


Figure 1.1: Study area

2. Appraisal of the coastline closest to the dredging area

2.1. Introduction

By reference to Figure 1.1 it can be appreciated that the coastline most likely to be affected by any changes to the Goodwin Sands lies between South Foreland, about 2.5 km to the east of Dover Harbour, and Ramsgate on the Isle of Thanet. The northern part of this stretch of the eastern Kent coastline, to the north of Deal, is known as Sandwich Bay which includes the smaller Pegwell Bay lying to north of the mouth of the River Stour.

This frontage is exposed to waves arriving from the north-east, travelling down the North Sea, and from the east, south-east and south sectors although the modest fetches across to the coast of mainland Europe decrease the effect of winds approaching the area from directions further south of east. The Isle of Thanet north of Ramsgate provides shelter to the coastline of Sandwich Bay, and particularly Pegwell Bay, from the north-easterly storm waves that dominate the wave climate well offshore of the Goodwin Sands. However for

almost all the wave directions and for most of the frontage between South Foreland and Ramsgate, those sandbanks provide the greatest protection to the coast.

2.2. Character of the coastline

Along the southern part of this frontage, between South Foreland and Walmer, the shoreline is backed by chalk cliffs. In general, these cliffs are fronted by a narrow inter-tidal area comprising a gently shelving wave-cut chalk platform with a scant and mobile veneer of flint and chert clasts. Where the cliffs have receded unevenly, for example forming the small indentation of St Margaret's Bay, there are more permanent accumulations of gravel that form shingle beaches.

From Walmer to the mouth of the River Stour in Pegwell Bay, the coastal hinterland is very low-lying. Indeed from Deal Pier north, this alluvial hinterland lies below the level of the crest of the beaches. The remains of Sandown Castle mark the northern end of the seawall at the northern end of Deal and from that point northward, the beaches form the natural flood defence.

From Walmer to Deal, the beaches are of shingle and vary in width being approximately 100 m wide in front of Walmer Castle but decreasing markedly north of Deal Pier.

Between Sandown Castle and the mouth of the River Stour the beaches change in character becoming increasingly sandy with extensive dunes landward of the inter-tidal beach at the northern end of this frontage. While there probably is a gravel beach ridge along this whole frontage, it is increasingly covered by sand to the north of the Sandwich Bay Estate. In addition the sandy lower part of the inter-tidal zone becomes wider and increasingly muddy along this same northern part of the frontage. The northern end of this beach, known as Shell Ness, has extended northward, deflecting and lengthening the low water channel of the River Stour. This spit provides shelter for the development of saltmarsh further landward.

Offshore from this whole coastline there are numerous banks and channels that modify deep water wave conditions before they reach the shoreline. The most striking of these sandbanks are the Goodwin Sands which stretch from as far south as St Margaret's Bay and as far north as Ramsgate. Various parts of the Goodwin Sands and the smaller Brake Bank, which lies about 2 to 3 km directly offshore of Sandwich Bay Estate, all dry at low tide. Even at higher tidal levels, however, these banks form a natural low-crested breakwater and provide partial shelter to the coastline between Dover and Pegwell Bay. The Goodwin Sands, in particular, are constantly moving altering both their plan shape and profiles; in doing so, they must alter the nearshore wave conditions and hence the movements of beach sediment leading to variations in the plan shape of the coastline. This variability, however, does not seem to have been of sufficient concern to lead to any past studies of the effects on the coastline of historical changes in these sandbanks. Further discussion of the processes and changes in Goodwin Sands is presented later in this report.

In addition to these drying banks, there are other less dramatic seabed features that will affect waves before they reach the coastline. These include Deal Bank, offshore and to the east-south-east of Deal Castle, and Cross Ledge north of Brake Bank. The former was cited by Halcrow (2010) as influential in altering waves reaching the Deal frontage and the Cross Ledge also occasionally dries, so also acting as a natural low-crested breakwater for Pegwell Bay.

As a consequence, wave conditions along the coastline are both substantially smaller than those offshore and likely to vary both along the shoreline and over time as the various sandbanks alter.

2.3. Coastal defences

There are no coastal defence structures along much of the coastline between Dover Harbour and Pegwell Bay. However there are flood embankments set back from the coastline between Pegwell Bay and Walmer that provide a secondary defence to marine inundation and hence protect assets further landward in this low lying area (Halcrow, 2010). Along the coastline itself, there is a seawall and groynes in St Margaret's Bay and other seawalls to the south of and at Kingsdown itself. These structures have reduced the rate of recession of the chalk cliffs locally. Further north, there are few formal defence structures along the frontage from Kingsdown to Walmer and on towards Deal, with the substantial shingle beach forming a natural coastal defence.

From Deal Castle to the remains of Sandown Castle a seawall and groynes hold the shoreline seaward of where it would otherwise have been, creating an artificial headland (Halcrow, 2010). As a consequence, the shingle beach in front of the seawall, particularly north of Deal Pier, has suffered erosion and lowering leading to problems of wave overtopping. This resulted in a major beach recharge scheme being carried out in winter 2012/13. Problems with this scheme led to further works to improve beach levels during winter 2014/2015.

Immediately north of Sandown Castle there is a rock revetment and further north an earth/colliery shale embankment revetted with concrete armour units protects part of the Sandwich Bay Estate frontage.

2.4. Coastal processes and changes

Along the southern part of this coastline, where they are unprotected, the chalk cliffs are gradually eroding and receding landwards. Estimates of the average annual rate of cliff top recession vary but are given as between 0.1 and 0.5 m/year (Halcrow, 2010). Even where seawalls have been built to reduce the recession of the faces of the cliffs, the wave-cut platforms seaward of them continue to lower, making it increasingly difficult to retain beach sediments in front of the coastal defences.

Longshore drift along this coastline was investigated using tracers in a study undertaken by Hydraulics Research Ltd. (1961) and this study indicated the drift varied seasonally with sediment moving northwards in summer and southwards in winter. Over the long-term, however, the net drift along the whole frontage from Dover Harbour to Pegwell Bay is northwards.

There is little fresh sand or gravel being added to the beaches either from the south or from erosion of the chalk cliffs and nearshore seabed. It is therefore not surprising that the beaches in St Margaret's Bay and near Kingsdown are suffering from erosion. A recent report by the Channel Coastal Observatory (2013) has analysed beach changes along three cross-sections in St Margaret's Bay. Their analysis shows a loss of 20% of the sediment from the northern profile in this Bay, and a gain of 9% in its southern part, between 2004 and 2013. While this analysis is not comprehensive in the sense of calculating changes in the total volume of beach sediment, it does suggest a long-term problem of beach lowering in this bay.

There are also problems retaining beaches near Kingsdown located immediately north of St Margaret's Bay. Here too beach lowering is being caused by the northward longshore drift not being replaced by sediment arriving from further south. This problem has been countered by beach recharges and continuing beach material recycling operations, resulting in very variable beach widths from south of Kingsdown to as far north as Walmer Castle.

Beach levels and volumes between Walmer Castle and Deal Pier have remained stable between 2003 and 2014. While there has been a chronic problem of beach lowering from Deal Pier to the remains of Sandown Castle and extending slightly further north, recent recharge schemes have restored the beach along this frontage and it is now generally higher and wider than in 2004. Just north of Sandown Castle, beach volumes have increased recently in an area that was eroding prior to the beach recharge; it seems likely that this is a result of some of that recharge bypassing the seawall in front of the Castle.

From here northwards, the changes in the beach have traditionally been smaller. Overall this part of the coastline has gradually accreted, most markedly at its northern end (Shell Ness) where the sandy beach ends in a spit that had prograded considerably in modern times (estimated by Robinson and Cloet, 1953 at 5.5 m/year). While in part this growth has been fed by gravel travelling along the seafront at Deal, the substantial volume of sand that has accumulated here recently must have arrived from elsewhere.

The pattern of sediment movement along this part of the coastline is complicated. According to Halcrow (2010) predominantly fine sediment (sand and silt) which enters Pegwell Bay derives 'from the east (cliff recession), south (alongshore transport), the River Stour and from the offshore sandbank of Goodwin Sands'.

While onshore sand transport to the beach south of the mouth of the River Stour is extremely likely, the source and route of this transport is not obvious and has not been proven or, as far as we know, investigated in any detail. There are substantial areas of sand on the seabed offshore of Pegwell Bay (Balson and Harrison, 1988) including on Cross Ledge and Brake Bank, and Cloet (1961) postulated that the Brake Bank would eventually move onto the shoreline. It seems most likely, therefore, that the sand arriving onto the coastline in Sandwich Bay has come from closer inshore than the Goodwin Sands.

3. Goodwin Sands – processes and changes

According to Halcrow (2010), the Goodwin Sands and other banks off Sandwich Bay are believed to be a relict feature of the rapid period of sea level rise during the Holocene Marine Transgression (about 10,000 years ago). While it was once thought they were islands that had been drowned by the rising sea levels, this theory was challenged by Cloet (1954). On the basis of cores through the banks, and comparison of old hydrographic charts, he concluded that they were deposits of sand and gravel on a chalk substratum at depths of 16 to 24 m below Chart Datum. He also concluded that the hydrographic surveys over the past 200 years indicated that the banks had generally increased in size over that period (Cloet, 1954).

According to Robinson and Cloet (1953), the shape of the Goodwins is formed by the interaction of ebb and flood channels. Their assessment was that during the flood tide, flow is channelled north-eastwards into Trinity Bay and the area between the coast and Brake Bank while the principal south flowing ebb tide channels are the Gull Stream separating Brake Bank from the Goodwins and to the east of the Goodwins.

The interaction of the banks with the tidal currents was also examined by Kenyon and Cooper (2005), who characterised the Goodwins as 'open shelf sinuous banks'; they concluded that this type of bank system may be inherently unstable. That same report concluded that these banks are in a sediment transport convergence zone with bed load transport approaching from both the south-west past South Foreland and from the north-east past North Foreland. This implies that the relict deposits in this area left by the transgression may have since been added to by present-day sediment transport processes. This conclusion echoes that previously reached by Cloet (1954).

In more detail, Kenyon and Cooper (2005) indicated bed-load sediment movement eastwards past Dover Harbour and then turning north-eastward around South Foreland and passing between the coastline and the Goodwin Sands, with some sediment arriving on the western flank of the banks in the same general area as the dredging area proposed by DHB. At the same time, they indicate bed load sediment from the North Sea travelling past the mouth of the Thames Estuary reaches the northern and eastern flanks of the Goodwin Sands as well as travelling down the Gull Stream between their northern end and Ramsgate.

This sediment transport pattern suggests not only a continuing addition of sediment to the Goodwin Sands but also a direct supply into Pegwell Bay from both the north-east and from the south inshore of the Goodwins.

The overall pattern of bed-load sediment transport approaching the Goodwin Sands, while complicated, is much simpler than the movements within the bank system itself, judging by the substantial and rapid changes in their morphology. The lack of complete surveys of the whole bank system makes study of their changes or calculation of the volume of sediments they contain very difficult. We have not found any recent studies or scientific papers assessing the overall changes in the Goodwin Sands, although there have been repeated surveys of some parts of these banks.

Because of the dangers to navigation posed by the shifting banks, the United Kingdom Hydrographic Office (UKHO) publish the results of regular bathymetric surveys of parts of the seabed around the periphery of the Goodwin Sands. These re-surveys give some hint of the changes in the sandbanks but do not extend across their whole width or length.

In a previous study for DHB, HR Wallingford compared bathymetric surveys of the South Goodwin Sands dated 1995-1998 and 2006. This report concluded that overall the volume of this part of the Goodwin Sands above the -10 m Chart Datum (CD) contour, of about 170 million cubic metres, had hardly altered in the intervening 8-11 years. However the study did note that the profile of the bank had altered so that the amount of sediment above the 0 m CD contour had increased from about 4.4 to 5.7 million cubic metres.

The latest comparison of changes in the southern part of the South Goodwins (UKHO, 2013a) shows part of the bank (South Sand Head) extending southwards between 2009 and 2012. Another report on a resurvey covering the majority of the South Goodwins shows it accreting along its western flank and eroding along its eastern (seaward) edge during the same period. Interestingly, this recent landward movement of the South Goodwins is opposite to that reported by Cloet (1954) who had remarked 'it would be unwise to attempt any predictions' on the basis of the changes he had analysed.

4. Scope of the Coastal Impact Study

4.1. Background to the present Coastal Impact Study

The Goodwin Sands system is a dynamic, highly mobile sedimentary environment which contains significant volumes of sand and gravel. Goodwin Sands has been dredged to provide aggregate for infrastructure projects at the Port of Dover and Ramsgate, with five licences being issued previously for extraction from areas on both the North Goodwin and South Goodwin Sands (Areas 293/1, 304, 342, 352 and 365) with over 9.5 million tonnes (6.3 million m³) extracted between 1976 and 1998.

DHB dredged material from Goodwin Sands in the 1970s to provide fill material for the construction of the Hoverport terminal. DHB also dredged several million cubic metres of sediment from Area 342 (which partially overlaps with the proposed dredging area) on the South Goodwin Sands between 1984 and 1996

for land reclamation at the Eastern Docks. In addition, material has also been dredged from Goodwin Sands for use as aggregate for the construction of the Channel Tunnel Terminal.

DHB is now proposing to dredge a further 2.5 million cubic metres (approximately) of fine to coarse sand and gravel from an area of seabed on South Goodwin Sands, located approximately 19 km from the Port of Dover but only about 5 km from the nearest point on the coastline (Figure 1.1). The aggregate dredging is anticipated to be undertaken using one or two trailing suction hopper dredgers (TSHDs) and will be transported within the dredger(s) to Dover for use as fill material.

This CIS report describes our investigation into how dredging the western flank of the South Goodwin Sands may affect the hydrodynamic and sedimentary environments in the surrounding area including the local coastline.

4.2. Requirements and scope of this Coastal Impact Study

Coastal managers often raise concerns about the possible effects on shorelines, and particularly on beaches, which may be caused by offshore aggregate dredging.

In the UK, there is no clear evidence of problems being caused by such dredging in the last 80 years or more. Nevertheless a precautionary approach is always taken when assessing the possible effects on coastlines of offshore aggregate extraction before permission is given for any dredging. These assessments have been developed and improved over many years.

For each individual extraction licence application, it has long been standard practice in the UK to carry out a specific CIS.

The scope of this Coastal Impact Study has been drawn up to match the best practice guidelines set out in BMAPA and The Crown Estate (2013). Those guidelines were produced in consultation with the MMO, Natural Resources Wales, Natural England, JNCC, the Environment Agency, English Heritage (now Historic England), Cefas and others.

The main concerns defined in those guidelines, and investigated in this study, are that dredging on the Goodwin Sands might have one or more of the following effects:

- Changing wave conditions at (or close to) the coastline, resulting from alterations of the patterns of wave refraction over the dredged depression;
- Increasing wave heights at the coastline by the removal of sandbanks or similar features within the dredging areas, if these are sufficiently high to dissipate wave energy by friction or wave breaking;
- Altering the tidal currents close to the coastline, thus disrupting the sediment transport in the nearshore zone or over the lower part of the foreshore;
- Altering or interrupting the natural sediment supply from offshore to the coastline by trapping of sediment within the dredged areas, or reducing a potential supply;
- Causing beach “draw-down”, i.e. when storm waves erode sediment from the upper part of beaches and deposit it into dredged depressions, where it remains.

In this particular study, it needs to be recognised that the proposed dredging area is close to the crest of sandbanks that provide shelter to part of the eastern coast of Kent (see Figure 1.1) and that it lies closer to that coastline than most marine aggregate extraction areas.

The first two of these concerns require assessment of how the dredging will alter waves travelling over the extraction area on their way towards the coast. Dredging inevitably increases water depths within the

extraction areas, at least for a time, and the resulting changes in the seabed contours alter the way that waves propagate over them. These localised changes in wave propagation patterns could then, at least theoretically, continue to affect waves all the way to the shoreline, resulting in changes in the wave height and/or in the wave direction at the coast. Such changes could then alter the strength of longshore currents, littoral drift rates and hence the plan-shape of the coastline.

Assessing changes in waves involves the representation of seabed levels before and after aggregate dredging and modelling of the transformations of appropriate offshore wave conditions. This is undertaken both before and after the dredging to show the impact of the proposed project.

Similarly computer modelling of tidal propagation before and after the dredging has lowered bed levels is needed to assess whether current speeds and directions are altered close to the coast. Since sediment transport over the offshore seabed is usually dominated by tidal currents with some enhancement due to wave stirring, it is usual to consider how dredging will affect the rates and directions of the movement of sediments in and around the dredging area using a similar modelling approach.

The final issue, of beach drawdown, can be addressed at the outset. There is deeper water between the coastline and the proposed dredging area than in that area itself, even after the proposed extraction. In addition, the dredging areas are much further offshore than the seaward limit of any of the beaches between South Foreland and Ramsgate. Taken together, these observations ensure that sediment will not be drawn off the beaches and find its way into the depressions left by the dredging.

5. Effects of the proposed dredging on waves

As is now standard practice in such studies, the wave modelling and impact assessment was carried out for very large and extremely rare wave conditions. Following calibration of the wave model against locally collected data, baseline and predictive runs were undertaken for 200 year return period wind and wave conditions as these would pose the greatest risks to the coastline and its coastal defences.

In the wave modelling two options for the proposed dredging were studied. Scenario 1 represented dredging 1.12 m depth of material evenly across the whole of the proposed extraction area whereas Scenario 2 simulated lowering the seabed by 1.95 m in just the northern end of the proposed dredge area where the bulk of the resource is located. As has been used for aggregate studies elsewhere the amount of sediment proposed to be removed has been increased by 60% in the modelling studies to provide a precautionary view of the potential impact of the dredging. Hence, both the depth change scenarios described above involve removal of approximately 4,000,000 m³ of material from areas identified as having sand and leaving a layer of at least 0.5 m of sand in those areas after dredging in accordance with established practice to facilitate recovery of benthic communities.

The modelling indicated very little change in wave height as a result of the proposed dredging and no change at the coastline. The main effect was caused by a small difference in the way waves will refract around the edge of the sandbank leading to a slight redistribution of the wave energy. The predicted changes in significant wave height (H_s) due to dredging are limited in very spatial extent with no predicted effect extending to the coastline. The magnitude of change in H_s is generally limited to 0.02-0.10 m, even under the extreme conditions tested. An example of the predicted effect is shown in Figure 5.1. This figure shows the baseline wave height and direction for 1:200 year return period wave conditions from 90°N at mean low water spring tide (upper frame) and mean high water spring tide (lower frame).

The complete wave modelling report is included in this report as Appendix A.

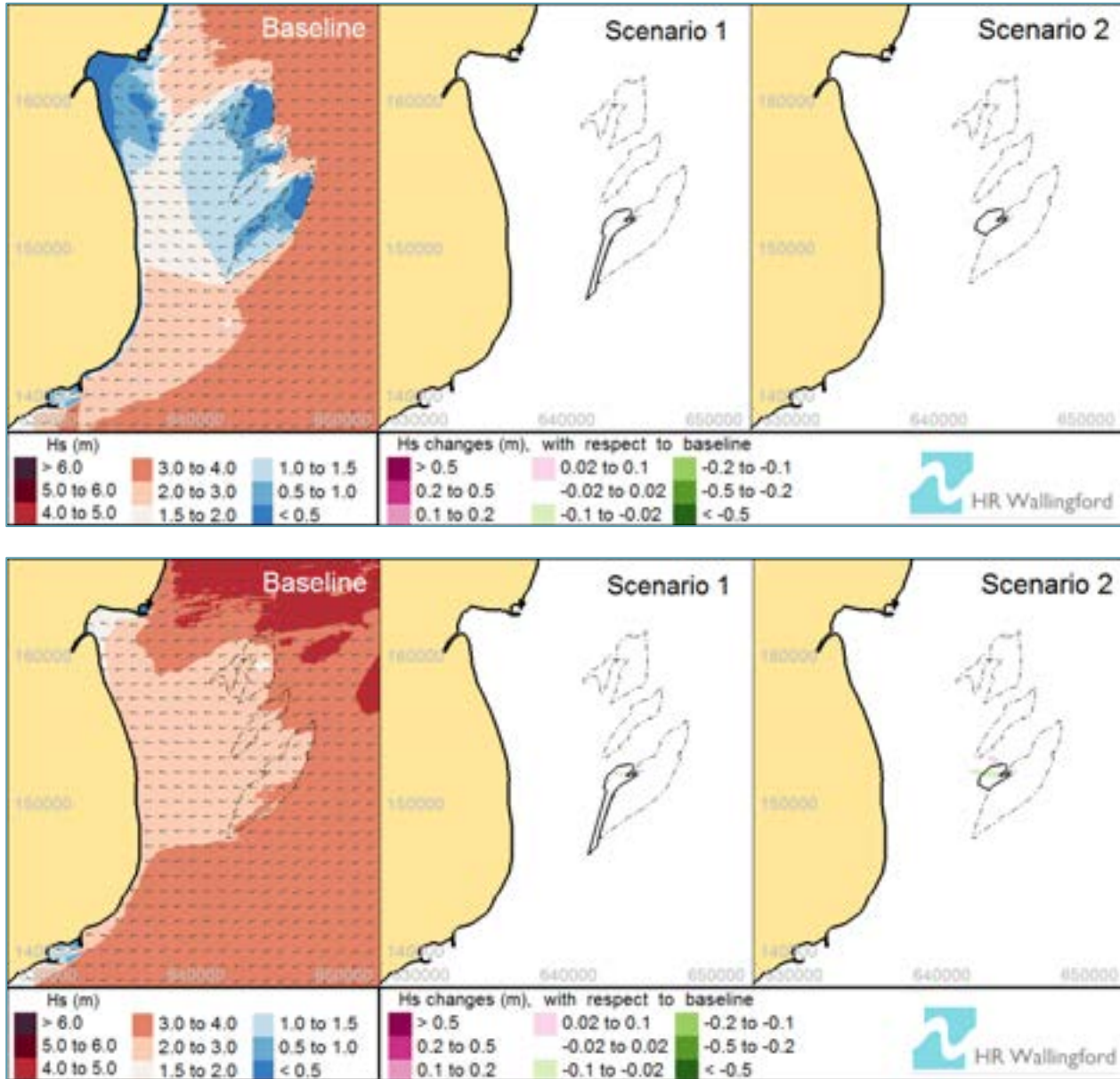


Figure 5.1: 1:200 year return period wave conditions from 90°N at MLWS (upper frame) and MHWS (lower frame): Baseline H_s and differences due to dredging

6. Effects of the proposed dredging on tidal flows

An existing 2D, depth averaged tidal flow model of the English Channel and Southern North Sea was locally refined in the area of Goodwin Sands. The model was validated for currents in the area of the proposed dredging against data collected at the site for the present EIA studies. For the flow modelling, only Scenario 1 was considered, i.e. an even lowering of the full dredging area by 1.12 m.

The model was then run for a period of more than a month for the existing and post-dredge cases and the differences in currents plotted. All of the current speed differences due to the dredging in excess of 0.05 m/s have been found to be within about 1 km from the area where dredging is proposed. Hence no widespread effect on tidal currents due to the proposed dredging is anticipated including no effect at the coastline.

Figure 6.1 and Figure 6.2, below show the predicted effects of the works on tidal currents at the times of highest flow to the north (Figure 6.1) and to the south (Figure 6.2). These figures confirm the limited effect of the dredge, both in term of magnitude and extent of change to tidal currents.

The complete tidal flow modelling report is included in this report as Appendix B.

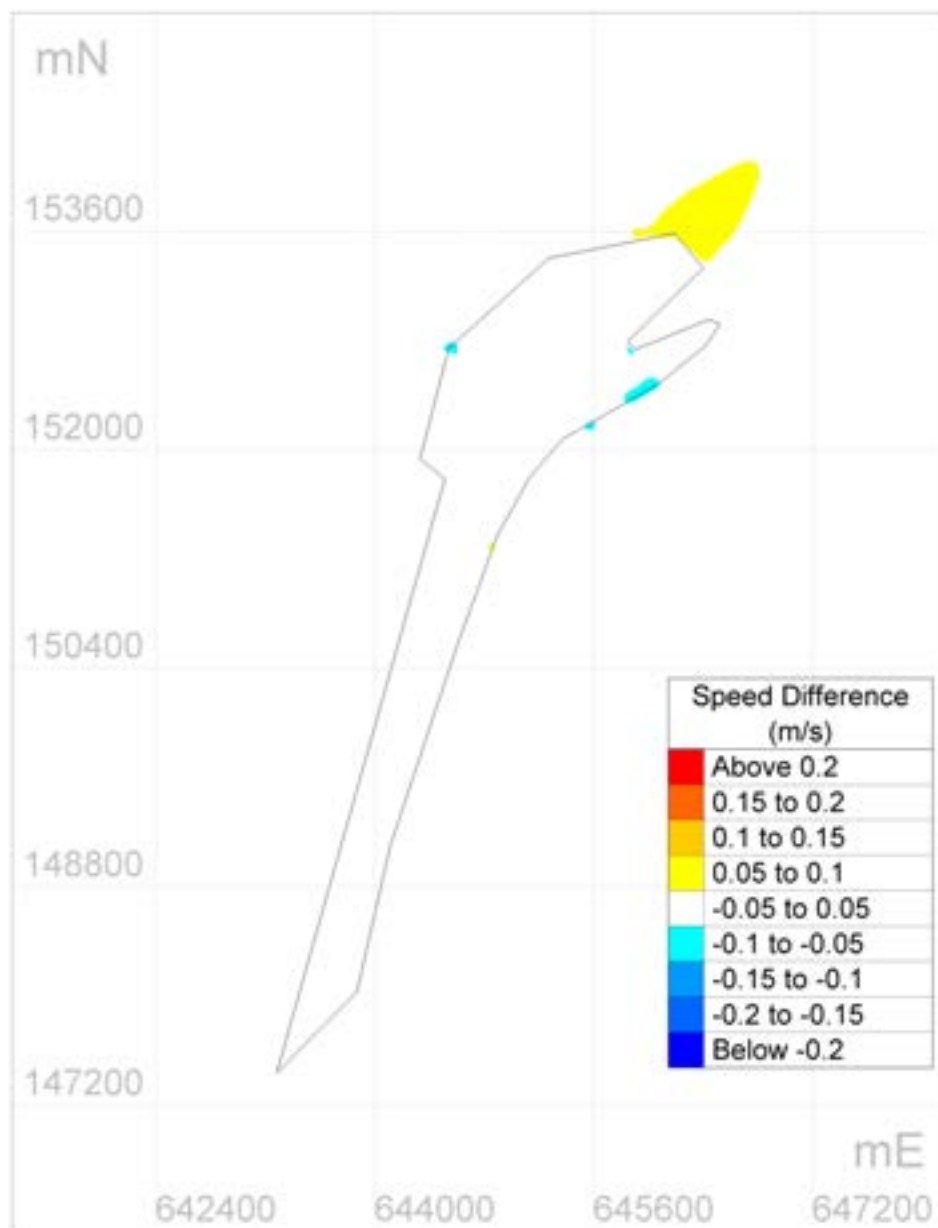


Figure 6.1: Difference in tidal current at time of maximum current towards the north

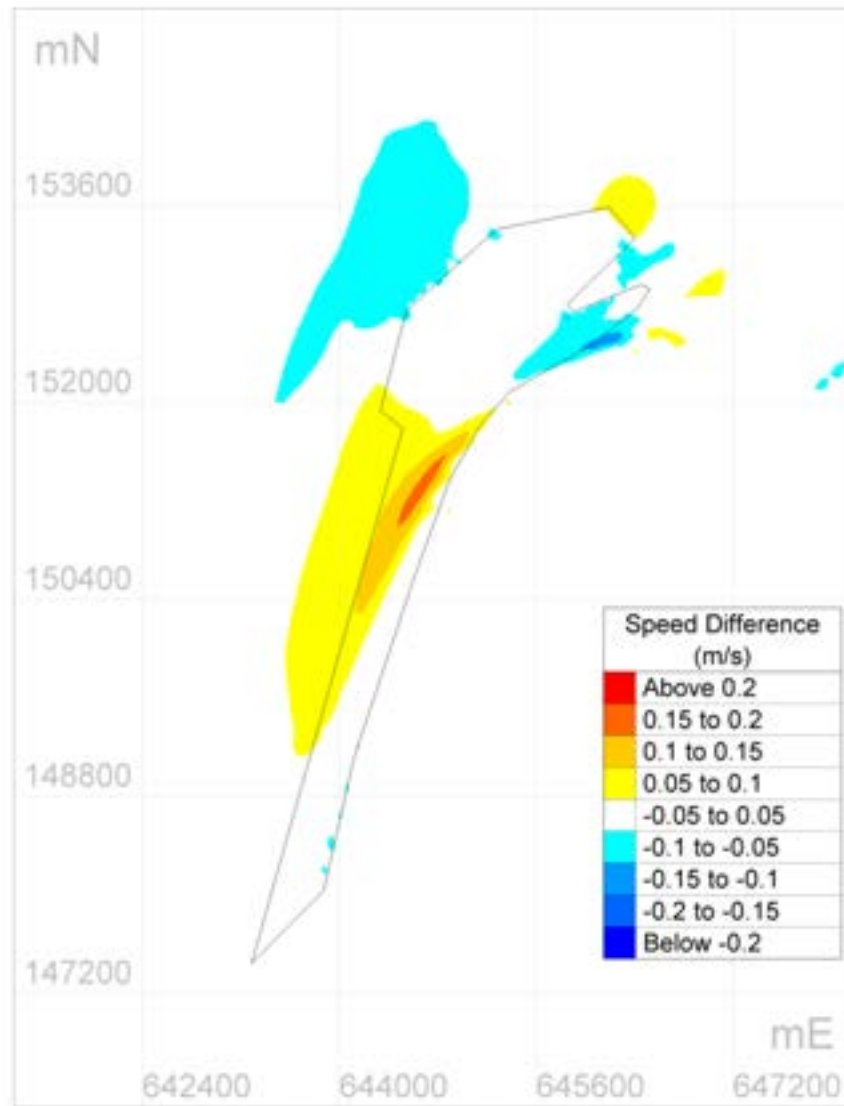


Figure 6.2: Difference in tidal current at time of maximum current towards the south

7. Effects of the proposed dredging on sediment transport

The sediment transport model SISYPHE has been used to calculate the sediment transport around Goodwin Sands. The results from simulations before and after the proposed bed lowering have been compared to assess the impact of the dredging on the sediment transport and consequential seabed changes.

The modelling combined the wave and tidal flow model to drive sediment transport, coupled with morphological bed updating. For the sediment transport modelling the wave model was re-run for representative wave conditions rather than the extreme waves described in Section 5. As might be

anticipated, based on the small effects of the dredging on waves and tidal flows, the predictions of sediment transport suggested only small changes in the residual sediment transport and erosion/deposition pattern due to the proposed dredging. These changes were all in the immediate area of the dredging site and in most locations were shown as a reduction in predicted potential erosion within the dredging site itself, and an associated reduction of potential sedimentation rate in the deeper channel areas next to the dredging area. No effect of the changes to the waves and tidal flows on sediment transport was predicted near the coastline.

The sediment transport modelling results suggested that there is a small northward sediment transport pathway through the Straits of Dover, which might feed Goodwin Sands with additional material, although the amount of material available for transport there is very limited. Little or no sediment seemed to escape from the banks of the Goodwin Sands to the north. This supports the conclusion of Kenyon and Cooper (2005) (Section 3) of a sediment convergence zone at the Goodwins. This indicates that the volume of the banks is expected to be stable, perhaps even growing at a very slow rate. This view of a generally stable bank volume is confirmation of earlier work, reported, for example in HR Wallingford (2008) that concluded that the volume of the sandbanks is constant or fractionally increasing.

The complete sediment transport modelling report is included in this report as Appendix C.

8. Conclusions

This study has been carried out to predict possible effects of dredging in a proposed new marine aggregate extraction area located on the western flank of the South Goodwin Sands. Particular attention has been paid to the possibility of this dredging adversely affecting the coastline of eastern Kent.

The scope and methodology of this Coastal Impact Study have been selected in order to apply a set of well-established criteria that address the concerns that such dredging might have one or more of the following effects along any coast or close inshore:

- Changing wave conditions, as a result of alterations in the patterns of wave refraction over the dredged depressions;
- Increasing wave heights by the removal of sandbanks or similar features within the dredging areas, if these are sufficiently high to dissipate wave energy by friction or wave breaking;
- Altering the tidal currents close inshore, thus disrupting the sediment transport in the nearshore zone or over the lower part of the foreshore;
- Altering or interrupting the natural sediment supply from offshore to the coastline by trapping of sediment within the dredged areas, or by reducing a potential sediment supply;
- Causing beach “draw down”, i.e. when storm waves erode sediment from the upper part of beaches and deposit it into dredged depressions, where it remains.

In the previous sections of this report, we have described numerical modelling of the extent to which the proposed dredging of the South Goodwins might alter waves, tidal flows and the transport of sediment over the seabed. The first two of the concerns in the above bulleted list were considered by carrying out the modelling described in Section 5 of this report.

Our wave modelling has indicated that there will be no noticeable changes in wave conditions close to any part of the coastline. This is despite the fact that exceptionally severe wave conditions have been simulated

and examining changes caused by the extraction at different tidal levels. Of particular concern in this study were any changes in nearshore wave heights at high tide when coastal defences would be most at risk and the shelter provided by the Godwin Sands was least. At the low tide level considered, the proportional increase in depth caused by the dredging will be greatest, hence maximising the changes to waves travelling over the extraction area. In both cases, however, the modelling showed changes in wave heights would be limited to within and very close to the limits of the extraction area, and not extend more than a small proportion of the distance to the nearest point on the coastline. We conclude the dredging will have no effect on wave conditions along the coastline of Kent.

The next two bulleted concerns listed above relate to the potential for tidal flows to be affected by aggregate dredging, thus also affecting the movement of sediment over the seabed in and around the dredging area. These possible changes were examined by tidal flow and sediment transport modelling, as explained in Sections 6 and 7.

Over some parts of the study area, tidal flows and the associated sediment transport rates are predicted to alter as a result of the lowering of seabed levels in the proposed dredging area. However, none of the modelling has indicated that there will be any significant changes in tidal currents or sediment transport rates along or close to any coastline. This is despite the fact that the modelling has taken a conservative approach to simulating such changes, by considering a large tidal range and by substantially exaggerating the amount of sand that would be removed.

Local to the proposed dredging area, there will be changes to the hydrodynamic and hence the sediment transport regime, so that bed levels close to the dredging area will alter. The main concern is that as a consequence the height of the crest of the South Goodwin bank may reduce, hence reducing the shelter from waves that it presently provides to the eastern coast of Kent. We have examined this possibility using the results of past monitoring of the Goodwin Banks following similar aggregate dredging campaigns, and by considering the processes that have maintained these banks in much the same position and with much the same crest levels over the last few thousand years (in Section 3 above). Based on these considerations, we have concluded that the proposed dredging will not alter the crest level of the South Goodwin bank. However, as is standard best practice for marine aggregate licences, we do recommend monitoring of the dredging area before, during and after the extraction.

Having completed our consideration of all the standard concerns regarding the possible impacts of the proposed aggregate dredging from the South Goodwin Sands, we have therefore concluded that there will be no effects along the eastern Kent shoreline, and therefore no significant coastal impacts. However, as is standard best practice for marine aggregate licences, we recommend monitoring of the dredging area before, during and after the extraction.

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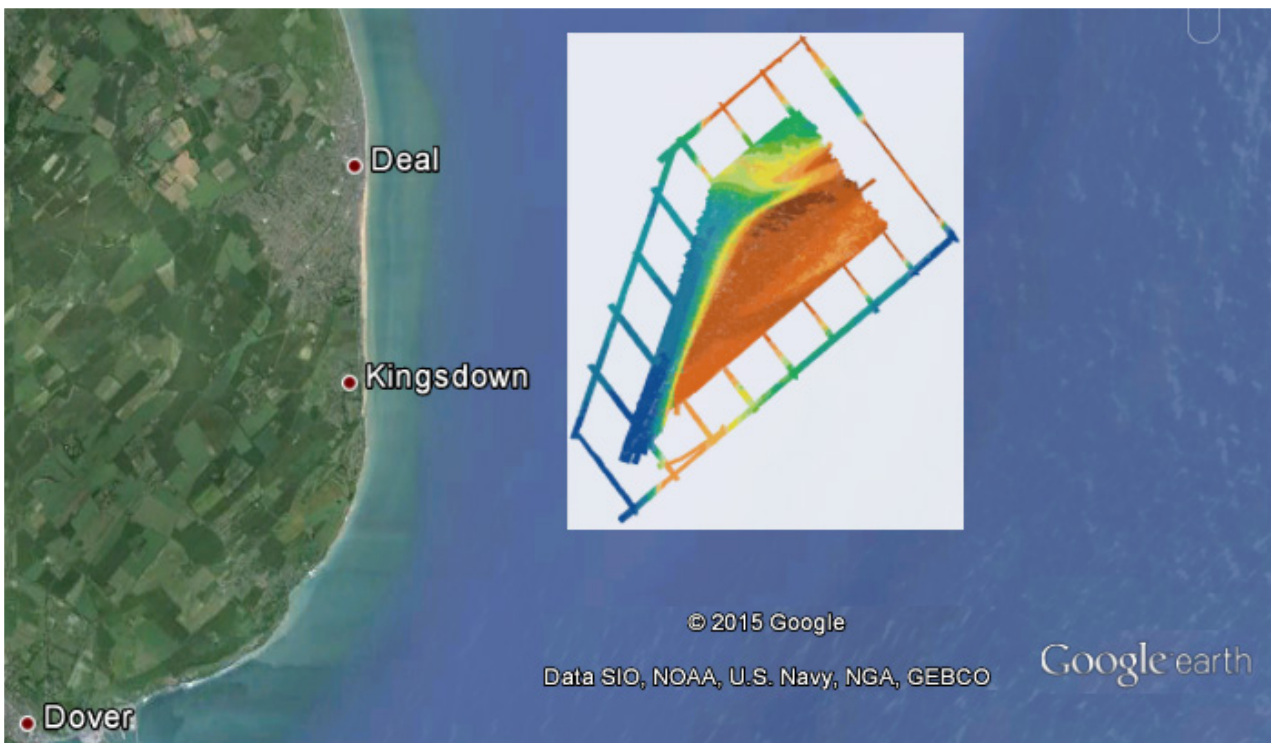
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Appendices

A. Wave modelling report

Goodwin Sands Aggregate Dredging Coastal Impact Study and EIA

Wave modelling



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Prepared



Approved



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Executive Summary

Dover Harbour Board (DHB) is proposing to dredge sand and gravel from the South Goodwin Sands off the coast of Kent for use as fill material for the Dover Western Docks Revival development at the Port. DHB is proposing to dredge up to 2.5 million m³ of sand and gravel from the subtidal parts of the South Calliper sandbank at the South Goodwin Sands, located approximately 12 km north east of the Port of Dover (Figure 1.1). Marine aggregate dredging requires a Marine Licence from the Marine Management Organisation (MMO). Royal HaskoningDHV, on behalf of the DHB, is undertaking an Environmental Impact Assessment (EIA) to support the application for a Marine Licence for consent to dredge.

HR Wallingford is providing inputs to the EIA and Coastal Impact Study (CIS), establishing the magnitude, spatial extent and duration of changes to the physical environment directly caused by the proposed aggregate dredging. The focus of the modelling described in this report is on changes in waves caused by dredging on the Goodwin Sands. As is now standard practice in such studies, this assessment is carried out for very large and extremely rare wave conditions. In this study 1 in 200 year wind and wave conditions were considered as these would pose a high risk to the coastline and its coastal defences under baseline conditions. More common wave conditions were also modelled as input to the sediment transport and morphology study.

The modelling indicates very little change in wave height as a result of the proposed dredging. The main effect was caused by a slight difference in the way waves refract around the edge of the sandbank leading to a slight redistribution of the wave energy. The predicted changes in significant wave height (H_s) due to dredging are limited in spatial extent with no predicted effect extending to the coastline. The magnitude of change in significant wave height is limited to 0.02-0.10 m within an area extending at most 4 km from the edge of the proposed dredging area, even under the extreme conditions tested.

To put these changes into context the wave modelling also considered historical bathymetries to show the variation in wave conditions resulting from the evolution of the Goodwin Sands and nearby sandbanks. The modelling of historical bathymetries indicates more variation in significant wave height than was predicted with the post-dredging bathymetries. It is noted that some of these differences may be attributed to the use of more refined / recent bathymetry data sources in the present day model bathymetry in areas away from the study area compared to the historical bathymetries. However it is clear that the changes in wave conditions due to the variability of the sandbanks are significantly greater than the effects of the proposed dredging.

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1. Introduction

Dover Harbour Board (DHB) is proposing to dredge sand and gravel from the South Goodwin Sands off the coast of Kent for use as fill material for the Dover Western Docks Revival development at the Port. DHB is proposing to dredge up to 2.5 million m³ of sand and gravel from the subtidal parts of the South Calliper sandbank at the South Goodwin Sands, located approximately 12 km north east of the Port of Dover (Figure 1.1). Marine aggregate dredging requires a Marine Licence from the Marine Management Organisation (MMO). Royal HaskoningDHV, on behalf of the DHB, is undertaking an Environmental Impact Assessment (EIA) to support the application for a Marine Licence for consent to dredge.

HR Wallingford first considered the required studies to support dredging on the Goodwin Sands in 2008 when a phased, outline scope was proposed; including a historical bathymetric review and wave modelling to inform a Coastal Impact Study (CIS). The historical bathymetric review covering the period 1986-2006 was completed and reported on in HR Wallingford (2008).

For the present study HR Wallingford is providing inputs to the EIA and CIS, establishing the magnitude, spatial extent and duration of changes to the physical environment directly caused by the proposed aggregate dredging. The focus of the computer modelling described in this report is on changes in waves caused by dredging on the Goodwin Sands rather than modelling extreme waves as might be undertaken to analyse coastal flooding due to extreme overtopping or provide design conditions at the coast. Therefore in this study individual severe **offshore** conditions were required as boundary conditions. As is now standard practice in aggregate studies, this assessment is carried out for very large and extremely rare wave conditions. In this study 1 in 200 year wind and wave conditions were considered as these pose a high risk of coastal defence failure and consequential coastal flooding. In this context, 1 in 200 year conditions are extreme cases with a statistically derived probability of occurring once every 200 years.

The proposed dredge area lies close to various sensitive locations including protected wrecks, designated areas, anchorages and sites associated with particular ecological value such as seal haul out sites and *sabellaria spinulosa* reef as shown in Figure 1.2. The potential for the proposed dredging to change the physical processes at these sites requires particular attention.

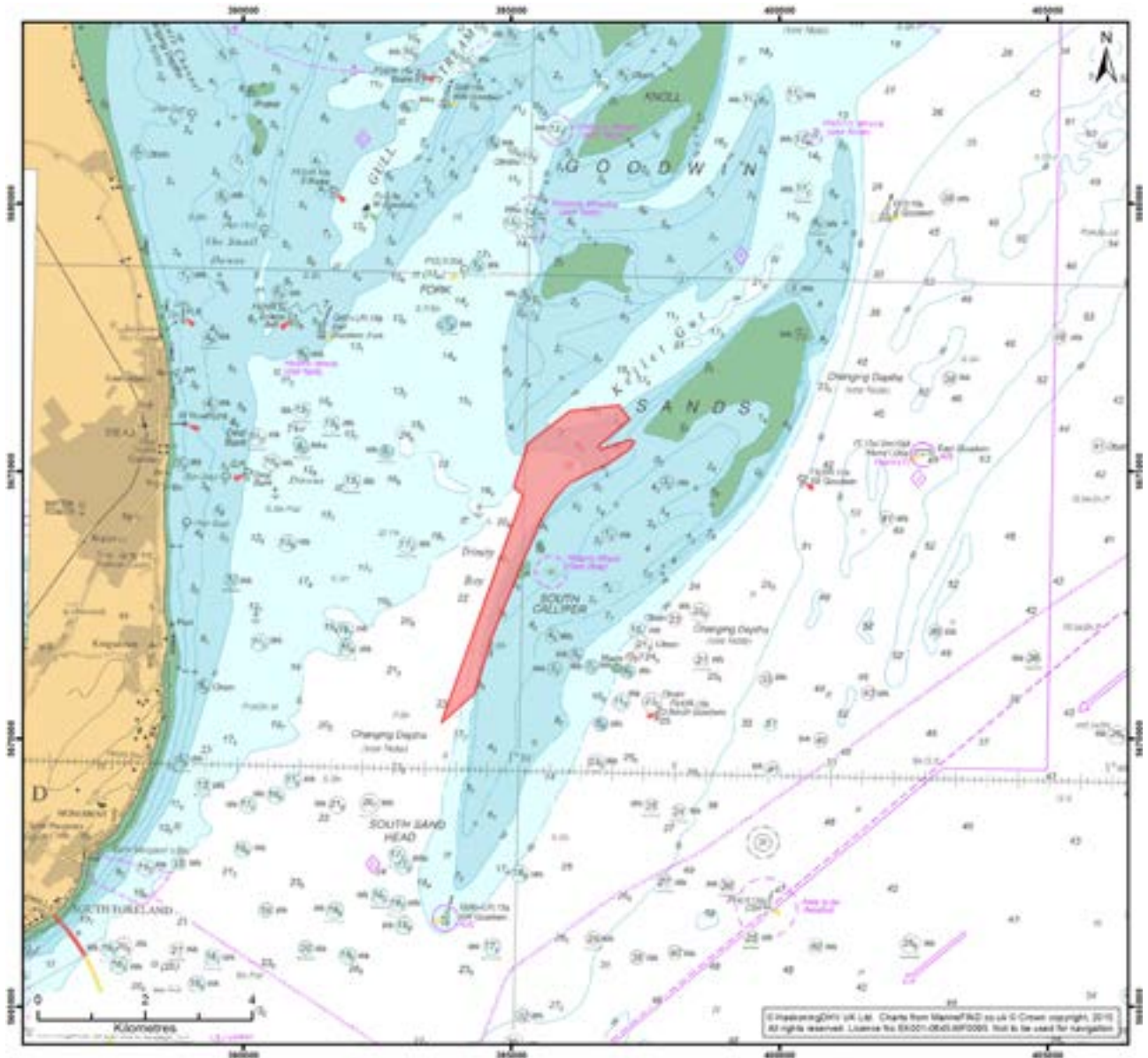


Figure 1.1: Location of proposed aggregate dredging area

Source: RHDHV Drawing PB2107_ES_003

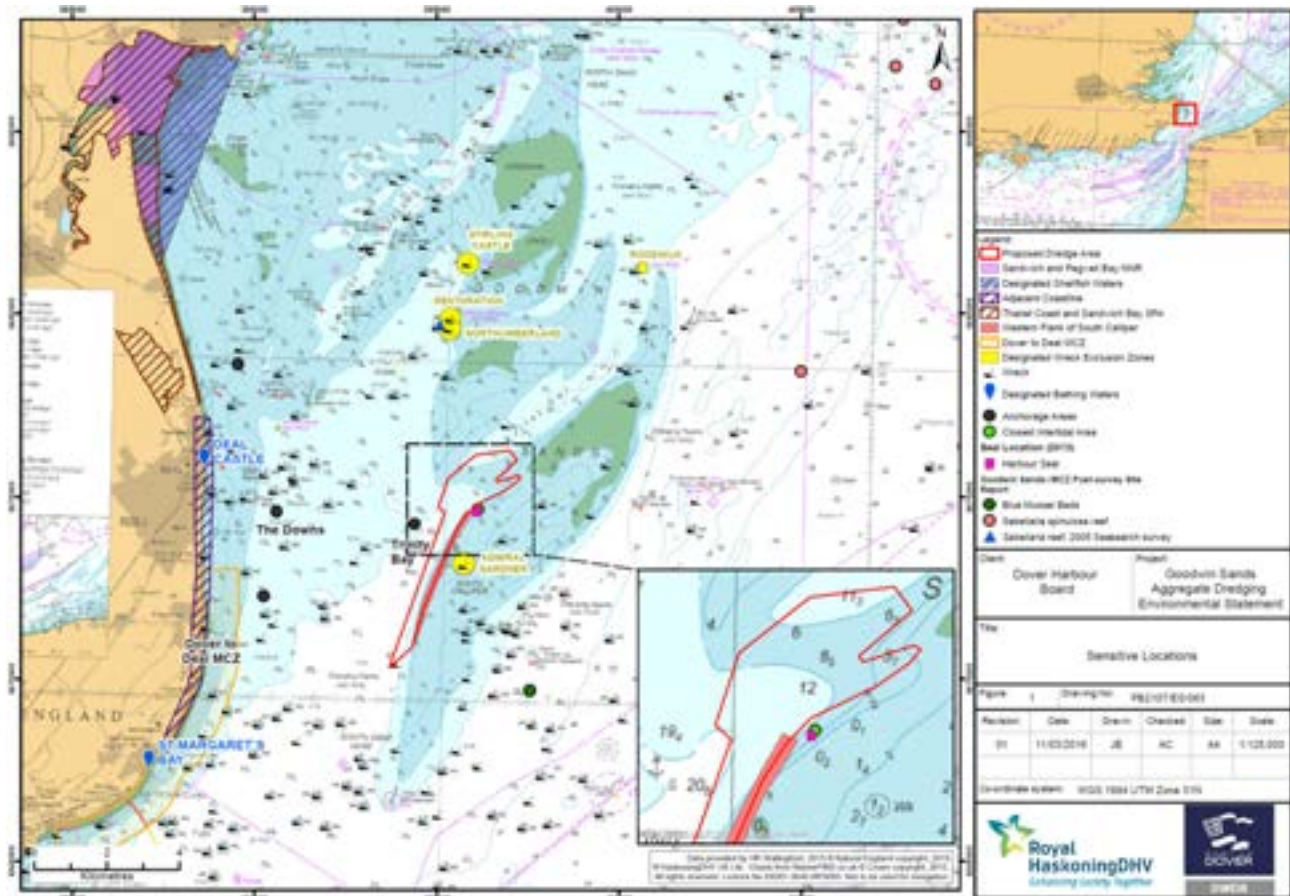


Figure 1.2: Sensitive locations in area of proposed aggregate dredging area

Source: RHDHV drawing PB2107_ES_063

2. Scenarios tested

2.1. Historical, baseline and post-dredging scenarios

The conditions represented in the models are briefly described as:

- A “baseline” case, that is the present-day bathymetry without dredging;
- A post-dredging scenario, Scenario 1, dredging 1.12 m depth of aggregates in Area 1 (see Figure 2.2);
- A post-dredging scenario, Scenario 2, dredging 1.95 m depth of aggregates in Area 2 (see Figure 2.2).

Scenario 1 covers the full dredge area being applied for. Scenario 2 represents the same volume of dredging within a sub area in the northern section of the proposed dredge area within which the majority of the resource has been identified.

It is proposed that up to approximately 2.5 million m³ of material will be dredged from Goodwin Sands and transported to Dover for use as aggregate in the Western Docks project. As has been used for aggregate studies elsewhere the amount of sediment removed has been increased by 60% in the modelling studies to provide a precautionary view of the potential impact of the dredge. Hence, both the scenarios involve removal of approximately 4,000,000 m³ of material from areas identified as having sand; leaving a layer of at least 0.5 m of sand in those areas after the dredge in accordance with established practice to facilitate recovery of benthic communities.

In addition to baseline and dredged conditions, historical representations of the Goodwin Sands and the other nearby sandbanks were used in the wave model to assess the variation in wave conditions resulting from the evolution of the seabed over time. These historical cases can be briefly described as:

- A “1995-98” case; the best estimate of the bathymetry in the late 1990s;
- A “2006” case; the best estimate of the bathymetry in 2006.

The vertical datum used for this study is Mean Sea Level (MSL). For ease of reference, levels are often reduced to mCD (Deal) in the figures of this report.

2.2. Bathymetry data

2.2.1. Baseline and post-dredging bathymetries

The area of the EGS International Ltd bathymetry survey collected for the present project in mid-2015 is shown in Figure 2.1. It is shown to provide a reasonable coverage of the South Goodwin Sands and covers the whole of the resource exploration area. It is noted that the southernmost face of the sandbank is only defined by transverse cross-sections extending about one kilometre away from the main survey area. These data allow the wave paths across the Goodwin Sands to be represented accurately in the models, which will be important when considering possible changes to the physical environment.

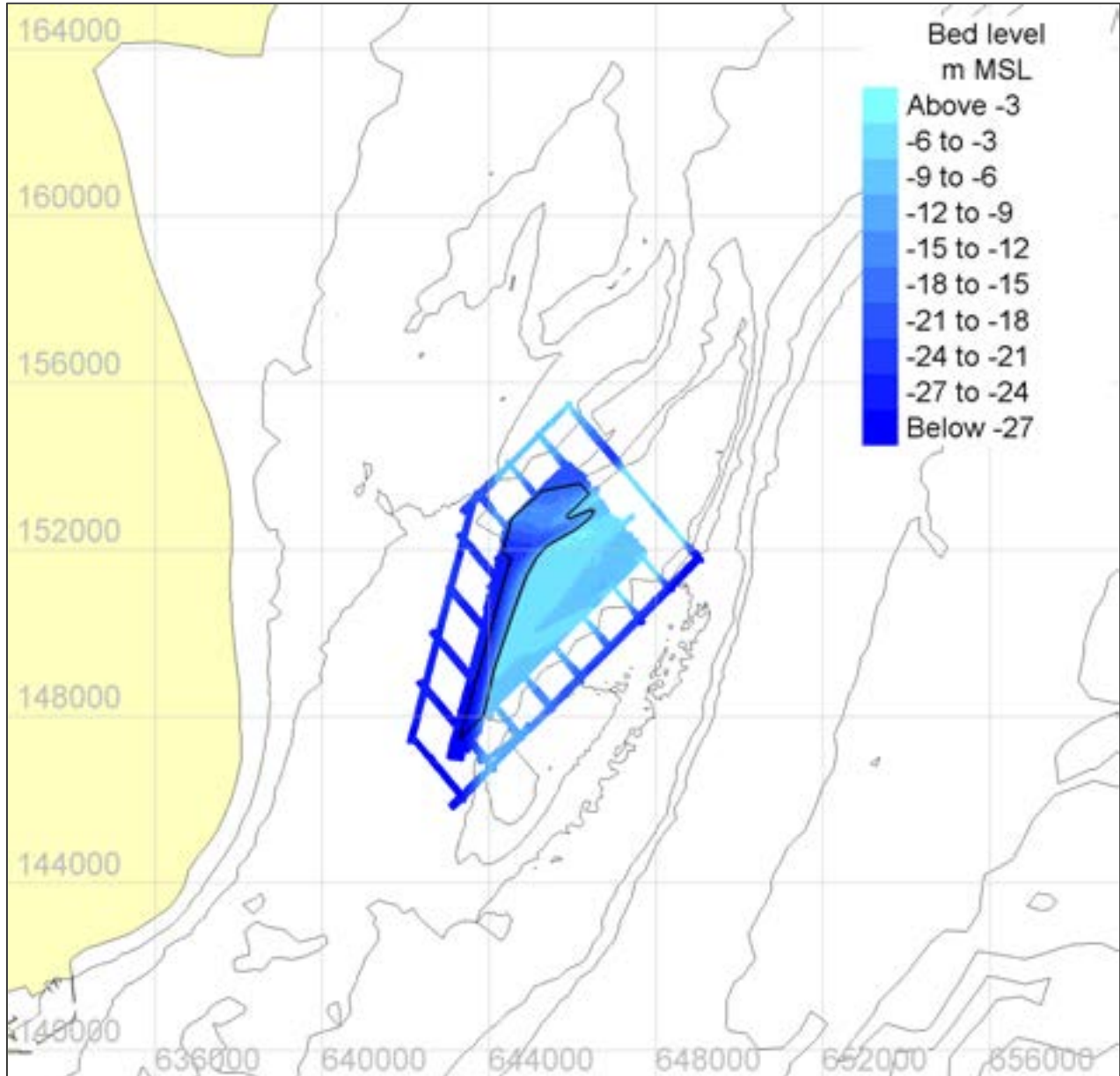


Figure 2.1: Spatial extent of the 2015 bathymetric survey of Goodwin Sands, with proposed dredge area indicated by the black polygon

Source: Data from EGS International Ltd (2015)

Additional bathymetry data for the rest of the model area were taken from:

- Recent TruDepth bathymetry from SeaZone, using the latest available survey data from the United Kingdom Hydrographic Office (UKHO); and,
- Nautical Chart data in European (non-UKHO) waters.

Bathymetry data from these different sources were merged for use in the baseline models, where more recent / resolved data took precedence over older or less resolved data. The representation of the baseline and post-dredged bathymetries, for use in the wave model, is shown in Figure 2.2. The same data were

used to develop the representations of the baseline and post-dredging bathymetries used for the flow and sediment transport models.

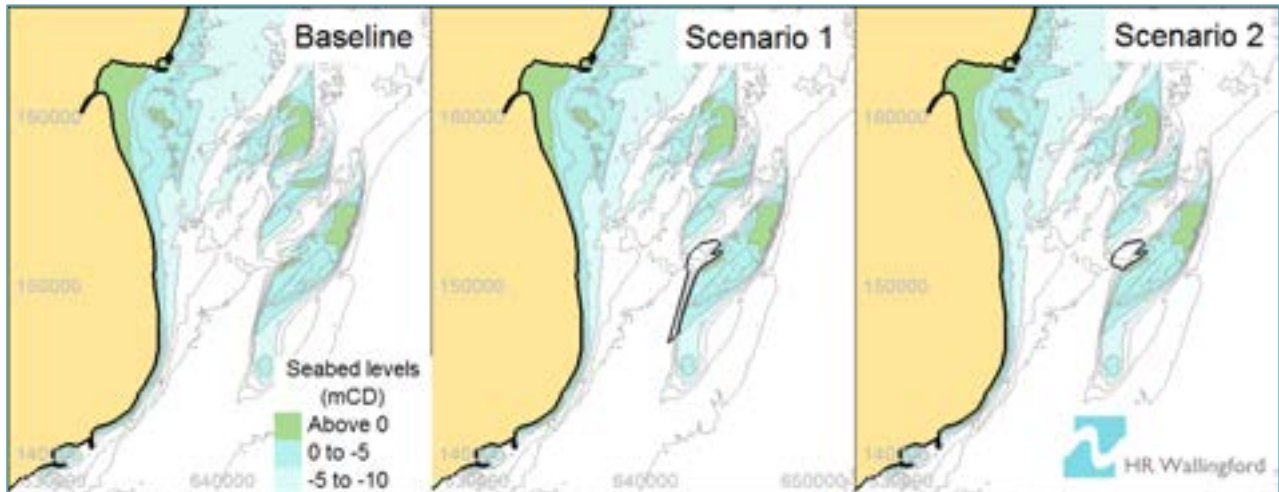


Figure 2.2: Baseline and two post-dredging bathymetries used in the wave model, with proposed dredge area indicated by the black polygon

2.2.2. Historical bathymetries

Bathymetry data for the historical representations of the seabed were taken from earlier HR Wallingford studies of the Goodwin Sands (2008). In these studies, three recent “epochs”, i.e. times when one or more detailed bathymetric surveys had been carried out covering the whole of the South Goodwin Sands, were considered. These epochs provided as good an instantaneous “snapshot”, at different times over the last 30 years, of the continually evolving sandbank, as possible. After review of all the available data sets, the following data were obtained from SeaZone:

- 1986 – 1988 surveys as fair-sheets (scanned and provided in digital form);
- 1995 – 1998 surveys as fair-sheets (scanned and provided in digital form);
- 2006 charted data obtained as contour lines.

The 1986-1988 data were later discarded on the grounds that the data were sparser than anticipated; following transect lines rather than providing a good coverage of the sandbanks. Figure 2.3 and Figure 2.4 illustrate the extent of the 1995-98 and 2006 data respectively.

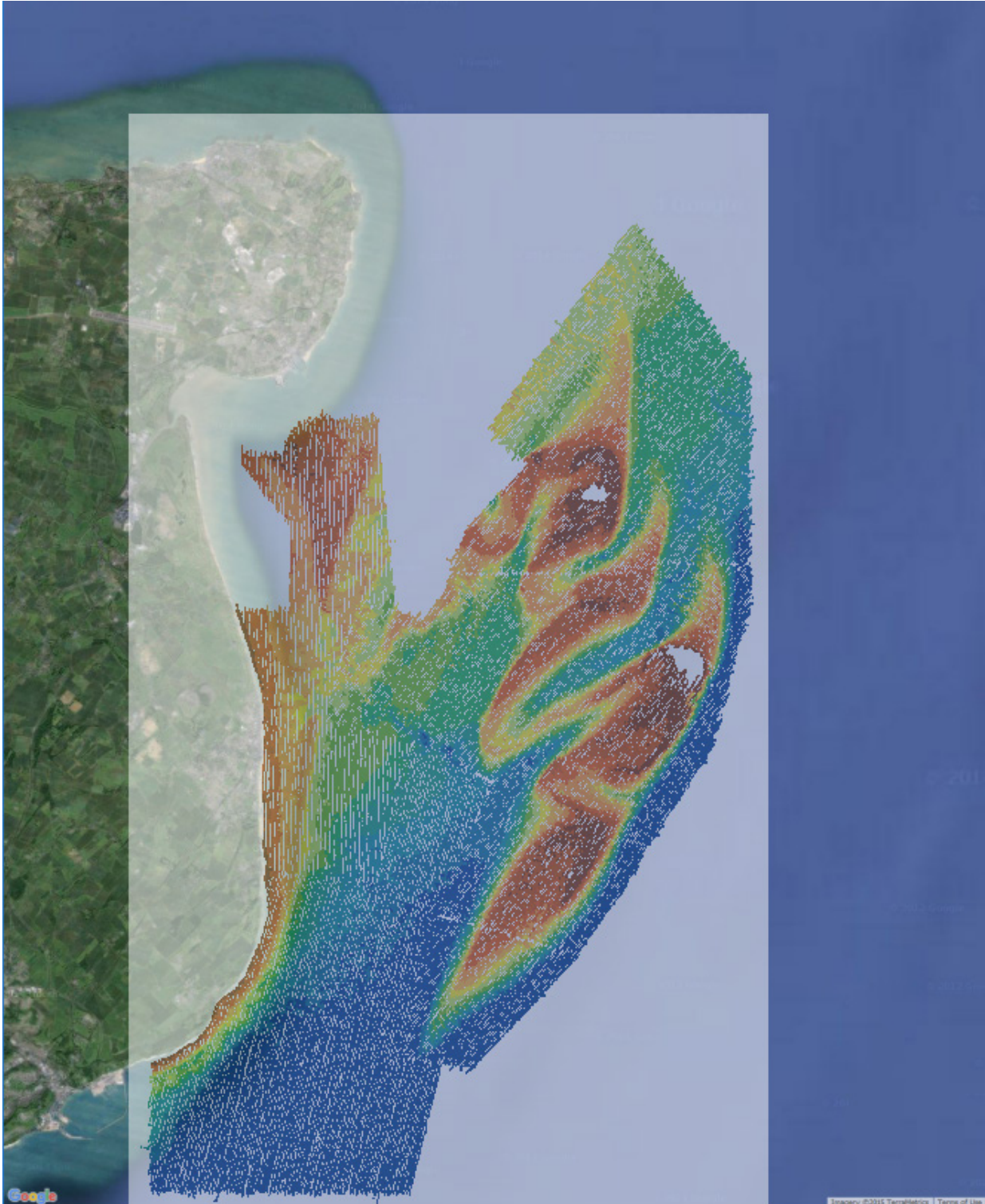


Figure 2.3: Spatial extent of the 1995-1998 TruDepth data, overlaid on Google imagery

Source: HR Wallingford (2008)

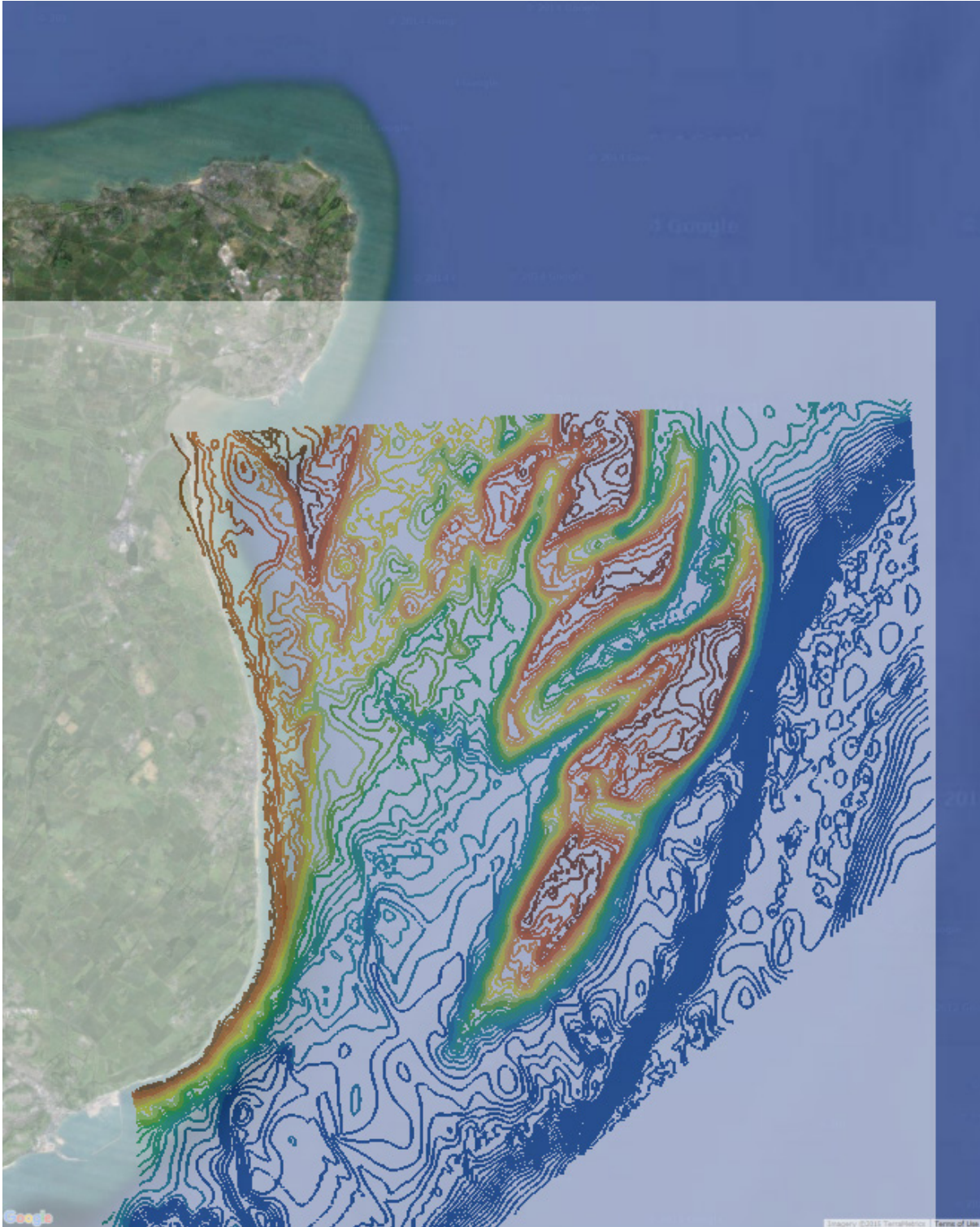


Figure 2.4: Spatial extent of the 2006 charted data, overlaid on Google imagery

Source: HR Wallingford (2008)

The data for each epoch were supplemented with Nautical Chart data for the rest of the model area, and the combination of the different sources of data was made such that more recent / resolved data always took precedence over older or less resolved data. The representation of the historical bathymetries, for use in the wave model, is shown in Figure 2.5. The baseline bathymetry is also reproduced in Figure 2.5 for reference.

It should be noted that aggregate dredging was continuing on the South Goodwin Sands during the period of the 1995-1998 data and therefore the bed levels include some anthropogenic influence and the bed changes shown between 1995-98 and 2006 are not only due to natural processes.

It is noted that the use of more refined / recent bathymetry data sources in the baseline seabed representation away from the sandbanks than in the historical representations results in differing seabed levels offshore of the Goodwin Sands. This is not shown at the resolution of Figure 2.5.

The bed differences shown in Figure 2.5 around South Goodwin Sands are notable with a reduction in the area above Chart Datum (particularly in the area near the proposed dredging), a coalescence of the two bank sections shown in 1995-98 to one continuous bank in 2015 and an extension of the southern end of the bank towards the south and west. These are major morphological changes which are likely to be due to the long term tidal and wave forcing rather than anthropogenic influences such as aggregate dredging.

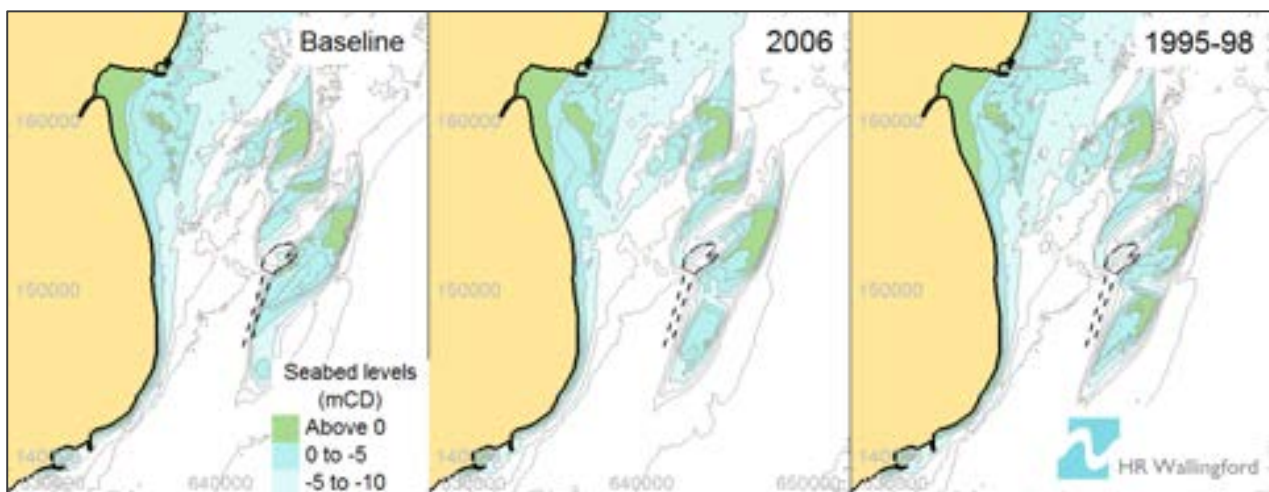


Figure 2.5: Baseline and two historical bathymetries used in the wave model, with proposed dredge area indicated by the black, dashed polygon

2.3. Wave conditions simulated

It is now standard practice in coastal impact studies to consider very large and extremely rare wave conditions that would pose a high risk to the coastline and its coastal defences. Following model validation, the test cases run in the wave model were, therefore, focused on 1 in 200 year return period wave conditions from a range of 4 directions: north-easterlies from the North Sea, locally generated east and south-easterlies, and south-westerlies from the English Channel. Because the extent and effects of changes in wave conditions will be closely related to the tidal level at the time, the wave modelling has been carried out for 3 water levels: Mean Low Water Springs, Mean High Water Springs and an extreme 1 year water level including allowance for sea level rise (SLR). Table 3.3 in Section 3.4 presents the conditions considered in this study in more detail.

3. Wave modelling

3.1. Model applied

Modelling waves in the Dover Strait is a complex task, involving consideration of the effects of the Goodwin Sands and other nearby sandbanks on waves propagating from a variety of directions, as well as local wave generation. In order to transform the chosen offshore wave conditions over the area of the Goodwin Sands, and also account for wind-wave generation over the same area, a SWAN¹ wave transformation model was set up. SWAN is an internationally adopted model developed by the Technical University of Delft. It is a public-domain 3rd generation spectral wave model representing the following processes acting on a complete directional wave spectrum:

- Wave growth due to the wind;
- Wave shoaling and refraction;
- Wave reflections and far-field diffraction;
- Depth-induced breaking, bottom friction and white-capping; and
- Non-linear wave-wave interactions.

The SWAN model is ideally suited to the transformation of wave energy spectra, under continued wind growth, where wave conditions (and in this case *changes* in wave conditions between model runs) are required over the entire model area. It is, therefore, an appropriate model to address the effects of dredging on the Goodwin Sands.

A nested grid system was used in this study, with a coarse resolution (500 m) outer grid covering the Dover Straits and the Thames Estuary, extending across to the French / Belgian / Dutch coast to include the full wave generation area. A finer resolution (100 m) inner grid was defined between Dover and Margate, extending about 18 km offshore. Figure 3.1 shows the extent and resolution of the system of SWAN nested grids. The locations of the UK Met Office (UKMO) European Waters model grid points used to drive the wave model are also shown in Figure 3.1 (yellow pins).

3.2. Boundary conditions

UK Met Office model points close to the SWAN model boundaries were selected to define the offshore wave conditions (point 62, 41 for north to easterlies; point 65, 39 for south-westerlies). The data at these boundary points includes all the wave generating processes outside the model area.

A point inside the model domain (point 63, 41) was selected to give wind conditions more representative of those over the study area, and therefore model the more locally generated wind wave conditions. Wave and wind data were obtained at these points covering a period of almost 20 years between 15/10/1986 and 31/03/2006. This long data period is appropriate to derive 1 in 200 year return period wave conditions for an impact study, the aim of which is to assess changes to the physical environment.

¹ Simulating WAVes Nearshore (SWAN)



Figure 3.1: SWAN wave model extent and grids, UKMO European Waters model grid points (yellow pins) and wave measurement locations (blue pins)

3.3. Validation

3.3.1. Data sources

It was originally proposed to validate the wave model against wave data from the Channel Coast Observatory at Goodwin Sands. Wave parameters at this location (51°14'48.16"N 1°28'52.03"E) are recorded using a Datawell Directional WaveRider Mk III buoy. The data buoy was first deployed on 06 June 2008 and has been recording since then. Unfortunately this does not overlap with the period when the UK Met Office European Waters model offshore data (used to drive the wave model) is available.

The Channel Coast Observatory, however, holds historical data at Deal Pier. This is directly onshore of the Goodwin Sands, and as such is ideally suited for validation of the wave model. Wave parameters at the Deal Pier location (51°13' 25.652"N 01°24' 33.332"E) are recorded using a Rosemount WaveRadar Rex. The instrument was installed on Deal Pier on 25 August 2005, giving an overlap period of just over seven months with the UK Met Office model offshore data.

The location of the Goodwin Sands and the Deal Pier instruments is marked with blue pins in Figure 3.1.

Initial quality checks of the Deal Pier records indicated that the peak wave periods T_p did not correlate well with those from the Goodwin Sands buoy for the times when both instruments were recording, casting some doubt as to the reliability of the Deal Pier wave periods. A high frequency cut-off is also apparent in the records, with no mean wave period observed under 3 seconds (s). For these reasons, the observed wave

periods were discarded and comparison with modelled wave periods not attempted in this study. The validation exercise concentrated rather on agreement in significant wave height.

Analysis of the wave height data at Deal Pier for the calibration period did not suggest the waves were depth limited by their location near the coastline. Therefore the data was considered appropriate to calibrate the wave model.

3.3.2. Significant wave heights

The 2006 historical seabed map (see Section 2.2.2) was used in the validation runs as this was closest bathymetry dataset to the period of observations.

It is our experience that wave model results are most sensitive to the wave growth formulation and associated wind speed. Sensitivity to the following different combinations of wave growth formulation and scaling of the wind speed were, therefore, investigated in this analysis:

- Komen wind growth formulation, with model wind speeds unmodified;
- Komen wind growth formulation, with model wind speeds marked up by 10%;
- WestHuysen wind growth formulation, with model wind speeds unmodified;
- WestHuysen wind growth formulation, with model wind speeds marked up by 10%.

The results of this analysis are presented below in the form of time histories of observed (continuous line) and predicted (dots) significant wave height at Deal Pier during the first two months of observations.

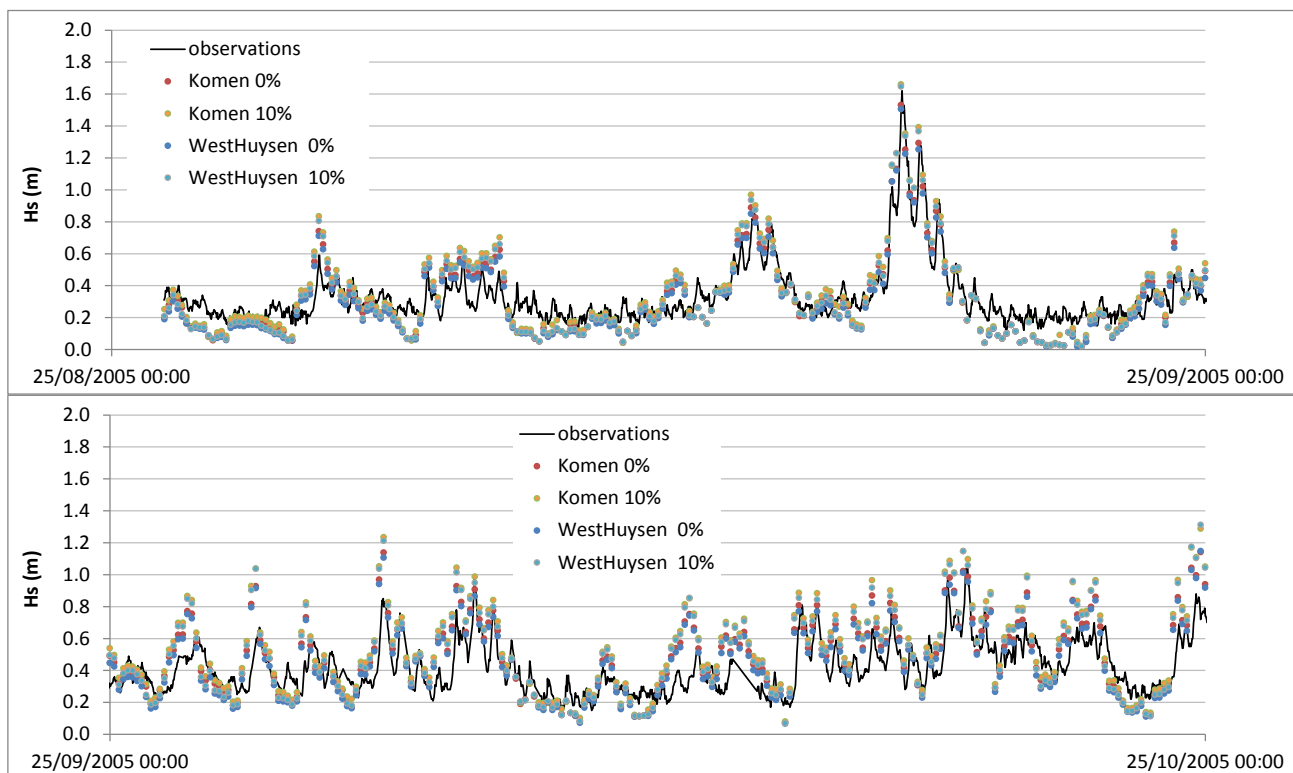


Figure 3.2: Time histories of observed and predicted significant wave height at Deal Pier

The results of the validation tests show that closer agreement with observed wave heights was reached without scaling up the source wind speeds applied over the model area. Marginally better agreement was reached overall with the Komen wind growth formulation. This is in line with our previous experience in this area. A scatter plot of SWAN predicted vs. observed significant wave height is shown in Figure 3.3 for the period during which both observations and offshore wind/wave data were available. This figure indicates a slight positive bias for big events, meaning that the model tends to slightly over-estimate the significant wave height at Deal Pier for waves greater than about 0.25 m.

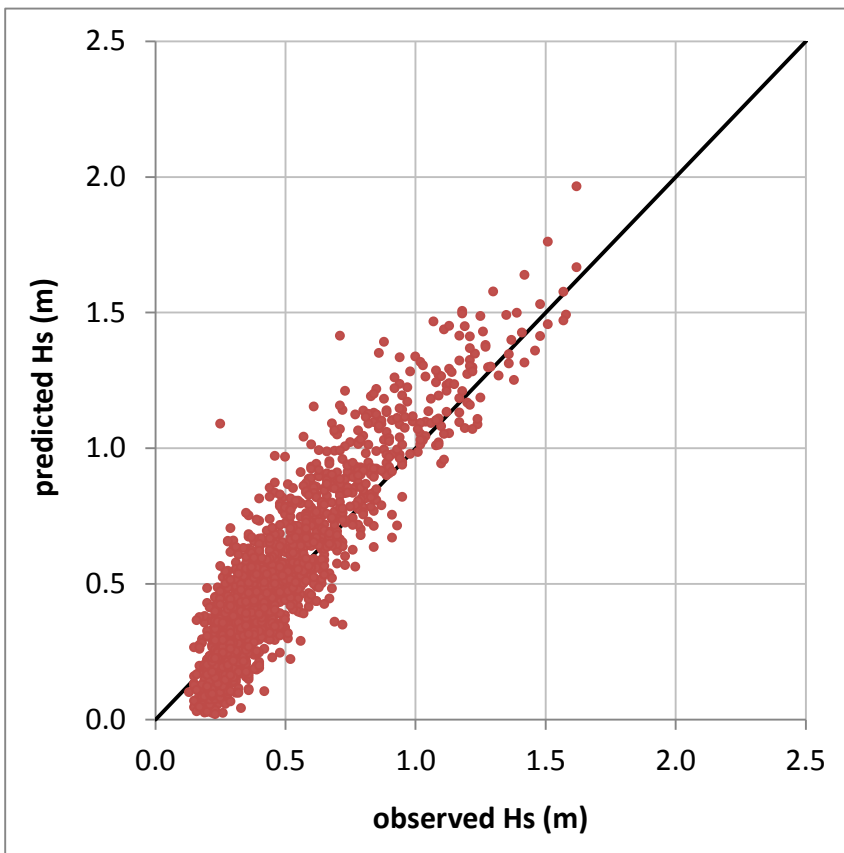


Figure 3.3: SWAN predicted vs. observed significant wave height at Deal Pier

3.3.3. Suitability of the wave model for this assessment

The comparison of observed and predicted wave height at Deal Pier (Figure 3.3) shows the wave model is able to represent adequately the significant wave heights at the coastline using the applied forcing conditions. By extension, it is deemed suitable to predict wave conditions over the study area including the effect of the Goodwin Sands on waves at the coastline and, of equal or greater importance here, any changes in wave height likely to be caused by introduction of the dredging of the Goodwin Sands.

3.4. Scenario testing

The SWAN model was run for the baseline present-day bathymetry and for the 2 post-dredging scenarios presented in Section 2.2.1. Historical bathymetries were subsequently tested to assess the natural variation in wave conditions resulting from the natural evolution of the Goodwin Sands and nearby sandbanks, and so

put any effects of the dredging into context. The 1 in 200 year return period wave conditions were tested, from a range of 4 directions and at 3 water levels.

3.4.1. Boundary wave conditions

Data from the UK Met Office model points 62, 41 and 65, 39 close to the SWAN model boundaries (locations shown in Figure 3.1) were obtained covering a period of almost 20 years between 15/10/1986 and 31/03/2006. The distribution of waves from the data at the two points is shown in Figure 3.4 and Figure 3.5.

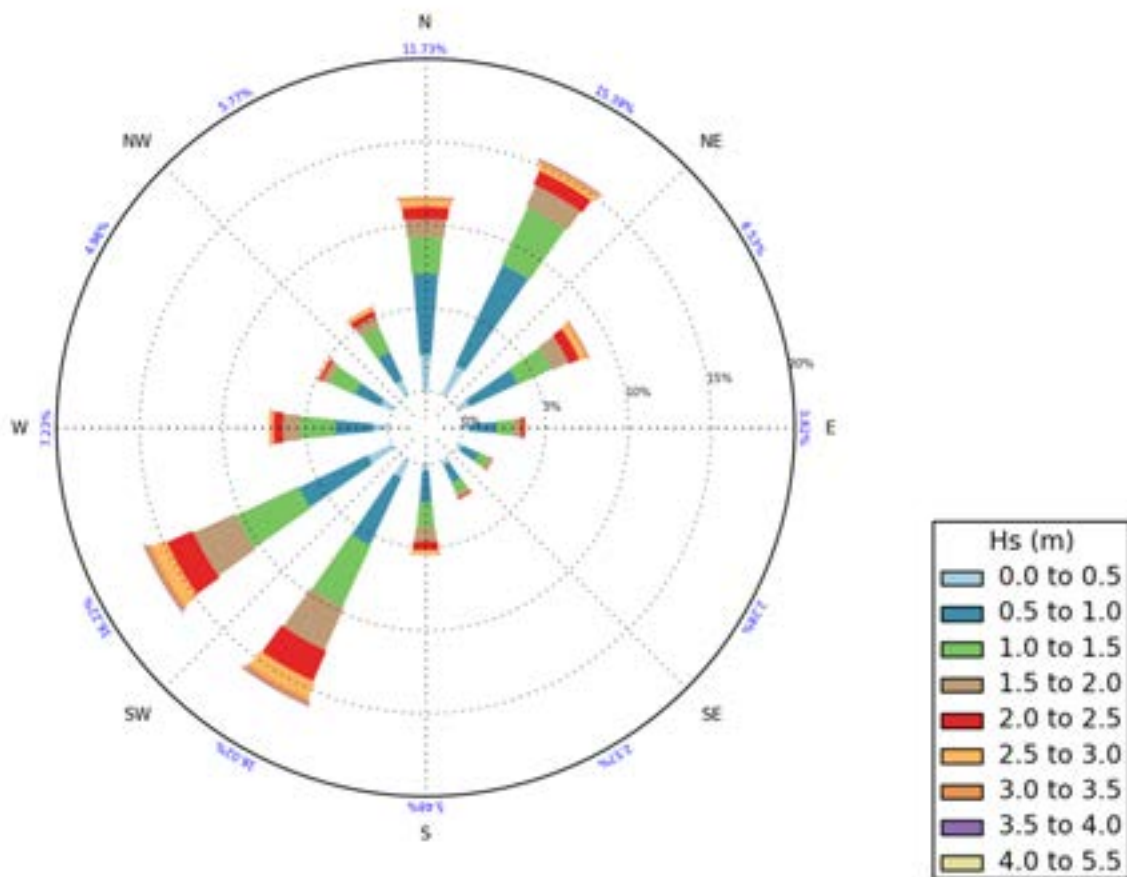


Figure 3.4: UKMO model point 62,41 wave rose

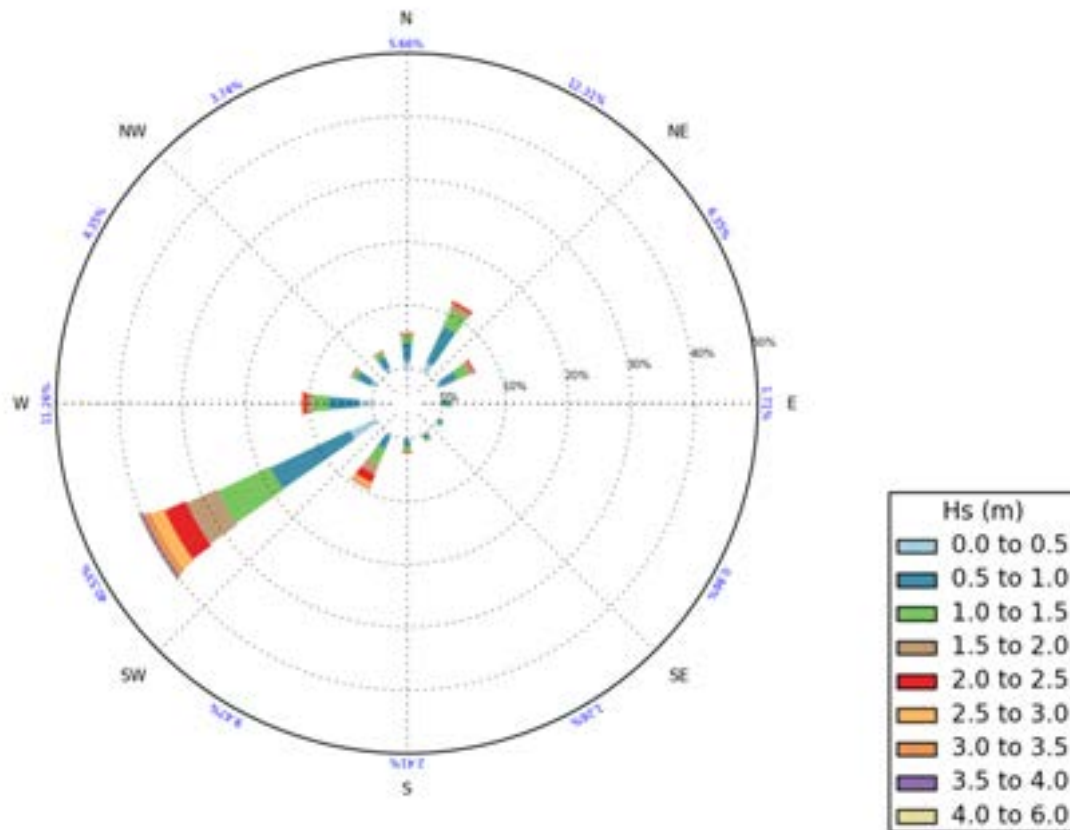


Figure 3.5: UKMO model point 65,39 wave rose

These data were analysed to provide estimates of 1 in 200 year return period wave conditions from the North Sea and from the English Channel respectively (Table 3.1).

Table 3.1: Estimated 1 in 200 year return period extreme wave conditions

Direction (°N)	H _s (m)	T _p (s)
30	5.2	10.7
90	4.4	10.1
240	6.8	11.9

3.4.2. Wind conditions

Data from the UK Met Office model point 63,41 (location shown in Figure 3.1 and summarised in Figure 3.6) were obtained and analysed to provide estimates of 1 in 200 year return period wind conditions generating local waves (Table 3.2).

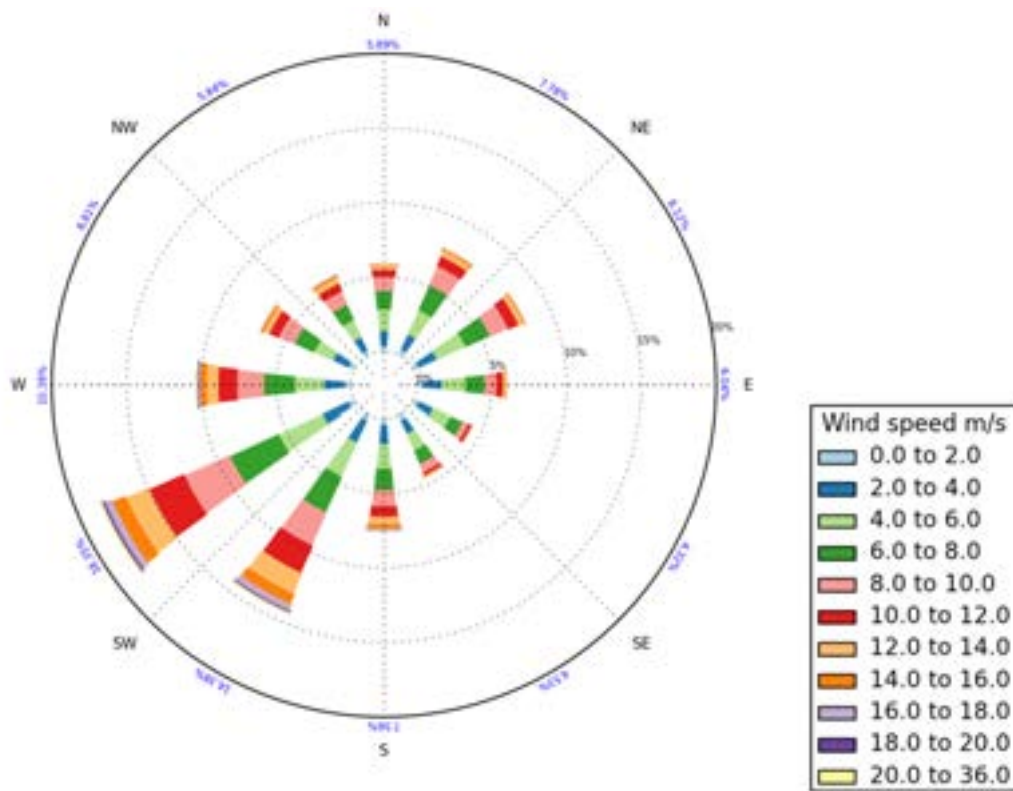


Figure 3.6: UKMO model point 63,41 wind rose

Table 3.2: Estimated 1:200 year return period wind speeds offshore Goodwin Sands

Direction (°N)	Wind speed (m/s)
90	18.6
120	19.5

The winds required to sustain the 1 in 200 year return period waves from 30°N and 240°N (Table 3.1) were estimated separately as 25.8 m/s and 33.5 m/s respectively. It is noted that they do not correspond to 1:200 year return period winds.

3.4.3. Sea levels

From Admiralty tide tables for 2015, MHWS and MLWS for Deal are 6.3 and 0.9 mCD, respectively. The model was also run for an extreme water level, including sea level rise, for the effects of future climate change to be considered. The 1 year water level at Deal was estimated to be 7.1 mCD based on design sea levels published by the Environment Agency (2011), to which a 0.5 m allowance for climate change was added corresponding to a period 50 to 100 years into the future.

3.4.4. List of model runs

Compiling the information in Sections 3.4.1-3.4.3 gives the model runs listed in Table 3.3. Wave conditions 1 and 2 are for waves from the North Sea, wave condition 3 is for locally wind generated waves, and wave condition 4 is for waves from the English Channel.

Table 3.3: Wave model impact assessment runs

Wave condition	Boundary wave condition			Wind condition		Sea levels
	H _s	T _p	Dir	Speed	Dir	
	(m)	(s)	(°N)	(m/s)	(°N)	(mCD)
1	5.2	10.7	30	25.8	30	0.9, 6.3 and 7.6
2	4.4	10.1	90	18.6	90	0.9, 6.3 and 7.6
3	--	--	--	19.5	120	0.9, 6.3 and 7.6
4	6.8	11.9	240	33.5	240	0.9, 6.3 and 7.6

The model runs concentrated on waves at high and low water: high water was chosen because this is when the waves have most effect on coastal defences and low water was chosen as this condition gives the greatest proportional change in water depth due to the dredging so would be expected to be the time when the effects of the dredging are most pronounced.

The effect of tidal currents was not included in the scenario testing. The footprint of change to current due to the dredge was shown to be small by the tidal flow modelling (HR Wallingford, 2016a) so any effect of current on waves would be extremely similar for the baseline and post-dredging cases.

The wave model was also run for more frequent conditions to provide input into the sediment transport studies. This is discussed in in the sediment transport modelling report (HR Wallingford, 2016b).

3.5. Model results

3.5.1. Differences in wave conditions due to dredging

The results of the wave modelling for the baseline and post-dredging scenarios are presented in Figure 3.7 to Figure 3.10. Each figure comprises three parts: a left pane showing area plots of baseline significant wave heights; and middle and right panes showing area plots of differences in significant wave height between post-dredged and baseline cases. A minimum threshold value of 0.02 m was adopted in the figures below to show any changes in significant wave height. Reductions in wave heights predicted to be caused by the dredging are shown in green and increases in pink. The sandbank locations, as represented in the baseline model, are indicated by schematised dashed lines for reference.

3.5.2. Historical differences

Results for the historical scenarios are presented in Figure 3.11 to Figure 3.14 in the forms of significant wave height from individual model runs, for the baseline bathymetry, and difference in significant wave height between historical and baseline conditions. Changes in significant wave height greater than 0.02 m, predicted to be caused by the natural movement of the sandbanks are shown in pink for increases and green for decreases. The sandbank locations, as represented in the baseline / historical models, are indicated by schematised dashed lines for context.

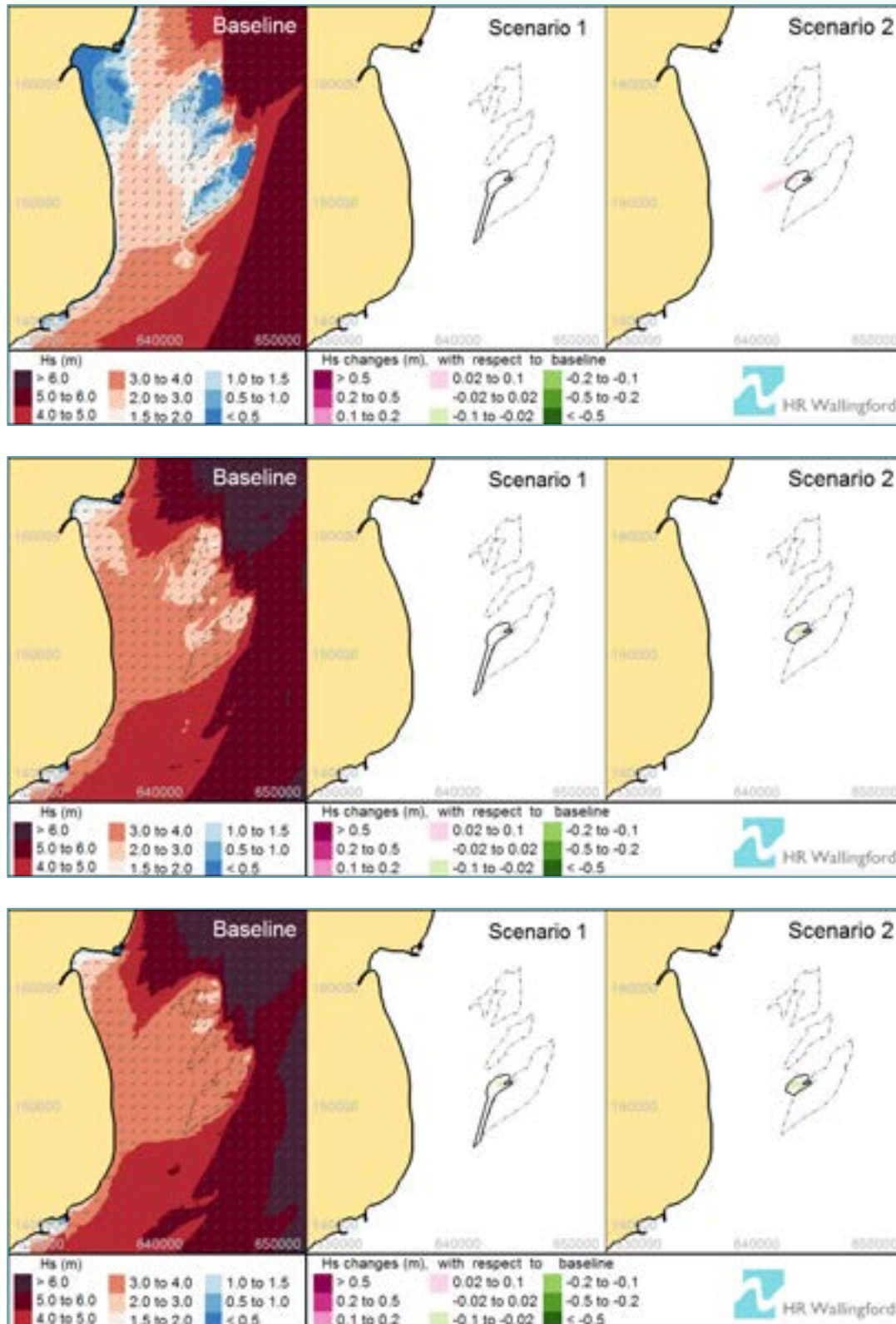


Figure 3.7: 1 in 200 year return period wave conditions from 30°N at MLWS (top), MHWS (middle) and 1 year water level with SLR (bottom): Baseline H_s and differences due to dredging. Proposed dredge area is indicated by a black polygon

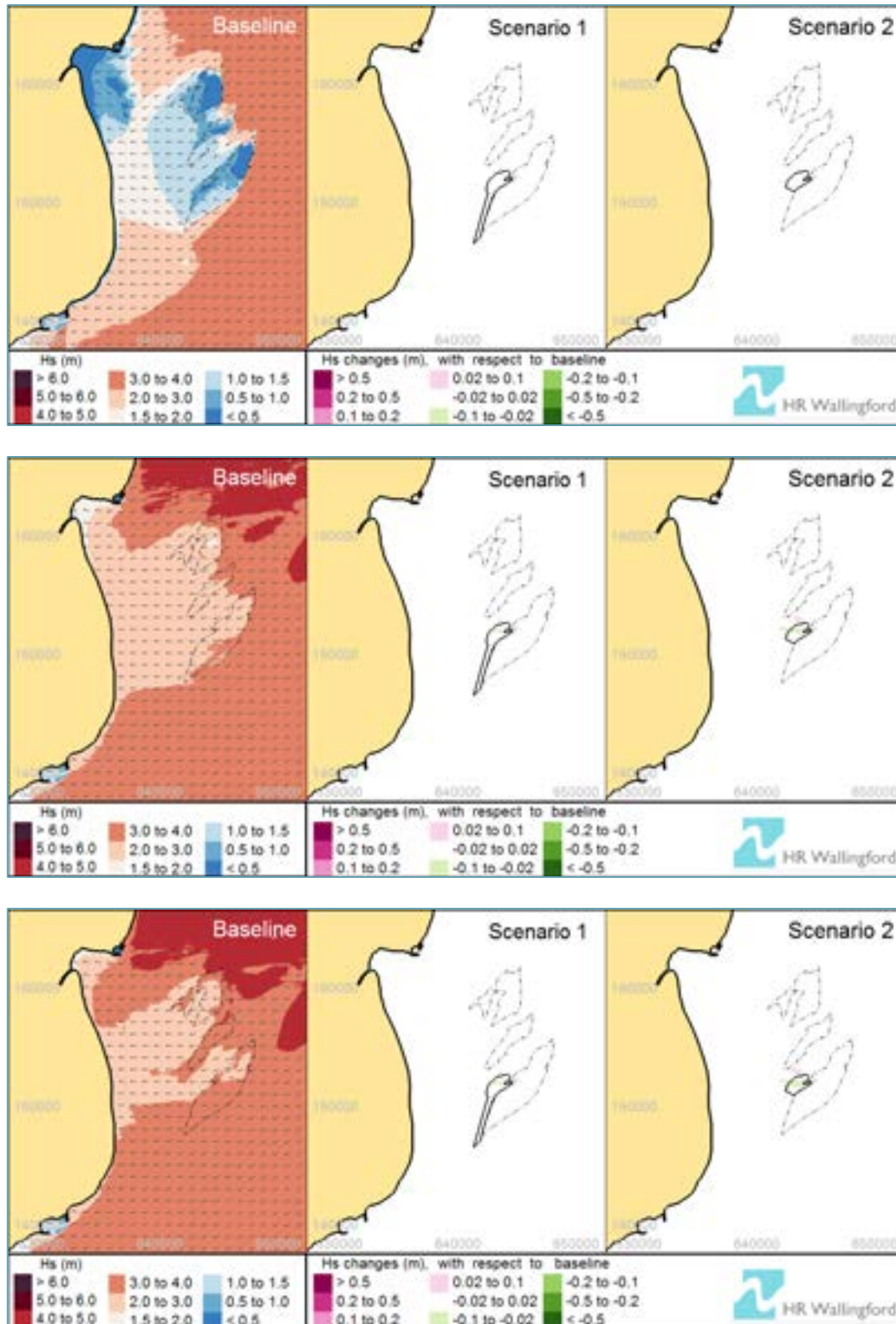


Figure 3.8: 1 in 200 year return period wave conditions from 90°N at MLWS (top), MHWS (middle) and 1 year water level with SLR (bottom): Baseline H_s and differences due to dredging. Proposed dredge area is indicated by a black polygon

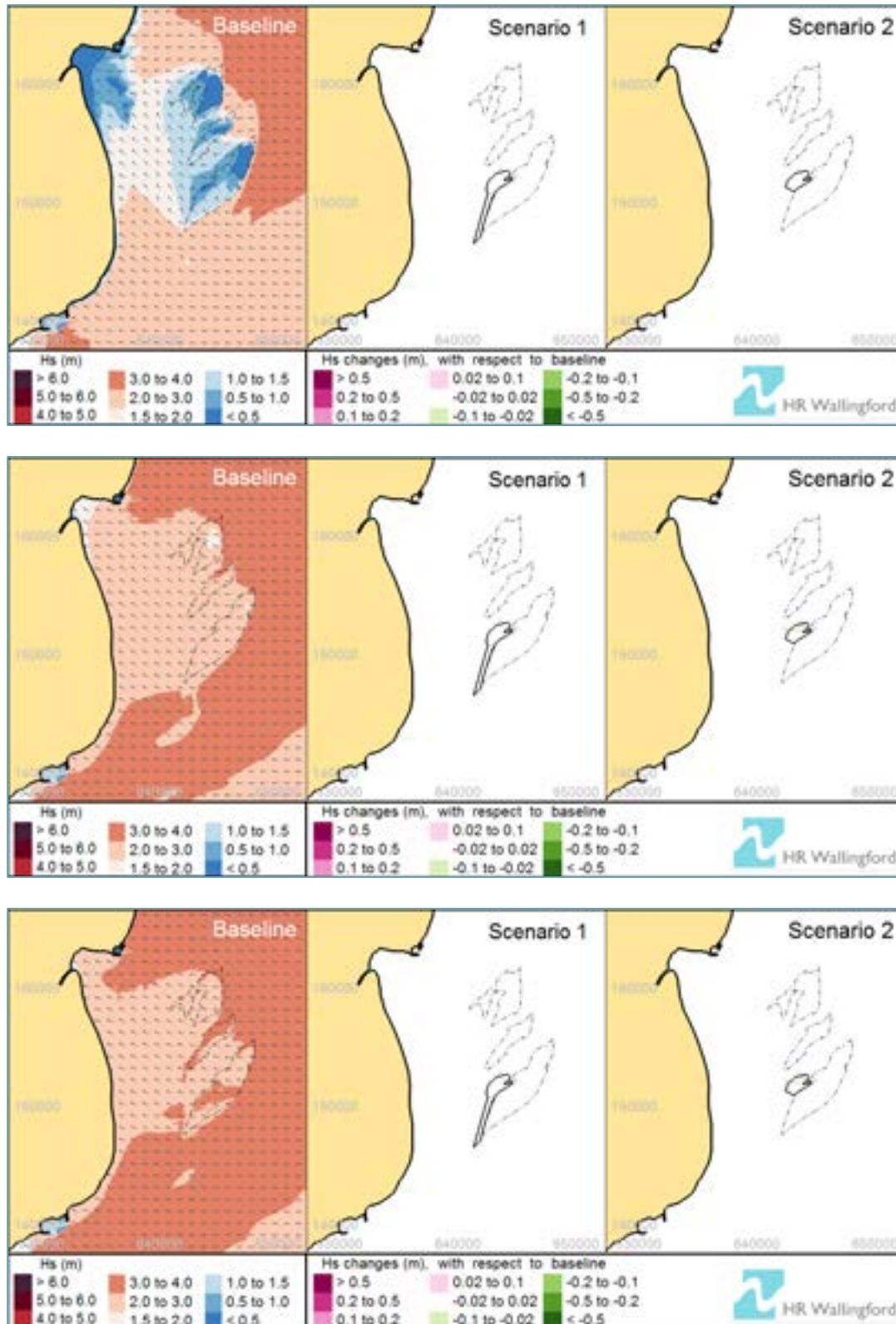


Figure 3.9: 1 in 200 year return period wave conditions from 120°N at MLWS (top), MHWS (middle) and 1 year water level with SLR (bottom): Baseline H_s and differences due to dredging. Proposed dredge area is indicated by a black polygon

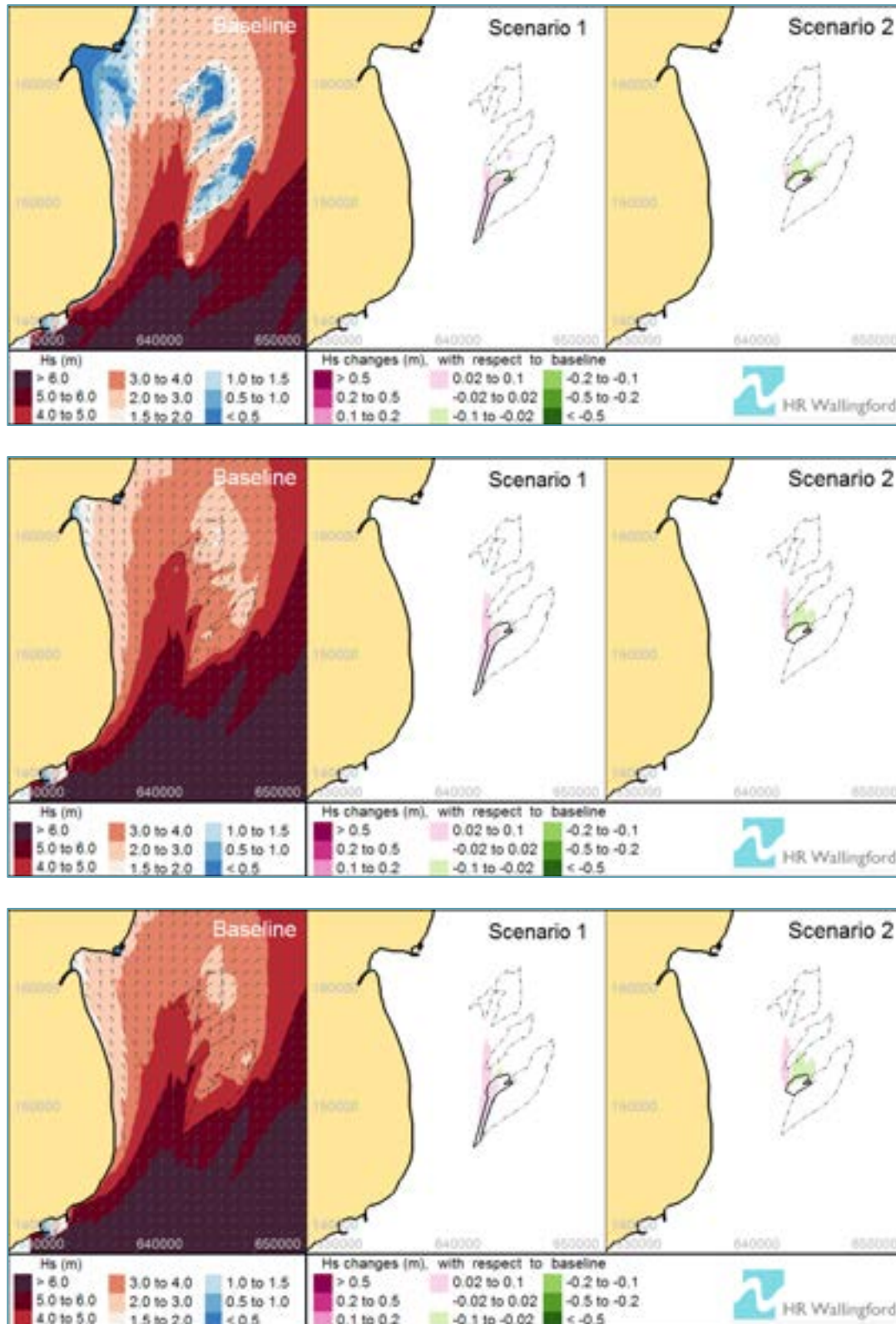


Figure 3.10: 1 in 200 year return period wave conditions from 240°N at MLWS (top), MHWS (middle) and 1 year water level with SLR (bottom): Baseline H_s and differences due to dredging. Proposed dredge area is indicated by a black polygon

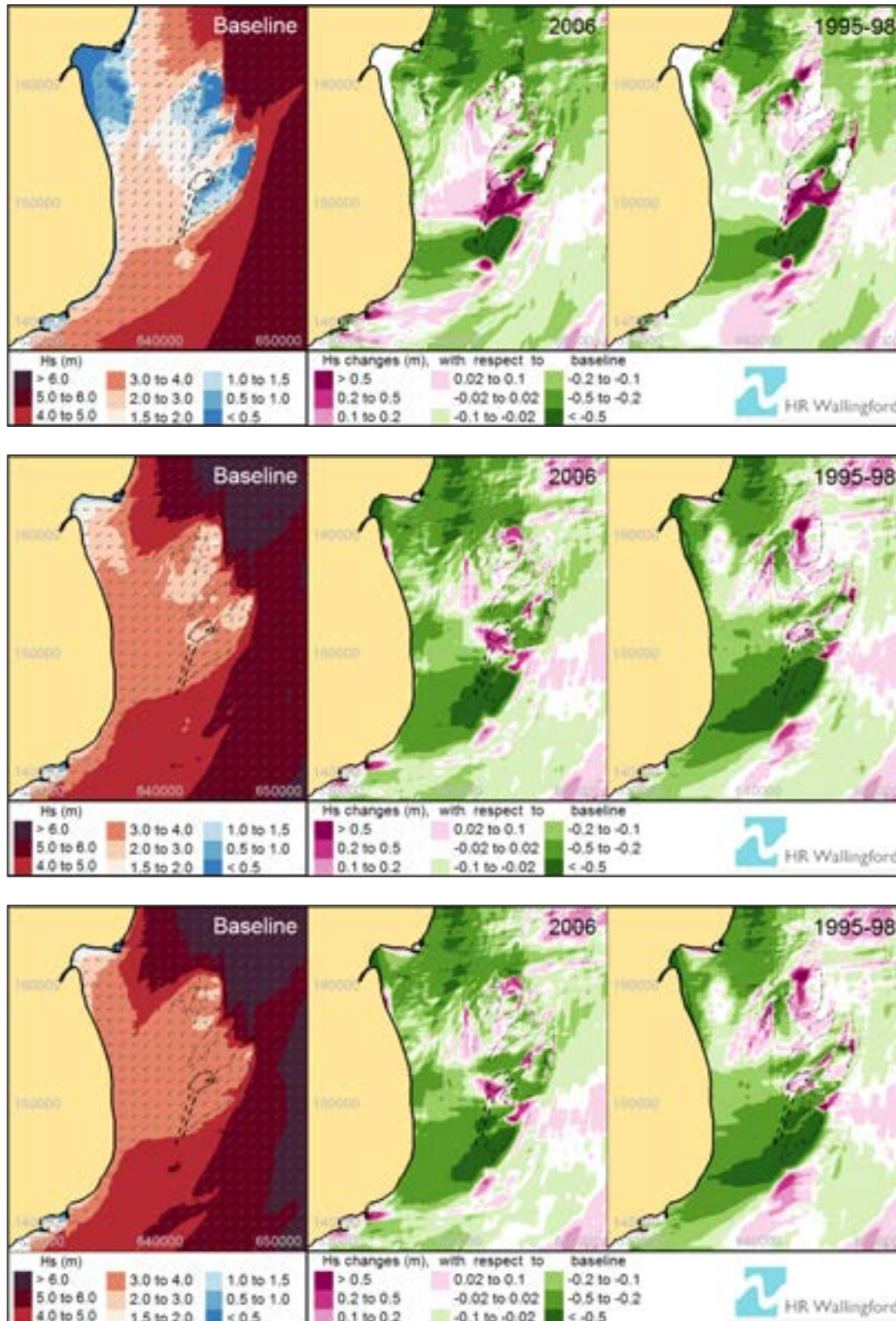


Figure 3.11: 1 in 200 year return period wave conditions from 30°N at MLWS (top), MHWS (middle) and 1 year water level with SLR (bottom): Baseline and differences due to bathymetric change. Proposed dredge area is indicated by a dashed, black polygon

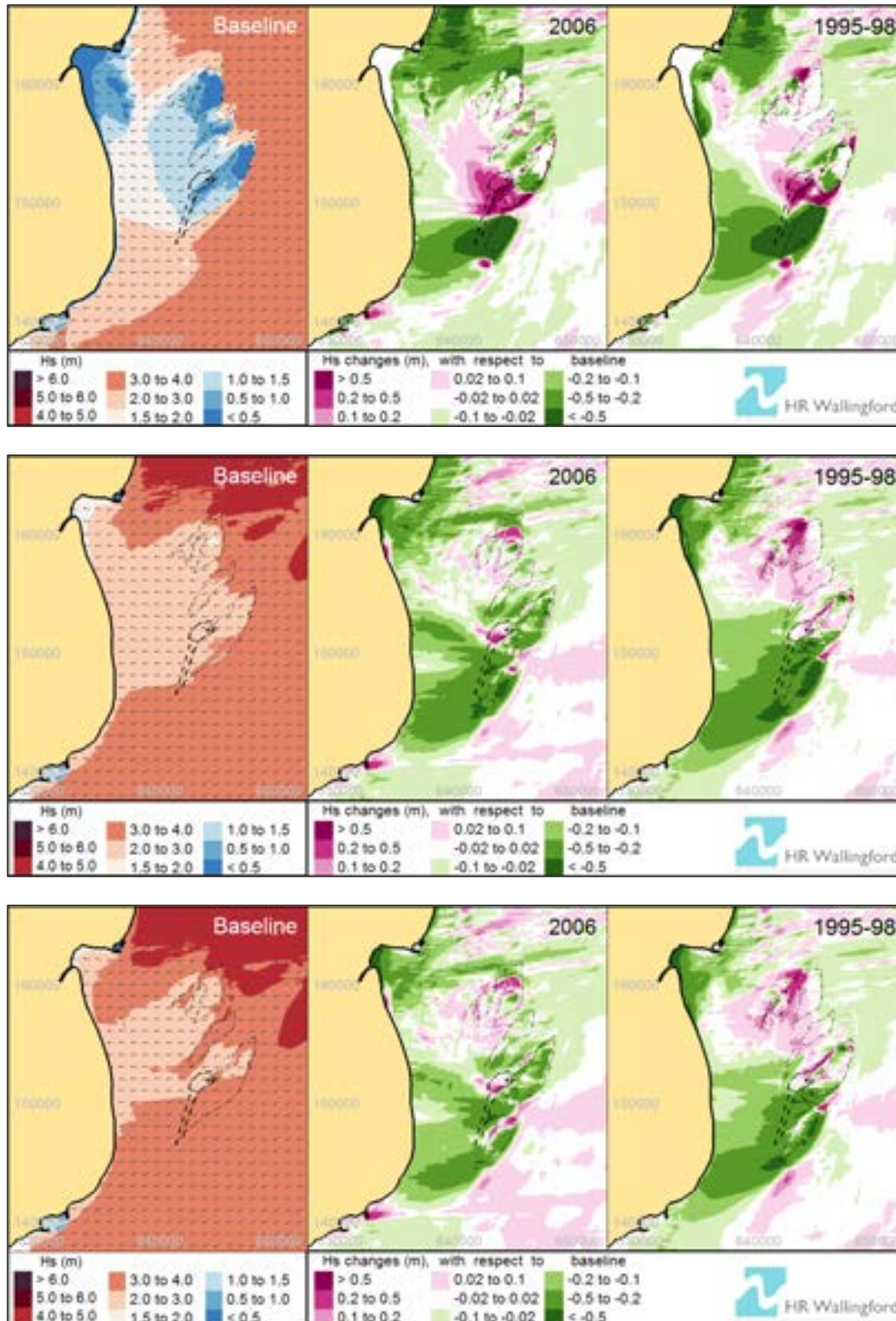


Figure 3.12: 1 in 200 year return period wave conditions from 90°N at MLWS (top), MHWS (middle) and 1 year water level with SLR (bottom): Baseline and differences due to bathymetric change. Proposed dredge area is indicated by a dashed, black polygon

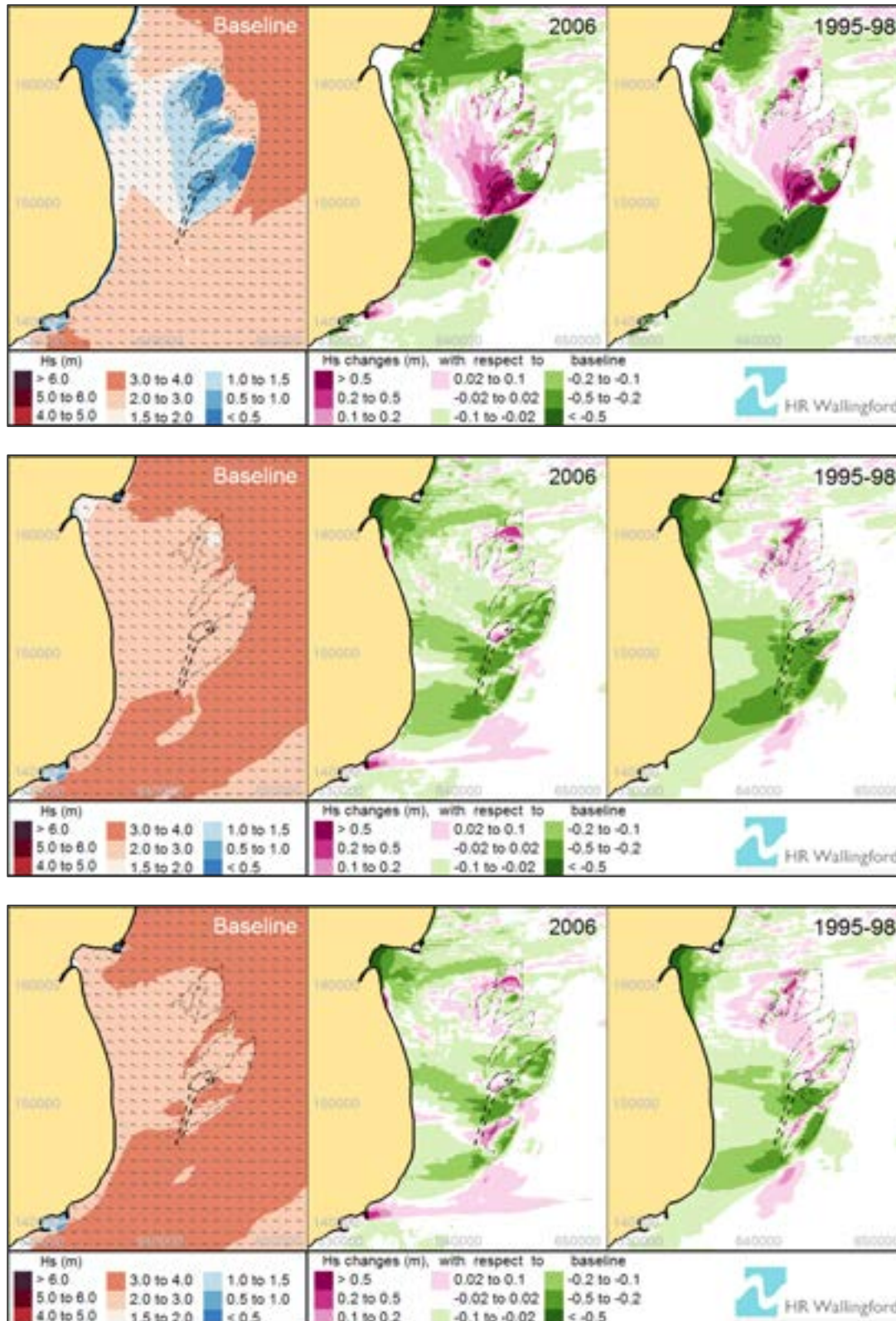


Figure 3.13: 1 in 200 year return period wave conditions from 120°N at MLWS (top), MHWS (middle) and 1 year water level with SLR (bottom): Baseline and differences due to bathymetric change. Proposed dredge area is indicated by a dashed, black polygon

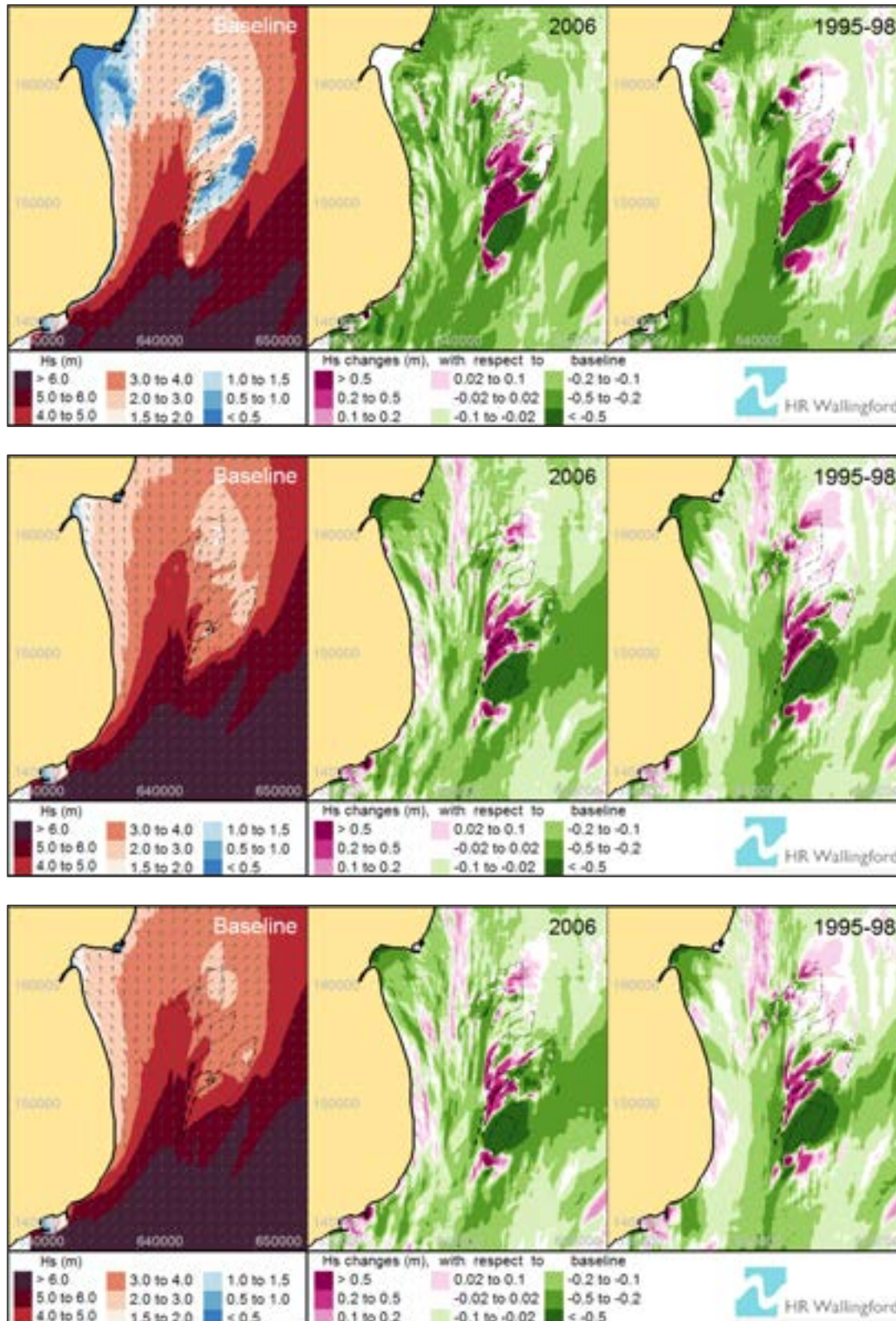


Figure 3.14: 1 in 200 year return period wave conditions from 240°N at MLWS (top), MHWS (middle) and 1 year water level with SLR (bottom): Baseline and differences due to bathymetric change. Proposed dredge area is indicated by a dashed, black polygon

4. Discussion

4.1. Predicted effects of dredging on wave conditions

This study has used project-specific survey data collected over the Goodwin Sands exploration area by EGS International Ltd supplemented by the most recent available bathymetric data over the study area. It has used a state-of-the-art wave model to test 1 in 200 year wave conditions, as is now standard practice in Coastal Impact Studies, to see if the proposed dredging on the Goodwin Sands could have any effect on wave conditions in the coastal areas.

The result plots, shown in Figure 3.7 to Figure 3.10, illustrate increases and decreases in significant wave height (H_s) above and below a threshold of ± 0.02 m. Smaller differences would be insignificant, and hardly measureable in reality.

The modelling indicated very little change in wave height as a result of the proposed dredging. The main effect was caused by a slight difference in the way waves refract around the edge of the sandbank leading to a slight redistribution of the wave energy. The predicted changes in significant wave height due to dredging are limited in spatial extent and are generally limited to 0.02-0.10 m, even under the extreme conditions tested. No effect is predicted at the coastline for any of the modelled wave conditions (Figure 3.7 to Figure 3.10).

With wind/wave conditions from 90°N (Figure 3.8) and wind/wave conditions from 120°N (Figure 3.9) the predicted changes in the significant wave height caused by the dredging are minimal, sometimes less than the 0.02 m threshold, as a consequence of the shorter wave period and smaller wave height approaching the Goodwin Sands from these directions.

Wave conditions from 240°N (Figure 3.10) show the greatest extent of changes to the significant wave height. This can be attributed to waves from this direction travelling along the axis of the dredging area and propagating further in that direction than they would without the dredging.

Both dredging scenarios tested, either the full proposed dredge area being applied for (Scenario 1) or deeper dredging only within the northern section of the area (Scenario 2), appear to give acceptable levels of change in wave conditions. Negligible change in wave conditions is predicted at the coastline.

4.2. Footprint of effect

The wave modelling has predicted the effect of the dredging on extreme waves for a range of incoming wave directions and water levels. To identify an overall footprint of change to wave conditions due to the proposed dredge (shown in red on Figure 4.1), the area within which the wave height is changed by more than 0.02 m (increase or decrease) for any of the simulations has been plotted (blue outline on Figure 4.1). The threshold of 0.02 m does not necessarily suggest a significant effect will occur within this area however for changes in wave height smaller than this value any effect on waves can be considered as negligible. It should also be noted that the simulated conditions are for extreme wave conditions, for more typical waves the area of change to wave height of 0.02 m would be much smaller.

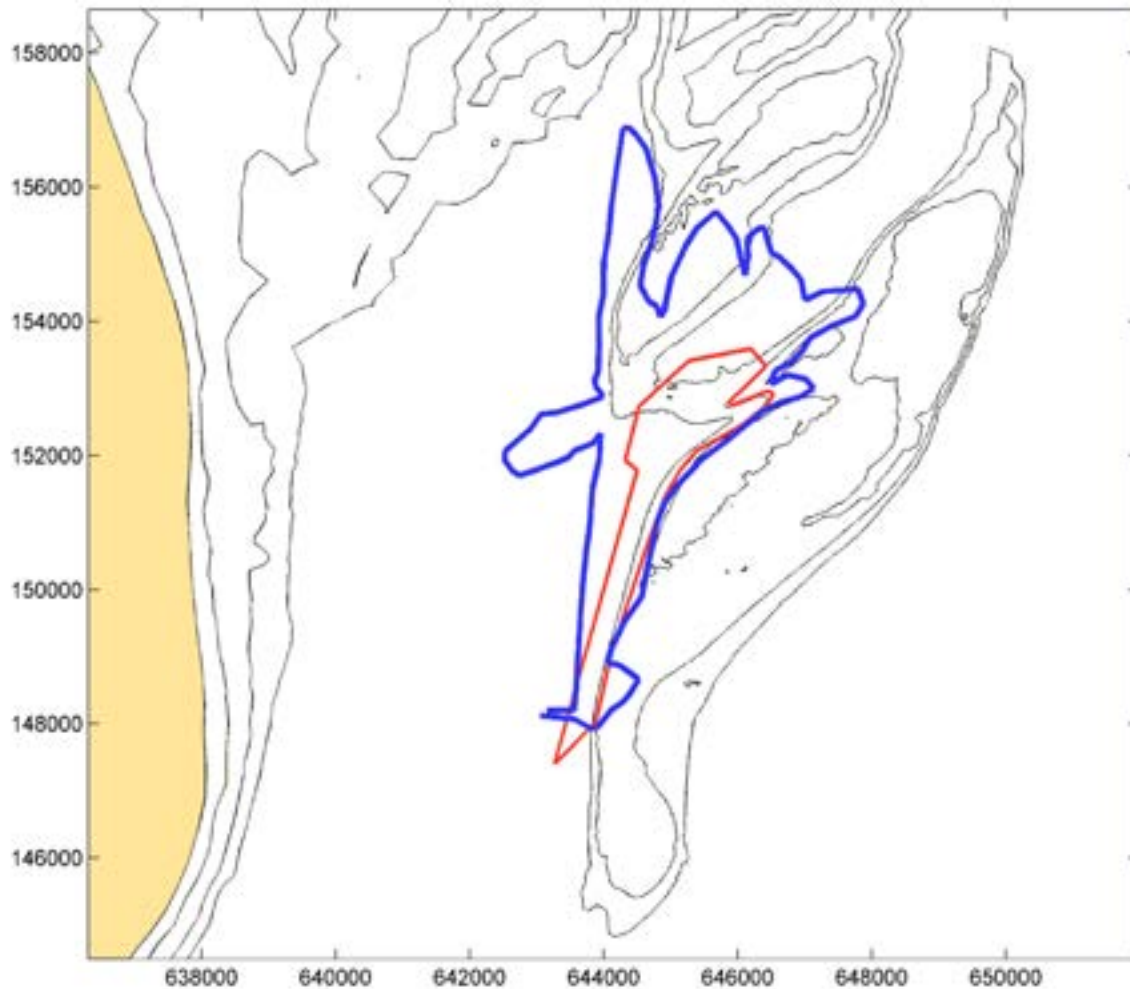


Figure 4.1: Summary footprint of effect of dredging on waves – Scenario 1

The footprint of effect does not extend to any of the sensitive locations as shown in Figure 1.2 with the exception of one wreck site which is at the northernmost extent of the footprint of effect, some 4 km distant from the edge of the proposed dredge area. Sediment transport modelling has been used to investigate any implication of the changes in wave height, combined with tidal currents, on sediment transport and patterns of seabed erosion and deposition. No effect on seabed erosion or deposition was shown at the identified wreck site (HR Wallingford 2016b).

4.3. Historical context

To put the predicted changes into context, the modelling also considered historical bathymetries to predict the natural variation in wave conditions resulting from the natural evolution of the Goodwin Sands and nearby sandbanks. The results plotted in Figure 3.11 to Figure 3.14, illustrate increases and decreases in significant wave height using the same colour scale as in Figure 3.7 to Figure 3.10.

The simulated results indicate significantly more natural variation in significant wave height than was the case with the post-dredging bathymetries. It is noted that some of these differences may be attributed to the use of more refined / recent bathymetry data sources in the present day seabed representations away from

the sandbanks than in the historical representations. Despite this factor it is clear that the changes in wave conditions due to the natural variability of the sandbanks are significantly greater than the effects of the proposed dredging.

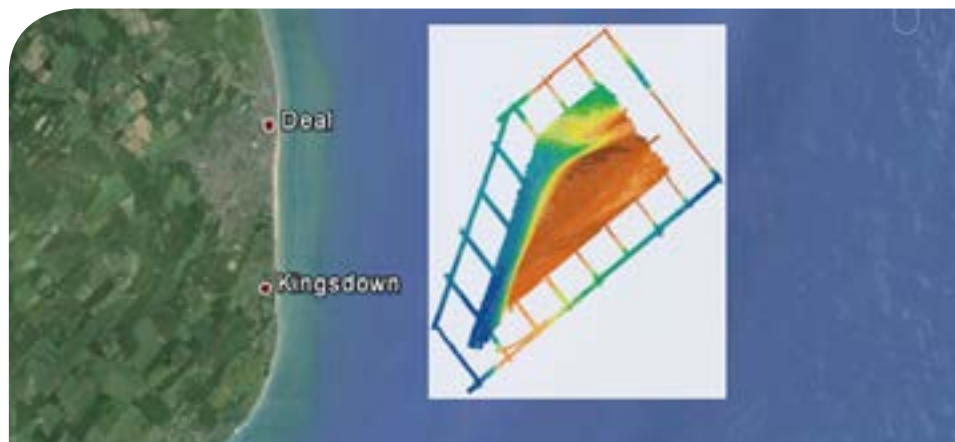
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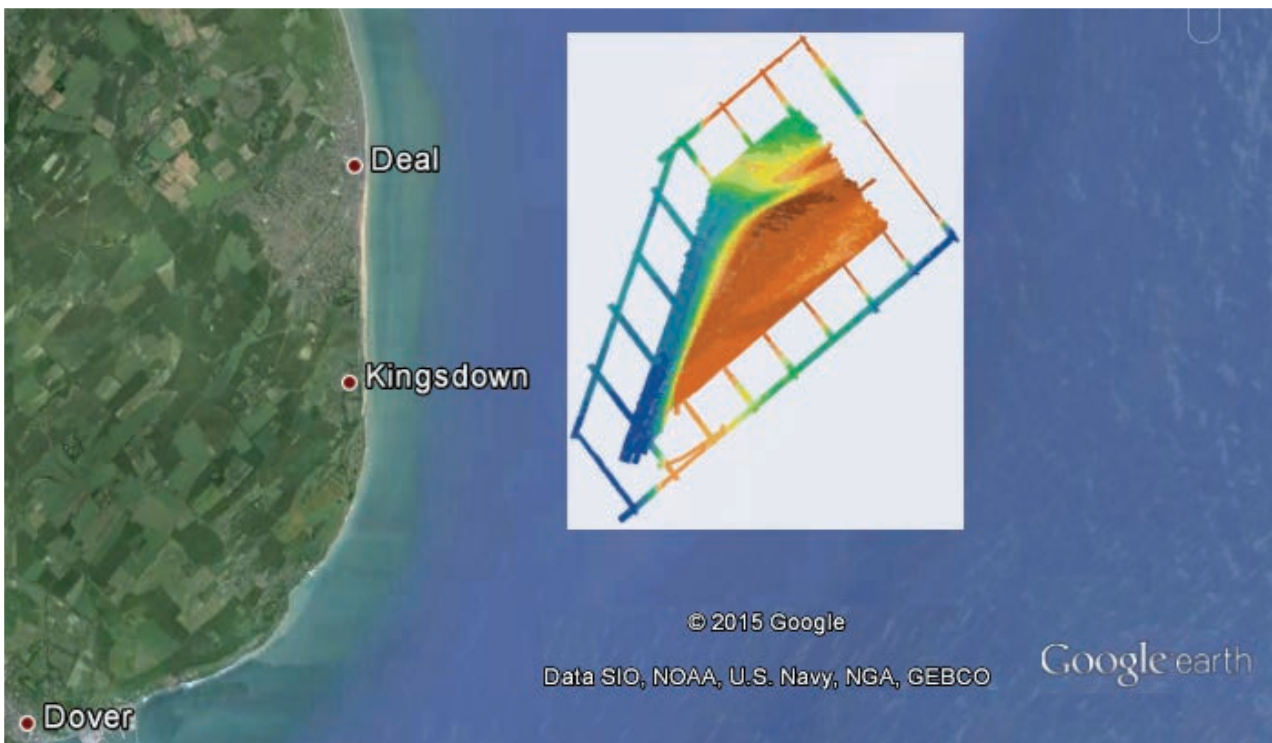
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B. Tidal flow modelling report

Goodwin Sands Aggregate Dredging Coastal Impact Study and EIA

Tidal flow modelling



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Executive Summary

Dover Harbour Board (DHB) is proposing to dredge sand and gravel from the South Goodwin Sands off the coast of Kent for use as fill material for the Dover Western Docks Revival development at the Port. DHB is proposing to dredge up to 2.5 million m³ of sand and gravel from the subtidal parts of the South Calliper sandbank at the South Goodwin Sands, located approximately 12 km north east of the Port of Dover (Figure 1.1). Marine aggregate dredging requires a Marine Licence from the Marine Management Organisation (MMO). Royal HaskoningDHV, on behalf of the DHB, is undertaking an Environmental Impact Assessment (EIA) to support the application for a Marine Licence for consent to dredge.

HR Wallingford is providing inputs to the EIA and Coastal Impact Study (CIS), establishing the magnitude, spatial extent and duration of any changes to the physical environment. The focus of the modelling described in this report is on changes in tidal currents caused by dredging at the Goodwin Sands.

An existing 2D, depth averaged flow model of the English Channel and Southern North Sea has been locally refined in the area of Goodwin Sands. The model was validated for currents in the area of the proposed dredge against data collected at the site for the present EIA studies.

The model was run for a period of more than one month for the existing and post-dredge cases and the differences in currents plotted. All of the current speed differences due to the dredging in excess of 0.05 m/s have been found to be within about 1 km from the proposed dredging area. Hence no widespread effect on tidal currents due to the proposed dredging is anticipated.

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1. Introduction

Dover Harbour Board (DHB) is proposing to dredge sand and gravel from the South Goodwin Sands off the coast of Kent for use as fill material for the Dover Western Docks Revival development at the Port. DHB is proposing to dredge up to 2.5 million m³ of sand and gravel from the subtidal parts of the South Calliper sandbank at the South Goodwin Sands, located approximately 12 km north east of the Port of Dover (Figure 1.1). Marine aggregate dredging requires a Marine Licence from the Marine Management Organisation (MMO). Royal HaskoningDHV, on behalf of the DHB, is undertaking an Environmental Impact Assessment (EIA) to support the application for a Marine Licence for consent to dredge.

HR Wallingford first considered the required studies to support dredging at the Goodwin Sands in 2008 when a phased, outline scope was proposed; including a historical bathymetric review and wave modelling to inform a Coastal Impact Study (CIS). The historical bathymetric review covering the period 1986-2006 was completed and reported on in HR Wallingford (2008).

For the present project HR Wallingford is providing inputs to the EIA and CIS, establishing the magnitude, spatial extent and duration of any changes to the physical environment directly caused by dredging on the Goodwin Sands. The focus of the modelling described in this report is on changes in tidal currents caused by dredging on the Goodwin Sands. The flow model results were also required as input to the modelling of sediment transport and morphological change.

The proposed dredge area lies close to various sensitive locations including protected wrecks, designated areas, anchorages and sites associated with particular ecological value such as seal haul out sites and *sabellaria spinulosa* reef as shown in Figure 1.2. The potential for the proposed dredging to change the physical processes at these sites requires particular attention.

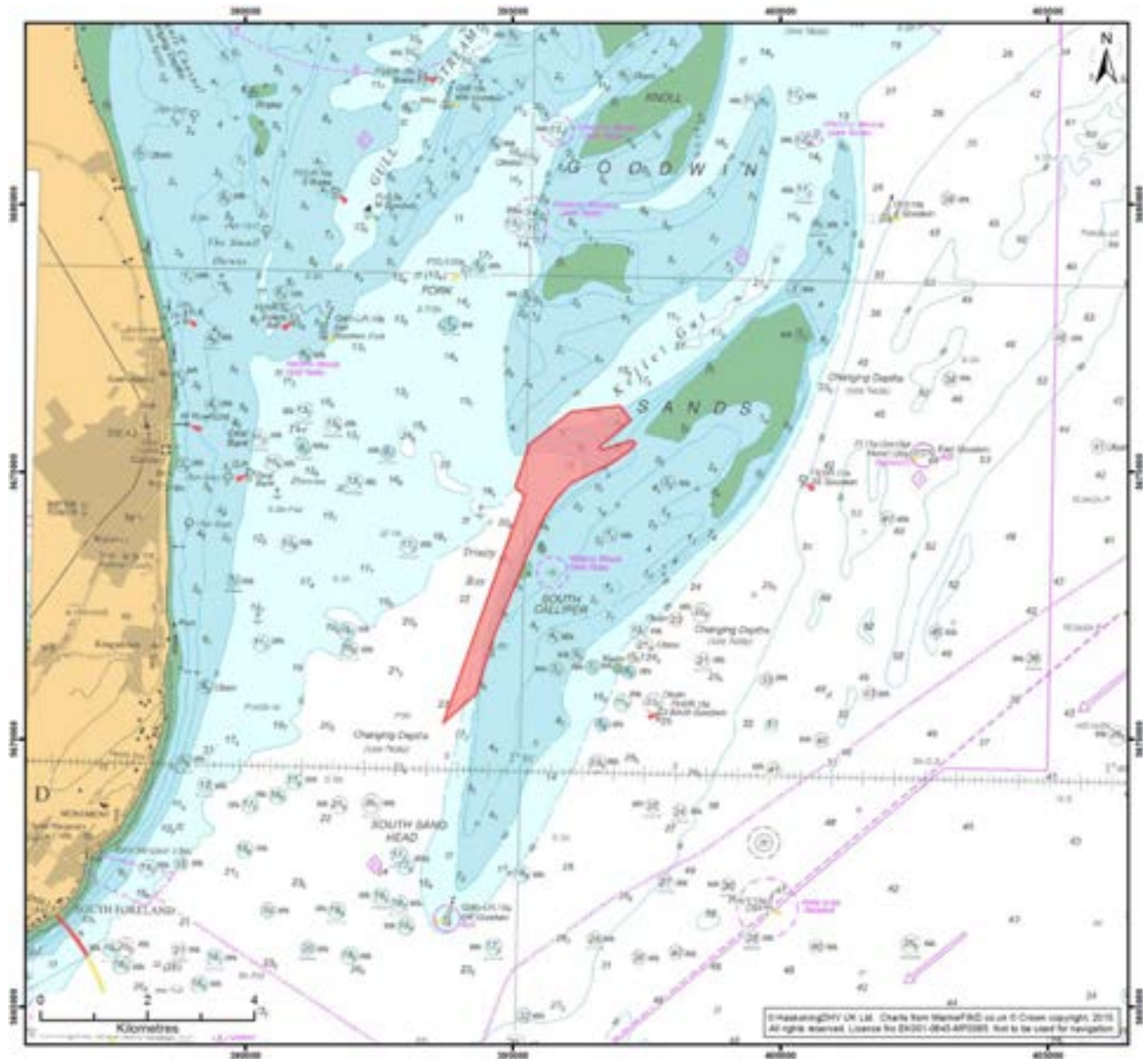


Figure 1.1: Location of proposed aggregate dredging area

Source: PHDHV Drawing PB2107_ES_003

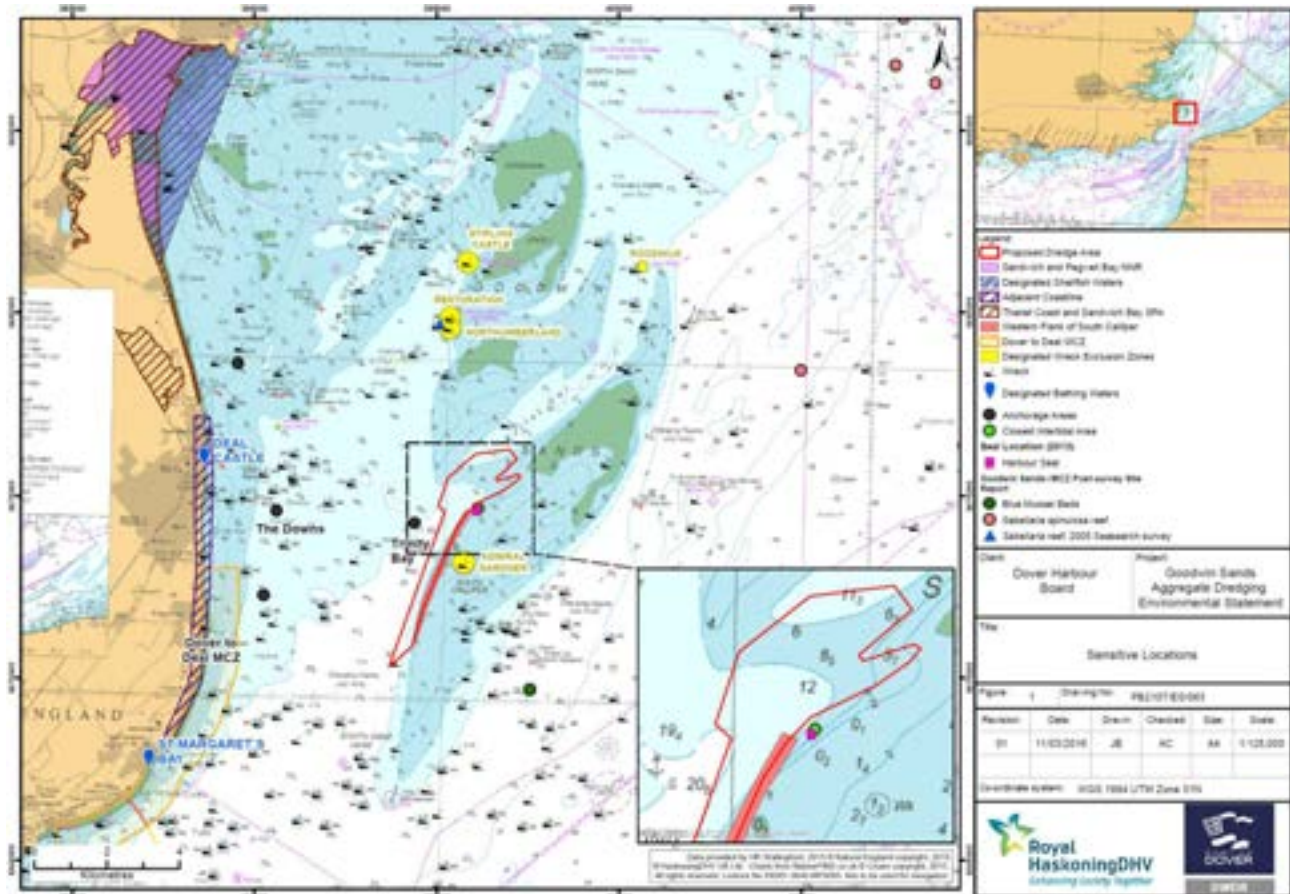


Figure 1.2: Sensitive locations in area of proposed aggregate dredging area

Source: RHDHV drawing PB2107_ES_063

2. Scenarios tested

2.1. Historical, baseline and built scenarios

The conditions represented in the models are summarised as:

- A “baseline” case, that is the present-day bathymetry without dredging;
- A post-dredging scenario, dredging up to 1.12 m depth of aggregates in the full dredge area being applied for.

The scenario with dredging covering the full dredge area being applied for was modelled to provide the largest spatial extent of an effect on tidal currents.

It is proposed that up to approximately 2.5 million m³ of material will be dredged from Goodwin Sands and transported to Dover for use as aggregate in the Western Docks project. As has been used for aggregate studies elsewhere the amount of sediment removed has been increased by 60% in the modelling studies to provide a precautionary view of the potential impact of the dredge. Hence, the post-dredging scenario involved removal of approximately 4,000,000 m³ of material from areas identified as having sand. A layer of at least 0.5 m of sand was left in the dredged areas in accordance with established practice to facilitate recovery of benthic communities. Removal of this volume resulted in the average depth of dredging of 1.12 m as modelled.

2.2. Bathymetry data

2.2.1. Baseline and post-dredging bathymetries

The area of the EGS International Ltd bathymetry survey collected for the present project in mid-2015 is shown in Figure 2.1. The survey provided detailed bathymetry data in the full area of resource exploration undertaken by DHB surrounded by sections at 1 km spacing to capture the form of the sandbank immediately surrounding the exploration area. The survey is shown to provide a reasonable coverage of the South Goodwin Sands. It is noted that the southernmost face of the sand bank is only defined by the transverse cross-sections extending about one kilometre away from the main survey area.

Additional bathymetry data for the rest of the model area were taken from:

- Recent TruDepth bathymetry from SeaZone, using the latest available survey data from the UKHO,
- Nautical Chart data in European (non-UKHO) waters.



Figure 2.1: Spatial extent of the 2015 bathymetric survey of the Goodwin Sands, with proposed dredge area indicated by the black polygon

Source: EGS International Ltd (2015)

Bathymetry data from these different sources were merged for use in the baseline model, where more recent / resolved data took precedence over older or less resolved data. The data was converted to be relative to Mean Sea Level (MSL) which is a flat vertical datum required by a model covering a large area of sea rather than using Chart Datum (CD) which, as it is a measure of lowest astronomical tide level, varies throughout the model area.

The model representation of the baseline and post dredged bathymetries, for use in the tidal flow model, are shown in Figure 2.2 and Figure 2.3. Figure 2.4 shows the difference in bathymetry inserted into the model to represent the proposed dredging.

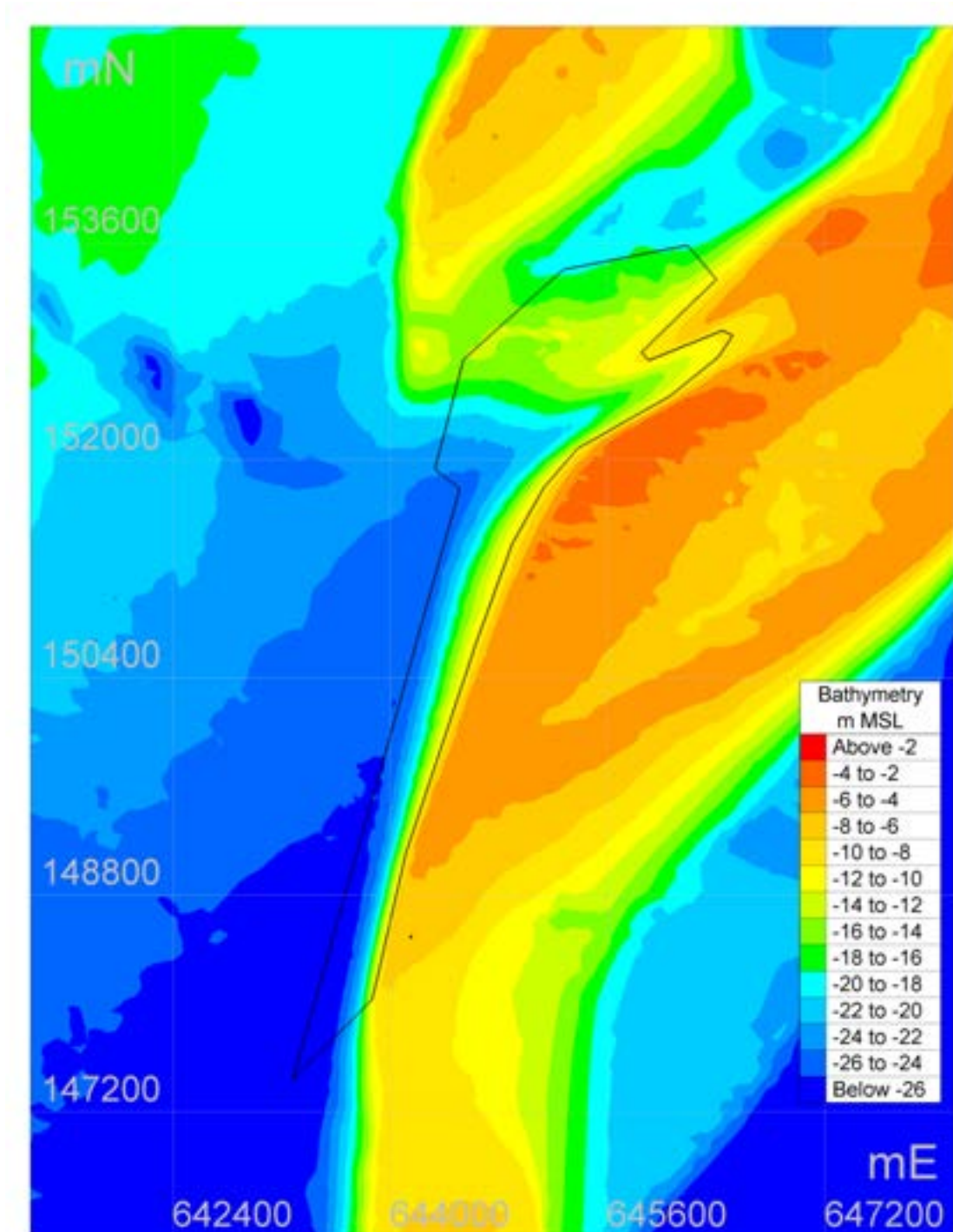


Figure 2.2: Baseline case model bathymetry, with proposed dredge area indicated by the black polygon

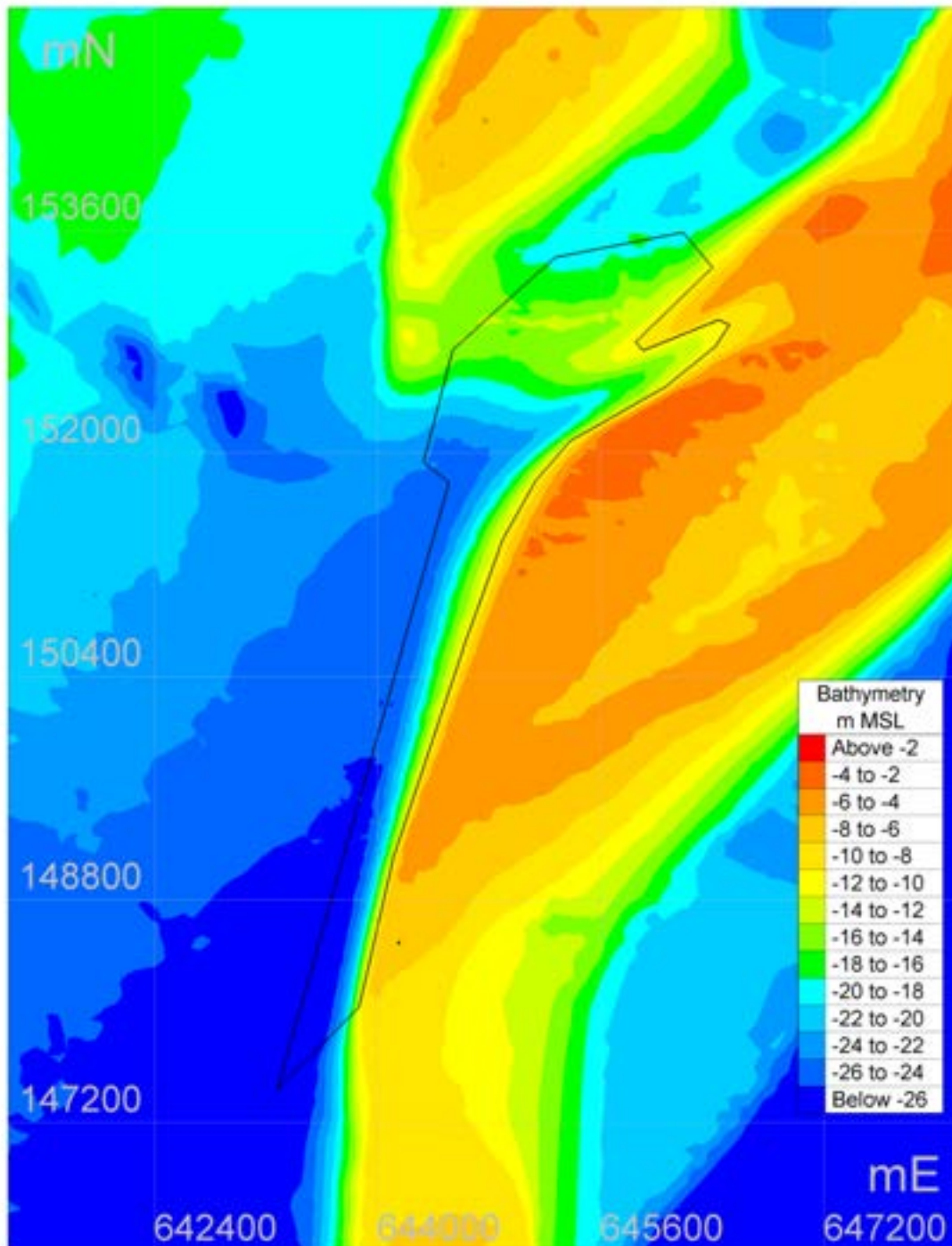


Figure 2.3: Post dredging case model bathymetry, with proposed dredge area indicated by the black polygon

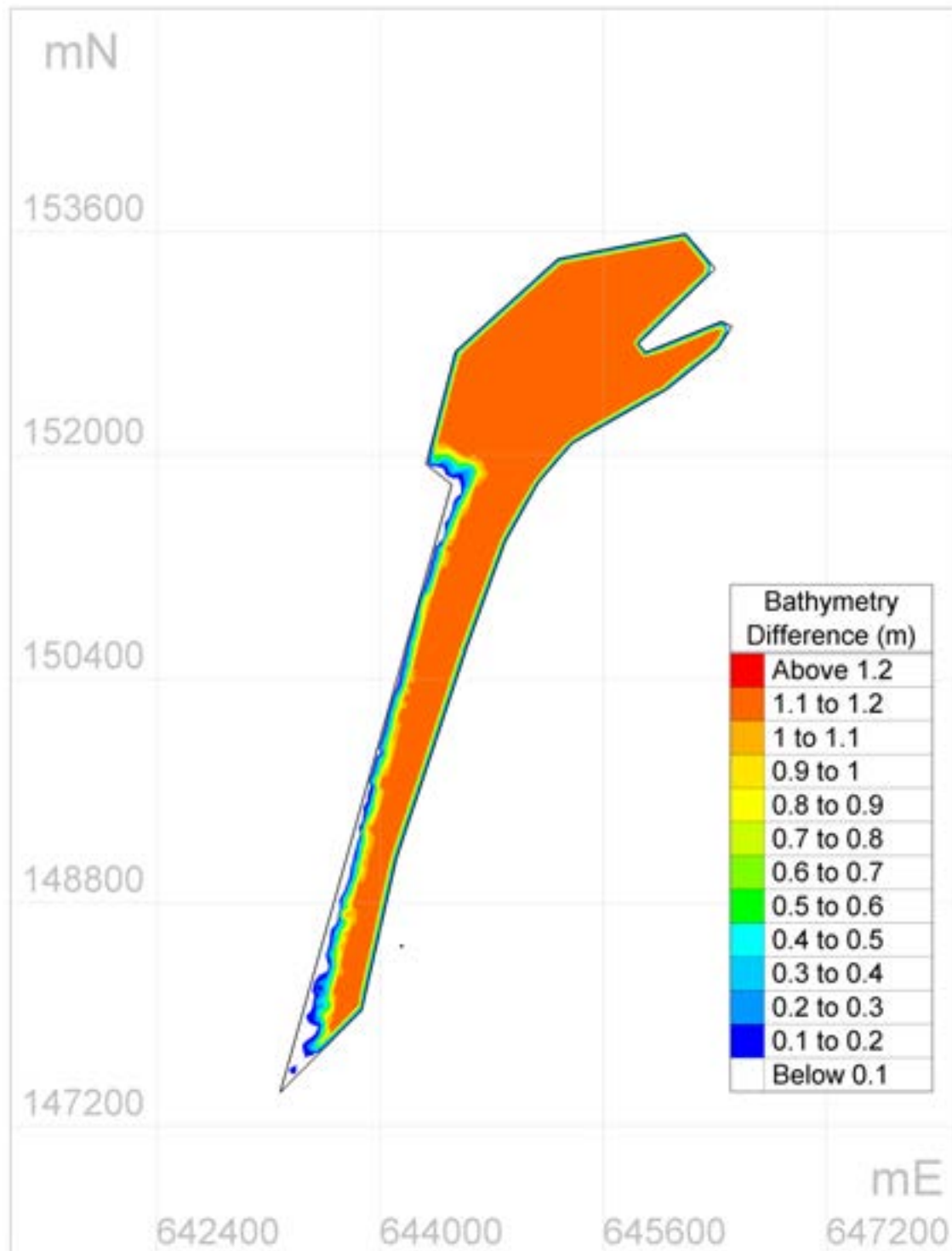


Figure 2.4: Change in bathymetry associated with the proposed dredging, with proposed dredge area indicated by the black polygon

3. Tidal flow modelling

3.1. Model applied

TELEMAC-2D was used to model an area covering the eastern English Channel and the southern North Sea. A two dimensional depth averaged flow model was considered suitable for this project because strong currents occur in the area of interest (up to 1.5 m/s) so stratification effects are unlikely to be significant influences on the vertical variation in current magnitude. In these circumstances a logarithmic current magnitude profile as used by a 2D, depth averaged model is considered acceptable.

The largest mesh size was on the model outer boundary and is 25,000 m. The smallest mesh size was at the area of proposed dredging and was approximately 50 m which provides a good resolution of the dredged depression. Figure 3.1 shows the model domain and mesh. The model coordinate system is British National Grid (OSGB36). The model vertical datum is Mean Sea Level, which is assumed to be constant over the area.

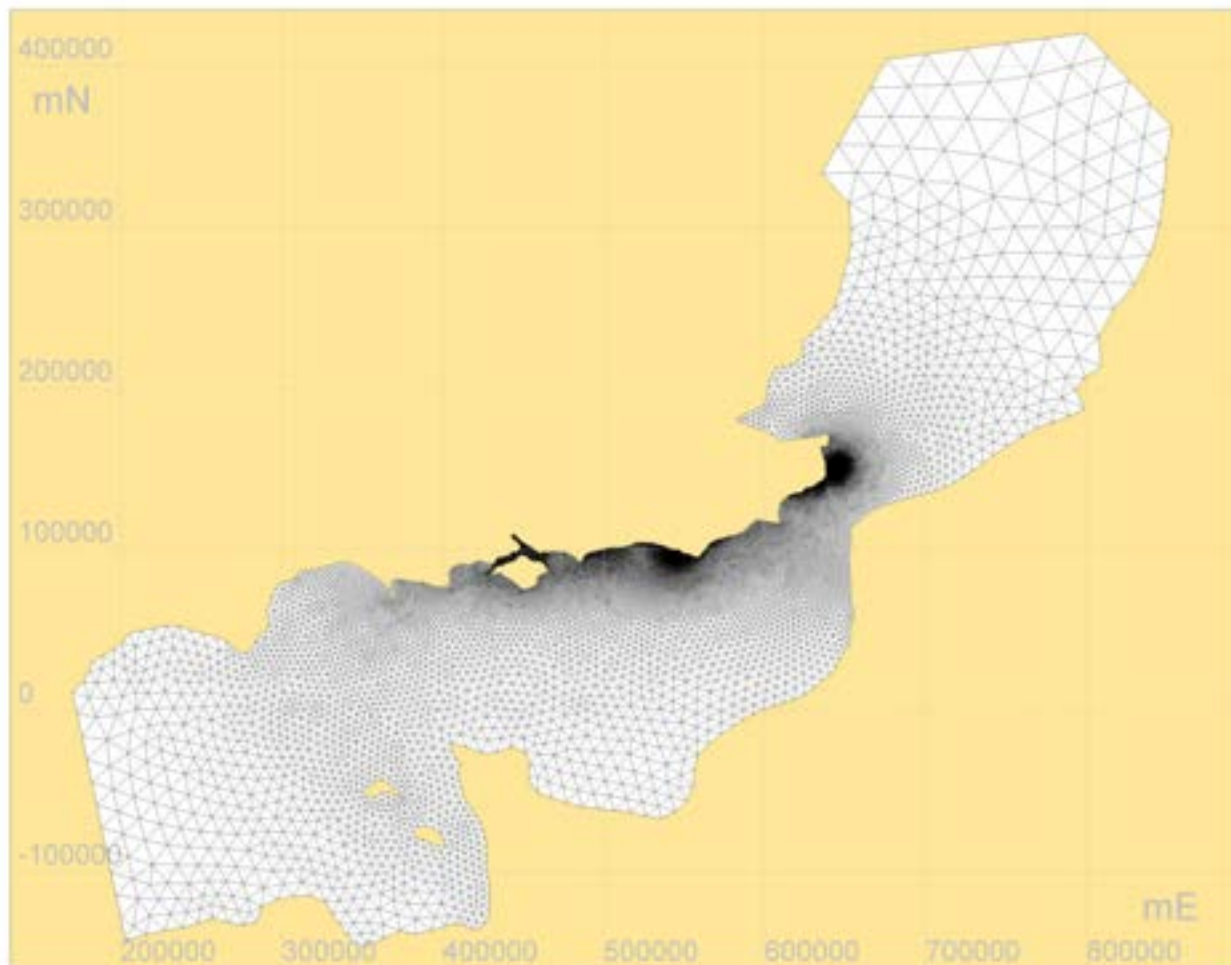


Figure 3.1: TELEMAC-2D model extent and mesh

The model is driven by imposing the water surface elevation at the North and West open boundaries. The imposed elevation is derived using the TPXO European Shelf harmonic constituents. The TPXO model has a resolution of 1/30 degree (approximately 3.7 km).

The effect of wind was not included as the tidal currents are strong and winds are not expected to have a significant influence on the currents in the area of interest.

3.2. Model validation

The model has been calibrated for use at other locations, however to confirm the model's performance at the study area around Goodwin Sands a validation exercise was required.

Acoustic Doppler Current Profiler (ADCP) current observations have been collected for the present project at the point indicated on Figure 3.2. The period of the ADCP measurements was from 30th July 2015 to 22nd September 2015. This period has been used for the TELEMAC-2D model simulations. The model simulation runs from 30th July 2015 to 23rd September 2015. The ADCP deployment is described fully in EGS (2015).

A number of model runs have been done with different values of the Nikuradse roughness length for seabed friction. Some runs used a uniform roughness length throughout the model. Other runs used a higher value of friction in the shallow water areas in the region of the bathymetry survey. This enhanced friction was intended to allow for the effects of the mega-ripples and sand waves known to be present on Goodwin Sands. The data for each 'bin' (i.e. each sub section of the vertical profile) recorded by the ADCP have been processed to give the depth averaged observed current speed and direction for each time. The Mean Absolute Error (MAE, the average difference between observed and modelled depth average current) on the current speed at the ADCP location was calculated for each run. The MAE of the modelled water elevation at Deal Pier (the closest, well established, permanent tide gauge) was also calculated for each run, comparing to the synthesised water elevation time series derived from tidal harmonics.

Many sediment transport equations are based on the current speed cubed. Therefore, to provide a measure of model accuracy which might be related to sediment transport rates the MAE of the observed and simulated speeds raised to the power of three was also calculated and included in Table 3.1.

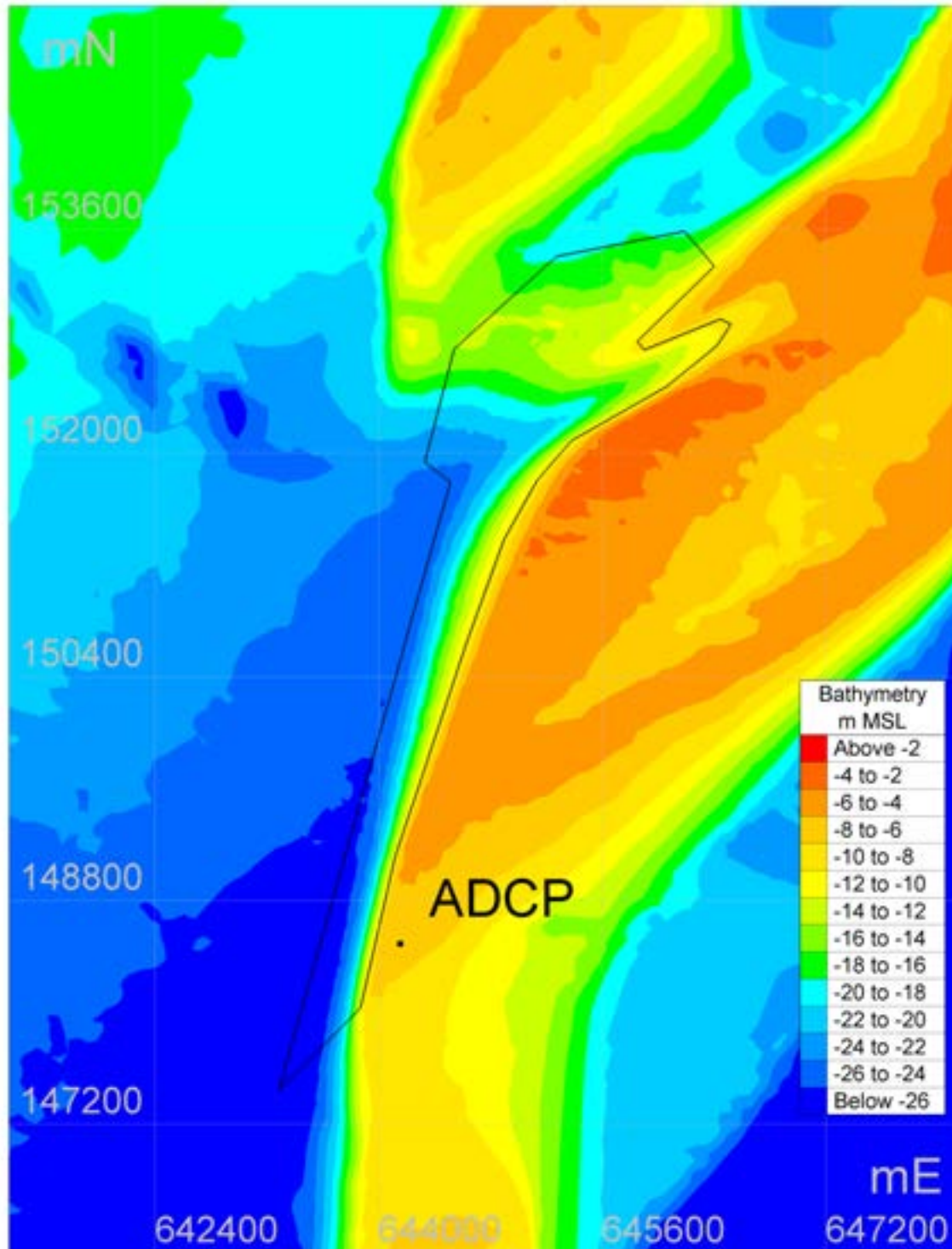


Figure 3.2: Location of ADCP measurements at Goodwin Sands, with proposed dredge area indicated by the black polygon

Table 3.1 shows that the smallest errors on both current speed and water elevation were obtained in the runs that had a roughness length of 0.2 m and 0.5 m implemented locally. Comparison of the speed and direction time series indicated that the best agreement with the ADCP measurements was achieved by the run with the roughness length of 0.2 m locally.

This run is used as the basis for all subsequent results presented in this report. The mean error of 0.1 m/s is small compared to the range of currents observed with maximum depth average currents of more than 1.5 m/s. The tide range at Deal is more than 6 m during spring tide periods so the mean error in tidal level of 0.09 m is also small in comparison.

Table 3.1: Model validation results – Mean Absolute Error (MAE)

Roughness length (m)	MAE of model current speed compared to ADCP (m/s)	MAE of model current speed cubed compared to ADCP current speed cubed (m/s) ³	MAE of tidal elevation at Deal Pier (m)
0.05	0.14	0.33	0.09
0.10	0.10	0.21	0.13
0.25	0.11	0.23	0.20
0.05 (0.2 locally)	0.10	0.21	0.09
0.05 (0.5 locally)	0.10	0.20	0.09
0.05 (1.0 locally)	0.12	0.26	0.09

Figure 3.3 to Figure 3.8 show a series of time histories of speed and direction for 7 day periods; following convention the current direction is the direction in which the current is flowing. These figures plot the depth averaged ADCP measurements together with the model result at the ADCP location. Good agreement can be seen between the model and the measurements including the dominance of flood tide current speed over ebb tide at this location.

The only areas of slight concern are some over-prediction of current speed during the low neap period of the 5th to 8th September and some curious short sharp periods of high current during the period 31st August to 3rd September (Figure 3.7). The latter is a curious feature especially as there is no sign of it on similar (large) size currents on 2nd to 4th August (Figure 3.3) or even on the overnight tides of 31st August to 1st September or 1st September to 2nd September. For these periods the observed current suddenly increases to its greatest magnitude late in the west-going (ebb) tidal period, for example, from 1.2 m/s to 1.8 m/s on the 1st September giving the strongest current measured during the whole ADCP deployment.

The origin of this feature, which occurs on some spring tides (but not others), is hard to establish. It is seen in several bins so is unlikely to be random noise. It occurs close to low water so may be related to formation of bed features for comparatively short periods which reduce water depths and produce jetting of the currents at the site of the ADCP. This seems a possible explanation as periods of burial of the meter by sediment occurred during the deployment. Such a phenomenon could cause high current when the water is low either by the mobile bed features being of a suitable shape to produce the enhanced currents or by the effect of waves on the bank being sufficient to drive a current when the water level is low. The hypothesis of increased currents being caused by burial is backed up by the high currents recorded during the period 13th – 16th September (Figure 3.9) when burial of the meter was reported by EGS (2015).

Figure 3.10 plots a time series of model elevation at Dover together with the elevation derived from C-MAP. Figure 3.11 is the equivalent figure for Deal. Generally good agreement can be seen, with the model slightly under-predicting the tidal amplitude.

The model is considered to be well calibrated in comparison to the observed current speeds and directions with the exception of what appear to be unusual and short lived current speed spikes during spring tides at the start of September. Understanding the origin of this phenomenon, which occurs only on a couple of days during the 54 day survey period, is not considered significant for the purpose of the prediction of the long-term impacts of the proposed dredging at Goodwin Sands on tidal flows.

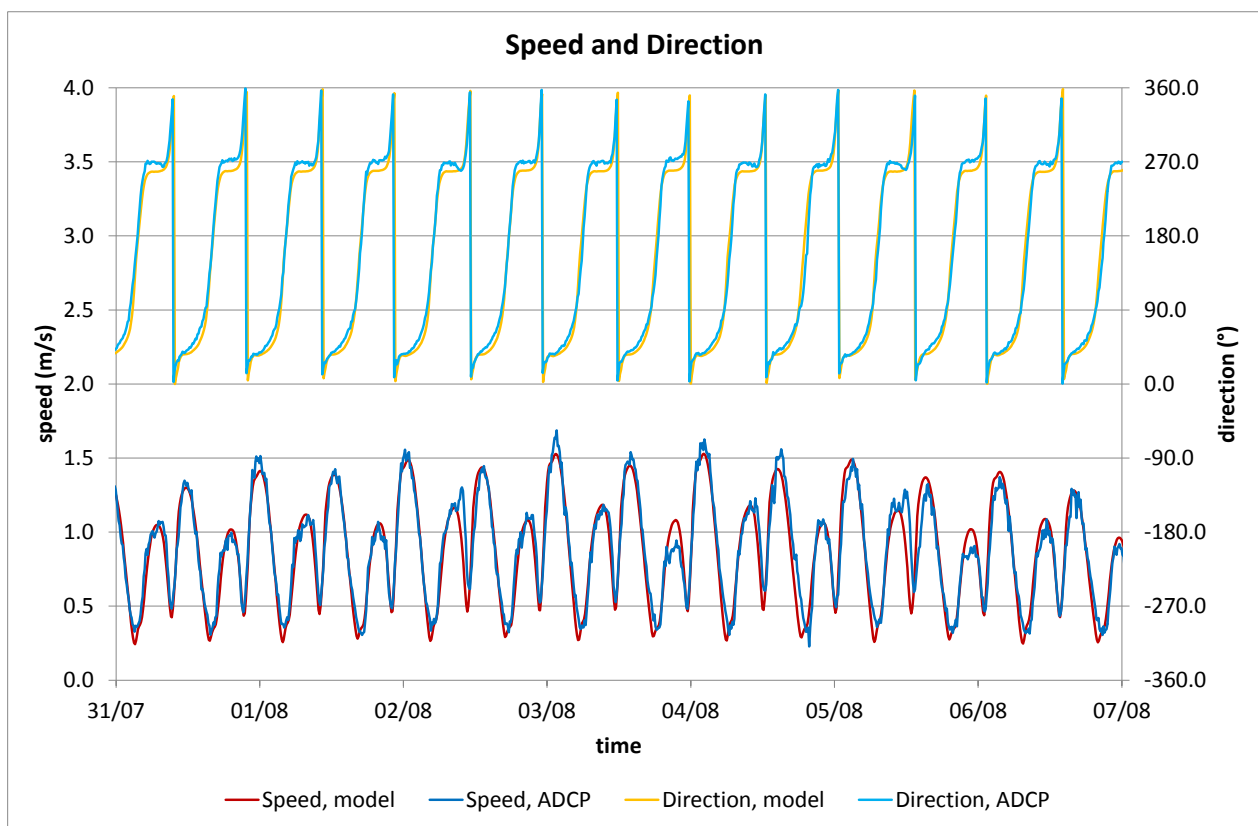


Figure 3.3: Comparison of modelled and observed depth average currents 31/07/15 – 07/08/15

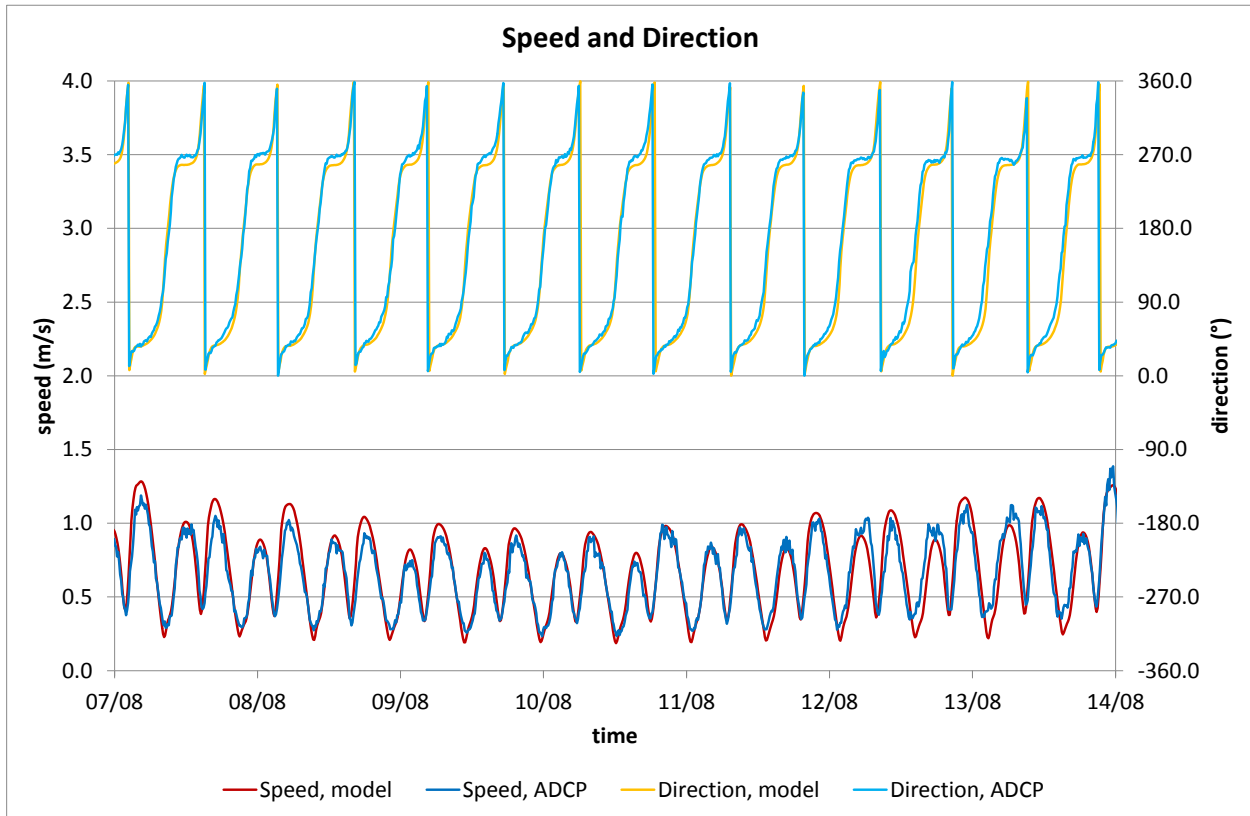


Figure 3.4: Comparison of modelled and observed depth average currents 07/08/15 – 14/08/15

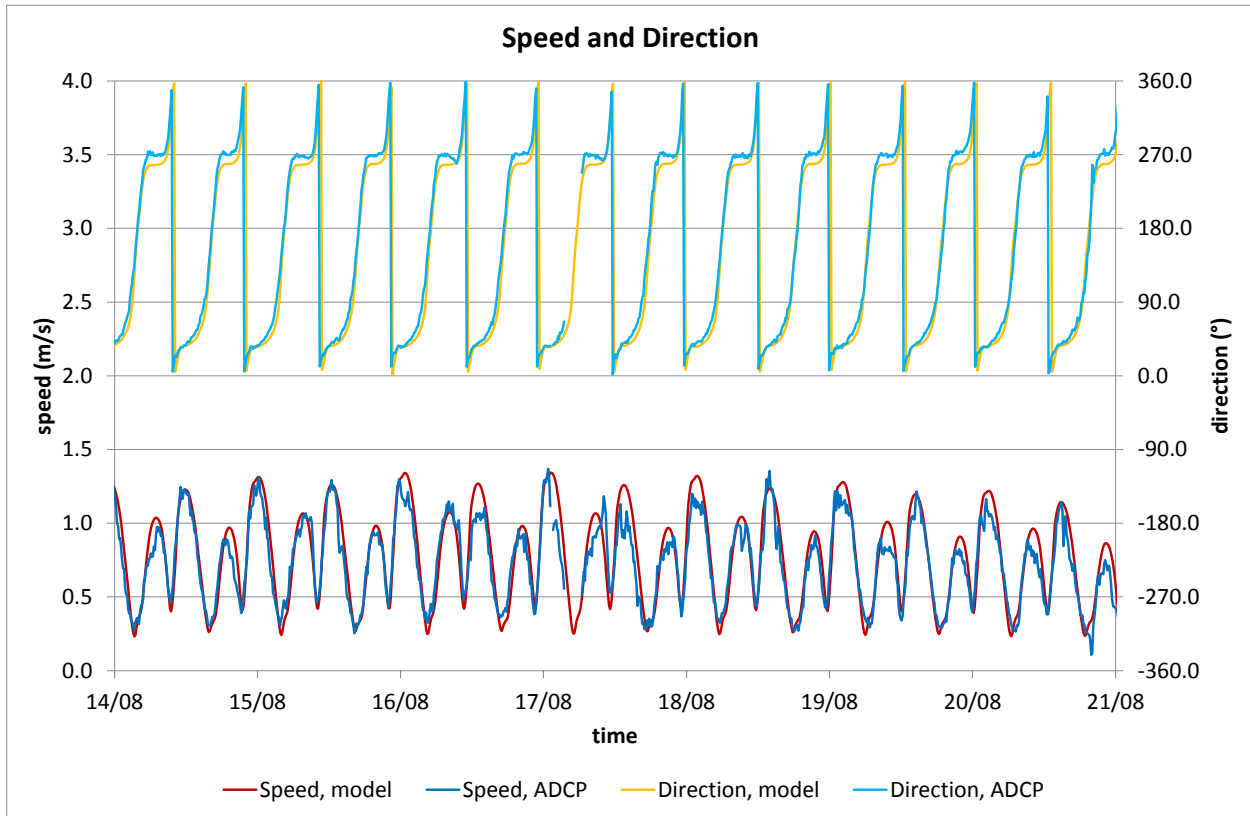


Figure 3.5: Comparison of modelled and observed depth average currents 14/08/15 – 21/08/15

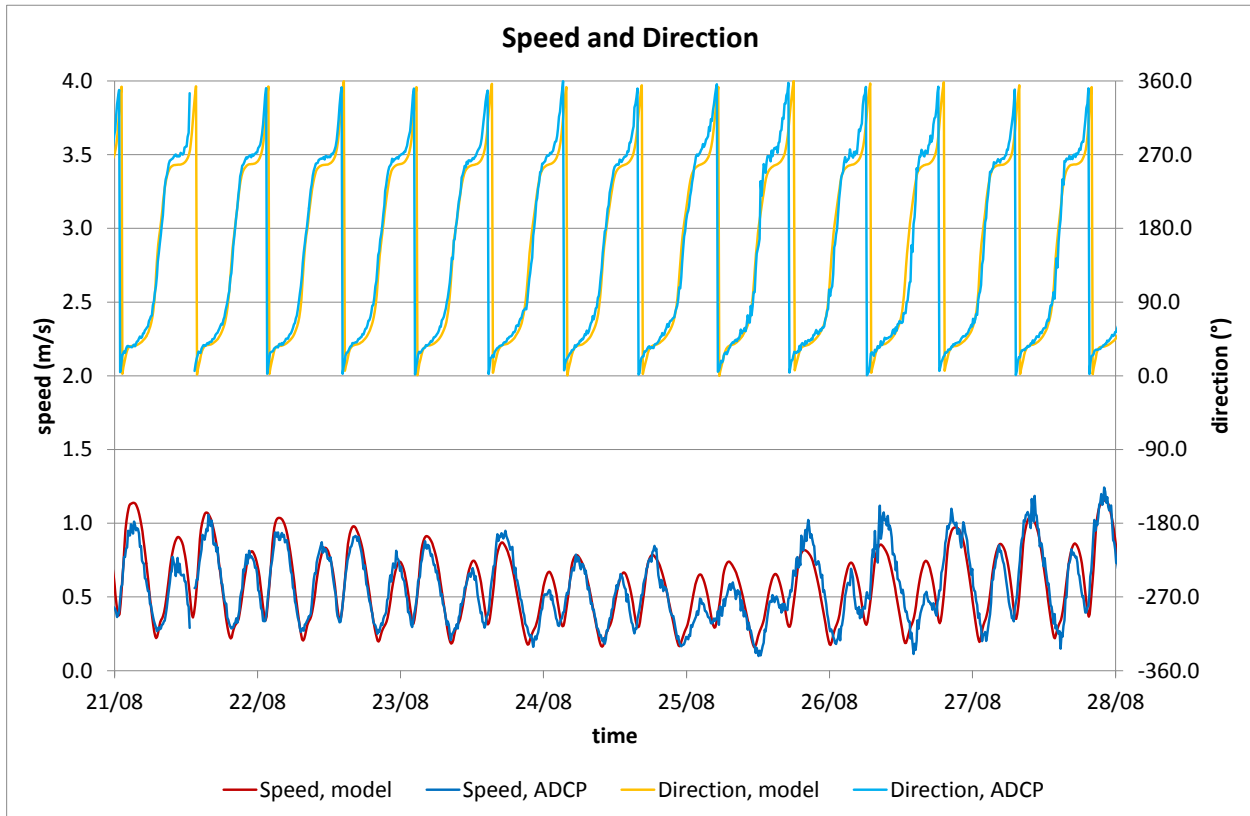


Figure 3.6: Comparison of modelled and observed depth average currents 21/08/15 – 28/08/15

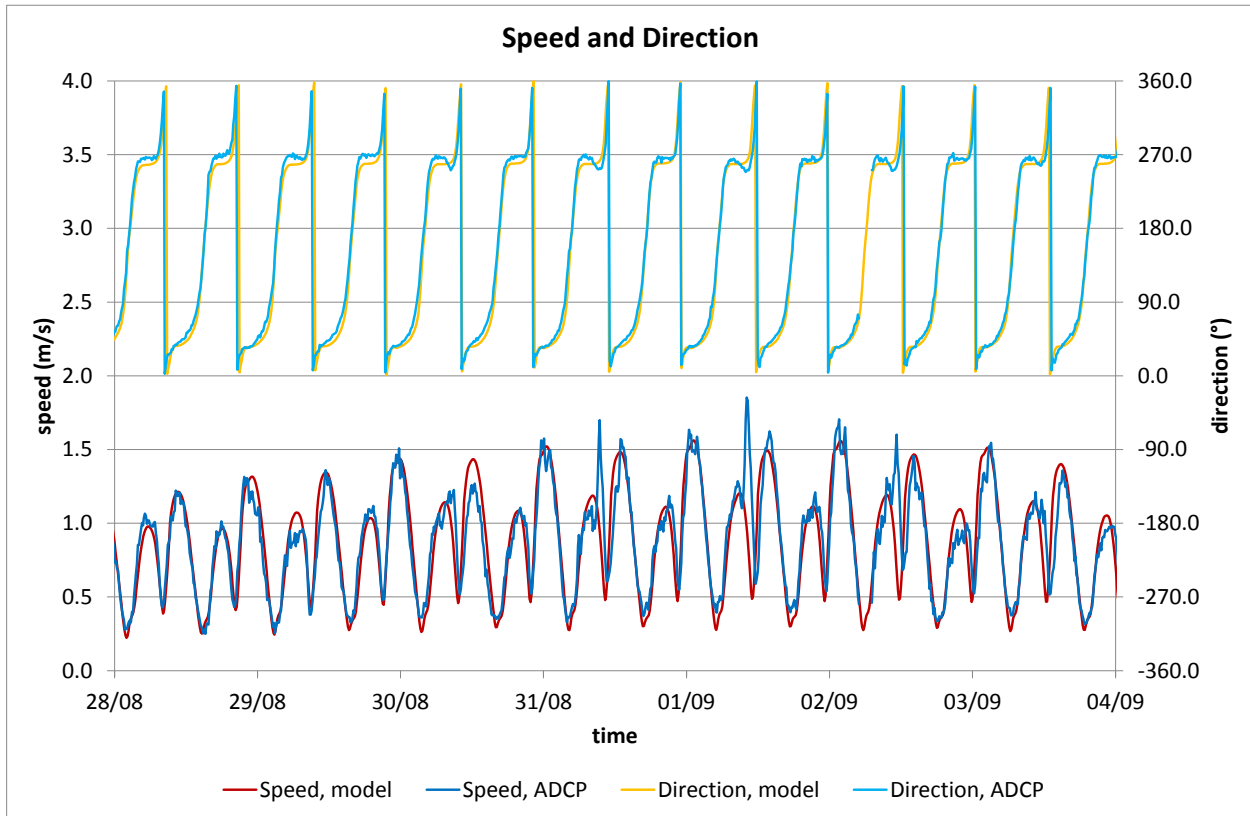


Figure 3.7: Comparison of modelled and observed depth average currents 28/08/15 – 04/09/15

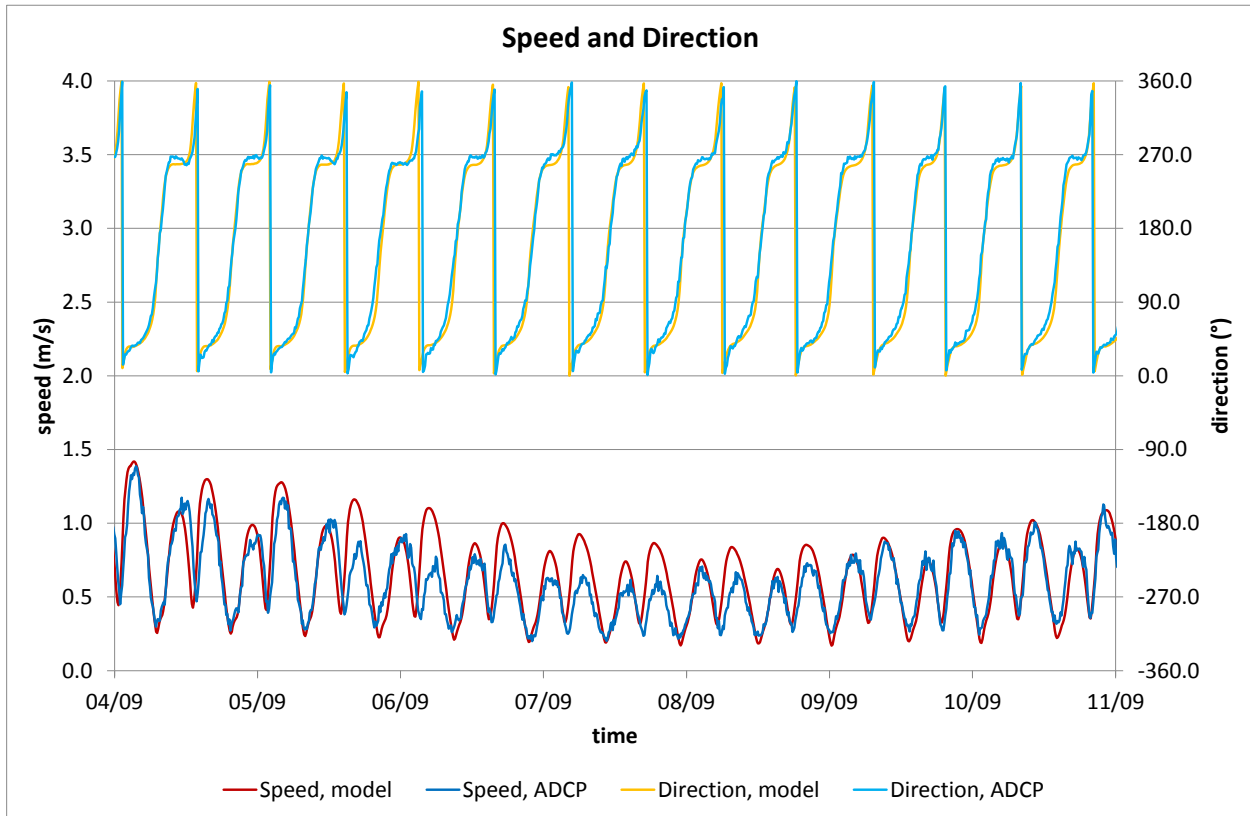


Figure 3.8: Comparison of modelled and observed depth average currents 04/09/15 – 11/09/15

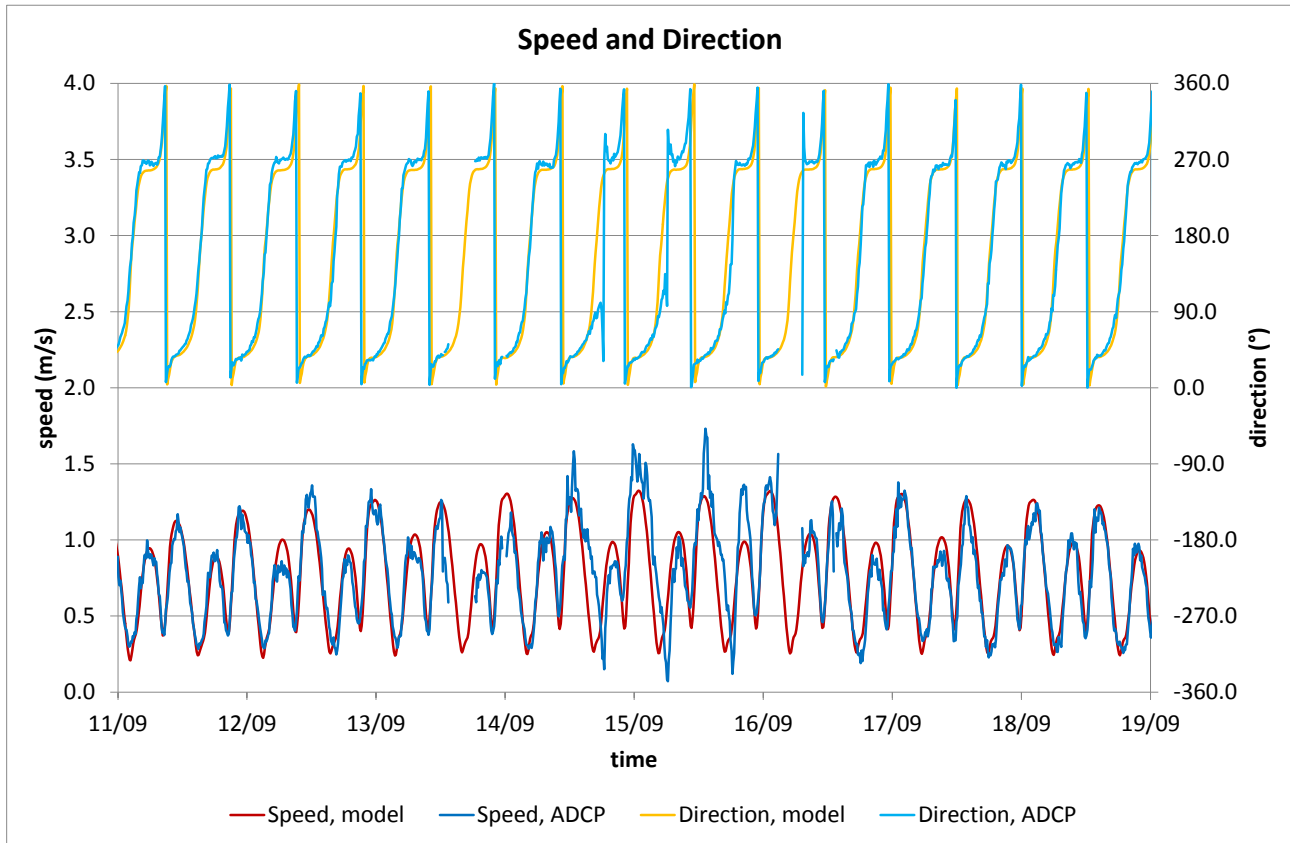


Figure 3.9: Comparison of modelled and observed depth average currents 11/09/15 – 19/09/15

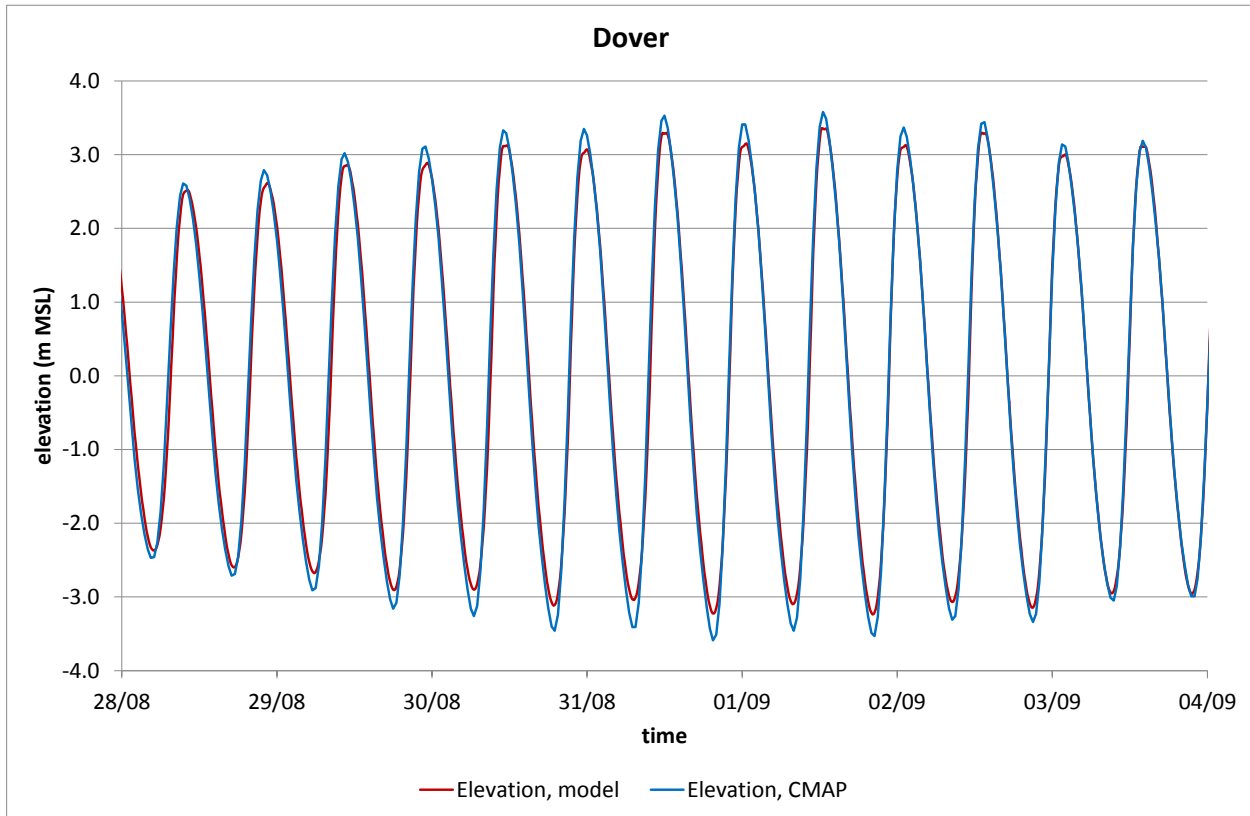


Figure 3.10: Comparison of modelled and synthesized tidal elevation at Dover 28/08/15 – 04/09/15

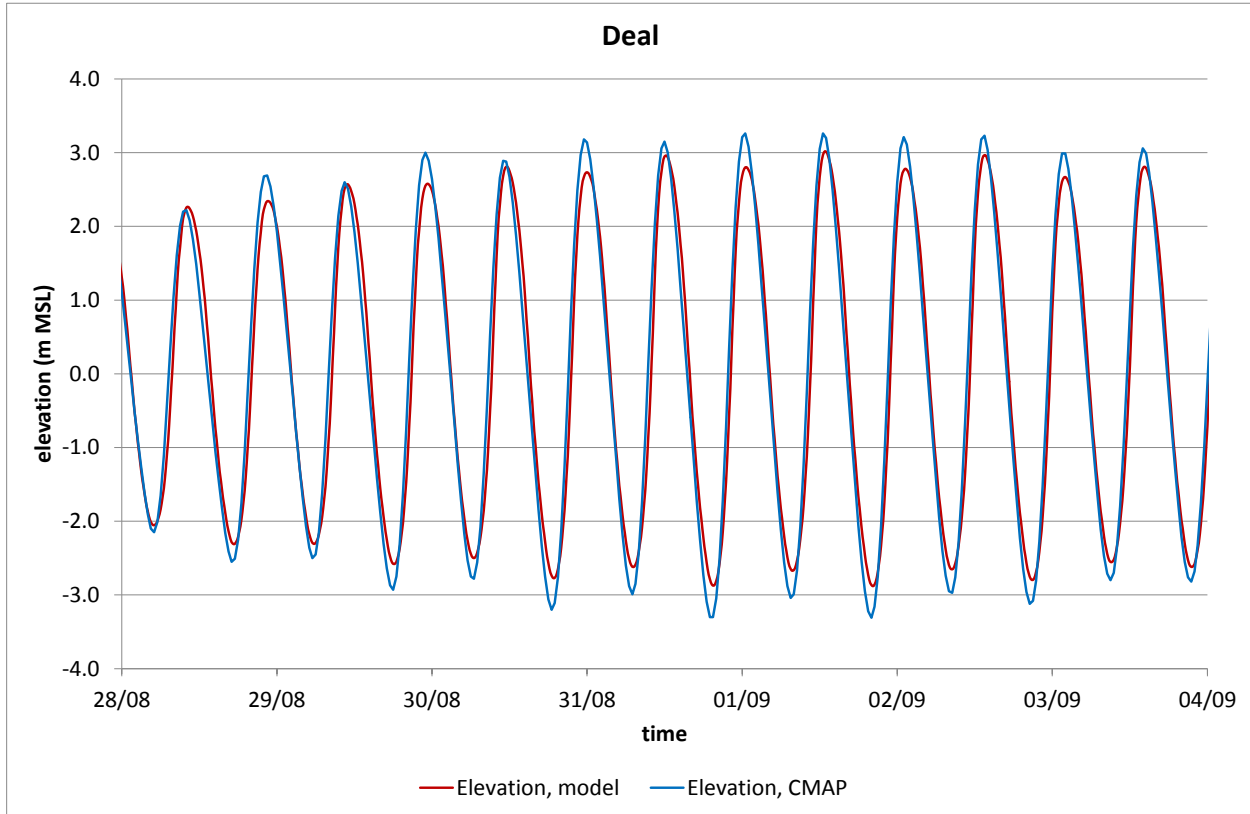


Figure 3.11: Comparison of modelled and synthesized tidal elevation at Deal 28/08/15 – 04/09/15

3.3. Predictive runs

The TELEMAC-2D model was re-run for the same simulation period as used for the validation exercise with the dredging completed, using the bathymetry illustrated in Figure 2.3. The difference between the model depth average current speed with dredging and without dredging was calculated.

Figure 3.12 to Figure 3.15 plot snapshots of the velocity vectors superimposed on speed coloured contours for four times using the baseline (pre-dredge) bathymetry. For reference the outline of the dredged area is also plotted on these figures as a black polyline. Figure 3.12 shows the current pattern for the time of maximum flow to the north (01:00, 01/09/15). Figure 3.13 shows equivalent results for the time of maximum flow to the south (09:00, 01/09/15). Figure 3.14 is the situation at the time at which there is the largest speed increase (09:50, 01/09/15) and Figure 3.15 shows the model results at the time at which there is the largest speed reduction predicted (22:40, 31/08/15).

These four times capture the range of effects of the dredge at the times of largest currents and the largest effect of the dredge at any time in the simulation. In this way the complete footprint of effect of the proposed dredging on tidal currents can be understood.

Figure 3.16 to Figure 3.19 plot the speed difference at the same times as the velocity vector figures. The largest effects of the dredging are shown by Figure 3.18 and Figure 3.19. Figure 3.18 shows that the

maximum speed increase is between 0.15 and 0.2 m/s. Figure 3.19 shows that the maximum speed decrease is between 0.1 and 0.15 m/s.

All of the current speed differences due to the dredging in excess of 0.05 m/s have been found to be within about 1 km from the proposed dredging area. Hence no widespread effect on tidal currents due to the proposed dredging is anticipated.

3.4. Footprint of effect

The tidal flow modelling has predicted the effect of the dredging on tidal currents for various tidal ranges. To provide a footprint of potential effect on tidal currents associated with the dredge the absolute (positive or negative) differences in the pre and post-dredge tidal current speeds have been calculated every 10 minutes during the 54 day simulation. The maximum current speed difference predicted at any stage of the simulation was then calculated and compared to the maximum current speed predicted. A 5% threshold was used to show the area within which any effect on tidal currents might be detectable as shown by Figure 3.20. The threshold of 5% does not necessarily suggest a significant effect will occur within this area however for changes in current smaller than this value any effect of the dredging on tidal currents can be considered as negligible. It can be seen that the predicted footprint of effect on tidal currents does not extend to any of the sensitive sites shown in Figure 1.2.

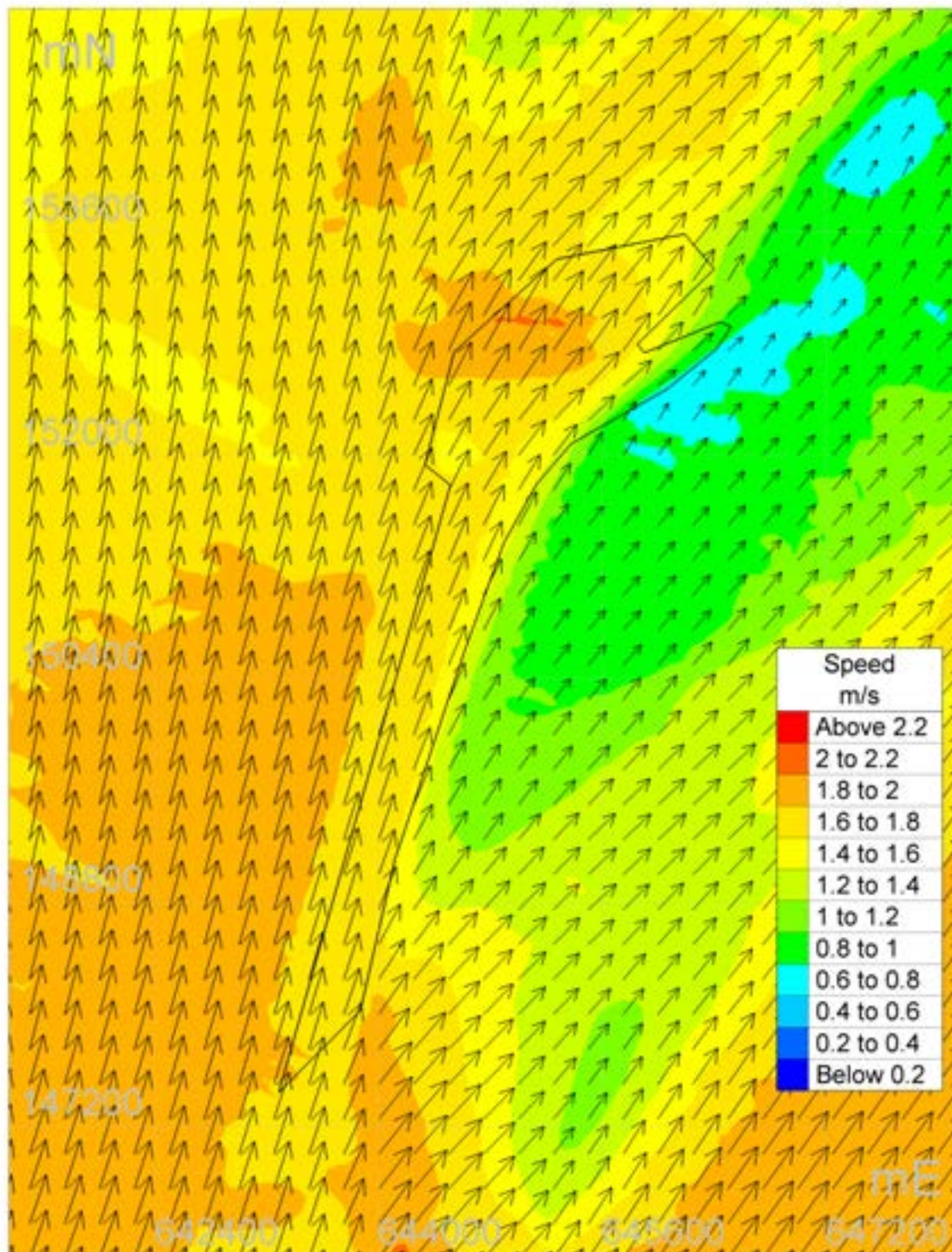


Figure 3.12: Baseline tidal current at time of maximum current towards the north, with proposed dredge area indicated by the black polygon

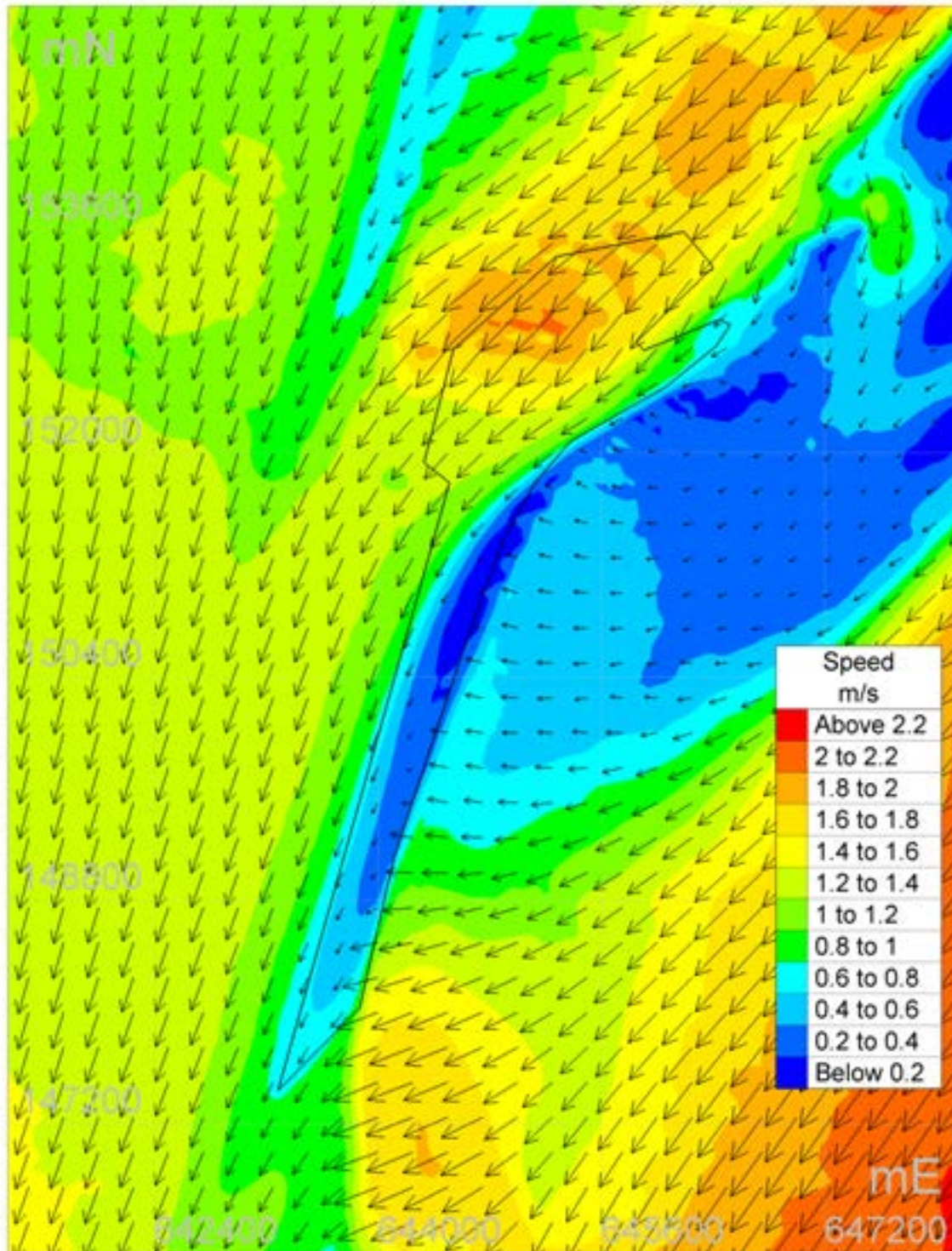


Figure 3.13: Baseline tidal current at time of maximum current towards the south, with proposed dredge area indicated by the black polygon

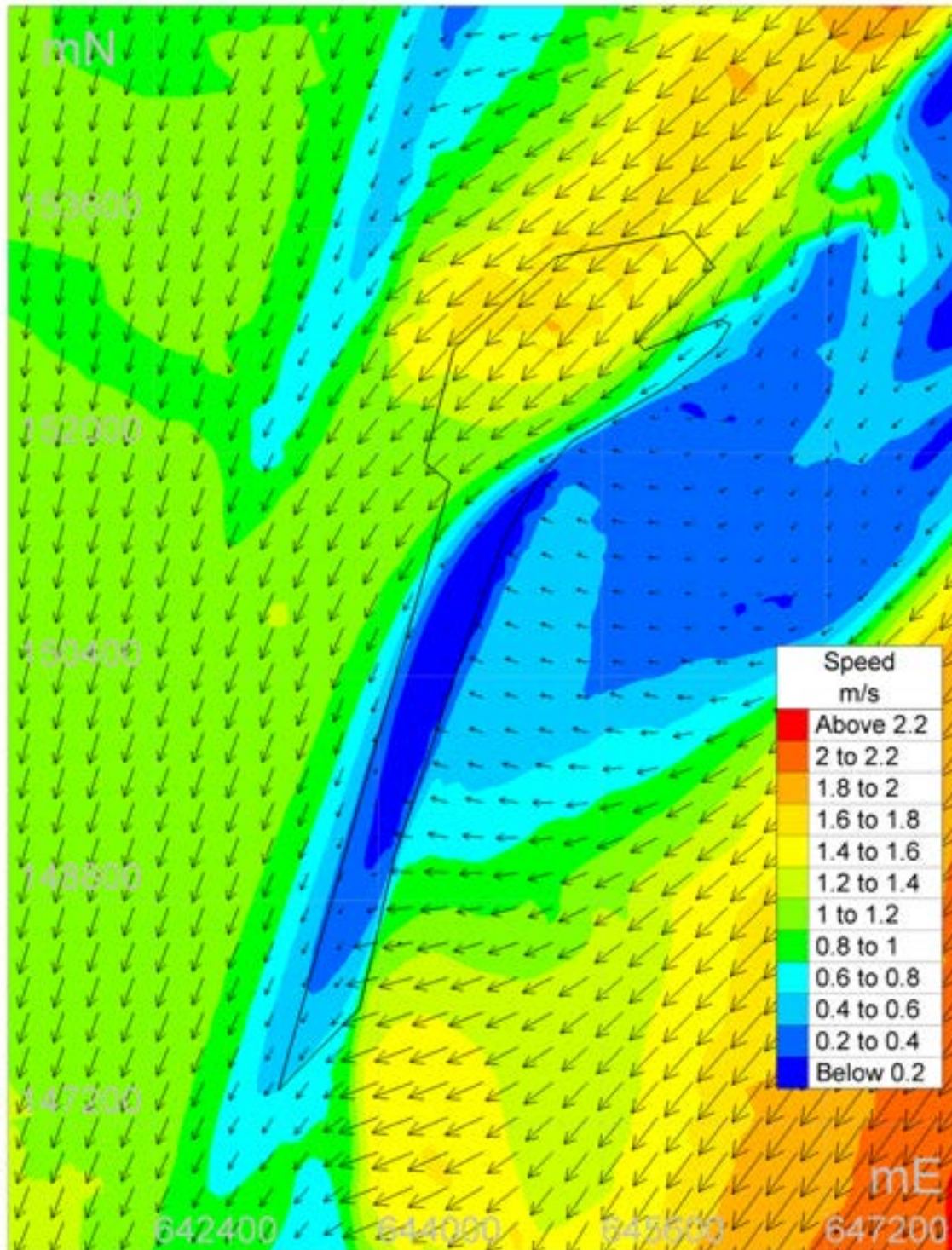


Figure 3.14: Baseline tidal current at time of maximum current increase, with proposed dredge area indicated by the black polygon

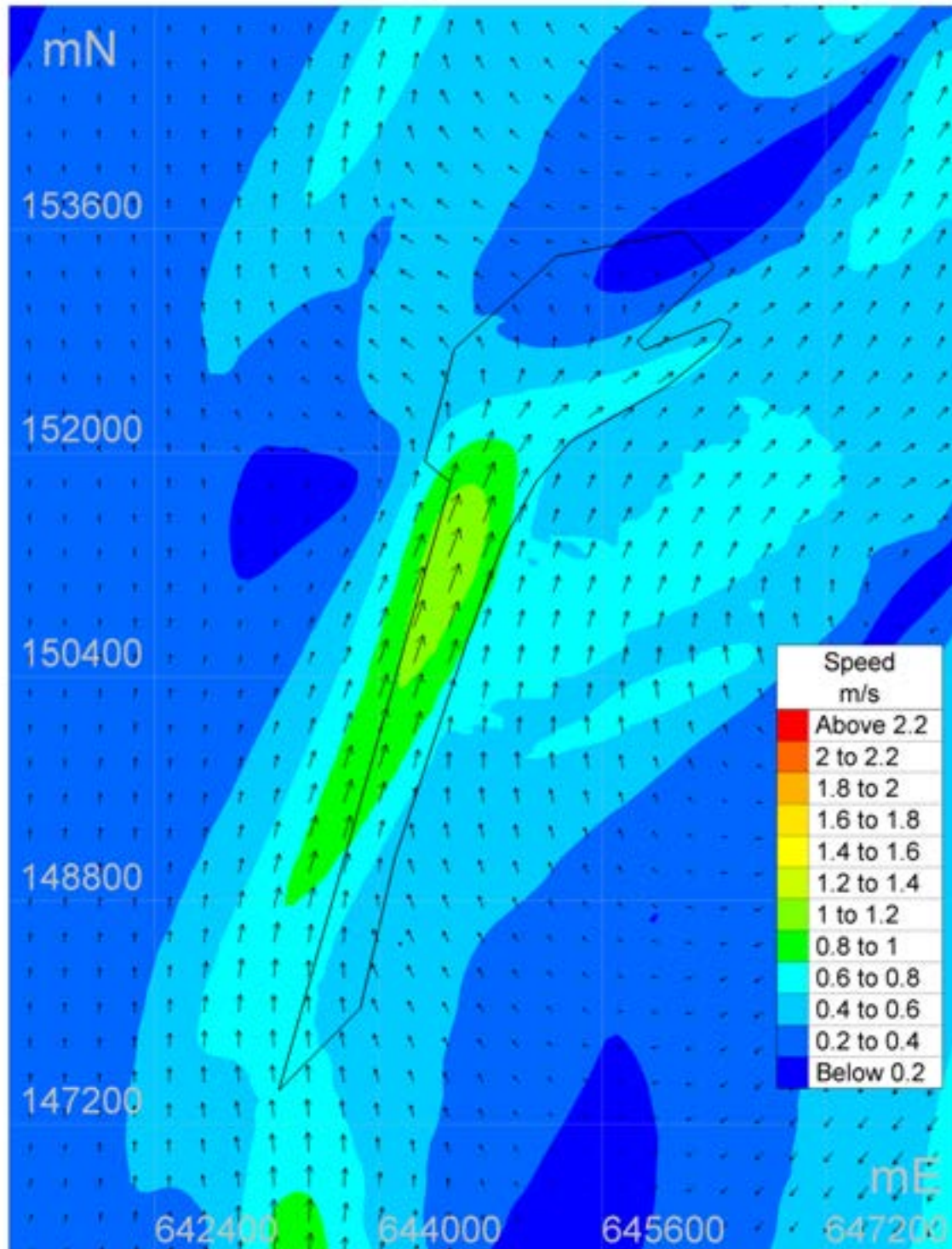


Figure 3.15: Baseline tidal current at time of maximum current reduction, with proposed dredge area indicated by the black polygon

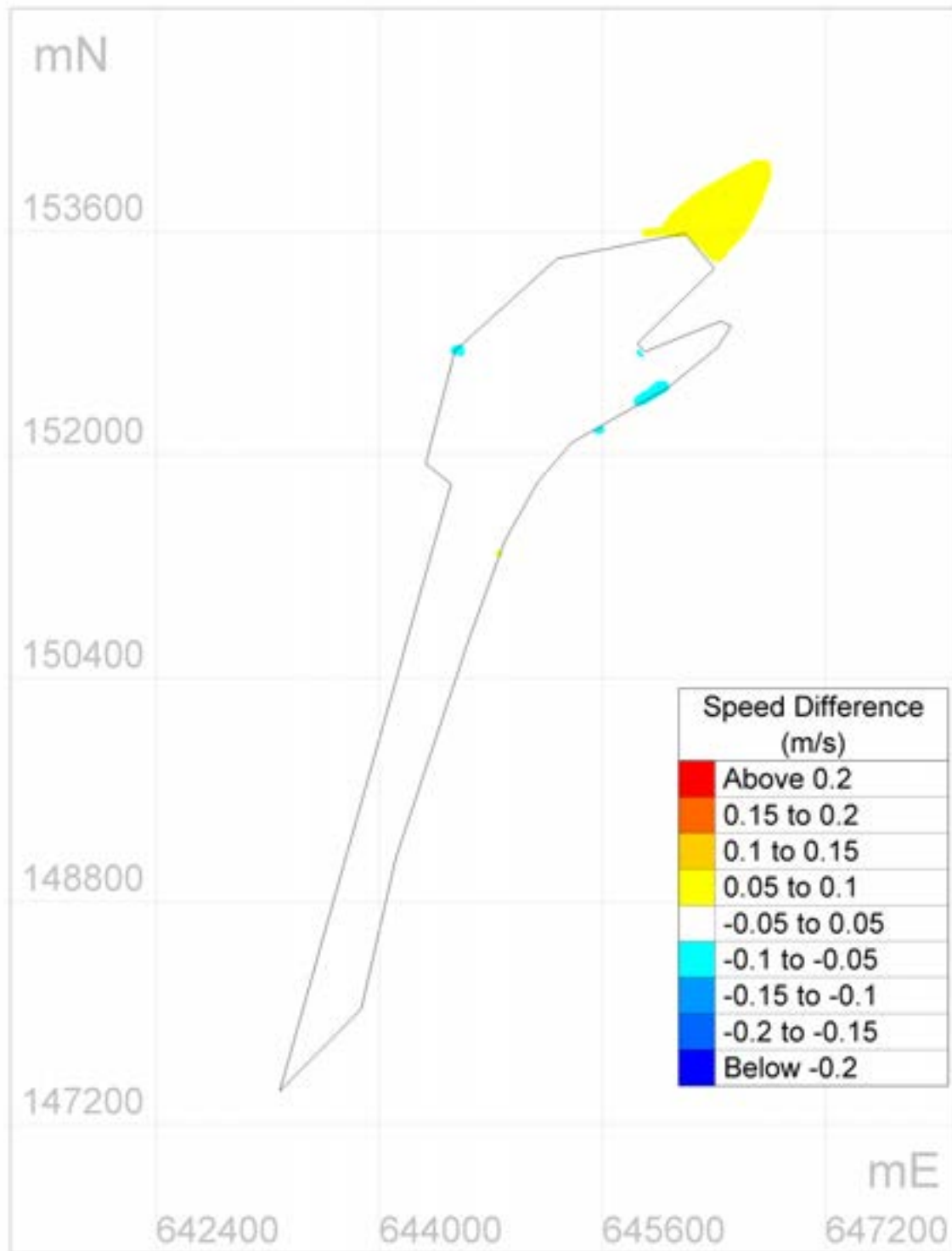


Figure 3.16: Difference in tidal current at time of maximum current towards the north, with proposed dredge area indicated by the black polygon

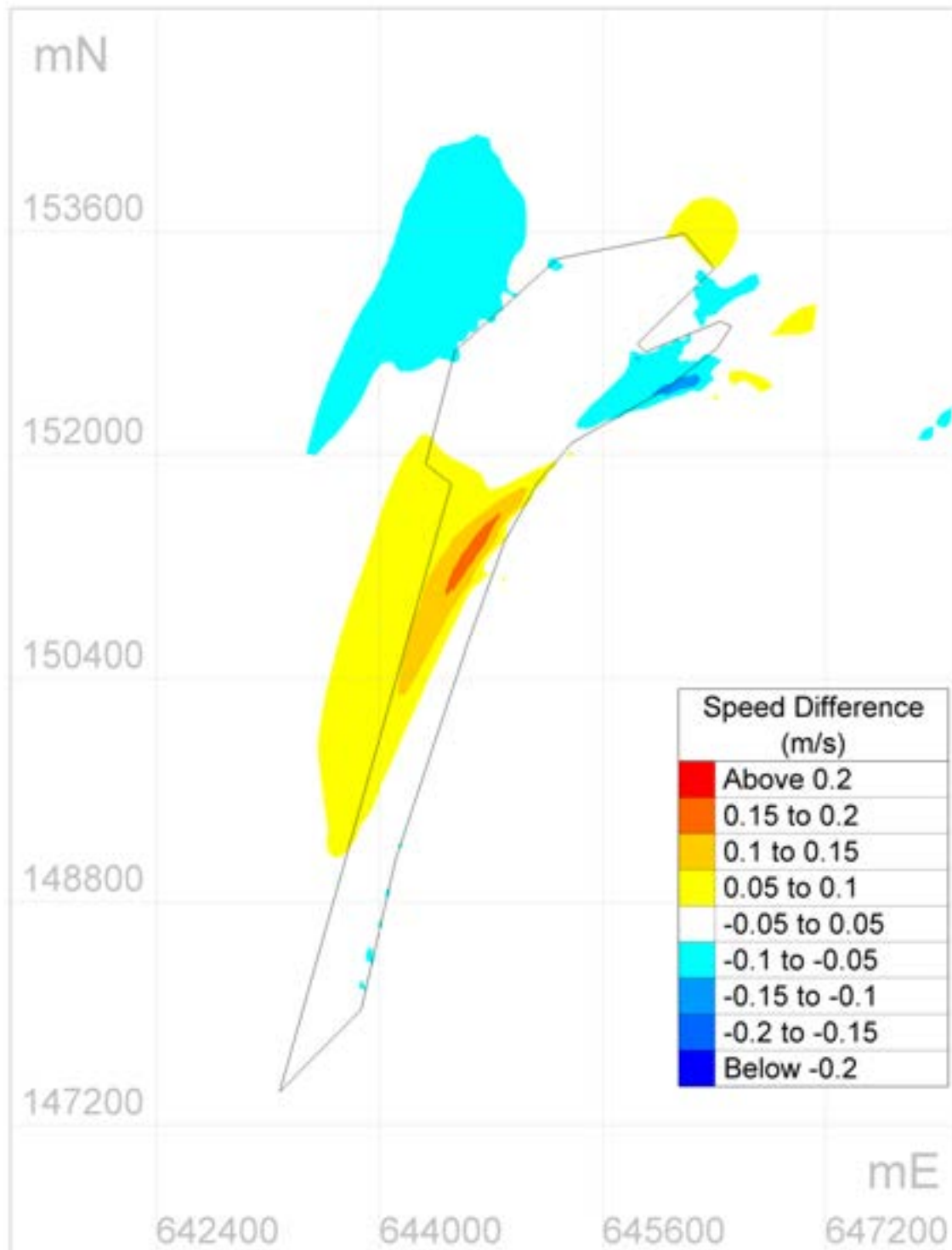


Figure 3.17: Difference in tidal current at time of maximum current towards the south, with proposed dredge area indicated by the black polygon

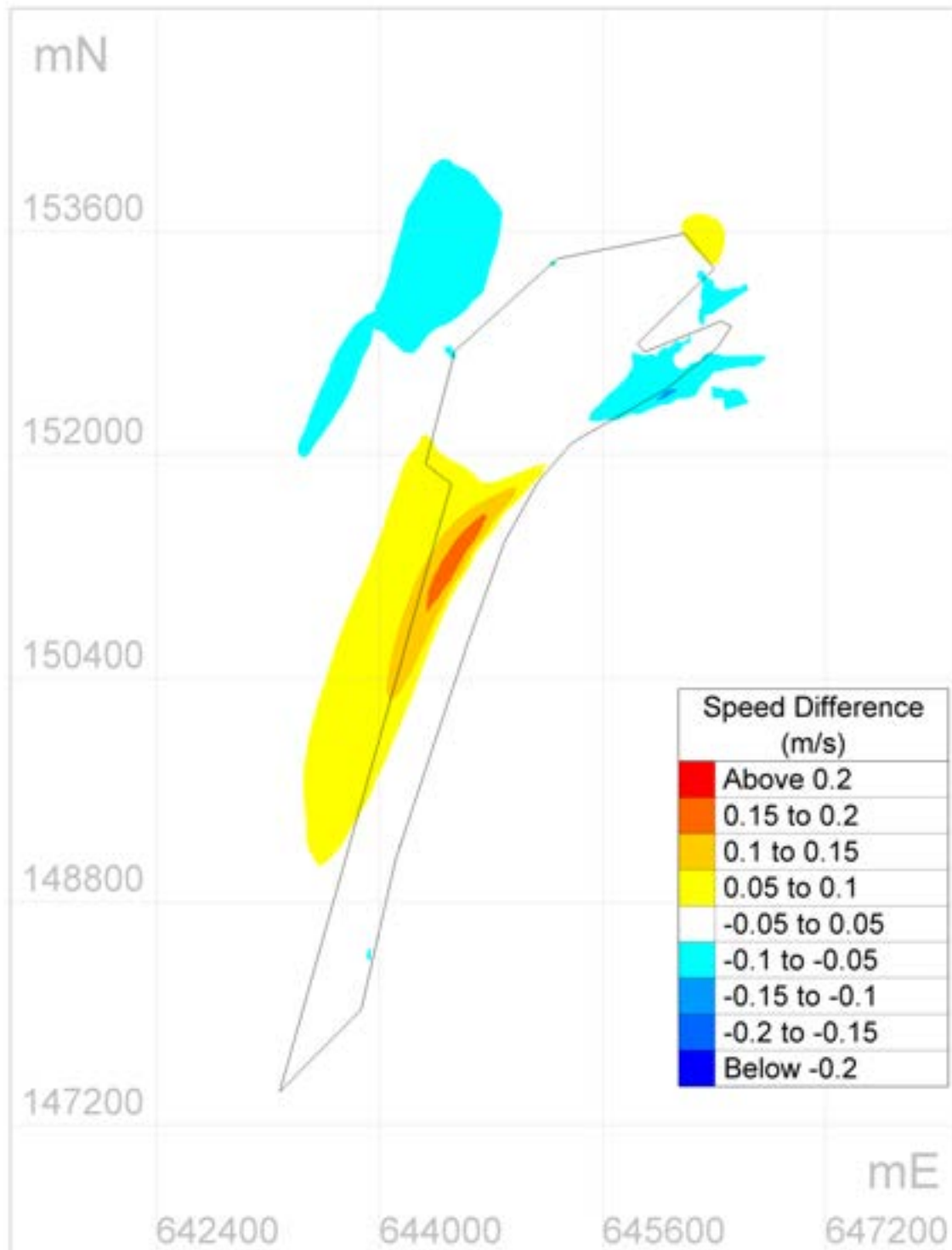


Figure 3.18: Difference in tidal current at time of maximum current increase, with proposed dredge area indicated by the black polygon

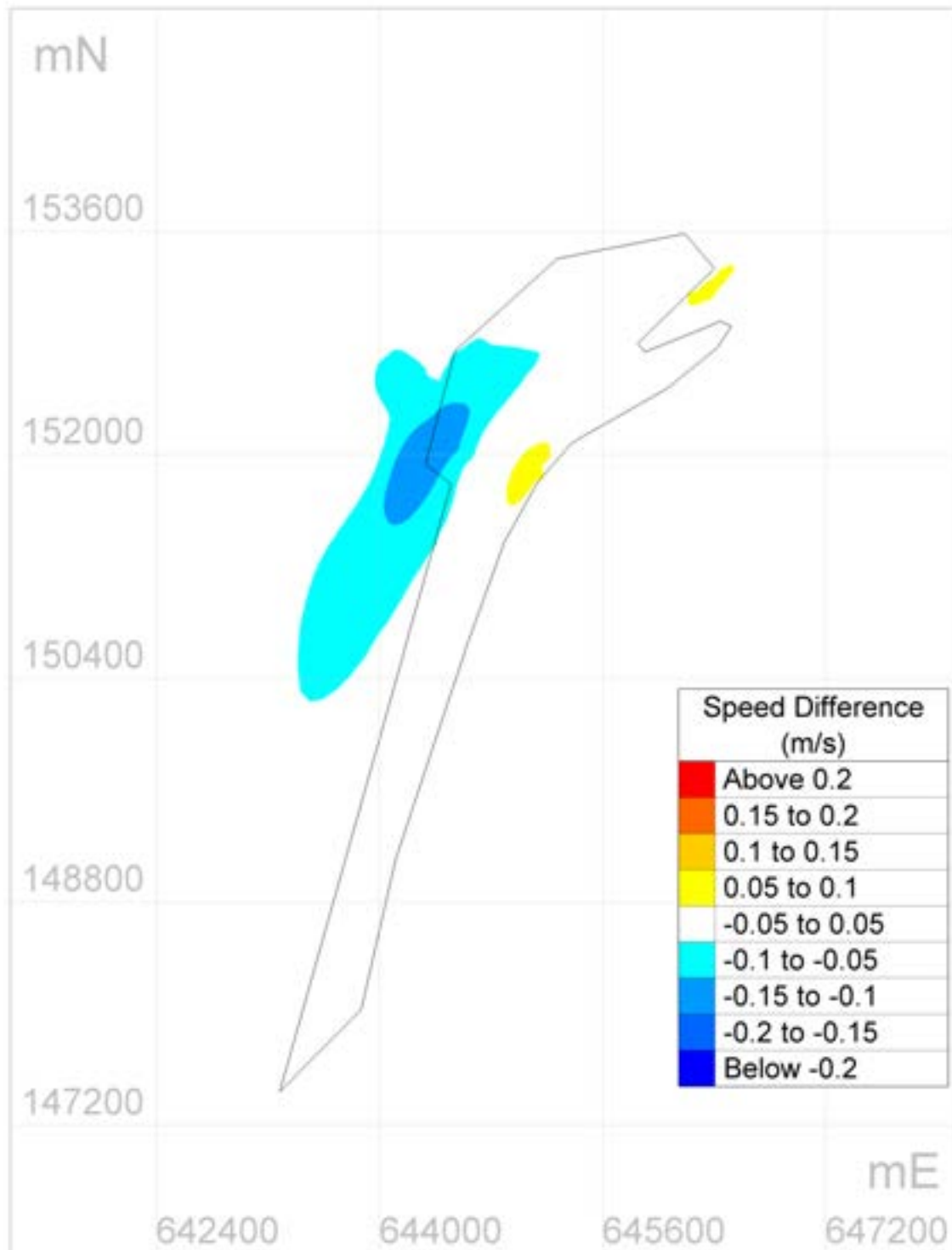


Figure 3.19: Difference in tidal current at time of maximum current decrease, with proposed dredge area indicated by the black polygon

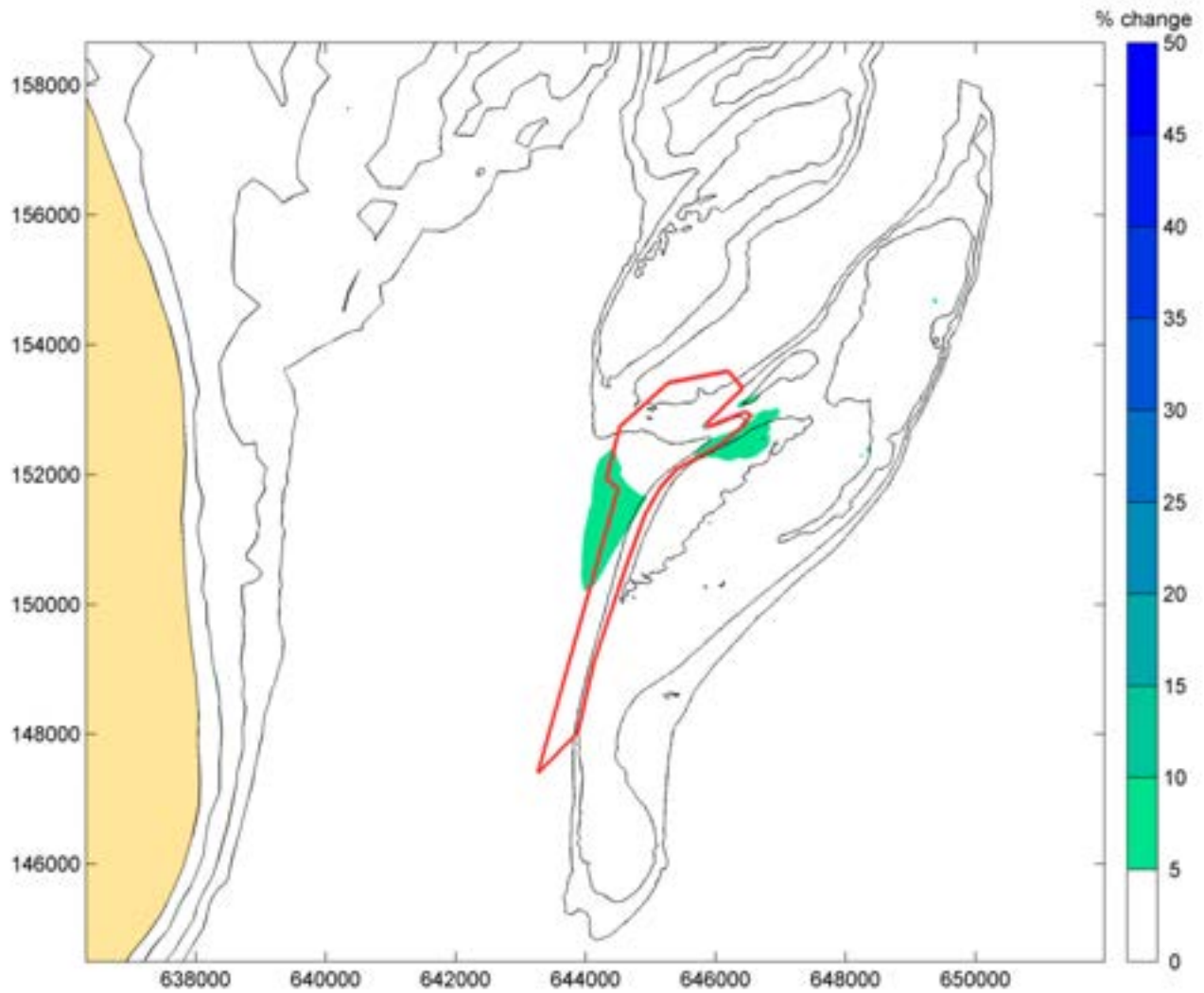
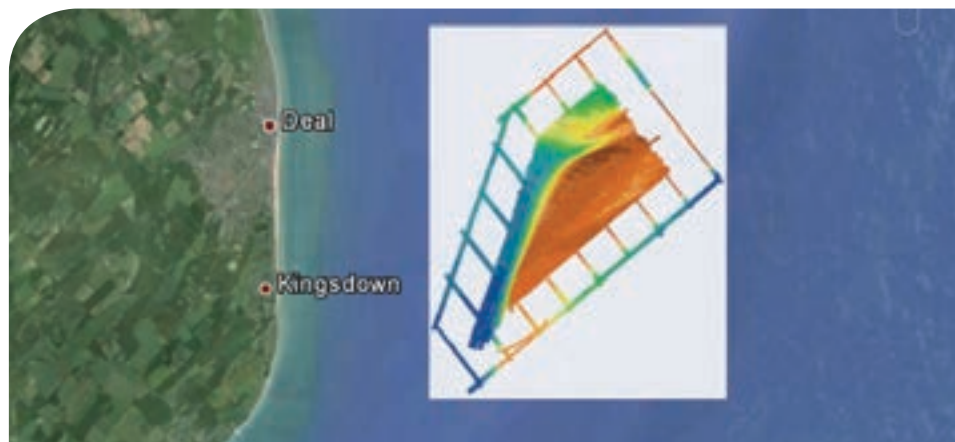


Figure 3.20: Footprint of effect of dredging on tidal currents

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EGS (2015). Goodwin Sands geophysical Survey. Operations Report. EGS Job No. 5432.

HR Wallingford (2008). Goodwin Sands, Study of historical changes. Technical Note DDM6067_TN01.



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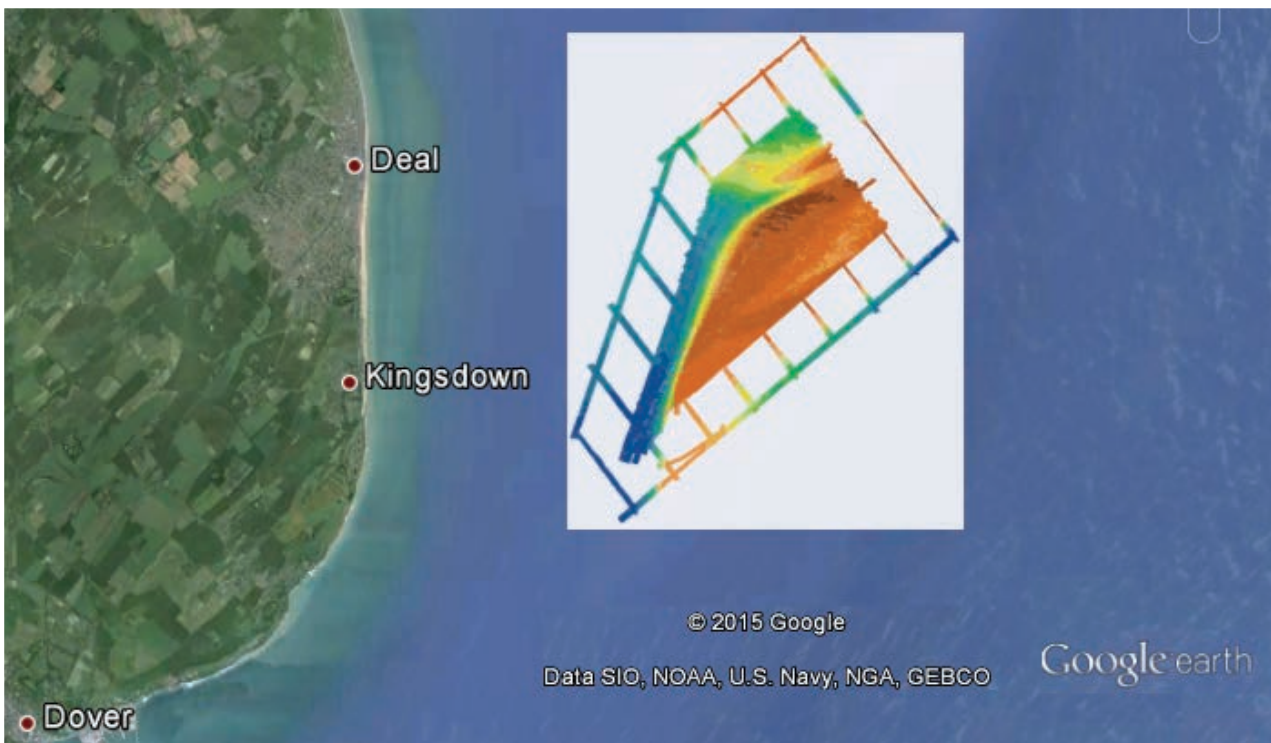
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C. Sediment transport modelling report

Goodwin Sands Aggregate Dredging Coastal Impact Study and EIA

Sediment Transport and Morphology



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Executive Summary

Dover Harbour Board (DHB) is proposing to dredge sand and gravel from the South Goodwin Sands off the coast of Kent for use as fill material for the Dover Western Docks Revival development at the Port. DHB is proposing to dredge up to 2.5 million m³ of sand and gravel from the subtidal parts of the South Calliper sandbank at the South Goodwin Sands, located approximately 12 km north east of the Port of Dover (Figure 1.1). Marine aggregate dredging requires a Marine Licence from the Marine Management Organisation (MMO). Royal HaskoningDHV, on behalf of the DHB, is undertaking an Environmental Impact Assessment (EIA) to support the application for a Marine Licence for consent to dredge.

HR Wallingford is providing inputs to the EIA and Coastal Impact Study (CIS), establishing the magnitude, spatial extent and duration of changes to the physical environment. The focus of the modelling described in this report is on changes in sediment transport and morphology caused by the proposed dredging on the Goodwin Sands.

The sediment transport model SISYPHE has been used to calculate the sediment transport patterns and rates around Goodwin Sands. The results from simulations with and without the proposed aggregate dredging have been compared to assess the impact of the dredging on the sediment transport and consequential seabed changes.

The modelling suggested only small changes in the residual sediment transport and erosion/deposition pattern due to the proposed dredging. These changes are all close to the proposed dredging area and in most locations are evidenced by a reduction in predicted potential erosion rate within the dredging area, and a reduction of potential deposition rate in the deeper channel areas next to the dredging area. No impact on the sediment transport processes which control the naturally changing form of the South Goodwin Sands, including the intertidal areas of the sandbanks, is predicted.

The sediment transport results suggest that there is a small northward sediment transport pathway from the Straits of Dover, which feeds Goodwin Sands with additional material, although the amount of material available for transport there is very limited. Little or no sediment escapes from the banks of the Goodwin Sands to the north. This suggests that the volume of the banks is expected to be stable, perhaps even growing at a very slow rate.

This view of a generally stable bank volume is confirmation of earlier work that concluded that the volume of the sandbanks is constant or gradually increasing.

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1. Introduction

1.1. Background to the modelling study

Dover Harbour Board (DHB) is proposing to dredge sand and gravel from the South Goodwin Sands off the coast of Kent for use as fill material for the Dover Western Docks Revival development at the Port. DHB is proposing to dredge up to 2.5 million m³ of sand and gravel from the subtidal parts of the South Calliper sandbank at the South Goodwin Sands, located approximately 12 km north east of the Port of Dover (Figure 1.1). Marine aggregate dredging requires a Marine Licence from the Marine Management Organisation (MMO). Royal HaskoningDHV, on behalf of the DHB, is undertaking an Environmental Impact Assessment (EIA) to support the application for a Marine Licence for consent to dredge.

HR Wallingford first considered the required studies to support dredging on the Goodwin Sands in 2008 when a phased, outline scope was proposed; including a historical bathymetric review and wave modelling to inform a CIS. The historical bathymetric review covering the period 1986-2006 was completed and reported on in HR Wallingford (2008).

For the present study HR Wallingford is providing inputs to the EIA and CIS, establishing the magnitude, spatial extent and duration of changes to the physical environment directly caused by the proposed aggregate dredging. The focus of the computer modelling described in this report is on changes, caused by dredging, on the wave and flow conditions and consequential changes in sediment transport patterns in and around Goodwin Sands, the adjacent sandbank system, in the nearshore waters and along the adjacent coastal areas.

The proposed dredge area lies close to various sensitive locations including protected wrecks, designated areas, anchorages and sites associated with particular ecological value such as seal haul out sites and sabellaria spinulosa reef as shown in Figure 1.2. The potential for the proposed dredging to change the physical processes at these sites requires particular attention.

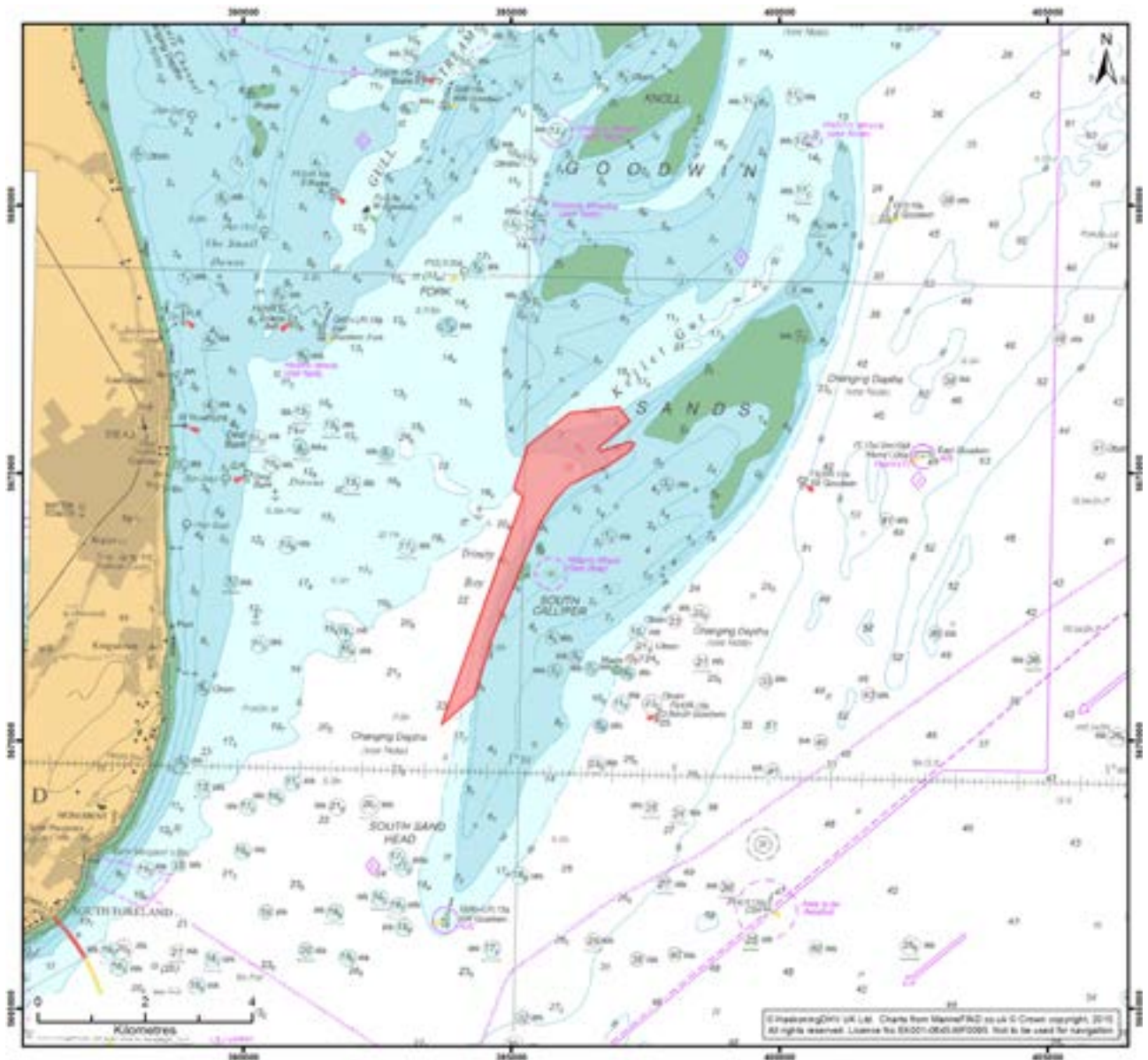


Figure 1.1: Location of proposed aggregate dredging area

Source: PHDHV Drawing PB2107_ES_003

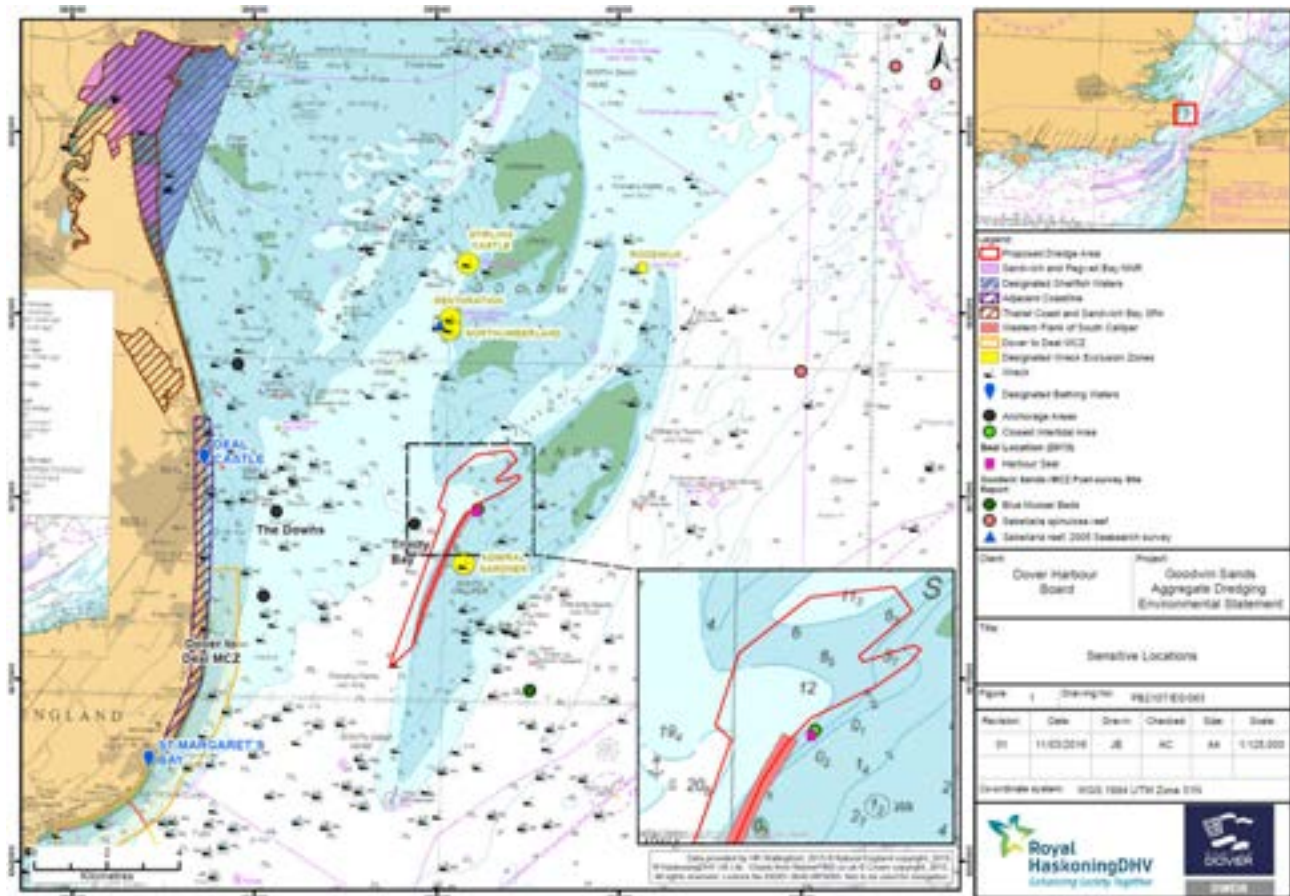


Figure 1.2: Sensitive locations in area of proposed aggregate dredging area

Source: RHDHV drawing PB2107_ES_063

2. Modelling approach

2.1. Sediment model

For this element of the study the validated, finite element based, depth-averaged flow model TELEMAC-2D and the integrated sediment transport model were employed to simulate sediment transport by tidal flows, enhanced by waves.

To simulate non-cohesive (sandy) sediment transport, the SISYPHE sediment transport module of the TELEMAC system was used. SISYPHE is the state-of-the-art sediment transport model used at HR Wallingford, capable of modelling sedimentary systems containing very fine to medium sands (with median grain diameters between 60 and 500 microns) which move along with the flow either in suspension or as bed load. The main factors controlling sand transport included in the model are: advection by currents, settlement under gravity, wave stirring, turbulent diffusion in all directions and exchange of sediment between the flow and the bed. Appendix A provides a technical description of the SISYPHE model.

Both TELEMAC-2D and SISYPHE use an unstructured triangular model mesh. This mesh allows complex coastlines and seabed features to be modelled accurately with user defined levels of detail applicable in a particular area of interest. Larger model mesh elements are used to remove the model's imposed boundary conditions away from the area of interest.

For this study, TELEMAC-2D, SISYPHE and the wave model SWAN have been run. The flow and sediment models are run fully coupled, with the orbital velocities being provided by the wave model fed back into TELEMAC-2D. The establishment and calibration of the flow model is described in HR Wallingford (2015b).

The SWAN wave model was used to simulate the propagation of wave energy through the model domain. For this element of the study, the structured grid version of SWAN was employed, which uses a finite difference mesh that covers an equivalent extent to the flow model mesh. To simulate the effects of varying water levels on the wave propagation, the SWAN model takes water level input from the flow model. The results from the wave model are then interpolated onto the nodes of the unstructured flow model mesh. For more information on the wave modelling undertaken see HR Wallingford (2015a).

The results from the wave simulation and the flow simulation were then combined to serve as input to SISYPHE to calculate the sediment transport patterns and resulting bed change infill.

2.2. Scenarios tested

The conditions represented in the models are briefly described as:

- A “baseline” case, that is the present-day bathymetry without dredging;
- A “just after dredging” scenario (Scenario 1), referring to the seabed bathymetry immediately after the full dredging of about 4,000,000 m³, achieved by dredging 1.12 m depth of aggregates but leaving at least 0.5 m of sand in accordance with established practice to facilitate recovery of benthic communities (see Figure 3.2).

The removed volume, described above, is a 60% enhancement of the target volume to be removed of 2,500,000 m³ as is typically done to provide precautionary impact predictions for aggregate dredging studies.

The vertical datum used for this study is Mean Sea Level (MSL). For convenience, levels are often reduced to mCD (Chart Datum at Deal) in the figures of this report.

3. Data sources

3.1. Bathymetry

The area of the EGS International Ltd bathymetry survey undertaken in 2015 is shown in Figure 3.1. It is shown to provide a good coverage of the South Goodwin Sands. It is noted that the southernmost face of the sandbank is only defined by transverse 1 km spaced, cross-sections extending about one kilometre away from the main survey area.

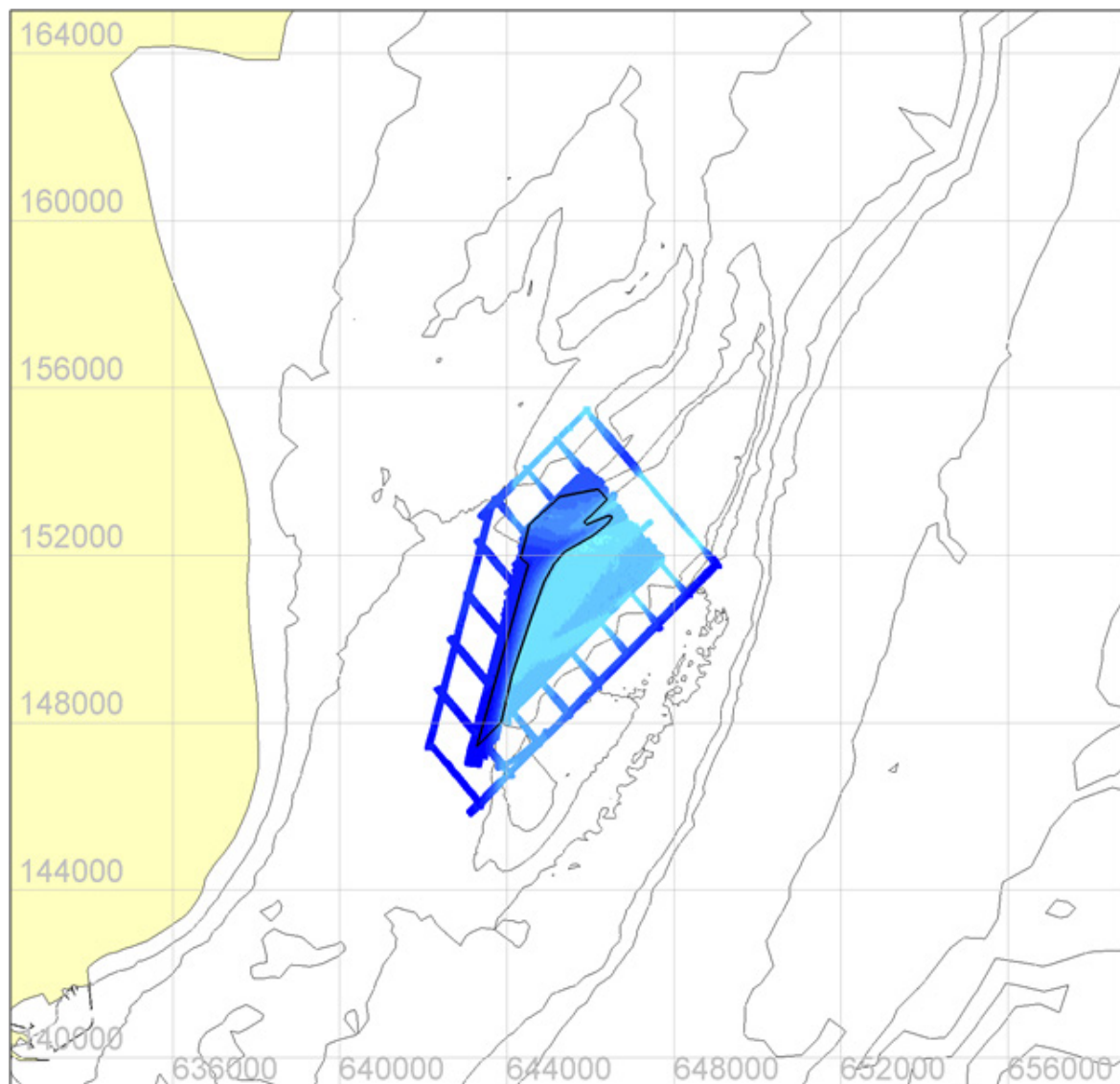


Figure 3.1: Spatial extent of the 2015 bathymetric survey of the Goodwin Sands. Proposed dredge area shown as black polygon.

Source: EGS International Ltd (2015)

Additional bathymetry data for the rest of the model area were taken from:

- recent TruDepth bathymetry from SeaZone, using the latest available survey data from the Admiralty;

- nautical chart data in European waters.

Bathymetry data from these different sources were merged for use in the baseline models, where more recent / resolved data took precedence over older or less resolved data. The representation of the baseline and post dredged bathymetries, for use in the sediment transport model, is shown in Figure 3.2. The same data were used to develop the representations of the baseline and post dredging bathymetries in the flow and wave models.

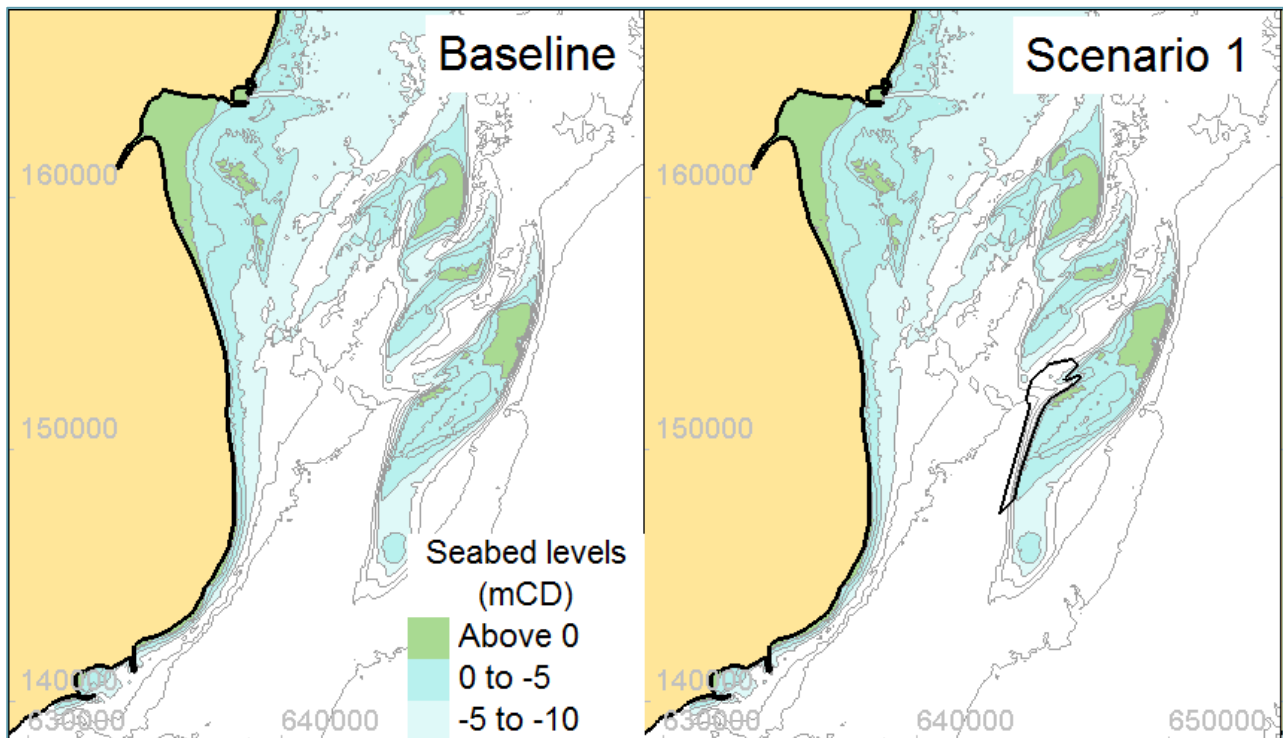


Figure 3.2: Baseline and post-dredging bathymetries used in the sediment transport model (black polygon on right hand image shows proposed dredging area)

3.2. Sediment

The composition of the seabed sediments around the aggregate dredging area is very mixed, with median grain sizes ranging from 168 microns to 37 mm. Surficial bed grab data taken for a benthic survey as part of the project (Marine Ecological Surveys Ltd, 2015) shows South Goodwin Sands as being predominantly fine (125-250 μm) and medium (250-400 μm) sand (Figure 3.3). As the sediment transport fluxes are expected to be dominated by the finer sediment fractions, the modelling has sought to investigate the worst case scenario of a uniform bed material of 100 μm . This will identify the largest potential sediment transport rates and hence show the largest potential change in these rates and the largest likely range of morphological change associated with the proposed dredge. For the purposes of the study abundant sand was assumed to be present throughout the model domain.

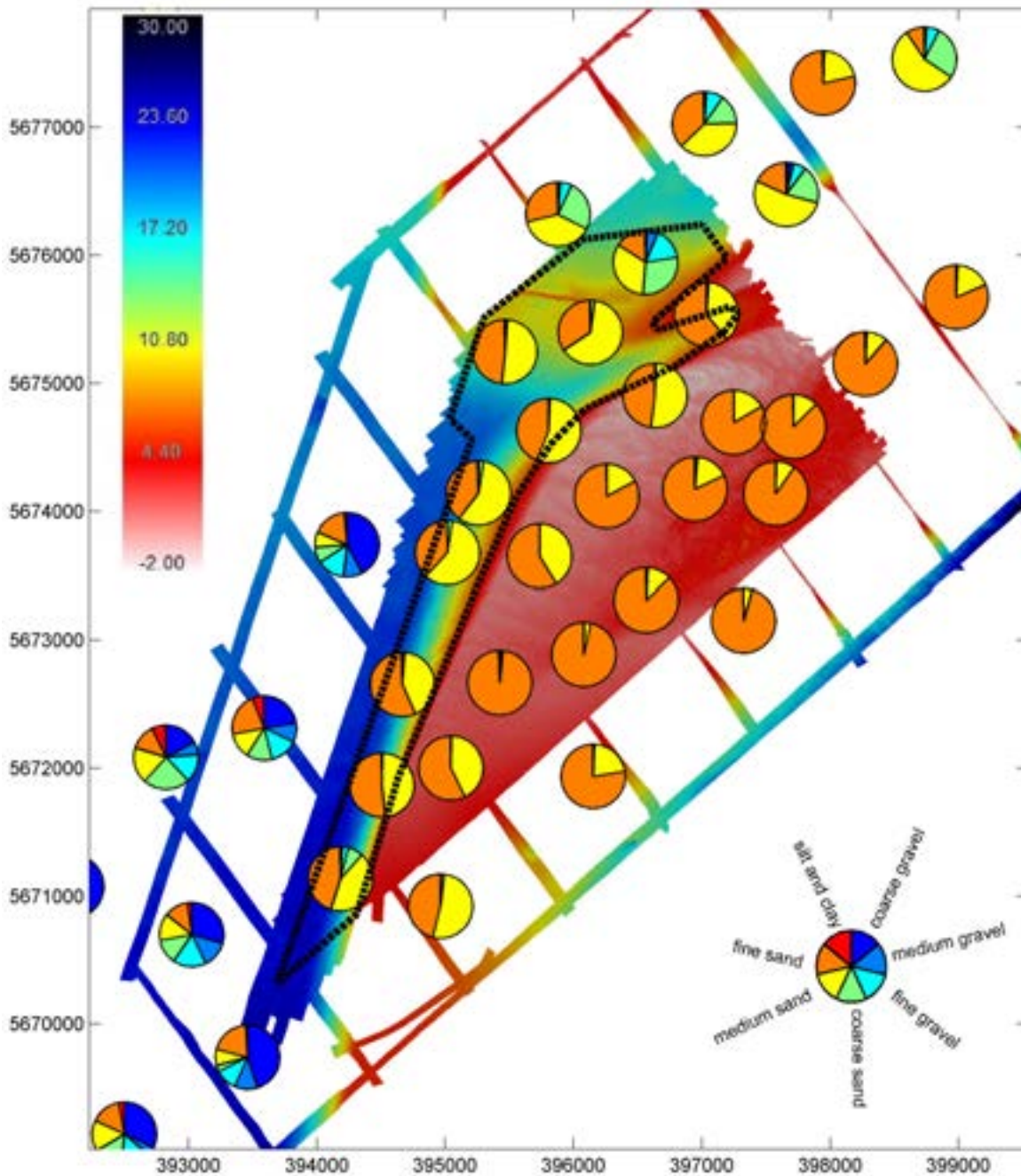


Figure 3.3: Surficial sediment types present at South Goodwin Sands

Source: Marine Ecological Surveys Ltd (2015)

3.3. Hydrodynamic inputs

The sediment transport modelling uses the calibrated flow and wave models of the present study (described in HR Wallingford, 2015a and 2015b). It uses the first spring neap cycle modelled in the flow model report, considered to be a typical cycle representative for the local flow conditions. The wave model is applied for a set of conditions to represent the yearly averaged sediment transport conditions. The choice of wave conditions is described in Section 3.4.

3.4. Representative wave conditions

For morphodynamic predictions, sediment transport is calculated for a typical tidal cycle combined with a representative wave condition, following Chesher *et al* (2005). This method uses energy considerations to derive representative wave height, which gives the same sediment transport rates for one wave condition as would result from modelling using a whole year's wave climate. This representative wave height H_{rep} is calculated for every relevant wave direction using:

$$H_{rep} = \left(\frac{\sum_{i=1}^n f_i H_i^{\vartheta}}{\sum_{i=1}^n f_i} \right)^{\frac{1}{\vartheta}},$$

in which H_i is the wave height of wave i from the wave climate that occurs with frequency f_i . Finally, ϑ is a power, which should be equal to 4.3 for situations with wave driven currents, where wave breaking is important or 2.4 for situations where only wave stirring is important. A value of 2.4 has been used in the present study as the sediment transport is due to currents with wave stirring.

From the open source UKMO wave data, which covers a period of 30 years, the offshore wave climate at the study area was extracted as presented in Table 3.1.

Table 3.1: Wave climate data, with counts in parts per 100,000

Direction (°N)→		346	16	46	76	106	136	166	196	226	256	286	316
↓Height, H _s (m)		15	45	75	105	135	165	195	225	255	285	315	345
0	to 0.5	2549	907	263	151	121	103	121	278	1407	1761	1315	1645
0.5	to 1	7872	3883	1953	1139	920	911	1238	2106	5001	3549	2535	3099
1	to 1.5	3586	2844	1790	742	445	512	886	2788	4860	2868	2279	1871
1.5	to 2	1466	1222	806	297	141	190	518	2138	3730	1576	704	1115
2	to 2.5	820	840	495	109	30	46	237	1144	2514	1222	432	701
2.5	to 3	473	350	270	23	9	9	60	610	1514	632	201	436
3	to 3.5	256	100	55		2		21	173	580	306	117	238
3.5	to 4	57	64					2	36	194	139	18	48
4	to 4.5	18	18					2	4	53	48	11	16
4.5	to 5									11	16	4	7
5	to 5.5										2		4
5.5	to 6										5		
6	to 6.5							2	278	1407	1761	1315	1645
Probability of occurrence (%)		17.1	10.2	5.6	2.5	1.7	1.8	3.1	9.3	19.9	12.1	7.6	9.2

Using the calculation above, the representative waves were determined (Table 3.2) from this wave climate. All waves with a direction between 226 and 255 degrees north are neglected as these waves propagate offshore and therefore any effects of the dredging will not influence the coastline. The remaining directions are grouped in pairs to derive 3 wave events that together represent 80% of the time. The remaining time is assumed to have a calm sea state.

Table 3.2: Wave model runs for input in the sediment transport model

Boundary wave condition			Wind condition		Sea levels
H _s	T _p	Dir	Speed	Dir	
(m)	(s)	(°N)	(m/s)	(°N)	(mCD)
1.39	6.2	350	10.7	350	1.50 and 3.56
1.47	5.9	41	11.6	41	1.50 and 3.56
1.74	6.7	231	12.3	231	1.50 and 3.56

Results for the wave modelling on the baseline bathymetry are presented in Figure 3.4 in the form of area plots of significant wave height from individual representative model runs.

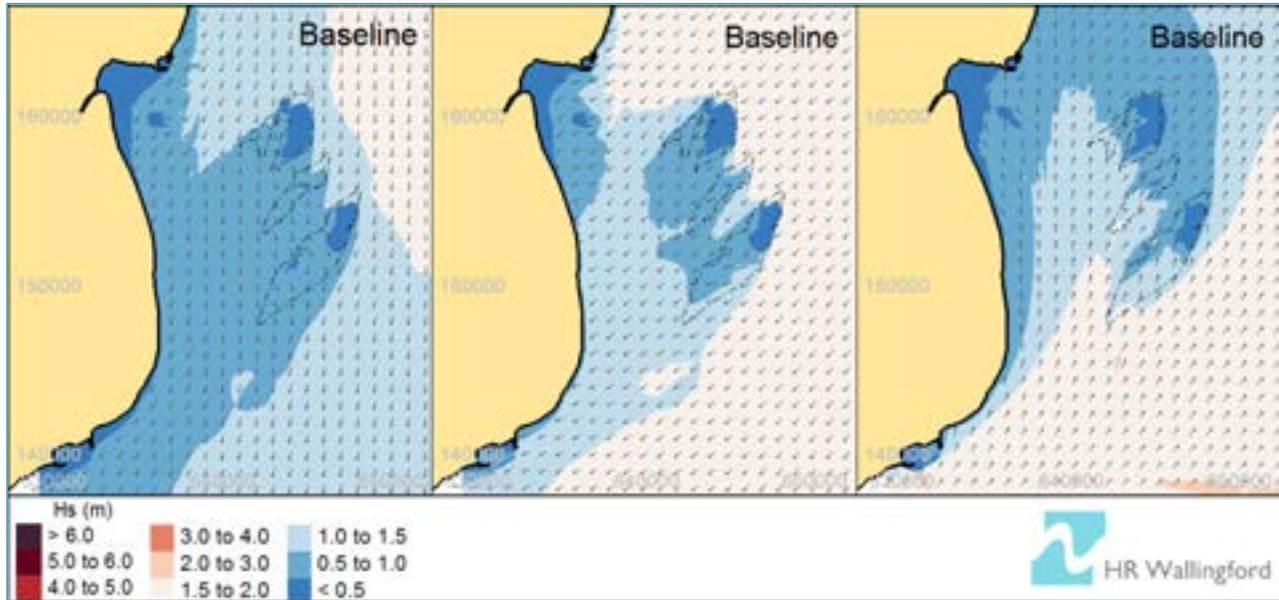


Figure 3.4: Baseline H_s at Mean Low Water with “representative” wind/wave conditions. Incident boundary wave directions from, left to right, 350°N, 41°N and 231°N.

4. Model results

The model simulations are presented by plotting the pattern and rate of sediment flux and by the predicted rate of bed change. The sediment flux is also summed over the simulated period to provide a view of the residual transport pattern – i.e. with the tidal variation removed.

The sediment modelling reveals that there is significant potential sediment transport in the area around Goodwin Sands. At the time of peak northward flow, the sediment transport is northward over the whole area. Contrastingly, during at the time of peak southward flow, whilst the sediment transport is southward in the deeper channels, very little transport is shown in the shallower areas between the sandbanks and the coast. The peak transport rates are about $2 \times 10^{-3} \text{ m}^2/\text{s}$, or $7 \text{ m}^3/\text{m}/\text{hour}$ (Figure 4.1 and Figure 4.2).

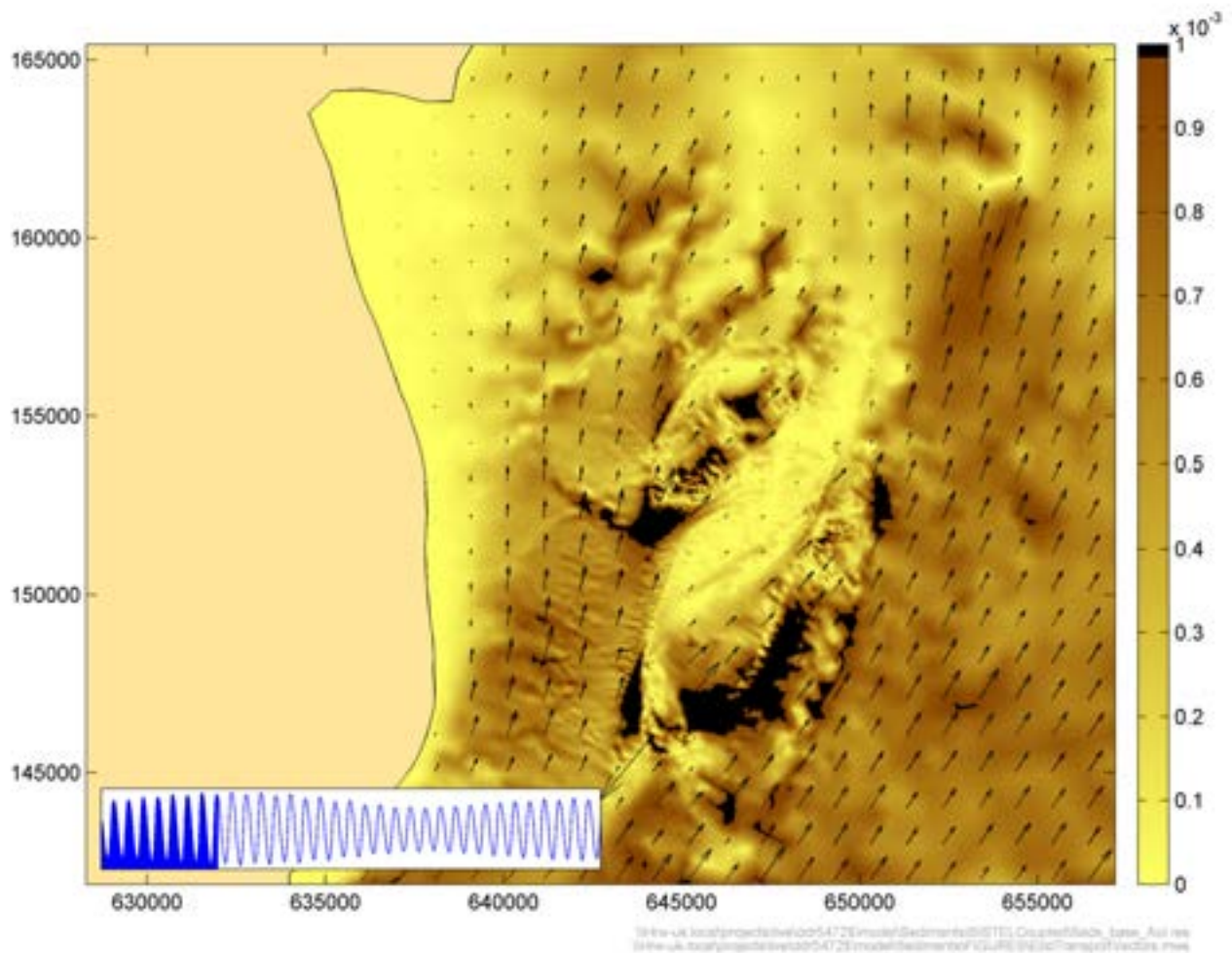


Figure 4.1: Peak northward sediment transport (colours and scaled vectors). The time series in blue shows the water level at the time of the plot

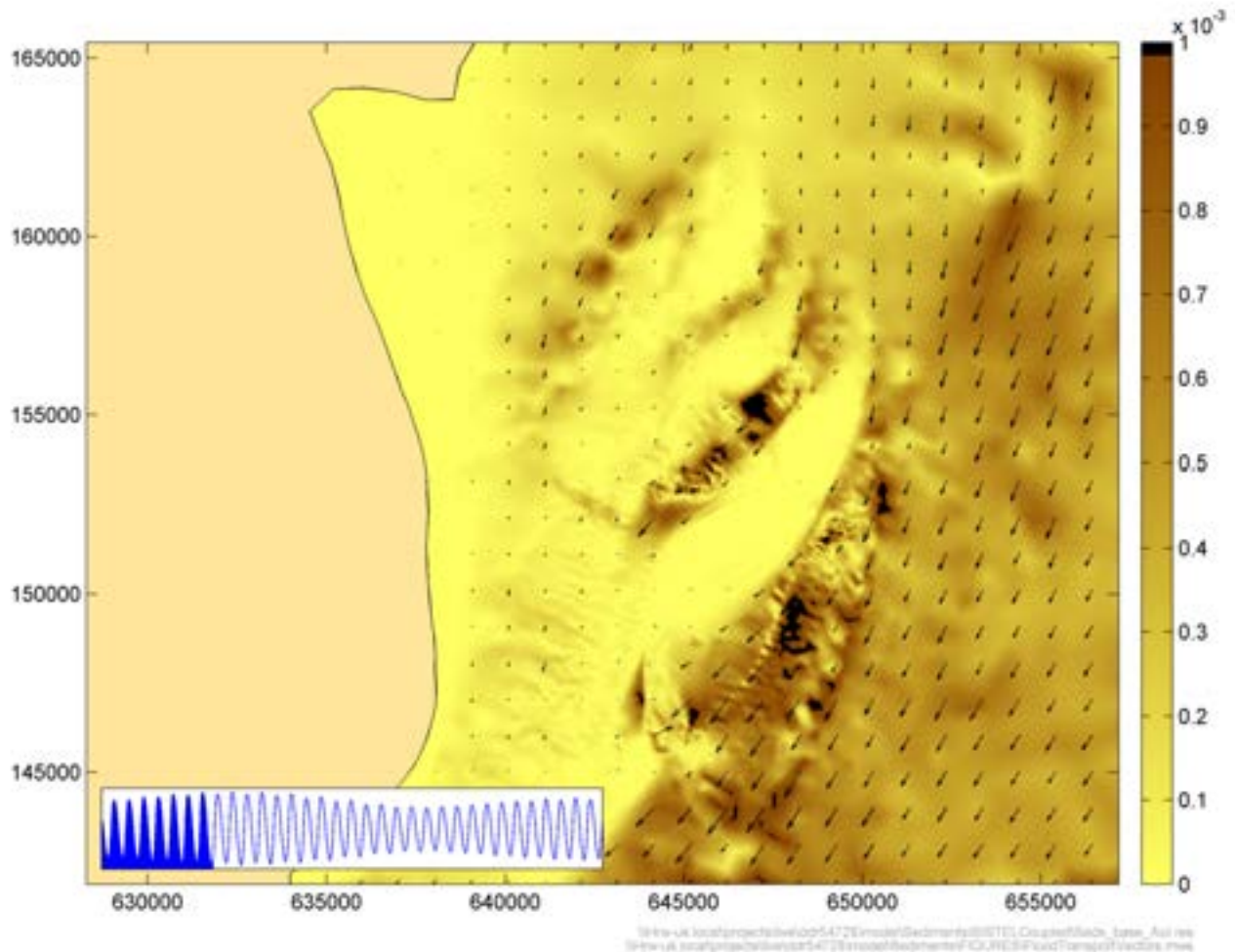


Figure 4.2: Peak southward sediment transport (colours and scaled vectors). The time series in blue shows the water level at the time of the plot

Averaged over the spring-neap cycle, the residual transport shows a sediment recirculation pattern around Goodwin Sands (Figure 4.3). The vectors show the sediment transport rates averaged over a spring-neap cycle, while the colours quantify the magnitude of the residual transport rates for the baseline situation. The highest values, near the slopes of Goodwin Sands, are about $0.0002 \text{ m}^2/\text{s}$, roughly 10% of the peak transport rates. In general, however, the residual transport rates are lower than this.

The pattern of residual sediment transport is dominated by the clockwise circulation around the sandbank system. This circulation cell is the driving mechanism for the sandbank maintenance. The model results indicate a potential sediment feed to the bank system from the south, with all residual transport going north. However, the actual amounts of material supplied are likely to be small, as there is very little sand present south of Goodwin Sands. To the north of the study area, the residual transport vectors are very small. This suggests that there is a little loss of material to the northwest of the banks, and potentially a small gain from the northeast.

As presented by Figure 4.3, comparison of the residual sediment transport vectors of the baseline case (white vectors) with those calculated for the dredged case (black vectors) show that the dredging has a very limited effect on the transport pattern. At the location of the dredging, the residual transport rates reduce, indicating that the system will compensate the deepening by depositing more/eroding less within the proposed dredge area (indicated by the green polygon). Additionally, small reductions of the residual transport rate are visible to the south, west and north of the dredging area. This suggests that minor changes in seabed composition may occur over time in this area due to reduced erosion or increased deposition. The important conclusion is that there are no significant deviations of sediment transport vectors from the baseline directions and hence the pattern of sediment circulation is not affected by the dredging.

The interpretation of the residual transport pathways is confirmed by the erosion and deposition pattern plotted below. Showing bed change is complicated as the same change could be an increase in erosion or reduction in deposition, depending on the background process occurring. The two figures below separate the changes in areas of baseline erosion (left frame) from areas of baseline deposition (right frame). Small but significant changes are predicted over the dredging location. These are mostly occurring as a reduction of the potential erosion rate (Figure 4.4, left frame) in areas where the model predicts erosion for the baseline situation. In locations where the baseline model predicts deposition, the impact is mostly a reduction of the deposition rate (Figure 4.4, right frame). By comparison of Figure 4.4 with Figure 1.2 it can be seen that no change in potential erosion or deposition patterns are predicted at the identified sensitive sites.

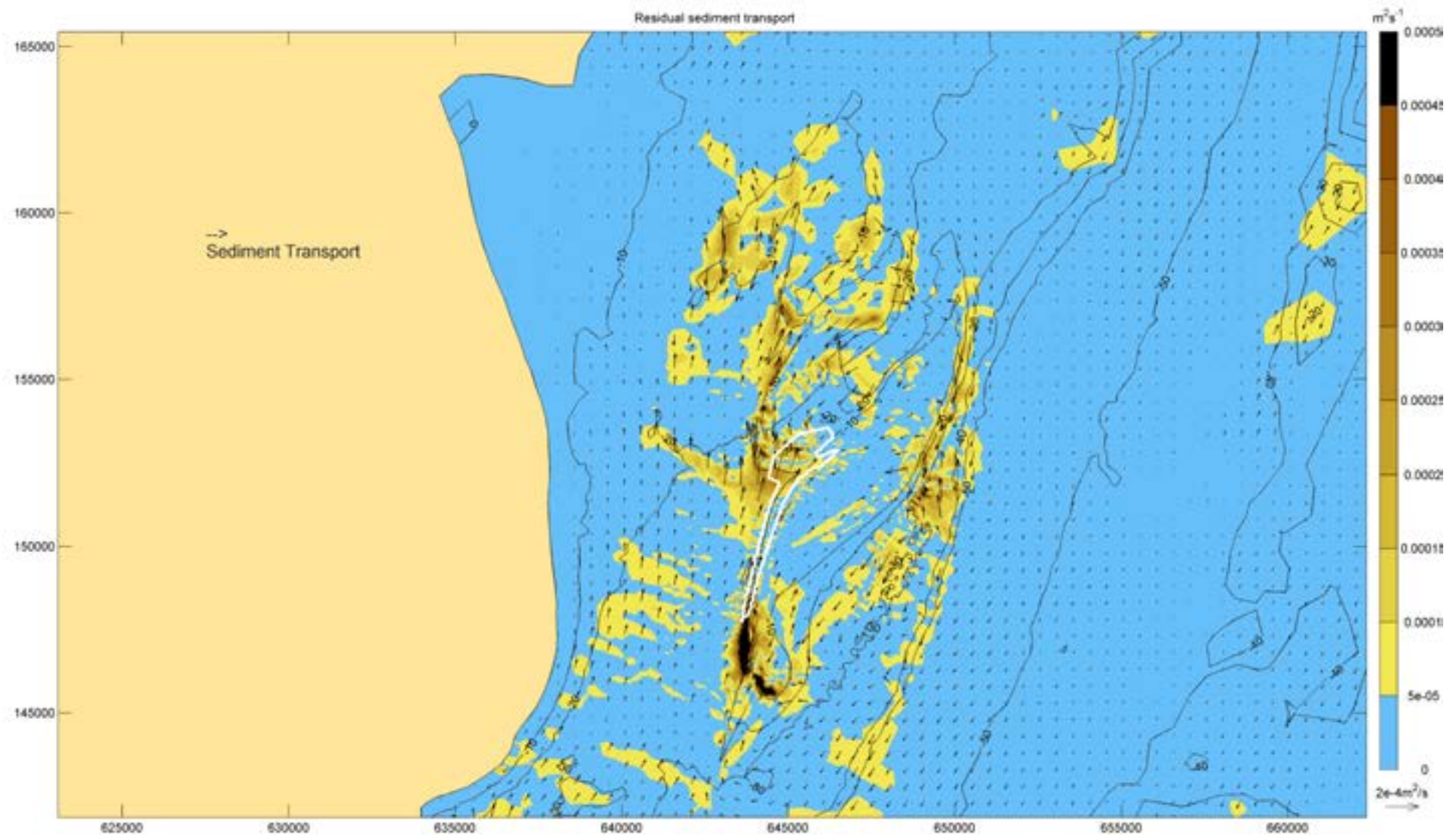


Figure 4.3: Residual sediment transport vectors and rates (colours). The isolines show the seabed levels, the dredging area is denoted by the white polygon

Source: \\hrw-uk.local\projects\live\ddr5472\$\model\Sediments\FIGURES\ TransportVectorsPolygon.png

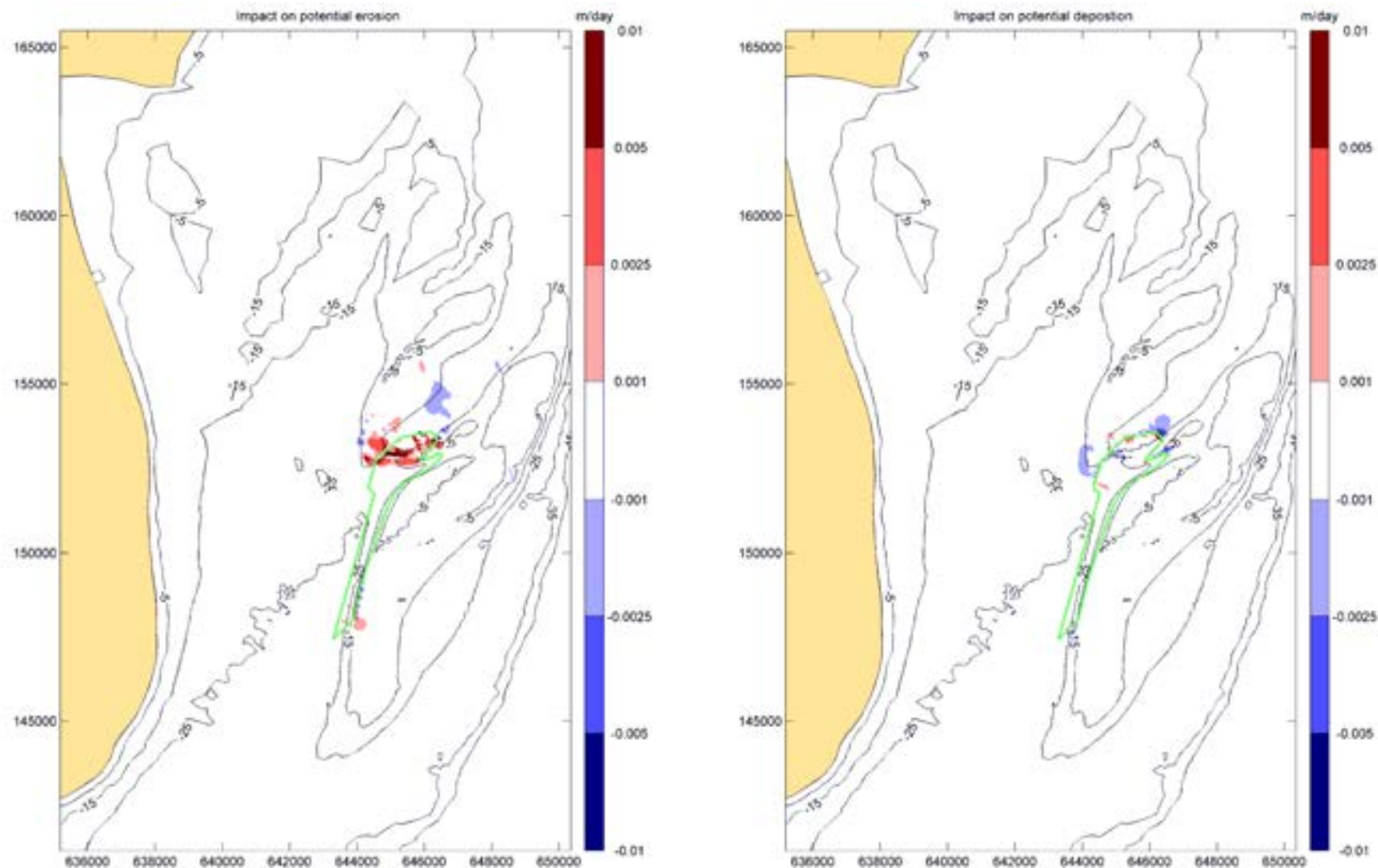


Figure 4.4: Changes in erosion (left) and deposition (right). Red indicates a larger increase in bed level due to the aggregate dredging, blue a lower increase in bed level

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5. Analysis of historical data analysis

Bathymetry data for the historical representations of the seabed were taken from earlier HR Wallingford (2008) studies of the Goodwin Sands. In these studies, three recent “epochs” were studied, i.e. times when one or more detailed bathymetric surveys had been carried out covering the whole of the South Goodwin Sands. These datasets were considered to provide a series of good snapshots of the continually evolving sandbank at different times over the last 30 years. After review of all the available data sets, the following data were obtained:

- 1986 – 1988 surveys as fair-sheets (scanned and provided in digital form);
- 1995 – 1998 surveys as fair-sheets (scanned and provided in digital form);
- 2006 charted data obtained as contour lines.

The 1986-1988 data were later discarded on the grounds that the data were sparser than the other surveys with a risk of unrepresentative results; following transect lines rather than providing a good coverage of the sandbanks. Figure 5.1 and Figure 5.2 illustrate the extent of the 1995-98 and 2006 data respectively.

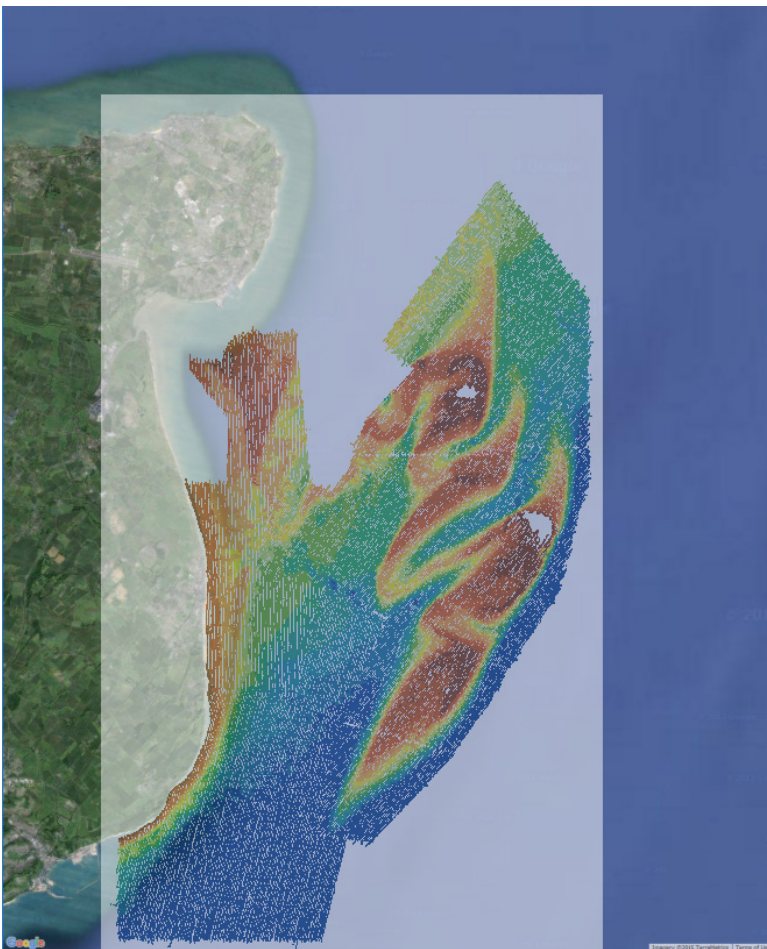


Figure 5.1: Spatial extent of the 1995-1998 TruDepth data, overlaid on Google imagery

Source: HR Wallingford (2008)

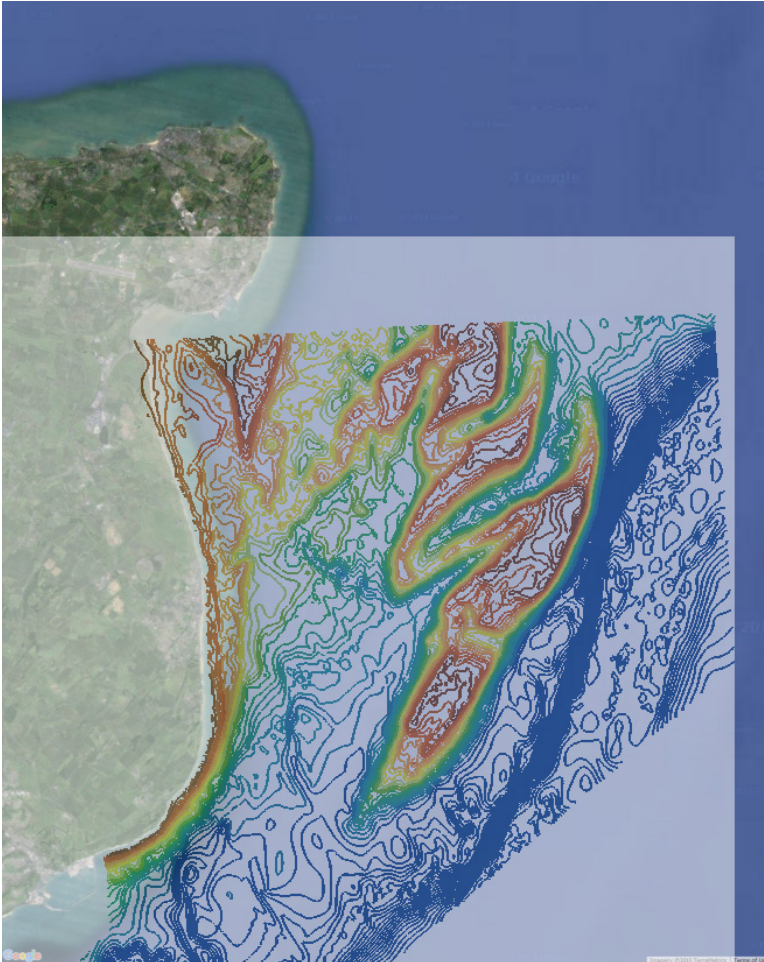


Figure 5.2: Spatial extent of the 2006 charted data, overlaid on Google imagery

Source: HR Wallingford (2008)

The data for each epoch were supplemented with nautical chart data for the rest of the model area, and the combination of the different sources of data was made such that more recent / resolved data always took precedence over older or less resolved data. The representation of the historical bathymetries, for use in the wave model, is shown in Figure 5.3. The baseline bathymetry is also reproduced in Figure 5.3 for reference.

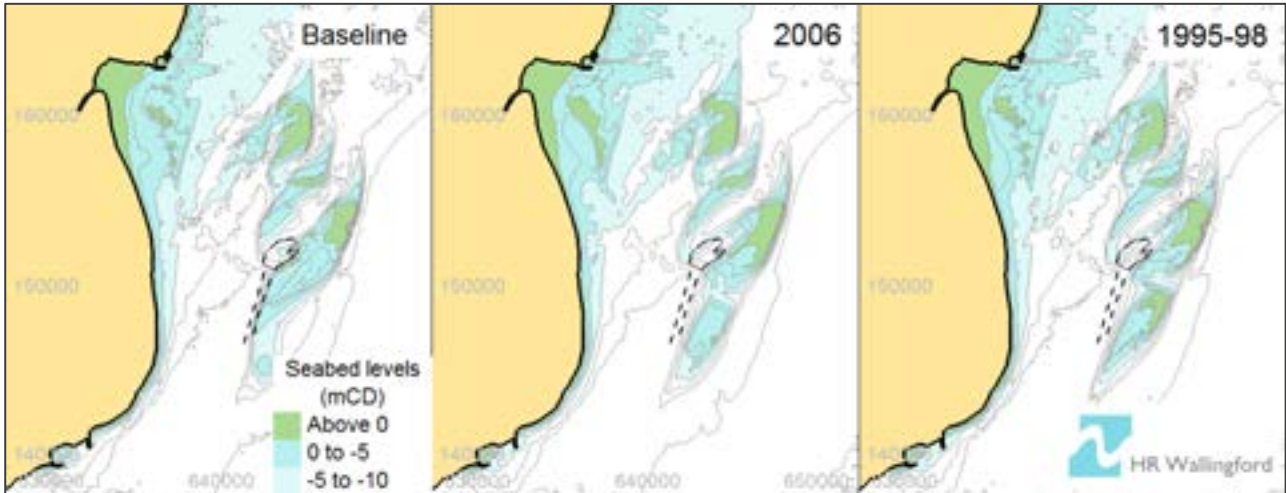


Figure 5.3: Baseline and two historical bathymetries used in the wave model

The historical bathymetry data from 1995 to the present show that the sandbank system is changing. From a configuration with four sandbanks, the system is changing into a three bank configuration where the two most southern banks are merging into one as the southernmost bank migrates north. On the southern end, potentially a new fourth bank has started to form, which is expected to grow in size over the next decade. The bathymetric changes observed are many meters in some locations.

On the northern end of the bank system, there is little change in the bathymetry, the observed differences can be explained by changes in resolution of the survey data alone. This suggests very little residual transport for this northern part as is shown by the sediment transport modelling.

The previous study of Goodwin Sands, by HR Wallingford (2008), suggested that the volume of the bank is stable, and possibly marginally increasing. The latest data supports that conclusion.

6. Bedforms analysis

The high resolution data collected during the summer of 2015 for the present project was assessed to identify bedforms. The input data used for the analysis was the raw data from the survey without adjustment to the vertical datum of Mean Sea Level as used for the modelling; hence the depths in the following figures are relative to Chart Datum.

Four types of bedforms can be identified: ripples, dunes related to wave action, flow related dunes and sandwaves. Large sandwaves are present on top of the bank (Figure 6.1). These sandwaves are visible all along the dredging area. The sandwaves generally are asymmetric, with the steeper side facing north, indicating that the residual transport is northward.

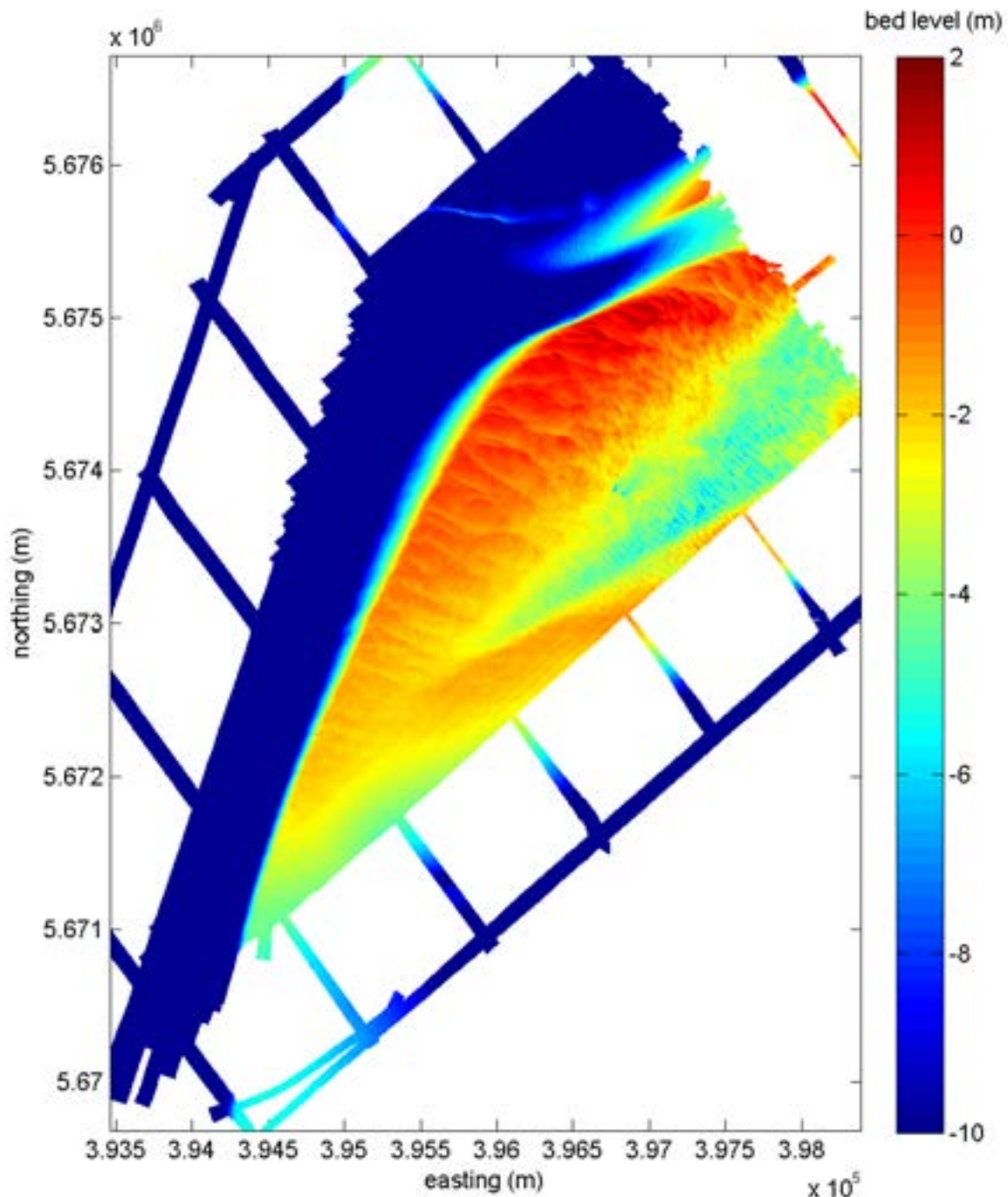


Figure 6.1: Bathymetry data showing asymmetric sandwaves on top of South Goodwin Sands

On the shallowest northern part of the bank, large dunes are visible, with a height of up to about 2 m (Figure 6.2). This suggests that there is a high rate of sediment transport due to fast (~1 m/s) tidal currents and wave action on the shallow parts of the bank. In some locations, superimposed on these dunes, ripples can be identified. Again, the asymmetry in the bedforms suggests that the sediment transport direction is

towards the north. However, the effects of storms on the dune migration direction and size will not necessarily be represented in the survey depending on the time elapsed since the most recent storm event before the survey.

Further to the south, flow related dunes are visible. Figure 6.3 shows the disturbance from the mean bed level, caused by the dunes. These dunes are 1.5 m to 2 m high, again suggesting high sediment transport rates. These bedforms are very irregular in size and shape, with longer bedforms to the west of the surveyed area and shorter ones to the east in shallower water. In between there are quite a lot of discontinuities in the pattern of bedforms. In general the orientation of the crests is slightly diagonal to the slope of the bank. This pattern suggests that the sediment transport is mostly along the slope, but with a significant component up the slope in the south-east corner of the plot. This is evidence that the residual transport pattern is maintaining the height of the sandbank in that there is a supply mechanism for sediment up the slope.

In general, the bedforms indicate that there is a high rate of sediment transport (indicated by the height of the dunes), with a residual transport towards the north up and over the sandbank.

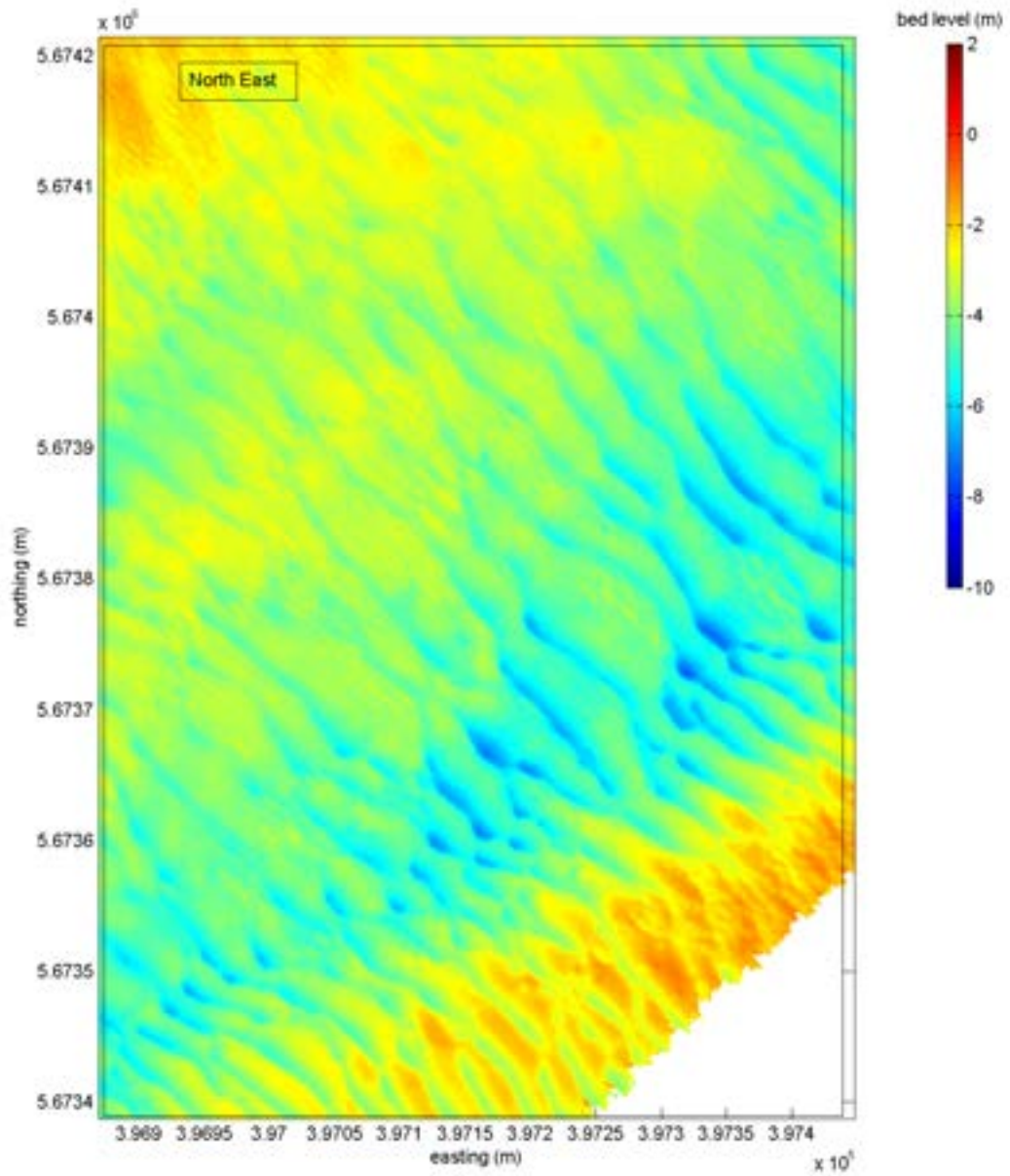


Figure 6.2: Large dunes visible on the shallow parts of South Goodwin Sands

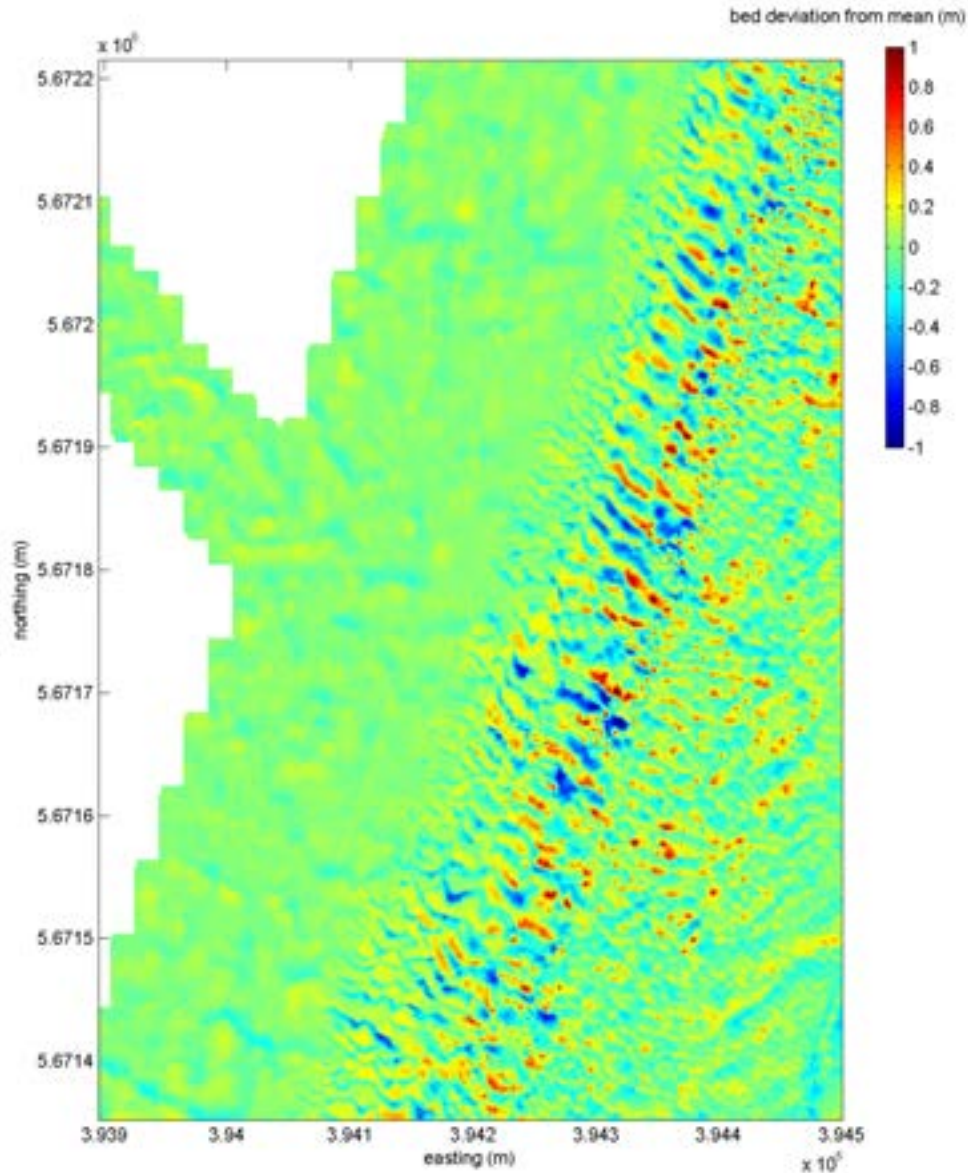


Figure 6.3: Flow related dunes on the slopes of South Goodwin Sands. The colours indicate the deviation from the mean bed level, caused by the dunes.

7. Discussion and conclusions

The sediment transport model SISYPHE has been used to calculate the sediment transport pattern around Goodwin Sands. The results from simulations with and without the proposed aggregate dredging have been compared to assess the impact of the dredging on the sediment transport and seabed changes.

The sediment transport results show a clockwise residual transport pattern around Goodwin Sands, with a northward drift to the west and a southward drift to the east of the banks. This recirculation cell maintains the presence of the sandbank system.

The model results also suggest that there is a small residual northward transport from the Straits of Dover, which feeds Goodwin Sands with additional material, although the amount of material available for transport there is considered to be small. Little or no sediment escapes from the banks to the north. This suggests that the volume of the banks is expected to be stable, perhaps even growing at a very slow rate. This finding provides some confirmation of earlier work (HR Wallingford, 2008) that concluded that the volume of the sandbanks is constant or gradually increasing.

The proposed aggregate dredging only causes minor and localised changes to the magnitude of the residual sediment transport rate and erosion/deposition pattern. The pattern of transport remains broadly unchanged with any slight changes predicted to be close to the proposed dredging. In most locations the changes are indicated by a reduction in predicted erosion rate within the dredging area, and a reduction of potential deposition rate in the deeper channel areas next to the proposed dredging area. No impact on the sediment transport processes which control the naturally changing form of the South Goodwin Sands, including the intertidal areas on the banks, is predicted.

8. References

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Appendices

A. Description of SISYPHE-HR

SISYPHE-HR is the state-of-the-art sediment transport model used at HR Wallingford. It combines the best of the SISYPHE sediment transport model, publicly available as part of the open source TELEMAC model suite (originally developed by the National Hydraulics Laboratory of the French Electricity Board – EDF-LNH), with additional formulations to incorporate HR Wallingford's extensive knowledge and experience of simulating sediment transport and bed evolution previously included in HR Wallingford's sediment transport model SANDFLOW-2D.

SISYPHE-HR can be applied as a stand-alone post-processor model, using input from flow (e.g. TELEMAC) and wave (e.g. TOMAWAC or SWAN) models. Alternatively, SISYPHE-HR can be run coupled to a TELEMAC flow model, whilst exchanging information on a time step level.

A.1. Theoretical background

SISYPHE-HR can model sedimentary systems containing very fine and fine sands (with median grain diameters d_{50} between 0.06 and 0.25 mm) which mainly move in suspension. The model can also be used to identify trends in the case of medium sand (d_{50} between 0.25 and 0.5 mm). If the sediment contains a high proportion of clay or silt particle sizes less than 0.06 mm, it would be more appropriate to use models capable of simulating mud transport, e.g. the DELWAQ mud transport model used at HR Wallingford.

The main factors controlling sand transport are:

- advection by currents;
- settlement under gravity;
- turbulent diffusion in all directions (but only the vertical component is of significance under most circumstances);
- exchange of sediment between the flow and the bed.

The study of sand transport generally is very complex but more so in the case of estuaries or coastal areas. This is because the water movements are continually changing, with the rise and fall of the tide, and there is usually a wide range of sediments on the bed and possibly areas without mobile sediment, leading to unsaturated and oversaturated loads in the water.

A.1.1. Sediment transport formulations

The evaluation of bed exchanges requires a formulation for the sediment transport rate. SISYPHE-HR offers the choice between a total load transport formula and a combination of a concentration equation with a bedload transport formula.

Within SISYPHE-HR, the preferred option is the SANDFLOW-2D approach for suspended load transport, which determines the concentration based on the suspended load formula of Soulsby-van Rijn combined with the bedload predictor of Soulsby-Van Rijn. Other available bedload transport predictors are the Meyer Peter-Muller and the Einstein Brown formula. Three alternative equations are available to prescribe the reference concentration: Zyserman and Fredsoe, Bijker, and Van Rijn. Alternatively, one can use one of the total load formulae: Soulsby-Van Rijn, Bijker, Bailard and Dibanjnia and Watanabe, Engelund-Hansen.

The choice of sand transport relation requires a careful consideration of the site conditions and the limitations of the transport formulae. It should be borne in mind that most relationships found in the literature are based on river or channel data where sediments are more narrowly graded than in estuaries. Usually, there is cohesive material present in estuary sediments and this may alter the transport properties. SISYPHE-HR has the capability to model such mixed sediment systems, however it is noted that the behaviour of mixed sediments is not well understood.

A.2. Model Application

The application of the model and interpretation of the results requires a good understanding of sand physics. Firstly it is important to choose representative values for the main parameters. Ideally these should be based on laboratory tests of actual sediment samples from the site.

This may be done using measured suspended sediment concentrations and/or measured transport rates. However, these concentrations and transport rates usually cover short periods and are prone to measurement uncertainty and randomness in the forcing conditions. Ideally, observed bathymetric changes are used as well, as these give a better indication of the long-term processes.

In addition, it should be appreciated that sand transport is not an exact science. Accordingly, whatever model is used, and whatever parameter values are chosen it is essential that results required an expert assessment. Provided this is done SISYPHE-HR provides a valuable engineering tool.

As with all models, it is preferable to calibrate and validate a model build with SISYPHE-HR. Even though SISYPHE-HR has been tested and validated against observations, each specific model application requires adaptation to the local conditions, by determining relevant sediment characteristics, choosing the best transport predictor and incorporating relevant hydrodynamics.

A.3. Model Inputs

SISYPHE-HR requires free surface elevation and flow velocities from a TELEMAC-2D flow model simulation (or depth-averaged values of from a TELEMAC-3D simulation), together with information describing the initial distribution of sand on the bed. If wave stirring is considered important, wave orbital velocities from an area wave model such as TOMAWAC or SWAN are required.

If available, a boundary data file specifying time-varying or constant sediment concentrations at the model open boundaries can be used, but often the preferred option is to use equilibrium conditions at the boundary whilst locating these boundaries sufficiently far away from the area of investigation. Other parameters required include the typical sediment grain size distribution, or a single median grain size. If available, other basic sediment properties, such as settling velocity and threshold shear stress for initiation of motion, can be used or alternatively these can be estimated using formulations included in the model.

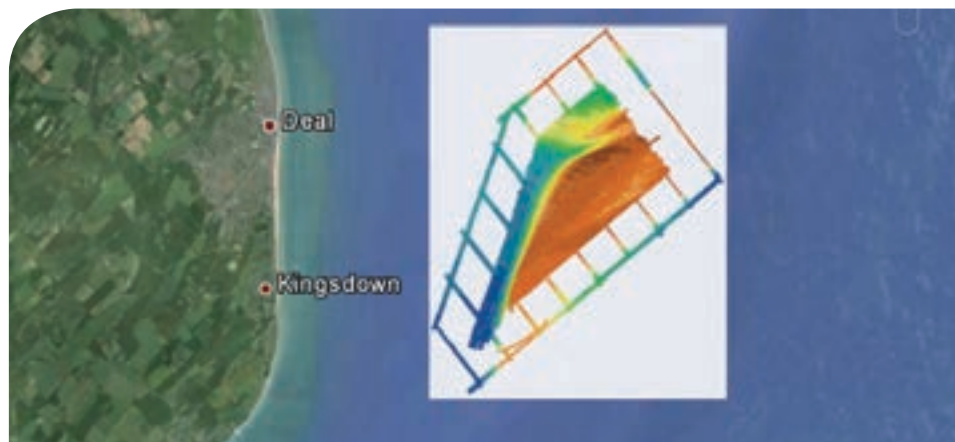
Data is input to SISYPHE-HR using ASCII data and steering files, and unformatted direct access results files from TELEMAC equivalent. The steering files are set up using the context sensitive editor included in the user interface. SISYPHE-HR can be applied as a stand-alone post-processor model, using input from flow (e.g. TELEMAC) and wave (e.g. TOMAWAC or SWAN) models. Alternatively, SISYPHE-HR can be run coupled to a TELEMAC flow model, whilst exchanging information on a time step level, including bed updating.

SISYPHE-HR is controlled using HR Wallingford's user interface PYXIS, which includes an extensive model logging system with error checking, version control and run description. This interface enhances quality control of the model set-up and simulations and guarantees that simulations can be reproduced in the future.

A.4. Model OUTPUTS

SISYPHE-HR produces a single binary output file containing relevant flow information, suspended concentrations for all grain size classes, the resulting bedload and suspended load transport rates, and the erosion-deposition patterns and instantaneous bed levels resulting from these transport rates at user selected intervals during the simulation.

The SISYPHE-HR model results can be presented graphically and where required analysed further using various plotting and post-processing tools available at HR Wallingford.



HR Wallingford is an independent engineering and environmental hydraulics organisation. We deliver practical solutions to the complex water-related challenges faced by our international clients. A dynamic research programme underpins all that we do and keeps us at the leading edge. Our unique mix of know-how, assets and facilities includes state of the art physical modelling laboratories, a full range of numerical modelling tools and, above all, enthusiastic people with world-renowned skills and expertise.



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