CONTENTS

9 MARINE ECOLOGY

9.1 Introduction

This section details the marine biological resource within the study area. Baseline conditions are presented, upon which an assessment of the potential impacts associated with the construction, operation and decommissioning of the Thanet Offshore Wind Farm (Thanet) and export cable route is made.

9.2 Assessment Methodology

9.2.1 Data collection

Information on the marine biological resource of the outer Thames Estuary, the southern North Sea and the eastern English Channel are relatively widespread compared to many other areas of the marine environment. General descriptions of the range of habitats and species present are available in a number of sources including *inter alia* offshore wind farm studies (e.g. London Array and Gunfleet Sands), marine natural area profiles (Jones *et al*, 2004 a and b) and surveys carried out by authorities, such as the Joint Nature Conservation Committee (JNCC) and the Centre for Environment, Fisheries and Aquaculture Science (CEFAS). Such existing information has been drawn upon within this section to provide support in the establishment of the baseline conditions. However, as the availability of specific information on the Thanet study area does not provide sufficient information for the assessment of potential effects, detailed site specific studies were commissioned as part of the Environmental Impact Assessment (EIA) process.

Following agreement with English Nature and CEFAS, a combination of sampling methods were used to sample the benthic subtidal and intertidal communities within the study area. Special attention was paid, throughout, to species and habitats of conservation significance. These are described below.

9.2.2 Intertidal survey

A survey of the proposed export cable route across the intertidal flats of Pegwell Bay was carried out between 26th and 29th May 2005. The survey methodology was designed to define the main habitat types and key community components in the northern area of Pegwell Bay. The survey comprised:

- An overview of the main intertidal and shoreline habitats and communities in the vicinity of the export cable route; and
- A semi-quantitative assessment of box core samples sieved over a 1mm mesh, and 0.25m^2 quadrat counts of organisms on rocky substrata.

In total, a series of 38 stations were sampled according to this methodology. The intertidal sampling locations are presented in **Figure 9.1**.

Data was collected on approximate numbers of individuals, and described using the Marine Nature Conservations Review (MNCR) SACFOR scale. The SACFOR scale is a widely used method of recording the abundance of marine benthic fauna. The relative abundance of organisms is ranked as follows:

S = Superabundant
A = Abundant
C = Common
F = Frequent
O = Occasional
R = Rare

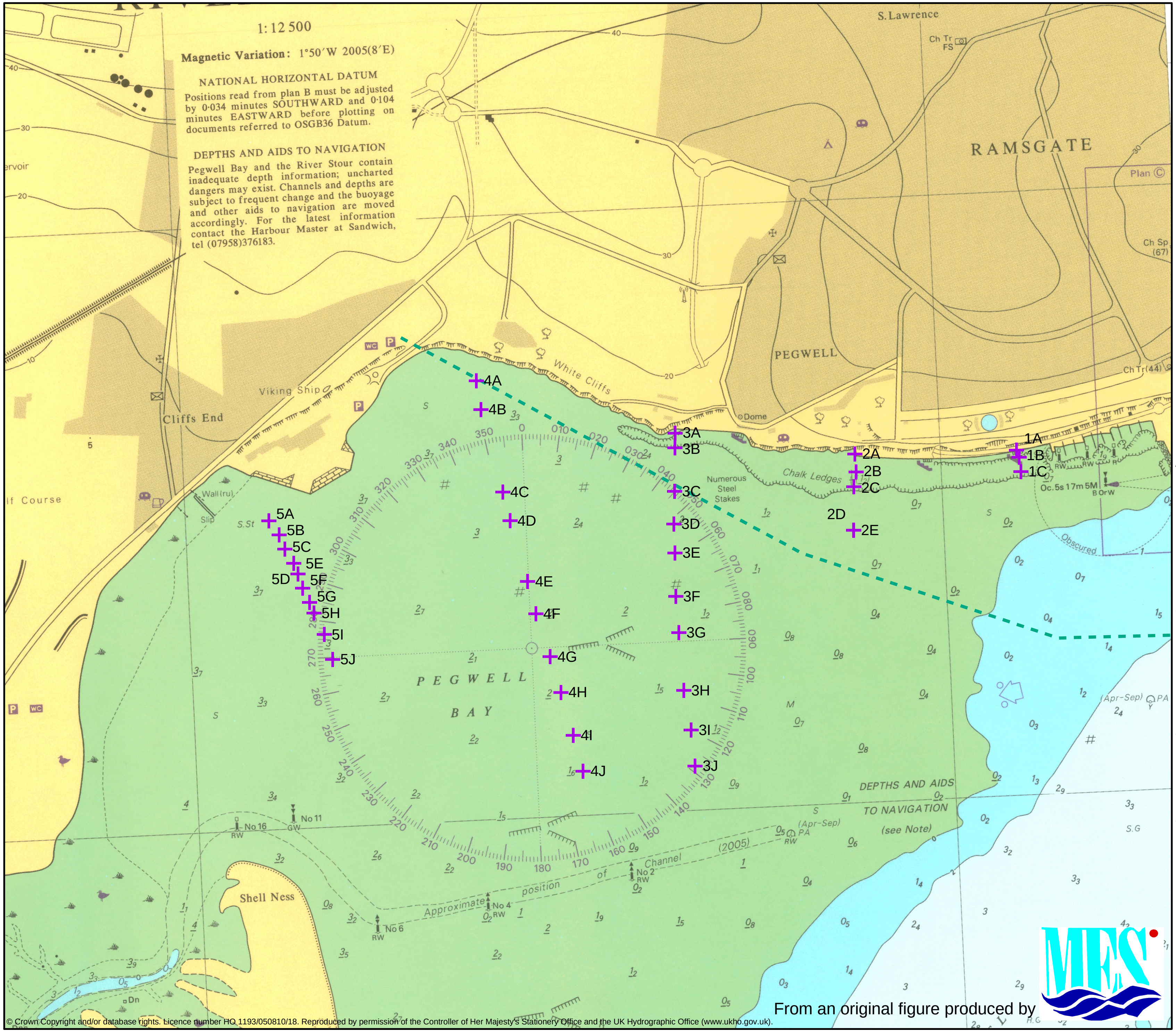
9.2.3 Subtidal benthic grab survey

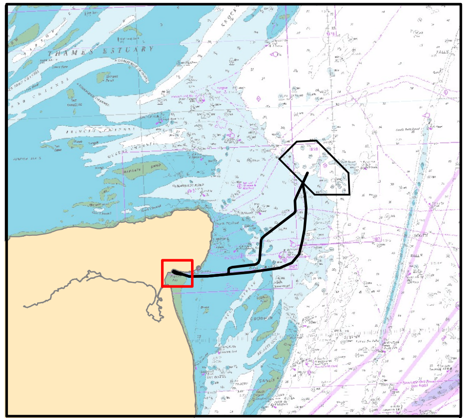
The particle size composition of substrate and its associated benthic infauna was assessed between 27th May 2005 and 9th June 2005 through a programme of Hamon grabs at 64 pre-selected sampling locations within the Thanet site and the export cable routes. Three replicate samples were taken at each station, unless the substrate proved too hard to take a full 'grab'. Seabed imaging was used at such stations in order to provide a description of the community present. A sub-sample was taken from each grab sample for Particle Size Distribution (PSD) analysis. Independent sediment samples were also taken at the most landward stations along the export cable route, for chemical analysis. The positions of the 64 sampling stations for the benthic survey are presented in **Figure 9.2**. Details of the survey methodology are provided in **Appendix 9.1**.

9.2.4 Subtidal epibenthic survey

Titan Environmental Surveys Ltd (Titan) undertook surveys of the subtidal epifauna within the Thanet study area between 28th and 30th July 2005, in conjunction with surveys of the juvenile fish population of the site. The survey was carried out using a local commercial fishing vessel and samples were collected using a 2m beam trawl at pre-determined sites. The survey methodology was agreed in advance with CEFAS and involved slow trawling speeds, between 1 to 1.5 knots, over distances of 200m to ensure sampling of different sediment types and sustained contact of the gear with the seabed.

A total of 27 beam trawl surveys were obtained at the locations shown in **Figure 9.3**. They included six in the wind farm area, six tidal excursion sites, three control sites to the north, three control sites to the south and nine in the vicinity of the export cable routes. The locations were chosen with reference to target locations, geophysical survey results and local knowledge to determine appropriate areas for beam trawling operations. Exact positions were chosen on site after consultation with the vessel skipper, taking into consideration ground conditions, tide and navigational constraints. Further details on the survey methodology and the exact position of each trawl are presented in **Appendix 9.2**.





Legend:

- Intertidal Sampling Locations
- Proposed Cable Route

Title:

INTERTIDAL SAMPLING LOCATIONS

Project:

THANET OFFSHORE WIND FARM

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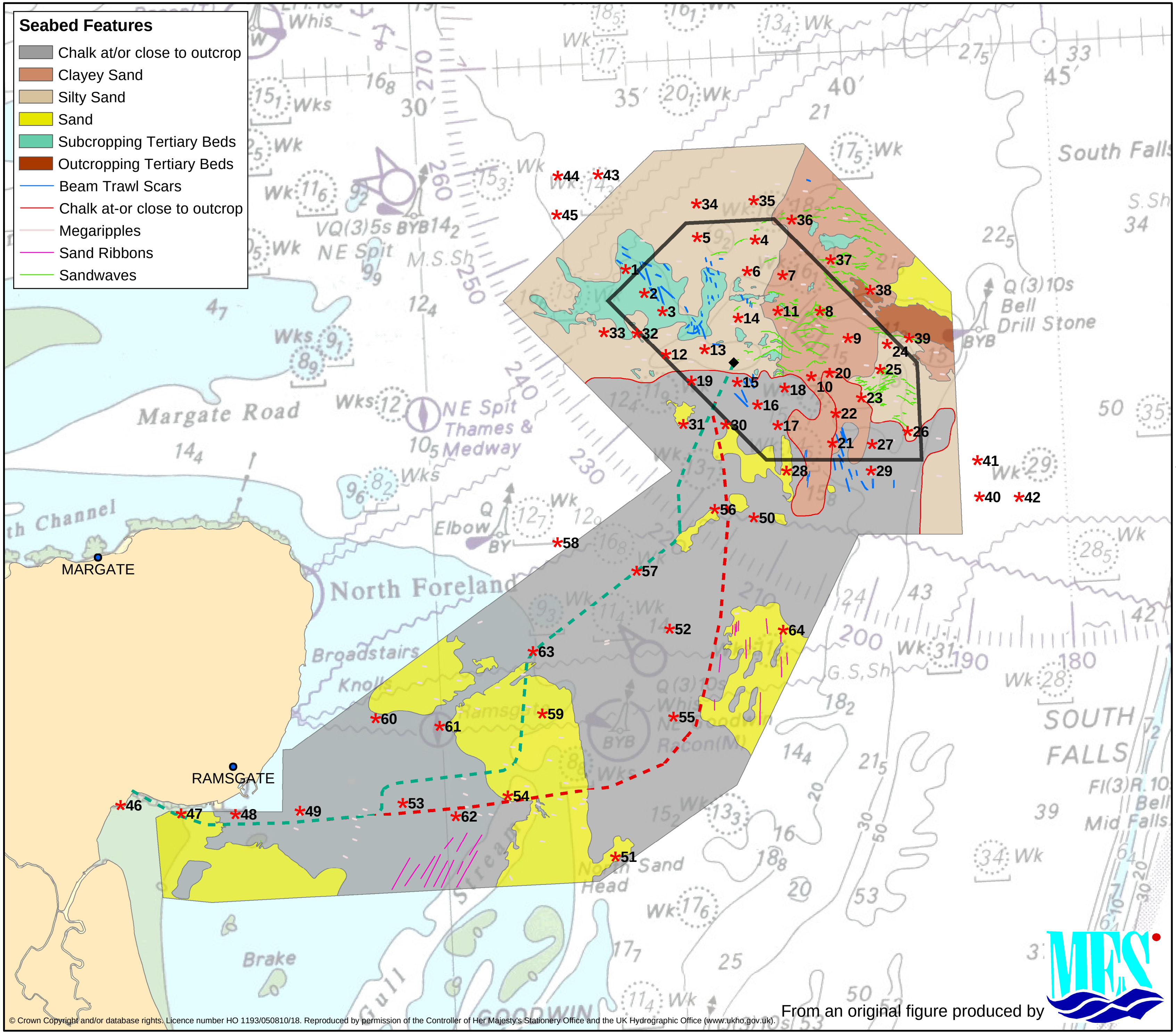
Revision No: 001

ROYAL HASKONING



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Legend:
- Wind Farm Site Location
- Proposed Cable Route 1
- Proposed Cable Route 2
- Grab Sampling Locations
- Offshore Substation

Title:
SUBTIDAL GRAB SAMPLING LOCATIONS

Project:
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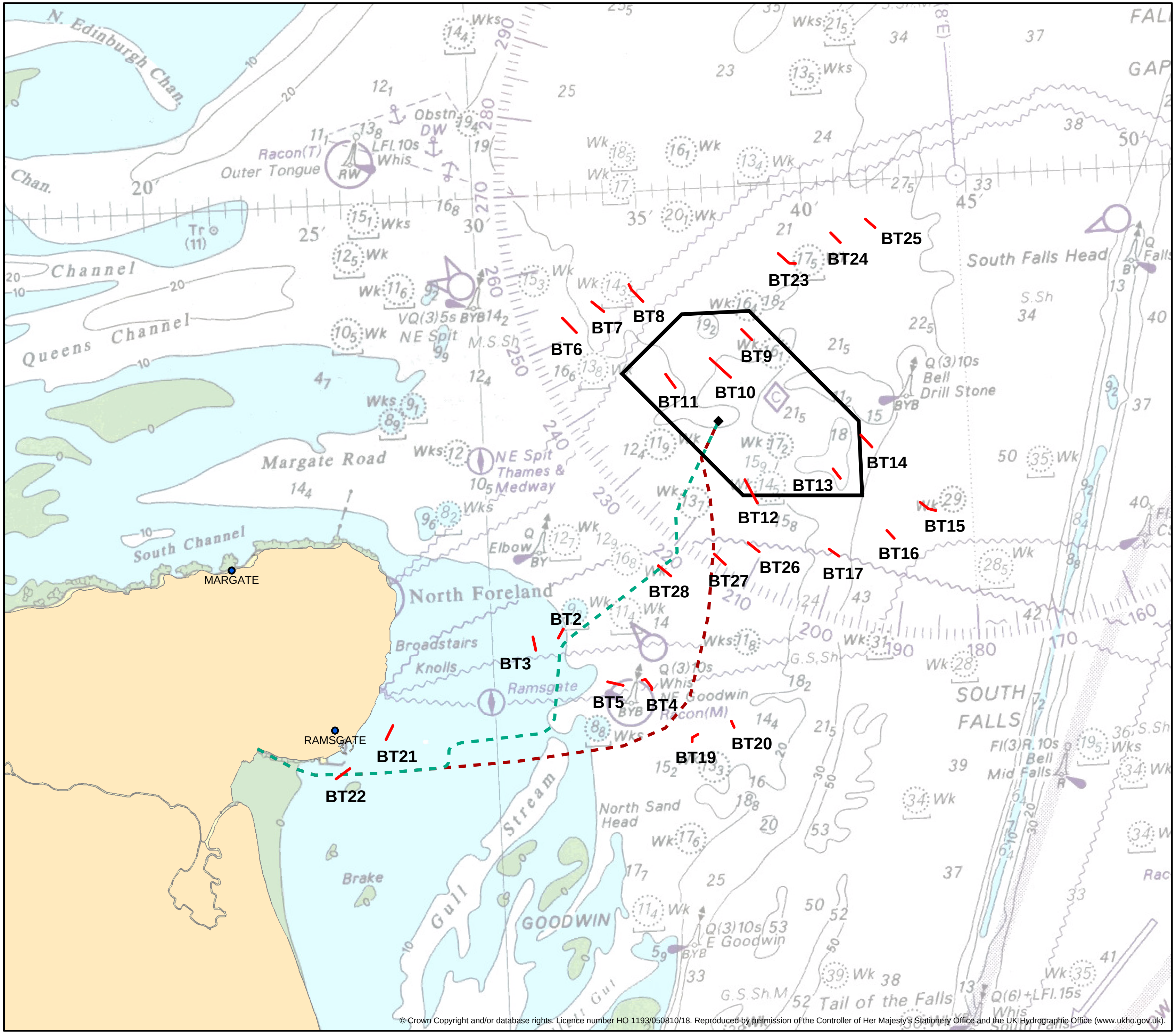
ROYAL HASKONING



Legend:

- Wind Farm Site Location
- Proposed Cable Route 1
- Proposed Cable Route 2
- Beam Trawl Locations
- Offshore Substation

Title:

SUBTIDAL BEAM TRAWL SAMPLING LOCATIONS

Project:

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9.2.5 Data analysis

Multivariate analysis was carried out using the PRIMER version V6 software package (Clarke and Warwick, 1994; Clarke and Gorley, 2001) in order to determine any similarities between samples and groupings of communities/species.

For infaunal samples, biomass was also recorded for the major phyla present and PSD analysis was undertaken in taken in order to define the sediment distribution within the samples. A detailed discussion of the statistical tests employed in the analysis is given in **Appendix 9.1**.

9.2.6 Sediment chemistry

Samples were taken from four stations (two intertidal and two subtidal) during the infaunal survey of the cable routes to determine sediment quality. The concentrations of the following determinands were measured:

- A range of metals;
- A range of polyaromatic hydrocarbons (PAHs); and
- A range of polychlorinated biphenyls (PCBs).

The analysis methodologies involved are described in detail in **Appendix 9.1**.

Following discussion with CEFAS, it was concluded that there was no evidence of potential contamination within the Thanet site boundary and that no specific chemical analysis would be required for this area.

9.3 Existing Environment

9.3.1 Intertidal ecology

As discussed in **Section 2, Project Details** the preferred route for the export cables is to cross the intertidal flats of Pegwell Bay and make landfall to the north of the disused hoverport (see **Figure 9.1**).

Pegwell Bay is a sheltered embayment of muddy sand on the east side of the Isle of Thanet, which is exposed over a wide area (approximately 542 hectares) at low tide. The Bay is bounded by low chalk cliffs that form the southern and eastern side of Ramsgate and Cliffs End, which are in turn fronted by a wave-cut chalk platform. The Bay extends westwards into low lying marshland that borders the lower estuary of the River Stour, inland towards the port of Sandwich. The southern extent of the Bay is known as Sandwich Flats and is separated from the northern area by the River Stour.

Pegwell Bay is of considerable importance as a feeding area for wading birds, and for the flora and fauna that inhabit the range of intertidal and transitional coastal habitats found within the Bay. The site's importance to biodiversity and geodiversity is reflected in the number of conservation designations it holds, including:

- Site of Special Scientific Interest (SSSI);
- National Nature Reserve (NNR);

- Special Protection Area (SPA);
- Ramsar Wetland of International Importance (Ramsar); and
- Special Area of Conservation (SAC).

The reasons behind these designations are discussed in detail in (**Section 4, Policy Framework and Guidance**).

The intertidal survey of Pegwell Bay identified four main habitat types and associated communities:

- Wave-cut chalk platforms at the base of the chalk cliffs and sea defences;
- Upper midshore boulders and reefs;
- Midshore muddy sandflats; and
- Saltmarsh and associated mudflats.

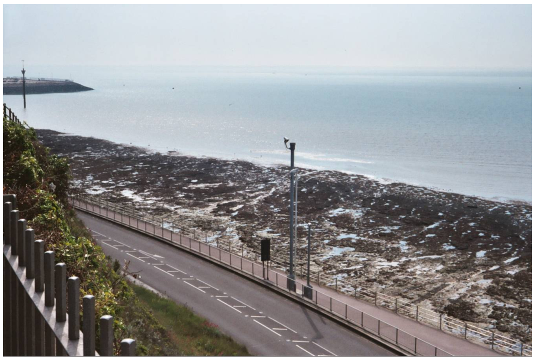
Wave-cut chalk platforms and upper midshore boulders

Wave-cut chalk platforms are a feature of eroding cliffs and constitute an important geological feature of the north Kent coast. Such platforms extend from the coast at the village of Pegwell, east-southeast towards the Port of Ramsgate, where they form an extensive chalk apron extending down to approximately mid-tide level in front of the sea defences.

These platforms typically support a variety of algae and marine invertebrates that are distributed in distinct zones related to their tolerance of exposure and desiccation.

A general view of the wave-cut platform that forms the foreshore to the west of the Port of Ramsgate is shown in **Plate 9.1**.

Plate 9.1 Looking east (l) and west (r) along the wave-cut platform



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The foreshore in this area is characterised by the following organisms, some of which are shown in **Plate 9.2**.

Flora

Corallina officinalis	- Frequent in pools (10-19% cover)
Lichina pygmaea	- Rare (1-5% cover)
Cladophora rupestris	- Occasional (5-9% cover)
Laurencia sp.	- Common (20-39% cover)
Ulva lactuca	- Occasional (5-9% cover)
Enteromorpha intestinalis	- Frequent in pools (10-19% cover)
Chondrus crispus	- Frequent on lower reef (10-19% cover)

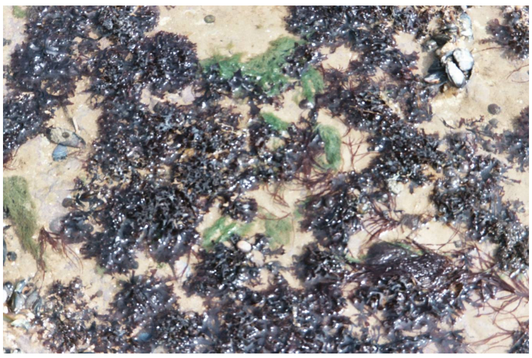
Fauna

Patella vulgata	- Common (10-99/m^2)
Semibalanus balanoides	- Abundant (40-79% cover)
Elminius modestus	- Common (20-39% cover)
Littorina saxatilis	- Common on sea wall (100-999/m^2)
Littorina littorea	- Common on platform (100-999/m^2)
Crassostrea sp.	- Common on lower reef (1-9/10m^2)
Mytilus edulis	- Superabundant on midshore (10-99/m^2)
Lanice conchilega	- Superabundant on midshore (100-999/m^2)
Arenicola marina	- Frequent in sand patches (1-9/10m^2).
Pomatoschistus sp.	- Common in pools (1-9/10m^2)
Nucella lapillus	- Frequent with egg masses (1-9/10m^2).

Plate 9.2 Communities present on the foreshore and midshore

(a)

(b)



(c)

(a) Sea defence colonised by limpets *Patella vulgata*, and barnacles *Semibalanus balanoides* and *Elminius modestus.*

(b) Reef community of mussels *Mytilus edulis* and sand mason worms *Lanice conchilega*.

(c) Typical algal assemblage of the foreshore.

Source: photographs used with permission of Marine Ecological Surveys Ltd. photo library. All images © http://www.mesl-photolibrary.co.uk

The wave-cut chalk platform and foreshore continues westwards where it extends to the midshore and is fronted by a wide expanse of muddy sand. The species present are, on the whole, similar, if a little less rich, to those described previously. The fauna of this habitat is dominated by the mussel *Mytilus edulis*, which is attached to the chalk substrate through a thick layer of pseudofaeces. This community is colonised by the sand mason worm *Lanice conchilega,* which is the dominant species throughout the site. The *Mytilus/Lanice* reef community dominate the midshore (see **Plate 9.2**). This community is highly tolerant of siltation and exposure to air.

None of the species recorded are listed as being of conservation significance under the Habitats Directive. However, it is felt that the *Mytilus* reef and associated assemblage is certainly of conservation significance locally, as it is the only assemblage of its type in the study area. The geological feature of the wave-cut chalk platform is a designated feature of the SSSI.

Midshore muddy sandflats

Pegwell Bay is dominated by a wide expanse of intertidal muddy sand that extends from the lower part of the wave-cut chalk platform at mid-tide level, down to mean low water. The habitat supports typical species of infauna including the lugworm *Arenicola marina*, other polychaetes including *Scoloplos armiger* and *Nephtys hombergii*, bivalves including the edible cockle *Cerastoderma edule* and the Baltic tellin *Macoma balthica*.

Plate 9.3 shows a general view of the mudflats with the chalk cliffs at Pegwell in the background (d). The worm casts are of lugworm *Arenicola marina,* which is exploited extensively for bait during the low tide period and as many as 500 worms are dug per person per tide (e). An average number of six bait diggers per day were recorded on the three days of the survey in June 2005.

Plate 9.3 Muddy sandflat communities

(d)

(e)

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An additional feature of the muddy sandflats at Pegwell Bay is the dominance of the sandmason worm over much of the mid to lower shore area, especially in the north of the Bay. This species commonly occurs in dense patches around the UK coast.

To the south, on the northern side of the River Stour channel, the substrate becomes muddier and supports species such as the alga *Enteromorpha intestinalis*, along with the commonly encountered polychaetes *Nephtys* sp and lugworm *Arenicola marina*.

Intertidal mudflats commonly support invertebrate species that are of significance as a food resource for both juvenile fish and wading birds. Those at Pegwell Bay undoubtedly support dense populations of typical food items for wading birds, and are important in their own right for the communities that they support. The flats form part of the Pegwell Bay SSSI and are classified as being of conservation significance under Annex I of the Habitats Directive. The species recorded during the survey are typical of muddy sandflats and are capable of relatively rapid recolonisation and recovery following disturbance. They are also adapted to relatively high levels of suspended solids under natural conditions, living as they do in dynamic nearshore habitats.

Saltmarsh and associated mudflats

The emergent/developing saltmarshes on the southern side of the River Stour are of ecological significance for a range of roosting, nesting and feeding birds. These marshes are not, however, considered to be within the potential area of impact associated with the export cable route.

Observations of the *Spartina* saltmarsh to the north of the disused hoverport show that the marsh is patchy and is either very early in its development or is recovering after a period of dieback. Nevertheless, it is worth noting that such early establishments of saltmarsh provide a potentially important fringing habitat for a range of floral and faunal species. It is possible that the northern saltmarsh would become equally significant if allowed to develop over time (see **Plate 9.4**) however, its significance in terms of conservation value is considered to be limited at present.

Plate 9.4 ***Spartina* saltmarsh to the north of the hoverport**

Source: © Royal Haskoning

The community present in the mudflats around the saltmarsh is characterised by the presence of relatively dense patches of the green alga *Enteromorpha intestinalis*, along with the ragworm *Hediste diversicolor*, the burrowing amphipod crustacean *Corophium volutator* and the small gastropod mud snail *Hydrobia ulvae*. Also common, though less abundant, are the edible cockle *Cerastoderma edule* and the Baltic tellin *Macoma balthica*. These species are known to be preferred prey resources for a range of wading birds, including those of nature conservation importance within Pegwell Bay

The concrete skirt of the disused hoverport provides a hard substrate, which has in turn, facilitated the settlement and colonisation of a relatively dense algal assemblage, comprising mainly *Enteromorpha* and bladder wrack *Fucus vesiculosus*. This community is not commonly encountered within Pegwell Bay and is not considered to be of high ecological importance.

Saltmarsh and the associated mudflats are of importance to the functioning of a system, as habitats in their own right and as feeding areas for birds and fish. They are also often used as fish nursery areas. The range of infaunal species present tends to be less than in the fully saline muds located further to seaward, but the species that are there may be present in high numbers. Due to their high position on the shore, these habitats provide a food resource area that is available for wading birds after other areas of intertidal have been submerged.

Saltmarsh can be regarded as being of importance to the continued integrity of the designated site. However, it should be noted that the emergent *Spartina* saltmarsh in the vicinity of the export cable route, at the northern end of Pegwell Bay, is of considerably less importance than that found south of the hoverport, due to its size and dominance of the pioneer plant *Spartina* spp. compared to the more mature and diverse community found to the south.

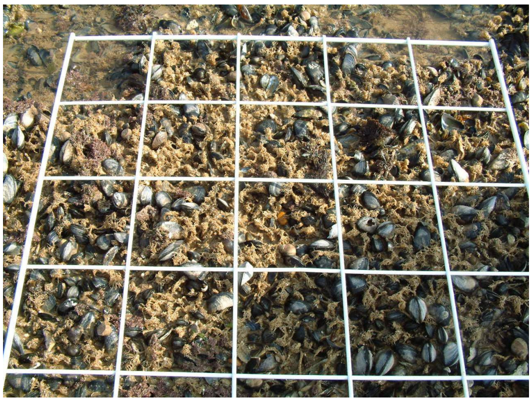
Distribution of fauna and flora

The semi-quantitative distribution of fauna and flora was assessed from a series of five transects, arranged at approximately right angles to the line of the export cable route. Each transect comprised up to ten samples.

Each location was sampled according to the methodology described in **Section 9.2.2** and comprised a combination of quadrat and 0.1m^2 box cores. The position of each sample site was recorded using GPS. **Plate 9.5** shows some of the sampling activities.

Once sampled and analysed, the resulting data for each habitat type in Pegwell Bay was used to create an overview map of the habitat types present in the intertidal zone (see **Figure 9.4**). The species presence and abundance lists for each transect are presented in **Appendix 9.3**.

Plate 9.5 Intertidal survey method photos



(f)

(g)

(h)

(f) Quadrat used to assess the abundance of organisms on the wave-cut platform.

(g) A 0.1m^2 box corer deployed for quantitative extraction of the infauna of soft deposits.

(h) Sieving of the contents of the box corer over a 1mm mesh sieve.

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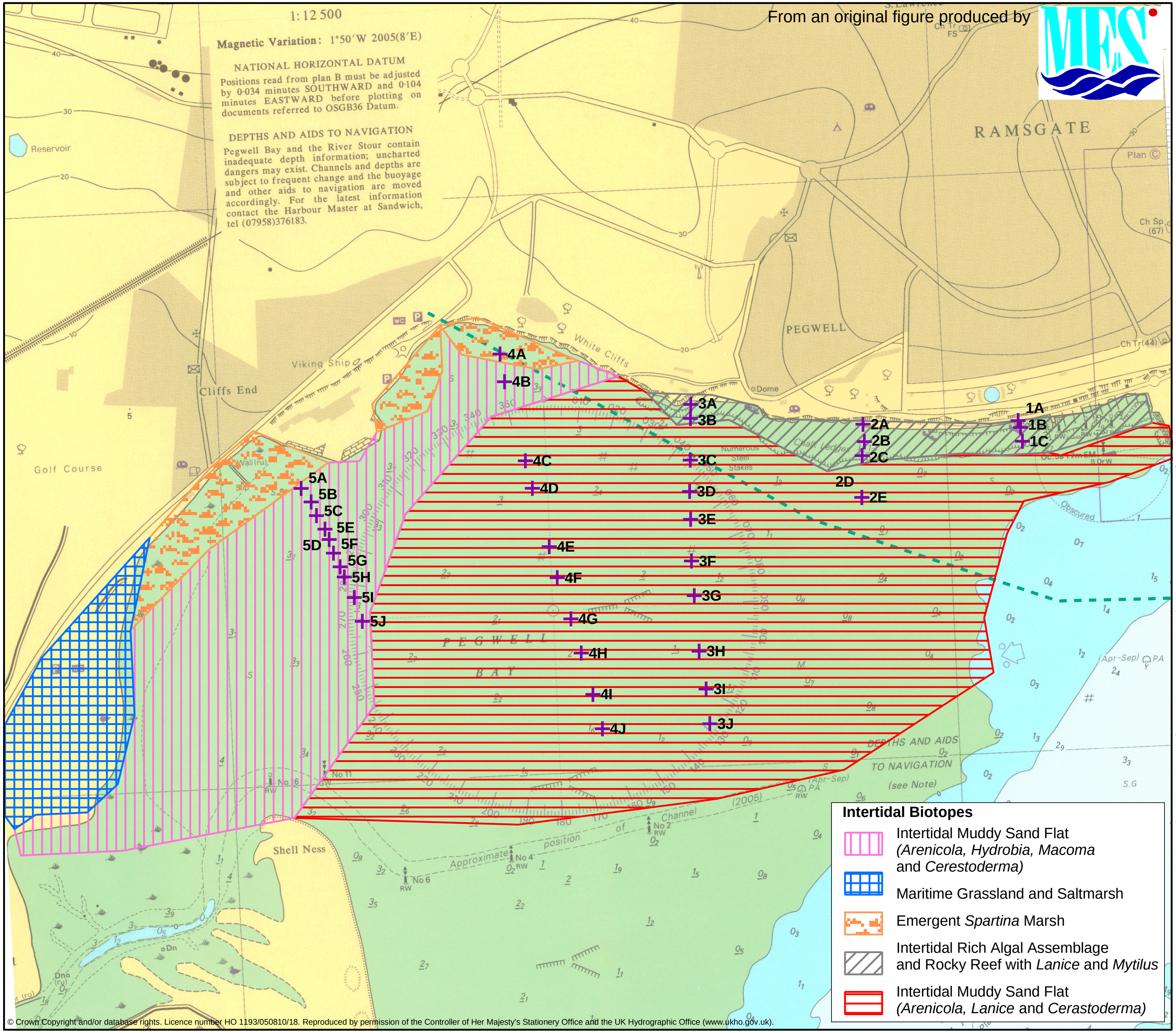

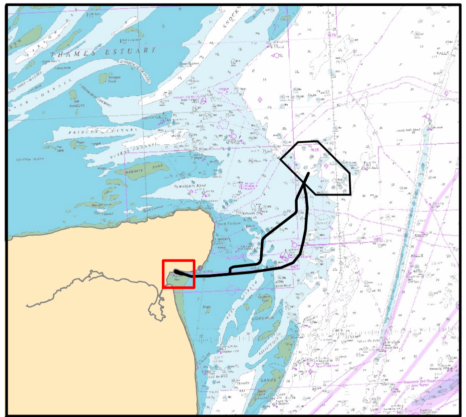

Legend:

- Wind Farm Site Location
- Proposed Cable Route
- Intertidal Sampling Locations

Title:

INDICATIVE DISTRIBUTION OF HABITAT TYPES IN PEGWELL BAY

Project:

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9.3.2 Subtidal ecology

The Thanet site falls within the sea area that forms a transitional boundary between the southern North Sea and eastern English Channel regions. The seabed within these regions is generally lacking in hard substrata, except where the underlying bedrock comes to the seabed surface, and is dominated by sands and gravels (e.g. Brown *et al*, 1998). In places, the sand forms offshore sandbanks, some of which can rise up to 40m from the seabed. The southeast region is considered to support some 5.8% of the total submerged sandbank habitat in Europe (Jones *et al*, 2004b). Such sandbank habitats provide important feeding areas for diving seabirds and predatory fish as well as spawning and nursery grounds for a range of commercially important fish species.

Mobile sand dominated habitats, as found in the southern North Sea, are generally considered to be species poor and are characterised by robust species such as annelid worms and fast burrowing bivalves (Jones *et al*, 2004a). Where sediments are more stable and coarse, i.e. sandy gravels and gravely sands, the benthic community can become richer and support species such as brittlestars and, in more stable areas, a sessile fauna including ascidians and anemones.

The general description of the benthic community within the study area and surrounding environs is supported by the findings of a range of studies in the public domain. Examples include the surveys undertaken as part of EIA work for offshore wind farm developments at Gunfleet Sands, Kentish Flats and London Array, which all report polychaete dominated communities that are generally species poor but at their richest in deeper waters, on more stable substrate.

Aggregations of the ross worm *Sabellaria spinulosa*, considered to be biogenic reefs, are known to occur in the region. Such aggregations have been reported to the northeast of the Thanet site (Browning, 2002; Jones *et al*, 2004a) and examples of crust forming and melon sized aggregations have been reported in the Thames Estuary by Atrill *et al* (1994). Local fishermen throughout the region report frequent occasions when substantial quantities of *S. spinulosa* are dredged up in bottom trawls.

The fishermen have reported that *S. spinulosa* is present within the Thanet site and surrounding area and that it has increased in abundance and extent since the British fleet stopped trawling the area in the last few years, although the southern area of the Thanet site is still trawled by vessels from the Belgian fleet. For a discussion of fishing activities in the area, see **Section 12, Commercial Fisheries**. Similar evidence has been reported in the Environmental Statement for the London Array project (RPS, 2005), where fishermen also report frequent encounters with *S. spinulosa* between the Knock and Long Sand sandbanks. The *S. spinulosa* is thought to be ephemeral in nature for much of its extent, as reports of encounters in trawls decrease during the winter.

Under the right conditions, *S. spinulosa* has the potential to form reef-like aggregations, commonly referred to as 'biogenic reefs'. In its reef forming state, *S. spinulosa* is subject to its own Habitat Action Plans (HAP), as part of the UK Biodiversity Action Plan (BAP), and represents a priority habitat under the EU Habitats Directive. The ecological value of *S. spinulosa* reefs arises from the stability and heterogeneity the structure provides on an otherwise uniform and mobile seabed. The presence of such reefs increases the biodiversity, biomass and species richness of the area, as a range of other species utilise the structural complexity of the reef for shelter and feeding.

High abundance of *S. spinulosa* was recorded in grab samples 21 and 22 (see **Figure 9.2**) during the site specific studies for the Thanet site. This high abundance indicated that the southern area of the site had the potential to support reef forming aggregations and a specific survey methodology was established to investigate the extent and distribution of *S. spinulosa.* This survey is discussed further in **Section 9.3.3**.

Sediments

The particle size distribution (PSD) of the deposits at each of the stations sampled in and adjacent to the Thanet site is summarised in **Appendix 9.4** along with data grouped into the percentage of gravel (2-64mm), sand (0.063-2mm) and silt and clay (<0.063mm) in **Appendix 9.5**. Samples where no PSD is recorded relate to stations at which there was hard substrate and the sample was either very small or non-existent.

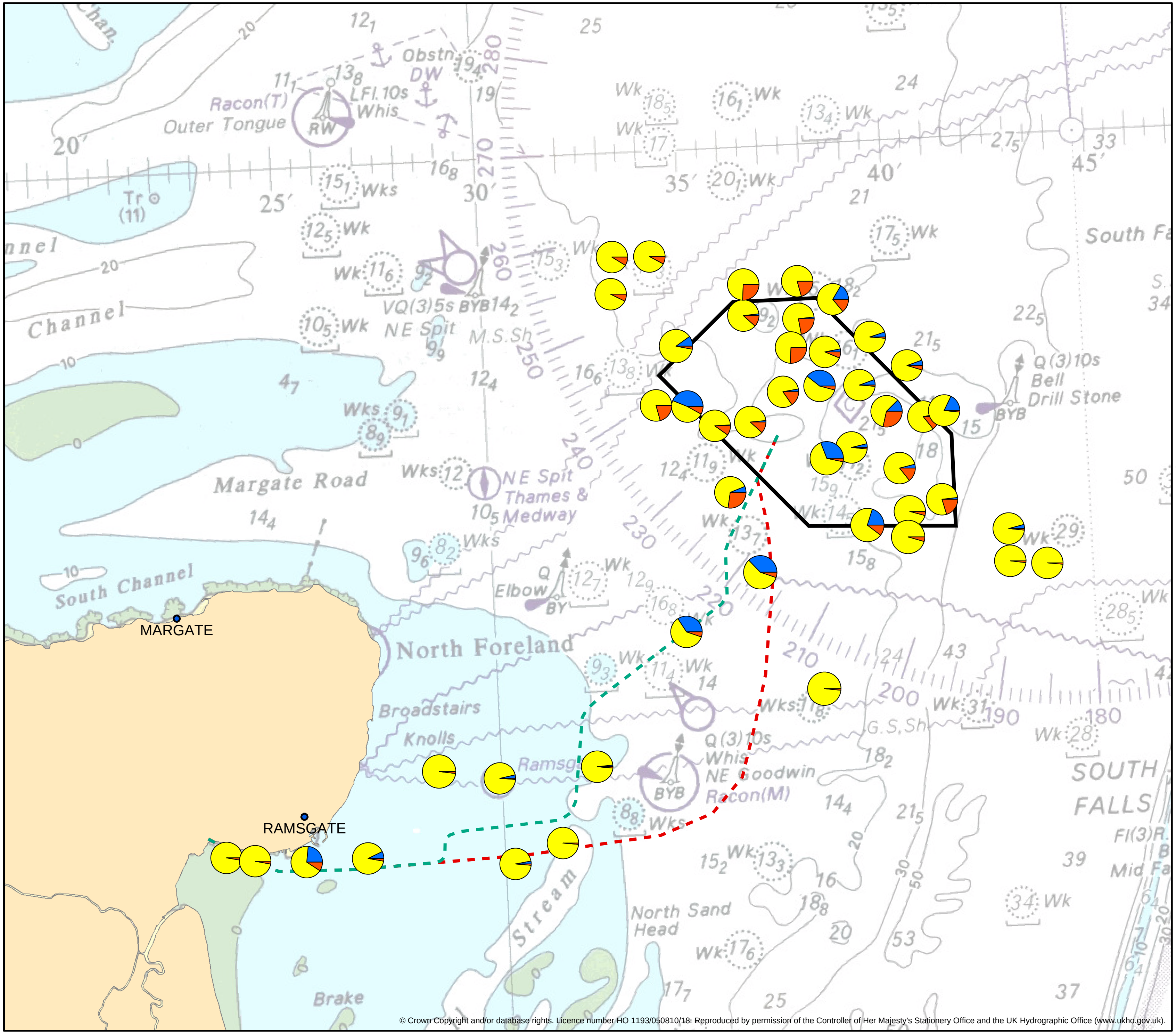
The relative proportion of gravel, sand and silt in the study area is shown in **Figure 9.5**. This clearly supports the generalised picture of this section of the southern North Sea, as the study area is characterised by a predominance of sandy deposits with occasional and varying deposits of silt, clay and gravel. Chalk bedrock, overlain with a thin veneer of sand was also encountered over large areas of the Thanet site, especially in the southwestern corner. It was not possible to obtain a sample for PSD in these areas, however, it was possible to obtain seabed images. **Plate 9.6** provides a selection of these images.

The images in **Plate 9.6** clearly demonstrate the presence of small stones and cobbles and chalk overlain with a thin veneer of sediment. This highlights the patchy nature of the benthic habitats in the study area.

Multivariate analysis of sediment composition

Analysis of the similarities and differences between the sediment samples collected from the Thanet site was carried out using group average sorting dendrogram and multidimensional scaling (MDS) methods. In this case, untransformed data has been used to compare the similarity of deposits based on the relative proportion of particles summarised in **Appendix 9.5**. Similarity between sediment samples is measured using normalised Euclidean distance where a small distance indicates a high level of similarity.

A group average sorting dendrogram showing the similarity between the sediments, based on Euclidean distance, taken at 119 of the sample stations in the Thanet site is shown in **Figure 9.6**. This identifies a predominant sediment grouping relating to sandy substrates.



Legend:

- Wind Farm Site Location
- Proposed Cable Route 1
- Proposed Cable Route 2
- % Gravel
- % Sand
- % Silt

Title:

RELATIVE PROPORTION OF SAND, GRAVEL AND SILT IN SEABED SAMPLES

Project:

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Plate 9.6 Seabed imagery of hard substrates


TH 2.jpg


TH 3.jpg


TH 15.jpg


TH 16.jpg

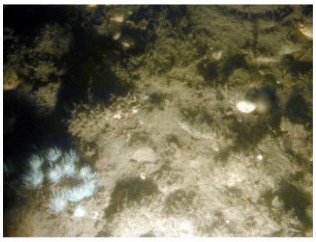

TH 17.jpg


TH 19.jpg


TH 20.jpg


TH 25.jpg


TH 28.jpg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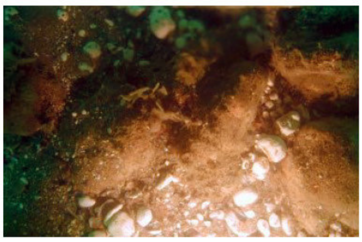
TH 50.jpg


TH 51.jpg


TH 53.jpg


TH 58.jpg


TH 63.jpg

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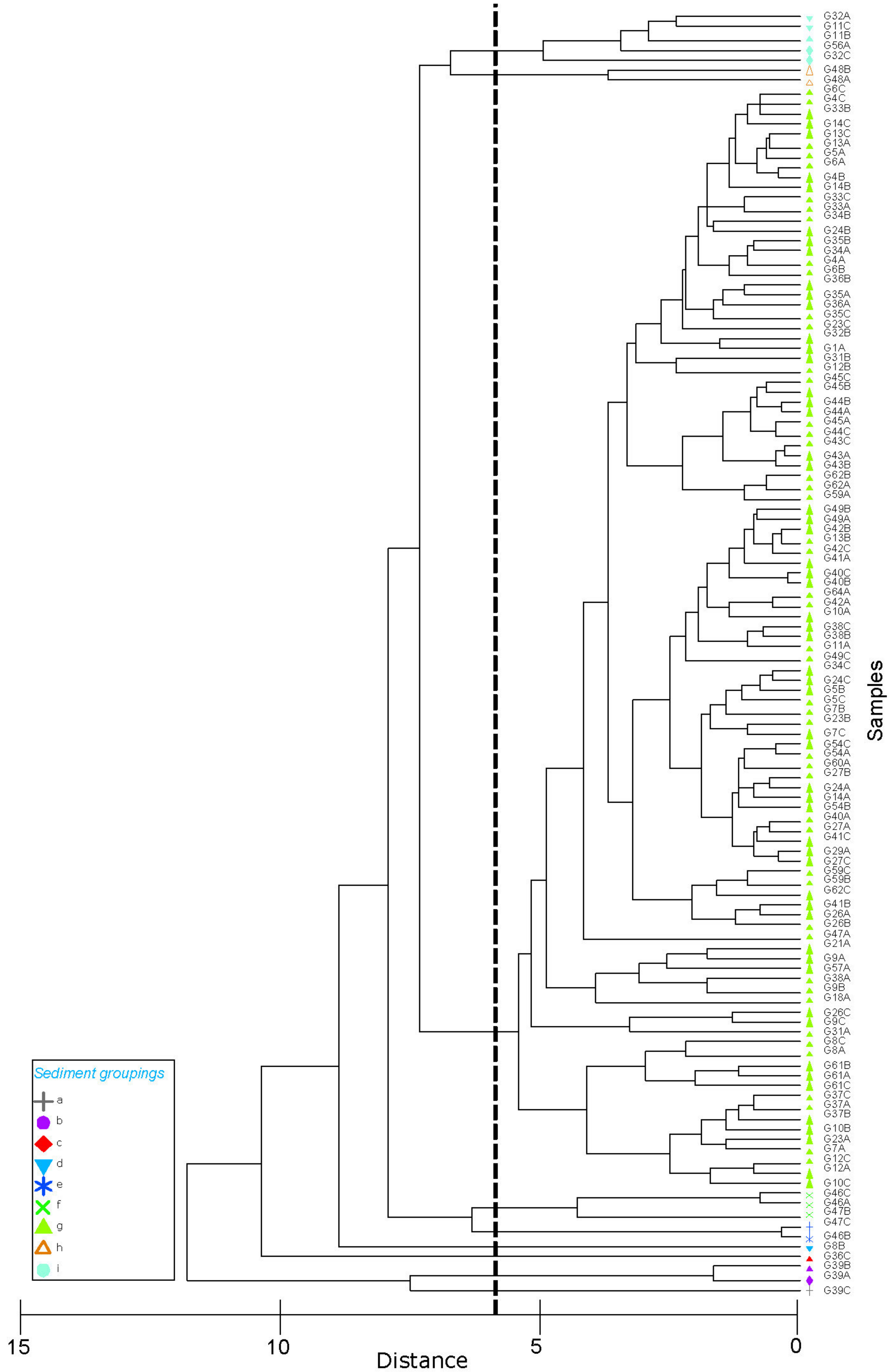
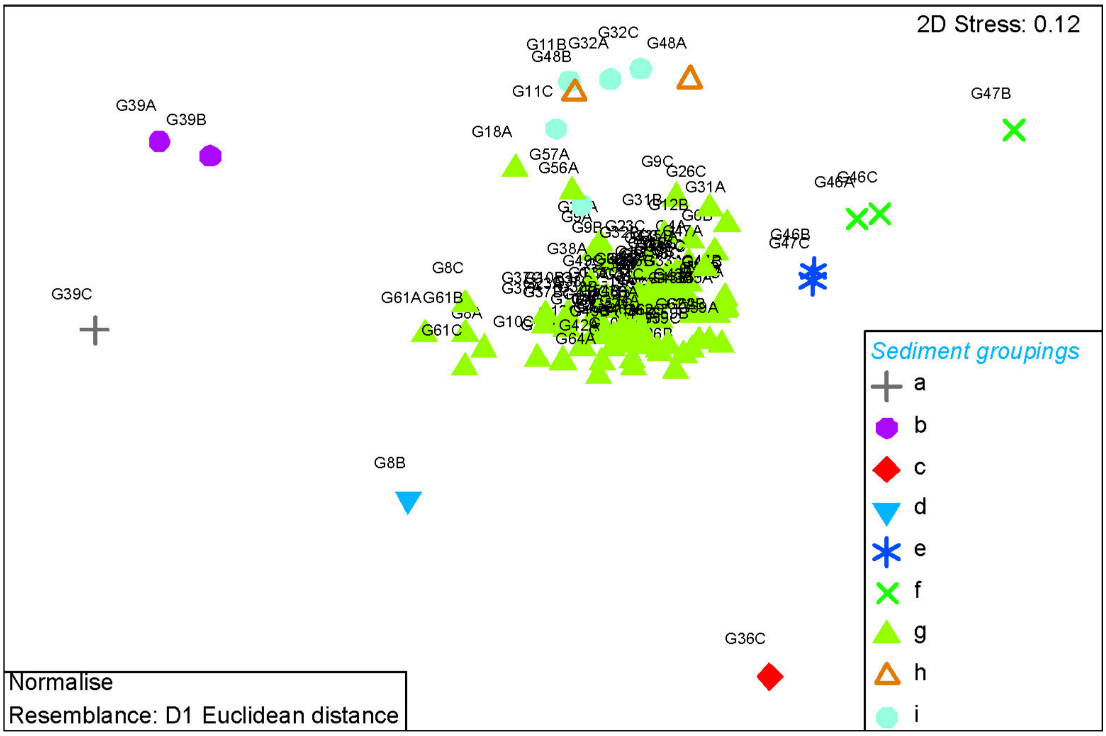
Figure 9.6 Similarity dendrogram of sediments sampled from within the Thanet site



The corresponding two-dimensional multidimensional scaling (MDS) ordination superimposed with the groups identified in the dendrogram is shown in **Figure 9.7**.

Figure 9.7 Two-dimensional MDS ordination of untransformed sediment samples



Inspection of **Figures 9.6** and **9.7** shows that the majority of samples fall into one group of sandy sediments (**Group g**). The remaining groups contain few samples and are clearly separated from the main group. They are sufficiently dissimilar to one another (high Euclidean distance) as to fall into an additional eight groups. Stations 32, 11 and 56 (**Group I**) are characterised by gravel. Station 48 (**Group h**) comprised stones and clay. Stations 46 and 47 (**Group e** and **Group f**) were effectively intertidal stations comprising well sorted fine to medium sand (see **Appendix 9.5**). Station 39 (**Group a** and **Group b**) was a shelly sample. Stations 8B and 36C (**Group c** and **Group d**) should be regarded as unclassified.

Sediment quality

There are no UK environmental quality standards for sediment quality. Therefore, for the purposes of establishing baseline sediment quality conditions for the export cable route, the Canadian 'Sediment Quality Guidelines for the Protection of Aquatic Life' have been used for comparison against survey data. These guidelines were published by the Canadian Council for Ministers of the Environment (CCME) in 1999 and updated in 2001. According to the CCME, the guidelines provide scientific benchmarks, or reference points, for evaluating the potential for observing adverse biological effects in aquatic systems. The guidelines have been derived from available toxicological information (following a CCME protocol), reflecting the relationships between sediment concentrations of chemicals and any adverse biological effects resulting from exposure to these chemicals. In the absence of UK sediment quality guidelines, the Canadian guidelines provide one of the most comprehensive sets of sediment quality criteria available. They are used for a broad range of applications including environmental benchmarking, unlike some other sediment quality classification systems that are targeted towards assessing the chemical risks of the disposal of dredged material.

The guidelines comprise two assessment levels. The lower level is referred to as the threshold effects level (TEL) and represents a concentration below which adverse biological effects are expected to occur rarely. The higher level, known as the probable effect level (PEL), defines a concentration above which adverse effects are expected to occur frequently. The TELs and PELs are used to identify the following three ranges of chemical concentrations:

- Below the TEL: the minimal effect range within which adverse effects rarely occur i.e. less than 25% of effects;
- Between the TEL and PEL: the possible effect range within which adverse effects occasionally occur; and
- Above the PEL: the probable effect range within which adverse effects frequently occur i.e. more than 50% of effects.

According to the CCME, the TEL is consistent with the definition of a Canadian interim sediment quality guideline (ISQG) and the PEL is recommended as an additional sediment quality assessment tool for identifying sediments in which adverse biological effects are more likely to occur. The PELs and ISQGs are presented in **Table 9.1**.

The Canadian guidelines do not include effects levels for nickel, a metal commonly found in the marine environment. However, for sediment quality guidelines for the disposal of dredged material at sea, it is assumed that a concentration below 100 mg/kg would not be of concern (CEFAS, 2001).

Potential sources of contamination of marine sediments and surface water in the immediate study area include two dredge spoil disposal grounds, a former crude sewage outfall associated with the Port of Ramsgate and potential migration of contaminated materials from the disused hoverport located on the northern foreshore of Pegwell Bay.

The hoverport site was originally reclaimed from the mudflats of Pegwell Bay via the removal of alluvial deposits and replacement with engineered colliery shale waste (Geo-Environmental Services Ltd., 2004). Ground contamination has been reported on the hoverport site. Elevated levels of magnesium, copper and sulphate associated with the fill material have been recorded from boreholes. Elevated concentrations of hydrocarbons have also been detected in the groundwater and are thought to be associated with the former underground fuel storage and topside vehicle maintenance areas. Whilst it is thought that the heavy metals are retained within the hoverport structure, there is concern that hydrocarbons are leaching into coastal waters and sediments via groundwater flow and through the hoverport's central outfall (Geo-Environmental Services Ltd., 2005).

The results of the chemical analyses carried out at four stations along the export cable route are shown in **Appendix 9.6**. There was no evidence of raised levels of any of the PAH suite, the PCB congeners, or either the Tri-Butyl or Di-Butyl-Tin. The lack of PAH contamination at a detectable level suggests that the sediments within the area of the export cable route are not affected by any PAHs leaching from the disused hoverport.

There was, however, evidence of raised levels of heavy metals in stations 48 and 49, where values approached 10-20 times those in sediments from Pegwell Bay at stations 46 and 47.

The results of the analysis of sediment samples 46, 47, 48, 49 and 50 are presented in **Table 9.2**.

Table 9.1 Canadian sediment quality guidelines

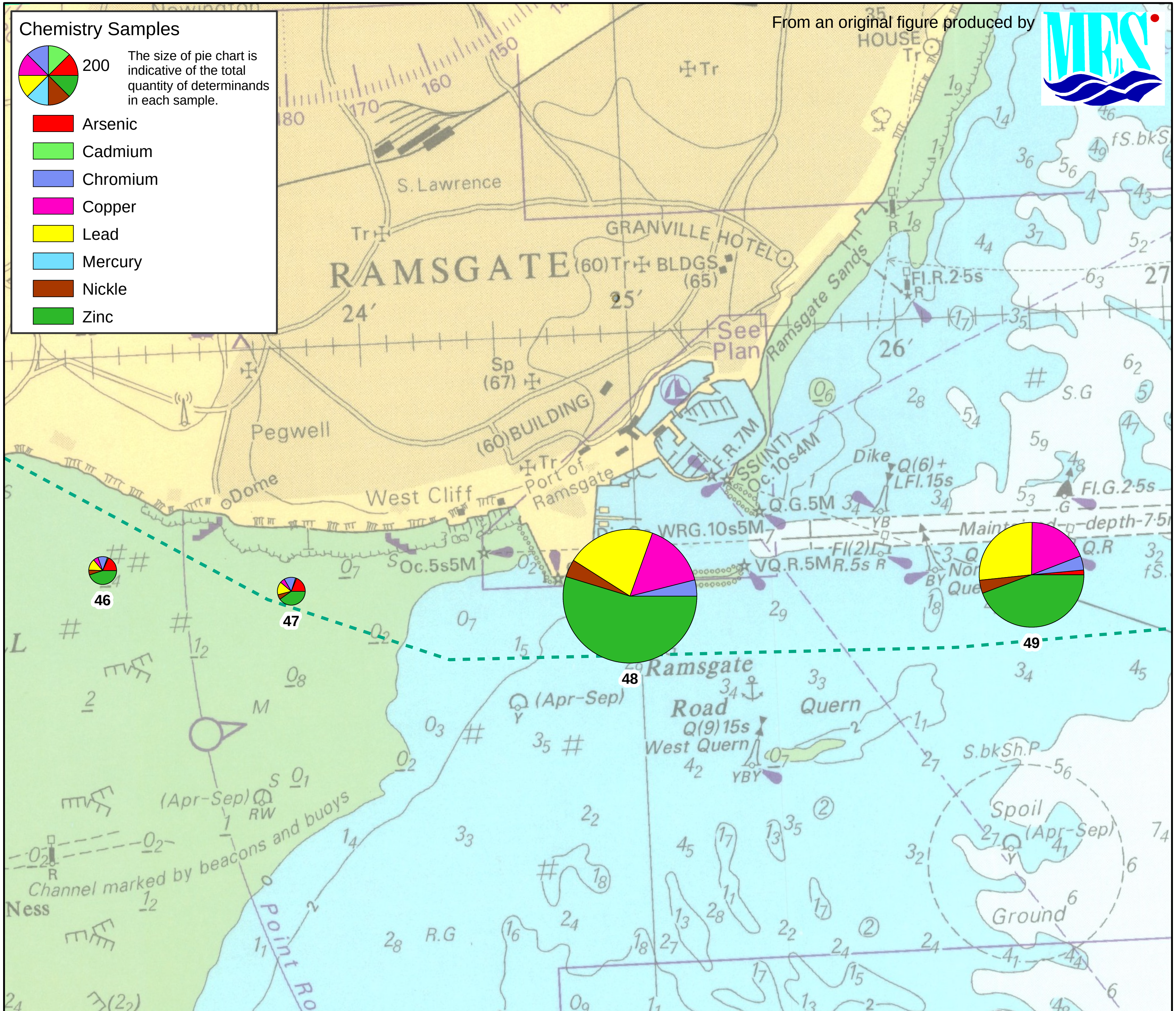
Substance	Units (dry sediment)	ISQG	PEL
Arsenic	mg/kg	7.24	41.6
Cadmium	mg/kg	0.7	4.2
Chromium	mg/kg	52.3	160
Copper	mg/kg	18.7	108
Lead	mg/kg	30.2	112
Mercury	mg/kg	0.13	0.7
Zinc	mg/kg	124	271
PCBs: total PCBs	µg/kg	21.5	189
PAHs: Acenaphthene	µg/kg	6.71	88.9
PAHs: Acenaphthylene	µg/kg	5.87	128
PAHs: Anthracene	µg/kg	46.9	245
PAHs: Benz(*a*)anthracene	µg/kg	74.8	693
PAHs: Benzo(*a*)pyrene	µg/kg	88.8	763
PAHs: Chrysene	µg/kg	108	846
PAHs: Dibenz(*a,h*)anthracene	µg/kg	6.22	135
PAHs: Fluoranthrene	µg/kg	113	1,494
PAHs: Fluorene	µg/kg	21.2	144
PAHs: Naphthalene	µg/kg	34.6	391
PAHs: Phenanthrene	µg/kg	86.7	544
PAHs: Pyrene	µg/kg	153	1,398

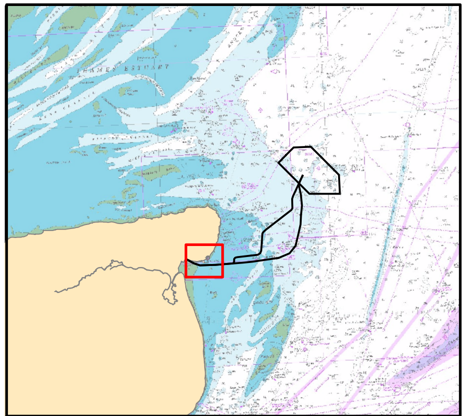
Table 9.2 Heavy metal chemistry in samples 46 to 49

Determinand	Units	46	47	48	49
Arsenic (Total)	mg/kg	8.1	8.5	7.2	9.1
Cadmium (Total)	mg/kg	< 0.50	< 0.50	3	0.74
Chromium (Total)	mg/kg	< 5.0	6	40	28
Copper (Total)	mg/kg	< 2.5	< 2.5	160	120
Lead (Total)	mg/kg	5.9	6.8	220	170
Mercury (Total)	mg/kg	< 0.20	< 0.20	0.33	0.42
Nickel (Total)	mg/kg	< 2.5	2.6	44	26
Zinc (Total)	mg/kg	20	18	560	280

Table 9.2 shows that, on the whole, levels of heavy metals in the sediment samples are below the PEL and are generally in line with the ISQG. However, at stations 48 and 49 the levels of copper, lead and zinc are above the PEL. The three heavy metals, which are associated with phytotoxicity issues, are copper, nickel and zinc.

The heavy metal chemistry results are expressed as square root graduated pie diagrams in **Figure 9.8**. The levels of zinc, lead and copper dominate the heavy metal suite. It is considered highly likely that the origin of this increase in heavy metals is due to the presence of a former licensed dredge spoil disposal site (Port Ramsgate TH145) in the immediate vicinity of the sample.





Legend:

Wind Farm Site Location

Proposed Cable Route

Title:

COMPARATIVE HEAVY METAL CHEMISTRY IN SAMPLES 46 TO 49

Project:

THANET OFFSHORE WIND FARM

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Date:	Figure:
14/10/2005	9.8

Scale: 0 0.1 0.2 0.3 0.4 Kilometres

Revision No: 002

ROYAL HASKONING

Subtidal benthic biological resource

A wide range of benthic invertebrate species were recorded from the Thanet site area, in all a total of 266 species were identified. Photomicrographs of a few examples of the benthic fauna are shown in **Plate 9.7**.

A full list of the species sampled is given in **Appendix 9.7**, the corresponding biomass data in grams of ash free dry weight (AFDW) recorded for each phylum is given in **Appendix 9.8**. The relative contribution of Annelida, Crustacea, Mollusca, Echinodermata and miscellaneous phyla to the macrofauna are shown in **Figure 9.9**.

Figure 9.9 Relative contribution of faunal groups to species diversity, abundance and biomass of samples

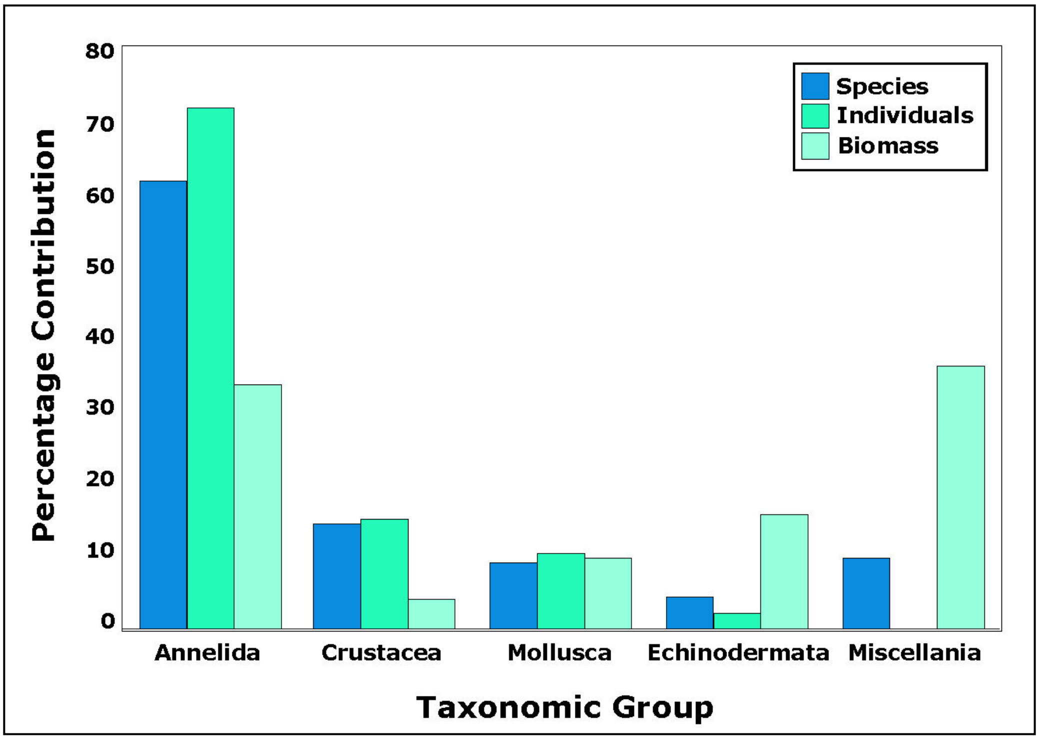


Figure 9.9 clearly shows the dominance of annelids that would be expected in samples taken from the predominantly sandy sediments of the southern North Sea. Crustaceans, molluscs and miscellaneous phyla are present in much lower numbers and are represented by relatively few species. The Annelida and Miscellania species, the majority of which are colonial, make an important contribution to the biomass of the community as a whole. The high biomass percentage contribution shown by the Miscellania can be ascribed to the presence of a large number of sea anemones in station 31A, the dead man's finger *Alcyonium digitatum* in station 52A, and pipe weed *Alcyonidium diaphanum* in station 32A. Echinoderms, though present in small numbers, represented a significant proportion of the biomass.

The contribution of the top ten organisms to the overall abundance is illustrated in **Figure 9.10**.

Figure 9.10 Top ten species contributing to the overall abundance of individuals sampled

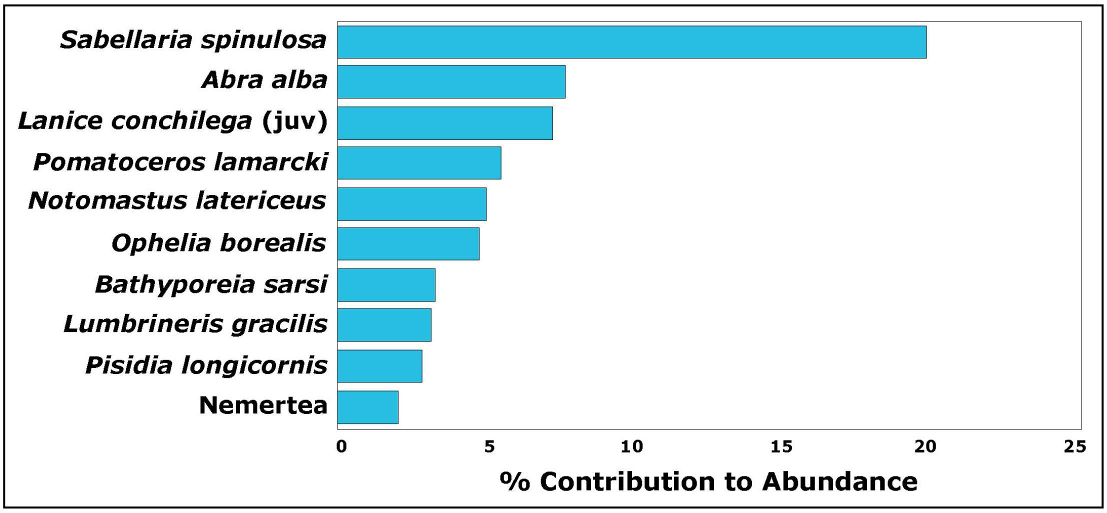
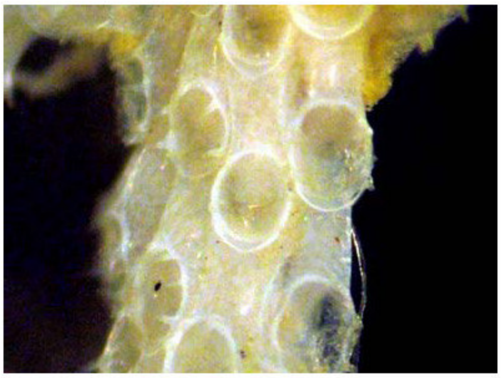


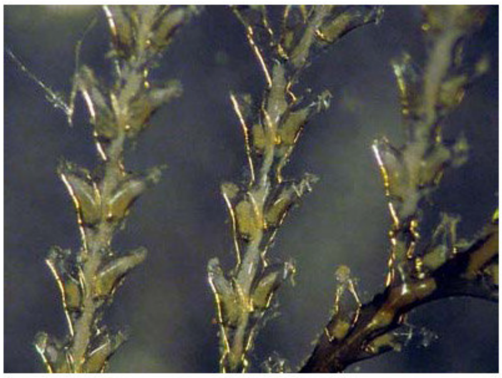
Figure 9.10 mirrors the results shown in **Figure 9.9**, with six of the top ten contributors to abundance being annelids. The highest contributor to the overall abundance was *S. spinulosa*, which was mostly located in stations 21 and 22.

Values for the number of species (**S**), individuals (**N**), biomass (**B**) and also body size (**B**/**N**) of benthic invertebrates at each of the sampling stations are summarised in **Appendix 9.9** and **Figures 9.11** to **9.13**.

Plate 9.7 Examples of benthic fauna



Electra pilosa



Sertularia cupressina

Gammarus salinus

Diastylis sp

Aora gracilis

Pholoe inornata

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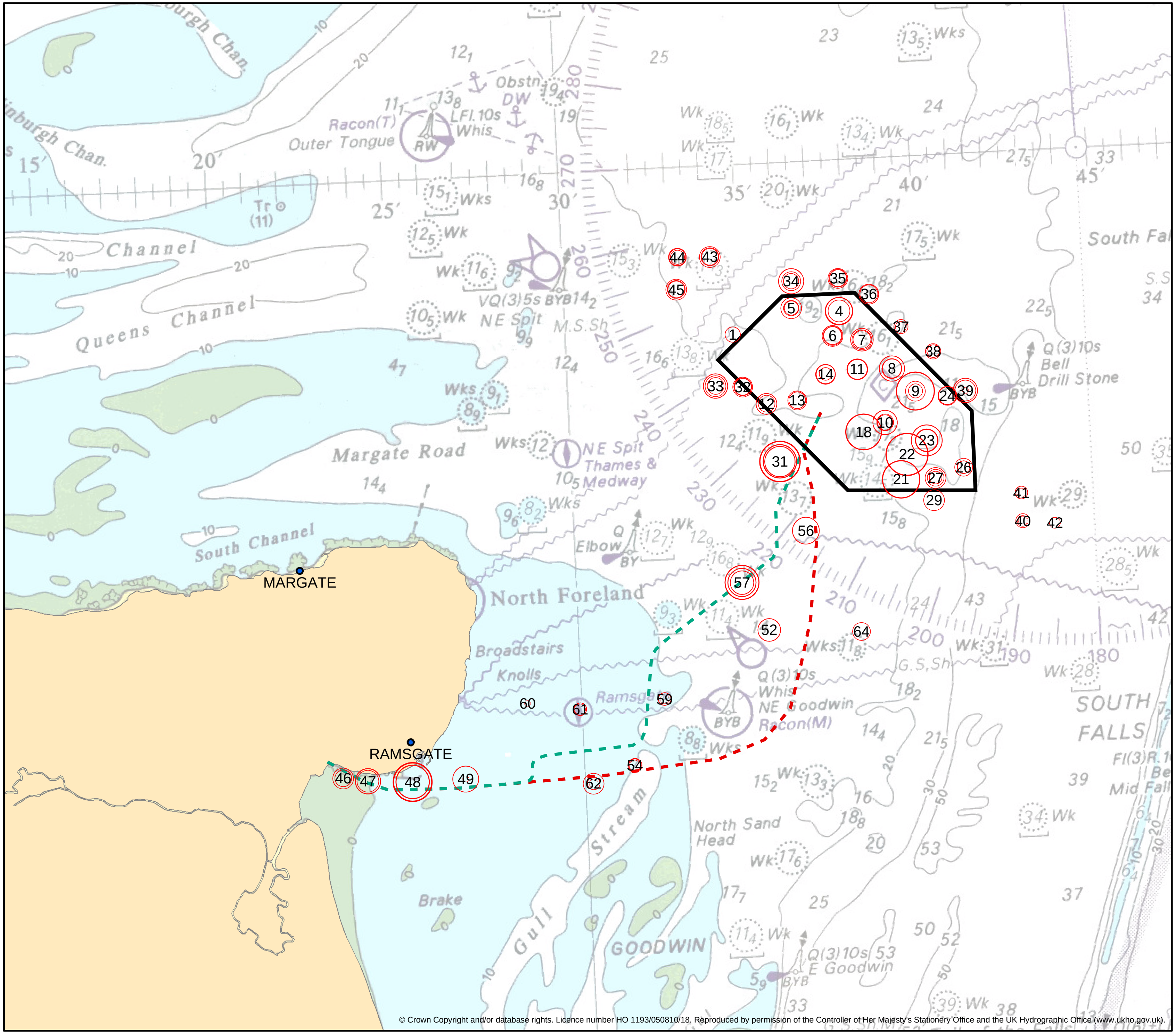

Legend:

- Wind Farm Site Location
- Proposed Cable Route 1
- Proposed Cable Route 2

Number of Species (Sample Station)

- 1
- 5
- 10

Title:

NUMBER OF SPECIES RECORDED PER SAMPLE

Project:

THANET OFFSHORE WIND FARM

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Date:	Figure:
25/10/2005	9.11

Scale:	Revision No:
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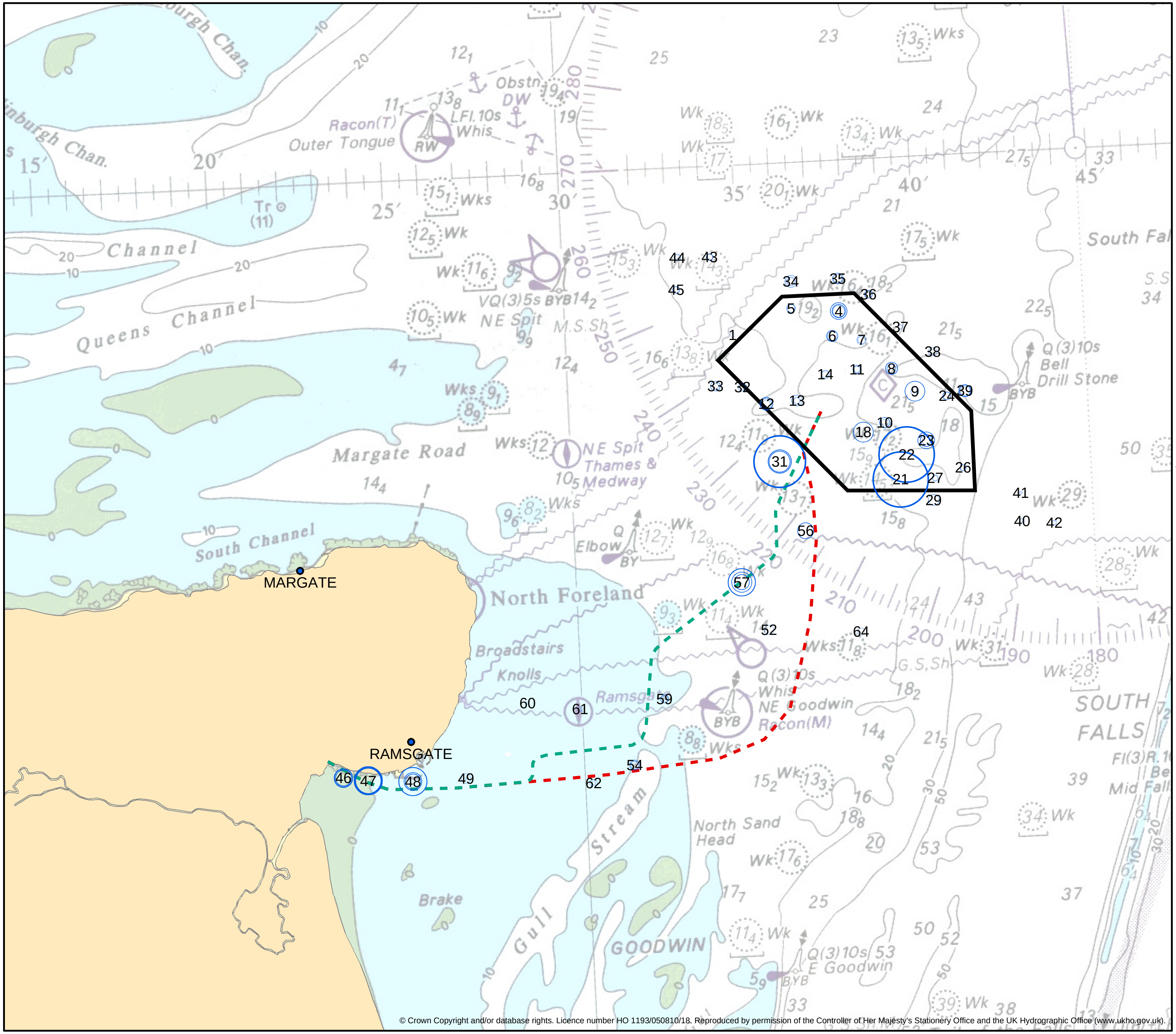
ROYAL HASKONING



Legend:

- Wind Farm Site Location
- Proposed Cable Route 1
- Proposed Cable Route 2

Number of Individuals

1,000
100
10

Title:

NUMBER OF INDIVIDUALS RECORDED PER SAMPLE

Project:

THANET OFFSHORE WIND FARM

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31/10/2005	9.12

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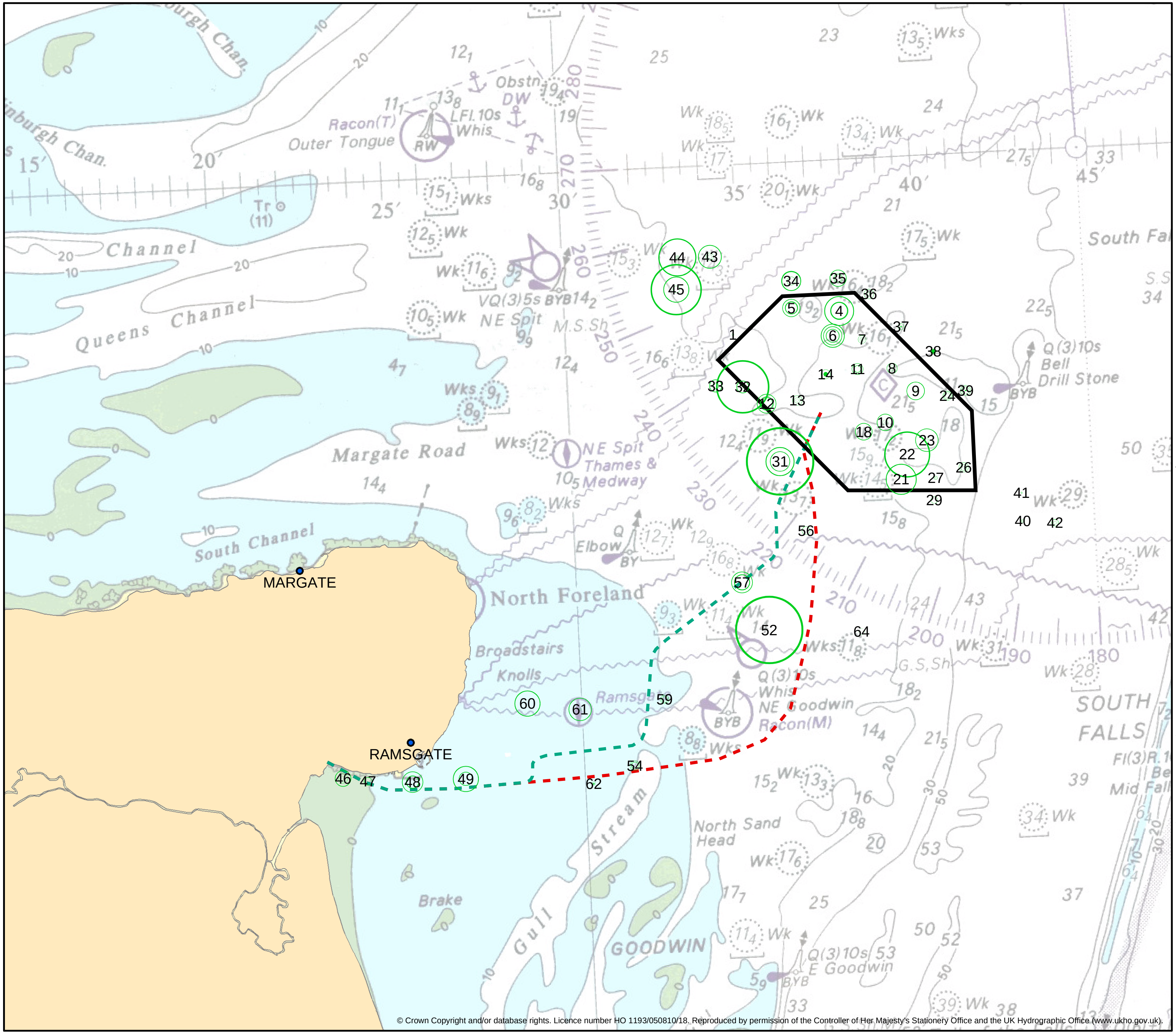
ROYAL HASKONING



Legend:
- Wind Farm Site Location
- Proposed Cable Route 1
- Proposed Cable Route 2

AFDW Biomass of Collected Samples (grammes)

10
5
1

Title: AFDW BIOMASS OF COLLECTED SAMPLES

Project: THANET OFFSHORE WIND FARM

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Date:	Figure:
25/10/2005	9.13

Scale: 0 1 2 3 4 Kilometres

Revision No: 003

ROYAL HASKONING

Although **Figure 9.11** makes it appear that the number of species is relatively uniform, the number of species ranges from 3 to 44 species per station throughout the survey area. The species numbers are mostly low (5 to 10 species), with a small number of stations (e.g. 9, 21, 22, 31 and 48) being represented by high numbers (30 to 40 species).

Figure 9.12 shows the number of individuals to be very variable ranging from zero (stations 49B and 60A) to 857 (station 22a) per 0.1m² Hamon grab. The cluster of stations comprising stations 21A and 22A in the centre of the survey area has particularly high species abundance reflecting the occurrence of *S. spinulosa*. The high number of individuals found at station 31A reflects the presence of a large number of the bivalve *Abra alba*.

Many of the stations within the Thanet site and beyond have a relatively high and very variable biomass (**Figure 9.13**). The elevated biomass of the central stations (21 and 22) is again due to very high numbers of *S. spinulosa* and associated epifauna such as the porcelain crab *Pisidia longicornis.* The high biomass of station 31A represents high numbers of *A. alba,* station 32A the presence of *A. diaphanum*, station 45A represents the presence of three specimens of the heart urchin *Echinocardium cordatum*, and station 52A the dead man's finger *Alcyonium digitatum.*

Multivariate analysis of community composition

Multivariate analysis of community composition in the study area was carried out using the Primer V6 package of statistical analysis tools. The analysis takes into account the species variety and relative abundance of each taxonomic group and allows inferences to be made on the characterising species that comprise the major communities in the survey area. A group average sorting dendrogram[1] showing the percentage similarity between the faunal communities sampled at each station is shown in **Figure 9.14**.

Figure 9.14 demonstrates the high level of heterogeneity of the benthic community with the study area insofar as the majority of the similarities are no greater than 40%. This analysis, which is supported by reference to the actual species data, shows that the biological communities at each of the survey stations are highly variable and have few characteristics in common. This dissimilarity is probably due in the most part to the variability of substrate types across the site and the relatively small number of species recorded in many of the samples. As so many of the samples have so few characteristics in common, it is not possible to form an identifiable group or 'community' in the recognised sense that is statistically separable from others in the study area.

As further visual evidence of this dissimilarity and general lack of community structure, **Figure 9.15** presents the two-dimensional MDS ordination that accompanies the dendrogram.

[1] The dendrogram is based on Bray-Curtis similarity of square root transformed abundance data.

Figure 9.14 Dendrogram showing percentage similarity of benthic infauna between samples

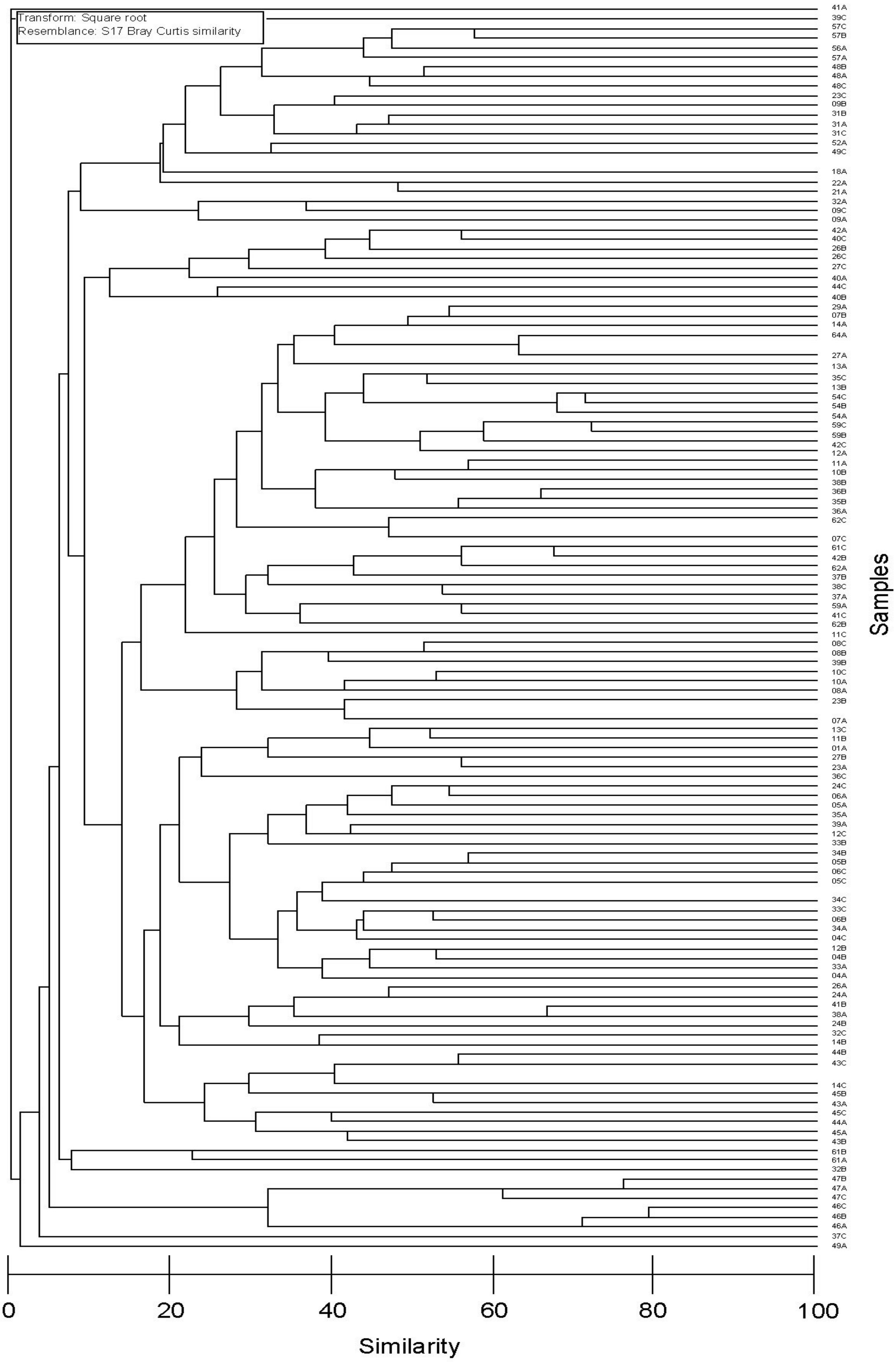
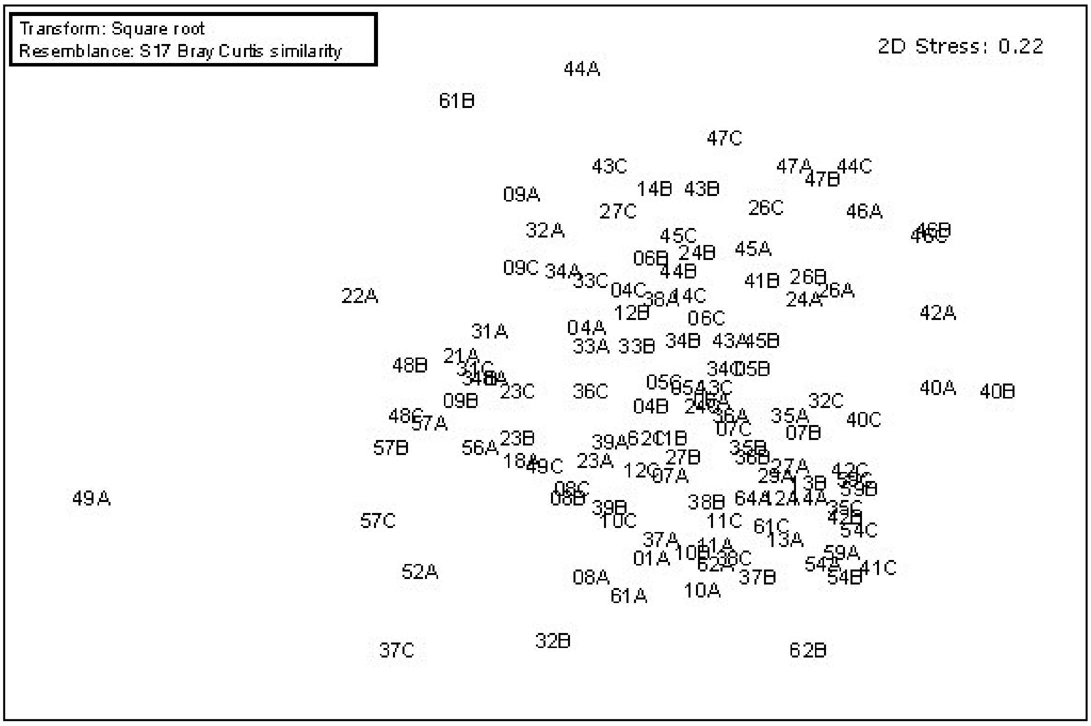


Figure 9.15 MDS ordination showing the dissimilarity in infaunal community structure within the survey area



In order to ensure that the lack of definable communities was not a function of the fact that the statistical weighting of abundant species had been reduced by a square root transformation of abundance data, the data were rerun through Primer without transformation. This approach potentially allows for determination of whether distinct faunal communities characterised by high abundance of species such as *S. spinulosa* or *A. alba* would be identifiable. However, no similarity was observed and no distinct community was discernable, even in areas of high *S. spinulosa* abundance.

Analysis of the percentage similarity of identifiable faunal groups using the SIMPER sub-routine within PRIMER was not carried out given the dissimilarities discussed above.

The high level of dissimilarity also means that a habitat classification figure, using the JNCC biotope method, would be unrepresentative of the actual assemblage, as the biotope would have to be defined based on the sediment type it is most closely related to rather than the range of characterising species it contains.

The data collection and subsequent analysis shows that the biological resource within the study area is largely typical of communities encountered on similar substrates throughout the southern North Sea and eastern English Channel.

The only species and assemblage of true potential conservation significance in the survey area is *S. spinulosa*. A high abundance of this species was encountered at sampling locations 21 and 22, which were considered as having the potential to represent sites of conservation significance. Following discussion and agreement with English Nature, a detailed survey to define the nature and distribution of *S. spinulosa* habitats in and adjacent to benthic stations 21 and 22 was carried out. The methods and results of this survey are discussed in detail in **Section 9.3.3**.

Epifauna

A total of 40 invertebrate species and 22 fish species were recorded from the beam trawls. The results listing catch numbers per trawl is provided in **Appendix 9.2** along with photographs of all beam trawl catches.

The brittle star *Ophiura affinis* was the numerically dominant epibenthic species found in the survey due to their extremely high densities in two of the beam trawls in the northeast of the turbine area (BT11 and 10), and in the three control sites to the northeast of the Thanet site (BT6, 7 and 8). These areas are characterised by fine sandy sediments.

The shrimp *Crangon allmani* and the brown shrimp *Crangon crangon* were also found in large numbers. The brown shrimp occurred in greatest densities in the six beam trawls within the wind farm area (BT9, 10, 11, 12, 13 and 14) and in the three control sites to the northeast of the site (BT6, 7 and 8). *C. allmani* was prevalent at the control site to the southwest of the Thanet site (BT15 and 16) and at the reference sites to the northwest of the site (BT23, 24 and 25). The pink shrimp *Pandalus montagui* was also found in significant numbers on the beam trawls located in the vicinity of the proposed cable route (BT2, 3, 4, 5, 19, 20, 21, 22, 26, 27 and 28). The sea urchin *Psammechius miliaris* was also found in large numbers in beam trawls over the cable route, other than the most inshore trawls (BT2, 3, 4, 5, 19, 20, 26, 27 and 28).

S. spinulosa was present in low numbers in beam trawls 11, 12, 13 and 22, but totally filled the beam trawl net at site 17. All catches of *S. spinulosa* were found in small encrustations on stones and shell fragments. The indication from this is that it was not reef forming at any of the locations where beam trawling was carried out, although it is not possible to confirm this from the beam trawl alone.

In order to identify the community composition of the epifauna, a series of multivariate analyses have been carried out using the PRIMER v6 software. To compare the similarity of the faunal composition of the different trawl samples, a Bray-Curtis similarity index was first calculated using a log X+1 transformation. The results of this are presented in a dendrogram (see **Figure 9.16**). By representing the similarity index graphically, it is possible to distinguish groups of samples, which are similar in faunal composition. Four groups of species have been able to be distinguished which are similar at the 40% level. The similarity of these groups is illustrated in **Figure 9.17**.

Figure 9.16 Dendrogram showing percentage similarity of benthic epifauna between samples

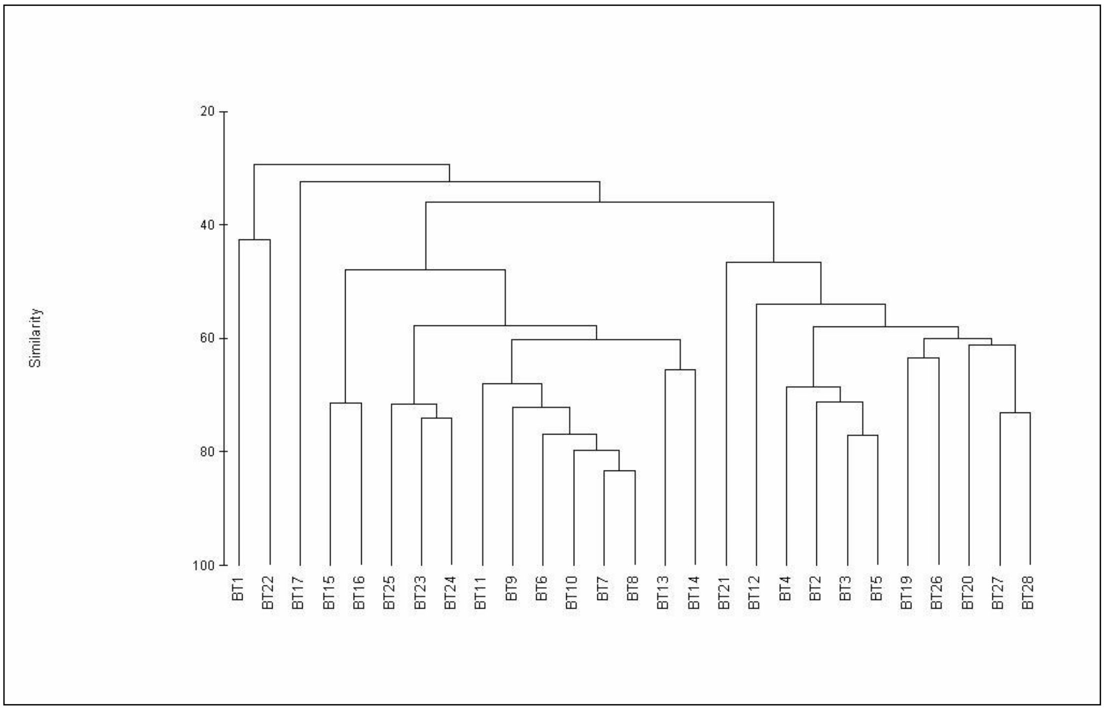
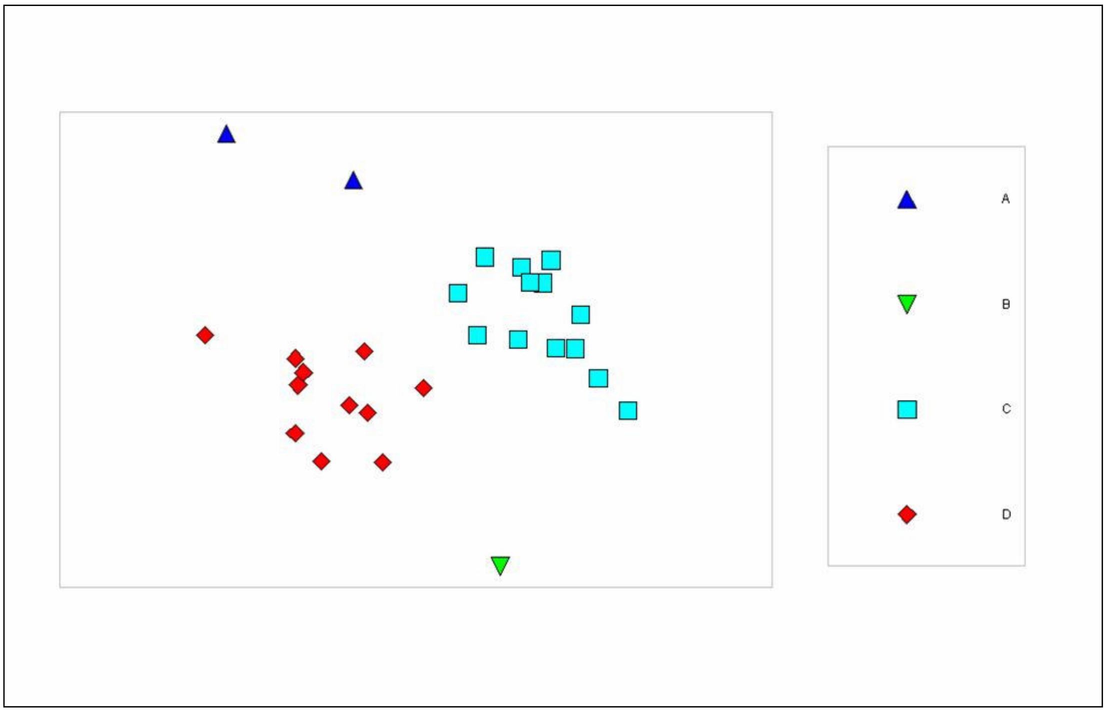


Figure 9.17 MDS ordination showing the similarity at 40% in epifaunal community structure within the survey area



SIMPER analysis has been undertaken to determine which species typify the benthic community at each survey. Group A only comprises two samples (BT1 and BT22), which are characterised by the common starfish *Asterias Rubens* and the hermit crab *Pagurus bernhardus*. Group B only comprises one sample (BT17), which cannot be classified with any of the other samples. Trawl BT17 returned high numbers of *S. spinulosa*, which is known, when encountered in sufficient aggregations, to facilitate the presence of an epifauna that is unique in comparison to surrounding areas of seabed. BT17 contained unusually high numbers of the pea crab *Pisidia longicornis*, a species often associated with *S. spinulosa*. It is possible to conclude from this that the *S. spinulosa* at BT17 is important in determining the epifaunal assemblage present.

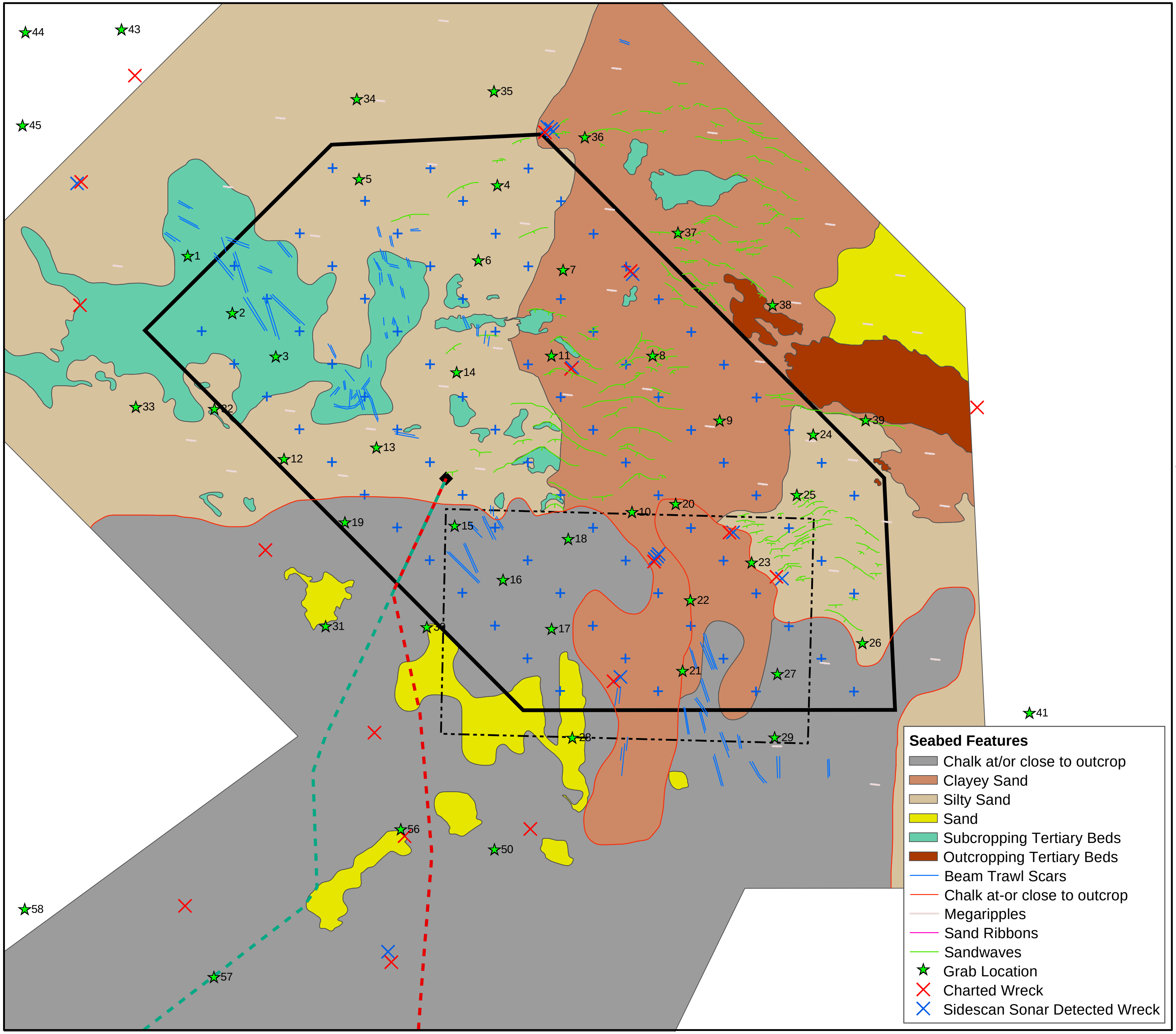
The majority of samples fall within Group C, which is characterised by high abundances of the brittle star *Ophuira affinis* and to a lesser extent the shrimps *Crangon allmani* and *Crangon crangon*. Up to 7,231 individual brittlestars were recorded in these samples. A total of 11 samples fall within Group D, which is characterised by the sea urchin *Psammechinus miliaris,* the shrimp *Pandalus montagui,* and the starfish *Asterias rubens*.

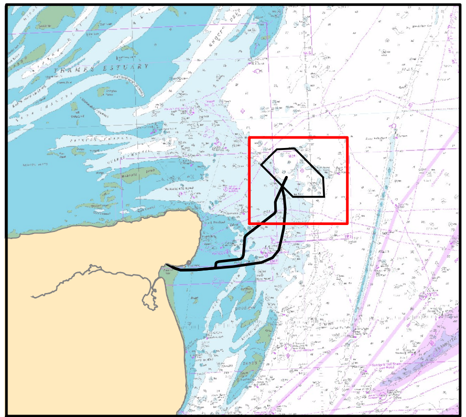
9.3.3 *Sabellaria spinulosa* survey

High numbers of individuals of *S. spinulosa* were found in grab samples 21 and 22. Following this discovery, a small number of sites were sampled with a dropdown camera, a number of which revealed the presence of *S. spinulosa* with variable abundance, and as being generally patchy in appearance.

The results of the benthic faunal analysis discussed in **Section 9.3.2** showed that *S. spinulosa* was commonly encountered throughout much of the middle section of the Thanet site. However, *S. spinulosa* is only of conservation significance when it is present in its reef forming assemblages. It was decided, therefore, to define a survey area for the detailed survey that was based upon the photographic evidence that had already been collected and also upon an analysis of the geophysical survey results showing seabed features and sediments within the study area in general. The seabed features presented in **Figure 9.2** clearly show the presence of sand waves and megaripples throughout much of the central, northeastern and southeastern areas of the Thanet site. This suggests that much of the central and northern sections of the site is too dynamic in nature to support the establishment of *S. spinulosa* reefs, rather it is more likely that any *S. spinulosa* encountered here will be patchy and ephemeral in nature.

The southern limit of the site, from west to east, does not have the mobility of other areas, as revealed by the large sand waves encountered elsewhere. Here the geophysical survey shows that there is a thin veneer of clayey sand overlaying the chalk bedrock, which outcrops in places. It is in this area where the habitat provides the right characteristics suitable for *S. spinulosa* development being in an area of strong currents, and fed with a constant sediment and food supply from the surrounding mobile sand areas. This area also coincides with sample locations 21 and 22. A survey area was defined in the southern area of the Thanet site based on these results and interpretations and subsequently agreed with English Nature. **Figure 9.18** shows the final location of the survey area.





Legend:

- Wind Farm Site Location
- Proposed Cable Route 1
- Proposed Cable Route 2
- Offshore Substation
- *S. spinulosa* Survey Area

Title:

LOCATION OF SABELLARIA SPINULOSA SURVEY AREA

Project:

THANET OFFSHORE WIND FARM

Source: Main Chart - Not to be used for navigation.

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Date:	Figure:
25/10/2005	9.18

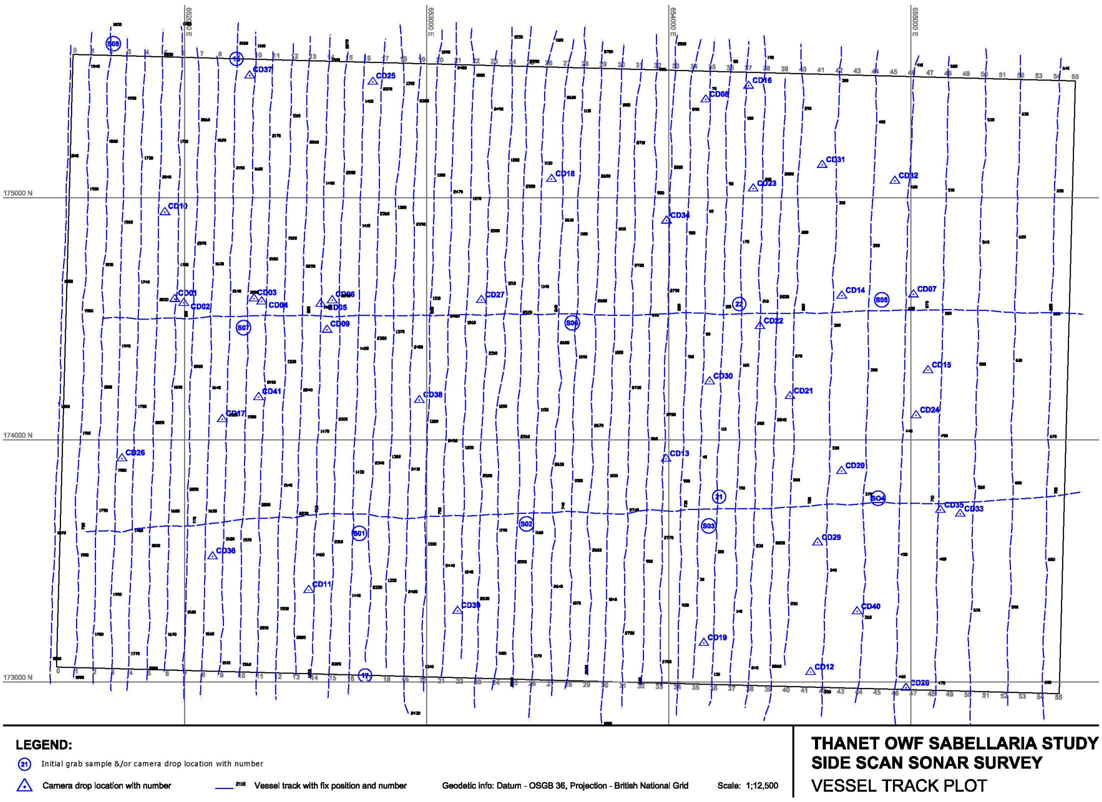
Scale:	Revision No:
0 0.25 0.5 0.75 1 Kilometres	004

ROYAL HASKONING

A grid of survey lines was drawn over the survey area and a high resolution side-scan sonar was then deployed and operated at a frequency of 500kHz and towed at a distance of 7-15m above the seabed. Raw data from the sonar transceiver, together with heading and navigation data, was sent to a computer running the C-View Data Management Package (SDMP), where it was logged and displayed. Navigation and position data was also logged and transformed to British National Grid before being sent to the SDMP.

Survey lines were initially run at 75m intervals to ensure better than 100% overlap on the sonar tracks. However, after a few trial runs it was decided to change to 85m intervals, as this still ensured 100% coverage. Due to deteriorating weather conditions, the intervals were increased to 150m over the far eastern section of the survey area. This separation still allowed for 100% coverage. **Figure 9.19** shows the track plot for the survey box.

Figure 9.19 Side-scan sonar track plot

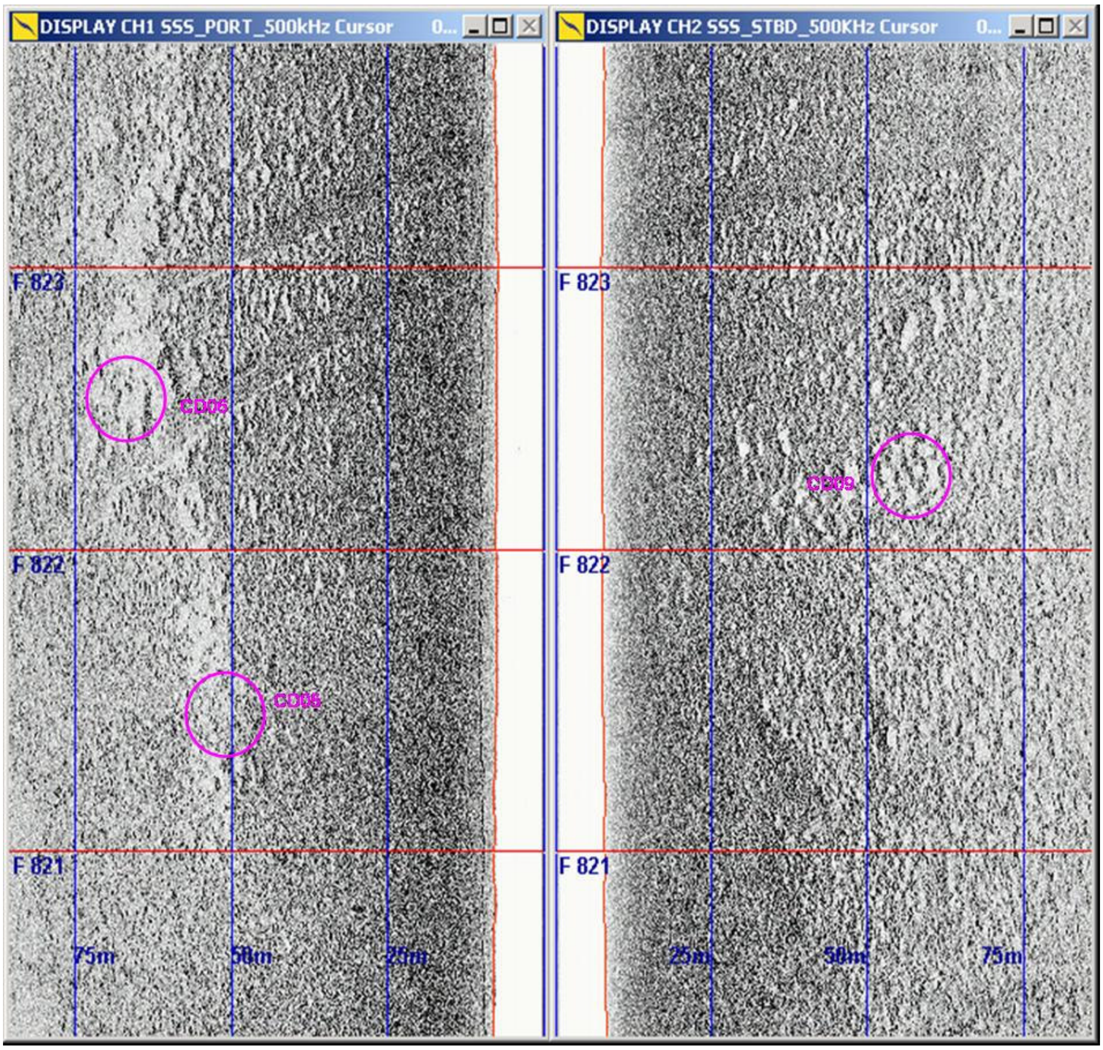


The side-scan data were examined at the end of each day and areas of possible *S. spinulosa* growth were identified by their unique textured appearance and corroborated by plotting sites of known *S. spinulosa*, identified in the previous survey. Four levels of texturing were identified and assumed to signify differing *S. spinulosa* growth:

- None;
- Accretions;
- Moderate growth; and
- Dense growth/possible reef.

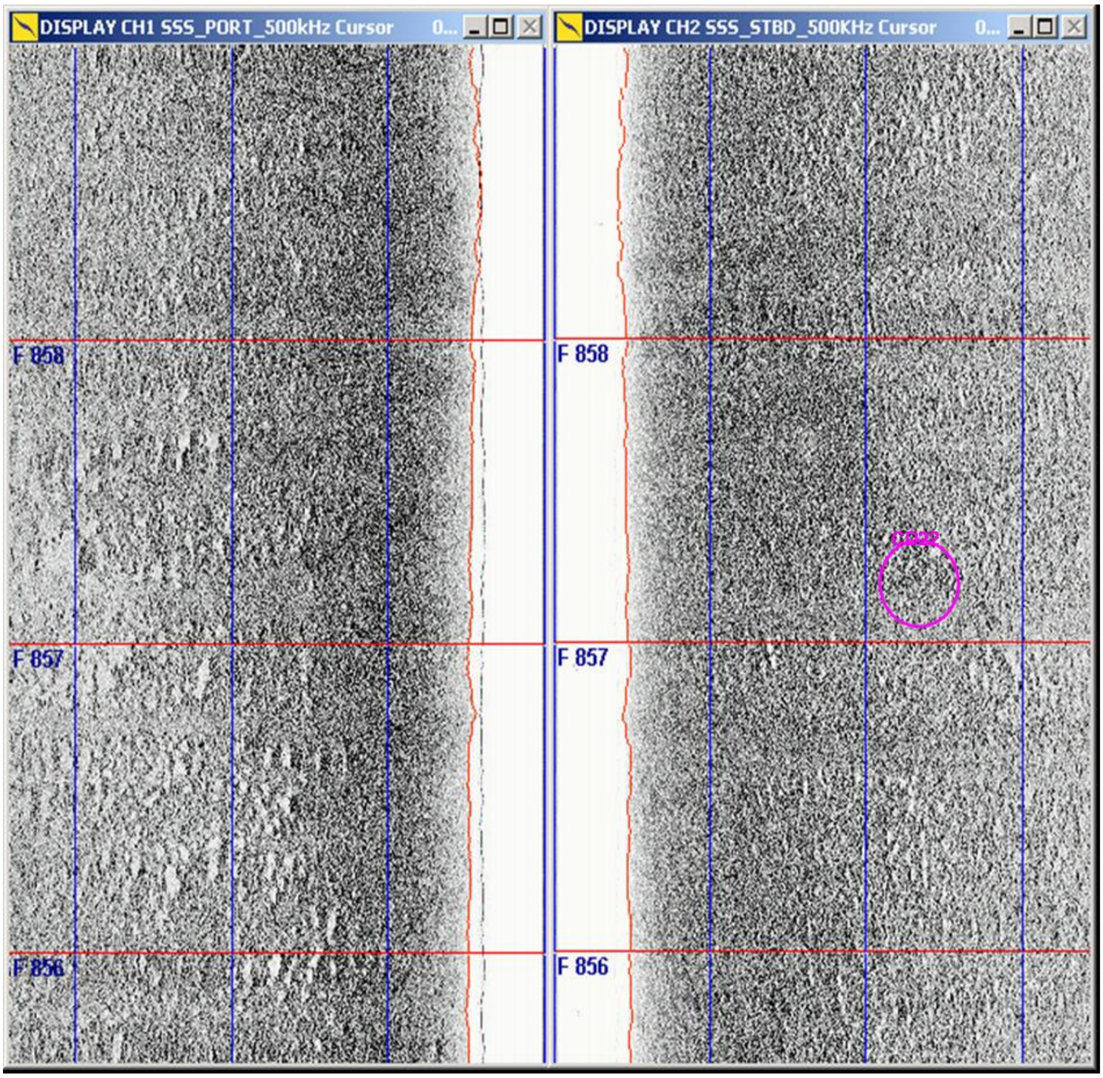
Plates 9.8, **9.9** and **9.10** show sections of side-scan sonar data illustrating the different textures and their interpretation in terms of *S. spinulosa* growth.

Plate 9.8 Selection of side-scan sonar data showing seabed texturing (a)



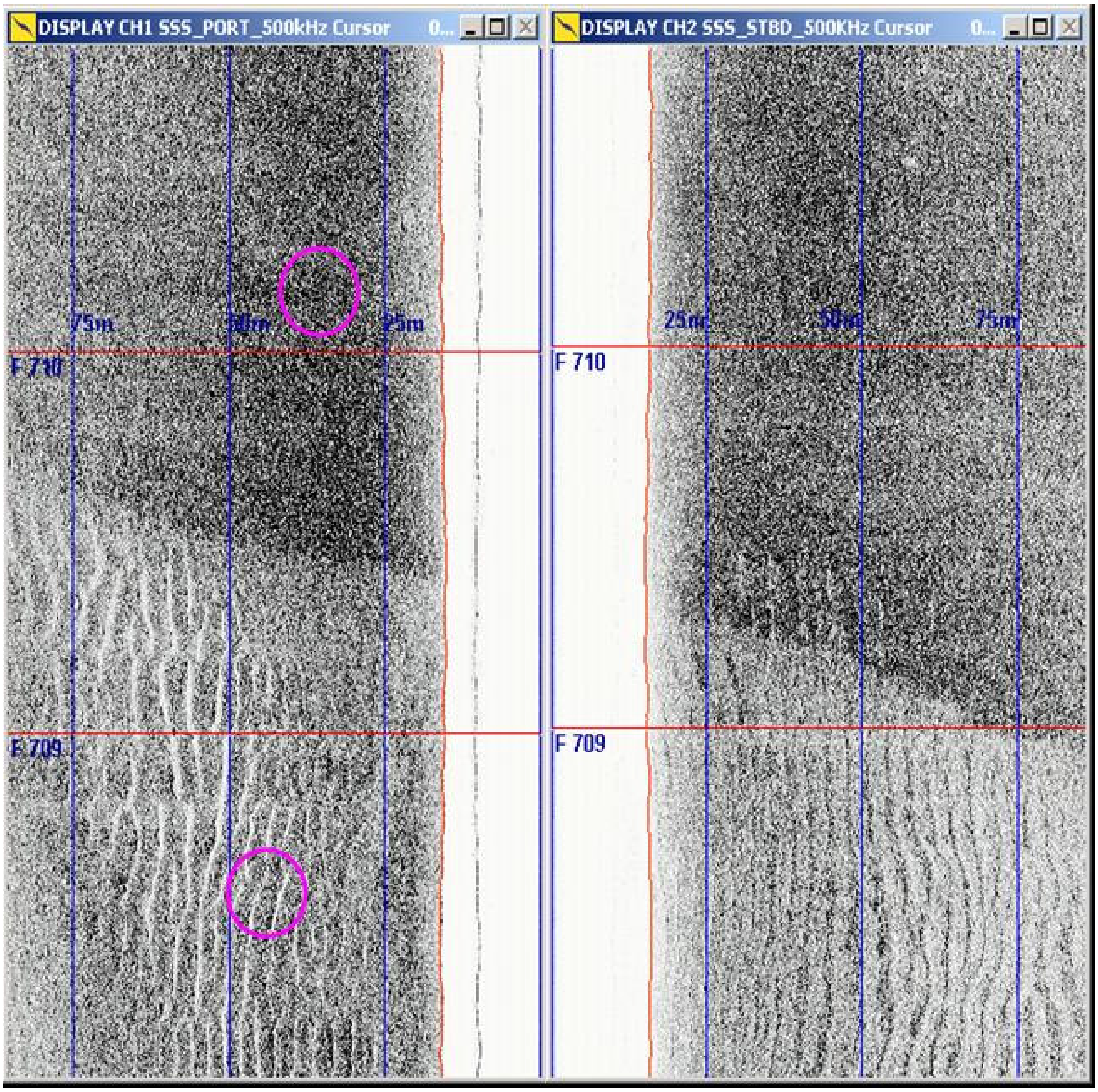
Note: Raised texture on the left was interpreted as 'dense growth/possible reef'. Less prominent stippling on the right was interpreted as 'moderate growth'. Beam trawl scars are also clearly visible on the left hand image, cutting through the raised texturing.

Plate 9.9 Selection of side-scan sonar data showing seabed texturing (b)



Note: Left, 'moderate growth'. Right, 'low density growth'.

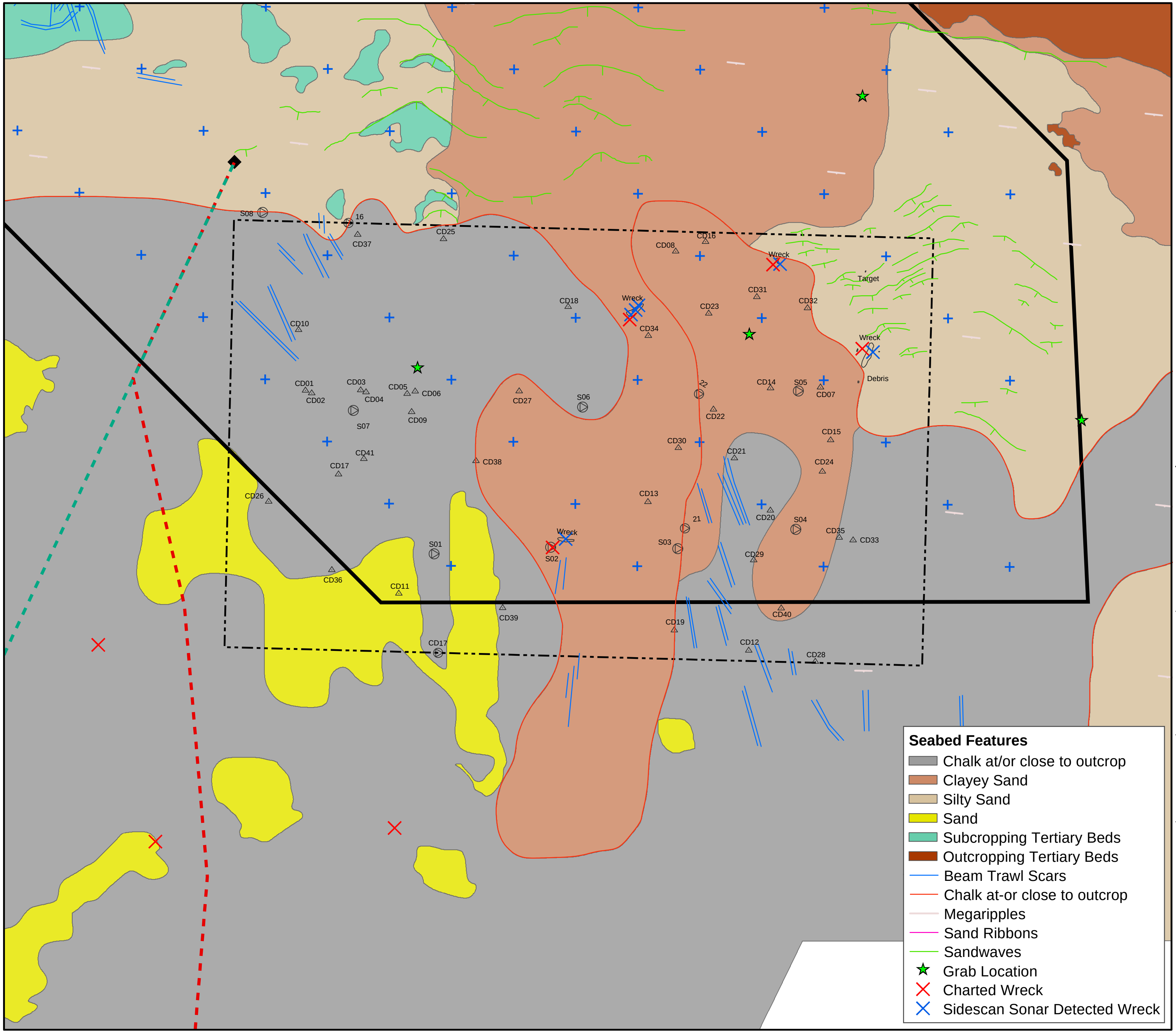
Plate 9.10 Selection of side-scan sonar data showing seabed texturing (c)

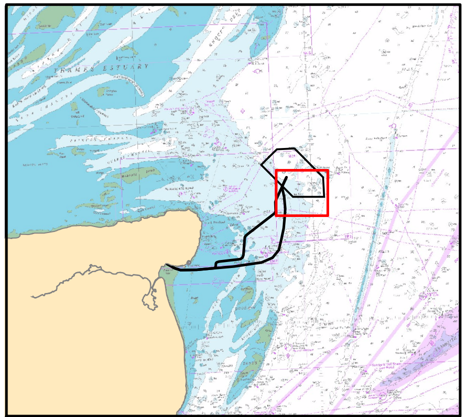


Note: There is a distinct difference in substrates encountered on this track. The lighter texture is an extensive sandy area and the darker area is a gravely substrate.

Dropdown camera surveys

The side-scan interpretation was ground truthed through the deployment of a dropdown camera that had been specially adapted for work in high turbidity environments. Three photographs were taken at each site, approximately 1-2m apart, to give an indication of the small scale variability in the substrate type. The camera drops were positioned in areas that were thought to represent each of the *S. spinulosa* classifications, and also in areas defined as having no *S. spinulosa*, such as sand waves. The positions of the dropdown locations are presented in **Figure 9.20**.





Legend:
- Wind Farm Site Location
- Proposed Cable Route 1
- Proposed Cable Route 2
- Offshore Substation
- *S. spinulosa* Survey Area
- Drop Down Camera Location
- Grab Sample Location

Title:

LOCATIONS OF DROPDOWN CAMERA GROUND TRUTHING SITES

Project:

THANET OFFSHORE WIND FARM

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Date:	Figure:
31/10/2005	9.20

Scale: 0 0.25 0.5 Kilometres

Revision No: 003

ROYAL HASKONING

The photographs taken at each location are presented in **Appendix 9.10**. The photographs were initially assigned a *S. spinulosa* classification on a scale of 1 to 4 where:

1 = Dense growth / possible reef;

2 = Moderate growth / patchy reef;

3 = Accretions; and

4 = No *S. spinulosa.*

The classifications were based upon the prediction of the density shown in side-scan sonar plots. These photographs were then analysed together to form the overall classification for each area (see **Appendix 9.11**). It should be noted that some sites such as C01 that were initially interpreted as being 'dense growth/possible reef', based on the side-scan plots, were upon further analysis reduced to 'moderate growth'.

Figure 9.21 is the output of the interpretation of the side-scan sonar data and the ground truthing.

The results of this survey show that *S. spinulosa* is present over a large part of the survey area, mostly present as low to moderate patchy growth. Small areas of dense growth, which may constitute reef, are present at the western edge of the survey area as well as through the central section. There is a distinct band of sand waves, which runs along the eastern edge of the survey area and smaller patches of sand waves through the central section.

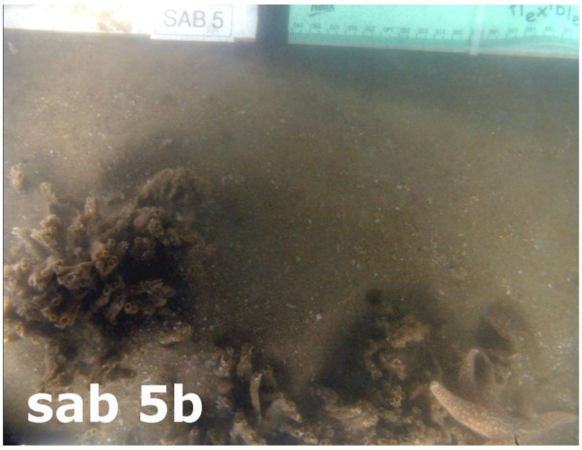
Whilst there was a very good correlation, for the most part, between the photographs and the side-scan sonar data, it is worth noting that this was not always the case and in some areas where dense *S. spinulosa* was expected, there was none present in the photographs. The type of dropdown camera system used in this survey was specially adapted to provide good photographs in the very poor visibility experienced on this site. However, this method is only able to give information about a very small area (approximately $0.1m^2$) and as such it does not give an overview of the site, rather only snap shot views.

The lack of correlation between photographs and side-scan sonar data at a small number of sites, is most likely, therefore, to reflect the patchiness of the *S. spinulosa* growth in this area. It should be noted however, that there is a small chance that the texturing picked up by the side-scan sonar is simply the textured sandy substrate rather than the *S. spinulosa* reef itself, in which case, the growth may not be quite as widespread as illustrated in **Figure 9.21** and should be considered as an overestimation of *S. spinulosa* distribution and abundance in the study area.

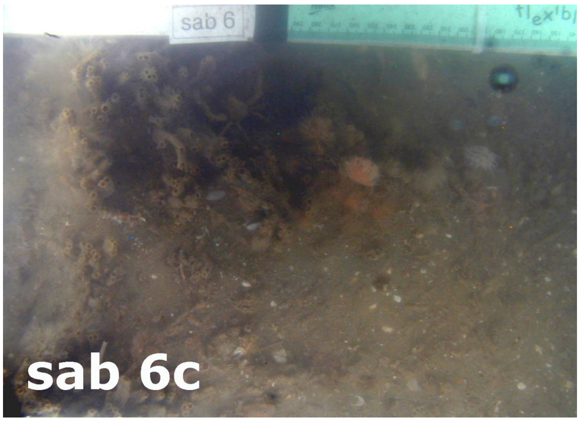
Plate 9.11 provides examples of photographs of a) dense, b) moderate and c) patchy *S. spinulosa* aggregations.

Plate 9.11 Examples of *S. spinulosa* aggregations

(a) High density aggregation

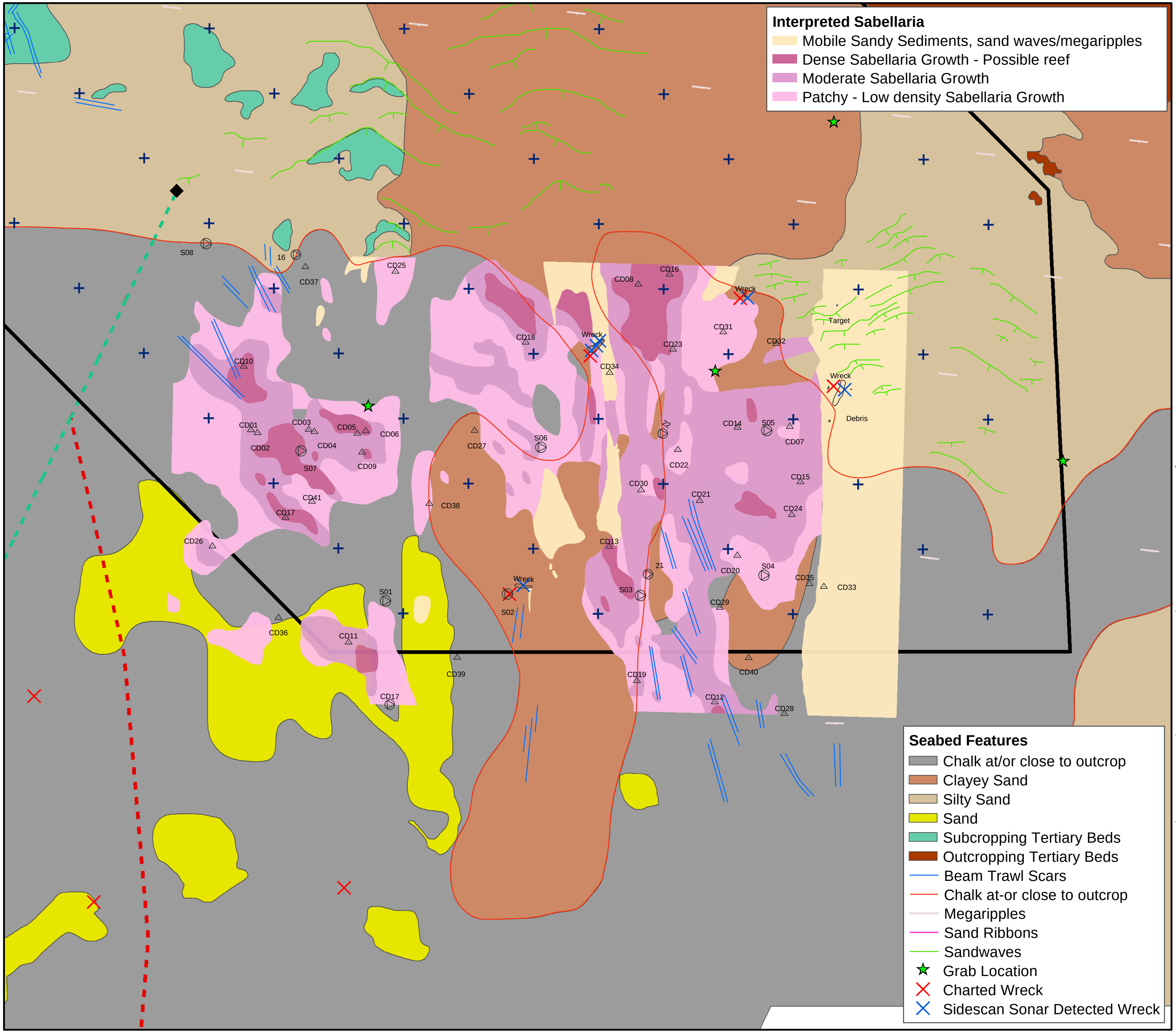


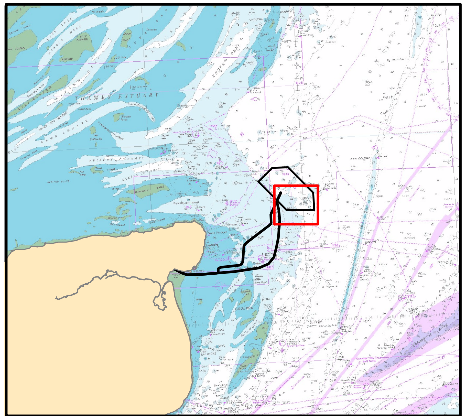
(b) Moderate density aggregation



(c) Low density aggregation.

Source: photographs used with permission of Marine Ecological Surveys Ltd. photo library. All images © http://www.mesl-photolibrary.co.uk





Legend:

- Wind Farm Site Location
- Proposed Cable Route 1
- Proposed Cable Route 2
- Offshore Substation
- Turbine Locations x 83 (not micro-sited)
- Drop Down Camera Locations
- Grab Sample Location

Title:

INTERPRETED SABELLARIA SPINULOSA DISTRIBUTION AND DENSITY

Project:

THANET OFFSHORE WIND FARM

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Date:	Figure:
31/10/2005	9.21

Scale: 0 0.25 0.5 Kilometres

Revision No: 004

ROYAL HASKONING

9.4 Impacts during Construction (intertidal activities)

9.4.1 Impacts due to habitat disruption

Benthic invertebrates

Construction impacts in the intertidal area of Pegwell Bay relate to the ploughing operations associated with the cable laying process. The methodology for laying the intertidal section of the export cables uses a bespoke plough that has the ability to backfill the narrow cut created as the cable is laid. The method of cable laying is described in detail in **Section 2**.

The intertidal cable route would be laid across the midshore muddy sandflats of Pegwell Bay and would not cross the more ecologically sensitive wave-cut chalk platforms along the northern foreshore or the geologically important chalk cliffs behind. The flats form part of the Pegwell Bay SSSI/SAC/SPA/Ramsar/NNR site and support a community, which is commonly encountered in similar substrates around the coast, dominated by polychaetes such as lugworm and, to a lesser extent, bivalves such as edible cockles and Balthic tellin. These species form part of the available prey resource for the SPA bird population.

The cable plough would cut a narrow trench, typically 250mm wide, and would simultaneously lay and bury the cable to a minimum target depth of 1m. The action of the plough lifts a wedge of sediment, deposits the cable at the base of the trench and the lifted sediment falls back on itself, burying the cable (see **Section 2**).

The habitat disturbance caused by the cable laying process would lead to disturbance and mortality of a number of benthic invertebrates in the direct path of the burial. On the whole however, the species present within the muddy sandflats are tolerant of disturbance and are widely distributed throughout the midshore of the Bay. Those individuals removed by the cable laying process would be readily replaced through natural recruitment in a short space of time. Accordingly, this does not represent a significant adverse effect on the ability of the designated site to support a viable prey species population for wading water birds.

Given the dominance of a small number of species across the large expanse of muddy sandflat within Pegwell Bay and the high level of tolerance of the species present to disturbance, the laying of export cables across the Bay represents an impact of **negligible** significance.

Saltmarsh habitat

The export cable route makes its landfall in the vicinity of a small area of *Spartina* saltmarsh to the north of the disused hoverport apron. The saltmarsh is in its early stages of development, possibly due to it being either 'emergent' or as a result of recovery after dieback, and is of lower conservation value than the more developed saltmarsh that borders the lower estuary of the River Stour.

If ploughing were to be used across this area then some saltmarsh habitat would be lost. Although this would represent an impact of **negligible** significance, given the low conservation value of this area of saltmarsh, it is important that the potential for the saltmarsh to continue to develop is not lost completely. The most effective way for this to be achieved would be to bring the two export cables ashore in an area where there is no saltmarsh growth. If this is not possible, then any potential damage to the *Spartina* could be mitigated through temporary translocation of the saltmarsh plants away from the area of impact, followed by replacement and enhancement following cable burial. Methodologies for translocation and enhancement would follow the guidance presented in the Environment Agency/Defra publication '*The Saltmarsh Management Manual*' (Royal Haskoning, 2005) and the Chartered Institute of Water and Environmental Management (CIWEM)/Royal Society for the Protection of Birds (RSPB) document '*The saltmarsh creation handbook: a project manager's guide to the creation of saltmarsh and intertidal mudflat*'. A methodology for translocation and enhancement would be agreed in advance with English Nature and the Pegwell Bay NNR Steering Group if this option is followed.

A further option involves the use of directional drilling techniques to take the cable underneath the saltmarsh habitat without causing any damage to this habitat, and thus removing the need for translocation and enhancement to be carried out. The impact of directional drilling would not, however, be of any less significance than 'open cutting' in the intertidal, given the low conservation importance of the saltmarsh in this area. 'Open cutting' is, therefore, considered to be the preferred option.

In order to minimise the footprint of the potential impact on intertidal habitats, the working width of cable laying activities within the intertidal would be kept to a minimum. Plant access to the site would be clearly marked and fenced off to prevent incursion of workers and/or materials into other areas of the site.

With the adoption of either of the above mitigation measures, and given the low conservation importance of the saltmarsh present, it is anticipated that the impact upon saltmarsh habitat within the designated site would be of **negligible** significance.

9.4.2 Impacts due to changes in water quality

Given that the construction works in the intertidal would resuspend sediment, there is the potential for any sediment-bound contaminants to be released into the water column and be redistributed. Furthermore, contaminated sediment could be redeposited onto the seabed with potential adverse effects on the benthic community.

The results of the sediment quality survey are presented in **Section 9.3.2**. Although levels of the metals copper, lead and zinc are above the PEL, immediately outside and seaward of the Port of Ramsgate, these levels fall back to within the ISQG in the intertidal. Given that there are negligible concentrations of PAHs, metals and PCBs in the intertidal, the resuspension and deposition of material as a result of the construction works would have a **negligible** impact on benthic communities.

Resuspended material from cable laying in the vicinity of sample locations 48 and 49 (see **Figure 9.8**) has the potential to be deposited over the intertidal dependant upon tidal action. The sampling locations are close to an existing dredge spoil disposal site (Pegwell Bay TH140) and a former disposal site (Port Ramsgate TH145). The Port Ramsgate site is in the immediate area of sample location 48 and was used for the disposal of materials from the dredging of the vessel turning circle within the Port between 1992 and 1998. Sample 48 was taken over the location of the former disposal site. This is also considered to be the reason behind the elevated heavy metal concentrations encountered. A report by CEFAS on the impact of the disposal of marine dredged material on the Thanet and Sandwich Bay SAC (CEFAS, 2001) concluded that the operation of disposal sites TH140 and TH145 would have no adverse impact on the integrity of the European designated features of Pegwell Bay. Accordingly, it is considered that any impact on the benthic community as a result of the low levels of resuspension that would be associated with the cable laying operation in the vicinity of TH145 would be of **negligible** significance.

The cable ploughing operation over the intertidal would take place at low tide and, as such, minimises the potential for resuspension of sediments. However, the plough would cause the creation of a narrow corridor of loosened sediment, which may become resuspended on the next high tide. Such resuspension of sediments has the potential to impact upon the benthic community through smothering. The construction activity would occur over a very short timescale and the amount of suspended sediment produced is likely to be similar to that produced during stormy weather. The dominant species that define the benthic community in this area e.g. *L. concheliga*, *A. marina*, *H. ulvae* and *M. balthica*, are tolerant of increased turbidity and the minor degree of sediment settlement that would occur during construction. It is considered that the impact of settlement of resuspended sediment in the intertidal would be of **negligible** significance.

9.4.3 Impacts due to noise and vibration

Marine invertebrates, in general, do not possess the air filled spaces used by other organisms to detect noise and vibration. Rather than 'hearing' noise, these species 'feel' noise and vibration as a physical force that disturbs specially adapted hairs and statocysts, an organ that helps the organism to maintain orientation and is similar to the inner ear in humans. The noise and vibration associated with the cable laying operation across Pegwell Bay would not produce noise and vibration at a high enough intensity to cause physical damage to benthic species. As such, the potential impact is considered to be of **negligible** significance.

9.5 Impacts during Construction (subtidal activities)

9.5.1 Impacts due to habitat disturbance in the subtidal

Permanent loss of habitat and species in the footprint of the foundations and infrastructure

There would be permanent loss of seabed and associated communities directly within the footprint of the offshore structures. The size of the footprint is dependant upon the foundation type that is used. For the purposes of this impact assessment, a worst realistic case scenario has been adopted where all turbines would be supported by gravity based structures (GBS) with a diameter of 50m, which includes an allowance for scour protection around the structure (see **Section 2**). The total area of seabed that would be lost for each wind farm layout option utilising GBS is shown in **Table 9.3**. The table also shows the loss in relation to the Thames Estuary as a whole. The overall seabed surface area of the greater Thames Estuary was estimated by London Array to be some 5,300 km^2 (RPS, 2005).

Table 9.3 Direct loss of seabed as a result of construction

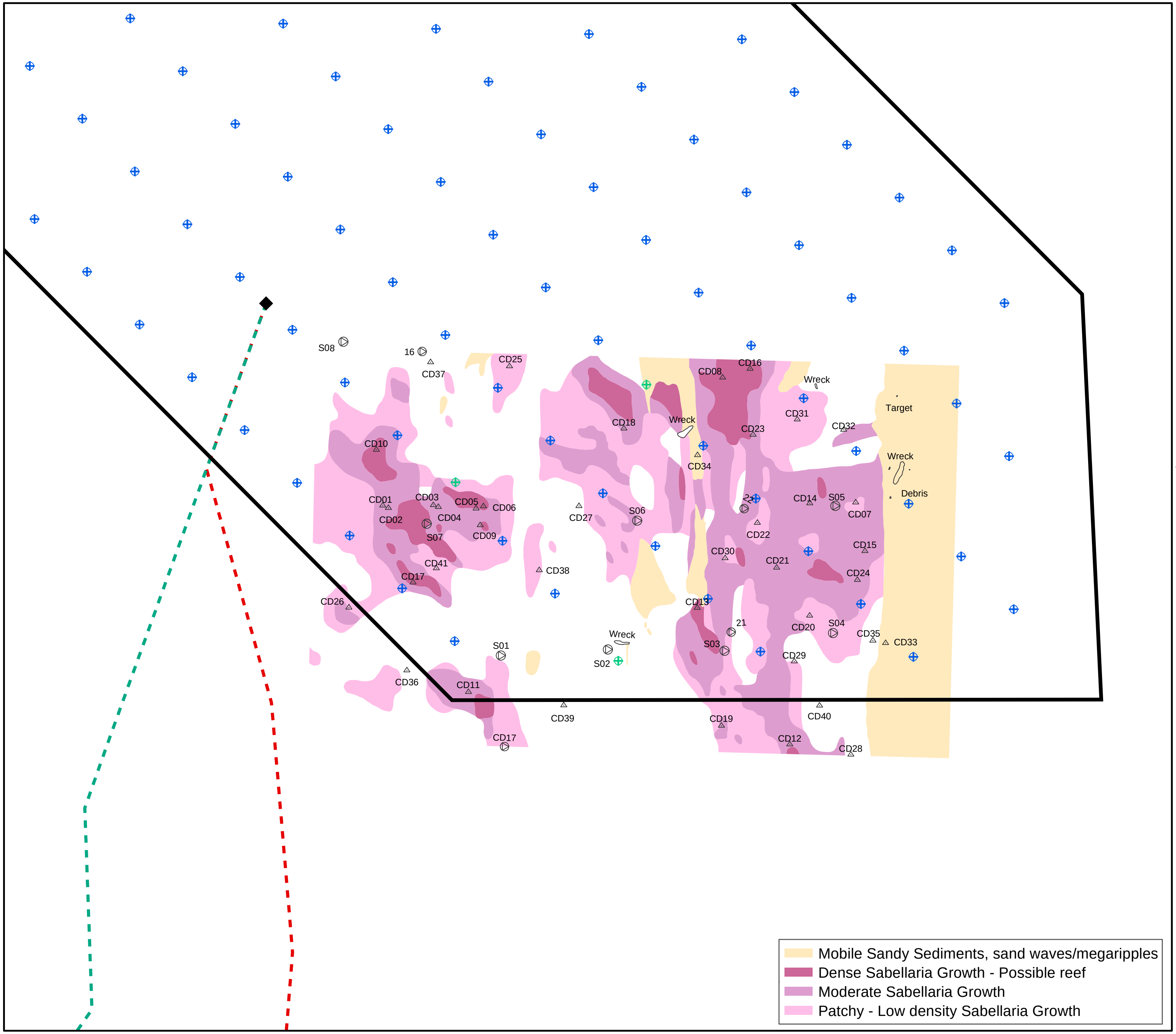
No. of turbines	Total surface area of wind farm	Total surface area of footprint	Loss of seabed within the Thanet boundary	Loss in relation to the Thames Estuary area
100	34.99 km^2	0.196350 km^2	0.564%	0.0037%
83	34.99 km^2	0.162970 km^2	0.465%	0.0030%
71	34.99 km^2	0.139408 km^2	0.398%	0.0026%
60	34.99 km^2	0.117810 km^2	0.336%	0.0022%

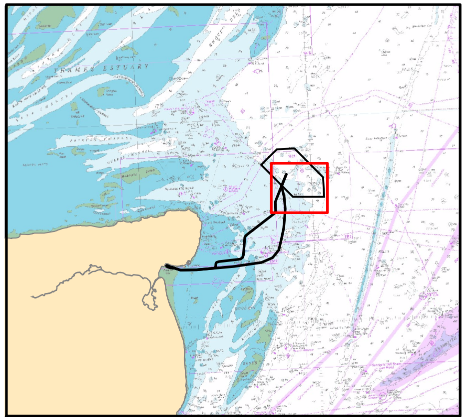
The high level of heterogeneity and dynamic nature of the seabed in this area means that it not possible to confidently calculate the potential loss of specific habitat types and associated benthic communities within the development boundary. Apart from the area of seabed that supports a high abundance of *S. spinulosa*, the benthic assemblage within the Thanet site is commonly encountered on similar substrates throughout the southern North Sea and eastern English Channel. In this context, the overall percentage of the benthic assemblage that would be lost is very small. This is considered to be an impact of long term, **minor adverse** significance.

The installation of foundations and wind farm infrastructure also has the potential to cause direct loss of areas of *S. spinulosa* that have been identified as being dense enough in aggregation to be considered as being potential reef structures. The high conservation importance of this habitat type means that any direct loss that damages the integrity of the reef structures or adversely affects their development would be considered as being significant. The risk of a significant adverse impact arising can be considerably reduced through the micro-siting of turbine structures away from the areas of identified dense aggregation. The use of micro-siting as an option to ensure a minimal impact on areas of dense *S. spinulosa* abundance has been agreed in principle with English Nature.

Thanet Offshore Wind Limited (TOW) is committed to carrying out pre-construction surveys of the *S. spinulosa* within the Thanet site. The results of these surveys will be used to further inform the positioning of turbines such that any potential damage to the reef structures is minimised and that further development of the reefs can occur. **Figures 9.22** to **9.25** show the options for micro-siting for each potential layout of the wind farm based on the baseline *S. spinulosa* distribution and density within the study area. These micro-siting options would be revisited in conjunction with English Nature, prior to the final layout of the wind farm being confirmed. With this mitigation in practice and, given the high recovery rates and selective settlement of this species, it is anticipated that the impact on *S. spinulosa* as a result of direct loss during construction would be of short term, **minor adverse** significance.

The use of monopiles over the entire site would result in similar impacts but over a reduced area. The overall, worst case footprint for up to 100 turbines, and allowing for scour, would be approximately 16% of that for the GBS.





Legend:

- Wind Farm Site Location
- Proposed Cable Route 1
- Proposed Cable Route 2
- Offshore Substation
- Turbine Locations Including 50m Buffer Zone
- Micro-sited Turbine Locations Including 50m Buffer Zone

Title:

MICRO-SITING OPTIONS
100 TURBINE LAYOUT

Project:

THANET OFFSHORE WIND FARM

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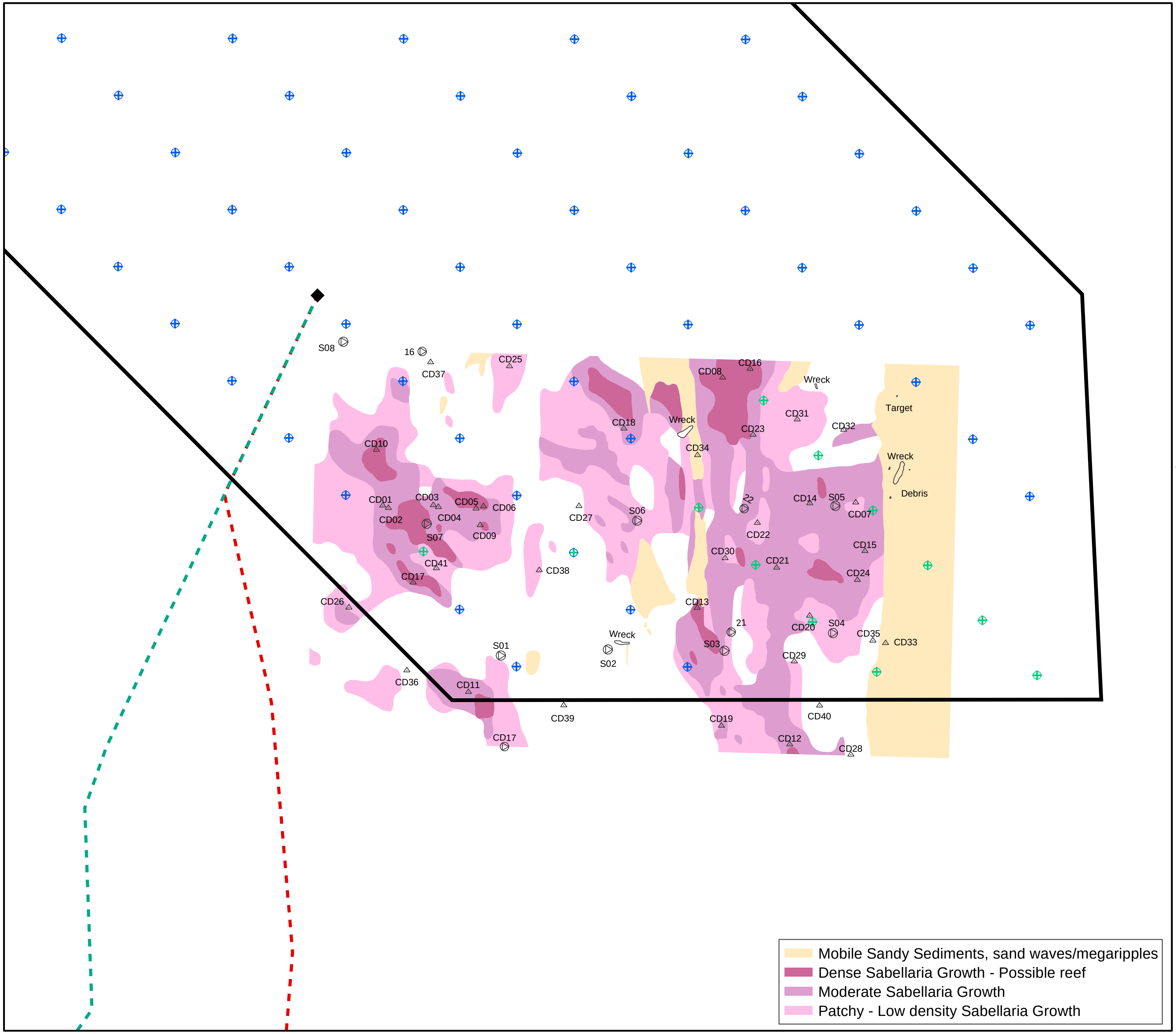
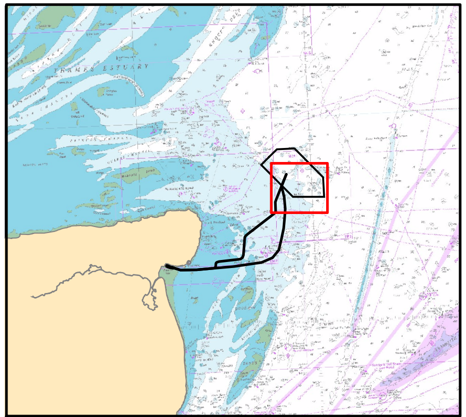
ROYAL HASKONING





Legend:

- Wind Farm Site Location
- Proposed Cable Route 1
- Proposed Cable Route 2
- Offshore Substation
- Turbine Locations Including 50m Buffer Zone
- Micro-sited Turbine Locations Including 50m Buffer Zone

Title:

MICRO-SITING OPTIONS
83 TURBINE LAYOUT

Project:

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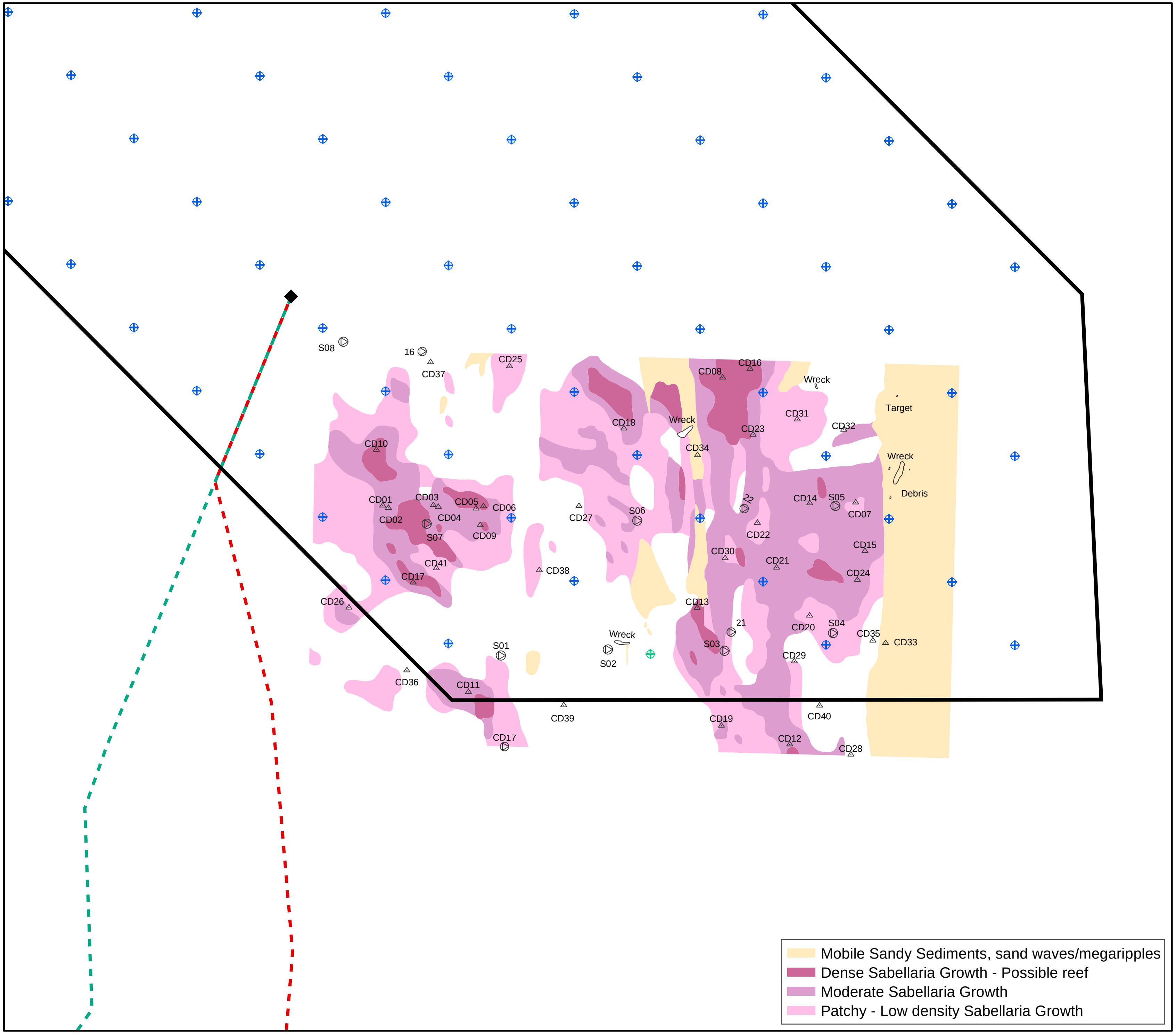
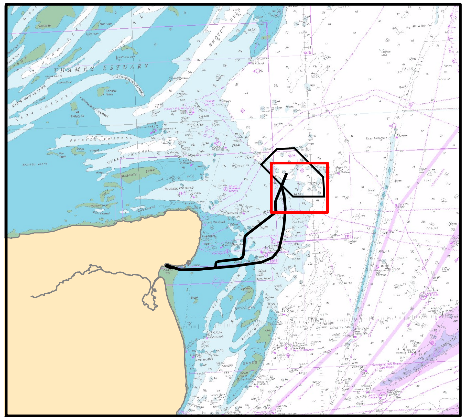
Date:	Figure:
31/10/2005	9.23

Scale:	Revision No:
0 0.25 0.5 Kilometres	007

ROYAL HASKONING





Legend:

- Wind Farm Site Location
- Proposed Cable Route 1
- Proposed Cable Route 2
- Offshore Substation
- Turbine Locations Including 50m Buffer Zone
- Micro-sited Turbine Locations Including 50m Buffer Zone

Title:

MICRO-SITING OPTIONS
71 TURBINE LAYOUT

Project:

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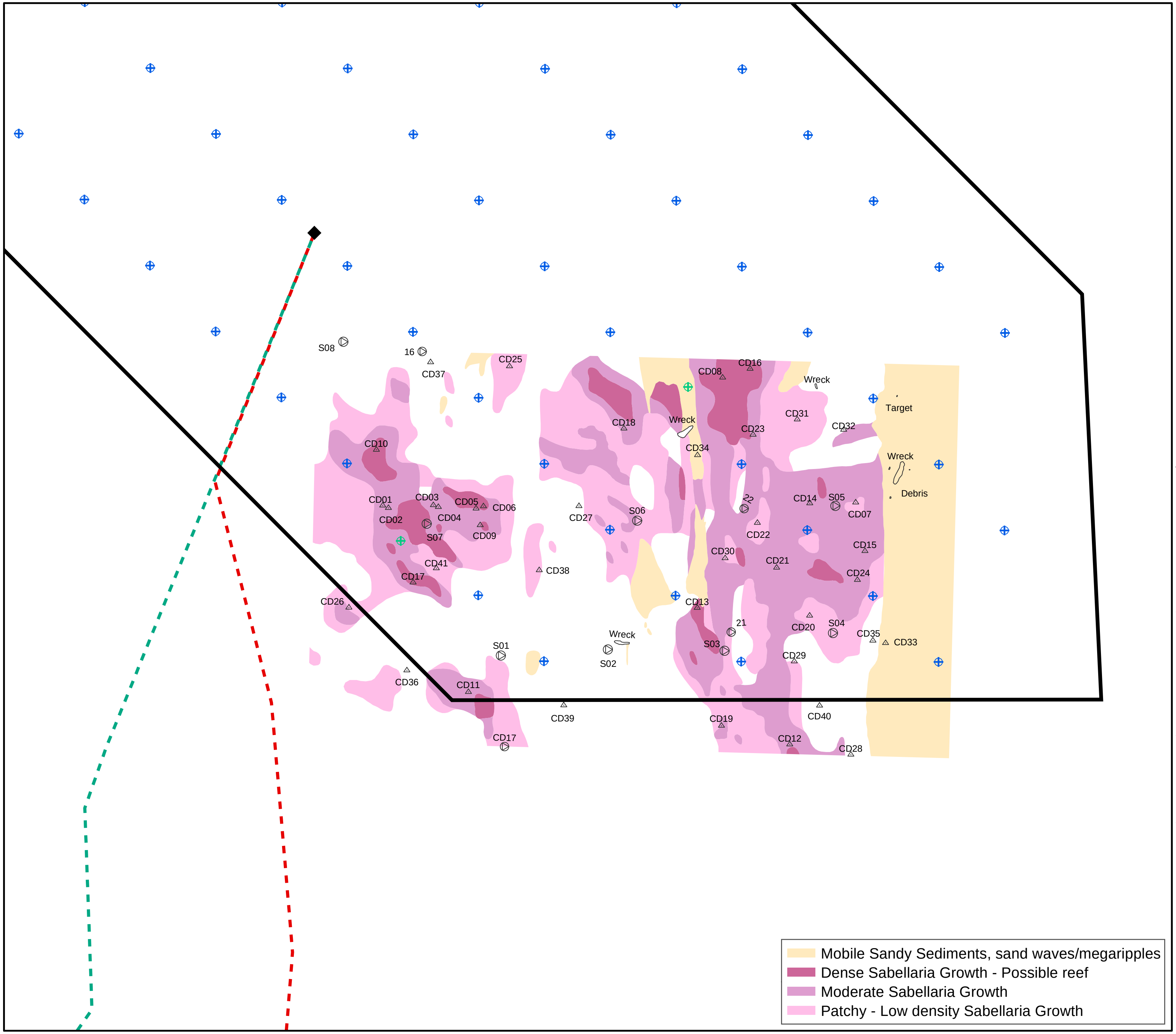
SMG	SDG	9P5164/12/601

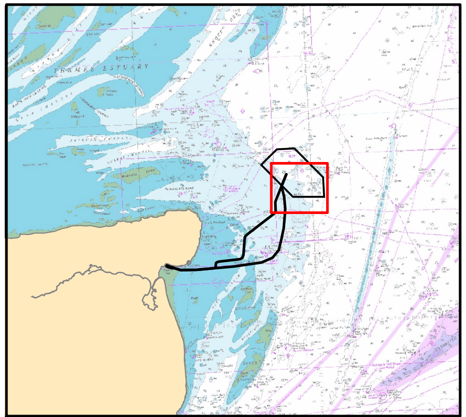
Date:	Figure:
31/10/2005	9.24

Scale: 0 0.25 0.5 Kilometres

Revision No: 007

ROYAL HASKONING





Legend:

- Wind Farm Site Location
- Proposed Cable Route 1
- Proposed Cable Route 2
- Offshore Substation
- Turbine Locations Including 50m Buffer Zone
- Micro-sited Turbine Locations Including 50m Buffer Zone

Title:

MICRO-SITING OPTIONS
60 TURBINE LAYOUT

Project:

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SMG	SDG	9P5164/12/600

Date:	Figure:
31/10/2005	9.25

Scale:	Revision No:
0 0.25 0.5 Kilometres	007

ROYAL HASKONING

Direct impact on habitats and species through the movement of construction plant

There would be direct disturbance of the seabed and associated species around each of the offshore structures due to the presence and movements of construction vessels around the site during construction.

The working area around each of the offshore structures is more difficult to quantify than the permanently affected area. However, it is assumed that the majority of disruption would be caused by the feet of the jack-up vessels and anchor patterns of construction vessels around these locations. At most, this area is not likely to exceed 1-2% of the area of permanent loss associated with the footprint of the foundations (RPS, 2005). There would also be a minor disruption from slight increases in suspended sediment as the jack-up feet and anchors touch the seabed. Where appropriate, restrictions would be enforced on where vessels could jack-up or anchor to further protect sensitive areas.

The site covers some 35km^2 and construction activities would occur over a period of one or two seasons, dependant upon programme restrictions. In this spatial and temporal context, and given the high recovery rate of the majority of species encountered, the direct impact upon the seabed as a result of construction activities is considered to be of **negligible** significance.

The use of monopile foundations across the whole site is considered to be a viable option using a 'drive/drill/drive' method (see **Section 2**). As such, this approach may be feasible within the area known to support dense aggregations of *S. spinulosa*. Use of jack-up vessels and anchors in this area could lead to damage to the *S. spinulosa*. However, as previously discussed, it is envisaged that micro-siting of turbines would be used to avoid areas of dense *S. spinulosa*. As part of the micro-siting approach, restrictions would be applied to the locations within the micro-siting area where the vessels would be allowed to jack-up or anchor. By minimising the potential for construction activities to interact with the dense aggregations of *S. spinulosa* the potential impact is considered to be of **negligible** significance.

Direct impacts on habitats and species through the laying of the interturbine cables

The construction phase will involve the installation of up to 40-80km of interconnecting cables, between the turbines and the offshore substation. Similar to the impacts of other construction activities, cable installation will cause direct disturbance to the benthic assemblage in the short term. As previously discussed, the benthic assemblage within the study area is spatially, highly heterogeneous and is dominated by annelid worms, especially the reef forming polychaete *S. spinulosa*. In areas known to support dense aggregations of *S. spinulosa,* the existing survey results and the subsequent pre-construction survey that TOW has committed to undertaking, would be used, along with turbine micro-siting, to ensure that interturbine cabling is laid to avoid dense aggregations of *S. spinulosa,* as far as practicable. The potential impact on the benthic resource due to interturbine cabling is considered to be of short term, **minor adverse** significance.

Direct impacts on habitats and species through the laying of the export cables

The method of cable laying for the two export cables to the landfall, each up to 26.5km long, most probably via the use of a cable plough (see **Section 2**), is such that it minimises the footprint of the activity to within a very limited area either side of the cable trench. Therefore, the impacts on benthic habitats and species would be unlikely to be widespread and would be restricted to the seabed within the Thanet site and along the export cable route. The benthic assemblage recorded in the area of the export cable route is largely typical of much of the southern North Sea and eastern English Channel (see **Figures 9.11** to **9.14**). In this context, it is considered that the subtidal cable laying operation would have an impact of short term, **minor adverse** significance.

Along the export cable route, it would be necessary to cross two existing in service telecommunications cables. The approach to cable crossing is described in detail in **Section 2**. It is anticipated that cables would be crossed using concrete mattresses with dimensions of 5m x 3m x 300mm thickness. These mattresses would be laid along the cable route for a minimum length of 50m. The export cables would be laid on top of these mattresses and covered by top mattresses of half the thickness of the bottom mattresses. The laying of these mattresses represents a loss of seabed of 150m^2 for each cable crossing i.e. 600m^2 in total. The benthic assemblage along the route of the export cables, is considered to be relatively species poor and of low abundance. The overall loss as a direct result of cable crossing structures is considered to be of **negligible** significance in this context.

Indirect impacts of increased suspended sediments within the wind farm

The increased levels of suspended sediments that could arise as a result of the construction activities are discussed in detail in **Section 6, Hydrodynamics and Geomorphology**.

Increases in suspended sediment can have an adverse impact on marine life through smothering and/or blockage of feeding siphons as well as on reproductive processes. The severity and significance of this impact would largely depend on the sensitivity of the species to the impact and the conservation value of the species in question.

Fine sediment brought into suspension due to scour around the foundations or construction operations would be transported downstream, with the distance dependent on the hydrodynamics at the time of disturbance and on the settling velocity of the sediment. Coarse sediments, such as sand and gravel, would settle almost immediately, but finer silt and clay material may be carried for considerable distances, and may not settle until a different hydrodynamic regime is encountered. Chalk fines, even at low concentrations, would cause the seawater to become visibly milky over a wide area (HR Wallingford, 2005).

Sediment transport would also be influenced by the cable burial process. Regardless of burial method, seabed sediments would be disturbed, causing increased suspended loads during laying operations and increased potential for subsequent resuspension. As with foundation construction, the impacts would depend on the construction method employed, composition of the seabed and the sensitivity of the natural environment during the construction period. Sand and coarser sediment would only be dispersed over a short distance, typically metres for coarse sand and up to a few hundred metres for very fine sand, while fines such as silt and chalk, will be carried in suspension over the full distance of the tidal excursion of about 10km for the main site and offshore cable route (HR Wallingford, 2005).

The Thanet study area is naturally turbid and has moderately high levels of suspended sediment throughout the year (30mg/l summer and 60mg/l winter) (HR Wallingford, 2005). It is against this naturally occurring background level that increases due to construction activities are assessed.

Driven and drilled monopiles would cause low volumes of suspended sediment, as both construction methodologies do not result in large quantities of spoil coming into contact with the water column (see **Section 2**). GBS would also lead to short term disturbance as some form of seabed levelling is likely to be required prior to placement. It is not expected that these increases would be significantly higher than the naturally occurring levels and would be of relatively short duration, given the dispersive nature of the strong currents in the area. The benthic assemblage within the Thanet site is tolerant of the levels of suspended sediment and settlement that would be expected as a result of the construction activities. As an example, *S. spinulosa*, the species of highest conservation significance within the study area, has been classified by the Marine Life Information Network (MarLIN) as presented in **Table 9.4**.

Table 9.4 Sensitivity of *S. spinulosa* to suspended sediment impacts

	Intolerance	Recoverability	Sensitivity	Evidence / Confidence
Smothering	Low	Immediate	Not Sensitive	Moderate
Increase in suspended sediment	Low	Immediate	Not Sensitive	Moderate
Increase in turbidity	Tolerant	Not Relevant	Not Sensitive	Low

Source: table adapted from http://www.marlin.ac.uk/species/adult_sens_Sabellariaspinulosa.htm (see this website for further information on the sensitivity assessment).

It is anticipated that any impact of suspended sediment during the construction process of the wind farm would be of short term duration and would be of **negligible** significance.

Impact of increased suspended sediment along the export cable route

Sediment transport would also be influenced by the cable burial. Some disturbance of seabed sediment is anticipated causing increased suspended loads during laying operations and increased potential for subsequent resuspension. As with foundation construction, the impacts would depend on the construction method employed, composition of the seabed and the sensitivity of the natural environment during the construction period.

It is envisaged that cable laying would be carried out using a cable plough due to the prevalence of hard, flinty chalk along the export cable route. The type of plough that would be used is described in **Section 2**, along with a description of its operation. Ploughing is considered to cause the least disturbance, as excavated seabed material is largely returned as the cable is laid. Jetting is not appropriate in areas of exposed chalk and sandstone. Trenching creates the greatest disturbance and depends on natural processes to backfill. Given the availability and mobility of the surface sands across most of the main site, it is likely that natural infill would be rapid.

It is assumed that about 0.02m^3 of sediment per metre of cable run would be put into suspension by ploughing in silty sand or chalk (Fisher *et al,* 1979). Resuspended chalk or silt would be rapidly distributed throughout the water column and would be carried by the diurnal tidal excursion for up to 10km. The spatial differences in tidal currents, both through the water column and with distance offshore, will result in shear dispersion of the plume, resulting in the growth of the size of the plume and reduction of concentrations of chalk or silt within the plume. HR Wallingford (2005) predicts that a cable plough moving at 0.3m/s would release peak concentrations of suspended sediment of around 3mg/l, which is only about 10% of typical summer background levels and 5% of typical winter background levels. It is likely that disturbed chalk would be clearly visible as a milky plume. Concentrations would reduce with a half-life of the order of a few tides to a week, depending primarily on tidal conditions, and the plume would drift with the residual current (HR Wallingford, 2005). The settling velocity of chalk is negligible and so there would not be any temporary or permanent deposition on the seabed.

The species found along, and in the vicinity of the export cable route regularly experience high levels of turbidity and variable rates of deposition, dependant upon time of year and tidal state. It is anticipated that any impacts associated with the release of suspended sediments during cable laying activities would be short term in duration and of **negligible** significance, given the likely use of cable ploughing installation.

9.5.2 Impacts due to changes in water quality

Given that the construction works would lead to the resuspension of sediment, there would be the potential for any sediment-bound contaminants to be released into the water column and be redistributed. If redeposited onto the seabed, such contaminated sediment could have an adverse impact upon the benthic assemblage. However, following discussions with CEFAS, it was decided that, as there was no evidence of historic contamination at the Thanet site, that surveys of sediment chemistry need only be undertaken along the cable route in the vicinity of the Port of Ramsgate and Pegwell Bay.

The samples collected at stations 48 and 49, in the vicinity of the Port of Ramsgate, showed increased levels of the heavy metals zinc, copper and lead, which were all at concentrations above the PEL. These high levels, however, dropped to well below the PEL within a few hundred metres, where samples were collected over the intertidal area of Pegwell Bay.

Sample 48 showed the most highly elevated concentrations of heavy metals, most probably due to historic contamination associated with the presence of licensed dredge spoil disposal site Port Ramsgate TH145. However, this site also supported the highest number of species from any three replicate samples along the export cable route, suggesting that the infauna in this area is not adversely affected by the above normal heavy metal concentration.

The cable installation method would not involve the resuspension of large quantities of sediment and that will resettle over a relatively small area. Given the diluting effect of the water column and the fact that the species present appear tolerant of the prevailing sediment conditions, the potential impact of resuspension of contaminated sediments during construction is considered to be of **negligible** significance.

Water quality also has the potential to be adversely affected by the release of chemicals associated with the construction process. However, the potential for this to occur during the construction of an offshore wind farm is considered to be low. All major components of the offshore structures are manufactured on land, which significantly reduces the range of chemicals and materials that could be released. The risk is, therefore, limited to spillages of lubricants and the fuels required for the installation plant. It is also likely that grouting chemicals would be used to join sections of the turbine towers and may be used for the installation of monopole foundations, if used.

The Installation Contractor for the wind farm would be expected and contractually obliged to follow best working practice during all offshore operations, including the use and management of grouting chemicals. An Environmental Management Plan (EMP) would be produced as part of the contract documents to ensure that all potential pollution sources are identified and that measures are taken to limit the potential for a pollution incident to occur and to rapidly respond to any accidental release, however unlikely. These measures, combined with the diluting and dispersive nature of the receiving environment, would result in a potential impact of **negligible** significance.

9.5.3 Impacts due to noise and vibration

Many natural and anthropogenic sources of noise are produced in the marine environment covering a wide range of sound levels. Some examples of anthropogenic noise sources and the noise levels produced are presented along with the original reference in **Table 9.5**.

Table 9.5 Examples of anthropogenic underwater noise levels

Source description	Level (dB)	Reference
Small drill	147	Nedwell *et al* (1993)
Large drill	143	Nedwell *et al* (1993)
Impact wrench	180	Nedwell *et al* (1993)
Small grinder	150	Nedwell *et al* (1993)
Large grinder	146	Nedwell *et al* (1993)
Cox's bolt gun	220 (peak)	Nedwell *et al* (1993)
Pile driving	218 (peak)	Richardson *et al* (1995)
Supertankers and container ships	180 to 190	Arveson and Vendittis (2000)
Bulk cargo ship	178 to 192	Richardson *et al* (1995)
Commercial and military sonar systems	180 to 230	Mercer *et al* (1996)
1kg TNT charge, unconfined	274	Barrett (1996)

Source: adapted from table presented at http://www.underwaternoise.org.uk/ (last accessed 23/09/05)

The greatest source of construction noise would be that associated with pile driving, which is estimated to be at worst 260 to 270dB @ 1m. It is likely that a noise of this intensity would have an impact radius of 10m from source (RPS, 2005). Within this area, benthic species are likely to display changes in behaviour such as withdrawing into burrows and stopping feeding activities. The risk of mortality would be high and physiological damage would almost certainly occur if invertebrate species were particularly close to the piling operation. However, within the immediate area around the pile, it is expected that some of the habitat would be lost to scour protection and cabling. If gravity foundation structures were to be used instead of monopiles, the loss of benthic invertebrates would be higher, due to smothering, than those killed due to the piling operation.

The noise generated during the construction of the Thanet project is considered to be localised and temporary and would potentially affect a very limited number of individuals of an assemblage of species that is very widespread and commonly encountered throughout the region. As such, the impact is considered to be of **negligible** significance.

The installation of monopiles using a 'drive/drill/drive' methodology (see **Section 2**) is considered to be a feasible option within the area of the Thanet site known to support *S. spinulosa*. This means that there is potential for the vibration caused by the impact of the pile driving hammer to adversely impact upon the integrity of dense *S. spinulosa* aggregations and, in the worst case, causing the structures to break down.

As previously discussed, TOW is committed to undertaking pre-construction surveys of the *S. spinulosa* in the wind farm area. The results of this survey would be used to inform micro-siting of turbines and interconnecting cables to ensure that damage to dense aggregations of *S. spinulosa* is avoided, as far as practicable. While it is not possible to definitively quantify the area around the monopile that would be affected by pile driving vibration of sufficient intensity to damage *S. spinulosa* structures, the area is not believed to exceed the area that would be lost as a result of the placement of a GBS. If the monopiles are micro-sited away from the dense aggregations by the same distance as would be used for GBS, it is expected that there would be an impact of **negligible** significance on dense *S. spinulosa* aggregations.

9.6 Impacts during Operation (intertidal activities)

9.6.1 Impacts due to changes in current regime in the intertidal

As the export cables would be buried, it is not anticipated that any alteration in current regime in the intertidal area of Pegwell Bay would arise as a result of the operation of the wind farm. As such, **no impact** is predicted.

9.6.2 Impacts due to maintenance activities in the intertidal area

It may be necessary, on a very rare occasion, to gain access to the export cables for repairs. Based on a typical failure rate for subsea cables of less than one incident every 100km per year, this would equate to approximately one incident every 25 to 40 years for the intertidal cables. In the event that the intertidal cables do have to be repaired, it is likely that the benthic assemblage in the immediate vicinity of the works would be disturbed and some small scale mortality may occur. Any such impact is likely to be short term in duration and highly localised in extent. This would be further minimised by the maintenance team following good working practice to ensure that they limit the ecological footprint of the activity. It is, therefore, anticipated that any impact arising as a result of maintenance would be of **negligible** significance.

9.7 Impacts during Operation (subtidal activities)

9.7.1 Impacts due to changes in coastal processes

Section 6 describes the predicted changes to coastal processes, as a result of the Thanet project, including effects on waves, currents and sediment movement/scour.

Following construction, the turbines and associated structures would cause localised alterations in current flow, which could cause increased turbulence during peak flow and increase the potential for scour to occur. Scouring of sediments around the base of monopiles and GBS would occur in all sediment types. The extent of scour that would occur is dependant upon the seabed sediment type in the vicinity of the structure. A monopile structure of 6m diameter, located on top of an unlimited depth of sandy sediment could lead to a scour pit forming that is 24m long and 9m deep. For a GBS of 35m diameter, scour is more likely to be in the order of 8m long by 2.1m deep. This scenario is unlikely at the Thanet site except on the largest sand waves. The hard chalk bedrock is either at or close to the surface of the seabed throughout much of the site and so scour would be much less than predicted in almost all cases.

Scour of the seabed would affect the benthic community present. However, scouring rates would rapidly decrease following the initial phase after construction, as a new equilibrium is reached and the seabed, including any scour protection laid, would be readily recolonised by a range of mobile and sessile fauna, resulting in an impact of **negligible** significance.

S. spinulosa reef structures have the potential to be adversely affected by scouring. The scour area for a GBS of 35m diameter has been calculated, in ideal conditions, as being 8m long and 2.1m deep. In reality, the mobile material in the southern sector of the site is rarely greater than 1m in depth, so the level of scour would be expected to be significantly less than this. Also, the worst case scenario for the direct loss of seabed in the case of GBS has been estimated to be a 50m diameter, based on a 35m structure and an allowance for scour protection. Even with the small degree of scour, GBS is considered to be a worst case scenario as, although the scour effect of monopiles would occur over a larger area (roughly 300m^2), this is considerably less than the overall footprint of the GBS (1,964m^2). As discussed previously, micro-siting would be used to ensure that foundation structures or interturbine cabling avoided, wherever possible, areas of dense *S. spinulosa* aggregations. It is therefore anticipated that any potential impact upon dense *S. spinulosa* aggregations as a result of scour would be of **negligible** significance.

Assuming a final spacing between turbines of at least 450m, and more than 700m in the dominant north-south tidal flow direction, it is considered unlikely that there would be any overall sheltering effect that could give rise to broad scale accretion or erosion of sand or gravel over the area of the wind farm (HR Wallingford, 2005). As such, it is anticipated that there would be a negligible impact on the movement of mobile sediments along the seabed from current baseline conditions and, as such, **no impact** on the general benthic assemblage is expected and **no impact** on the ability of *S. spinulosa* to continue to form dense aggregations is anticipated.

In terms of waves, HR Wallingford (2005) concludes that the effect of the turbines and associated structures on waves within the wind farm would be of negligible significance, even in a situation of increased storminess and sea level rise. As such, it is anticipated that there would be **no impact** on the benthic community.

9.7.2 Impacts due to operational and maintenance activities

It is not anticipated that routine operational and maintenance activities would involve any direct or indirect impact on the seabed and therefore **no impacts** on the marine benthic or epibenthic resource are anticipated. Any major unscheduled activities that could involve disturbance to the seabed would be discussed with the appropriate regulators if deemed necessary.

9.7.3 Impacts due to operational noise

While there is no defining proof, it is considered highly unlikely that benthic invertebrate fauna would be adversely affected by the low levels of noise and vibration that is associated with operating wind turbines (Vella *et al*, 2001). Marine fauna rapidly colonise hard structures placed in the sea and are found on noise and vibration producing structures such as oil and gas drilling rigs. Monitoring of turbine towers at Horn's Rev in Denmark has shown that rather than avoiding wind turbine structures, epifaunal abundance and biomass has increased locally with no negative effect (Bio/Consult, 2004). Operational noise and vibration impacts upon benthic invertebrate fauna are, therefore, considered to be of **negligible** significance.

9.7.4 Impact of heating effects of buried cables

As the interturbine and export cables are to be buried, any thermal impact from the operating cables at the seabed would be minimal. Heat generated by the cables is absorbed and dissipated in the surrounding environment. Any potential increase in seabed sediment temperature would be expected to be in the range of a fraction of a degree. Seawater temperature increase, just above the seabed, would be expected to be almost undetectable and in the range of 0.000003^{o}C (RPS, 2005). Benthic species would not be adversely affected by a temperature increase of this magnitude. As such, any potential impact is considered to be of **negligible** significance.

9.7.5 Impact of electromagnetic fields

Impacts of electromagnetic fields (EMF) in the marine environment are the subject of some debate and considerable research effort. The main issue of concern is the potential impact on electrosensitive species of fish, such as elasmobranchs, in terms of stimulating avoidance or attraction reactions and the knock-on effect on commercial fisheries (see **Section 12**). The potential impact on benthic and epibenthic invertebrates is even less understood than that on fish. However, it is anticipated that the impact of EMF on the behaviour, distribution and navigation of the invertebrate assemblage is likely to be **negligible**, as these invertebrates do not use EMF in any aspect of their behaviour.

9.7.6 Recovery of benthic fauna following construction

The species present throughout the area surveyed as part of the intertidal and subtidal sampling programme is characterised by species that are considered to be largely tolerant of the disturbance that would be caused during the construction programme. The benthic assemblage that is not permanently lost in the footprint of the proposed wind farm but is impacted by the construction activities would be expected to recolonise rapidly via recruitment from surrounding populations. Mobile species would be the most likely initial colonisers, with the infauna returning during the first spawning periods following construction. While recovery of the benthic assemblage lost during construction can be seen as being beneficial in terms of reducing the overall loss of species and individuals as a result of construction, it cannot be seen as a beneficial impact associated with the development as a whole and, therefore, **no impact** is predicted.

Any impacts on the dense *S. spinulosa* assemblage in the southern sector of the site would be minimised, as far as practicable, through the micro-siting of turbines and interturbine cables during construction. Anecdotal information from local fishermen suggests that *S. spinulosa* growth in this area was once more extensive than it is at present. There is general agreement that the reef structures were trawled to near complete destruction in recent years and that the present assemblage is in a state of recovery following the cessation of trawling by the British fleet. Trawling is still undertaken in this area by vessels from the Belgian fleet and trawl damage to the *S. spinulosa* was apparent in the side-scan sonar survey. However, the trawling is sufficiently low in intensity so as to allow the *S. spinulosa* to begin to recover.

The recovery of *S. spinulosa* appears to have been fairly rapid, with dense aggregations occurring after just a few years. The phenomenon of fast growth following damage to *S. spinulosa* has been documented in recent years (e.g. Vorberg, 2000). Re-growth was observed to be five times faster than normal growth during experimental destruction of a reef. Studies suggest that physical factors, such as temperature and water quality, have only minor influences on settlement (Wilson, 1970), but experiments have shown that *S. spinulosa* larvae are strongly stimulated to metamorphose and settle on contact with the cement-like secretions of other *S. spinulosa*, whether they are adults, other juveniles or old, deceased colonies (Wilson, 1970; Schäfer, 1972; Foster-Smith and Hendrick, 2003).

The main limiting factor for the continued recovery of *S. spinulosa* in the southern section of the Thanet site is considered to be the repetitive damage caused by trawling. *S. spinulosa* is relatively short lived and, therefore, the continued integrity of a reef structure is heavily reliant on frequent new settlements of juveniles. If this new growth is regularly removed by trawling, then the base of the reef structure will become increasingly fragile and slowly break down. *S. spinulosa* is also susceptible to storm damage due to its brittle nature.

Providing care is taken to minimise damage to existing *S. spinulosa* structures, it is possible that the Thanet project would promote the future development and recovery of the reefs. The foundations may act to ‘shelter’ the *S. spinulosa* from storm damage and, in order to ensure the safety of fishing vessels and crew, it is unlikely that trawling methods of fishing would be permitted within the wind farm boundary (see **Section 14, Shipping and Navigation**). As such, it would be expected that *S. spinulosa* reefs would continue to recover and would increase in extent during operation. The increase in this species/habitat of conservation significance, while not directly attributable to the presence of the wind farm, would be considered to be a favourable development in terms of the conservation value of the seabed in this area.

9.7.7 Colonisation of foundations and associated structures

It is expected that once installed, any hard structures above the seabed would be rapidly colonised by a range of epibenthic species. The nature of the colonisation is difficult to predict, as no similar structures to wind turbines are present in the immediate area. However, it is possible to predict the likely assemblage based on evidence from other sources. Typical colonising fauna of this type of structure includes hydroids, sponges, bryzoans and anemones.

Colonisation of monopiles and scour protection at the Horn's Rev offshore wind farm in Denmark has been monitored since 2003. The first monitoring survey recorded 16 taxa of seaweeds colonising the turbine towers and scour protection, although the majority of algae were found on the towers, as opposed to the scour protection. A total of 65 invertebrate taxa were registered, with nine being considered as being 'very mobile' such as the edible crab *Cancer pagurus*. Mobile species tended to be restricted to the scour protection, whereas, more sessile species were found on the turbine towers (Bio/Consult, 2003). There was a statistically significant difference between communities at different sites, demonstrating the opportunistic and phased nature of colonisation. Other commonly encountered species included the tube dwelling amphipod *Jassa Marmorata* and the skeleton shrimp *Caprella linearis*, with starfish, anemones, bryzoans and the tube building polychaete *Pomatoceros triqueter* being locally abundant. An estimation of the epifauna biomass suggested that there was an eight-fold increase in food availability compared to the baseline conditions within the array (Bio/Consult, 2003). Accordingly, increases in the number of fish species present were noted from 3 to 14 between March and September in the first year of monitoring. This included species such as bib, cod and whiting, which were observed around the turbine structures and thought to be feeding on the epifauna.

While the actual species involved may differ, similar colonisation to that reported from Horn's Rev is to be expected for the Thanet project. Localised increases in epiphytic[2] biodiversity and biomass is likely to result in increases in localised abundance of fish species and mobile fauna that would utilise the towers and scour protection for feeding and shelter. While the turbines and foundations would be sufficiently apart to not be considered as forming a 'reef like' structure, the provision of significant hard standing, especially in the case of GBS, would have a localised effect on the communities present within the wind farm. The increase in abundance that is likely to occur does not imply an increase in population sizes of the species involved. What would actually occur is more akin to an 'aggregating' effect rather then an increase in productivity. While the localised increase in species abundance and biodiversity that would be associated with the colonisation could be seen as beneficial, it is considered that the overall impact of the development would be **negligible**.

[2] Plants that relies on another plant for mechanical support but not nutrients.

9.8 Impacts during Decommissioning

The Energy Act has not yet provided any clear guidance on the legislation related to the decommissioning of offshore wind farms. However, it is almost certain that all of the offshore structures would have to be removed to the seabed i.e. partial removal. The nacelle and towers would be removed in reverse operation to construction using a heavy lift vessel. Cables would be disconnected after being isolated offshore and pulled out of the J-tubes.

It is likely that the subsea cables would be left buried and notified as being disused. Gravity base structures could be totally removed, or in the case of monopiles cut off at a depth of 2.0m below the seabed. TOW is committed to monitoring the development of the benthic community, particularly *S. spinulosa*, within the wind farm area. If the monitoring shows colonisation of the foundation structures and surrounding area that would be significantly impacted by the removal of the structures then it may be possible to agree a decommissioning programme that allows for structures to remain on the seabed. This option would be particularly relevant in the southern section of the site.

It is anticipated that the *S. spinulosa* population would continue to increase in extent and density over the lifetime of the wind farm and that significant reef structures would have the potential to form. Removal of the foundations in this area would have a significant adverse impact on any *S. spinulosa* reef aggregation in the immediate area surrounding the structure and, therefore, having an adverse impact on the ecologically important assemblages associated with the reef.

A Decommissioning Plan would be agreed with the Department of Trade and Industry (DTI) and The Crown Estate prior to commencement of construction and reviewed periodically to ensure that it continues to be appropriate.

9.9 Cumulative Impacts

The potential impacts associated with the construction and operation of the Thanet project are considered to be short term in duration and, in almost all cases, of negligible significance. Accordingly, it is considered that there would be **no cumulative impacts** associated with the Thanet project and other offshore developments on benthic fauna in the Thames Estuary area.

9.10 Monitoring Proposals

A detailed monitoring programme covering a suite of environmental parameters will be developed and implemented following consultation with the appropriate authorities. This will include for detailed specifications regarding methodologies, monitoring locations, monitoring frequency, duration, schedules and reporting, as well as establishing control sites. This programme will be based on comments received in response to publication of the Environmental Statement (ES) and the conditions outlined in the consenting documents relating to the project. An outline of the anticipated monitoring programme is provided below.

Infauna

In terms of the benthic biological resource in the study area, detailed surveys have been undertaken to establish the baseline existing conditions throughout the study area. It is anticipated that infaunal monitoring would continue during the initial years of operation. A selection of monitoring sites would be established in conjunction with English Nature and CEFAS. The monitoring sites cover the area of potential indirect effect of both the Thanet site and the export cable route. Survey, sampling and analysis methodology will be the same as for the baseline survey.

S. spinulosa

Although part of the epifaunal assemblage in its own right, *S. spinulosa* would require specific monitoring commitments due to its presence in dense reef forming aggregations. This ES predicts that, following construction of the Thanet project, the *S. spinulosa* in the southern sector of the site would continue its current pattern of recovery and increase in extent and density over time.

TOW is committed to monitoring the development of the *S. spinulosa* assemblage during the initial years of operation. The monitoring plan would be discussed and agreed with English Nature and CEFAS. It is anticipated that monitoring would involve the continued analysis of the broad scale development of the *S. spinulosa* on an annual basis through dropdown video surveys. This could be supported by high intensity side-scan sonar surveys every two years, dependant upon the feasibility of deploying sonar equipment within the wind farm.

9.11 Summary

A number of site specific surveys were undertaken in order to establish the marine ecological interest at the site and along the cable route. These included benthic sampling, side-scan sonar and dropdown camera and a series of epibenthic trawls.

The intertidal

The intertidal area of Pegwell Bay is characterised by muddy sandflats. The flats are dominated by the polychaete worms *Lanice conchilega* and *Arenicola marina* and also support populations of bivalve molluscs such as edible cockle and Baltic tellins. The foreshore comprises a length of wave-cut chalk platform, fronting the chalk cliffs between Ramsgate and Cliffs End, and areas of *Spartina* saltmarsh either side of a disused hoverport. While the habitats and species present are of value as a food resource for wading birds, they are, on the whole, tolerant of the range of impacts that may arise as a result of the construction, operation and decommissioning of the Thanet project.

The subtidal

The seabed in the vicinity of the Thanet site is characterised by predominantly sandy deposits with varying proportions of silt/clay and gravel. The area was further characterised by chalk platforms overlaid with a veneer of sand, and small stones. Elsewhere, along the line of the export cable route ashore in Pegwell Bay, the sediments comprise predominantly muddy sand.

A wide range of benthic invertebrate species was recorded from the Thanet site area, in all a total of 266 species were identified. The number of species varies from 3 to 44 species per station throughout the survey area. The species numbers are mostly low (5 to 10 species), with just a few stations being represented by high numbers (30 to 40 species). The number of individuals was very variable, ranging from zero (stations 49B and 60A) to 857 (station 22A) per 0.1m² Hamon grab. The cluster of samples comprising stations 21A and 22A in the centre of the survey area have particularly high species abundance reflecting the occurrence of *Sabellaria spinulosa*.

Multivariate analysis shows that the biological communities at each of the survey stations are very variable with few characteristics in common. This partly reflects the variability of the substrate and also the relatively small number of species recorded in many of the samples. Few of them therefore have sufficient species in common to form an identifiable group or 'community' that is statistically separable from others in the survey area.

Relatively large numbers of *S. spinulosa* were recorded in the benthic survey, particularly at stations 21 and 22. A small number of sites were then examined with a dropdown seabed camera, and these showed patchy *S. spinulosa* communities within the survey area other than at stations 21 and 22. A more detailed survey of the distribution of potential *S. spinulosa* communities was therefore carried out using a combination of high-resolution side-scan sonar and seabed digital stills camera system specially adapted for use in areas of poor visibility.

The main conclusions from this survey are summarised below:

- *S. spinulosa* occurs in moderate to low density patchy growth over much of the southern part of the Thanet site, with some areas of high density *S. spinulosa* growth occurring in the mid and western sections of the survey area.
- On the whole, there was a good correlation between the perceived distribution of *S. spinulosa* identified from the high resolution side-scan sonar data and that identified using the underwater photographs showing this to be an effective method of assessing the overall distribution of *S. spinulosa* in this area.
- Variability evidence in the underwater photographs indicates that the *S. spinulosa* growth is quite patchy in this area, which is likely to be at least in part due to trawl damage.
- *S. spinulosa* communities have been widely reported in the area by the local fishermen and are reported to be increasing in density following cessation of beam trawling by the Ramsgate vessels. Despite this, there is reported trawling by foreign vessels using heavy bottom gear and it remains true that the main threat to *S. spinulosa* is disturbance by heavy bottom gear by fishing vessels.
- Extensive trawl damage evident in the side-scan sonar data confirmed that this is the most likely limiting factor for *S. spinulosa* growth in the area and it is thought that this is likely to be preventing it from forming larger more consolidated reef structures.

TOW is committed to undertaking pre-construction surveys of the *S. spinulosa* aggregations in the southern sector of the Thanet site. It is anticipated that this survey would inform the micro-siting of turbines and interturbine cabling in order to ensure that **no adverse** impacts on dense aggregations of *S. spinulosa* occur as a result of the construction, operation and decommissioning of the Thanet project.

Overall, the biological communities recorded in the survey area are typical of coarse deposits of the southern North Sea and eastern English Channel and **no significant adverse** effects on the marine ecology due to the construction, operation or decommissioning of the wind farm and associated infrastructure are anticipated.