

Environmental Effect Pathways between Marine Aggregate Application Areas and Sandeel Habitat:

Regional Cumulative Impact Assessments



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Making Sense of the Marine Environment™



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The cover image of Greater Sandeel *Hyperoplus (Ammodytes) lanceolatus* is taken from: Gervais H. and Boulart C., 1877. *Les Poissons de Mer. Troisième volume*. Paris.

Date	Originator	Version	Action	Signature
30/07/2013	Phil Latto	0.1	For internal review	
02/08/2013	Dafydd Lloyd Jones	0.2	Internal quality control	
06/08/2013	Phil Latto	0.3	For Client Review	
08/08/2013	Phil Latto	0.4	Client Amended	
14/08/2013	Ian Reach	0.5	For MMO/RAG Review	
09/11/2013	Ian Reach	0.6	Post-MMO/RAG Consultation Draft	
16/12/2013	Phil Latto	1.0	Final Version	

GLOSSARY

Abbreviation	Description	Definition
ADZ	Active Dredge Zone	A defined zone within a production licence where dredging is actually occurring
AIS	Automatic Identification System	The Automatic Identification System is an automatic tracking system used on ships and by vessel traffic services (VTS) for identifying and locating vessels by electronically exchanging data with other nearby ships, AIS Base stations and Satellites.
BGS	British Geological Survey	The BGS provides expert services and impartial advice in all areas of geoscience. Their client base is drawn from the public and private sectors both in the UK and internationally.
BMAPA	British Marine Aggregate Producers Association	The representative trade body for the British marine aggregate industry
Cefas	Centre for Environment, Fisheries and Aquaculture Science	The Government's technical advisor on the marine and freshwater natural environment, fisheries science, aquaculture, mariculture and marine pollution
CIA	Cumulative Impact Assessment	Process by which the cumulative and in-combination effects from multiple sources on the environment, and its constituent parts, is determined.

	The Crown Estate	Governed by an Act of Parliament acting as the property manager for the Crown (where such is not the private property of HM the Queen). It works supportively with government; in Westminster, in Scotland, Wales, Northern Ireland and at a local level regarding leasing the UKCS to allow business development
	Cumulative Impacts	Additive impacts resulting from dredging at more than one site.
	Draghead	Equipment on the end of a dredge pipe that is in contact with the seabed during dredging
	Dredge Pipe	Equipment through which water and sediment is drawn from the seabed to the dredger
	Dredger	A generic term describing a ship capable of removing sediment from the seabed
EIA	Environmental Impact Assessment	Process by which the effects of a plan or project on the environment, and its constituent parts, is determined.
EIA Directive	Environmental Impact Assessment Directive 2011/92/EU	The Directive from the European Commission that requires an EIA to be undertaken for certain projects
EMS	Electronic Monitoring System	The 'black box' monitoring system on board a dredger that records the vessel's position and activity to ensure that dredging is only undertaken within permitted zones
	Entrainment	The unintentional collection of fish during marine aggregate extraction. Fish are drawn into the draghead and passed up the dredge pipe to the dredger

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IFCA	Inshore Fisheries and Conservation Authority	The Government's statutory agencies tasked with managing inshore fisheries and the sustainable use of the UK seas at a regional scale. There are 10 regional IFCAs in total
	In-combination Impacts	Additive impacts resulting from marine aggregate dredging and other marine activities such as fishing, shipping etc.
JNCC	The Joint Nature Conservation Committee	The Government's statutory advisor on the marine natural environment from 12 to 200 nm and UK territories
MAREA	Marine Aggregate Regional Environmental Assessment	Assessment of marine aggregate extraction environmental effects at a regional sea scale considering cumulative effects. It is a non-statutory instrument.
	Marginal Habitat Sediments	In the context of this methodology this is the sediment division/unit represented by sandy Gravel which sandeel may select as habitat. This sandeel habitat has adequate sediment structure but will only support low numbers of sandeel – see also Suitable
Marine Aggregate EIA WG	Marine Aggregate Environmental Impact Assessment Working Group	A quorum of marine environmental consultants (engaged in production of Environmental Statements or technical reports for marine aggregate production companies) consisting of: ABPmer Ltd; ERM Ltd; Fugro EMU Ltd; MarineSpace Ltd; and Marine Ecological Surveys Ltd.

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MMO	Marine Management Organisation	The executive non-departmental public body responsible for most activities licensed within the marine environment
MWR	Marine Works (Environmental Impact Assessment) Regulations (as amended 2011)	The domestic legislation that transposes the EIA Directive into UK law and applies to marine licence applications for marine aggregate extraction licences
NE	Natural England	The Government's statutory advisor on the English natural environment out to 12 nm
	Preferred Habitat Sediments	In the context of this methodology these are the sediment divisions/units which sandeel favourably select as habitat – see also Prime and Sub-prime
	Prime (Habitat)	Sandeel habitat which has the ideal sediment structure and supports the greatest number of sandeel
PIZ	Primary Impact Zone	The zone within which impacts resulting from the passage of the draghead over the seabed surface occur – also known as the direct impact zone
RAG	Regulatory Advisors Group	A group of statutory and technical advisors to the Regulator the MMO regarding marine aggregate extraction operations and impacts. Members include Natural England, Cefas, the JNCC and English Heritage
REC	Regional Environmental Characterisation	Broadscale description at a regional sea scale of the environment associated with marine aggregate extraction licences.

	Sandeel	There are 5 species of sandeel present in UK waters; these are the Greater Sandeel <i>Hyperoplus lanceolatus</i> Le Sauvage, 1824; Corbin's Sandeel <i>H. immaculatus</i> Corbin, 1950; the Lesser Sandeel <i>Ammodytes tobianus</i> Linnaeus, 1758; Raitt's Sandeel <i>A. marinus</i> Raitt, 1934; and the Smooth Sandeel <i>Gymnammodytes semisquamatus</i> Jourdain, 1879. Where "sandeel" is referred in this report it should be read to collectively represent these 5 species.
SIZ	Secondary Impact Zone	The footprint of effects arising as a result of the proposed dredging activity not associated with the PIZ – also known as the indirect impact zone
SPA	Special Protection Area	These are strictly protected sites classified in accordance with Article 4 of the EC Birds Directive, which came into force in April 1979. They are classified for rare and vulnerable birds (as listed on Annex I of the Directive), and for regularly occurring migratory species.
	Sub-prime (Habitat)	Sandeel habitat which has acceptable sediment structure and supports an intermediate number of sandeel
	Suitable (Habitat)	Sandeel habitat which has adequate sediment structure but will only support low numbers of sandeel

VMS	Umbrella Species	Species selected for making conservation-related decisions, typically because protecting these species indirectly protects the many other species that make up the ecosystem or ecological community of its habitat.
	United Kingdom Territorial Waters	The region of waters surrounding the United Kingdom, in which the country claims sovereign rights
	Vessel Monitoring System	Vessel monitoring systems are used in commercial fishing to allow fisheries regulatory organizations to monitor the position, time at a position, and course and speed of fishing vessels. They are usually deployed on fishing vessels >12 m length
	Wider Regional Sea Area	The area considered to be relevant in this assessment of sandeel habitat which ranges from the Firth of Forth south to an area just west of the Isle of Wight and out to the boundary of the UK territorial waters.

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Assessing the Possible Environmental Effect Pathways between Marine Aggregate Application Areas and Sandeel Habitat:

Regional Cumulative Impact Assessments

1. Introduction

This report and the assessments that it presents are intended to supplement the respective Marine Aggregate Regional Environmental Assessment (MAREA) reports that have been commissioned by the UK marine aggregate production companies (ERM Ltd, 2010, 2012; EMU Ltd, 2012a, 2012b). A strategic review of all the MAREAs was conducted by MarineSpace Ltd on behalf of the British Marine Aggregate Producers Association (BMAPA) (MarineSpace Ltd, 2013a-d). Within the MAREA reports sandeel habitat was consistently identified as requiring assessment within individual application Environmental Statements (ESs). Considering the universal nature of the issue, MarineSpace advised that sandeel habitat should be characterised and investigated at a national and regional strategic level through cumulative impact assessment (MarineSpace Ltd, 2013a-d).

There are a number of marine aggregate licence renewals and new applications expected within the next 11-25 months – many of which are business critical to the operators concerned, and of strategic importance to the UK marine aggregates industry as a whole. To aid the efficient delivery of marine aggregate licence applications under the Marine Works Regulations (as amended 2011) (MWR), ABPmer Ltd, ERM Ltd, Fugro EMU Ltd, MarineSpace Ltd, and Marine Ecological Surveys Ltd (a consortium of marine environmental consultants engaged in production of ESs or technical reports for marine aggregate production companies; henceforth referred to as the Marine Aggregate Environmental Impact Assessment Working Group (EIA WG)) have been engaged by BMAPA and Royal Haskoning DHV, on behalf of the marine aggregate production companies, to facilitate the delivery of regional cumulative impact assessments (CIAs).

The metrics, parameters and thresholds describing the environmental characteristics of sandeel habitat, and the screening exercise, spatial analysis and CIAs presented in this report, are intended to generate information of sufficient resolution and confidence to support an EIA for any marine aggregate licence application under the MWR application process.

The methodology used to develop the screening assessment procedure has evolved and been agreed through discussions (and a workshop) held by the Marine Aggregate EIA WG (Latto *et al.*, 2013; Appendix A). The method statement builds upon consultation and advice provided by the Marine Management Organisation (MMO) and the Regulatory Advisors Group (RAG) (MMO, 2013).

1.1. Sandeel – Ammodytidae Bonaparte, 1832

There are five species of sandeel present in UK waters; these are the Greater Sandeel *Hyperoplus lanceolatus* Le Sauvage, 1824; Corbin's Sandeel *H. immaculatus* Corbin, 1950; the Lesser Sandeel *Ammodytes tobianus* Linnaeus, 1758; Raitt's Sandeel *A. marinus* Raitt, 1934; and the Smooth Sandeel *Gymnammodytes semisquamatus* Jourdain, 1879.

All sandeel species are known to exclusively feed on the phytoplankton and zooplankton which inhabit the water column by filter-feeding during the daylight hours (Freeman *et al.*, 2004). Due to their small size and large numbers they are an important prey items for numerous fish species, as well as seabirds and marine mammals (Engelhard *et al.*, 2008). Therefore sandeel species are an important part of the marine food web acting as an *umbrella species* linking primary productivity (from plankton biomass) to the higher trophic levels (apex predators). Reductions in biomass of these species can have impacts ranging up the food chain to higher trophic levels and apex predators. Indeed there have been links found between population decreases in seabird species, such as the black-legged Kittiwake *Rissa tridactyla*, and reductions in sandeel recruitment (Furness, 2002; Frederickson *et al.*, 2004; Daunt *et al.*, 2008; Birdlife International, 2008; JNCC, 2013).

It has been suggested that sandeel display a high level of site fidelity making them potentially vulnerable at a sub-population level to direct habitat loss (removal) (Madsen, 1990; Jensen *et al.*, 2011). Due to the known environmental effects associated with marine aggregate extraction operations, the resources targeted (sands and gravels) and the overlap with known sandeel population ranges, it is likely that there are effect-receptor pathways. Quantification of these pathways and footprints and assessment of magnitude of effects will set context and allow environmental assessment for upcoming marine aggregate licence applications, alone and cumulatively.

1.2. Aims and Objectives

The objectives of this report are to present the considerations of environmental effects from marine aggregate extraction activities on sandeel habitat. The analysis and assessments have considered:

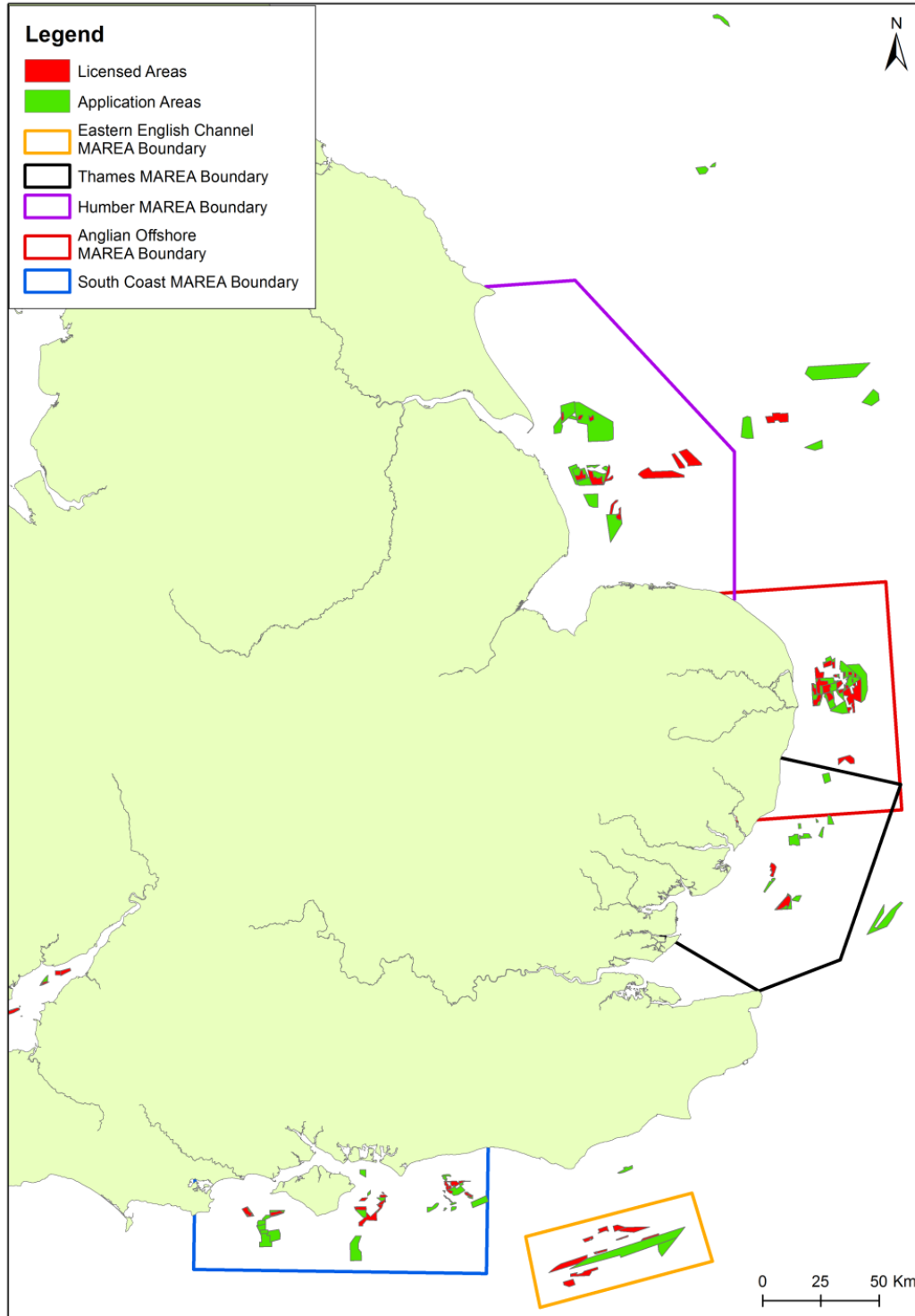
- Screening all application areas for environmental effect-receptor pathways and footprints; and
- Conducting 4 regional CIAs delineated by the MAREA regional boundaries.

In its simplest form the aim of this report is to screen all marine aggregate extraction application areas against spatial overlap with areas of seabed that have the potential to support sandeel populations. Any application area that demonstrates a spatial overlap with the seabed area in question will be screened into requiring an assessment of the environmental effects to deliver a MWR-compliant ES.

Second to the screening exercise, the aim is to determine the significance of any cumulative exposure pathways and environmental impacts on habitat or seabed area that has the potential to support sandeel populations. This is done for all marine aggregate production licences and application areas and also with other seabed user activities that are known to have a seabed footprint or which interact with known populations of sandeel. This is delivered via a regional CIA

conducted for each of the 4 MAREA regions¹ (Humber, Anglian, Outer Thames Estuary and South Coast).

Figure 1.1: Marine Aggregate Regional Environmental Assessment Study boundaries, existing marine aggregate licences and application areas. (Source: The Crown Estate)



¹ The Eastern English Channel region is not included as part of the assessments detailed in this report.

1.3. Cumulative effect pathways

In English territorial waters there are several seabed user industry activities that are likely to interact with sandeel habitat e.g. dredge and benthic trawl fisheries; offshore windfarm arrays; marine aggregate extraction; dredge disposal sites; telecommunications cable routes; and oil and gas supply pipelines. These activities are considered at a MAREA scale as part of the CIAs, to assess any possible damage or deterioration to the potential habitat that sandeel may make use of. The spatial analysis conducted has allowed levels of contribution to environmental cumulative effects from existing and proposed marine aggregate operations with other seabed user sector footprints to be determined. The rationale for the assessments within this report is to determine the worst case environmental footprint of all activities, allowing precautionary assessments to be conducted.

It is important to note that the considerations of seabed user footprints (aside from marine aggregate licence areas) presented within this report itself relate to the spatial extent of the exposure/interaction between the sector and seabed sediments and habitat that has the potential to support sandeels. Values and quantities presented in this report do not directly relate impact assessments; they merely present a quantification of spatial area for comparison between seabed user sector footprints. Considerations of the cumulative impacts are presented in the regional CIAs.

1.4. Sandeel habitat and the scale of the study and assessments

As mentioned in Section 1.1, the nature of sandeel habitat has quite specific characteristics which are still not well understood (see references cited in Section 1.1). While it is not a fault of the study or the regional CIAs, the assessment, by necessity, has used data at a macro-scale that does not allow the necessary resolution to actually identify specific discrete and individual areas of seabed with the potential to act as sandeel habitat. This is mainly due to the fact that sandeel habitat is typically associated with localised features. In reality actual habitat, or habitat that could be used for by sandeel in the future, will likely comprise discrete spatial extents, although these may be spread across wide areas of suitable seabed sediment habitat at a regional-scale e.g. flanks of subtidal sandbanks. While it will be the role of site-specific Environmental Impact Assessments (EIAs), and associated monitoring as part of the licence conditions, to determine the potential presence of such localised habitat features, this report, and the regionals CIAs, are still able to provide relevant analyses to enable a consideration of potential effect-pathways at a wider seas- and regional-scale.

It is clear from the study and the regional CIAs undertaken that in general terms marine aggregate extraction represents a relatively small contribution to the spatial interaction with areas of seabed likely to represent sandeel habitat, or which have the potential to be habitat, in comparison with other anthropogenic activities. The distribution and extents of seabed sediments able to support sandeel, is such that marine aggregate extraction is unlikely to significantly restrict the ecology of the species and adult populations at a regional or wider regional sea scale.

2. Methods used in the assessment

The MMO and the RAG have advised (at a meeting held on 01 May 2013 (MMO, 2013) and in subsequent consultation after the submission of previous drafts of this report) the types of effect and effect-receptor pathways that need to be considered as part of the requirements of the EIA Directive as transposed to the MWR. For sandeel populations the environmental effects and effect-receptor pathways of potential impacts, and how they are to be considered, are:

- Direct removal of potential habitat, along with physical alteration of the structure of the sediments from direct contact with the draghead. These effect-receptor pathways relate to the primary impact zone (PIZ);
- Smothering of individuals through deposition from the sediment plumes and sediment mobilisation were not considered in the assessment resulting in the exclusion of the secondary impact zone (SIZ) from the EIA's²;
- The regions of historic occupation which currently are not utilised by sandeel but can be *re-colonised* due to subsequent seabed recovery after the cessation of impacts. The area of seabed associated with potential *re-colonisation*, following the cessation of dredging is represented only by the PIZ³;
- Potential population level effect of marine aggregate dredging on sandeel are not considered to be required to be assessed under the MWR application process (MMO, 2013)⁴; and
- Entrainment of sandeel by the dredger draghead was requested by Cefas to be considered in relation to a previous sandeel entrainment study conducted on the Nash Bank in 1995. This study found that while sandeels were collected during aggregate extraction, all individuals were returned alive to the water column in an undamaged condition by the standard screening processes employed on dredgers (ABP Research and Consultancy Ltd, 1995). Therefore entrainment effects on sandeel are not considered significant in the context of this assessment.

Therefore, no consideration will be provided of the effects associated with:

- Sediment plumes on the SIZ e.g. fines smothering buried sandeel;
- Entrainment of larvae and adults; and
- Any effects resultant at an adult population scale from receptor-effect pathways listed above and presented in the box below.

² The secondary effects of aggregate extraction, increased concentrations of suspended sediments in the water column and smothering (from deposition of particles), have been shown to be inconsequential to sandeel species (Pérez-Domínguez and Vogel, 2010).

³ Determinations regarding the potential for *re-colonisation* regarding requirements to leave the seabed in an appropriate state at the end of the term of the licence period, will also be drawn from an application's ES.

⁴ Sandeel have been shown to display a degree site fidelity to suitable habitat, post settlement (Jensen *et al.*, 2011), and as such impacts to a localised area can have wide ranging effects on sub populations of sandeels. The *foci* of the assessments presented in this report are concerned with effect pathways on habitat with the potential to support sub populations and therefore the meta-population level is not considered.

The MMO and RAG have advised that a statement should be included in all marine aggregate licence area ESs detailing that adult population level effects are not required to be assessed (MMO, 2013a).

Marine aggregate licence applications in relation to an EIA of likely effects with sandeel preferred habitat sediments will specifically need to consider effect-receptor pathways from:

The Primary Impact Zone:

- **Direct removal of suitable sediment (habitat); and**
- **Recovery of preferred habitat sediments to support re-colonisation.**

The methodology used in this report is applied in 2 stages:

- Stage 1.** Habitat indicator and exposure pathway mapping and screening of spatial interactions for application areas; and
- Stage 2.** Regional CIA.

Stage 1 applies the adapted spatial screening methodology from Latto *et al.* (2013) and results in a screening of receptor-exposure-effect pathways between marine aggregate licence and application areas and habitat seabed areas with the potential to support sandeel populations. The pathways are analysed in a Geographical Information System (GIS), and a confidence assessment of the data used is applied (Appendices C-F). These areas of seabed with the potential to contain potential sandeel habitat are identified through the overlap of data layers that are deemed indicative of sandeel occupation. The greater the number of overlapping data layers then the greater the 'heat' mapped and the higher the confidence that the seabed may be suitable for sandeels.

Licence and application areas which have overlap (i.e. an exposure footprint exists) with receptor layers (i.e. potential habitat) are screened into further assessment and proceed to the Stage 2 assessment. Any licence or application areas which produce no exposure pathway are screened out at the end of Stage 1 and do not require further consideration for EIA or CIA.

Stage 2 conducts a CIA for each of the marine aggregate strategic regions (Figure 1.1) using the MAREA regional boundaries and the respective MAREA impact assessment protocols and methodologies (suitably adapted as necessary to the scope of this assessment) (ERM Ltd, 2010, 2012; EMU Ltd, 2012a, 2012b; Appendices H-K). The rationale for this process allows the regional CIAs to act as supporting reports to each of the MAREAs; regarding the characterisation of sandeel habitat and subsequent impact assessment.

2.1. Precautionary envelope

To set a suitable level of precaution within the study it is assumed for the purposes of quantifying spatial interactions between marine aggregate dredging impact pathways and areas with the potential to support sandeel populations, that the entire extent of the application area is treated as the PIZ i.e. dredging is assumed to occur anywhere within the boundary of the licence or application area. This worst case scenario will assume the highest level of spatial interaction possible. This rationale is also applied where other seabed user footprints associated with plans or projects (yet to

be licensed, constructed or deployed) are likely to interact with potential sandeel habitat (see Section 2.3.1 for further detail).

The worst case scenario is considered precautionary as it over-estimates the spatial extent of Active Dredge Zones (ADZs), within any, and all, licence and application areas, and the extent of associated sediment plumes. In reality the footprint of dredging activity (ADZ) is likely to be discrete and localised (within the wider area of the licence/application area) for periods of time associated with the aggregate resource, its volume and market demand for that resource/product. Therefore, in relation to effect-receptor pathways:

- Direct removal of sandeel habitat would only occur during a dredging event. The presence of a dredger in the licence area is a time-limited event and if the sediments of a whole licence area were preferred sandeel habitat, a single, or small number of, dredging events would only affect a small portion of the area; and
- It is assumed that habitat loss/conversion occurs across the totality of the licence/application area with a transition from potentially suitable to wholly unsuitable habitat in regards to sediment composition i.e. a shift from preferred and/or marginal sediment habitat type to unsuitable sediment habitat type. In reality there are several reasons why this is unlikely to actually happen, not least the monitoring and mitigation measures required of the industry in modern licence conditions.

2.2. Revisions to the methods used in the assessment – post consultation with the MMO and RAG

It should be noted that following submission of a working draft report (version 0.5) to the MMO for consultation, subsequent revisions were requested to the previously agreed methodologies and the analyses, results and determinations presented in the report, by the MMO and the RAG. Through September and October 2013 a series of meetings were held between BMAPA, representatives of the EIA WG, the MMO and RAG to address the changes to the rationale for the assessments, alterations and clarifications regarding the confidence assessment methodology, data layer analyses to be used, and the subsequent presentation of results and determinations (Cefas, 2013a, 2103b; MMO, 2013b, 2013c).

The discussions held at the meetings have adjusted the rationale for the study detailed in this report and the attached regional CIAs (as agreed in the 01 May 2013 meeting; MMO, 2013a) (Cefas, 2013a, 2013b; MMO, 2013b, 2013c; Appendix L). This is reflected in the Appendix A addendum and the version 6.0 confidence assessment protocol presented in Appendix B.

2.2.1. 'Heat' mapping

The focus of the spatial (mapping) assessments is through the analyses of multiple overlaps of data layers used in the assessment methodology and the resultant 'heat'. In effect the greater the number of data layers overlaps, then the higher the 'heat' and the associated confidence that the area of seabed mapped has the potential to support sandeel. Whilst the 'heat' mapping existed in the version 0.5 draft report, clarification is provided within this final report version 1.0 regarding the use of the seabed sediment classification previously referenced as preferred and marginal habitat types. These seabed sediments and their associated Folk classes are not directly indicative of

spawning habitat *per se*, but are representative of the sediment types that are known to be associated with habitat used by sandeel. These sediment types are now referenced as preferred and marginal habitat sediment classes (see Section 2.3 and Addendum to Appendix A). The emphasis is now on using these habitat sediment classes as a 'base-map' (unchanged from the methodology in Appendix A) and overlaying the other data layers considered within the methodology to produce the 'heat' maps developed for each of the regions assessed.

As part of the extended consultation process the confidence assessment protocol and methodology was revised to re-classify the 'heat' mapping process and extend the 'heat' classes to ensure consideration of the full range of data layers (see Appendix B for full detail of the protocol and methodology). The previous methodology mapped 'heat' as three classes: **low** = 1-4 data layer score overlaps, **medium** = 5-8 data layer score overlaps and **high** = 9-12 data layer score overlaps. Cefas indicated that there were additional data layer overlaps that could theoretically be possible. Therefore a fourth class of 'heat' has been categorised as **very high** = 13-16 data layer score overlaps. It should be noted that the 'very high' class cannot be mapped in this study (including any of the regional CIAs) as the required number of data layer overlaps is not achieved i.e. there is no area of seabed where all layers overlap allowing a score of 13-16. The revised methodology has been agreed with Cefas and the MMO (Cefas, 2013a, 2013b; MMO, 2013b, 2013c).

2.2.2. Entrainment of sandeel during aggregate extraction

Potential impacts on sandeels following entrainment during the extraction of marine aggregates were raised by the MMO and RAG following the submission of the consultation draft version 0.5 report. The RAG requested that reference be made to an entrainment study, specifically targeting sandeel, which occurred on the Nash Bank in the Bristol Channel in 1995 (ABP Research and Consultancy Ltd, 1995). This study found that sandeel, specifically *Ammodytes tobianus*, were collected during extraction operations; however the study determined that all individuals were returned to the water column alive and in an undamaged condition by the standard screening practices employed by the aggregate industry.

As discussed at the start of Section 2, entrainment effects on sandeel are not being considered within this assessment as agreed with the MMO (MMO, 2013a). However, the results of the Nash Bank entrainment study are relevant and the MMO and RAG have subsequently advised that the effects of entrainment on sandeels are required to be considered at the individual licence level through EIA.

2.2.3. Specific stipulations regarding data used in the report and cumulative impact assessments

As part of the consultation on the draft report, the MMO and the RAG have provided a series of specific stipulations regarding the data used in the report and cumulative impact assessments. Details of these conditions are presented in Appendix L along with a Marine Aggregate EIA WG position regarding these matters. Where appropriate the EIA WG has included the consideration of these factors on the data used as part of the analyses and subsequent determinations presented within the CIAs and this report.

Regardless of these stipulations the EIA WG has confidence in the approach adopted as it draws on multiple and different data sources and is fit for purpose in terms of regional scale assessments.

2.3. Stage 1 assessment methodology

The Stage 1 methodology maps and screens the spatial interactions between marine aggregate licence and application areas (the effect footprints) with sandeel (the receptor) indicative habitat data layers. This is the ‘heat’ mapping using the ‘heat’ classes of low, medium, high (and theoretically very high) as discussed in Section 2.2.1 above. The methodology uses a tiered approach to map habitat (preferred and marginal habitat sediments), ecological space, and various data layers that demonstrate the presence of sandeel presence e.g. spawning data (Coull *et al.*, 1998) and fisheries VMS data etc. These multiple data layers and the associated ‘heat’ of spatial overlaps indicate appropriate receptor-exposure pathways as identified in Latto *et al.* (2013) (Appendix A). The methodology scopes down from population distributions at wider regional sea area level; through potential habitat at a sea/basin-scale; to potential habitat extent at an appropriate regional scale (as determined by the MAREA study boundaries; see Figure 1.1). These data are used to produce the broadscale sandeel habitat characterisation map (the base-map). The base-map is then used in conjunction with existing licence and application area boundaries (PIZ footprint) and data indicative of potential sandeel habitat to allow licence and application area-specific screening to be conducted (see Latto *et al.*, 2013; Appendix A).

Any existing licence area or application area that overlaps with an extent of suitable habitat identified at Stage 1 is screened into further assessment i.e. there is a receptor-effect exposure pathway.

Any existing licence area or application area without any spatial overlap identified through Stage 1 is screened out of further assessment i.e. there is no receptor-effect exposure pathway.

The Folk sediment classification (Folk, 1954) has been used to describe seabed habitat as this is also the classification scheme used to underpin the British Geological Survey’s (BGS’s) 1:250,000 scale seabed sediment maps. This sediment classification has subsequently been used within the Marine Aggregate Regional Environmental Characterisation (REC) and MAREA reports. Using the Folk (1954) classification enables compatibility of the sandeel habitat environmental assessments with a range of products (e.g. MAREAs, marine planning areas) and data sources (e.g. BGS 1:250,000 maps).

The review and analysis of the source data for sandeel habitat (see Latto *et al.*, 2013; Appendix A) resulted in the development of the seabed sediment classification presented in Figure 2.1. The sediment divisions, referred to as **habitat sediment classes** (using the Folk classification; see Appendix A and associated addendum), have the potential to support sandeel populations and are presented in Tables 2.1 and 2.2.

This habitat classification, and the sediment divisions used, was ratified by the MMO and RAG at a meeting held on 01 May 2013 (MMO, 2013). First it is important to note that the use of these sediment divisions will over-represent the full range of habitat with the potential to support sandeel populations. This is due to the percentage of fine sands (included with all grades of Sand in the Folk classification) and Gravels within the sediment divisions. However, without a complete re-working of

all the BGS data (used in developing the 1:250,000 scale sediment maps), an exact representation of sandeel habitat is not possible. The MMO and RAG agreed that such an exercise is beyond the requirements of any specific EIA (as required under the MWR). Therefore the best-fit Folk sediment classification, as described in Appendix A and presented in Figure 2.1, has been used to conduct the assessments within this report.

Table 2.1: Description of potential sandeel habitat sediment classes. (From Latta *et al.*, 2013; Appendix A)

Preferred habitat sediment class	In the context of this methodology these are the sediment divisions/units represented by Sand, slightly gravelly Sand and gravelly Sand which sandeel favourably select as part of their habitat requirements. It should be noted that other physical, chemical and biotic factors contribute to the overall definition of potential spawning habitat – see also <i>Prime</i> and <i>Sub-prime</i> descriptions.
Marginal habitat sediment class	In the context of this methodology this is the sediment division/unit represented by sandy Gravel which sandeel may select as part of their habitat requirements. This sediment class has adequate sediment structure but is less favourable than preferred habitat – see also <i>Suitable</i> descriptions.
Unsuitable habitat sediment class	Seabed sediment classes which have inadequate sediment structure to be chosen by sandeel.
Prime Habitat Sediment Class	In the context of this methodology these are the sediment divisions/units represented by coarse Sand, slightly gravelly Sand and gravelly Sand with ideal sediment structure that supports sandeel populations – see also <i>preferred habitat sediment class</i> . It should be noted that other physical, chemical and biotic factors contribute to the overall definition of potential spawning habitat
Sub-prime Habitat Sediment Class	In the context of this methodology this is the sediment divisions/units represented by finer Sand, slightly gravelly Sand and gravelly Sand which has acceptable sediment structure and supports sandeel populations. This sediment class has adequate sediment structure but is less favourable than <i>prime habitat sediment</i> – see also <i>preferred habitat sediment class</i>
Suitable habitat sediment class	Sandeel habitat sediment which has adequate sediment structure but is likely to only support low sandeel abundances. This is represented by gravelly Sand and sandy Gravel Folk sediment classes – see also <i>marginal habitat sediment class</i>

Second, it is important to clarify that the habitat sediment classification is not the only parameter (datum) that indicates potential sandeel habitat. There are other environmental (physical, chemical and biotic) parameters such as: oxygenation, siltation, water depth, location of sandbank flanks, which all contribute to the suitability of seabed habitat to be used by sandeel.

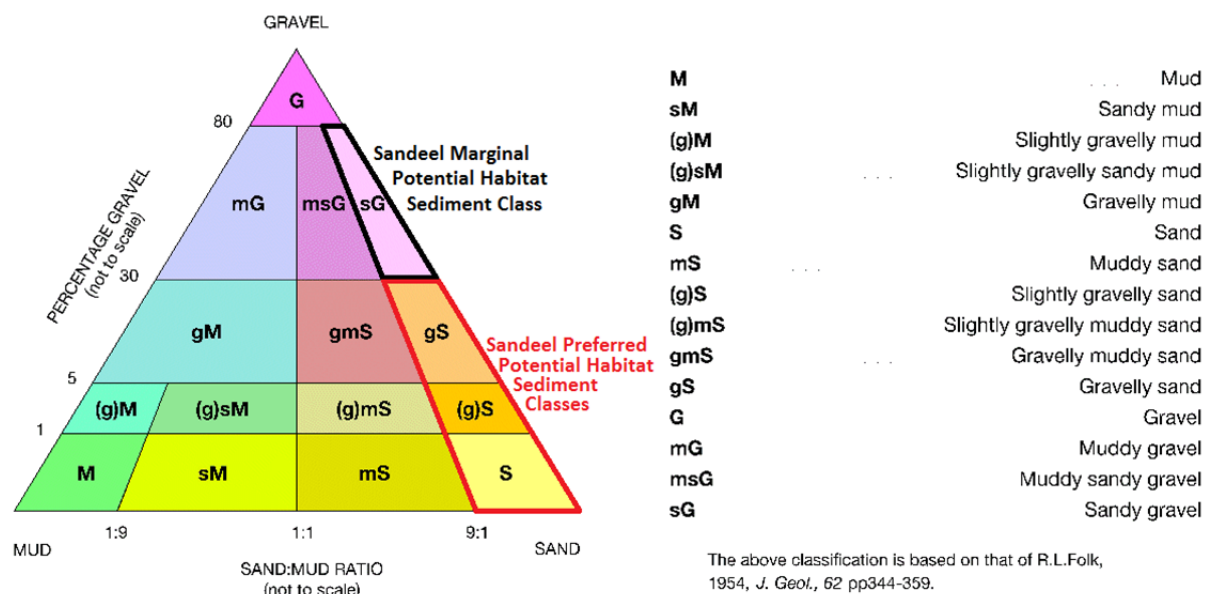
Considering the wide range of environmental parameters that determine Atlantic Herring spawning, it is important to note that the use of the habitat sediment classes alone will always over-represent the range of habitat with the potential to support Atlantic Herring spawning events. This results in the rationale for using as many indicative data layers as possible and determining representation of potential for spawning based on the 'heat' of the spatial overlaps (of the data used). It is also important to note that sandeel are faithful to a discrete area of seabed sediment after recruitment (Jensen *et al.* 2011). Therefore data indicating regions of spawning have been used where available to act as a proxy for adult occupation of habitat e.g. the Coull *et al.* (1998) data.

Table 2.2: The partition of sandeel habitat sediment classes. (Source: Folk, 1954; From Latto *et al.*, 2013; Appendix A)

% Particle contribution (Muds = clays and silts <63 µm)	Habitat sediment preference	Folk sediment unit	Habitat sediment classification
<1% muds, >85% Sand	Prime	Part Sand, Part slightly gravelly Sand and part gravelly Sand	Preferred
<4% muds, >70% Sand	Sub-prime	Part Sand, Part slightly gravelly Sand and part gravelly Sand	Preferred
<10% muds, >50% Sand	Suitable	Part gravelly Sand and part sandy Gravel	Marginal
>10% muds, <50% Sand	Unsuitable	Everything excluding Gravel, part sandy Gravel and part gravelly Sand	Unsuitable

Considering the wide range of environmental parameters that determine sandeel habitat, it is important to note that the use of the habitat sediment classes alone will always over-represent the range of habitat with the potential to support sandeel populations. This results in the rationale for using as many indicative data layers as possible and determining representation of potential for habitat based on the 'heat' of the spatial overlaps (of the data used).

Figure 2.1: The Folk sediment triangle indicating sandeel preferred and marginal potential habitat sediment classes. (Source: Folk, 1954; From Latto *et al.*, 2013; Appendix A)



2.4. Stage 2 assessment methodology

At Stage 2 the regional CIAs are conducted (one for each of the four MAREA regions assessed in this report: Humber, Anglian, Outer Thames Estuary, and South Coast). All existing licence areas and application areas that are screened in at the end of Stage 1 will contribute to a cumulative effect footprint. Furthermore there may be cumulative effects with other seabed user industries with the same environmental effect exposure pathways and footprints. Stage 2 maps the effect footprints of all known and foreseeable activities (plans or projects) and assesses the levels of spatial interaction with potential sandeel habitat 'heat' maps. Through this process the level of contribution of marine aggregate extraction-specific effect footprints can be related to those from other sectors. The percentage of area of habitat overlap (percentage of contribution per activity) at a regional (MAREA) scale can be calculated. These values can be related to the potential sandeel habitat extents within the MAREA region, facilitating the CIA. No inferences on the respective significance of user activities interacting with areas of seabed that may have the potential to support sandeel populations are made within this report.

As the regional CIAs are intended to synergise with each of the MAREAs (regarding the impact assessment of potential sandeel habitat) then the respective MAREA impact assessment protocols and methodologies will be used during this stage (EMU Ltd, 2012a, 2012b; ERM Ltd, 2010, 2012). This provides a consistency of approach, with this sandeel assessment building on an existing structure. However, the MAREA methodology was intended to address regional-scale issues for broad groups of receptors, so where appropriate the assessment has been adapted to provide a more effect-specific approach (Appendices H-K). Therefore the regional CIAs are not direct supplements to the existing MAREAs but are intended as synergistic assessments that address the gaps regarding sandeel specific impacts identified within the MAREAs (MarineSpace Ltd, 2013a, 2013b, 2013c, 2013d).

2.4.1. Seabed user footprints

The seabed user footprints have been established to ensure that seabed footprints are represented as realistically as possible. Where available, exact footprints have been sourced and used. However, due to the spatial scale over which many of the footprints occur, the type of data available e.g. VMS, and considering the available information associated with some projects still in the planning stage, it has not been possible to map all the footprints in detail. Instead a standard (generic) footprint has been applied to ensure consistency. Table 2.3 outlines the seabed user sector, the footprint applied and the rationale for this.

As stated above, where available, exact footprints have been used to generate the spatial interaction with the seabed. Where a seabed user footprint can only be established in outline (the standard footprint), a generic approach to establishing a realistic worst case detailed footprint has been adopted to ensure that the full spatial footprint of interaction with the relevant habitat can be established. Therefore, where a standard footprint has been used, the worst case interaction with the relevant habitat has been established i.e. the footprint has been mapped to interact with the greatest extent of the relevant habitat, rather than an interaction with a minimal area.

The results of the seabed user sector footprint analyses present a spatial analysis of the data only (see Section 4). No inferences on the respective significance of user activities interacting with areas of seabed that may have the potential to support Atlantic Herring spawning are made within this report.

Table 2.3: Seabed User Spatial Footprint Parameters

Seabed User	Generic Footprint	Parameter Rationale	Data source
Pipelines	700mm diameter	Pipelines do vary in diameter depending upon their purpose. An average representation of this range of pipeline diameter is used, which will also account for any protection required.	Crown Estate
Power Cables Proposed Power Cables	300mm diameter	Power cables vary in their diameter depending up on their role (export, interconnection, distribution etc.). An average diameter of 300mm was used to take into account the cable footprint and any protection or movement that might be required.	Oceanwise
Telecommunication Cables	50mm diameter	Standard practice for telecommunications cable within shallow seas is to armour them, resulting in a diameter of 50mm.	Oceanwise
Disposal Sites	As stipulated by Cefas		Cefas
Commercial Fisheries Only those fishing gear types that directly interact with the seabed were used.			
Demersal Trawling	Footprint of 5 years of VMS data (2007-2011)	5 years of VMS data was utilised and where activity occurred within the VMS 1.8nm x 3nm rectangle it was included as part of the footprint. This therefore locates where this type of activity is most likely to occur.	MMO
Dredging Gear	Footprint of 5 years of VMS data (2007-2011)		MMO
Offshore Windfarms (OWF)			
Operating OWF	50m diameter	Where the turbine footprint is known a standard footprint diameter has been applied to each turbine location. The average footprint takes account of turbine foundation and anti-scour footprint and variations in foundation design.	Crown Estate And Oceanwise
OWF under Construction	50m diameter		

Seabed User	Generic Footprint	Parameter Rationale	Data source
Proposed OWF	75m diameter	Where the OWF site boundary is known, but no turbine footprint has been confirmed as of June 2013, and standard turbine grid has been applied. The grid dimensions are 1,155m x 1,617m. The applied grid and the greater foundation diameter take into account that the majority of these sites are Round 3 (or extensions to existing sites) and will therefore be further offshore and in deeper water. Therefore, larger turbines with greater blade sweep are expected to be deployed, resulting in increased distances between turbines (in comparison with Round 1 and 2 arrays, and with larger foundation footprints and any associate anti-scour protection.	
Aggregate Extraction Areas			
Current Licence Area	Licence boundary	The boundary co-ordinates were downloaded from the Crown Estate website in June 2013. They represent the entire footprint over which aggregate extraction could occur.	Crown Estate
Application Area	Application boundary		
Option Area	Option boundary		

2.5. Confidence assessment methodology

Confidence in the mapped sandeel potential habitats is required for the PIZ exposure pathway. Any confidence assessment that is informed through multiple data layers needs to:

- Assess the confidence in each data layer; and
- Determine the combined confidence in multiple layers.

Individual layers may have either spatially uniform or variable confidence, depending on the underlying data. All data are assessed to ensure a robust exposure pathway screening exercise and subsequent environmental assessments have been conducted as part of this study.

An overview of the confidence assessment process is presented here; however the detailed Confidence Assessment Protocol is presented in Appendix B and informs a thorough understanding of the rationale and methods used within this study. The rationale and methodology used in Confidence Assessment Protocol version 6.0 (Appendix B) have been discussed with the MMO, RGA and specifically Cefas and are agreed (Cefas, 2013a, 2103b; MMO, 2013a, 2013b, 2013c).

2.5.1. Data considered

The spatial datasets considered in the confidence assessment to inform the location of sandeel potential habitat included:

- Seabed sediment Folk classification: BGS;
- Seabed sediment Folk classification: MAREA;
- Seabed sediment Folk classification: RECs;
- Fishing Fleet: VMS;
- Fishing Fleet: MMO sightings;
- Fishing Fleet: Inshore Fisheries and Conservation Authorities (IFCA) sightings;
- Spawning Grounds: Eastern Sea Fisheries Joint Committee (ESFJC); and
- Spawning Grounds: Coull *et al.* (1998).

All datasets are in a polygon format (area of special extent), as opposed to point, line or raster/gridded data, as this allows them to be combined and to give an overall assessment.

2.5.2. Data omitted

The MMO fishing fleet sighting records required interpolation to create polygons for the data layers. This dataset was omitted from the study after plotting the relevant gear types against the VMS data layers (see Appendix B for full details) as the comparison indicated that the VMS data already showed corresponding gear types in the same locations as presented by the MMO sightings, except for a very few cases that were not considered significant. Therefore use of the MMO fishing fleet sighting data would result in duplication of data. An addition source of VMS data, specific to sandeel fisheries, was available for the Dogger Bank region of the North Sea. This data formed part of the Dogger Bank Creyke Beck Environmental statement and detailed the VMS data of Danish sandeelers operating around the Dogger Bank round 3 OWF development area (Brown and May Marine Ltd, 2012); unfortunately this data could not be supplied to the EIA WG and as such was omitted from the analyses.

The Inshore Fisheries and Conservation Authority (IFCA) dataset has also been excluded, as the full coverage dataset (representative of all IFCAs) was not supplied within the required timescales for this study. Were possible these data should be sourced for consideration within any licence-specific EIA. The MMO are currently facilitating the provision of these data to the marine aggregate sector.

The REC seabed sediment layer has been excluded because the BGS 1:250,000 scale seabed sediments version 3 dataset (BGS SBS version 3 dataset) (which is used in the confidence assessment) has been confirmed to include REC data from the Humber, East Coast and South Coast studies, but not for the Outer Thames region. Furthermore the MAREA seabed sediment data also includes REC data in its interpretation. Therefore additional use of the REC data would result in duplication of data.

2.5.3. Confidence test method

2.5.3.1. Confidence in the data

Following review of various approaches used to date, including MESH⁵, UKSeaMap⁶, and the MMO's approach, a scoring proforma has been developed to apply to confidence assessments as shown below (Table 2.4). This was adopted where there were no supporting spatial data to inform spatial variation in confidence.

The first five parameters (method, vintage, positioning, coverage, quality standards) are concerned with the data, i.e. how confident is the Marine Aggregate EIA WG in the data being as described, whether this is seabed sediment, spawning grounds or fishing activity?

Note that 'coverage' does not, specifically, assess spatial coverage but instead the extent of the data. If an overall reduced score was given to a dataset because it did not spatially cover the entire project area, this would reduce the score of this parameter in areas where it does indicate sandeel habitat, which is not relevant. The study is interested in the data where it is provided. If it is not provided at a location, a result of zero feeds into the overall combined confidence.

⁵ <http://www.searchmesh.net/default.aspx?page=1635>

⁶ http://jncc.defra.gov.uk/pdf/UKSeaMap2010_TechnicalReport_7_ConfidenceExternalReview.pdf

Table 2.4: Data parameters and weighting used in the Confidence Assessment Protocol and Methodology.

Confidence Test	Considerations	Weighting
Method	Technique to gather, process and interpret the data, robustness and reliability, best practice, publication	1
Vintage	Age of data and suitability of age to intended use	1
Positioning	Accuracy of locations provided	1
Coverage	Coverage of the data in terms of what is included, density of points, gaps in data. Note this does not assess spatial coverage*	1
Quality Standards	Quality control information provided, review internally, externally	1
Indicator of Habitat	Suitability of the dataset to inform of sandeel habitat	5

2.5.3.2. Confidence in the spawning data indicating sandeel habitat

As previously discussed it has been identified that sandeel are faithful to a discrete area of seabed sediment after recruitment (Jensen *et al.*, 2011), thus regions of spawning (Coull *et al.*, 1998) may act as a proxy for adult occupation of habitat.

The final parameter, 'indicator of habitat', is not concerned with the data themselves, but the confidence in the data indicating habitat i.e. when there are no direct data on habitat measurements (such as seabed sediments), what confidence is there that the data may inform or indicate sandeel habitat? As this project is using the data to assess the likelihood or confidence of sandeel habitat locations, this indicator parameter is fundamental to the outcome and, therefore, is heavily weighted. A weighting of 5 has been assigned during development of this methodology, and given the expert opinion of the Marine Aggregate EIA WG. A value of 5 results in this parameter holding the same weight as all the preceding 5 parameters combined.

2.5.3.3. Spatial variation in confidence

All datasets were assessed in order to consider whether any supplied parameters could be used to inform spatial variation in the confidence; whether applied to confidence in the data themselves or confidence in the indication of sandeel habitat. This was only concerned with parameters that reduced certainty about the data; i.e. variation in fishing time (VMS) does not reduce certainty in the data.

It was concluded that only two datasets had spatial variation in a parameter that informs confidence: seabed sediment Folk class for each of BGS and MAREA. This is addressed separately in section 2.5.5 below.

2.5.4. Scoring

For each parameter or confidence test shown, a score between 0 and 3 is assigned, where 0 = unknown and 3 = high confidence (Table 2.5). However for the 'indicator of habitat' (final parameter in Table 2.4), a score of 0 would mean it is unknown whether the dataset can be used to infer habitat locations. This is not applicable for this parameter; as if this were the case the layer should not be included in the project. Therefore a score of 0 for 'indicator of habitat' = very low confidence.

Table 2.5: Confidence scores used in the Confidence Assessment Protocol and Methodology.

Score	Score category
0	Unknown / none*
1	Low
2	Medium
3	High

* For the parameter 'indicator of habitat', a score of 0 = very low confidence (see above for the rationale)

The final confidence for an individual layer is calculated by adding the weighted scores, then normalising to a range of 0 to 5 (see Appendix B).

2.5.5. Confidence in the seabed habitat sediments data indicating potential sandeel habitat

As detailed in Latto *et al.* (2013), sandeel are known to prefer Sand, slightly gravelly Sand and gravelly Sand seabed sediments; and also have a marginal habitat sediment class of sand Gravel. Therefore the Folk sediment classification provides a spatially variable indicator to habitat and hence the level of confidence is also variable (see Section 2.3; Appendix A).

The level of confidence in Folk classes indicating potential sandeel habitat needs to consider two variables. First, it needs to consider the confidence that the Folk category contains the correct sediment class, e.g. there is more confidence in Sand indicating potential sandeel habitat (hence the 'preferred habitat sediment') than sandy Gravel (the 'marginal' habitat sediment) (Appendix A; Latto *et al.*, 2013). This field is termed 'Folk category indicates marginal/preferred habitat' and is represented by the Y-axis in the matrix below.

Second, the scoring needs to consider whether the Folk class boundaries, i.e. the upper and lower limits of each of gravel, sand and mud, are representative of the potential sandeel habitat, or not, e.g. the Folk category sandy Gravel contains sediment types outside of the marginal range for sandeel habitat i.e. there is the possibility that the Folk sandy Gravel class may contain >50% gravels, in which case this is unfavourable to support sandeel populations. This is shown on the X-axis in the matrix below and termed 'Folk category over represents/correctly represents'.

Normally, such matrices are provided for parameters scored from low to high, or numerically, 1 to 3. However in this case, it is never possible that the BGS data can indicate sandeel habitat with high confidence as it is only an indicator, i.e. direct measurements of habitat carry much greater confidence. Therefore the matrix is scored from 0 to 2. As detailed in Section 2.3.4 above, where scoring the indicator for habitat, a zero score does not imply 'unknown', but 'very low' instead.

Each of the two parameters is scored separately from 0 to 2 (very low to medium); then the two are combined as shown in the matrix.

Generic Matrix

	Folk category over represents = 0 (very low)	Folk category represents correctly = 2 (medium)
Folk category indicates marginal habitat sediment = 0 (very low)	0 (very low)	1 (low)
Folk category indicates preferred habitat sediment = 2 (medium)	1 (low)	2 (medium)

As per the method statement for sandeel, of the four Folk categories that represent potential sandeel habitat sediment class (Sand (S), slightly gravelly Sand((g)S), gravelly Sand (gS) and sandy Gravel (sG)), only the marginal habitat sediment sandy Gravel over-represent the habitat divisions. This reduces the confidence in the data layer. In contrast a greater degree of confidence is placed in the preferred habitat sediments as these are correctly represented by the Folk category. Therefore the matrix results are as follows:

Sandeel Matrix

	Folk category over represents = 0 (very low)	Folk category represents correctly = 2 (medium)
Folk category indicates marginal habitat sediment = 0 (very low)	sG = 0 (very low)	N/A
Folk category indicates preferred habitat sediment = 2 (medium)	N/A	gS, (g)S, S = 2 (medium)

The habitat can only have a very low or low assessment due to the Folk classification limitations. If an exposure pathway exists, then the detail of the extent of preferred habitat sediment in relation to marginal habitat sediment presence and magnitude of effects will then be considered within the application's EIA.

2.5.6. Confidence in the combined data

Table 2.6 below shows the results of each of the confidence assessments per layer plus the final single layer confidence score.

These ‘final single layer’ confidence scores represent the value (or weight of evidence) that each dataset has as an ‘indicator of sandeel habitat’, taking both the quality of the data into account as well as their suitability to be used to indicate locations of sandeel habitat (see Appendix B for detail)

Each individual layer is first scored on five parameters or tests relating to the data themselves: each of these tests result in a score of 0 to 3 (Section 2.5.4 and also Appendix B). These scores are then summed for each individual layer and then normalised back to a range of 0 to 3 (i.e. by dividing by the total possible score, 15, and multiplying by the range, 3). This is the total normalised value, and is provided for reference only to show how the datasets differ, irrespective of their ability to indicate potential habitat.

A single score is provided next for the confidence in the layer indicating potential habitat for sandeel. This test results in a score of 0 to 3.

The total weighted score then combines all the parameter scores together. The parameter scores for confidence in the data are added to the weighted indicator score which is weighted through multiplication by 5. By multiplying by 5, the indicator score has equal weight to all the other 5 scores combined. The total weighted score for a given layer can therefore range from 0 to 30 (i.e. 5 parameter scores up to a maximum each of 3 = $(5 * 3) = 15$; plus one score up to 3 and multiplied by 5 = 15: giving a total of 30).

The Total Normalised sandeel score is then calculated by normalising the total weighted score for sandeel to a range of 0 to 5 (i.e. by dividing by the total possible score of 30 and multiplying by the range, 5). Whilst these values could have ranged 0 to 3 as with the rest of the scores, this did not allow enough variation between the datasets. A range of 5 was considered to show a suitable level of variation (very low = 1, low = 2, medium = 3, high = 4 and very high = 5). These individual data layer values, presented as ‘Total Normalised’ in red text in Table 2.5, were assigned to each shapefile attribute table ready to contribute towards the final combined confidence mapping layers (see Section 3).

In all scores within the confidence assessment, a low number reflects low confidence in the data indicating habitat, whereas a high number reflects high confidence. For the combined data layer maps the ‘hotter’ or more intense the colour then the higher the probability that the associated seabed has the potential to support sandeel habitat. These are the ‘heat’ maps presented in Section 3.4 and used within the regional CIAs (Appendices C-G).

Table 2.6: Final Confidence Assessment per Individual Layer (Appendix B)

Confidence test	Method	Vintage	Positioning	Coverage	Quality Standards	Dataset Scoring Source	Total Normalised	Total Normalised	Total Weighted Score	Indicator of sandeel habitat
Range from 0 to >>	3	3	3	3	3		3	3	30	5
Weight	1	1	1	1	1			5		
MAREA Preferred sediment	2	3	3	3	2	MESL	3	2	23	4
ESFJC	2	2	1	1	0	EMU	1	2	16	3
Coull et al	1	1	1	2	0	MESL	1	2	15	3
BGS Preferred sediment	2	1	3	3	2	MESL	2	2	21	4
VMS	3	3	3	2	3	EMU	3	0	14	2
MAREA Marginal sediment	2	3	3	3	2	MESL	3	0	13	2
BGS Marginal sediment	2	1	3	3	2	MESL	2	0	11	2
IFCA Sightings	2	3	1	1	1	EMU	2	0	8	1

The combined confidence ('heat maps', see Section 3.4) is the sum of all layers at any one location. This has been produced by simply adding the score for each layer to a total: therefore, the greater the number of over-lapping data layers, the higher the probability that the seabed location represents potential sandeel habitat.

2.5.7. Data layers included in combined confidence

As noted above, the IFCA sightings data were not used in the combined confidence. Therefore the total score at any location was the sum of the sediment type used (whether BGS/MAREA and preferred/marginal), ESFJC, Coull *et al.* and VMS. These total scores have been plotted both numerically, as well as a simplified categorisation into **low**, **medium**, **high** and **very high**. A justification for the categories chosen is given in the following section.

It should be noted that it was not possible to combine both the BGS and MAREA seabed sediment as indicators of habitat and it is advised that the best seabed sediment data are used at any individual licence area, as appropriate (MAREA data used as base-map for the Humber and Anglian regions; and BGS data used as the base-map for the Outer Thames Estuary and South Coast regions). To facilitate the use of either the BGS or the MAREA data, the combined confidence probability has been calculated separately, using both BGS and MAREA datasets as separate base-maps. Therefore, two combined confidence assessments are available for the receptor species in each of the MAREA study areas: sandeel with BGS data; and sandeel with MAREA data.

A temporal range is associated with the data layers, with some data representing concurrent use of the seabed by, or representation of the presence of sandeel, within the same period of time e.g. VMS data from 2010 is concurrent with the 2010 ESFJC data. Where this temporal and spatial overlap occurs then a higher certainty that the data are indicating potential sandeel habitat can be deduced. This is not to say that there is a lack of confidence where there is a spatial overlap of data layers but these are outside of a shared temporal overlap. These cases may result from data gaps e.g. Coull *et al.* used data up to 1998 but the VMS dataset is from 2006-2012. In this example the lack of temporal overlap has not been penalised, as both datasets are valid in indicating the potential for that area of seabed to support sandeel, with a level of certainty that this may have been the case at 1998 and between 2006 and 2012. The screening process assumes an additive nature both for space and time as part of the precautionary assessment process in determining the extent of seabed with the potential to support sandeel populations.

2.5.8. Range of data presented

If all layers were to coexist at one location, the maximum possible score would be where MAREA preferred sediment is used (higher score than MAREA marginal sediments and BGS preferred/marginal sediments). Therefore, the total possible score is:

$$4 \text{ (MAREA pref.)} + 3 \text{ (ESFJC)} + 3 \text{ (Coull et al.)} + 2 \text{ (VMS)} = 12.$$

This maximum score is termed the '**maximum possible data layers score**'. This is the greatest score achievable considering the associated confidence associated with any one data layer. Theoretically, a higher maximum combined score could be achievable if all data layers had the maximum score of 5 associated with each of them. As detailed in Section 2, this is however not the case so the '**maximum possible data layers score**' is the 'real' maximum score that can be achieved using the data layers available to the assessment (regional cumulative impact assessments).

What is shown by the total confidence score associated with the '**maximum possible data layers score**' is the 'weight of evidence to indicate habitat' or 'quantity of overlap in layers to indicate habitat', i.e. the more layers present that indicate habitat, the higher the confidence; providing that all layers cover all licence regions. The scoring provides an assessment-specific (using the data available at the time of the assessment) one off national presentation of data, showing the range of data and theoretically possible overlaps, indicating the potential that an area of seabed has the habitat suitable to support sandeel.

Therefore a top range of 16 (the maximum number of layer scores that could theoretically overlap) was used in the analyses. The actual results only extend up to 12 as the data layers required for the maximum possible data layers score do not concurrently occur at any one location i.e. they are spatially restricted in such a way that they are unable to all overlap in anyone space within the study areas considered. However, in the future, additional data coverage may result in an increased spatial overlap of data layers that could increase from 12 up to 16).

2.5.9. Categorisation of data layer overlap – ‘heat’

Two different methods to categorise the ‘heat’ of layer-overlap were considered: ‘equal interval’ and ‘quantile’ ArcGIS methods. The quantile method was rejected as it is not useful to emphasise areas of equal data coverage. Also this method does not allow use of the total maximum possible score i.e. from 13 up to 16 layers overlapping.

Therefore intervals of 4 overlapping data layers were chosen to develop the categorisation of ‘heat’ associated with mapping i.e. 1-4, 5-8, 9-12, 13-16.

3. Results

3.1. Introduction

The spatial distribution of receptor indicator footprints and PIZ data allow exposure pathways to be analysed in a GIS. Concurrently, a confidence assessment of both individual data layers and the combined exposure layers is applied. Licence and application areas which have overlap (i.e. an exposure footprint exists) with receptor layers (potential habitat) are screened into further assessment and proceed to the Stage 2 assessment.

The MAREA scale assessments can also put into the context of a Wider Geographical Region; which is the area considered to be relevant to this assessment for sandeel and was previously determined in Latta *et al.* (2013) through consultation with the RAG and MMO (MMO, 2013a). The wider regional sea area ranges from the Firth of Forth south to an area just west of the Isle of Wight and out to the boundary of the UK territorial waters. Seabed sediment data has been sourced from the British Geological Survey (BGS) to cover this area (Figure 3.1). These data can be used to characterise the footprint of marine aggregate extraction footprints in relation to the total habitat within the southern North Sea and English Channel.

The initial data layer mapped is the representation of seabed sediment Folk classes at a national seas/basin scale showing the preferred and marginal habitat sediments classes known to be favoured by sandeel populations (refer to Latta *et al.* (2013); see Appendix A for rationale for determining preferred and marginal habitat sediments classes) (Figures 3.2 and 3.3). These data have been sourced from the BGS and are represented by the BGS 1:250,000 scale seabed sediments version 3 data (BGS SBS v3 data).

As these data also map seabed sediments outside of the MAREA regions these data will facilitate the assessment of any marine aggregate application areas that are located outside of the MAREA regional boundaries. These 'outlier' licence and application areas have undergone the Stage 1 screening exercise but have not been assessed as part of the Stage 2 assessment exercise presented in this report; as this has only been conducted for the licence and application areas within the MAREA regions.

Figure 3.1: The wider geographical region considered relevant to this assessment for sandeel habitat.

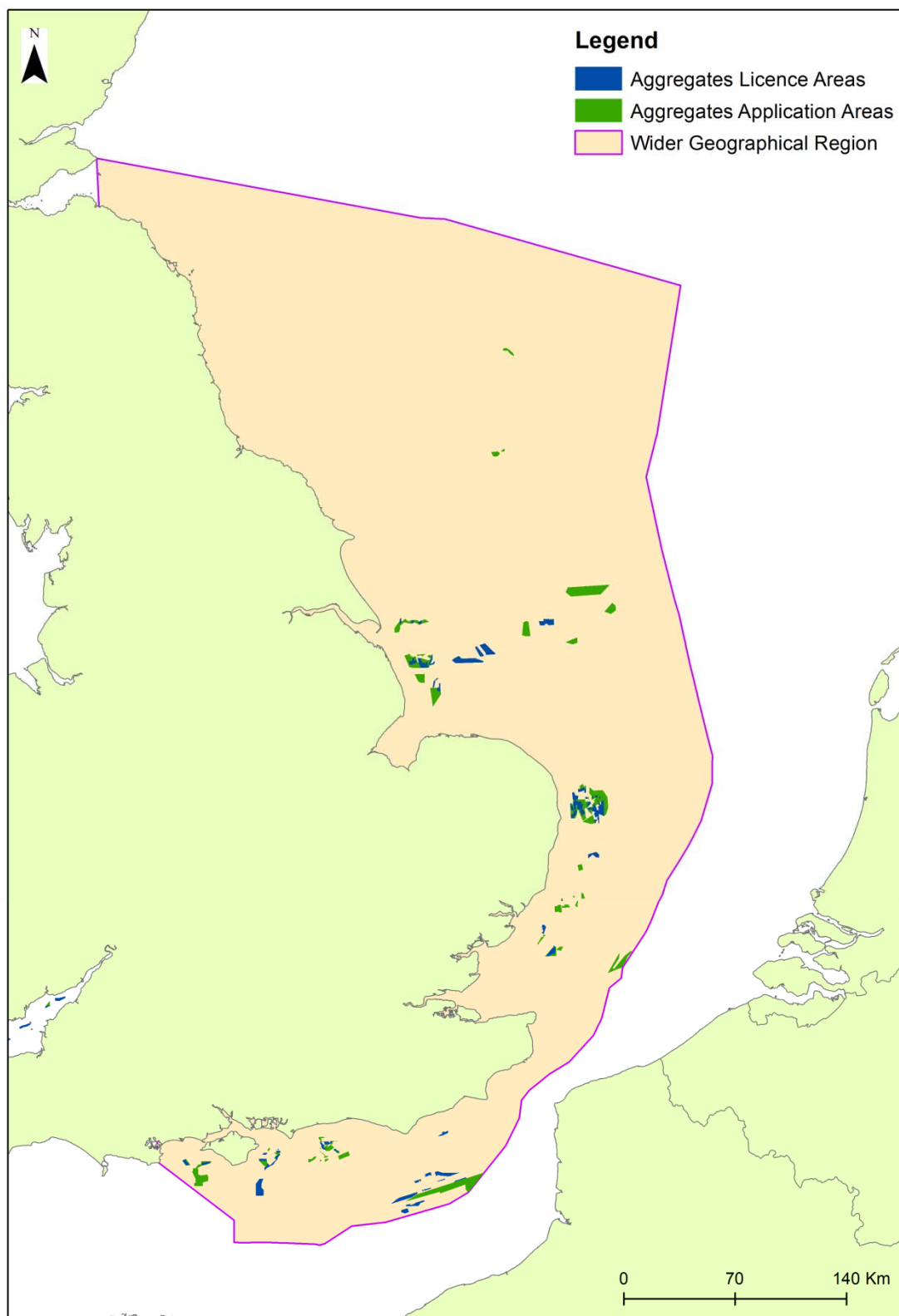


Figure 3.2: Distribution of the preferred habitat sediments classes with the potential to support sandeel populations. (Derived from 1:250,000 scale BGS Digital Data under Licence 2013/063 British Geological Survey. ©NERC.)

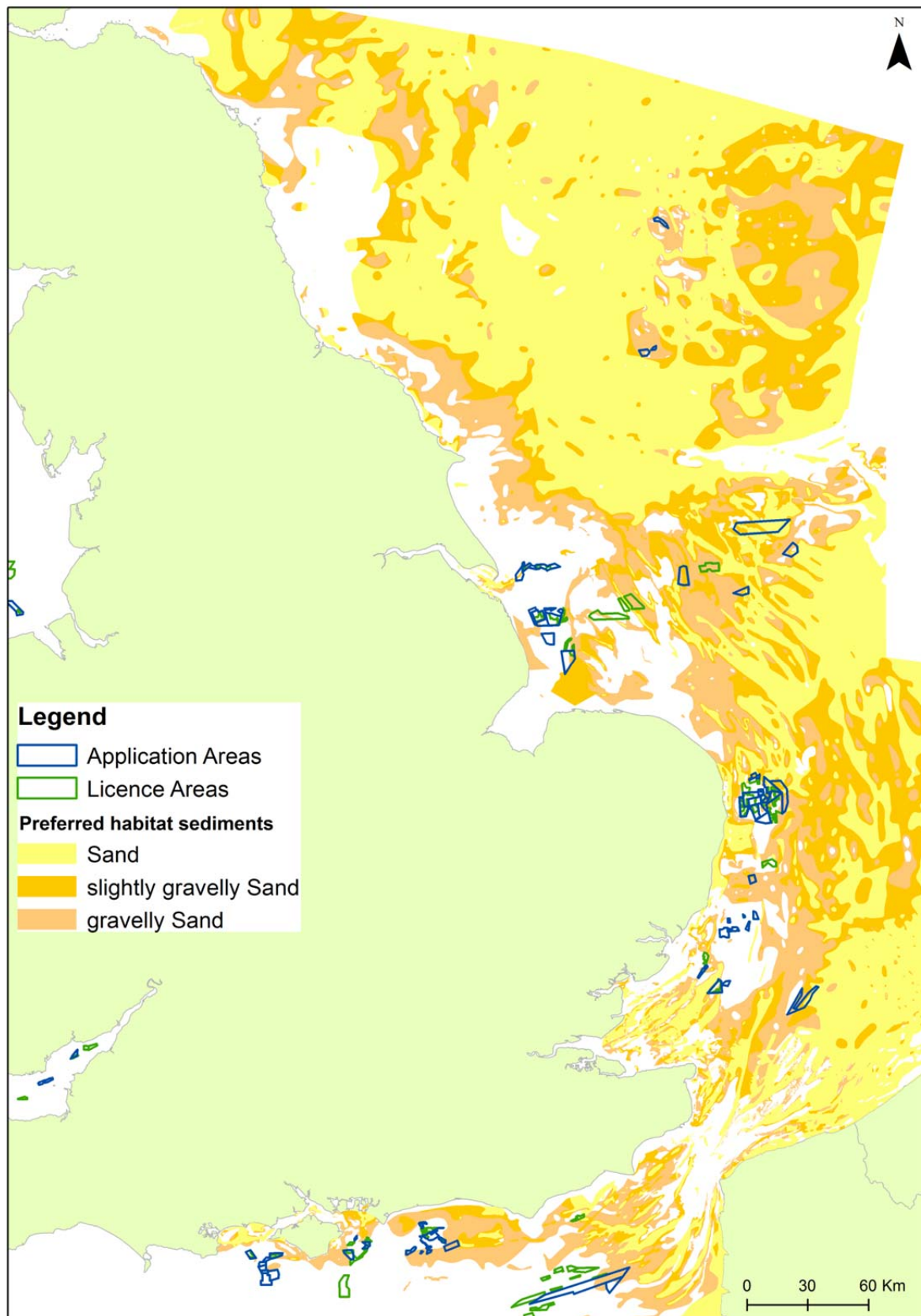
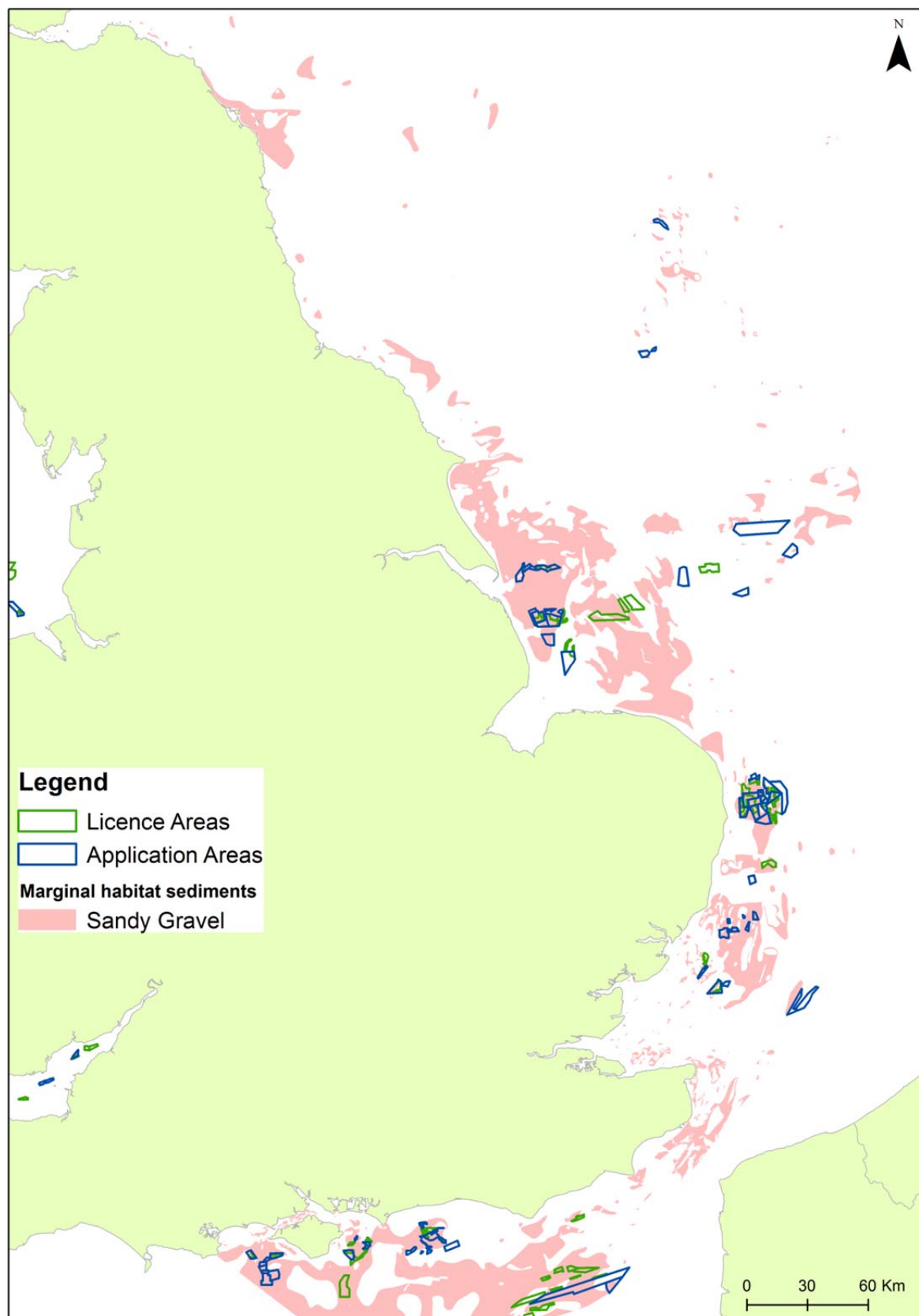


Figure 3.3: Distribution of the marginal habitat sediments class with the potential to support sandeel populations. (Derived from 1:250,000 scale BGS Digital Data under Licence 2013/063 British Geological Survey. ©NERC.)



3.2. Seabed sediment maps

The seabed habitat sediment maps at a wider seas and regional scale were generated to underpin the multiple data layer 'heat' maps. A level of analysis was conducted on the habitat sediment data layers alone to determine the distribution and extent of these data within the study area delineated by the BGS wider seas data coverage (Figure 3.1). Whilst not definitive regarding the determination of potential spawning habitat alone (hence the 'heat' mapping) these data and the initial analyses were deemed appropriate by the EIA WG. This considers the fact that no area of 'heat' should have a level of confidence above low, if it is not underpinned by a suitable sediment type; either preferred or marginal habitat sediment. This relates to the ecological importance of seabed sediments in structuring spawning beds.

Considering that the methodology to identify seabed with the potential to support sandeel populations adopts a 'heat' mapping approach, then the results of analyses using just the habitat sediment data alone are arguably of little value when factoring the other data used; and wider environmental parameters that are currently un-mappable, such as seabed sediment oxygenation. However, as the habitat sediments are a fundamental physical factor that underpins the determination of potential sandeel habitat the analyses are presented for consideration. These are located in Appendix M of this report.

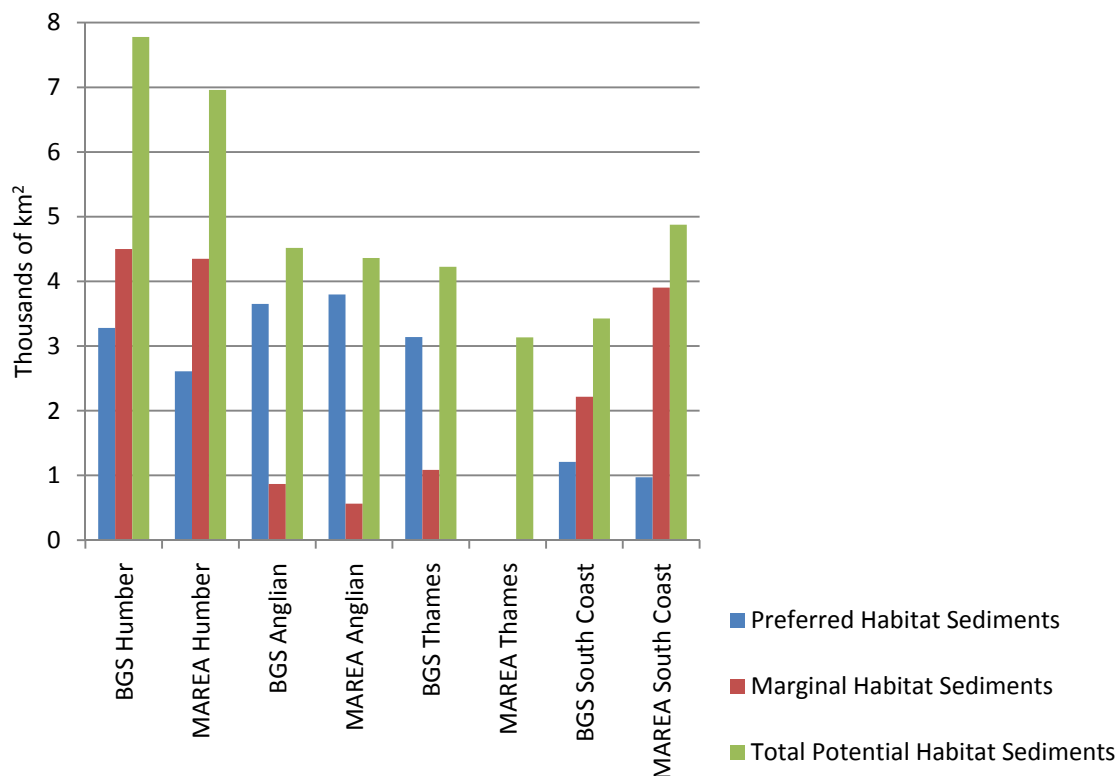
3.3. Comparison between the BGS and MAREA seabed sediment habitat data

Comparisons between the BGS and MAREA seabed sediment habitat extent data shows that the calculated values for the Humber and Anglian regions align; with similar representation of total habitat sediments and also the division between preferred and marginal habitat sediments (Figure 3.4). In contrast there appears to be a level of disparity for both the Outer Thames Estuary and South Coast regions between the BGS and MAREA data. The MAREA data indicate a larger extent of marginal habitat sediments in the South Coast region whereas the grouping of sediment classes in the Outer Thames has prevented the determination of the preferred and marginal habitat sediments classes.

It is likely that some of the discrepancies between the BGS and MAREA seabed sediment data relate to data vintage and seabed bedform mobility e.g. the slight decrease in preferable habitat in the Humber MAREA data may reflect both the more recent data acquisition and the known mobility of sandy sediments within parts of that region in comparison to the BGS data (ERM Ltd., 2012).

The different ways that the seabed sediments data have been presented in each of the respective MAREA study reports may contribute to any discrepancies between the MAREA and BGS data. For the Outer Thames Estuary and South Coast MAREAs certain Folk sediment classification divisions have been amalgamated to aid interpretation (ERM Ltd, 2010; EMU Ltd, 2012b). The Outer Thames Estuary MAREA combined the sandy Gravel and gravelly Sand divisions together as a single mapping unit; whereas the South Coast MAREA combined the Gravel and sandy Gravel component of the Folk classification.

Figure 2.5.9.4: Comparison of the mapped extents of sandeel habitat: within the Humber, Anglian, Outer Thames Estuary and South Coast regions and between the BGS and MAREA data. (Derived from 1:250,000 scale BGS Digital Data under Licence 2013/063 British Geological Survey. ©NERC.; EMU Ltd, 2012a, 2012b; ERM Ltd, 2010, 2012)



Note that references to habitat relate to habitat sediments and are not an indicator of definitive habitat i.e. they relate to preferred habitat sediment and marginal habitat sediment and no considerations of habitat modifiers/additional parameters such as sediment oxygenation, micro-scale geomorphological features etc. have been applied

The MAREA sediment classifications were set up for the purpose of the MAREA assessments and remain fit for purpose for these tasks, but the presentation of the sediment data for the purposes of the Thames and South Coast MAREAs assessments means that they are not optimised for the purposes of the sandeel habitat screening assessment. The threshold between preferred and marginal habitat sediments sits across the division between gravelly Sand and sandy Gravel (see Figure 2.1; Latto *et al.*, 2013; Appendix A). Therefore the Outer Thames Estuary MAREA, specifically, may over or under-represent both the preferred and marginal habitat sediments, as neither can be distinguished. In this instance the EIA WG determined that the BGS data allowed more meaningful resolution for spatial analyses at the MAREA-scale. For the South Coast MAREA, combining Gravel and sandy Gravel proved problematic as the threshold between the marginal and unsuitable habitat sediments sits across this division; this results in an over representation of the extent of the marginal habitat sediments. Therefore as the South Coast MAREA data is unsuitable to allow the distinction between preferred and marginal habitat sediments the BGS data were used in its place.

In all the above cases, where Folk sediment classes have been generalised or combined, the lowest confidence is adopted, e.g. the confidence of a combined class of sandy Gravel and gravelly Sand to indicate sandeel habitat is 0 (very low).

As it was not possible (or necessarily desirable) to combine both the BGS and MAREA seabed sediment data as an indicator of potential sandeel habitat, the EIA WG has advised that the best seabed sediment data deemed appropriate are used within the study (and for any particular application area's ES). Therefore the combined confidence results are presented using the BGS and MAREA seabed sediment base-maps separately.

A comparison has been conducted per MAREA region between the BGS and MAREA seabed sediment base-maps, in order to ascertain the most appropriate spatial resolution to allow Stage 1 screening of application areas and Stage 2 regional CIA (see Figures M6-M9 in Appendix M). Considerations of the issues discussed above, and the overall confidence in each of the datasets (see Appendix B), have been taken into account when determining the most appropriate seabed sediment base-map to use. The resolution of the base-maps has been examined to identify which data best describe the boundaries between preferred and marginal habitat sediments, and bedforms and seabed geomorphological features. By comparing the MAREA and BGS seabed sediment maps at a regional scale, including the confidence assessment in those data (see Figures 3.11-3.14), the following seabed sediment data have been preferentially used within this study:

Region	Seabed Sediment Layer	Region	Seabed Sediment Layer
Humber	MAREA	Outer Thames Estuary	BGS
Anglian	MAREA	South Coast	BGS

3.4. Stage 1 Results – Exposure Pathways

The 'heat' maps (resulting from the multiple GIS data layer overlaps) allow a spatial assessment of receptor-pressure-exposure pathways to be described and analysed. These maps are presented in appendices for each of the four marine aggregate regions considered as part of this study:

- Appendix C: the Humber region;
- Appendix D: the Humber 'outlier' region;
- Appendix E: the Anglian region;
- Appendix F: the Outer Thames Estuary region; and
- Appendix G: the South Coast region.

The appendices present interactive maps showing the individual data layers considered to represent indication of potential sandeel habitat, and the attendant confidence/'heat' score associated with the data. Each data layer is presented and the spatial interactions with the PIZ footprints for the licence and application areas are illustrated.

A total combined data 'heat' map is also presented using either BGS or MAREA seabed sediment base-maps as appropriate:

- MAREA seabed sediment base-map for the Humber and Anglian regions; and
- BGS seabed sediment base-map for the Outer Thames Estuary and South Coast regions.

The 'heat map' shows the probability, for any seabed location, of the presence of sandeel potential habitat.

Any area of spatial overlap between a licence area or an application area and any of the data layers will result in that particular area screened into requiring an environmental assessment. Application areas will require an EIA to assess the significance of the exposure footprint. Existing licence areas will be screened in and identified as contributing to the Stage 2 regional CIA.

Licence and application areas outside of MAREA regions ('outlier' areas) have also been screened for the requirement of environmental assessment and compliance with the MWR. Whilst these are not considered as part of the MAREA-scale CIA, any application area screened in will require an EIA to assess the significance of environmental effects, including cumulative and in-combination effects. Existing 'outlier' licence areas are screened to facilitate consideration of cumulative and in-combination assessments with adjacent 'outlier' application areas, where appropriate or required.

The following sub-sections present screening tables that have been compiled from the data layers and the confidence in each layer. The tables indicate where there is any spatial overlap with each data layer, using the relevant confidence score for that layer. A total combined score is provided and then an indication of whether the licence or application area is screened into requiring further environmental assessment (EIA for application areas and consideration as contributing to part of a cumulative and in-combination assessments). The screening assessment considers only an area's PIZ and not the SI_Z, i.e. the secondary effects of aggregate extraction are deemed inconsequential to sandeel (MMO, 2013a).

Any spatial overlap will result in a licence or application area being screened into requiring an environmental assessment, regardless of the probability or confidence score associated with the overlap. It is for the EIA process to determine the significance and magnitude of any impacts that may result from any spatial interactions between the application area and the potential sandeel habitat at that location and within the MAREA-scale context.

3.4.1. Humber Region

Figures 3.4a and b illustrate the positions of the licence and application areas assessed for the Humber region, while Figures 3.5 and 3.6 overlay these areas on the confidence 'heat' map for potential sandeel habitat. It is clear that the regions of highest confidence (i.e. confidence score 9 and above) are those areas of seabed where the preferable habitat sediments overlaps with the Coull *et al.* (1998) sandeel spawning layer. This is most notable in the northern part of the region, and across the Dogger Bank. A smaller region of high confidence is associated with the Silver Pit, a bathymetric low (tunnel valley) in the centre of the MAREA area.

Figures 3.5 and 3.6, and Tables 3.1 and 3.2 show that more than two-thirds of licence and application areas overlap low and medium confidence regions. The Coull *et al.* (1998) spawning layer

extends across the east of the region, coming in close to the Holderness and north Norfolk coasts, while remaining offshore of the Lincolnshire coast.

Within the Humber MAREA region only Areas 440, 441/2 and 514/2 overlap areas with a confidence score higher than 7. The remaining application areas fall into the low and medium confidence levels, with confidence scores between 4 and 6; excluding Area 106/1 which has the lowest possible confidence score of 2. In contrast, Areas 483 and 466/1 are the only 'outlier' areas to fall into the medium confidence level, only overlapping areas with a highest confidence score of 6; the remaining 'outlier' areas all fall within the highest confidence level as they overlap regions with a confidence score of 9.

Subsequent to the delivery of the consultation version 0.5 draft report Cefas has indicated several data sources which may prove useful for further analysis as part of site-specific EIA (Cefas, 2013b). These include Taylor *et al.* (2007), Ellis *et al.* (2012), Lynam *et al.* (2013), fish survey data from the Dudgeon and Dogger Bank Creyke Beck offshore windfarms and the Cefas young fish survey data.

All areas within the Humber region, including the 'outlier' licence and application areas are screened in for assessment at site-specific EIA level (Table 3.1, Table 3.2).

Figure 3.4a: Licence and application areas within the Humber region considered within the screening and assessment study. (Source: The Crown Estate, 2013)

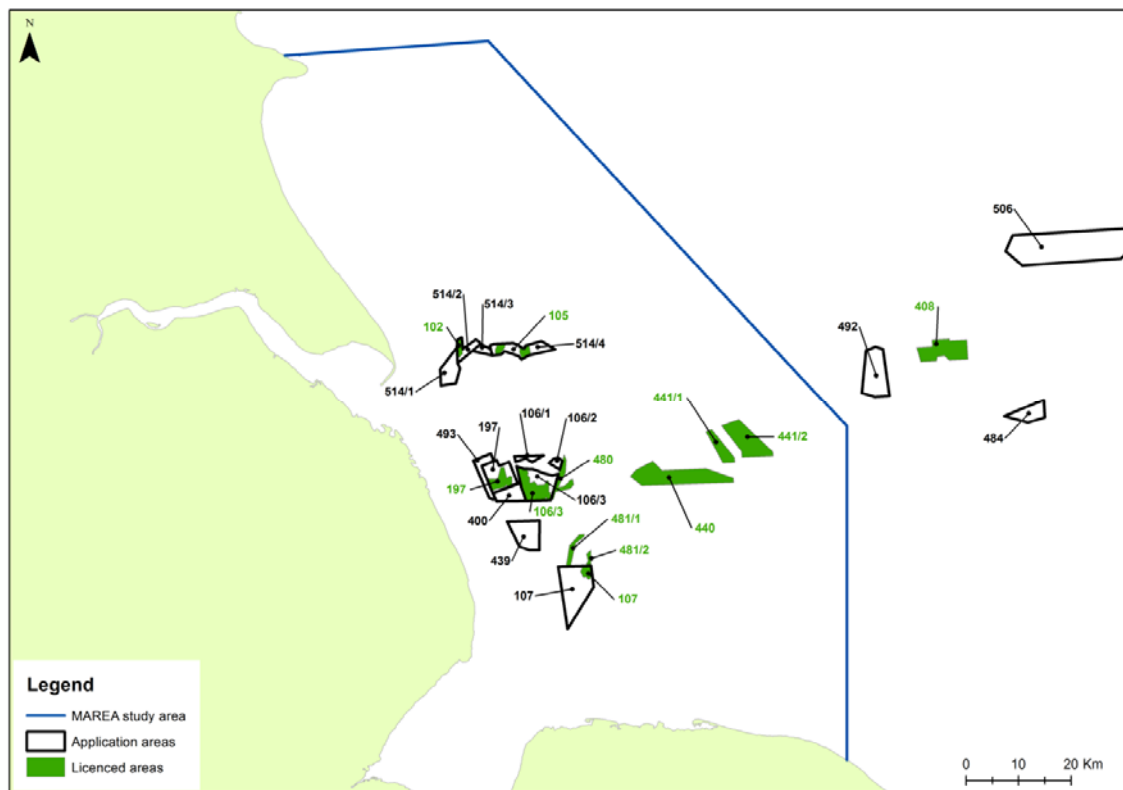


Figure 3.4b: 'Outlier' licenses and application areas within the Humber region considered within the screening and assessment study. (Source: The Crown Estate, 2013)

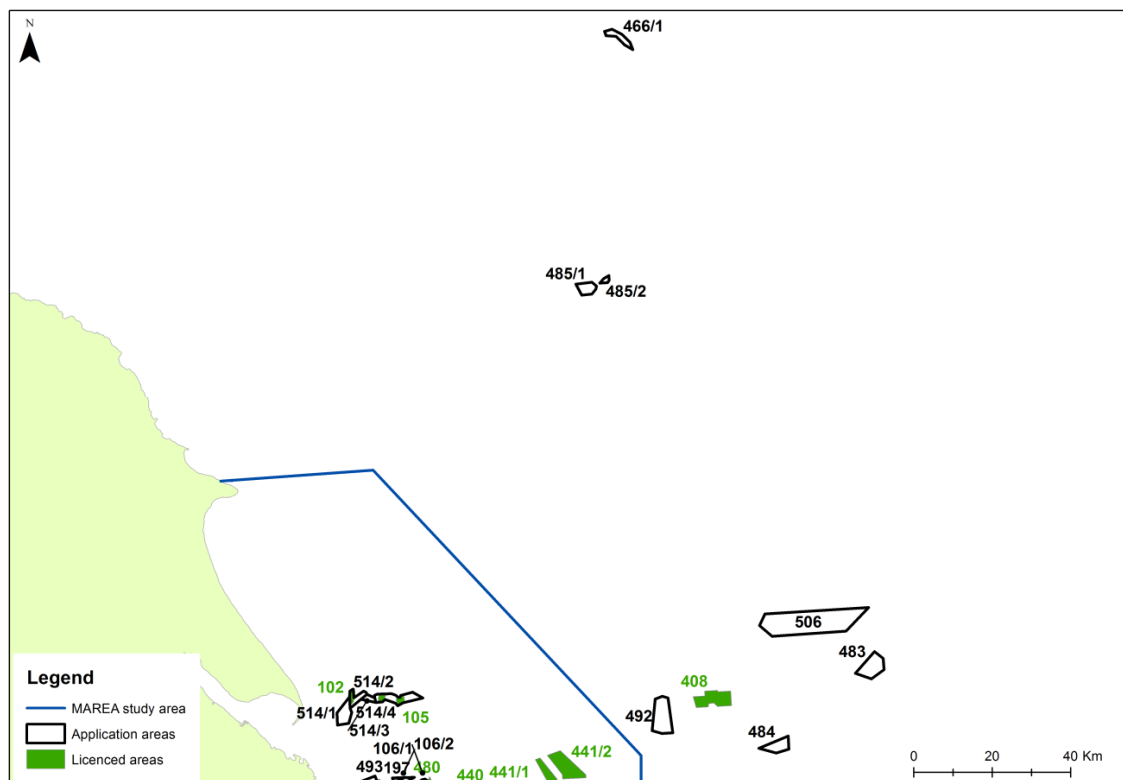


Figure 3.5: Humber Marine Aggregate Regional Environmental Assessment total combined data layer map.

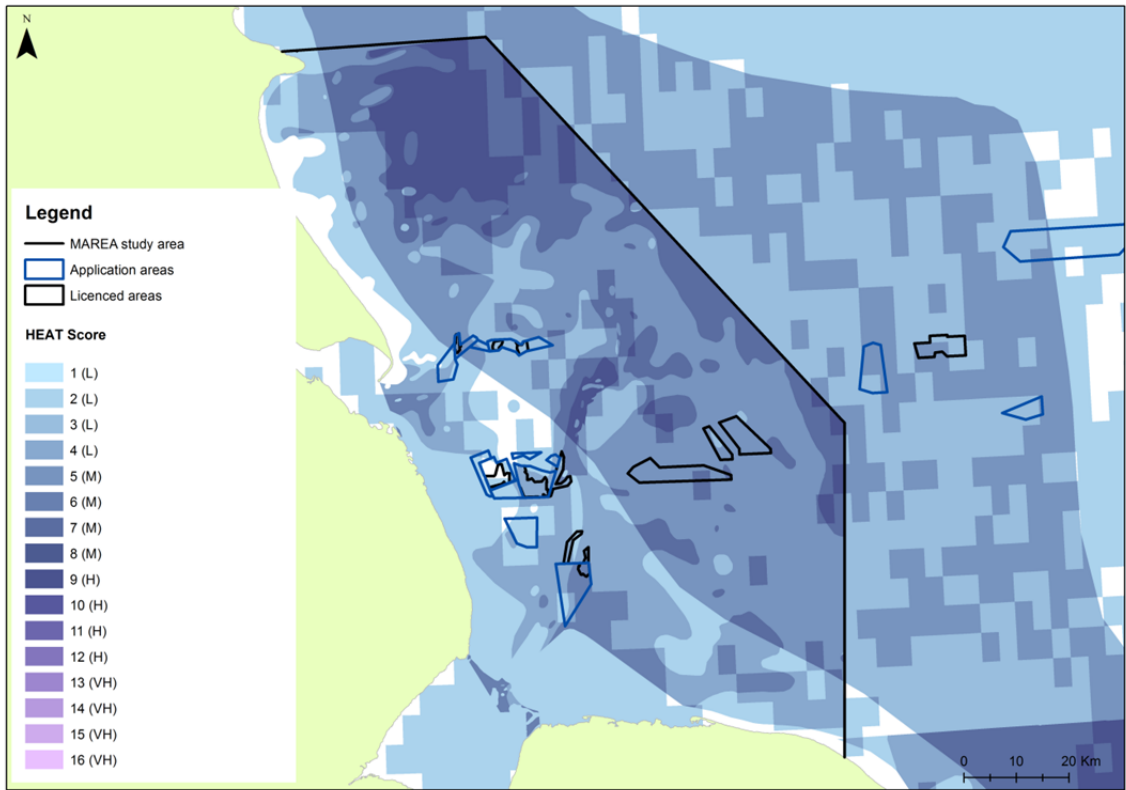


Figure 3.6: Humber region 'Outlier' Marine Aggregate Regional Environmental Assessment total combined data layer map.

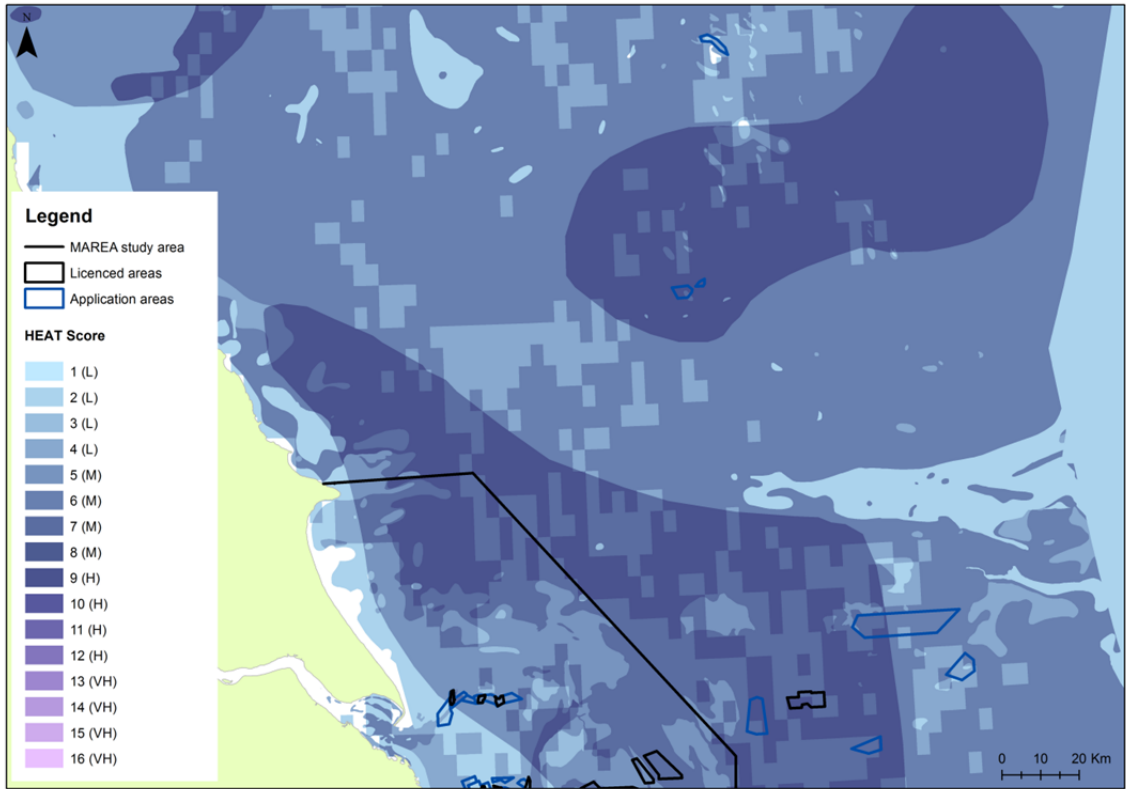


Table 3.1: Screening of Humber region renewal and application areas

Area (Status)	Licence Name (Operator)	Impact Zone	Habitat sediment Type		Coull <i>et al.</i> (1998)	ESFIC	VMS		In	Out
			Preferred	Marginal						
466/1 (Application)	North West Rough (CEMEX UK Marine Ltd)	PIZ	✓	✓			✓		In	
485/2 (Application)	Southernmost Rough (CEMEX UK Marine Ltd)	PIZ	✓	✓	✓		✓		In	
485/1 (Application)	Southernmost Rough (CEMEX UK Marine Ltd)	PIZ	✓		✓		✓		In	
506 (Application)	Humber 4 and 7 (DEME Building Materials Ltd)	PIZ	✓		✓		✓		In	
483 (Application)	Humber 5 (DEME Building Materials Ltd)	PIZ	✓	✓			✓		In	
514/3 (formerly 449) (Application)	New Sand Hole and Humber Extension (CEMEX UK Marine Ltd)	PIZ	✓	✓	✓				In	
514/1 (formerly 448) (Application)	New Sand Hole and Humber Extension (CEMEX UK Marine Ltd)	PIZ	✓	✓					In	
492 (Application)	Sole Pit (Hanson Aggregates Marine Ltd)	PIZ	✓		✓		✓		In	
484 (Application)	Humber 3 (DEME Building Materials Ltd)	PIZ	✓		✓		✓		In	
493 (Application)	Humber Overfalls (Lafarge Tarmac Marine Ltd)	PIZ	✓	✓			✓		In	
400 (Application)	North Dowsing (Hanson Aggregates Marine Ltd)	PIZ	✓	✓			✓		In	

439 (Application)	Inner Dowsing (Hanson Aggregates Marine Ltd)	PIZ	✓		✓	✓	In
514/2 (formerly 102) (Application)	Humber Estuary (CEMEX UK Marine Ltd)	PIZ		✓			In
106/1 (Application)	Humber Estuary (Hanson Aggregates Marine Ltd)	PIZ				✓	In
106/2 (Application)	Humber Estuary (Hanson Aggregates Marine Ltd)	PIZ		✓		✓	In
197 (Application)	Off Saltfleet (Lafarge Tarmac Marine Ltd)	PIZ		✓		✓	In
106/3 (Application)	Humber Estuary (Hanson Aggregates Marine Ltd)	PIZ		✓		✓	In
514/4 (formerly 105) (Application)	Humber Estuary (CEMEX UK Marine Ltd)	PIZ		✓	✓	✓	In
107 (Application)	South Inner Dowsing (CEMEX UK Marine Ltd)	PIZ	✓			✓	In

Table 3.2: Screening of Humber region licence areas

Area (Status)	Operator Name Licence	Impact Zone	Habitat sediment Type					In	Out
			Preferred	Marginal	Coull <i>et al.</i> (2008)	ESFIC	VMS		
102 (Licence)	West Humber (British Dredging Ltd)	PIZ	✓	✓	✓			In	
408 (Licence)	Coal Pit (Hanson Aggregates Marine Ltd)	PIZ	✓		✓		✓	In	

441/2 (Licence)	Outer Dowsing (Westminster Gravels Ltd)	PIZ	✓		✓		In
441/1 (Licence)	Outer Dowsing (Westminster Gravels Ltd)	PIZ	✓	✓	✓		In
480 (Licence)	106 East (Hanson Aggregates Marine Ltd)	PIZ	✓	✓		✓	In
197 (Licence)	Protector Overfalls (Lafarge Tarmac Marine Ltd)	PIZ		✓			In
440 (Licence)	Outer Dowsing (Westminster Gravels Ltd)	PIZ	✓	✓	✓		In
106/3 (Licence)	Wash (Hanson Aggregates Marine Ltd)	PIZ		✓		✓	In
481/1 (Licence)	Inner Dowsing (Van Oord Ltd)	PIZ	✓			✓	In
481/2 (Licence)	Inner Dowsing (Van Oord Ltd)	PIZ	✓				In
107 (Licence)	South Inner Dowsing (British Dredging Ltd)	PIZ	✓			✓	In
481/1 (Licence)	Inner Dowsing (Lafarge Tarmac Marine Ltd)	PIZ	✓			✓	In
481/2 (Licence)	Inner Dowsing (Lafarge Tarmac Marine Ltd)	PIZ	✓				In
105 (Licence)	East Humber (British Dredging Ltd)	PIZ		✓	✓		In

3.4.2. Anglian Region

Figure 3.7 illustrates the locations of the licence and application areas assessed for the Anglian region, while Figures 3.8 and 3.9 overlay these areas on the confidence 'heat' map for potential sandeel habitat. It is clear that the regions of highest confidence and probability (i.e. confidence

score of 9 and above) are those areas where seabed fisheries data are available, i.e. the ESFJC data layer and the Coull *et al.* (1998) data layer. This is most notable in the offshore eastern section of the region, and inshore off Great Yarmouth.

The Coull *et al.* (1998) layer has a degree of overlap with all but 4 inner-most licence and application areas; specifically Areas 251, 319, 496 and 511. The ESFJC layer, however, has no regions of overlap with the marine aggregate extraction areas as it is located further inshore of all Licence and Applications Areas.

Figures 3.8 and 3.9, and Tables 3.3 and 3.4 show that the majority of licence and application areas overlap medium to high confidence areas of seabed. The licences and applications to the south and east of the main Anglian block also overlap the VMS data layer increasing the confidence and probability of sandeel habitat in these areas.

All of the Licence and Application Areas within the Anglian MAREA region have a degree of overlap with an assessed data layer and therefore are all screened in for assessment at site-specific EIA level (Table 3.5, Table 3.6).

Figure 3.7: Licence and application areas within the Anglian region considered within the screening and assessment study. (Source: The Crown Estate, 2013)

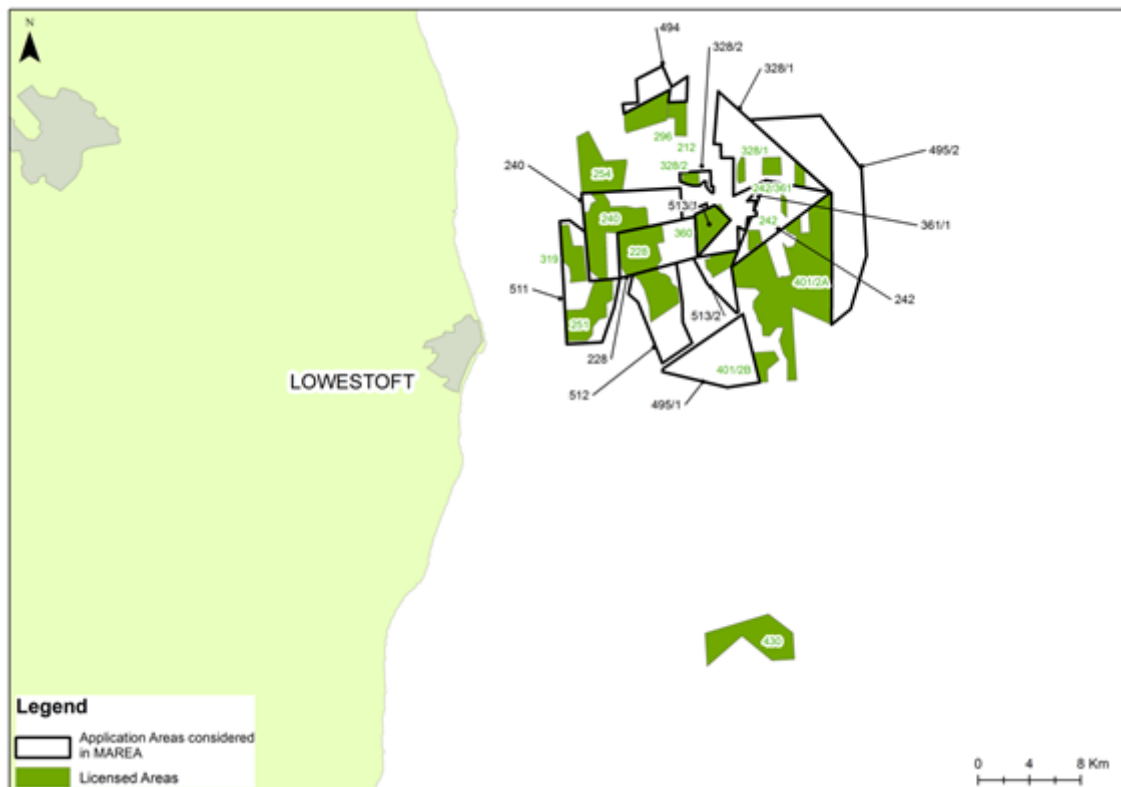


Figure 3.8: Anglian Marine Aggregate Regional Environmental Assessment total combined data layer map.



Figure 3.9: Zoomed in on the Anglian Marine Aggregate Regional Environmental Assessment total combined data layer map (note excludes Areas 430 and 496).



Table 3.3: Screening of Anglian region renewal and application areas.

Area (Status)	Licence Name (Operator)	Impact Zone	Habitat sediment Type		Coull <i>et al.</i> (1998)	ESFJC	VMS		In	Out
			Preferred	Marginal						
494 (Application)	North Cross Sands (Lafarge Tarmac Marine Ltd)	PIZ	✓		✓				In	
495/2 (Application)	Lowestoft Extension (Hanson Aggregates Marine Ltd)	PIZ	✓	✓	✓		✓		In	
495/1 (Application)	Lowestoft Extension (Hanson Aggregates Marine Ltd)	PIZ	✓	✓	✓		✓		In	
513/1 (Application)	TBC (CEMEX UK Marine Ltd)	PIZ	✓		✓		✓		In	
511 (Application)	TBC (CEMEX UK Marine Ltd)	PIZ	✓	✓			✓		In	
513/2 (Application)	TBC (CEMEX UK Marine Ltd)	PIZ	✓		✓		✓		In	
512 (Application)	TBC (CEMEX UK Marine Ltd)	PIZ	✓	✓	✓		✓		In	
328/1 (Application)	Off Great Yarmouth (Hanson Aggregates Marine Ltd)	PIZ	✓		✓		✓		In	
328/2 (Application)	Off Great Yarmouth (Hanson Aggregates Marine Ltd)	PIZ	✓		✓		✓		In	

361/1 (Application)	Cross Sands (Hanson Aggregates Marine Ltd)	PIZ	✓		✓			In	
242 (Application)	Cross Sands (Hanson Aggregates Marine Ltd)	PIZ	✓	✓	✓		✓	In	
240 (Application)	Off Great Yarmouth Extension (Hanson Aggregates Marine Ltd)	PIZ	✓	✓	✓			In	
328/3 (Application)	Off Great Yarmouth (Hanson Aggregates Marine Ltd)	PIZ	✓		✓		✓	In	
228 (Application)	Off Great Yarmouth (Volker Dredging Ltd)	PIZ	✓	✓	✓		✓	In	
361/2 (Application)	Cross Sands (Hanson Aggregates Marine Ltd)	PIZ	✓		✓			In	
361/3 (Application)	Cross Sands (Hanson Aggregates Marine Ltd)	PIZ	✓		✓			In	

Table 3.4: Screening of Anglian region licence areas.

Area (Status)	Licence Name (Operator)	Impact Zone	Habitat Sediment Type		Coull <i>et al.</i> (1998)	ESFJC	VMS		In	Out
			Preferred	Marginal						
296 (Licence)	Cross Sands (Lafarge Tarmac Marine Ltd)	PIZ	✓	✓	✓				In	
328/1 (Licence)	East Norfolk (Hanson Aggregates Marine Ltd)	PIZ	✓		✓		✓		In	
212 (Licence)	Norfolk (Hanson Aggregates Marine Ltd)	PIZ	✓	✓	✓				In	

254 (Licence)	Off Great Yarmouth (Lafarge Tarmac Marine Ltd)	PIZ	✓	✓	✓	✓		
328/2 (Licence)	East Norfolk (Hanson Aggregates Marine Ltd)	PIZ	✓		✓	✓		
360 (Licence)	East Lowestoft (CEMEX UK Marine Ltd)	PIZ	✓		✓	✓		
240 (Licence)	Cross Sands (Hanson Aggregates Marine Ltd)	PIZ	✓		✓			
319 (Licence)	North Lowestoft (British Dredging Ltd)	PIZ	✓	✓				
401/2A (Licence)	Yarmouth (Hanson Aggregates Marine Ltd)	PIZ	✓	✓	✓	✓		
228 (Licence)	Off Great Yarmouth (Volker Dredging Ltd)	PIZ	✓	✓	✓			
251 (Licence)	South Lowestoft (British Dredging Ltd)	PIZ	✓	✓		✓		
401/2B (Licence)	Yarmouth (Hanson Aggregates Marine Ltd)	PIZ	✓	✓	✓	✓		
430 (Licence)	Southwold East (CEMEX UK Marine Ltd)	PIZ	✓	✓	✓	✓		
430 (Licence)	Southwold East (Lafarge Tarmac Marine Ltd)	PIZ	✓	✓	✓	✓		
242 (Licence)	Lowestoft (Hanson Aggregates Marine Ltd)	PIZ	✓	✓	✓	✓		

242/361 (Licence)	Lowestoft (Hanson Aggregates Marine Ltd)	PIZ	✓	✓	In
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3.4.3. Outer Thames Estuary Region

Figure 3.10 illustrates the positions of the licence and application areas assessed for the Outer Thames region, while Figure 3.11 overlays these areas on the confidence ‘heat’ map for potential sandeel habitat. It is clear that the regions of highest confidence (i.e. confidence score 9-12 inclusive) are those areas of seabed where seabed fisheries data are available, i.e. the ESFJC data layer and the Coull *et al.* (1998) data layer. This is evident in along the eastern boundary of the Outer Thames MAREA region and approaching the mouth of the estuary itself.

Figure 3.11, and Tables 3.5 and 3.6 show that all of the licence and application areas within the Outer Thames MAREA region completely overlap against the VMS data. The Thames ‘outlier’ Applications also overlap with the VMS data layer, but not completely. The Coull *et al.* (1998) data layer excludes the northernmost application Areas but includes the southern Licences and the ‘outlier’ Application Areas. The ‘hottest’ area with the Thames MAREA region is strongly associated with the ESFJC data layer, which is overlapped by all of the other data layers; no aggregate extraction applications are associated with this region where the highest confidence and probability score of 12 is recorded.

Within the Outer Thames MAREA the PIZs for Areas 108/3, 447, 509/1, 501/2, 501/3, 510/1 and 510/2 overlie high confidence/probability areas of seabed. Both of the ‘outlier’ application areas 501/1 and 501/2 have a degree of overlap with high confidence/probability areas of seabed.

It was suggested by Cefas that the data collected during the fish ecology surveys undertaken by the London Array offshore Windfarm could prove useful when considering site specific EIA’s for the Outer Thames Region (Cefas, 2013b).

All areas within the Outer Thames Estuary region, including the ‘outlier’ application areas are screened in for assessment at site-specific EIA level (Table 3.5, Table 3.6).

Figure 3.10: Licence and application areas within the Outer Thames Estuary region considered within the screening and assessment study. (Source: The Crown Estate, 2013)

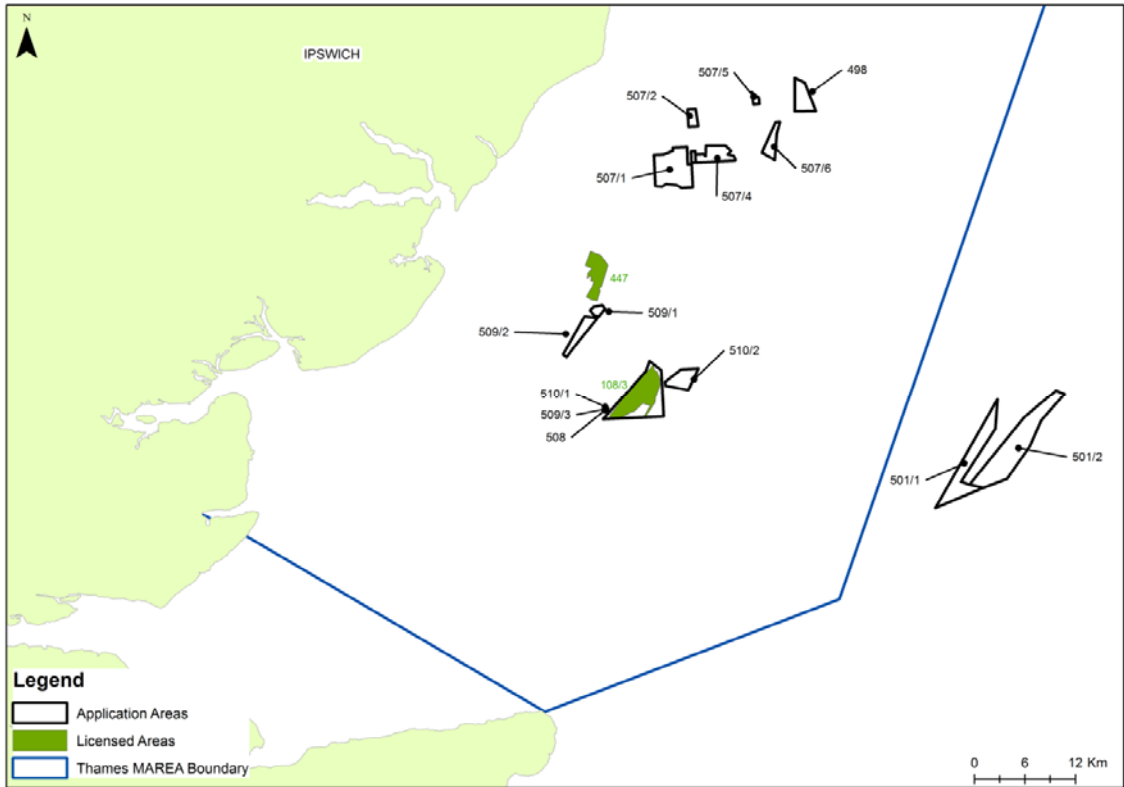


Figure 3.11: Outer Thames Estuary British Geological Survey total combined data layer map.

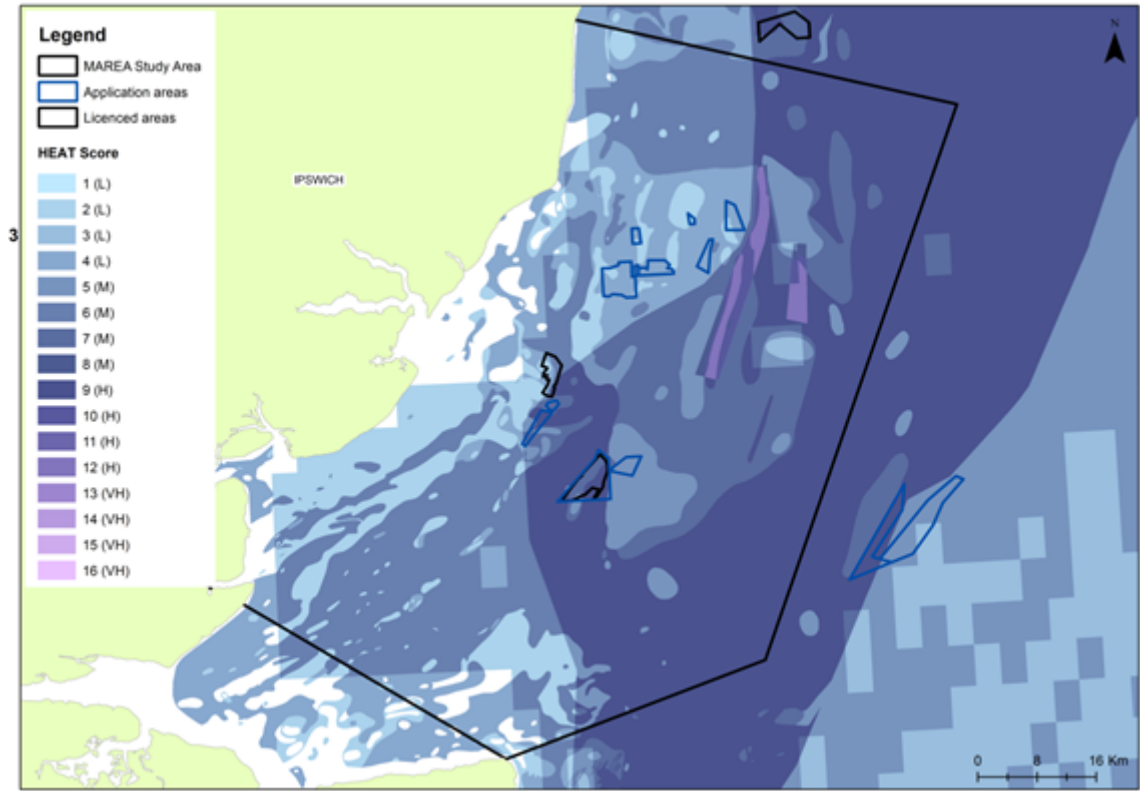


Table 3.5: Screening of Outer Thames Estuary region renewal and application areas.

Area (Status)	Licence Name (Operator)	Impact Zone	Habitat Sediment Type		Coull <i>et al.</i> (1998)	ESFJC	VMS		In	Out
			Preferred	Marginal						
507/5 (Application)	Shipwash (CEMEX UK Marine Ltd)	PIZ		✓			✓		In	
507/2 (Application)	Shipwash (CEMEX UK Marine Ltd)	PIZ		✓			✓		In	
507/4 (Application – Renewal)	Shipwash (CEMEX UK Marine Ltd)	PIZ		✓			✓		In	
507/1 (Application – Renewal)	Shipwash (CEMEX UK Marine Ltd)	PIZ		✓			✓		In	
507/3 (Application – Renewal)	Shipwash (CEMEX UK Marine Ltd)	PIZ		✓			✓		In	
508 (Application – Renewal)	Longsand (Britannia Aggregates Ltd)	PIZ	✓	✓	✓		✓		In	
509/1 (Application – Renewal)	Longsand (Lafarge Tarmac Marine Ltd)	PIZ		✓	✓		✓		In	
509/2 (Application – Renewal)	Longsand (Lafarge Tarmac Marine Ltd)	PIZ	✓	✓	✓		✓		In	
509/3 (Application – Renewal)	Longsand (Lafarge Tarmac Marine Ltd)	PIZ	✓	✓	✓		✓		In	
510/1 (Application – Renewal)	Longsand (CEMEX UK Marine Ltd)	PIZ	✓	✓	✓		✓		In	
510/2 (Application – Renewal)	Longsand (CEMEX UK Marine Ltd)	PIZ		✓	✓		✓		In	

507/6 (Application)	Shipwash (CEMEX UK Marine Ltd)	PIZ	✓	✓		✓	In
498 (Pre Application)	North Inner Gabbard (Britannia Aggregates Ltd)	PIZ		✓		✓	In
498 (Pre Application)	North Inner Gabbard (Volker Dredging Ltd)	PIZ		✓		✓	In

Table 3.6: Screening of Outer Thames Estuary region licence areas.

Area (Status)	Licence Name (Operator)	Impact Zone	Habitat Sediment Type		Coull <i>et al.</i> (1998)	ESFJC	VMS		In	Out
			Preferred	Marginal						
447 (Licence)	Cutline (Hanson Aggregates Marine Ltd)	PIZ	✓	✓	✓		✓		In	
108/3 (Licence)	Longsand (Britannia Aggregates Ltd)	PIZ	✓	✓	✓		✓		In	
447 (Licence)	Cutline (CEMEX UK Marine Ltd)	PIZ	✓	✓	✓		✓		In	
447 (Licence)	Cutline (Lafarge Tarmac Marine Ltd)	PIZ	✓	✓	✓		✓		In	

3.4.4. South Coast Region

Figure 3.12 illustrates the positions of the licence and application areas assessed for the South Coast region, while Figure 3.13 overlays these areas on the confidence ‘heat’ map for potential sandeel habitat. In the South Coast MAREA region there are no areas of high confidence (i.e. confidence score 9-12 inclusive) due to the lack of coverage by the ESFJC data layer (as the region is outside the jurisdiction of the Eastern IFCA and thus beyond the ESFJC data coverage). As a result the highest confidence score possible in the South coast MAREA region is medium and can only be achieved where VMS data overlaps with the preferable habitat sediments.

VMS coverage is complete along the eastern edge of the South Coast MAREA region, and overlaps all of the Licences and Application Areas in the Owers sub-region. Around the Isle of Wight the coverage becomes sporadic with only partial coverage of the east of Isle of Wight and west of Isle of Wight sub-regions. VMS coverage increase with southward distance offshore, with the PIZ of Licence Area 407 being completely overlapped.

Figure 3.13, and Tables 3.7 and 3.8 show that the majority of licences and applications in the South Coast MAREA region fall within the lower confidence level. Only 6 licence and application areas overlap with the medium confidence and probability areas, and these are all located within the Owers sub-region. Areas 122/1B, 123/B, 122/1G, 123/G and 453 partially overlap with areas of medium confidence whereas Areas 122/1E, 123/E, 122/1F, 123/F and 499 completely overlap the medium confidence areas.

Following the review of the consultation version 0.5 draft report Cefas indicated that the fish ecology survey undertaken for the Navitus Bay offshore Windfarm and the Cefas Eastern English Channel beam trawl survey would provide useful data sources

All areas within the South Coast region are screened in for assessment at site-specific EIA level (Table 3.7, Table 3.8).

Figure 3.12: Licence and application areas within the South Coast region considered within the screening and assessment study. (Source: The Crown Estate, 2013)

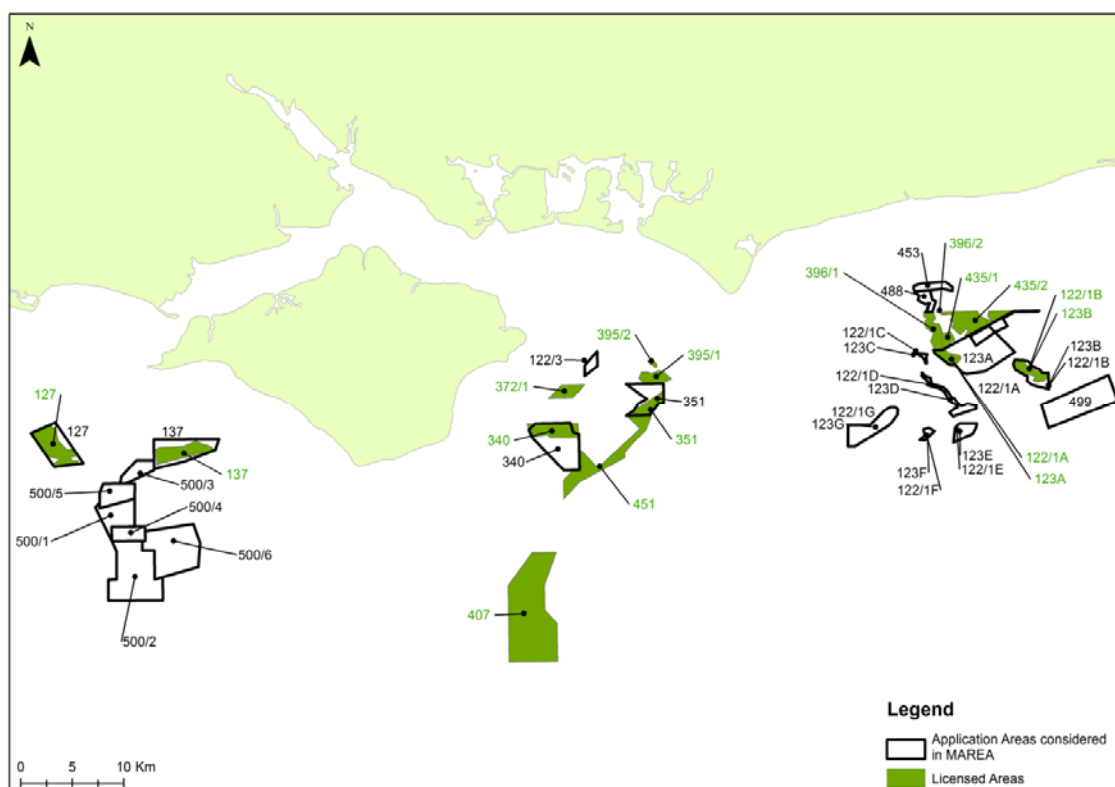


Figure 3.13: South Coast British Geological Survey total combined data layer map.

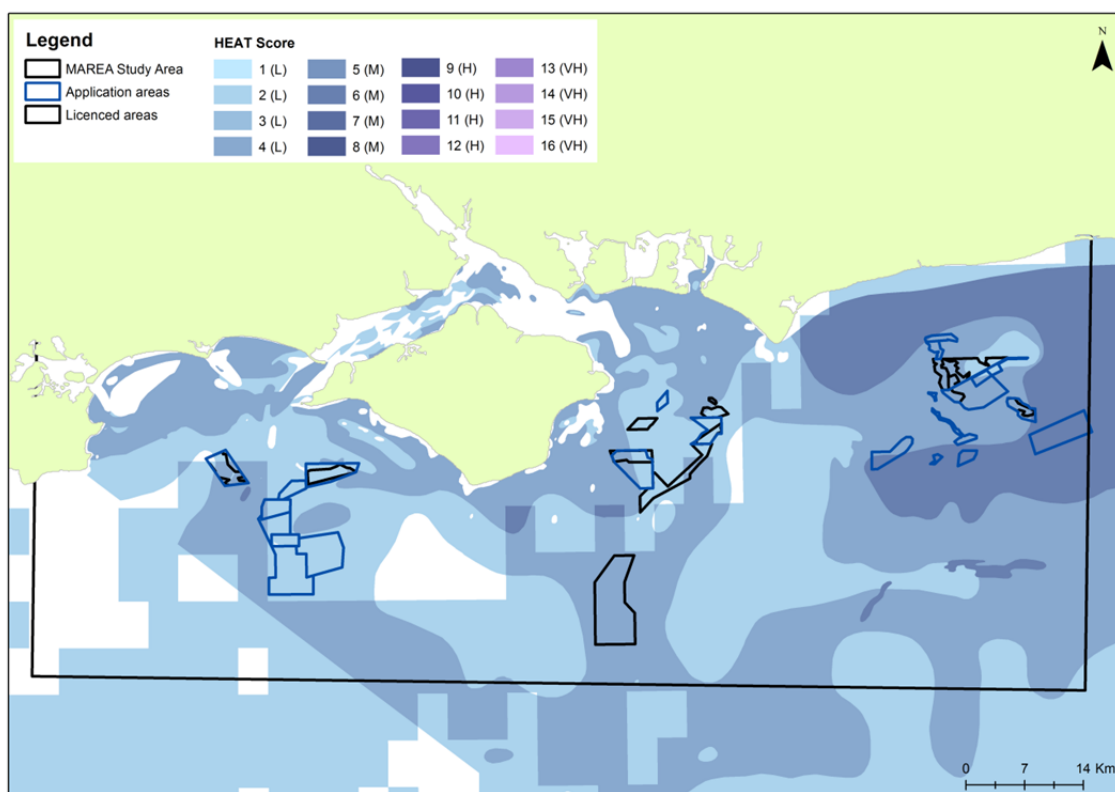


Table 3.7: Screening of South Coast region renewal and application areas.

Area (Status)	Licence Name (Operator)	Impact Zone	Habitat sediment Type		Coull <i>et al.</i> (1998)	ESFJC	VMS		In	Out
			Preferred	Marginal						
453 (Application)	Owers Extension (CEMEX UK Marine Ltd)	PIZ	✓	✓			✓		In	
453 (Application)	Inner Owers North (Lafarge Tarmac Marine Ltd)	PIZ	✓	✓			✓		In	
434 (500/3) (Application)	South of Needles Channel (Lafarge Tarmac Marine Ltd)	PIZ		✓			✓		In	

Environmental Effect Pathways Between Marine Aggregate Application Areas and Sandeel Habitat: Regional Cumulative Impact Assessments - Version 1.0

465/1 (500/5) (Application)	West Channel (Hanson Aggregates Marine Ltd)	PIZ	✓	✓	In
465/2 (500/6) (Application)	West Channel (Hanson Aggregates Marine Ltd)	PIZ	✓		In
437 (500/4) (Application)	South West Isle of Wight (Lafarge Tarmac Marine Ltd)	PIZ	✓		In
500/1 (Application)	South Wight (Hanson Aggregates Marine Ltd)	PIZ	✓	✓	In
500/2 (Application)	South Wight (Hanson Aggregates Marine Ltd)	PIZ	✓		In
500/1 (Application)	South Wight (Lafarge Tarmac Marine Ltd)	PIZ	✓	✓	In
500/2 (Application)	South Wight (Lafarge Tarmac Marine Ltd)	PIZ	✓		In
340 (Application - Renewal)	South East Isle of Wight (CEMEX UK Marine Ltd)	PIZ	✓	✓	In
340 (Application - Renewal)	South East Isle of Wight (Volker Dredging Ltd)	PIZ	✓	✓	In
137 (Application – Renewal)	Needles Isle of Wight (CEMEX UK Marine Ltd)	PIZ	✓	✓	In
407 (Application – Renewal)	St Catherine’s (CEMEX UK Marine Ltd)	PIZ	✓	✓	In

499 (Pre-Application)	Outer Owers (Hanson Aggregates Marine Ltd)	PIZ	✓		✓	In
351 (Application – Renewal)	South East Isle of Wight (Northwood (Fareham) Ltd)	PIZ	✓	✓		In
351 (Application – Renewal)	South East Isle of Wight (Volker Dredging Ltd)	PIZ	✓	✓		In
451 (Application – Renewal)	St Catherine’s (Westminster Gravels Ltd)	PIZ	✓	✓	✓	In
122/1A (Application – Renewal)	Owers Bank (Lafarge Tarmac Marine Ltd)	PIZ		✓	✓	In
122/1C (Application – Renewal)	Owers Bank (Lafarge Tarmac Marine Ltd)	PIZ		✓	✓	In
122/1B (Application – Renewal)	Owers Bank (Lafarge Tarmac Marine Ltd)	PIZ	✓	✓	✓	In
122/1D (Application – Renewal)	Owers Bank (Lafarge Tarmac Marine Ltd)	PIZ		✓	✓	In
122/1G (Application – Renewal)	Owers Bank (Lafarge Tarmac Marine Ltd)	PIZ	✓	✓	✓	In
122/1E (Application – Renewal)	Owers Bank (Lafarge Tarmac Marine Ltd)	PIZ	✓		✓	In
122/1F (Application – Renewal)	Owers Bank (Lafarge Tarmac Marine Ltd)	PIZ	✓		✓	In
123G (Application – Renewal)	Owers Bank (CEMEX UK Marine Ltd)	PIZ	✓	✓	✓	In
123F (Application – Renewal)	Owers Bank (CEMEX UK Marine Ltd)	PIZ	✓		✓	In

Environmental Effect Pathways Between Marine Aggregate Application Areas and Sandeel Habitat: Regional Cumulative Impact Assessments - Version 1.0

123E (Application – Renewal)	Owers Bank (CEMEX UK Marine Ltd)	PIZ	✓		✓	In	
123D (Application – Renewal)	Owers Bank (CEMEX UK Marine Ltd)	PIZ		✓	✓	In	
123C (Application – Renewal)	Owers Bank (CEMEX UK Marine Ltd)	PIZ		✓	✓	In	
123A (Application – Renewal)	Owers Bank (CEMEX UK Marine Ltd)	PIZ		✓	✓	In	
123B (Application – Renewal)	Owers Bank (CEMEX UK Marine Ltd)	PIZ	✓	✓	✓	In	
122/3 (Application – Renewal)	East Isle of Wight / North Nab (Lafarge Tarmac Marine Ltd)	PIZ		✓		In	
127 (Application – Renewal)	South West Isle of Wight (Hanson Aggregates Marine Ltd)	PIZ		✓	✓	In	
127 (Application – Renewal)	South West Isle of Wight (Lafarge Tarmac Marine Ltd)	PIZ		✓	✓	In	

Table 3.8: Screening of South Coast region licence areas.

Area (Status)	Licence Name (Operator)	Impact Zone	Habitat Sediment Type		Coull <i>et al.</i> (1998)	ESFJC	VMS		In	Out
			Preferred	Marginal						
435/2 (Licence)	Inner Owers (CEMEX UK Marine Ltd)	PIZ		✓			✓		In	
396/1 (Licence)	Inner Owers (Lafarge Tarmac Marine Ltd)	PIZ		✓			✓		In	
396/2 (Licence)	Inner Owers (Lafarge Tarmac Marine Ltd)	PIZ		✓			✓		In	
122/1A (Licence)	Owers Bank (Lafarge Tarmac Marine Ltd)	PIZ		✓			✓		In	
435/1 (Licence)	Inner Owers (Hanson Aggregates Marine Ltd)	PIZ		✓			✓		In	
395/2 (Licence)	Off Selsey Bill (Kendall Bros (Portsmouth) Ltd)	PIZ	✓						In	
122/1B (Licence)	Owers Bank (Lafarge Tarmac Marine Ltd)	PIZ	✓	✓			✓		In	
395/1 (Licence)	Off Selsey Bill (Kendall Bros (Portsmouth) Ltd)	PIZ	✓	✓					In	
351 (Licence)	South East Isle of Wight (Volker Dredging Ltd)	PIZ		✓					In	
372/1 (Licence)	North Nab (Hanson Aggregates Marine Ltd)	PIZ		✓					In	
451/2 (Licence)	St Catherine's (Westminster Gravels Ltd)	PIZ		✓			✓		In	

Environmental Effect Pathways Between Marine Aggregate Application Areas and Sandeel Habitat: Regional Cumulative Impact Assessments - Version 1.0

127 (Licence)	South West Needles (Hanson Aggregates Marine Ltd)	PIZ		✓	✓	In
340 (Licence)	Nab (CEMEX UK Marine Ltd)	PIZ	✓	✓		In
137 (Licence)	Area A (CEMEX UK Marine Ltd)	PIZ	✓	✓		In
451/1 (Licence)	St Catherine's (Westminster Gravels Ltd)	PIZ	✓	✓	✓	In
127 (Licence)	South West Needles (Lafarge Tarmac Marine Ltd)	PIZ		✓	✓	In
351 (Licence)	South East Isle of Wight (Northwood (Fareham) Ltd)	PIZ		✓		In
395/1 (Licence)	Off Selsey Bill (Lafarge Tarmac Marine Ltd)	PIZ	✓	✓		In
395/2 (Licence)	Off Selsey Bill (Lafarge Tarmac Marine Ltd)	PIZ	✓			In
123A (Licence)	Owers Bank (CEMEX UK Marine Ltd)	PIZ		✓	✓	In
123B (Licence)	Owers Bank (CEMEX UK Marine Ltd)	PIZ	✓	✓	✓	In
340 (Licence)	Nab (Volker Dredging Ltd)	PIZ	✓	✓		In

4. Stage 2 Results – Regional Cumulative Impact Assessment

Stage 2 of the process involves the production of a CIA for each of the MAREA regions, using the MAREA regional boundaries and the respective MAREA impact assessment protocols and methodologies (EMU Ltd, 2012a, 2012b; ERM Ltd, 2010, 2012; Appendices H-K). All the existing licence areas and application areas that have been screened in at the end of Stage 1 contribute to the cumulative effect footprint. Further there may be in-combination effects with other seabed user sectors with the same environmental effect exposure pathways and footprints.

Stage 2 maps the effect footprints of all known and foreseeable activities (plans or projects) and assesses the levels of spatial interaction with potential sandeel habitat. In establishing these footprints a worst case approach has been followed resulting in, what the EIA WG believes to be, the maximum footprints of interaction. The rationale for this process allows the regional CIAs to act as supporting reports to each of the MAREAs; regarding the characterisation of sandeel potential habitat and subsequent impact assessment.

The following sub-sections provide a summary of the conclusions of the CIAs for each region, with the full reports appended as Appendices H-K.

In order to assess the cumulative impacts of marine aggregate extraction on sandeel habitat it is only necessary to consider the impacts within the PIZ, (i.e. direct impacts) as indirect impacts within the SIZ are inconsequential to sandeels (Latto *et al.*, 2013). Dredging effects within the PIZ will potentially have a detrimental impact on sandeel through the direct removal and/or alteration of suitable habitat. The ability of the seabed within the PIZ to recover will also be considered.

4.1. Humber Region

This section summarises the results of a CIA for the Humber MAREA region, and which is presented in full as Appendix H. The aggregate licence, application and option areas (worst case PIZ) within the Humber MAREA region cumulatively overlap with 0.0 km² of very high 'heat' class, 0.0 km² of high 'heat' class, 147.1 km² of medium 'heat' class, and 278.7 km² of low 'heat' class. When these areas are then considered against the spatial extent of other anthropogenic pressures in the region the analysis shows that 106.5 km² of medium 'heat' class and 85.1 km² of low 'heat' class and is subjected only to pressure from dredging activity. Within the MAREA boundary there is 744.8 km² of high 'heat' class, 4555.7 km² of medium 'heat' class, and 3292.4 km² of low 'heat' class. Therefore none of the high 'heat' class is solely impacted by dredging activity; while 2.3% of the medium 'heat' class and 2.5% of the low 'heat' class within the Humber MAREA boundary are solely impacted by dredging activity.

The direct removal of suitable sediment is likely to affect sandeel habitat at the site-specific scale. Whilst this impact has the potential to be high in magnitude, the large extent of suitable habitat sediments in the Humber Region means that small-scale removal of suitable sediments (likely to occur in the ADZ of each licence area) is unlikely to have a large effect on wider sandeel habitat availability. Sediments are not likely to be completely removed during dredging, thus the duration of effect is short-term. Frequency is occasional, given the size of the combined ADZ footprint, and the likely return time of dredgers. The overall magnitude of the effects of direct removal of sediment on

sandeel habitat is considered **low** at the regional scale. Sandeel habitat is likely to be sensitive to the direct removal of sediment, however this assessment considers the overall tolerance is medium. Sandeel habitat has a medium adaptability to aggregate extraction, and any fining of habitat is unlikely to negatively affect sandeel habitat (given the preference for fine sediments). Recoverability of the receptor is assessed to be high given the regional habitat available and the low likelihood of negative impacts. The overall sensitivity of sandeel habitat to the direct removal of sediment is considered to be **medium**. **The cumulative impact of direct sediment removal on sandeel habitat is considered to be of minor significance in the regional context.**

Alteration of habitat structure within the regional PIZ footprint is likely to be site-specific and short-term, with effects only occurring in the active dredging areas of each PIZ, and lasting for no more than 1 year following the cessation of dredging. The frequency of this effect is assessed as rare, and the overall magnitude of effects arising from the alteration of habitat structure on sandeel habitat is considered **low**. Tolerance to alteration of habitat structure is classified as medium, and adaptability as high, especially given the large extent of suitable habitat in the region and the small relative area shown to be potentially impacted by aggregate extraction on a regional scale. Recoverability is assessed to be medium, based on the fact that dredge operators are required to leave the post-dredging seabed in a similar condition to its pre-dredging state, and the low likelihood of significant negative impacts. Sensitivity of sandeel habitat to the alteration of habitat structure is considered to be **medium** overall. **The cumulative impact of the alteration of habitat structure on potential sandeel habitat is considered to be of minor significance in the regional context.**

In addition to dredging, there are several other seabed user activities that have the potential to interact with sandeel potential habitat in the Humber MAREA region; these activities are:

- Offshore renewable arrays (including potential cable corridors);
- Trawl fisheries;
- Dredge fisheries;
- Oil and gas pipelines;
- Power cables and telecommunications; and
- Dredge disposal sites.

The potential impacts associated with seabed infrastructure such as offshore renewable arrays, oil and gas pipelines and telecommunications cables are loss of habitat as a result of seabed disturbance during installation. Trawl and dredge fisheries actively target the seabed and may result in the disturbance to suitable habitat and temporary loss of habitat during fishing.

Table 4.1 quantifies the interaction between the other seabed user activities and potential habitat across the Humber MAREA region, noting the total footprint figures represent seabed user interaction with potential habitat, albeit each sector interacting to a varying degree via different impact pathways. The results show that 676.3 km² of high 'heat' class, 1,658.1 km² of medium 'heat' class and 1,837.2 km² of low 'heat' class are within the footprint of all seabed user activity. This constitutes 87.3%, 36.4%, and 55.8% respectively of the total available sandeel high, medium and low 'heat' classes in the Humber MAREA region. The total value indicates that there is a degree of overlap between seabed users, with some areas of seabed receiving impacts from more than a single

sector i.e. the mobile activities such as dredge or trawl fishing overlap, to some degree, with the footprints of static activities.

Table 4.1 also shows that areas where dredging activity alone interacts with sandeel 'heat' class (i.e. where there is no overlap with any other activity). Dredging, alone, overlaps with 106.5 km² of medium 'heat' class and 85.1 km² of low 'heat' class (Table 4.1). This accounts for 2.3% of the medium 'heat' class and 2.5% of low 'heat' class within the Humber MAREA boundary, respectively. When considering these areas it should be noted that, in some cases, mobile fishing activity actively avoids dredging areas – and when dredging ceases it is likely that these areas will be targeted by fishing activity. It should also be noted that Table 4.1 presents a spatial analysis of the data only. No inferences on the respective significance of user activities are made.

Table 4.1: Footprint of Seabed User Activity on Potential Sandeel 'Heat' Class in the Humber MAREA Region.

Seabed User Activity	Overlap with high 'heat' class (km ²)	% of total available high 'heat' class	Overlap with medium 'heat' class (km ²)	% of total available medium 'heat' class	Overlap with low 'heat' class (km ²)	% of total available low 'heat' class
Operating Windfarm Turbine Footprint	0	0	0.15	0.003	0.29	0.008
Operating Windfarm Licence Areas	0	0	31.06	0.68	20.60	0.63
Under Construction Windfarm Areas	0	0	0	0	38.31	1.16
Proposed Windfarms Indic. Turbine Footprint	0.30	0.04	1.45	0.030	0.32	0.009
Windfarm Licence Areas Proposed	137.40	17.73	605.39	13.29	139.275	4.23
Trawl Fishery	509.72	65.78	782.66	17.18	1533.98	46.59
Dredge Fishery	386.13	49.83	358.01	7.86	56.41	1.71
Pipelines*	0.058	0.0075	0.342	0.0075	0.131	0.0040
Power Cables*	0.0007	0.0001	0.0103	0.0002	0.0149	0.0005
Telecommunications*	0	0	0.0003	6.5x10 ⁻⁶	0.0008	2.4x10 ⁻⁵
Worst Case Proposed Power Cables*	0.032	0.0041	0.069	0.0015	0.042	0.0013
Dredge Fines Disposal Sites	0.04	0.0052	17.79	0.39	105.65	3.21
Dredging Activity (PIZ)	0	0	147.08	3.23	278.74	8.47
TOTAL	676.3	87.28	1658.1	36.40	1837.2	55.80
Dredging Activity (PIZ) ONLY[†]	0	0	106.50	2.34	85.11	2.59

* Assumes that entirety of cable or pipeline is surface laid and not buried, and this therefore over represents footprint for these activities. † The area of seabed which has a footprint associated with dredging alone i.e. no overlap with any other activity

4.2. Anglian Region

This section summarises the results of a CIA for the Anglian MAREA region, and which is presented in full as Appendix I. The aggregate licence, application and option areas (worst case PIZ) within the Anglian MAREA region cumulatively overlap with 0.0 km² of very high 'heat' class, 220.5 km² of high 'heat' class, 192.8 km² of medium 'heat' class, and 79.0 km² of low 'heat' class. When these areas are then considered against the spatial extent of other anthropogenic pressures in the region the analysis shows that 90.5 km² of high 'heat' class, 120.3 km² of medium 'heat' class and 47.9 km² of low 'heat' class and is subjected only to pressure from dredging activity. Within the MAREA boundary there is 2,019 km² of high 'heat' class, 1,687 km² of medium 'heat' class, and 975 km² of low 'heat' class. Therefore 4.5% of the high 'heat' class, 7.1% of the medium 'heat' class and 4.9% of the low 'heat' class within the Anglian MAREA boundary are solely impacted by dredging activity.

Within the PIZs, seabed removal could potentially lead to a change in seabed habitat (structure), whereby the dredging exposes finer or coarser layers of sediment. Bathymetric changes could also occur due to seabed removal, which could lead to flow alteration and sediment disturbance. Sandeel display a degree of site fidelity, therefore it is important to consider the state of seabed habitats at the end of the licence term, and whether or not the PIZs have the potential to be re-colonised. The aggregates dredging industry is committed to a mitigation measure whereby the seabed post-dredging is to be returned to / left in a similar physical condition to that present before dredging. Sediments are furthermore not dredged completely but a layer of resource sediment; on average at least 0.5 m deep is left after cessation of dredging. These mitigation measures facilitate the recovery of the area following dredging and ensure that habitat sediments preferred by sandeel remains largely unchanged in extent. It is expected that, provided the sediment composition has not changed significantly, sandeel would rapidly re-colonise an area which has recently been dredged.

The direct removal of sediment suitable for sandeel in the PIZs of the Anglian MAREA region could affect up to 26% of the theoretically suitable seabed in the region (preferred and marginal habitat sediments combined). Without mitigation, the magnitude of this in a regional context would be high. However, due to the mitigation described, as well as the limited (15 year) duration of the aggregate licences, it is considered highly unlikely that large-scale habitat change would occur; however, small-scale patchy habitat change cannot be discounted. Consequently, magnitude is at worst assessed as **low** for this pathway. This is due to the small extent, medium-term duration and rare frequency anticipated for an event which would actually lead to habitat change due to seabed removal. It is assessed that sandeel have a medium tolerance, medium adaptability and high recoverability to the effects, and consequently a **medium** sensitivity to such change. **Taking into account the magnitude and sensitivity, the cumulative effect on sandeel of direct seabed removal within the Anglian MAREA region is assessed as Minor Significance.**

The direct contact of the draghead with the seabed could also lead to the physical alteration of the structure of the sediments that sandeel inhabit. However, it is not thought that areas affected by such changes would become immediately unsuitable. It is considered that radical changes to the habitat structure could be long-term in duration, but only occasional in frequency, and that the

extent would likely amount to a small percentage of the available habitat across the region. Consequently, magnitude is assessed as **medium** for this pathway. It is considered that sandeel have a medium tolerance, high adaptability and high recoverability to the predicted effects, and sensitivity is thus considered to be **low**. **Taking into account the magnitude and sensitivity, the cumulative effect on sandeel of alteration of sediments within the Anglian MAREA region is assessed as Minor Significance.**

In addition to dredging, there are several other seabed user activities that have the potential to interact with sandeel potential habitat in the Anglian MAREA region; these activities are:

- Offshore renewable arrays;
- Trawl fisheries;
- Dredge fisheries;
- Oil and gas pipelines;
- Power and telecommunication cables; and
- Dredge disposal sites.

The potential impacts associated with seabed infrastructure such as offshore renewable arrays, oil and gas pipelines and telecommunications cables are loss of habitat and habitat disturbance as a result of installation. Trawl and dredge fisheries actively target the seabed and may result in the disturbance to suitable habitat and loss of habitat during fishing.

Table 4.2 quantifies the interaction between the other seabed user activities and potential habitat across the Anglian MAREA region, noting the total footprint figures represent seabed user interaction with potential habitat, albeit each sector interacting to a varying degree via different impact pathways. The results show that 1,808.7 km² of high 'heat' class, 874.1 km² of medium 'heat' class and 478.8 km² of low 'heat' class are within the footprint of all seabed user activity. This constitutes 89.6%, 51.8%, and 49.1% respectively of the total available sandeel high, medium and low 'heat' classes in the Anglian MAREA region. The total value indicates that there is a degree of overlap between seabed users, with some areas of seabed receiving impacts from more than a single sector i.e. the mobile activities such as dredge or trawl fishing overlap, to some degree, with the footprints of static activities.

Table 4.2 also shows that areas where dredging activity alone interacts with sandeel 'heat' class (i.e. where there is no overlap with any other activity). Dredging, alone, overlaps with 90.5 km² of high 'heat' class, 120.3 km² of medium 'heat' class and 47.9 km² of low 'heat' class (Table 4.2). This accounts for 4.5% of the high 'heat' class, 7.1% of the medium 'heat' class and 4.9% of the low 'heat' class within the Humber MAREA boundary, respectively. When considering these areas it should be noted that, in some cases, mobile fishing activity actively avoids dredging areas – and when dredging ceases it is likely that these areas will be targeted by fishing activity. It should also be noted that Table 4.2 presents a spatial analysis of the data only. No inferences on the respective significance of user activities are made.

Table 4.2: Footprint of Seabed User Activity on Potential Sandeel ‘Heat’ Class in the Anglian MAREA Region.

Seabed User Activity	Overlap with high ‘heat’ class (km ²)	% of total available high ‘heat’ class	Overlap with medium ‘heat’ class (km ²)	% of total available medium ‘heat’ class	Overlap with low ‘heat’ class (km ²)	% of total available low ‘heat’ class
Operating Windfarm Turbine Footprint	0	0	0.06	0.003	0.002	0.0002
Operating Windfarm Licence Areas	0.66	0.03	7.88	0.47	0.25	0.03
Under Construction Windfarm Areas	0	0	0	0	0	0
Proposed Windfarms Indic. Turbine Footprint	3.32	0.16	0.47	0.03	0.08	0.008
Windfarm Licence Areas Proposed	1403.35	69.52	194.43	11.52	33.90	3.48
Trawl Fishery	1173.40	58.13	660.04	39.12	427.45	43.82
Dredge Fishery	0	0	0	0	0	0
Pipelines*	0.0604	0.0030	0.0765	0.0045	0.0701	0.0072
Power Cables*	0	0	0.0031	0.0002	0.0032	0.0003
Telecommunications*	0.0137	0.0007	0.0095	0.0006	0.0047	0.0005
Worst Case Proposed Power Cables*	0.0170	0.0008	0.0117	0.0007	0.0067	0.0007
Dredge Fines Disposal Sites	335.94	16.64	15.47	0.92	2.56	0.26
Dredging Activity (PIZ)	220.54	10.92	192.84	11.43	79.01	8.10
TOTAL	1808.7	89.60	874.1	51.80	478.8	49.08
Dredging Activity (PIZ) ONLY[†]	90.51	4.48	120.30	7.13	47.91	4.91

* Assumes that entirety of cable or pipeline is surface laid and not buried, and this therefore over represents footprint for these activities. † The area of seabed which has a footprint associated with dredging alone i.e. no overlap with any other activity.

4.3. Outer Thames Estuary Region

This section summarises the results of a CIA for the Outer Thames Estuary MAREA region, and which is presented in full as Appendix J. The aggregate licence, application and option areas (worst case PIZ) within the Outer Thames MAREA region cumulatively overlap with 0.0 km² of very high ‘heat’ class, 24.7 km² of high ‘heat’ class, 58.7 km² of medium ‘heat’ class, and 91.9 km² of low ‘heat’ class. When these areas are then considered against the spatial extent of other anthropogenic pressures in the region the analysis shows that none of the high ‘heat’ class; 3.9 km² of the medium ‘heat’ class

and 10.2 km² of the low 'heat' class is subjected only to pressure from dredging activity. Within the MAREA boundary there is 1,673 km² of high 'heat' class, 2,125 km² of medium 'heat' class, and 1,389 km² of low 'heat' class. Therefore none of the high 'heat' class, 0.2% of the medium 'heat' class and 0.7% of the low 'heat' class within the Outer Thames MAREA boundary are solely impacted by dredging activity.

The direct removal of suitable sediment and habitat alteration by dredging is considered to be site-specific in extent because it only occurs within the PIZ, is short-term in duration, and intermittent in frequency. Without mitigation the complete removal of suitable sediments within the cumulative PIZ footprint within the Outer Thames would be considered a high magnitude effect. However, the marine aggregate industry is required to leave a layer of sediment at the cessation of dredging similar to that which existed before dredging commenced; therefore, habitat removal is assessed as being of **low-medium** magnitude. Sandeel in the Outer Thames MAREA region are assessed as having a medium tolerance and adaptability to the removal of the available suitable spawning sediment and a high recoverability. This is due to the portion of the favourable sediments in the PIZ being unavailable during dredging, and the wide availability of other areas of preferred and marginal habitat sediments elsewhere within the MAREA region. Taking into account the tolerance, adaptability and recoverability the overall sensitivity of sandeel to removal of favourable sediment and habitat alteration is assessed as **medium**. **The cumulative impact of direct removal and alteration of suitable sandeel habitat within the Outer Thames MAREA region is assessed as of minor significance at most and possibly not significant.**

In addition to dredging, there are several other seabed user activities that have the potential to interact with sandeel potential habitat in the Outer Thames Estuary; these activities are:

- Offshore renewable arrays;
- Trawl fisheries;
- Dredge fisheries;
- Oil and gas pipelines;
- Power and telecommunication cables; and
- Dredge disposal sites.

The potential impacts associated with seabed infrastructure such as offshore renewable arrays, oil and gas pipelines and telecommunications cables are loss of habitat as a result of seabed disturbance during installation. Trawl and dredge fisheries actively target the seabed and may result in the disturbance to suitable habitat and temporary loss of habitat during fishing.

Table 4.3 quantifies the interaction between the other seabed user activities and potential habitat across the Outer Thames MAREA region, noting the total footprint figures represent seabed user interaction with potential habitat, albeit each sector interacting to a varying degree via different impact pathways. The results show that 1,340.2 km² of high 'heat' class, 1,947.9 km² of medium 'heat' class and 995.7 km² of low 'heat' class are within the footprint of all seabed user activity. This constitutes 80.1%, 91.7%, and 71.7% respectively of the total available sandeel high, medium and low 'heat' classes in the Outer Thames MAREA region. The total value indicates that there is a degree of overlap between seabed users, with some areas of seabed receiving impacts from more

than a single sector i.e. the mobile activities such as dredge or trawl fishing overlap, to some degree, with the footprints of static activities.

Table 4.3: Footprint of Seabed User Activity on Potential Sandeel ‘Heat’ Class in the Outer Thames MAREA Region.

Seabed User Activity	Overlap with high ‘heat’ class (km ²)	% of total available high ‘heat’ class	Overlap with medium ‘heat’ class (km ²)	% of total available medium ‘heat’ class	Overlap with low ‘heat’ class (km ²)	% of total available low ‘heat’ class
Operating Windfarm Turbine Footprint	0.28	0.02	0.43	0.02	0.09	0.006
Operating Windfarm Licence Areas	10.05	0.60	13.54	0.64	8.59	0.62
Under Construction Windfarm Areas	115.26	6.89	138.29	6.51	15.08	1.09
Proposed Windfarms Indic. Turbine Footprint	0.96	0.06	0.34	0.02	0	0
Windfarm Licence Areas Proposed	418.76	25.04	138.79	6.53	1.64	0.12
Trawl Fishery	1212.18	72.48	1812.49	85.31	953.87	68.66
Dredge Fishery	0	0	0	0	0	0
Pipelines*	0	0	0	0	0.0027	0.0002
Power Cables*	0.0144	0.0009	0.0150	0.0007	0.0196	0.0014
Telecommunications*	0.0076	0.0005	0.0070	0.0003	0.0025	0.0002
Worst Case Proposed Power Cables*	0.0066	0.0004	0.0131	0.0006	0.0146	0.0011
Dredge Fines Disposal Sites	235.89	14.10	329.07	15.49	197.49	14.21
Dredging Activity (PIZ)	24.71	0.01	58.71	2.76	91.88	6.61
TOTAL	1340.2	80.13	1947.9	91.68	995.7	71.67
Dredging Activity (PIZ) ONLY[†]	0	0	3.9	0.18	10.2	0.73

* Assumes that entirety of cable or pipeline is surface laid and not buried, and this therefore over represents footprint for these activities. † The area of seabed which has a footprint associated with dredging alone i.e. no overlap with any other activity

Table 4.3 also shows that areas where dredging activity alone interacts with sandeel ‘heat’ class (i.e. where there is no overlap with any other activity). Dredging, alone, overlaps with none of the high ‘heat’ class, 3.9 km² of medium ‘heat’ class and 10.2 km² of low ‘heat’ class (Table 4.3). This accounts for 0.2% of the medium ‘heat’ class and 0.7% of the low ‘heat’ class within the Outer Thames MAREA boundary, respectively. When considering these areas it should be noted that, in some cases, mobile

fishing activity actively avoids dredging areas – and when dredging ceases it is likely that these areas will be targeted by fishing activity. It should also be noted that Table 4.3 presents a spatial analysis of the data only. No inferences on the respective significance of user activities are made.

4.4. South Coast Region

This section summarises the results of a CIA for the South Coast MAREA region, and which is presented in full as Appendix K. The aggregate licence, application and option areas (worst case PIZ) within the South Coast MAREA region cumulatively overlap with 0.0 km² of very high 'heat' class, 0.0 km² of high 'heat' class, 44.3 km² of medium 'heat' class, and 300.9 km² of low 'heat' class. When these areas are then considered against the spatial extent of other anthropogenic pressures in the region the analysis shows that none of the high and medium 'heat' classes, and 89.9 km² of low 'heat' class and is subjected only to pressure from dredging activity. Within the MAREA boundary there is no high 'heat' class, 568.7 km² of medium 'heat' class, and 4,028.8 km² of low 'heat' class. Therefore none of the medium 'heat' class and 2.2% of the low 'heat' class within the South Coast MAREA boundary is solely impacted by dredging activity.

Extraction of the seabed will result in direct removal of sandeel habitat. Within the South Coast MAREA region the cumulative effect of direct habitat removal through dredging is regarded as having a **very low** magnitude. The effect of removal will be temporary, but will occur routinely over all dredging operations. The effect will occur in small amounts over the licence period, and the extent will over cover small areas of the seabed at one time (i.e. the area covered by each dredging campaign).

The sensitivity of sandeel to seabed removal is **medium-high** due to the low tolerance and adaptability and medium recoverability of the receptor to the effect. It is recognised that sediments identified in the PIZs include those considered favourable for sandeel; however, no areas were identified as having high confidence in their potential to be used by sandeels. Despite the current low to moderate confidence, suitable habitats may be colonised over time, therefore an effect can be considered to occur to the integrity of the habitat. **Taking into account the magnitude of the effect and the sensitivity of the receptor the cumulative impact of seabed removal on the sandeel population in the South Coast MAREA region is considered to be of minor significance.**

Following the cessation of dredging, licence holders are required to leave a layer of aggregate resource to a certain thickness (i.e. at least 0.5 m on average). The effect of leaving favourable habitat means that the impacts of dredging are not permanent, and this will allow recovery and re-colonisation of seabed that; either becomes exclusion zones while the licences are still active, or which is no longer dredged following the expiration of the licences.

In addition to dredging, there are several other seabed user activities that have the potential to interact with sandeel potential habitat within the South Coast MAREA region; these activities are:

- Offshore renewable arrays;
- Trawl fisheries;
- Dredge fisheries;
- Pipelines;
- Power and telecommunication cables; and
- Dredge disposal sites.

The potential impacts associated with seabed infrastructure such as offshore renewable arrays, oil and gas pipelines and telecommunications cables are loss of habitat as a result of seabed disturbance during installation. Trawl and dredge fisheries actively target the seabed and may result in the disturbance to preferred or marginal habitat sediments and temporary loss of habitat during fishing.

Table 4.4 quantifies the interaction between the other seabed user activities and potential habitat across the South Coast MAREA region, noting the total footprint figures represent seabed user interaction with potential habitat, albeit each sector interacting to a varying degree via different impact pathways. The results show that 552.5 km² of medium 'heat' class and 2614.6 km² of low 'heat' class are within the footprint of all seabed user activity. This constitutes 97.2%, and 64.9% respectively of the total available sandeel medium and low 'heat' classes in the South Coast MAREA region. The total value indicates that there is a degree of overlap between seabed users, with some areas of seabed receiving impacts from more than a single sector i.e. the mobile activities such as dredge or trawl fishing overlap, to some degree, with the footprints of static activities.

Table 4.4 also shows that areas where dredging activity alone interacts with sandeel 'heat' class (i.e. where there is no overlap with any other activity). Dredging, alone, overlaps with none of the medium 'heat' class and 89.9 km² of low 'heat' class (Table 4.4). This accounts for 2.2% of the low 'heat' class within the South Coast MAREA boundary. When considering this area it should be noted that, in some cases, mobile fishing activity actively avoids dredging areas – and when dredging ceases it is likely that these areas will be targeted by fishing activity. It should also be noted that Table 4.4 presents a spatial analysis of the data only. No inferences on the respective significance of user activities are made.

Table 4.4: Footprint of Seabed User Activity on Potential Sandeel ‘Heat’ Class in the South Coast MAREA Region.

Seabed User Activity	Overlap with high ‘heat’ class (km ²)	% of total available high ‘heat’ class	Overlap with medium ‘heat’ class (km ²)	% of total available medium ‘heat’ class	Overlap with low ‘heat’ class (km ²)	% of total available low ‘heat’ class
Operating Windfarm Turbine Footprint	0	0	0	0	0	0
Operating Windfarm Licence Areas	0	0	0	0	0	0
Under Construction Windfarm Areas	0	0	0	0	0	0
Proposed Windfarms Indic. Turbine Footprint	0	0	0.16	0.03	0.92	0.02
Windfarm Licence Areas Proposed	0	0	68.13	11.98	404.23	10.03
Trawl Fishery	0	0	538.57	40.02	1612.22	94.70
Dredge Fishery	0	0	432.90	76.12	1103.28	27.39
Pipelines*	0	0	0.0025	0.0004	0.0113	0.0003
Power Cables*	0	0	0	0	0	0
Telecommunications*	0	0	0	0	0.0014	3.4x10 ⁻⁵
Worst Case Proposed Power Cables*	0	0	0.0081	0.0014	0.0364	0.0009
Dredge Fines Disposal Sites	0	0	2.70	0.47	1272.31	31.58
Dredging Activity (PIZ)	0	0	44.34	7.80	300.94	7.47
TOTAL	0	0	552.5	97.15	2614.6	64.90
Dredging Activity (PIZ) ONLY[†]	0	0	0	0	89.90	2.23

* Assumes that entirety of cable or pipeline is surface laid and not buried, and this therefore over represents footprint for these activities. † The area of seabed which has a footprint associated with dredging alone i.e. no overlap with any other activity

5. Discussion and Conclusions

5.1. Stage 1 screening

Utilising the methods proposed in Latto et al. (2013) (Appendix A) and the associated confidence assessment (Appendix B) the Stage 1 screening assessment was able to successfully use the proposed data layers to produce a heat map for sandeel potential habitat. A wider regional sea area assessment, based on the BGS seabed sediment data layer extent, was able to indicate where the potential sandeel 'hotspots' were likely to occur, with the highest confidence in potential sandeel habitat closely following the ESFJC and Coull et al. (1998) layers. It is evident from the assessment of the wider geographic region, that large areas of high confidence and probability sandeel habitat occur outside of the MAREA regions, and potentially even beyond UK territorial waters which suggests that such habitats are not uncommon in the southern North Sea and English Channel.

Each data layer has an associated confidence score and weighting according to its 'value' as an 'indicator of habitat' (Appendix B). Rules for combining the multiple data and interpreting the 'heat' map were developed and applied (see Appendix B for the methodology). The combined confidence ('heat' map) is the sum of all layer's 'value' scores at any one location. Four equal interval 'heat' classes have been derived from the data; low, medium, high and very high. The first three classes relate to the overlaps actually present within the data analysed and mapped, and represent classification of the range of 'value' of the data used: low = 1-4; medium = 5-8; and high = 9-12. The fourth category, very high, represents a theoretical maximum range of overlapping data that could be achieved if the spatial coverage of the data were different: theoretically, if the data used were updated in the future it may be possible that spatial ranges are extended resulting in increased numbers of overlaps. The very high 'heat' class has a range of 13-16. This process was agreed with the MMO and Cefas (Cefas, 2013a, 2013b; MMO, 2013b, 2013c).

It is evident from the assessment of the wider regional sea area that large areas of medium and high 'heat' (confidence and probability) potential sandeel habitat occurs outside of the MAREA regions; and potentially even beyond the extent of the wider regional sea area considered – suggesting that such habitats are common in the southern North Sea and English Channel. Therefore a limiting factor for actual habitat occupation may be related to other factors such as the availability of sandbank features rather than the accessibility of broadscale habitat. The detection and mapping of these smaller scale features is beyond the capability of the current macro-scale data and this assessment.

The sandeel habitat assessment was focused by supplementing the BGS SBS v3 data layer with the regional MAREA seabed sediment interpretations, where appropriate, to produce marine aggregate-specific regional assessments. As discussed in Section 3.2 and Appendix M, the MAREA seabed sediment maps were selected as the base-map to assess the Humber and Anglian MAREA regions, whereas the BGS seabed sediment maps were chosen for the Outer Thames Estuary and South Coast MAREA regions and the 'outlier' licences. The interpretations of the data show that there are varying levels of confidence of in the presence of potential habitats within each of the MAREA regions.

Table 5.1: Summary of licences screened for EIA per MAREA region

MAREA Region	Total Licences Screened	
	In	Out
Humber	33	0
Anglian	33	0
Thames	20	0
South Coast	57	0

The screening assessment was successfully carried out for all four of the MAREA regions, as well as the ‘outlier’ licences. In the Humber, Anglian, Outer Thames and South Coast MAREA regions all licence and application areas were screened in for sandeel EIA at site-specific level (Table 5.1).

Table 5.2: Area of sandeel potential habitat related by ‘heat’ for the MAREA areas assessed

Heat Class	Area of ‘Heat’ Class (km ²)			
	Humber	Anglian	Thames	South Coast
Low	3,292	975	1,389	4,029
Medium	4,556	1,687	2,125	569
High	775	2,019	1,673	0
Very High	0	0	0	0

As a result of all licence and application areas being screened in for site-specific EIA, it is apparent that there is an association between aggregate extraction areas and potential sandeel habitat. This is not surprising, given the distribution and extent of these habitats (at a regional seas scale) which encompass Sand, slightly gravelly Sand, gravelly Sand and sandy Gravel (Latto *et al.*, 2013). Individual licence areas will interact, to a greater or lesser degree, with the potential habitats and the significance of the direct and indirect effects of dredging will be assessed through a site-specific EIA. This will take into account the extent of high, medium and low ‘heat’ (confidence) areas within each MAREA region, as well as the degree of site-specific overlap with each of these areas of ‘heat’ (confidence levels).

5.2. Stage 2 regional cumulative impact assessments

The CIAs produced for Stage 2 highlight the cumulative impact significance of marine dredging activities on sandeel habitats. Table 5.3 summarises the significance of the effects determined for each of the MAREA regions.

Table 5.3: Summary of impact significance determinations for cumulative dredging effects on sandeel habitat for each of the four MAREA regions

Effect	Humber	Anglian	Thames	South Coast
Direct removal and/or alteration of suitable habitat	Minor	Minor	Minor	Minor

Minor cumulative levels of significance are reported for all regions, although it is suggested that impacts may be 'Not Significant' within the Outer Thames MAREA region. In all regions mitigation measures are already in place to leave a layer of resource, on average at least 0.5 m thick, of seabed sediment similar to that which was present before dredging commenced. This will allow recovery and re-colonisation of licence areas at the end of the licence term, as favourable habitat has been seen to be preferentially colonised by sandeel if vacant (Holland *et al.*, 2005). In addition the wide availability of preferable and marginal sandeel habitat identified in the Stage 1 screening exercise suggests that any loss of habitat via direct removal or alteration would be minimal in context of the habitat available both regionally and at the regional sea area scale. It is worth noting that the fining of seabed sediments, typically associated with the dredging process, may actually enhance the amount of sandeel potential habitat available.

The scale of dredging can also be put into a wider area context by comparing the relative contributions of other seabed users within the wider regional region, as defined by Figure 5.2 (BGS SBS v3 coverage) and table 5.4.

Table 5.4 shows the relative contributions of each seabed user to the pressure on sandeel potential habitat across the wider regional sea area. The total area of sandeel low, medium and high 'heat' within the wider regional sea area is approximately 28,749.66 km², 55,961.12 km², and 24610.67 km², respectively. Table 5.4 shows that 79,772.08 km² (72.98%) of the total low 'heat' in the wider regional sea area is overlapped by the activities of seabed users, including marine aggregates. A total extent of 28,749.66 km² related to seabed user footprint overlaps with low 'heat', 55,961.12 km² with medium 'heat' and 24,610.67 km² with high 'heat'.

As might be expected, trawl fishing overlaps the largest areas of potential sandeel habitat, with 19,108.7 km² of overlap with high 'heat' (78% of the wider regional sea area total), 39,286.9 km² of overlap with medium 'heat' (70% of the wider regional sea area) and 11,758.9 km² of low 'heat' (41% of the wider regional sea area) being overlapped by this activity alone.

When considering overlap with potential sandeel habitat, Table 5.4 also indicates that offshore renewables, trawl fishing, dredge fishing and dredge fines disposal sites all have larger overlaps with both medium and high 'heat' areas than dredging activity does. Of the seabed users summarised in Table 5.4, only cables and pipelines have a smaller spatial overlap with potential sandeel habitat recorded as medium or high 'heat' in the wider regional sea area than dredging activity does.

A further consideration to the overall interaction is the degree of overlap between seabed users, with some areas of seabed receiving impacts from more than a single sector. Mobile activities such as dredge or trawl fishing are shown to overlap, to some degree, with the footprints of all static activities.

Table 5.4 also shows that there are some areas of the wider regional sea area where dredging activity, alone, interacts with potential sandeel habitats (i.e. there is no overlap with any other activity). Dredging, alone, overlaps with approximately 423.4 km² of low 'heat' potential habitat, and approximately 681.4 km² of medium 'heat' potential habitat and 213.9 km² of high 'heat' potential habitat in the wider regional sea area (Table 5.4). This accounts for 1.4% of low 'heat' potential habitat and 1.2% of the medium 'heat' potential habitat and 0.9% of the high 'heat' potential habitat within the wider regional sea area, respectively. When considering these areas, it should be noted that these analyses represent a conservative outcome, given the working assumption that the entirety of the PIZs would be impacted, when the reality is that only a very small portion of each would be affected at any moment in time. Areas of similar potential sandeel habitat also occur outside of the wider regional sea area analysed, and it should also be noted that, in some cases, mobile fishing activity actively avoids dredging areas – and when dredging ceases it is likely that these areas will be targeted by fishing activity.

Figure 5.1: The wider regional sea area considered relevant to this assessment for potential spawning habitat.

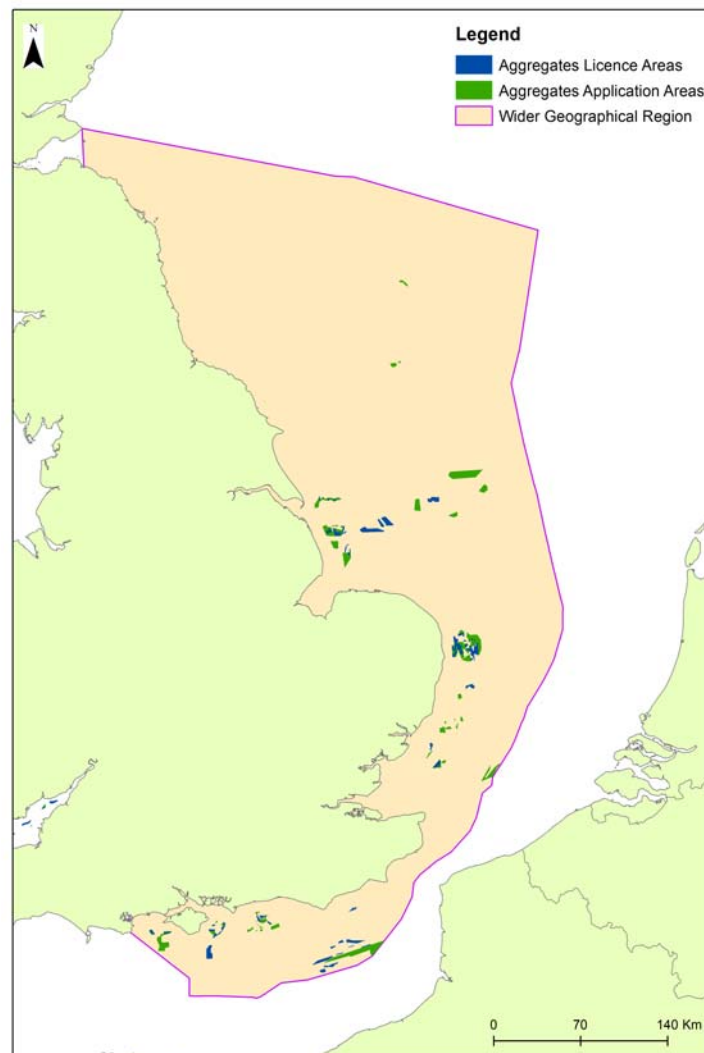


Table 5.4: Regional sea area Total Footprint of Seabed User Activity on Potential Sandeel Habitat, Based on the BGS SBS v3 Extents.

Seabed User Activity	Overlap with high 'heat' class (km ²)	% of total available high 'heat' class	Overlap with medium 'heat' class (km ²)	% of total available medium 'heat' class	Overlap with low 'heat' class (km ²)	% of total available low 'heat' class
Operating Windfarm Turbine Footprint	0.385	0.0003	0.711	0.001	0.429	0.001
Operating Windfarm Licence Areas	29.273	0.119	60.563	0.108	26.592	0.092
Under Construction Windfarm Areas	115.256	0.468	141.667	0.253	54.282	0.189
Proposed Windfarms Indic. Turbine Footprint	18.818	0.076	23.040	0.041	5.790	0.020
Windfarm Licence Areas Proposed	8036.78	32.656	9747.604	17.419	2438.869	8.483
Trawl Fishery	19108.723	77.644	39286.866	70.204	11758.871	40.901
Dredge Fishery	2935.467	11.928	4583.291	8.190	3530.253	12.279
Pipelines*	0.644	0.003	2.205	0.004	0.618	0.002
Power Cables*	0.034	0.0001	0.104	0.0002	0.048	0.0002
Telecommunications*	0.071	0.0003	0.081	0.0001	0.034	0.0001
Worst Case Proposed Power Cables*	0.049	0.0002	0.101	0.0001	0.083	0.0003
Dredge Fines Disposal Sites	1904.592	7.739	589.407	1.053	1687.211	5.869
Dredging Activity (PIZ)	631.604	2.566	2094.221	3.742	1038.517	3.612
TOTAL	21568.65	87.639	43062.63	76.951	15140.80	52.664
Dredging Activity (PIZ) ONLY[†]	213.94	0.869	681.39	1.218	423.39	1.374

* Assumes that entirety of cable or pipeline is surface laid and not buried, and this therefore over represents footprint for these activities. † The area of seabed which has a footprint associated with dredging alone i.e. no overlap with any other activity

When considering the overall impacts that will be caused to sandeel habitat by marine aggregate dredging and other seabed users it is important to consider the nature of the habitat; which will have specific characteristics that make it more or less preferable to sandeel. This assessment has investigated potential areas of sandeel habitat at a macro-scale, utilising indicators of sandeel presence to act as proxies for habitat occupation. Through no fault of this assessment the necessary resolution to identify discrete or specific habitat features with the potential to support sandeel is not provided. This is in part because the particular habitats occupied by sandeel are not solely

dependent upon the suitability of the seabed sediments, but rather a suite of other physical, chemical and biotic factors i.e. the flanks of sandbanks, attendant increased water flows, variations in oxygenation of the sediments etc. (Holland *et al.*, 2005; Englehard *et al.*, 2008). This habitat parameters are difficult to map effectively at the macro-scale due to factors such as subtidal banks mobility, localised nearbed flow rates etc. Consideration of these site-specific environmental and habitat parameters will be resolved through the application-specific ESs using the higher resolution of data acquired for the purposes of EIA. The 'heat' mapping will indicate the likelihood of sandeel presence and aid to fine-tune the considerations required of any specific EIA. This approach has been agreed with the MMO and RAG (Cefas, 2013a, 2013b; MMO, 2013b, 2013c).

5.3. Context for sandeel assessment

The Stage 2 assessments have determined the impact significance of aggregate extraction on potential sandeel habitat through assessing the cumulative impacts of aggregate dredging, as well as in-combination interactions with other seabed users, at the MAREA scale.

The worst case scenario is considered precautionary as it over-estimates the spatial extent of Active Dredge Zones (ADZs), within any, and all, licence and application areas, and the extent of associated sediment plumes. In reality the footprint of dredging activity (ADZ) is likely to be discrete and localised (within the wider area of the licence/application area) for periods of time associated with the aggregate resource, its volume and market demand for that resource/product. Therefore, in relation to effect-receptor pathways:

- Direct removal of sandeel habitat would only occur during a dredging event. The presence of a dredger in the licence area is a time-limited event and if the sediments of a whole licence area were preferred sandeel habitat, a single, or small number of, dredging events would only affect a small portion of the area; and
- It is assumed that habitat loss/conversion occurs across the totality of the licence/application area with a transition from potentially suitable to wholly unsuitable habitat in regards to sediment composition i.e. a shift from preferred and/or marginal sediment habitat type to unsuitable sediment habitat type. In reality there are several reasons why this is unlikely to actually happen, not least the monitoring and mitigation measures required of the industry in modern licence conditions.

In a study to support the Dogger Bank Creyke Beck offshore wind farm ES VMS data of fishing activity by Dutch sandeelers was used to determine potential sandeel habitat (Figure 5.2) (Forewind, 2013a). These data indicate distinct regions where a high density of fishing vessels were recorded and this was used as a proxy for sandeel presence. While these data only pertain to Dutch fishing vessels and not British and/or other nationalities it provides a useful snapshot of the locations of prime sandeel fishing grounds outside both the British 6 nm fishing limit and outside the MAREA regions (but relevant to the Humber 'outlier' application areas). While this information would have proved useful for analysis within the assessment conducted in this report, specifically in regard to the Humber 'outlier' application areas, the raw data was not available to the EIA WG. Subsequently the information presented in the Dogger Bank Creyke Beck ES has only been used to inform the discussion in a qualitative manner.

The VMS data show that there are favoured fishing grounds targeting sandeels and that these areas are associated with seabed morphological features i.e. subtidal sandbanks. The evidence from direct observations of the fishing activities themselves suggest that it is the flanks of sandbanks that are being targeted and that this habitat appears important to sandeel populations at a local-scale (Forewind, 2013a). The densest records for sandeeler vessels are clearly associated with the flanks of the Dogger Bank and other large-scale subtidal sandbank features (Figure 5.3).

The sandeel assessment reported in the Dogger Bank Creyke Beck ES aligns in principle with the classification of sandeel preferred and marginal habitat sediment classification detailed within Latto *et al.* (2013) and presented in this report (and the regional CIAs) (Forewind, 2013b). This is in-part because Brown and May Marine Ltd (which conducted the sandeel assessment for Forewind) had direct discussion with the EIA WG before establishing its rationale and methodology (Ian Reach, pers. comm.; Pia Orr, pers. comm.).

The data presented in the Dogger Bank Creyke Beck ES relates sandeel presence to seabed sediment particle size classification as presented in Figure 5.3 (Forewind, 2013b). The sandeel survey data conducted as part of the ES shows that there appears to be a preference for sandeels favouring sand as habitat (using the Folk (1954) classification) (Figure 5.3). The distribution of the sandeel caught as part of the survey also correlates with the distribution of the Dutch fishing fleet VMS data (Figure 5.4). No consideration of other environmental parameters was made within the supporting sandeel assessment technical report (Forewind, 2013b).

As is shown in Figure 5.2 the specific range of sandeel populations is not restricted to the UK territorial waters and extends further offshore in the southern North Sea. It is likely to also extend further west along the English Channel than is considered in this assessment such as along the southwest approaches and into the Bristol Channel.

As is evident from Figure 5.2 sandeel populations must have a wide availability of potential habitat both within the MAREA regions, and extending beyond the MAREA boundaries. At the wider regional sea area scale approximately 96,483 km² of suitable habitat sediments is available to sandeel (comprising 82,216 km² of preferred habitat sediments and 14,267 km² of marginal habitat sediments).

Figure 5.2: Overlay of Danish sandeel fishery VMS data within the foraging range of common guillemot from Flamborough Head and Bempton Cliffs SPA and footprint of development areas for Dogger Bank Creyke Beck, Dogger Bank Teesside A and B and Hornsea Project One. (From: Forewind, 2013b)

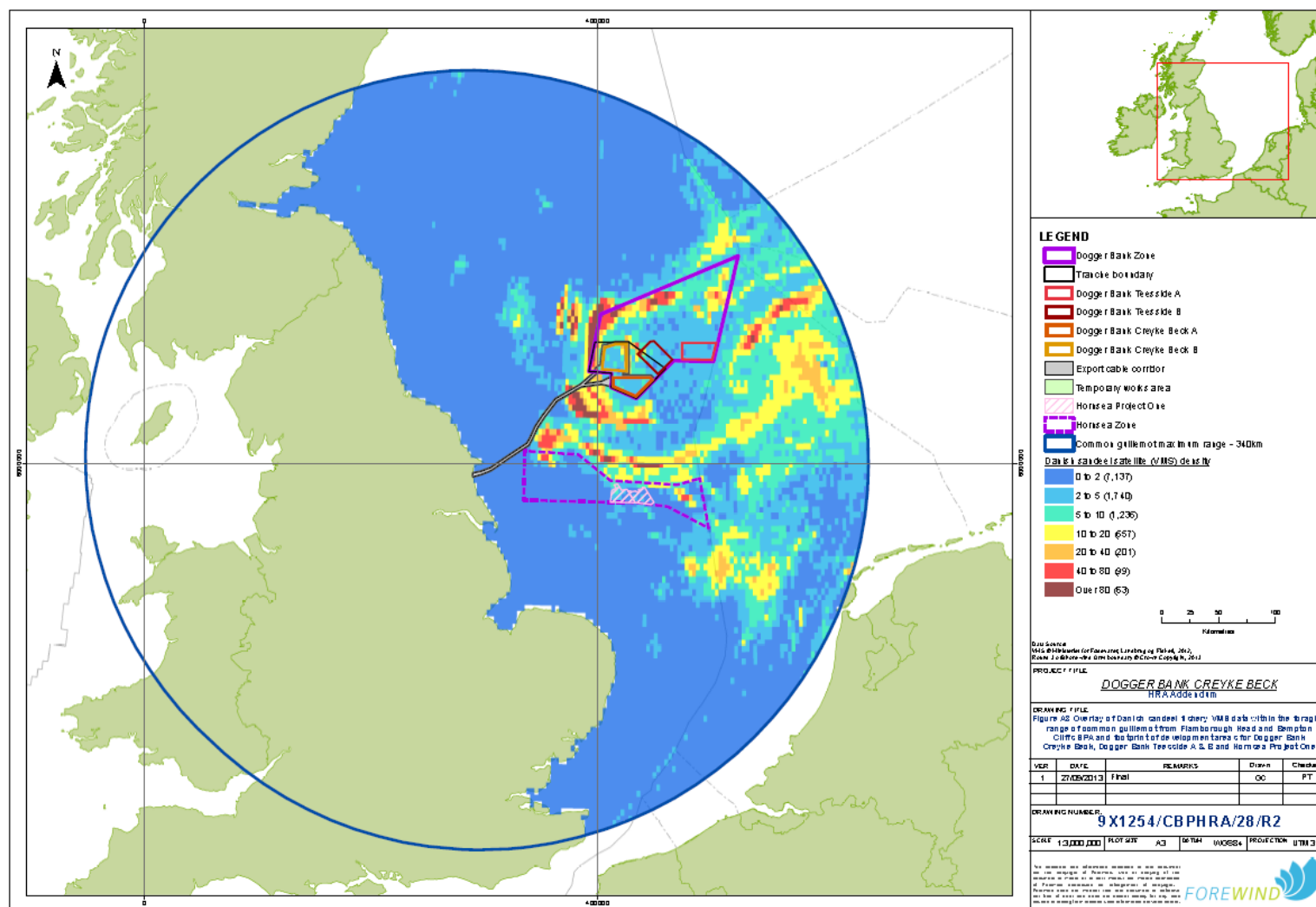


Figure 5.3: Spatial Distribution of Sandeel Species Overlaying Seabed Sediments. (From: Forwind, 2013a)

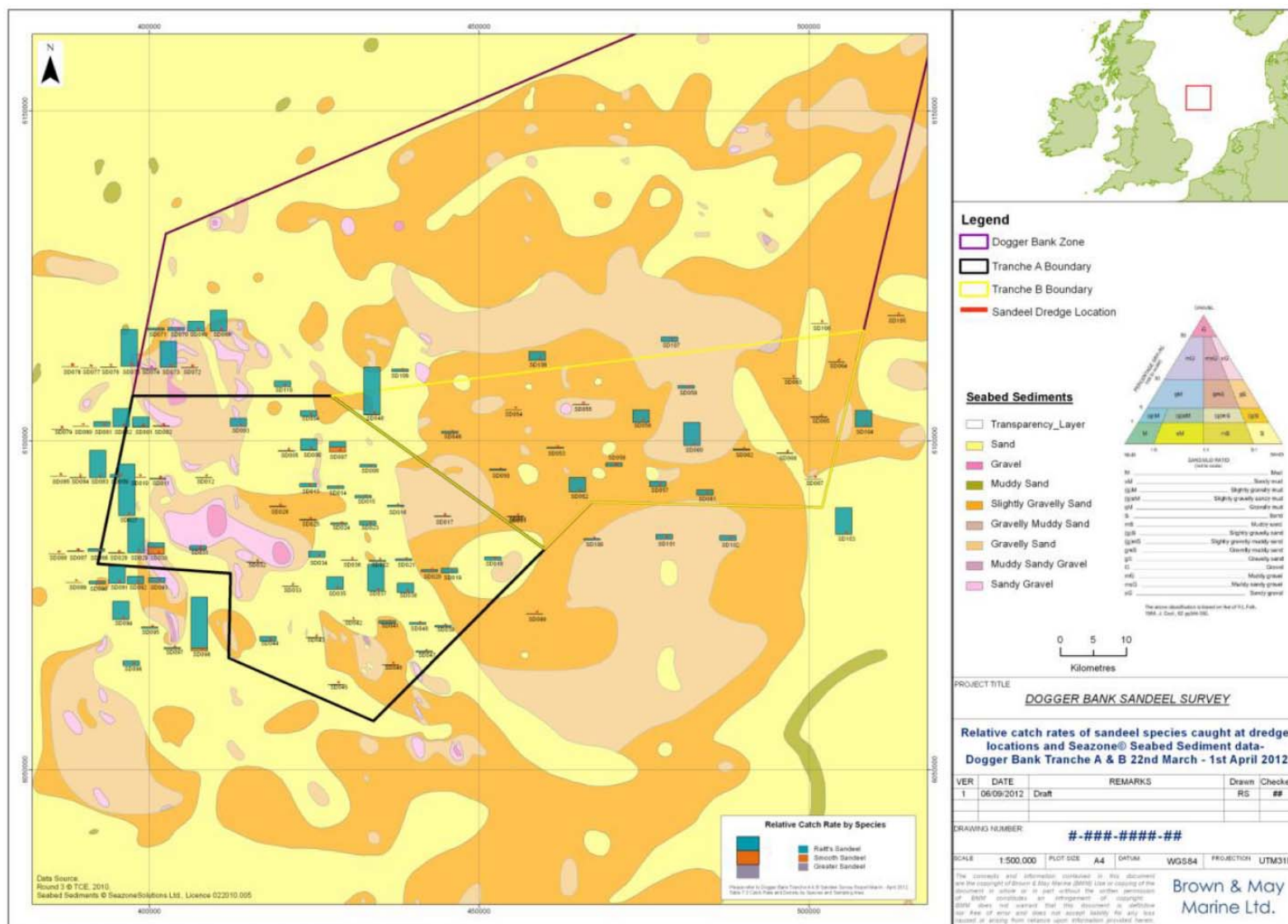
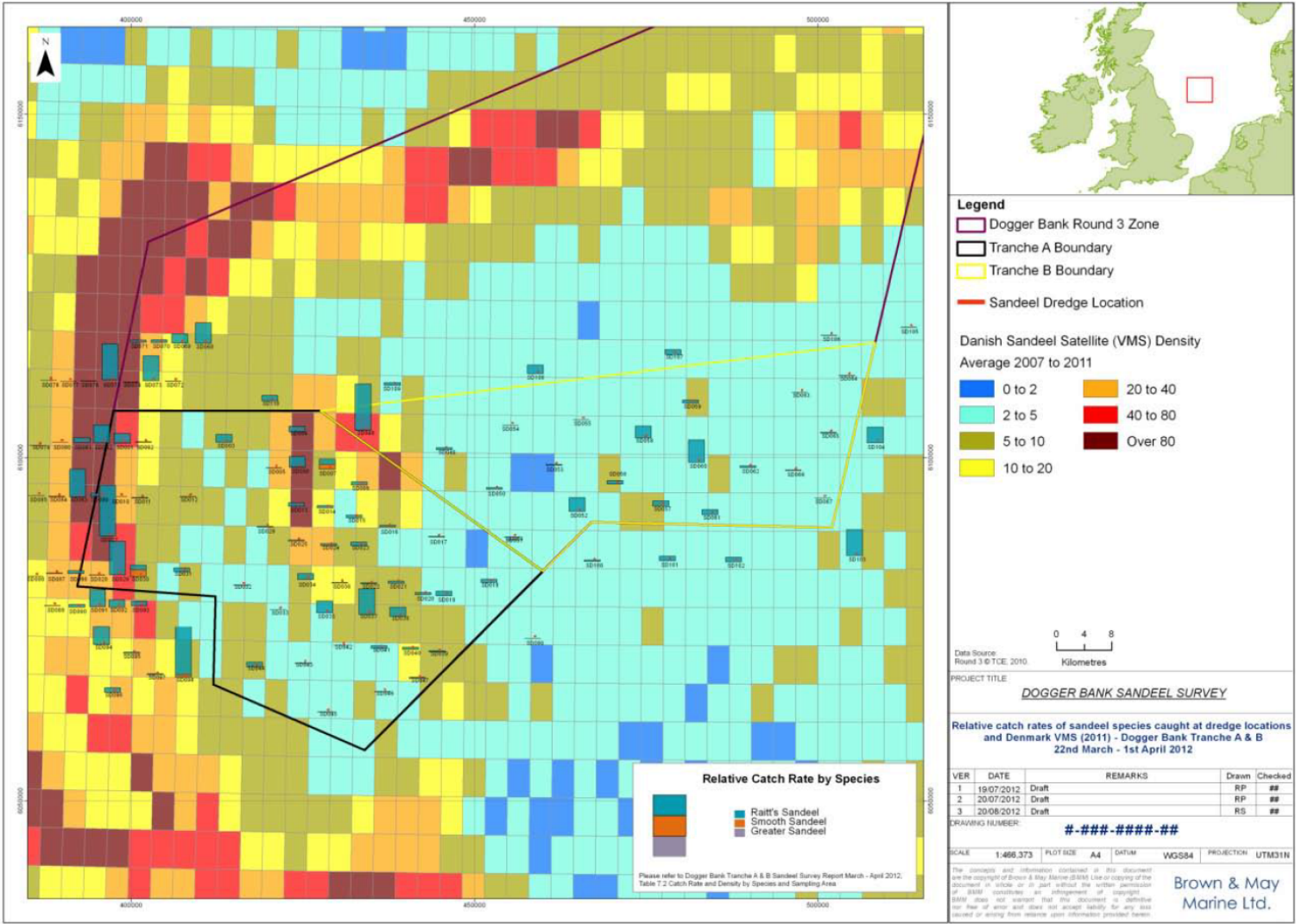


Figure 5.4: Spatial Distribution of Sandeel Species Overlaying Annual Satellite Density VMS Sightings of Danish Vessels of Over-15 m. (From: Forewind, 2013a)



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5.4. Conclusions

A key factor in reducing the significance of impacts is the industry standard practice of leaving at least a 0.5 m layer of resource sediment (on average) in a licence area at the end of any licence term. This maintains the seabed similar in composition to the sediment that existed before dredging began. This effectively means that the overall area of preferred and marginal habitat sediments available for sandeel should not change significantly post-dredging. In addition recovery and re-colonisation of areas can occur quickly once dredging has ceased; usually within 12-24 months (Tillin *et al.*, 2011; Hill *et al.*, 2011) and especially within regions of high seabed sediment transport/mobility, such as the Humber and Anglian regions (EMU Ltd, 2012a; ERM Ltd, 2012).

Entrainment has been highlighted by the MMO and RAG as requiring consideration at site-specific scale (MMO, 2013b, 2013c). It is worth highlighting that the effect of entrainment by dredgers has been investigated at the Nash Bank in the Bristol Channel (ABP Research and Consultancy Ltd, 1995). The study determined that standard screening practices used on the dredgers resulted in sandeel not being damaged by the entrainment process and that return to the water alive was possible. It did not make any statement about the survivability of sandeel once they had returned to the water column (ABP Research and Consultancy Ltd, 1995).

While a degree of variation is expected between regions and licence areas, based on spatial coverage of the data layers, the results of the in-combination spatial assessments indicate that while potential sandeel habitat is under pressure from anthropogenic activity, dredging activity only contributes to a small proportion of this e.g. an environmental footprint with only 1.2% of medium 'heat' areas and 0.8% of high 'heat' areas (at the wider regional sea area) that are not exposed to other seabed user activity. Set in context, the exposure pathways from all other seabed user activity combined (excluding marine aggregate activity), interacts with 86.8% of high 'heat' and 75.7% of medium 'heat' at the wider regional sea area scale.

In effect, restricting the marine aggregate footprint, will likely result in a negligible change in the status of sandeel habitat, both at a MAREA-scale, and also at the wider regional sea area (as considered within this study).

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7. Appendices

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Appendix A: Screening Spatial Interactions between Marine Aggregate Application Areas and Sandeel Habitat: A Method Statement

Addendum to Screening Spatial Interactions between Marine Aggregate Application Areas and Sandeel Habitat: A Method Statement

The Marine Aggregate Environmental Impact Assessment Working Group has revised the methodology in (Latto *et al.*, 2013⁷), specifically with regard to the parameterisation and classification of potential sandeel habitat and the associated sediments that underpin the habitat. No Folk sediment classes have been added or subtracted from the methodology. The re-classification has merely built upon the similar Atlantic Herring spawning habitat classification rationale that has been developed in parallel with this methodology (Reach *et al.*, 2013⁸).

It is also important to note that both Latto *et al.* (2013) and Reach *et al.* (2013) should include an appendix containing the confidence assessment protocol and methodology (as attached as Appendix B to this report).

The Folk sediment classification (Folk, 1954) has been used to describe seabed habitat as this is also the classification scheme used to underpin the British Geological Survey's (BGS's) 1:250,000 scale seabed sediment maps. This sediment classification has subsequently been used within the Marine Aggregate Regional Environmental Characterisation (REC) and MAREA reports. Using the Folk (1954) classification enables compatibility of the potential sandeel habitat environmental assessments with a range of products (e.g. MAREAs, marine planning areas) and data sources (e.g. BGS 1:250,000 maps).

The review and analysis of the source data for potential sandeel habitat (see Latto *et al.*, 2013) resulted in the development of the seabed sediment classification presented in Figure A1. The sediment divisions, referred to as **habitat sediment classes** (using the Folk (1954) sediment classification), have the potential to support sandeel populations and are presented in Tables A1 and A2. The alteration to the previous potential sandeel habitat classification regards the sub-division of the potential habitat, re-classification of preferred habitat sediment classes, and the allocation of a marginal habitat sediment class.

It is important to note and clarify that the habitat sediment classification is not the only parameter (datum) that indicates potential sandeel habitat. There are other environmental (physical, chemical and biotic) parameters such as: the flanks of sandbanks and the attendant increased water flows, variations in oxygenation of the sediments, depth; which all contribute to the suitability of seabed habitat to be used as habitat by sandeel.

Considering the wide range of environmental parameters that determine sandeel habitat, it is important to note that the use of the habitat sediment classes alone will always over-represent the range of habitat with the potential to support sandeel populations. This results in the rationale for

⁷ Latto P. L., Reach I.S., Alexander D., Armstrong S., Backstrom J., Beagley E., Murphy K., Piper R. and Seiderer L.J., 2013. *Screening Spatial Interactions between Marine Aggregate Application Areas and Sandeel Habitat*. A Method Statement produced for BMAPA.

⁸ Reach I.S., Latto P., Alexander D., Armstrong S., Backstrom J., Beagley E., Murphy K., Piper R. and Seiderer L.J., 2013. *Screening Spatial Interactions between Marine Aggregate Application Areas and Atlantic Herring Potential Spawning Areas*. A Method Statement produced for BMAPA.

using as many indicative data layers as possible and determining representation of potential for habitat based on the ‘heat’ of the spatial overlaps (of the data used).

Table A1: Description of potential sandeel habitat sediment classes. (Adapted from Latto *et al.*, 2013)

Preferred habitat sediment class	In the context of this methodology these are the sediment divisions/units represented by Sand, slightly gravelly Sand and gravelly Sand which sandeel favourably select as part of their habitat requirements. It should be noted that other physical, chemical and biotic factors contribute to the overall definition of potential spawning habitat – see also <i>Prime</i> and <i>Sub-prime</i> descriptions.
Marginal habitat sediment class	In the context of this methodology this is the sediment division/unit represented by sandy Gravel which sandeel may select as part of their habitat requirements. This sediment class has adequate sediment structure but is less favourable than preferred habitat – see also <i>Suitable</i> descriptions.
Unsuitable habitat sediment class	Seabed sediment classes which have inadequate sediment structure to be chosen by sandeel.
Prime Habitat Sediment Class	In the context of this methodology these are the sediment divisions/units represented by coarse Sand, slightly gravelly Sand and gravelly Sand with ideal sediment structure that supports sandeel populations – see also <i>preferred habitat sediment class</i> . It should be noted that other physical, chemical and biotic factors contribute to the overall definition of potential spawning habitat
Sub-prime Habitat Sediment Class	In the context of this methodology this is the sediment divisions/units represented by finer Sand, slightly gravelly Sand and gravelly Sand which has acceptable sediment structure and supports sandeel populations. This sediment class has adequate sediment structure but is less favourable than <i>prime habitat sediment</i> – see also <i>preferred habitat sediment class</i>
Suitable habitat sediment class	Sandeel habitat sediment which has adequate sediment structure but is likely to only support low sandeel abundances. This represented by gravelly Sand and sandy Gravel Folk sediment classes – see also <i>marginal habitat sediment class</i>

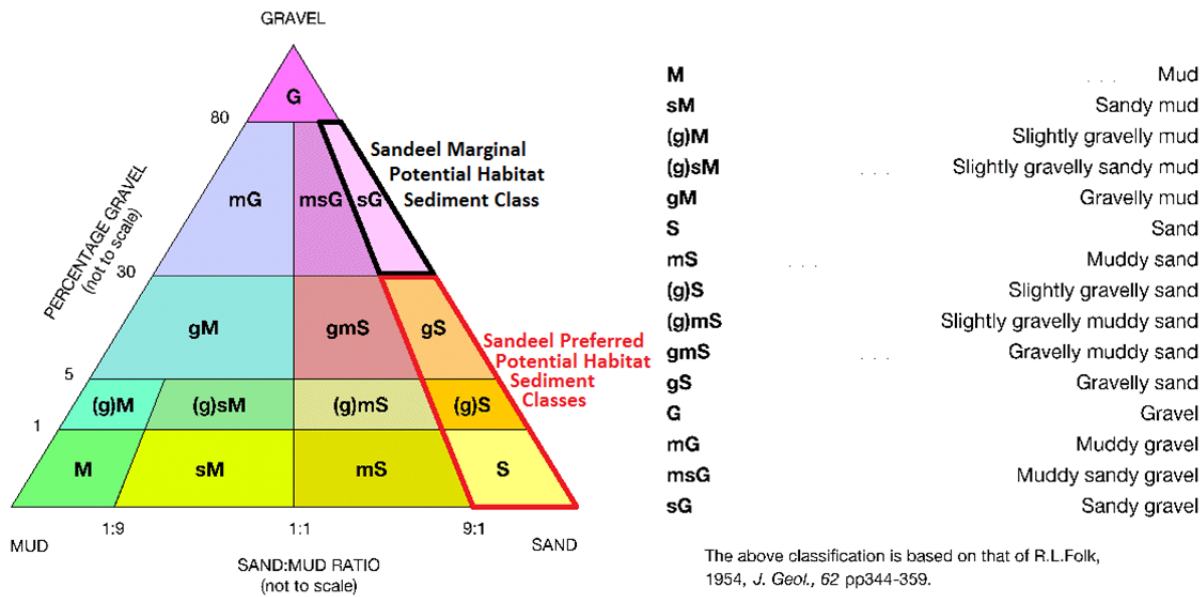
Table A2: The partition of Atlantic Herring potential spawning habitat sediment classes. (Source: Folk, 1954; adapted from Latto *et al.*, 2013)

% Particle contribution (Muds = clays and silts <63 µm)	Habitat sediment preference	Folk sediment unit	Habitat sediment classification
<1% muds, >85% Sand	Prime	Part Sand, Part slightly gravelly Sand and part gravelly Sand	Preferred
<4% muds, >70% Sand	Sub-prime	Part Sand, Part slightly gravelly Sand and part gravelly Sand	Preferred
<10% muds, >50% Sand	Suitable	Part gravelly Sand and part sandy Gravel	Marginal
>10% muds, <50% Sand	Unsuitable	Everything excluding Gravel, part sandy Gravel and part gravelly Sand	Unsuitable

This habitat sediment classification, and the sediment divisions used, was ratified by the MMO and RAG at a meeting held on 01 May 2013 (MMO, 2013⁹). It is important to note that the Folk (1954) sediment classes over-represent the suitability of an individual class to completely represent sediment habitat that will be used by sandeel. This is due to the inclusion of varying grades of sand (i.e. fine, medium, coarse (Wentworth, 1922)) within the Sand descriptor used in the classification. However without a complete re-working of all the BGS data used in developing the 1:250,000 scale sediment maps a direct representation of the various grades of sand is not possible. The MMO and RAG agreed that such an exercise is beyond the requirements of any specific EIA (as required under the MWR). Therefore the best-fit Folk sediment classification, presented in amended form as Figure A1, has been used to conduct the assessments within this report. This updates the Folk triangle presented and used in Latto *et al.* (2013).

⁹ Marine Management Organisation (MMO), 2013a. Note of the MMO and RAG Atlantic Herring potential spawning habitat mapping methodology meeting held on 01 May 2013.

Figure A.1: The Folk sediment triangle indicating sandeel preferred and marginal potential habitat sediment classes. (Source: Folk, 1954; adapted from Latto *et al.*, 2013)



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Appendix B: Confidence Assessment Protocol

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Appendix C: Data layers used for screening Humber MAREA region licence and application areas

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Appendix D: Data layers used for screening Humber 'outlier' region licence and application areas

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Appendix E: Data layers used for screening Anglian MAREA region licence and application areas

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Appendix F: Data layers used for screening Outer Thames Estuary MAREA region licence and application areas

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Appendix G: Data layers used for screening South Coast MAREA region licence and application areas

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Appendix H: Humber regional cumulative impact assessment

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Appendix I: Anglian regional cumulative impact assessment

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Appendix J: Outer Thames Estuary regional cumulative impact assessment

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Appendix K: South Coast regional cumulative impact assessment

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Appendix L: *Proviso* of specific stipulations, conditions, or limitations regarding data used in the report and cumulative impact assessments as indicated by the Centre for Environment, Fisheries and Aquaculture Science (Cefas)

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Appendix M: Potential sandeel habitat sediment maps and interaction with aggregate licence areas.

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