Appendices to:

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

A report for the British Marine Aggregates Producers Association by MarineSpace Ltd, ABPmer Ltd, ERM Ltd, Fugro EMU Ltd and Marine Ecological Surveys Ltd, 2013.

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

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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.*, 2013[1]), 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*., 2013[2]).

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 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).

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[1] 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.

[2] 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.

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 *Prime* and *Sub-prime* 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 *Suitable* 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 *preferred habitat sediment class*. 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 *prime habitat sediment*– see also *preferred habitat sediment class*
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 *marginal habitat sediment class*

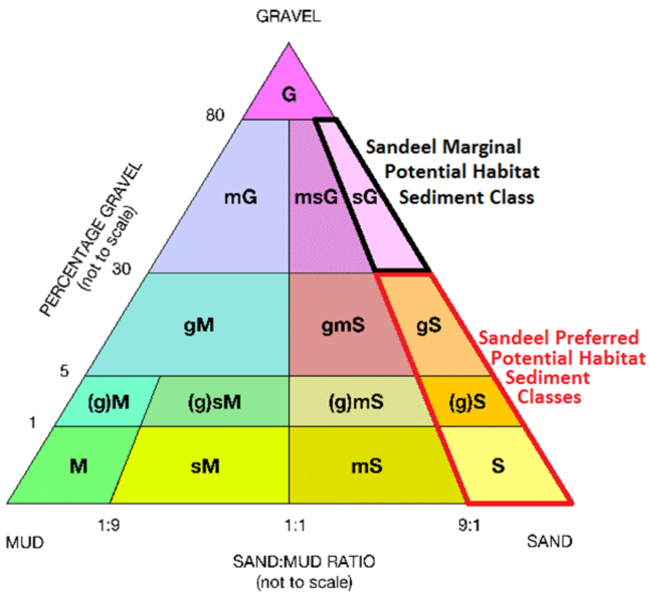
Table A2: The partition of Atlantic Herring potential spawning habitat sediment classes. (Source: Folk, 1954; adapted from Latto *et al.*, 2013)

% 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, 2013[3]). 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).

[3] 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)



M	Mud
sM	Sandy mud
(g)M	Slightly gravelly mud
(g)sM	Slightly gravelly sandy mud
gM	Gravelly mud
S	Sand
mS	Muddy sand
(g)S	Slightly gravelly sand
(g)mS	Slightly gravelly muddy sand
gmS	Gravelly muddy sand
gS	Gravelly sand
G	Gravel
mG	Muddy gravel
msG	Muddy sandy gravel
sG	Sandy gravel

The above classification is based on that of R.L.Folk, 1954, *J. Geol.*, *62* pp344-359.

Screening Spatial Interactions between Marine Aggregate Application Areas and Sandeel Habitat:

A Method Statement

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MarineSpace Limited has been commissioned by HaskoningDHV UK Ltd., a company of Royal HaskoningDHV, acting in its capacity as Minerals and Infrastructure Managing Agent for The Crown Estate, on behalf of: British Marine Aggregate Producers Association; Boskalis Westminster Limited; Britannia Aggregates Ltd; CEMEX UK Marine Limited; DEME Building Materials NV; Hanson Aggregates Marine Limited; Sea Aggregates Ltd; Tarmac Marine Dredging Limited; and Volker Dredging Limited; to produce a methodology to allow the consistent characterisation of the seabed with the potential to be used as habitat by sandeel species, *Ammodytes marinus*, *A. tobianus* and *Hyperoplus lanceolatus* in relation to marine aggregate application areas. This is facilitated in partnership with ABP marine environmental research Ltd, ERM Limited, Fugro EMU Limited and Marine Ecological Surveys Limited.

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.

Readers should note that this publication is subject to periodic revision and should ensure that they are in possession of the latest version.

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.

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21/02/2013	Phil Latto	0.1	For internal MarineSpace quality control	
25/02/2013	Ian Reach	0.2	QC and EIA WG and RAG review	
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04/06/2013	Phil Latto	1.1	Post-consultation revisions	
11/06/2013	Ian Reach	1.1	QC and final publication	

GLOSSARY

Abbreviation	Description	Definition
ADZ	Active Dredge Zone	A defined zone within a production licence where dredging is permitted to occur
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.
	Benthic	Relating to the seabed or organisms that live there.
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
	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
DEAL	Digital Energy Atlas and Library	A web-based service which provides information about UK exploration and production of hydrocarbons on the UKCS
DECC	Department of Energy and Climate Change	The Government department acting as the Regulator regarding energy infrastructure plans and

		projects
	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
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
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)	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.
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 licenses
NE	Natural England	The Government's statutory advisor on the English natural environment out to 12 nm
	Preferred (Habitat)	In the context of this methodology these are the sediment divisions/units which sandeel favourably select as habitat – see also Prime and Sub-prime
PINS	The Planning Inspectorate	A Governmental executive agency responsible for determining final outcomes of planning and enforcement appeals and public examination of local development plans
	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 licenses.
	Sandeel	There are 3 species of sandeel present in UK waters where exposure pathways to environmental effects from marine aggregate operations may exist. These are the Greater Sandeel *Hyperoplus lanceolatus* Le Sauvage, 1824; the Lesser Sandeel *Ammodytes tobianius* Linnaeus, 1758; and Raitt's Sandeel *A. marinus* Raitt, 1934. Where "*sandeel*" is referred in this report it should be read to collectively represent these 3 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

	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.
UKCS	United Kingdom Continental Shelf	The region of waters surrounding the United Kingdom, in which the country claims sovereign rights
UKOOA	UK Offshore Operators Association	Trade representative for the UK offshore oil and gas industry. It works closely with companies across the entire sector, governments and other stakeholders to address key issues for the sector
	Unsuitable (Habitat)	Sandeel habitat which has inadequate sediment structure and does not support sandeel
VMS	Vessel Monitoring System	Vessel monitoring systems are used in commercial fishing to allow environmental and 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 >10 m length

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Contents

List of Figures

List of Tables

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Screening Spatial Interactions between Marine Aggregate Application Areas and Sandeel Preferred and Marginal Habitat:

A Method Statement

1. Introduction

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 recently 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) (Jensen *et al.*, 2011). 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 great strategic importance to the UK marine aggregates industry as a whole. As such the Marine Management Organisation (MMO) and the Regulatory Advisors Group (RAG) have indicated that the impacts on habitats supporting sandeel species, from marine aggregate extraction, are required to be specifically considered by Environmental Impact Assessment (EIA). Identification of habitat likely to support sandeel and assessment of any receptor-exposure pathways will allow suitable mitigation to be established. This in turn may alleviate additional pressures on populations of seabirds and other sensitive apex predators.

Several seabed user industry activities are likely to interact with sandeel habitat in English territorial waters such as: dredge and sandeel fisheries; offshore windfarm arrays; telecommunications cable routes; oil and gas supply pipelines; and marine aggregate extraction. These activities should be considered as part of a cumulative impact assessment, at a suitable scale, when assessing any possible damage or deterioration to sandeel habitat.

To aid the efficient delivery of Full-Term Marine Licence (FTML) applications MarineSpace Ltd have been engaged by the British Marine Aggregate Producers Association (BMAPA) and The Crown Estate, on behalf of the marine aggregate production companies, to facilitate the delivery of a strategic protocol to address the environmental effects of marine aggregate extraction in relation to areas that have the potential to support sandeel habitat.

The methodology builds upon consultation and advice provided by the Marine Management Organisation (MMO) and the Regulatory Advisors Group (RAG).

The metrics, parameters and thresholds describing the environmental characteristics of sandeel habitat, and the spatial analysis and screening exercise 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 Marine Works Regulations (as amended 2011) (MWR) application process. However, it is acknowledged that the methodology in this report will be subject to periodic review and subsequent revised versions may be released as the scientific understanding of sandeel habitat preferences advances and/or when new data becomes available.

The method can be applied to any area of seabed supported by British Geological Survey 1:250,000 scale seabed sediment maps and can incorporate any species of demersal fish with ecosystem importance i.e. *umbrella species*, where metrics and parameters for habitat preference are known or can be calculated.

2. Method

Each part of the methodology depends upon screening spatial interactions between marine aggregate application areas and the sandeel preferred and marginal habitat. The autecology of sandeel species in the North Sea and English Channel is considered and the validity of mapping appropriate data-layers (including any limitations and confidence) are applied using a structured and tiered methodology.

The MMO and the RAG have advised (at a meeting held on 01 May 2013 (MMO meeting note, 2013) the types of effect and effect-receptor pathways that need to be considered as part of the methodology to satisfy the requirements of the EIA Directive as transposed to the MWR. *In lieu* of actual impact hypotheses to test, the environmental effects and effect-receptor pathways of potential impact on sandeel preferred and marginal habitat from marine aggregate extraction are only associated with the primary impact zone (PIZ) and <u>not</u> the secondary impact zone (SIZ). Direct removal of habitat, along with physical alteration of the structure of the sediments from direct contact with the draghead, need to be assessed. These effect-receptor pathways relate to the PIZ. Environmental effects from the sediment plumes and sediment mobilisation are not considered necessary. 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). Therefore the methodology will only be conducted using the PIZ footprint and <u>not</u> the SIZ.

The MMO and RAG have considered the environmental issues regarding entrainment of sandeels by the dredger draghead (MMO meeting note, 2013). They have indicated that entrainment effects are not considered significant in the context of an EIA. Therefore entrainment effects will not be considered in any marine aggregate area application under the MWR.

After an initial larval dispersal period, sandeel display a degree of site fidelity (Haynes *et al.*, 2011; Jensen *et al.*, 2011). Therefore it is important to consider the state of seabed habitats at the end of the licence term. The PIZs are considered representative of the seabed which have the potential to be *re-colonised* post-dredging (subsequent seabed recovery from impacts and ability to support sandeel communities over time). Determinations regarding the potential for *re-colonisation* will also be drawn from an application's Environmental Statement regarding requirements to leave the seabed in an appropriate state (similar to pre-dredge) at the end of the term of the licence period.

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

The Primary Impact Zone:

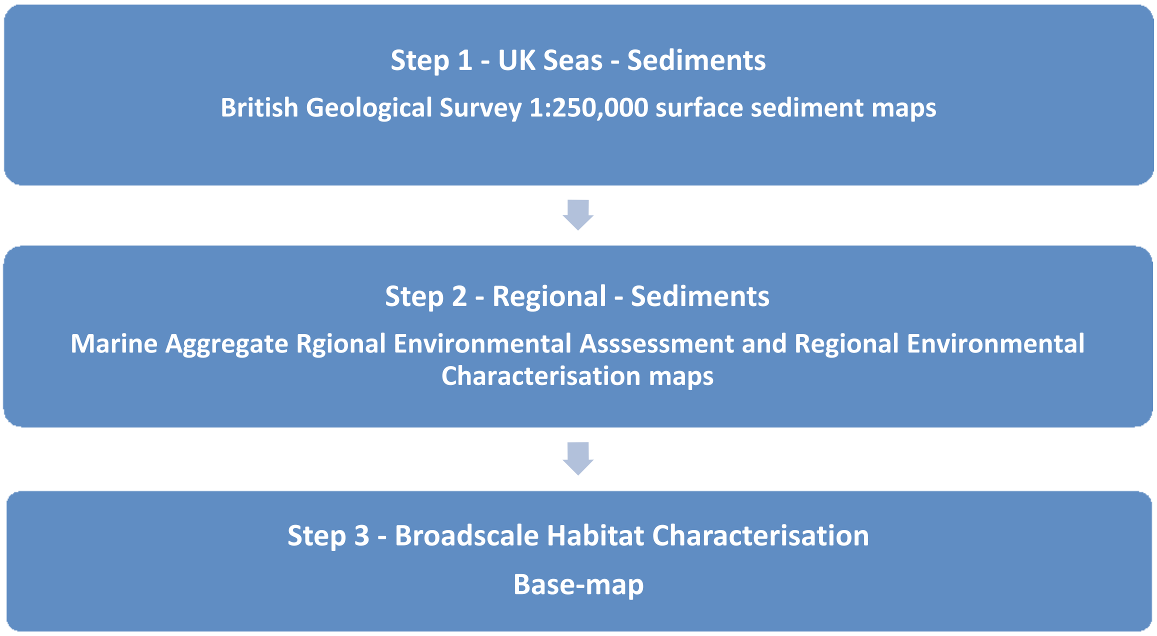
- **Direct removal of suitable sediment (habitat); and**
- **Recovery of preferred habitat to support *re-colonisation*.**

It is important to note that the methodology draws upon seabed sediment mapping and also the spawning ground assessment conducted by Coull *et al.* (1998), rather than the more recent assessment conducted by Ellis *et al.* (2012). Coull *et al.* (1998) considered both the known location of larvae and the relationship with preferred benthic habitat, whereas Ellis *et al.* (2012) related the distribution of fish larvae to the ICES sub-rectangles in which they were sampled. Therefore the assessment of the spatial scale at a national and regional scale is focussed on the habitat-related data from Coull *et al.* (1998), which supports more meaningful analysis.

It is not envisaged at this time that any additional survey data, or re-analyses of existing national or regional data, will be required to deliver the proposed methodology, above or beyond that already conducted during development of any Environmental Statement. However it is acknowledged that the methodology in this report will be subject to periodic review and subsequent revised versions may be released as the scientific understanding of sandeel habitat preferences advance and/or when new data becomes available.

The methodology presented in this report uses a tiered approach to map habitat and ecological space and assess appropriate receptor-exposure pathways: scoping down from potential habitat at a sea/basin-scale; to potential habitat extent at an appropriate regional scale (Figure 1). This part of the methodology results in a broadscale preferred and marginal habitat characterisation map (the base-map). Fine-scale, application area-specific, screening and cumulative assessment follow, building upon the base-map – Step 3 (Section 2.2; also see Figure 4).

Figure 1: Screening and mapping stages to develop sandeel habitat characterisation.



2.1. Production of the broadscale habitat characterisation base-map

Step 1 - UK Seas – Determining the extent of habitat for sandeel at an international/national sea/basin-scale – The initial seabed surface habitat layer is set at a biogeographic sea/basin (national) scale derived from the British Geological Survey (BGS) 1:250,000 scale seabed sediment maps (BGS, various dates. 1:250,000 seabed sediment map series). Considering the geographical location of the marine aggregate production regions in English territorial waters, the focus for this mapping layer will be the central and southern North Sea, including the English Channel.

Sandeel habitat preference has been investigated and described in various peer reviewed papers and grey literature (Macer, 1966; Reay, 1970; Wright *et al.*, 1998; Wright *et al.*, 2000; Holland *et al.*, 2005; van der Kooij *et al.*, 2008; Greenstreet *et al.*, 2010; Haynes and Robinson, 2011; Jensen *et al.*, 2011). In developing the methodology presented in this report the Marine Aggregate EIA WG has reviewed the available data and classifications. Close liaison has been sought with fish ecologists and scientists at Cefas as well as regular consultation with the MMO. Particular attention has been made to the parameters concerning particle size distribution data available and any ranges of preference, or thresholds used previously, to categorise sandeel habitat in UK waters. Appendix A presents relevant extracts of the source material and data used in this method statement and provides an interpolation of these data using the Folk sediment triangle (Folk, 1954).

The Folk sediment classification has been used as this is also the classification scheme used to underpin the BGS 1:250,000 scale surface sediment maps. This sediment classification has subsequently been used within the Regional Environmental Characterisation (REC) and Marine Aggregate Regional Environmental Assessment (MAREA) reports. These data are fundamental to Step 2 of the method as detailed below. Using the Folk (1954) classification enables compatibility of the final sandeel habitat Environmental Impact Assessment (EIA) with different products (e.g. MAREAs, marine planning areas) and data sources (e.g. BGS 1:250,000 maps).

Wright *et al.* (2000) and Holland *et al.* (2005) recently described sandeel habitat requirements as medium to coarse sand of a diameter between 0.25 and 2 mm, with a mud content of less than 10% (particles < 63 µm). Wright *et al.* (2000) demonstrated this range in a series of controlled laboratory-based experiments and the results were replicated in field observations by Holland *et al.* (2005). Most recently Greenstreet *et al*. (2010) have investigated the determinations made in Holland *et al.* (2005) and presented an alternative analysis. These latter two studies have reviewed and reconsidered all of the previous work on sandeel habitat preference (cited above). Therefore the basis for determining sandeel habitat used in this methodology is derived from the Holland *et al.* (2005) and Greenstreet *et al*. (2010) work and is presented in detail in Appendix A.

This classification and the sediment divisions proposed were ratified by the MMO and RAG at a meeting held on 01 May 2013 (MMO meeting note, 2013) and through subsequent discussions. 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 due to the percentage of mud component within them (see Appendix A for detail).

Holland *et al.* (2005) and Greenstreet *et al*. (2010) also concluded that suitable sandeel habitat can include a gravel component. Neither of their classifications align with the Folk classification (Folk, 1954) boundaries; both exceeding the threshold of 30% gravel between gravelly Sand and sandy Gravel. As described in Appendix A it is important to note that the sandy Gravel division (Folk, 1954) accounts for a range of 30-80% gravel content. Holland *et al.* (2005) state that suitable sandeel habitat has a threshold of 35% or less for gravel content. Greenstreet *et al*. (2010) cite a threshold up to 50% gravel for sub-prime habitat and between 50-80% gravel for suitable habitat. Comparing the Holland *et al.* (2005) and Greenstreet *et al*. (2010) conclusions it is apparent that there is a discrepancy between the respective classifications falling within/across the sandy Gravel division. This sediment division can potentially over-represent the suitability of the habitat for sandeels (given the range of gravel content between 30-80%). In a precautionary manner the methodology in this report includes the sandy Gravel division as a mapping layer; however this is considered to be marginal habitat for sandeels and is accorded less confidence than the preferred habitat sediment divisions.

Without re-examining all of the BGS data used in developing the 1:250,000 scale seabed sediment maps a direct representation of the habitat is not possible (see Appendix A for detail). 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 but precautionary Folk sediment classification as described in Appendix A and presented in Figure 2 will be used in this methodology.

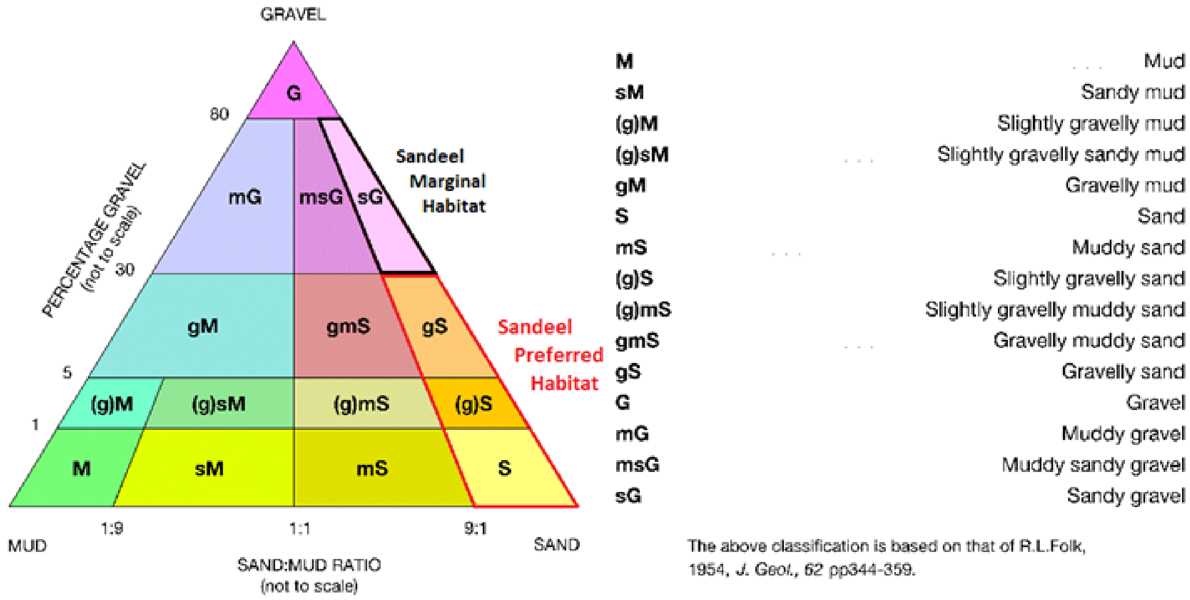
The Folk classification (Folk, 1954) sediment divisions' best describing the preferred habitat for sandeel species in UK waters are:

- Sand – S;
- slightly gravelly Sand – (s)gS; and
- gravelly Sand - gS.

The Folk classification (Folk, 1954) sediment division used to describe marginal habitat for sandeel species in UK waters is:

- sandy Gravel sG.

Figure 2: Folk triangle with sandeel preferred and marginal habitat indicated. (Source: Folk, 1954; Holland *et al.*, 2005; Greenstreet *et al.*, 2010)

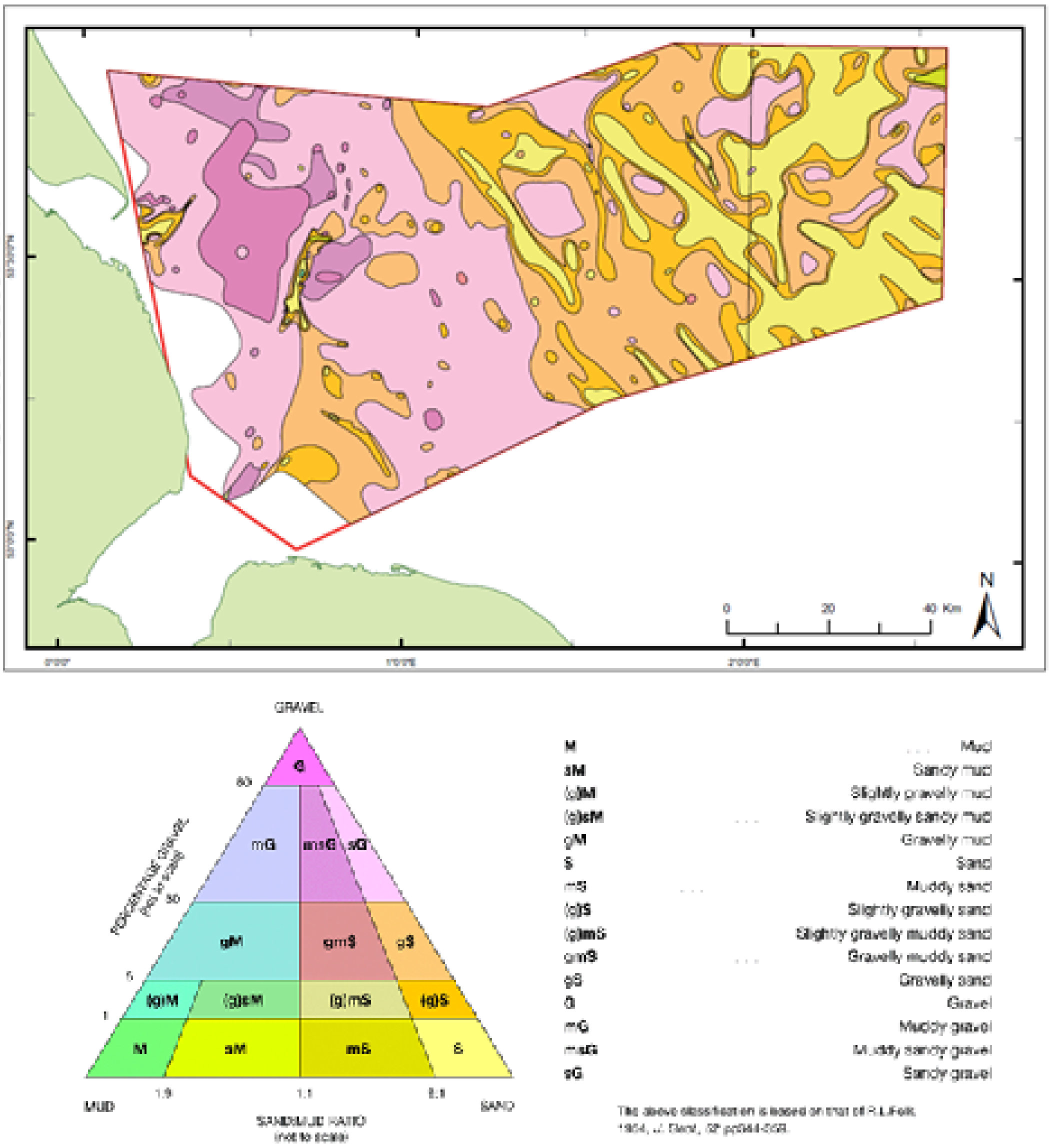


Step 1 uses the BGS data (as identified above) to map the habitat at an international/national scale with the potential to support sandeel preferred and marginal habitat. The total extent of the habitat can be identified and calculated. This value will subsequently be used when calculating the level of interaction between application areas, either alone or cumulatively, and the habitat receptor.

Step 2 - Regional – Determining preferred and marginal habitat for Sandeel in a regional context - Subsequently a detailed regional-scale consideration of preferred and marginal habitat using MAREA or REC BGS maps can be made. This should be done using the Folk classification (Figure 2) and the same habitat criteria used in Step 1. These data will allow a regional-scale representation of the sandeel preferred and marginal habitat to be set in context of the wider seas/basin-scale resource (from Step 1).

An example of the regional seabed sediment from a REC (the Humber) is presented in Figure 3 as an indication of the data resolution available.

Figure 3: Example of seabed sediment map and Folk triangle for the Humber region. (From: Tappin *et al.*, 2010)

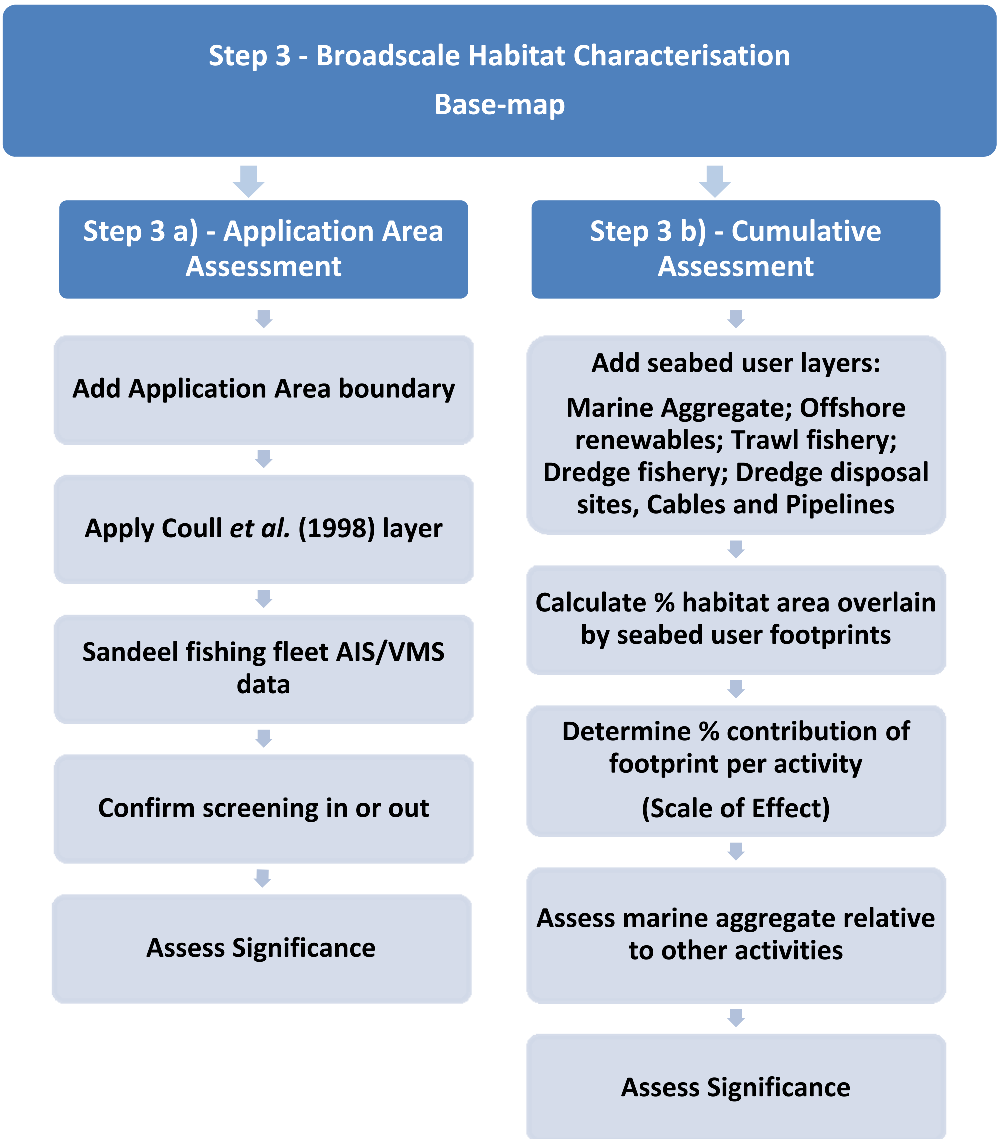


Note: Figure 3 is indicative only. Reference to the Humber REC (Tappin *et al.*, 2010) should be made to ascertain the full resolution of detail available for use in the methodology.

Steps 1 and 2 provide the Broadscale Habitat Characterisation Layers or the base-map. A calculation of sandeel preferred and marginal habitat can be conducted at this stage of Step 2. All sediments which fall outside the specified classifications do not need to be considered further in this assessment. This regional extent can subsequently be related as a percentage of the total habitat available at the international/national seas-scale (as identified in Step 1). This value along with the base-map can be used to inform both the individual application and cumulative assessments at Steps 3a) and b) respectively, through parallel processes (Figure 4).

2.2. Production of the application area-specific maps and cumulative effects assessment

Figure 4: Screening levels to enable application area and cumulative assessment between Marine Aggregate Application Areas and sandeel preferred and marginal habitat.



Step 3a) – Application Area Assessment – **i. Application Area boundary -** The first step under the application assessment approach (Figure 4) is to map the application area boundary. The method assumes that the boundary of the application area (the licence area) is representative of the potential PIZ i.e. an active dredge zone (ADZ) may occur anywhere within the application boundary during the period of the term applied for (15 years). As mentioned in Section 2 the direct removal of preferred and marginal seabed habitat within the PIZ of an application area is the receptor-exposure pathway considered in this methodology. The secondary effects of aggregate extraction, increased concentrations of suspended sediments and smothering, have been shown to be inconsequential to sandeel species (Pérez-Domínguez and Vogel, 2010). Therefore the receptor-exposure pathway analysis will only be conducted with the PIZ footprint and not the SIZ. The PIZ can be used to support determinations regarding post-dredging habitat recovery and the potential for *re-colonisation* of these seabed areas by sandeel.

No application areas are screened out at the end of Step 3a)i

By not screening out any application area at this step allows an initial mapping layer to be established against which further screening layers may be applied through Steps 3a)ii and iii. Therefore although an application area may not directly overlap a mapped area of habitat there may be additional data, e.g. fishing activity data, which indicates exposure pathways. This enables a reasonable level of conservatism to be incorporated into the methodology and ensures that all possible exposure pathways are considered before the final screening exercise at Stage 3a)iv. This rationale is also applied to Steps3a)ii and iii.

ii. Coull *et al.* (1998) layer - This data-layer draws upon the spawning ground assessment conducted by Coull *et al.* (1998), rather than the more recent assessment conducted by Ellis *et al.* (2012). Coull *et al.* (1998) considered both the known location of larvae and the relationship with suitable benthic habitat. Ellis *et al.* (2012) updated the distribution of fish larvae and information presented in Coull *et al.* (1998) but they related the mapping of this information to the ICES sub-rectangles in which they were sampled. In effect the resolution of effective mapping of these data for environmental considerations has been reduced (although it is useful as a fisheries management tool). For assessment in relation to sandeel species the focussed habitat-related data from Coull *et al.* (1998) supports more meaningful analysis.

The Coull *et al.* (1998) data-layer is mapped and overlap with any application area boundary is identified. Comparing the available sandeel distribution data (identified in Step 3a)ii against the preferred and marginal sediments identified in Steps 1 and 2 increases the confidence in identifying areas of seabed which are known not only to have sandeel present, but also the preferred and marginal habitat.

Due to uncertainties (low confidence) with the validity of the Coull *et al.* (1998) data-layer capturing the full range of sandeel spawning areas (due to age of and inability to acquire and re-analyse the data), application areas that fall outside the envelope are still progressed to the next stage of screening. This is also important for areas of seas with minimal coverage provided within the Coull *et al.* (1998) data-layer e.g. parts of the south Coast of England.

No application areas are screened out at the end of Step 3a)ii

iii. Sandeel fishing fleet AIS/VMS data - Given the uncertainty (low confidence) of the Coull *et al.* (1998) data-layer describing all of the sandeel spawning or nursery areas this spatial layer should be enhanced where possible. The method will supplement the Coull *et al.* (1998) layer with sandeel-targeted fisheries data (where these data are available) to enhance the distribution map. The application of Automatic Identification System (AIS) and Vessel Monitoring System (VMS) data-layers may extend the boundary of the Coull *et al.* (1998) envelope. It should be noted that there are limitations in the use of AIS and VMS associated with fishing vessel size as vessels <10 m length are not required to use AIS or VMS. Therefore these data will not be fully representative of the actual fishing activity occurring within the region. Data and information presented in any specific marine aggregate licence application ES will be used to enhance Step 3a)iii where possible. Using the finest resolution of data, areas of sandeel-targeted fisheries will be mapped and considered as part of the exposure pathway.

Fisheries landings data are not considered fit-for-purpose to be included in this methodology as an indication of targeted fisheries activity (due to the high uncertainty associated with linking any port of landing to the area of seabed where fish were caught). This rationale is deemed sound and supported by the MMO and RAG (MMO meeting note, 2013).

No application areas are screened out at the end of Step 3a)iii

iv. Confirm screening in or out - Spatial overlap between application area and the data layers described above will be used to screen application areas into/out of further assessment for effects i.e. a receptor-exposure pathway exists or it does not.

A higher confidence in exposure pathway is expected where there are multiple overlaps between any single application area (or associated SIZ) screened in at Step 3a)i and more than one of the data-layers from Steps 3a)ii and 3a)iii. Sediment habitat layers describing the range of preferred habitat sediment divisions (Sand, slightly gravelly Sand and gravelly Sand) (from the base-map, Steps 1 and 2) will possess the highest confidence. Areas identified as marginal habitat (sandy Gravel) will have a lower confidence than areas of preferred habitat. This is due to the fact that the sandy Gravel division (Folk, 1954), and associated mapping layer, may contain a large representation of seabed sediments with a greater than 50% gravel component (see Section 2.1 and Appendix A). Accordingly the extent of this habitat may over-represent habitat actually available to sandeel species. As such the confidence in this data-layer is reduced.

Following the seabed sediment layers, descending confidence will be ascribed to targeted fisheries data, then the Coull *et al.* (1998) layer. Individually the data-layers each hold a degree of confidence that sandeel are present, this is increased when 2 or more of these layers overlap with one another; with the highest confidence associated with a convergence of preferred habitat with the targeted fisheries data and the Coull *et al.* (1998) layers. Lower confidence will be applied where there is a convergence of marginal habitat with the targeted fisheries data and the Coull *et al.* (1998) layers. Application areas in which 2 or more data-layers are present but with no overlap will also carry a level of confidence that habitat likely to support sandeel present. Again, overlap with preferred habitat will rank higher than any overlap with marginal habitat.

Application areas with no spatial overlap with any of the data layers described in Steps 3a)i-iii above will be screened out of further assessment. They will not have to undergo EIA for sandeel preferred or marginal habitat as it is demonstrated that there is no receptor-exposure pathway.

For any application area not screened out then the resolution from Step 3a)iv is intended to allow application area-scale effects to be considered in an EIA where the application area boundary = PIZ = potential area for habitat removal.

Any application area that overlaps with an extent of sandeel preferred and/or marginal habitat identified at Step 3a)i and which has an overlap with any of the data-layers associated with Steps 3a)ii and 3a)iii is screened into further assessment and progresses to EIA i.e. there is a receptor-exposure pathway.

Step 3b) – Cumulative Assessment

- The cumulative impact assessment (CIA) process allows a characterisation of the seabed footprint of relevant seabed activities (Figure 4). This step enables an assessment of the cumulative two dimensional footprints of seabed user activities that interact with the characterisation base-map produced at the end of Step 2. The percentage of area of habitat overlap and scales of effect (percentage of contribution per activity) at a regional (MAREA) scale are calculated through this stage. These values can be related to the habitat extents from the characterisation base-map to enable a cumulative assessment.

The methodology adopts the rationale and metrics determined as fit-for-purpose for the MAREAs. The worst case scenario aligns with the MAREAs and Step 3a)i such that it is assumed that the boundary of the application area (the licence area) is representative of the PIZ i.e. an ADZ may occur anywhere within the application boundary during the period of the term applied for (15 years). Also the same as for Step 3b), the SIZ is not considered within the cumulative assessment as the secondary effects of aggregate extraction, increased concentrations of suspended sediments and smothering, have been shown to be inconsequential to sandeel species (Pérez-Domínguez and Vogel, 2010).

The cumulative assessment will consider the footprint of all the appropriate seabed user activities at a MAREA-scale. The boundary of the regional-scale CIA will be the same as indicated and mapped at Step 2 of this methodology. The relevant seabed user activities identified as interacting with sandeel preferred and and/or marginal habitat are listed in Table 1 below.

Where sandeel preferred and/or marginal habitat is located beyond the regional boundaries (delineated in Step 3), then those habitat components will be considered as outside the scope of this cumulative assessment. However this information may be usefully drawn into other components of an EIA e.g. when regarding interactions between sandeels and sensitive apex predators such as seabirds as classified populations of nearby Special Protection Areas (SPAs). These considerations are beyond the scope of this methodology *per se*, but the data-layer from Step 2 will be useful to inform any such assessment.

The footprint of marine aggregate operations can then be ranked with the other seabed user footprints allowing determinations of scale of effect to be made. At this stage of the process there will be sufficient information to enable a CIA to be conducted as part of the EIA.

Table 1: Seabed user activities likely to interact with sandeel preferred and marginal habitat at a regional scale

Seabed User Activity	Data
Marine aggregate licence areas	Application boundary; predicted/modelled SIZ; MAREAs; RECs; The Crown Estate
Offshore renewables arrays	Array footprint; EIA worst case habitat loss predictions; The Crown Estate; Planning Inspectorate; DECC
Trawl fisheries	VMS data; IFCA plots – related to preceding 10 year data
Dredge fisheries	VMS data; IFCA plots – related to preceding 10 year data
Oil and gas pipelines	EIA worst case habitat loss predictions; Planning Inspectorate; MMO; DEAL; DECC
Telecommunication cables	Subsea Cables UK; EIA worst case habitat loss predictions; Planning Inspectorate; MMO
Dredge fines disposal sites	Cefas data with plume footprints where known

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Appendix

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Appendix A

A sediment classification to enable determination of sandeel preferred and marginal habitat

Lesser Sandeel *Ammodytes marinus* display a strong diurnal cycle, occupying a position in the water column during the day where they feed on plankton in schools, before retreating into the seabed at night or when threatened (Freeman *et al.*, 2004). This behaviour limits the habitat that sandeel can occupy to areas of very specific sediment particle sizes, where penetration into the sediment is possible. Numerous studies have investigated the sediment preferences of sandeel species, identifying consistent habitat requirements (Macer, 1966; Reay, 1970; Wright *et al.*, 1998; Wright *et al.*, 2000; Holland *et al.*, 2005; van der Kooij *et al.*, 2008; Greenstreet *et al.*, 2010). Wright *et al.* (2000) and Holland *et al.* (2005) recently described sandeel habitat requirements as medium to coarse sand of a diameter between 0.25 and 2 mm, with a mud content of less than 10% (particles < 63 µm). Wright *et al.* (2000) demonstrated this range in a series of controlled laboratory-based experiments and the results were replicated in field observations by Holland *et al.* (2005). Most recently Greenstreet *et al*. (2010) have investigated the determinations made in Holland *et al.* (2005) and presented an alternative analysis. These two studies have reviewed and reconsidered all of the previous work on sandeel habitat preference (as cited above). Therefore the basis for determining preferred and marginal sandeel habitat used in this methodology is derived from the Holland *et al.* (2005) and Greenstreet *et al*. (2010) investigations.

Table A1: Wentworth particle size descriptions. (From: Wentworth, 1922)

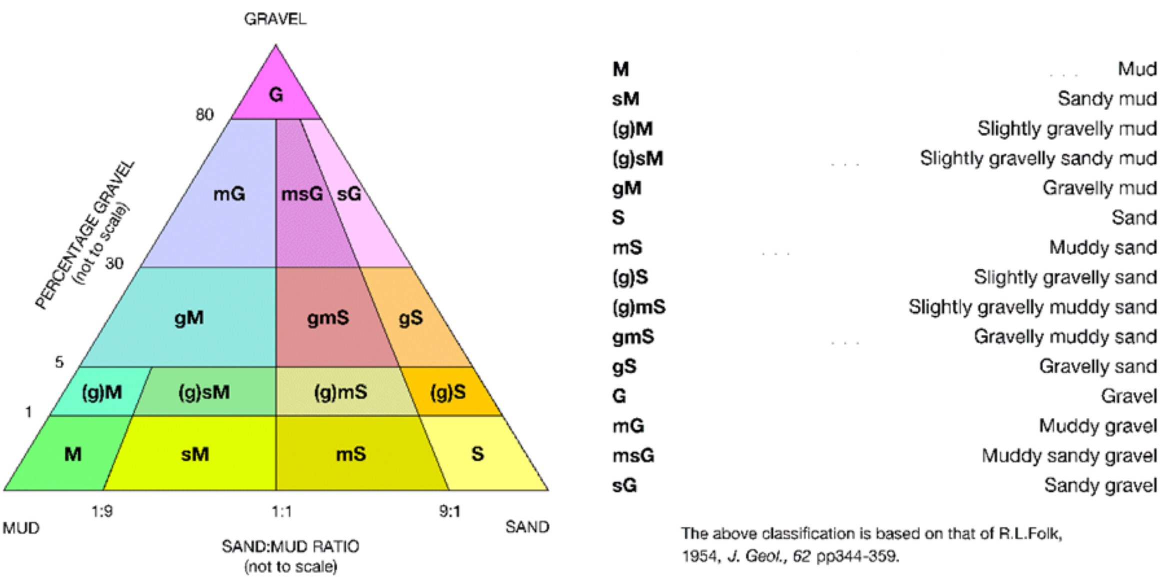
Particle size (mm)	Size terms (after Wentworth, 1922)	
>64	Cobbles	
64-32	Pebbles	very coarse
32-16		coarse
16-8		medium
8-4		fine
4-2		very fine
2-1	Sand	very coarse
1-0.5		coarse
0.5-0.25		medium
0.25-0.125		fine
0.125-0.062		very fine
0.062-0.031	Silt	coarse
0.031-0.016		medium
0.016-0.008		fine
0.008-0.004		very fine
<0.004	Clay	

Sedimentary analysis routinely separates samples based on the particle size of the component grains. The resulting size fractions have been described and standardised by Wentworth (1922) and are the accepted form of reporting the particle size distribution of sediments (Table A1). Folk (1954) produced a matrix to describe seabed sediments based upon the ratio of Sand to Mud in relation to the percentage Gravel within a sample (Figure A1). The British Geological Survey (BGS) has utilised the Folk (1954) classifications for mapping the seabed and cross referenced with the Wentworth scale for the divisions between Mud, Sand and Gravel (Table A2). This has become the standard particle size arrangement utilised in the broadscale 1:250,000 scale BGS seabed sediment maps and is widely reported elsewhere.

Table A2: The British Geological Survey division of Folk sediment classifications based upon the Wentworth (1922) scale. (Source: Wentworth, 1922; Folk, 1954)

Particle size (mm)	Size terms (after Wentworth, 1922)		Size terms (after Folk, 1954)
>64	Cobbles		Gravel
64-32	Pebbles	very coarse	
32-16		coarse	
16-8		medium	
8-4		fine	
4-2		very fine	
2-1	Sand	very coarse	Sand
1-0.5		coarse	
0.5-0.25		medium	
0.25-0.125		fine	
0.125-0.062		very fine	
0.062-0.031	Silt	coarse	Mud
0.031-0.016		medium	
0.016-0.008		fine	
0.008-0.004		very fine	
<0.004	Clay		

Figure A1: The Folk triangle and description of sediment codes. (From: Folk, 1954)

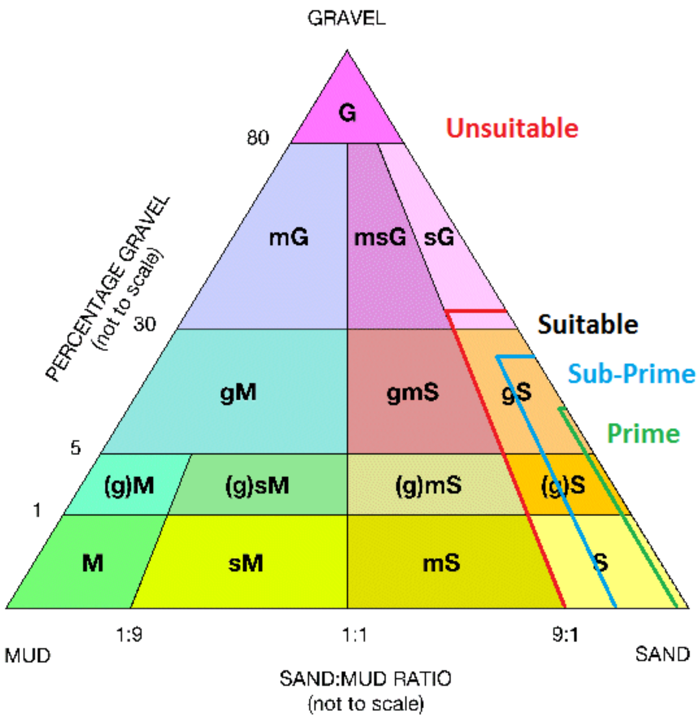


Describing the sediments in terms of the Wentworth (1922) scale Holland *et al.* (2005) identified prime to suitable[1] sandeel habitat (0.25 and 2 mm, with a mud content of less than 10%) and included the fractions very coarse sand, coarse sand and medium sand. Identifying this range on the

[1] See the Glossary of terms for the definition used in this method statement of Preferred, Prime, Sub-Prime, Suitable and Unsuitable sandeel habitat.

BGS modified Folk (1954) triangle proves complex. This is because the Sand descriptor on the triangle also includes fine and very fine sand as per the Wentworth (1922) scale and these have been shown to be negatively associated with sandeel abundance (Holland *et al.*, 2005). Despite this discrepancy, it is still possible to indicate where the habitat indicated in Holland *et al.* (2005) lies within the Folk triangle (Figure A2). It is apparent from Figure A2 that the prime habitat for sandeel covers a very small proportion of the Sand, slightly gravelly Sand and gravelly Sand divisions, whereas the region determined as suitable habitat includes the whole of these divisions and a small proportion of sandy Gravel (<35% gravel).

Figure A2: The suitability of sediments for sandeel habitat based on information provided in Holland *et al.* (2005). (Source: Folk, 1954; Holland *et al.*, 2005)

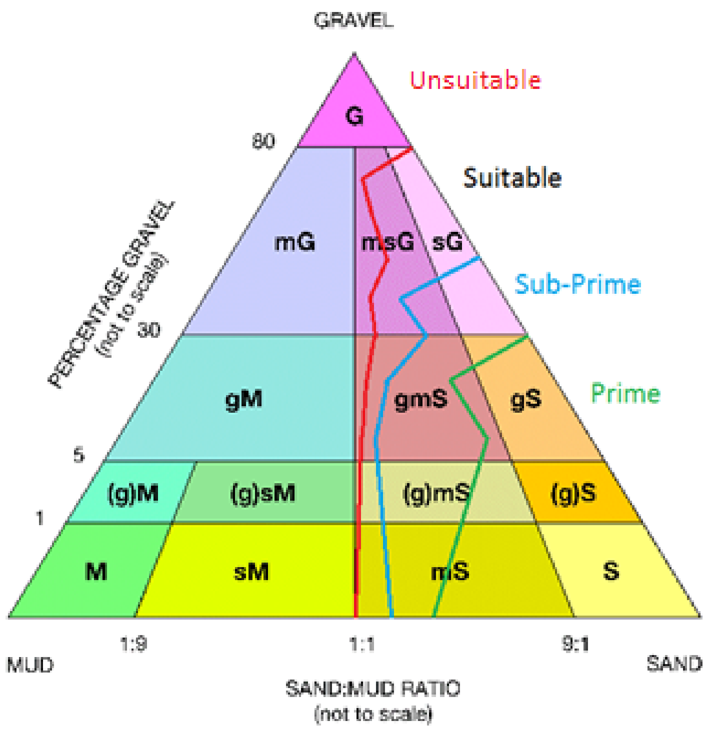


Greenstreet *et al.* (2010) reinterpreted the data contained in Holland *et al.* (2005) and grouped the very fine and fine sands together with the silts and clay (Table A3). By doing this they were able to interpret the division of habitat suitability in relation to the percentage of coarse sands compared to mud (mud measured as <0.25 mm). By grouping the fine sands with the mud it was then possible to plot the representative habitats onto the Folk triangle (Figure A3). It is important to note that in Figure A3 the fine sands are grouped with the mud and therefore this is not a representation of the BGS modified Folk classification nor does it relate to the widely available BGS 1:250,000 scale seabed sediment maps.

Table A3: The division of Folk sediment classifications based on information presented in Greenstreet *et al.* (2010) in relation to the Wentworth (1922) particle size scale. (Source: Wentworth, 1922; Folk, 1954; Greenstreet *et al.* 2010)

Particle size (mm)	Size terms (after Wentworth, 1922)		Size terms (after Folk, 1954)
>64	Cobbles		
64-32		very coarse	
32-16		coarse	
16-8	Pebbles	medium	Gravel
8-4		fine	
4-2		very fine	
2-1		very coarse	
1-0.5		coarse	Sand
0.5-0.25	Sand	medium	
0.25-0.125		fine	
0.125-0.062		very fine	
0.062-0.031		coarse	
0.031-0.016		medium	Mud
0.016-0.008	Silt	fine	
0.008-0.004		very fine	
<0.004	Clay		

Figure A3: The suitability of sediments for sandeel habitat based on information provided in Greenstreet *et al.* (2010). (Source: Folk, 1954; Greenstreet *et al.*, 2010)



Reviewing both the Holland *et al.* (2005) and the Greenstreet *et al.* (2010) interpretations of the sediment data (as indicated on the Folk triangles of Figures A2 and A3), a sandeel preferred and marginal habitat classification has been identified (Figure A4). This classification utilises the BGS modified Folk classification (Table A2) and has the intention of applying the results to the 1:250,000 scale seabed sediment maps. Greenstreet *et al.* (2010) included components of the muddy Sands within their prime, sub-prime and suitable habitat classification (Figure A3). However, when using the BGS 1:250,000 scale seabed sediment maps the division across the muddy Sands divisions cannot be made to effectively show the Mud to Sand ratio. If the methodology adopted to map the muddy Sand divisions this would result in a gross over-representation of sandeel preferred habitat (much more so than the mapping of sandy Gravels as discussed below).

By restricting the mud content of the sediments to no more than 10%, as in Holland *et al.* (2005) (they excluded muddy Sands from their selection of prime, sub-prime and suitable habitats for sandeels (Figure A2)), it is possible to limit the selection to the right hand side of the Folk triangle. This approach has been adopted in this methodology. Therefore the Holland *et al.* (2005) habitat consideration, excluding divisions containing more than 10% mud, has been adopted, whilst the Greenstreet *et al.* (2010) conclusion has been rejected.

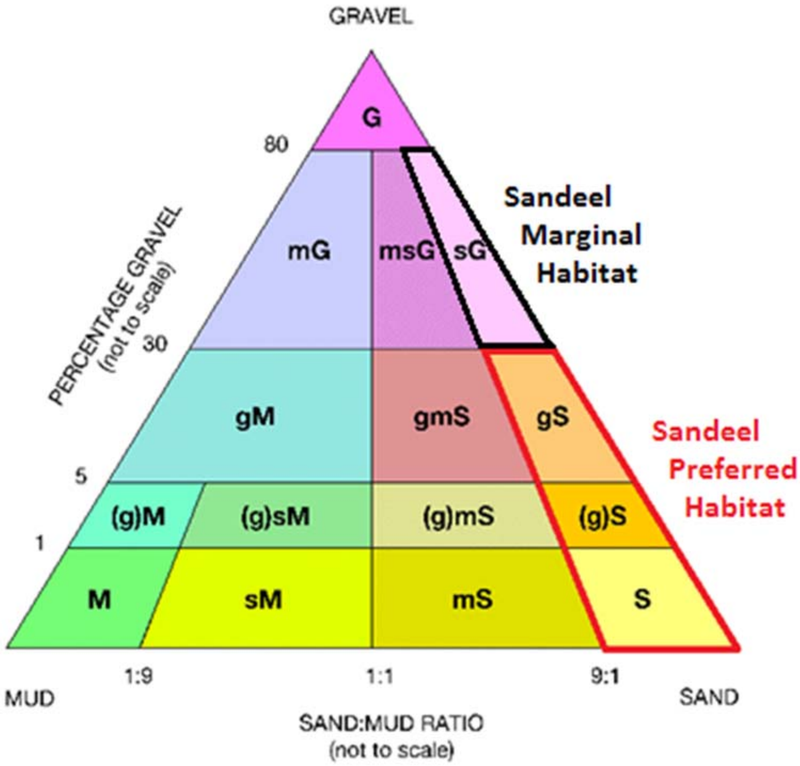
The Sand, slightly gravelly Sand and gravelly Sand divisions of the Folk classification are considered to represent sandeel preferred habitat i.e. the sediment divisions which sandeel favourably select as habitat.

Holland *et al.* (2005) and Greenstreet *et al*. (2010) also concluded that suitable sandeel habitat can include a gravel component. Greenstreet *et al.* (2010) identified the prime habitat as containing less than 30% gravel and the sub-prime habitat with a gravel component greater than 30% but less than 50%. They gave the boundary between suitable and unsuitable habitat as 80% gravel (Figure A3). Holland *et al.* (2005) described the threshold for sub-prime habitat as 25% gravel or less with sediment containing more than 35% gravel as unsuitable (Figure A2). Comparing the Holland *et al.* (2005) and Greenstreet *et al*. (2010) determinations it is apparent that there is a discrepancy between the respective classifications falling within/across the Folk (1954) sandy Gravel division. In the Folk classification gravel content greater than 30% and up to 80% is represented by the sandy Gravel division (with a 10% or less mud component). Using this classification there is an inability to divide the sandy Gravel division at the 35% or 50% level in the Folk classification. Therefore any representation of sandy Gravel (using the 1:250,000 scale BGS maps) will include the Greenstreet *et al*. (2010) classification of suitable habitat. However the sandy Gravel division will also map a large component of unsuitable habitat as determined by Holland *et al.* (2005).

Whilst it is acknowledged that mapping sandy Gravel may over-represent sandeel habitat, as the 35% gravel content cannot be determined, a precautionary approach has been adopted. As Greenstreet *et al*. (2010) include 50-80% component within their suitable habitat category then this methodology uses the sandy Gravel division. However, this is determined to be marginal habitat i.e. it is sandeel habitat with adequate sediment structure but will only support low numbers of sandeel.

Therefore the resulting sandeel habitat classification used for this methodology is represented by the Sand, slightly gravelly Sand and gravelly Sand divisions (preferred habitat) and sandy Gravel (marginal habitat) of the Folk (1954) triangle (Figure A4).

Figure A4: Folk triangle with preferred and marginal sandeel habitat indicated. (Source: Folk, 1954; Holland *et al.*, 2005; Greenstreet *et al.*, 2010)



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Appendix B: Confidence Assessment Protocol and Methodology Version 6

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Mapping the Potential for Atlantic Herring Spawning Habitat and Sandeel Habitat:

Confidence Assessment Protocol and Methodology (Version 6)

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ABP marine environmental research Limited, Environmental Resource Management Limited, Fugro EMU Limited, MarineSpace Limited, and Marine Ecological Surveys Limited have been commissioned by HaskoningDHV UK Limited, a company of Royal HaskoningDHV, acting in its capacity as Minerals and Infrastructure Managing Agent for The Crown Estate, on behalf of: British Marine Aggregate Producers Association; Boskalis Westminster Limited; Britannia Aggregates Limited; CEMEX UK Marine Limited; DEME Building Materials NV; Hanson Aggregates Marine Limited; Sea Aggregates Limited; Tarmac Marine Dredging Limited; and Volker Dredging Limited; to conduct regional cumulative impact assessments (CIAs) of marine aggregate application areas with seabed that has the potential to be used as: spawning habitat by Atlantic Herring *Clupea harengus*; and as habitat supporting sandeel species; *Ammodytes marinus*, *A. tobianus*, *Gymnammodytes semisquamatus, Hyperoplus lanceolatus* and *H. immaculatus*.

Contents

List of Tables

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1. Overview

1.1. Introduction

Confidence in the mapped Atlantic Herring potential spawning habitat and sandeel habitat or the '*Herring and sandeel indicator layers*' is required for all the exposure pathways (licence area + impact zone). Any confidence assessment that is informed through multiple data layers needs firstly to assess the confidence in each layer; and secondly to assess the combined confidence. The individual layers may either have spatially uniform or variable confidence, depending on the underlying data.

The rationale and methodology used in this report and applied to the regional Cumulative Impacts Assessments (CIAs), detailed in Reach *et al.* (2103) and Latto *et al.* (2103) have been discussed with Cefas and agreed (MMO, 2013).

1.2. Datasets Considered

The spatial datasets considered in the confidence assessment to inform the location of Atlantic Herring potential spawning grounds, and habitat likely to support sandeel, include:

- Substrate Folk Classification: British Geological Survey (BGS);
- Substrate Folk Classification: Marine Aggregate Regional Environmental Assessment (MAREA);
- Substrate Folk Classification: Regional Environmental Characterisation (REC);
- Fishing Fleet: Vessel Monitoring Systems (VMS);
- Fishing Fleet: Marine Management Organisation (MMO) Sightings;
- Fishing Fleet: Inshore Fisheries and Conservation Authorities (IFCA) Sightings;
- Spawning Grounds: Eastern Sea Fisheries Joint Committee (ESFJC);
- Spawning Grounds: Coull *et al.* (1998); and
- Spawning Grounds (Herring only): International Herring Larvae Surveys (IHLS)

In all cases, except International Herring Larvae Surveys (IHLS) which only target Atlantic Herring, the data inform the potential location of spawning grounds for Atlantic Herring and sandeel habitat. For any one data source, e.g. Eastern Sea Fisheries Joint Committee (ESFJC), the confidence assessments detailed below are generally the same for both Atlantic Herring and sandeel, as the same methods have been used in data collation/processing. However, in the case of seabed sediment data, the confidence does differ, as outlined below.

All datasets needed to be in a polygon format, as opposed to point data, as this allows them to be combined and give an overall assessment.

1.3. Datasets Omitted

Whilst there was some potential in interpolating the Marine Management Organisation (MMO) sightings data to form area (polygon) data, this dataset was omitted after plotting the relevant gear types (as detailed below for Vessel Monitoring System (VMS)) and comparing against VMS data. This indicated that the VMS data already show the relevant gear type in the same locations as presented by the MMO sightings, except in a very few cases that were not considered significant.

The Inshore and Fisheries Conservation Authority (IFCA) dataset has also been excluded as the full resolution (all IFCAs) dataset was not supplied within the required timescales.

The REC substrate 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 by BGS to include REC data (Humber, East Anglia, South Coast RECs); and the Marine Aggregate Regional Environmental Assessments (MAREAs) include REC data Therefore use of the REC data would result in duplication of data.

1.4. Confidence Test Method

1.4.1. Confidence in the Data

Following review of various approaches used to date, including MESH[1], UKSeaMap[2], the MMO's approach (MMO, 2013), a scoring proforma has been developed to apply to confidence assessments as shown below (Table 1.1). This was adopted where there were no supporting spatial data to inform spatial variation in confidence.

The first five parameters (method, vintage, positioning, resolution, quality standards) are concerned with the data themselves, i.e. how confident is the Marine Aggregate EIA WG in the data being as described?

Note that 'spatial coverage' has not been assessed but instead the resolution 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 spawning grounds, 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.

[1] http://www.searchmesh.net/default.aspx?page=1635
[2] http://jncc.defra.gov.uk/pdf/UKSeaMap2010_TechnicalReport_7_ConfidenceExternalReview.pdf

Table 1.1: 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
Resolution	Resolution of the data in terms of what is included, density of points, time series length and interval, gaps in data. Note this does not assess spatial coverage	1
Quality Standards	Quality control information provided, review internally, externally	1
Indicator of Spawning	Suitability of the dataset to inform spawning potential	5

1.4.2. Confidence in the data indicating spawning grounds

The final parameter, 'indicator of spawning', is not concerned with the data themselves, but the confidence in the data indicating spawning grounds i.e. when there are no direct data on spawning measurements (such as seabed sediments), what confidence is there that the data may inform or indicate spawning grounds? As this project is using the data to assess the likelihood or confidence of spawning ground 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.

1.4.3. 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 spawning grounds. This was only concerned with parameters that reduced certainty about the data so, for example, variation in abundance (as in the case of IHLS) or fishing time (VMS) does not reduce certainty in the data. With abundance, either there is spawning or there is not (presence/absence). This approach was approved by Cefas regarding the IHLS dataset (MMO, 2013).

It was concluded that only two datasets had spatial variations in a parameter that informs confidence: seabed sediment Folk class for each of the BGS and MAREA datasets. This is addressed separately in Section 2.1 and 2.3 below.

1.4.4. Scoring

For each parameter or confidence test detailed above (i.e. that contributes to the data layer's overall score), a score between 0 and 3 is assigned, where 0 = unknown and 3 = high confidence. However for the indicator of spawning (final parameter in table above), a score of 0 would mean it is unknown whether the dataset can be used to infer spawning 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 spawning = very low confidence.

Table 1.2: 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 spawning', 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. This is illustrated further in Section 3.

1.4.5. Confidence in the seabed sediments data indicating potential spawning habitat

As detailed in Reach *et al.* (2013), Atlantic Herring is known to prefer Gravel and sandy Gravel seabed sediments; and also have a marginal habitat sediment class of gravelly Sand. Therefore the Folk sediment classification provides a spatially variable indicator to spawning and hence the level of confidence is also variable (Appendix A and Addendum).

The level of confidence in Folk classes indicating potential spawning grounds 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 Gravel indicating Atlantic Herring potential spawning habitat (hence the 'preferred habitat sediment') than gravelly Sand (the 'marginal habitat sediment') (Appendix

A of MarineSpace Ltd *et al.*, 2013a; Reach *et al.*, 2013). This field is termed 'Folk category indicates marginal/preferred habitat[3]' 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 spawning habitat, or not, e.g. the Folk category Gravel contains sediment types outside of the preferred range for Atlantic Herring spawning habitat i.e. there is the possibility that the Folk Gravel class may contain >5% muds, in which case this is unfavourable to support Atlantic Herring spawning activity. 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 spawning grounds with high confidence as it is only an indicator, i.e. direct measurements of spawning carry much greater confidence, such as IHLS data. Therefore the matrix is scored from 0 to 2. As detailed in Section 1.4.4 above, where scoring the indicator for spawning, a zero score does not imply 'unknown', but 'very low' instead.

Each of the two parameters are scored separately from 0 to 2 (very low to medium); then the two are combined as shown in the matrix (Table 1.3).

Table 1.3: Generic matrix for habitat sediment type confidence used in the Confidence Assessment Protocol and Methodology.

	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)

[3] Whilst acknowledging that seabed sediment class is only one physical parameter that contributes to the overall habitat requirements for Atlantic Herring with the potential to support spawning e.g. oxygenation, nearbed transport rates, micro-scale seabed morphological features etc.

As per the method statement for Atlantic Herring, of the three Folk categories that contribute to potential spawning habitat (Gravel (G), sandy Gravel (sG) and gravelly Sand (gS)), all of these over-represent the habitat sediment divisions. This reduces the confidence. Therefore the matrix results are as follows in Table 1.4:

Table 1.4: Matrix for Atlantic Herring potential spawning habitat sediment type confidence scoring used in the Confidence Assessment Protocol and Methodology.

	Folk category over represents = 0 (very low)	Folk category represents correctly = 2 (medium)
Folk category indicates marginal habitat sediment = 0 (very low)	gS = 0 (very low)	N/A
Folk category indicates preferred habitat sediment = 2 (medium)	G, sG = 1 (low)	N/A

Similarly the sandeel preferred and marginal habitat sediment classification is represented in Latto *et al.* (2013) and used within the regional CIAs. This is detailed in Section 2.1.2 below with the rationale drawn from Latto *et al.* (2013) and also the Appendix A of MarineSpace Ltd *et al.* (2013b).

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 in relation to marginal habitat presence and magnitude of effects will then be considered within the application's EIA.

1.4.6. Confidence in the International Herring Larvae Survey data indicating potential spawning habitat

The IHLS has the highest confidence (final score of 5 – see Section 2.6) as it is a direct indicator of presence/absence of 0-ringer larvae at the surface of the spawning habitat i.e. where the 0-ringer larvae are caught indicates that spawning has occurred at that seabed location; it is a direct measure of spawning. For the larvae in the central and southern North Sea the 0-ringer size range is >0-10 mm length and for the east English Channel and south coast the size range is >0-11 mm (ECA and RPS, 2011; ICES, 2012; Reach *et al.*, 2013).

Number count cannot be used to inform spatial variation in the confidence. To align with the assessment of the other data-layers, the confidence is related to the standard/credibility of the data, not the scale of spawning. Therefore in the interpolated IHLS map, 0 = absence and ≥1 = present. However the Marine Aggregate EIA WG is keen that these count data should not be lost in the assessment process, i.e. number count should still be used to inform any EIA. The supporting IHLS interpolation exercise and GIS data-layer will facilitate this data review and inclusion within any EIA.

As mentioned previously, the IHLS data represents direct measurements of Atlantic Herring larvae of the appropriate size classes, there is no inference, it is direct data on spawning grounds, and accordingly has the highest confidence possible.

2. Individual Layers' Confidence Assessment

2.1. Habitat from BGS Folk classes (substrate)

2.1.1. Confidence in the BGS Data

The confidence in substrate needs to be assessed for both the data themselves and the level of confidence in it acting as an indicator of potential spawning habitat for Atlantic Herring and sandeel. The confidence in the data is scored and justified within the first five parameters in the table below. As these first five parameters are concerned solely with the data, they are identically scored for Atlantic Herring and sandeel. No spatial variation is provided for the confidence in the substrate data (i.e. the data themselves).

Table 2.1: British Geological Survey Folk Map Confidence Scores

Confidence test	Score*	Rationale - Please explain scoring with reference to all considerations
Method	2	This is assumed in absence of BGS input. The BGS substrate map and Folk classes are interpolated from PSA samples, multibeam and seismic surveys. Confidence for BGS SBS V3 has been inferred from the confidence provided by UKSeaMap (2010) as this is all that is available to assess within the timeframes of the Atlantic Herring and sandeel project. However BGS SBS V2 was used in UKSeaMap and also UKSeaMap used an additional 3 datasets: the hard substrata layer (Gafeira *et al.*, 2010); the Water Framework Directive (WFD) typology layer (Rogers *et al.*, 2003); and the NOC deep sea sediment layer (Jacobs and Porritt, 2009). Minor gaps between the substrate layer and the mean low water mark were subsequently filled using data from Marine Nature Conservation Review surveys. These survey methods are unknown, but are clearly approved for use by BGS in national mapping.
Vintage	1	This is assumed in absence of BGS input. BGS data are often old (>10 years).
Positioning	3	This is assumed in absence of BGS input. All locations are likely to be provided through accurate GPS systems.
Resolution	3	This is assumed in absence of BGS input. The density of survey data informs confidence in interpolation. Whilst the dataset uses a variety of data types (remote sensing, PSA), a case study example of PSA density has been assessed for the Humber REC, which shows a map of legacy data in the report. The data density is good.
Quality Standards	2	This is assumed in absence of BGS input. Data are clearly approved for use by BGS in national mapping.
Spawning Indicator	Herring = 1 or 0 sandeel = 2 or 0	See matrices below. Varies by Folk class category, Folk class boundary representation; and varies between Atlantic Herring and sandeel.

2.1.2. Confidence in the BGS Data Indicating Spawning Grounds

As detailed in the full reports, Atlantic Herring is known to prefer Gravel and sandy Gravel; and also have a marginal preference for habitats of gravelly Sand. Sandeel are known to prefer Sand, slightly gravelly Sand and gravelly Sand; and also to have a marginal habitat preference within sandy Gravel. Therefore the Folk sediment class provides a spatially variable indicator of spawning and habitat potential and hence level of confidence.

However the level of confidence in the Folk classes indicating potential spawning habitat needs to consider two variables. First, it needs to consider the confidence that the Folk category contains the correct seabed sediment, e.g. there is more confidence in Gravel indicating Atlantic Herring potential spawning habitat (hence the 'preferred habitat'), than gravelly Sand (the 'marginal habitat'). This is termed 'Folk category indicates marginal/preferred habitat' in the matrix below.

Secondly, it needs to consider whether the Folk class boundaries, i.e. the upper and lower limits of each of Gravel, Sand and Mud, are defined in the correct form to delineate the potential spawning habitat for Atlantic Herring or habitat used by sandeel, e.g. the Folk category Gravel contains sediment types outside of the preferred range for Atlantic Herring spawning and therefore has a lower confidence than, for example, the Sand class for sandeel which is suitably defined, i.e. sandeel preferred habitat is within the whole of the Sand class. This is termed 'Folk category over represents/correctly represents' in the matrix below. These considerations are illustrated fully in the main report.

Due to these two factors, a matrix has been developed to assess confidence in the BGS data indicating Atlantic Herring potential spawning habitat and sandeel habitat, as shown below. Normally such matrices are provided for parameters scored from low to high, or numerically, e.g. from 1 to 3. However, in this case, it is never possible that the BGS data can indicate potential spawning habitat with high confidence as it is only an indicator, i.e. direct measurements of spawning, such as IHLS, carry much greater confidence. Therefore the matrix is scored from 0 to 2. As detailed above, where scoring the indicator for spawning, a zero score does not imply 'unknown', but 'very low' instead.

Therefore, 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 in Table 2.2.

Table 2.2: Generic matrix for habitat sediment type confidence used in the Confidence Assessment Protocol and Methodology.

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

Atlantic Herring

As per the method statement for Atlantic Herring, all of the three Folk categories that represent potential spawning habitat for Herring (Gravel, sandy Gravel and gravelly Sand) over-represent the categories. This reduces the confidence. Also the greatest preference for habitat is at the gravelly end of the scale. This increases the confidence. Therefore the results are as follows in the matrix in Table 2.3.

Table 2.3: Matrix for Atlantic Herring potential spawning habitat sediment type confidence scoring used in the Confidence Assessment Protocol and Methodology.

	Folk category over represents = 0 (very low)	Folk category represents correctly = 2 (medium)
Folk category indicates marginal habitat = 0 (very low)	gS, sG = 0 (very low)	N/A
Folk category indicates preferred habitat = 2 (medium)	G = 1 (low)	N/A

Sandeel

As per the method statement for sandeel, of the four Folk categories that represent potential habitat for sandeel (sandy Gravel, gravelly Sand, slightly gravelly Sand and Sand), one of these over-represents the category: sandy Gravel. This reduces the confidence. Also the greatest preference for habitat is at the sandy end of the scale. This increases the confidence. Therefore the matrix results are as follows in Table 2.4.

Table 2.4: Matrix for sandeel habitat sediment type confidence scoring used in the Confidence Assessment Protocol and Methodology.

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

2.2. Habitat from MAREA Folk classes (substrate)

2.2.1. Confidence in the MAREA Data

The confidence scoring of the MAREA data is provided in the first five categories of the table below. The data density used to underpin both the BGS and MAREA sediment layers is relatively similar, although with a slight bias to marine aggregate areas in the MAREA data, as expected. However as new licences may be in areas not focused on during the MAREA, the resolution is considered to have the same level of confidence as BGS.

Table 2.5: Marine Aggregate Regional Environmental Assessment Folk Map Confidence Scores

Confidence test	Score*	Rationale - Please explain scoring with reference to all considerations
Method	2	Method of data collection varies between projects.
Vintage	3	All regional MAREA data collected in the last 10 years, some regions more recently than others.
Positioning	3	Accurate GPS recording of locations
Resolution	3	Density of sampling within each MAREA region is greatest in the vicinity of licence areas. As the project will use licence areas, the score reflects this.
Quality Standards	2	This is assumed in absence of information in report. Data are approved by MMO and RAG for use by BMAPA and supplied by professionals.
Spawning Indicator	Herring = 1 or 0 Sandeel = 2 or 0	See matrices below. Varies by Folk class category, Folk class boundary representation; and varies for Atlantic Herring and sandeel.

2.2.2. Confidence in the MAREA Data Indicating Spawning Grounds

The MAREA dataset has been addressed in the same way as per the BGS Folk class layer. However there are some discrepancies in the presentation of certain sediment classes that affect the way these data may be used to assess Atlantic Herring potential spawning habitat and habitat used by sandeel.

First, the MAREA datasets, whilst mostly complying with the Folk classification, sometimes combine two classes into one.

- The Thames MAREA has grouped sandy Gravel and gravelly Sand as a single mapping unit. However these two sediment classes delineate the threshold between marginal and preferred habitat for both Atlantic Herring and sandeel.
- The South Coast MAREA has grouped Gravel and sandy Gravel as a single mapping unit. However, only one of these two sediment classes, sandy Gravel, is suitable to be used as an indicator for sandeel (marginal habitat).
- In some cases even coarser groupings are made, collating more than two Folk classes, using a classification system that aligns with EUNIS (European Nature Information System). In UKSeaMap 2010, the four EUNIS broad sediment classes of coarse sediment, mixed sediment, sand and mud are assigned to the different Folk categories. (The allocation made in UKSeaMap 2010 is considered standard practice in the UK.) This groups three sediment classes within coarse sediment: Gravel, sandy Gravel and gravelly Sand. Whilst all these three Folk classes within coarse sediment are contained within the Atlantic Herring potential spawning habitat, the threshold between marginal and preferred habitat lies between two of these (sG and G). Also, for sandeel, the coarse sediment category includes an additional Folk class, Gravel, which is not a potential spawning habitat for sandeel.

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

Note: The MAREA data were supplied with the shapefiles clipped to each of preferred and marginal habitats, for each of Atlantic Herring and sandeel. Due to the issue of combined Folk sediment classes as noted above (for the Outer Thames and South Coast regions), this resulted in both the preferred and marginal shapefiles showing the same area of potential habitat, e.g. the combined Gravel and sandy Gravel class was present in each shapefile even though part of the sediment class mapped did not conform to the habitat parameters for the shapefile in question. In effect the shapefiles over-represent the preferred or marginal habitat and this misrepresentation is present in both shapefiles. Therefore, at the Outer Thames regional level (for both Atlantic Herring and sandeel) and at the South Coast (for sandeel) double-accounting of seabed occurs with an area incorrectly representing both marginal and preferred habitat which cannot occur in the real world; as the two layers are mutually exclusive. In the confidence layers produced, no overlap was allowed and any overlap is removed by taking the lower class, i.e. marginal.

The second difference with BGS data is in the overlapping of data between adjoining MAREA regions e.g. there can be some disagreement in interpreted Folk classes at overlapping MAREA locations. Again, the lowest confidence approach has been taken, e.g. if one MAREA predicts gravelly Sand whereas the other predicts Gravel, then in the case of Atlantic Herring, the lowest confidence (for gravelly Sand) is adopted.

2.3. Coull *et al.* (1998)

2.3.1. Confidence in the Coull *et al.* (1998) Data

The scores for the confidence in the Coull *et al.* (1998) data are provided in the first five parameters of the table below. There were no spatially varying parameters that could be used to inform confidence in the maps provided in the report (and no GIS available).

Table 2.6: Coull *et al.* (1998) Spawning Grounds Confidence Scores

Confidence test	Score	Rationale
Method	1	Data are based on collated distribution of eggs, larvae, young and commercially sized fish, seabed sediments, and acoustic visualisation techniques. However, no detail is provided as to the source of these data, their robustness, or age, and it is not clear how the maps have actually been compiled. However, it is stated that the data are sourced from reputable Government agencies (Cefas, FRS) which would indicate suitable techniques were used, and the paper from which the maps are taken has been published and referred to in subsequent publications (e.g. Ellis *et al.*, 2010).
Vintage	1	Report published 1998 and so data are at least 15 years old and patterns in spawning may have changed - it is stated that the map should not be seen as a rigid, unchanging description of presence or absence. It is not stated what range of data have been used in the report, or when they are from.
Positioning	1	As no method has been provided for how the boundary of spawning areas was produced, accuracy is not known.
Resolution	2	Full UK coverage is provided at relatively fine scale (although with limitations, as described above). The report states that the maps represent the widest known distribution given current knowledge (1998). It does not specify what area is covered but maps appear to cover all of the North Sea and English Channel (as relevant to this project). The resolution is down-graded however, due to a lack of coverage along the English south coast. There is no information provided on density of points to inform the maps. As noted above, it is stated that the map should not be seen as a rigid, unchanging description of presence or absence.
Quality Standards	0	No evidence of any quality standards.
Spawning Indicator	2	It is possible that no inference between actual data points is made and is direct mapping of spawning. However methods do not qualify this and only indicate so cannot be 100% sure.

2.3.3. Confidence in the Coull *et al.* (1998) Data Indicating Spawning Grounds

Whilst the Coull *et al.* (1998) layer has specifically been developed to show spawning grounds, the methods reported do not detail what types of data were used, lowering the confidence.

2.4. VMS Fishing Fleet

2.4.1. Confidence in the VMS Data

As outlined in the table below, the confidence in the VMS data (first five parameters in table) is strong, owing to the statutory requirement and standardised equipment to comply with domestic legislation. There are no parameters provided in the GIS that can be used to inform spatial variation in confidence, so the VMS data confidence is uniform.

Table 2.7: Vessel Monitoring System Gear Type Confidence Scores

Confidence test	Score	Rational
Method	3	Vessel monitoring systems (VMS) are satellite-based systems used in commercial fishing to allow environmental and fisheries regulatory organizations to monitor the position, time at a position, and course and speed of fishing vessels. VMS data are collected through specialist electronic equipment. All vessels over 12 m must operate VMS when at sea, to comply with EU law. The technical requirement for these devices is stated in the Commission Implementing Regulation (EU) which lays down detailed rules for the implementation of Council Regulation. Therefore the method of data collection is of a high standard
Vintage	3	2006-2012 up to date data.
Positioning	3	Positional data extracted from GPS-Derived Vessel Monitoring Data. These recordings are made using tamper-proof technology with an error less than 500 m at 99% confidence.
Resolution	2	The entire North Sea and English Channel are covered by VMS data. VMS systems have been compulsory since 2004 for >18 m vessels, with increasing control for smaller vessels until 2011 (>12 m). Therefore data resolution increases over time as the smaller vessels become included. No vessels <12 m including, for instance, the inshore under 10 m fisheries fleet are included in this data set.
Quality Standards	3	Data reviewed by the MMO and accompanied by MEDIN standard metadata.
Spawning Indicator	0	VMS data are split into demersal gear types and pelagic gears. The pelagic gears (industrial trawler, pelagic side trawler, pelagic stern trawler) target adult Atlantic Herring, as well as many other species; and therefore provide a low confidence indicator to spawning grounds and habitat. Whilst Atlantic Herring are highly mobile species, Atlantic Herring fishing generally occurs close to, and during, the spawning season and therefore there is some indication of the location of spawning grounds, albeit with very low confidence due to the targeting of other species. The demersal gears target sandeel as well as many other species; and therefore also provide a low confidence indicator to habitat. Sandeels are not very mobile and therefore the time of fishing activity within the year is not important, and any fishing activity with these gear types may therefore target sandeels. With the exception of industrial trawlers (Sandeeler) these gears are likely to be targeting a number of species and may not be targeting Atlantic Herring or sandeel at all. Therefore with the exception of Sandeelers there is low confidence in this data.

2.4.2. Confidence in the VMS Data Indicating Spawning Grounds

VMS data only provide differentiation between fishing locations by gear types, and therefore it is the gear types that have been used to inform spawning areas. As one gear type will target a number of species and not just Atlantic Herring or sandeel, the probability of it informing spawning grounds or habitat is very low. A full justification is provided in the table above. However, in summary, pelagic gears are an indicator of Atlantic Herring spawning areas; and demersal gears are an indicator of sandeel habitat as well as an indication of habitat damage and/or deterioration pressure footprints.

2.5. ESFJC fishing boundaries

2.5.1. Confidence in the ECFJC Data

The Eastern Sea Fisheries Joint Committee (ESFJC) (now the Eastern IFCA) GIS dataset specifically provides boundaries of Atlantic Herring, Sprat, and sandeel regions, together with month and season present, fishing gear used, and importance of any area to the fishers (targeted fishery vs. occasional) (amongst other variables). Whilst there were no variables suitable to determine spatial variation in confidence, the uniform confidence assessment for this layer is provided in the first five parameters of the table below.

Table 2.8: Eastern Sea Fisheries Joint Committee Spawning Grounds Confidence Scores

Confidence test	Score	Rationale
Method	2	These layers are the output of the Eastern Sea Fisheries Joint Committee's Fisheries Mapping Project, which has aimed to describe - using best available data and fishermen's knowledge - the extent of the main fisheries within the ESFJC District. Outputs are produced using the best available data and fishermen's knowledge, however best available data is not defined and a caveat is given detailing that the data should only be considered illustrative.
Vintage	2	2010 data - these data are illustrative of the types of activity within the District.
Positioning	1	Data produced using the best available data and fishermen's knowledge. Best available data is not defined and a caveat is given detailing that the data should be considered illustrative only.
Resolution	1	Unknown how many data sources were used to compile broadscale resolution. (Limited to the sea area under the Eastern IFCAs jurisdiction, however as detailed in the supporting report, this does not affect the score.)
Quality Standards	0	No evidence of any quality standards.
Spawning Indicator	2	No evidence of whether the data used to complete spawning maps come from knowledge of adult fish locations or spawning locations. Assume the latter due to the labelling of the dataset.

2.5.2. Confidence in the ESFJC Data Indicating Spawning Grounds

As the ESFJC datasets are specifically for Atlantic Herring, Sprat and sandeel (where adult sandeel locations are a good indicator of spawning areas), they are very relevant to inform spawning grounds. The ‘importance’ field (target vs. occasional) is unsuitable for confidence as this signifies presence, not confidence in presence. No other parameters are suitable to use, so a uniform confidence approach has been adopted.

2.6. International Herring Larvae Survey data

The International Herring Larvae Survey is coordinated by ICES and conducted annually by vessels from the Netherlands and Germany. The survey gives inference on the total biomass of autumn spawning Atlantic Herring in the North Sea (ICES, 2012).

The Stage 1 assessment considers any spatial overlap with the presence of Atlantic Herring yolk sac larvae (0-ringers), derived from suitable data sources such as the International Herring Larvae Surveys (IHLS). Cefas fish ecologists have advised that larvae <10 mm for the central North Sea should be used to filter the spatial extent of potential spawning habitat and <11 mm for the southern North Sea, east English Channel and south coast (ECA and RPS, 2011; ICES, 2012; MMO, 2013).

The IHLS data used provides information for the years 2002-2011.

The IHLS data-layers are used to enhance the information used in Stage 1, and inform the combined confidence. IHLS data, where available, are considered the most indicative of seabed areas with the potential to support Atlantic Herring spawning, as the surveys are specifically targeting Atlantic Herring larvae. As such the confidence in these data is the highest of any of the datasets used in this study (very high, score of 5).

It is important to note that there is limited IHLS data coverage for parts of the central and southern North Sea Atlantic Herring populations within UK Territorial Waters. Significant areas of the Humber, Anglian and Outer Thames marine aggregate regions fall outside the IHLS data coverage. Where this is the case, other relevant data sources were searched for and identified. The only additional data with coverage for Atlantic Herring larvae distribution and marine aggregate regions were sourced from the Triton Knoll offshore windfarm project (RPS, 2011). Atlantic Herring larvae surveys were conducted in 2009 and 2011. These provide coverage for part of the Humber MAREA study area and increase the data available for assessment for many of the ‘inner’ Humber region licence and application areas.

The IHLS dataset was supplied in spreadsheet (point) format (stations) for all years 2002-2011, showing a number of fields. Following discussion with Cefas (pers. comm.), the larvae abundance fields were rejected as these are dependent on the volume of water processed, which is related to the water depth. Instead, the number of larvae per square metre field was selected for the relevant larvae size range (<10 mm in the central North Sea and <11 mm in the eastern English Channel/southern North Sea).

Each sample or haul repeated the same no./m^2 for every length class, therefore, all duplicates were removed as the no./m^2 was indicative for the haul as a whole and not each length class. Secondly, spreadsheet formulae were used to amalgamate the data for all samples at the same location. This then calculated the number of samples within the time period for each station.

On review of the summarised data, in some cases, there was only one sample within a single year and in some cases only one year of data. As it cannot be confirmed that these data correlated with a spawning period, it was considered misleading to average out the no./m^2 field per location (based on the contributing samples). Instead, the maximum no./m^2 at any one location during the time period assessed, 2002-2011, was calculated for each location.

Also due to this potential issue, any locations where there were 3 samples, or fewer, in total over the period were removed from the dataset. This filtering improved the interpolation substantially as there were one or more surveys that did not align to the survey grid structure used in more recent IHLS surveys. The approach used has removed some bias in the data. To check that the resulting data were a suitable representation of the data overall, the dataset without any locations removed (i.e. <3 samples) was assessed against the filtered data (i.e. instances of >3 samples) and a good agreement between the two datasets was found.

The interpolation of the abundance (max no./m^2 within 2002-2011) was tested in ArcGIS for the available interpolation methods. Following various trials and comparison to the original point data, the Natural Neighbour method was considered most suitable and therefore applied to the point data (default settings).

To convert the raster interpolation to shapefile, contour lines were created (vector polyline) in a separate file. This allowed the interpolated data to be mapped and spatially analysed with other data-layers as part of the confidence assessment.

Whilst the IHLS data are effectively used as direct indicators of larvae presence/absence, the interpolation of the larvae density has been conducted to evaluate if any areas of UK waters have a higher level of recorded spawning than others. Figure 3.15 shows the coverage of the IHLS and Triton Knoll offshore windfarm data and the interpolation. The relationship of the Banks and Downs populations can be seen (Banks in the central and southern North Sea and the Downs in the east English Channel) with distinct ‘hotspots’ within the recorded distribution of the larvae.

Figure 3.15 shows that the Banks population, and its recorded spawning area, extends far to the north of the Humber region, but actually has very little spatial overlap with marine aggregate licence and application areas in that region. Application area 514 (including licence area 102 and 105) has a spatial overlap through both the PIZ and SIZ footprints.

For the Downs population there is a much higher incidence of spatial overlap between the PIZs and SIZs for numerous licence and application areas within the South Coast and Outer Thames Estuary and small number in along the eastern limits of the Anglian region. The highest densities of larvae associated with the Downs population are concentrated in the east English Channel. All of the East Channel region licence and application areas fall within densities of larvae in the range of 601-56,300 individuals (Figure 3.15; ECA and RPS, 2010a, 2010b, 2011). It is important to note that the East Channel region is not assessed as part of this study, and is considered under its own potential spawning habitat methodology and assessment process (ECA, 2011; ECA and RPS, 2010a, 2010b, 2011).

2.6.1. Interpolation of the IHLS Data

2.6.1.1. Preparation of the point data

The IHLS dataset was supplied in point format (stations) for all years 2002 – 2011, showing a number of fields. Following discussion with Cefas (pers. comm.), the larvae abundance fields were rejected as these are dependent on the volume of water processed, which is related to the water depth. Instead, the number of larvae per square metre field was selected for 1) larvae less than 10 mm in the Central North Sea and 2) larvae less than <11 mm in the eastern English Channel/southern North Sea (because of a recognised increased hatching size there) (ECA and RPS, 2011; ICES, 2011).

Each sample or haul repeated the same no./m^2 for every length class and so, firstly, all duplicates were removed. Secondly, spreadsheet formulae were used to amalgamate the data for all samples at the same location. This then calculated the number of samples within the time period for each station.

On review of the summarised data, in some cases there was only one sample within a year. As there is a chance this one month did not target a spawning period, it was considered misleading to average out the no./m^2 field per location (based on the contributing samples). Instead, the maximum no./m^2 at any one location during the time period assessed, 2002-2011, was calculated for each location.

Also due to this potential issue, any locations where there were 3 samples or fewer, in total, over the period were removed from the dataset. This manipulation improved the interpolation substantially as there were one or more surveys that did not align to the survey grid structure used in more recent IHLS surveys. The approach used has removed some bias in the data. To check that the resulting data were a suitable representation of the data overall, the dataset without any locations removed (i.e. <3 samples) was assessed against the manipulated data (i.e. instances of >3 samples) and a good agreement between the two datasets was found.

2.6.1.2. Interpolation

The interpolation of the abundance (max no./m^2 within 2002-2011) was tested in ArcGIS for the available interpolation methods. Following various trials and comparison to the original point data, the Natural Neighbour method was considered most suitable and therefore applied to the point data (default settings).

To convert the raster interpolation to shapefile (to allow combination with other data layers' confidence assessment), contour lines were created (vector polyline) in a separate file.

The choice of contour intervals was made based on the IHLS point data. By plotting these in four percentile categories, plus zero, the resulting categories shown in the table below were provided by ArcGIS. As equal interval contours were the only available option, 50 unit intervals were applied to the interpolated dataset. Only those contours fitting closely to the percentile categories of the point dataset were kept, with all others deleted. The table below shows the interpolation categories resulting from the contouring.

Table 2.9: International Herring Larvae Survey Abundance/Square Meter Categories

IHLS Point Data Percentile Categories	IHLS Interpolation Categories
0	0
>0 to ≤32	0 - 50
>32 to ≤195	50 - 200
>195 to ≤686	200 - 700
>686 to ≤56258	700 - 56300

The interpolated map was assessed against the original point data and it was found that only the zero category was poorly represented. Therefore this part of the map was created manually through digitisation. Finally, the map was cut to two areas covered by points (eastern English Channel/southern North Sea and central/northern North Sea.

2.6.2. Confidence in the IHLS Data

Number count cannot be used to inform spatial variation in the confidence. To align with other layers' assessment, the confidence should only relate to the standard / credibility of the data, not the scale of spawning. Therefore 0 = absence and ≥1 = present. However these data should not be lost in the assessment process, i.e. number count should still be used to inform the EIA. There were no other fields considered suitable to inform spatial variation of confidence in the data. The table below shows the confidence in the data itself (first five parameters).

Table 2.10: International Herring Larvae Survey Confidence Scores

Confidence test	Score	Rationale
Method	3	IHLS aims at the very young stages of freshly hatched Atlantic Herring in the vicinity of the spawning areas. Sampling is done with a modified Gulf III sampler. Methods have been standardised since 1990. The Multiplicative Larval Abundance Index was used since 1993, compensation mathematically for the gaps in coverage in time and space by utilizing multiple analysis of variance (Patterson and Beverage, 1994). Patterson, K. and Beverage, D.S. (1994) Report of the Herring larvae surveys in the North Sea and adjacent waters in 1994/1995. ICES CM 1994/H:21. Anonymous (1990) Manual for the International Herring Larvae Surveys South of 62°North. ICES, mimeo, 1990.
Vintage	3	A decade of data 2002-2011 has been used to create this layer. This is the most up to date data available at the time of writing and so has a high level of confidence in the distribution and abundance of Atlantic Herring larvae in the central North Sea and eastern English Channel.
Positioning	3	IHLS data contain positional data representing sample locations.
Resolution	3	Each sampling unit is one statistical rectangle of 30 x 30 nm and contains 9 stations, thus providing a representative larvae sampling grid over the entire spawning area. The IHLS dataset has since been interpolated. The interpolation includes all samples that have been surveyed more than or equal to 4 times (whether during one or multiple years). The values interpolated are the maximum value recorded at any one location within the time period. (Only the central North Sea and eastern English Channel regions are covered adequately in relation to aggregate licence areas, however as detailed in the supporting report, this does not affect the score.)
Quality Standards	3	Data collected by separate working groups, with each dataset checked for content and quality by the responsible ICES group.
Spawning Indicator	3	Direct mapping of spawning.

2.6.3. Confidence in the IHLS Data Indicating Spawning Grounds

As the IHLS data represent direct measurements of Atlantic Herring larvae of the appropriate size classes, there is no inference, it is direct data on spawning grounds, as shown in the table above.

3. Combined Confidence Layer

3.1. Confidence in the individual layers

Table 3.1 below shows the results of each of the confidence assessments per layer, plus the final single layer confidence score for Atlantic Herring and sandeel. A key is provided below to show how these were calculated.

Table 3.1: Final Confidence Assessment per individual layer

Confidence test	Method	Vintage	Positioning	Resolution	Quality Standards	Dataset Scoring Source	Total Normalised	Indicator of Herring Spawning	Total Weighted Score	Total Normalised	Indicator of Sandeel Habitat	Total Weighted Score	Total Normalised
Range from 0 to >>	3	3	3	3	3		3	3	30	5			5
Weight	1	1	1	1	1			5			5		
										Herring			**Sandeel**
IHLS	3	3	3	3	3	EMU	3	3	30	**5**			
MAREA Preferred	2	3	3	3	2	MESL	3	1	18	**3**	2	23	**4**
ESFJC	2	2	1	1	0	EMU	1	2	16	**3**	2	16	**3**
Coull et al	1	1	1	2	0	MESL	1	2	15	**3**	2	15	**3**
BGS Preferred	2	1	3	3	2	MESL	2	1	16	**3**	2	21	**4**
VMS	3	3	3	2	3	EMU	3	0	14	**2**	0	14	**2**
MAREA Marginal	2	3	3	3	2	MESL	3	0	13	**2**	0	13	**2**
BGS Marginal	2	1	3	3	2	MESL	2	0	11	**2**	0	11	**2**
IFCA Sightings	2	3	1	1	1	EMU	2	0	8	**1**	0	8	**1**

= Score provided by consortium

= Value tested in trials

= Value not altered in trials

xx = Final combined confidence score

Key to Table 3.1

Item number	Parameter	Description
1	Method	Provided in confidence proforma (see earlier section). Range 0 to3.
2	Vintage	Provided in confidence proforma (see earlier section). Range 0 to3.
3	Positioning	Provided in confidence proforma (see earlier section). Range 0 to 3.
4	Resolution	Provided in confidence proforma (see earlier section). Range 0 to 3.
5	Quality Standards	Provided in confidence proforma (see earlier section). Range 0 to 3.
6	Dataset Scoring Source	Company delivering scores
7	Total Normalised	Total of above parameter scores (vintage, resolution, quality standards, dataset sourcing source), then normalised back to range 0 to 3. Results rounded to nearest integer.
8	Indicator of Spawning Herring	Provided in confidence proforma (see earlier section). Range 0 to 3.
9	Total Weighted Score Herring	Combined scores, calculated as sum of (vintage, resolution, quality standards, dataset sourcing source) + (5 X indicator of spawning).
10	Total Normalised Herring	Total weighted score normalised back to a range of 0 to 5.
11	Indicator of Spawning Habitat	Provided in confidence proforma (see earlier section). Range 0 to 3.
12	Total Weighted Score Sandeel	Combined scores, calculated as sum of (vintage, resolution, quality standards, dataset sourcing source) + (5 X indicator of spawning).
13	Total Normalised Sandeel	Total weighted score normalised back to a range of 0 to 5.

These 'final single layer' confidence scores represent the value (or weight of evidence) that each dataset has as an 'indicator of Herring spawning/sandeel presence', taking both the quality of the data itself into account as well as it's suitability to be used to indicate locations of Herring spawning/sandeel habitat (i.e. all the previously described 'parameter' scores).

As described previously, each individual layer is first scored on five parameters or tests relating to the data itself: each of these tests result in a score of 0 to 3 (see Section 2). 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 parameter score is provided next for the confidence in the layer indicating potential spawning habitat for Atlantic Herring. This test results in a score of 0 to 3.

The total weighted score then combines all the parameter scores together (this does not use the total normalised value detailed above which was provided for reference only). The parameter scores for confidence in the data itself 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 Atlantic Herring score is each calculated by normalising the total weighted score for Atlantic Herring 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 1.5, were assigned to each shapefile attribute table ready to contribute towards the final combined confidence mapping layers (see Section 3.2).

3.2. Confidence in the combined data-layers

The combined confidence (heat maps) 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 spawning habitat. An example is provided in the Table 3.2 below.

Table 3.2: Example of Combined Confidence Score for Herring

Parameter	GIS Attribute Name	Value Score
VMS fishing fleet - pelagic	VMS	2
Coull *et al*. (1998) Herring	Coull	2
ESFJC Herring and Herring sprat	ESFJC	0
IHLS interpolation	IHLS	0
BGS Folk	BGS	3
MAREA Folk	MAREA_REC	0
Combined score using BGS (and excluding MAREA)	TOT_BGS	7
Combined score using MAREA (and excluding BGS)	TOT_MAREA	4
Simplified combined score BGS	CONF_BGS	Medium
Simplified combined score MAREA	CONF_MAREA	Low

The results of the confidence assessment can be seen in the associated GIS files, as well as the IHLS interpolation.

The spreadsheets showing the above information are also made available.

3.2.1. 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 IHLS (herring only), 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 to spawning grounds and it is advised that the best seabed sediment data are used at any individual licence, as appropriate. To facilitate the use of either the BGS or the MAREA data, the combined confidence probability have been calculated separately using each of BGS and MAREA datasets as separate base-maps. Therefore, two combined confidence assessments are available for each receptor species in each of the MAREA study areas: Atlantic Herring with BGS data; Atlantic Herring with MAREA data; 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 Atlantic Herring or sandeel, within the same period of time e.g. VMS data from 2010 is concurrent with the 2010 IHLS data. Where this temporal and spatial overlap occurs then a higher certainty that the data are indicating potential spawning 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 IHLS dataset is from 2002-2011. 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 spawning, with a level of certainty that this may have been the case at 1998 and between 2002 and 2011. 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 spawning activity.

3.2.2. 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 and BGS preferred/marginal) and for Atlantic Herring, as this would use one extra dataset (IHLS) than available for sandeel. Therefore, the total possible score is 5 (IHLS) + 3 (MAREA pref.) + 3 (ESFJC) + 3 (Coull et al.) + 2 (VMS) = 16. This maximum score is termed the 'maximum possible data layers score' (i).

However, irrespective of what the layer scores actually are, each layer is scored out of 5 and therefore the potential maximum score is 25 (i.e. = 5 (IHLS) + 5 (MAREA preferred) + 5 (ESFJC) + 5 (Coull et al) + 5 (VMS) = 25). This maximum score is termed the 'maximum possible generic score' (ii)

In comparison then, if we had 3 individual layers of medium confidence (3, as with ESFJC, MAREA preferred and Coull et al) and 2 layers not present at any one location, the total score would be 9 out of (i) 16 or (ii) 25. This is reflected in the perceived level of confidence.

Therefore, some factors require consideration when deciding whether to use maximum score for (i) the given data layers or (ii) the potential/generic scores overall. Firstly, what is shown by the total confidence score is the 'weight of evidence to indicate spawning grounds/habitat' or 'quantity of overlap in layers to indicate spawning grounds/habitat ', i.e. the more layers present that indicate spawning grounds/habitat, the higher the confidence; providing that all layers cover all licence regions. Secondly, it was agreed (MMO, 2013) that these final scores will not be amended if any new data are subsequently available in the future. Instead the scoring provides a 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 potential to support Atlantic Herring spawning or habitat suitable to support sandeel.

Considering the weight of available evidence and the precautionary scoring range, then method (ii) is not relevant e.g. if there was a score of 9 out of 25 using method (ii), this would infer that there is less than moderate confidence, and this isn't the case, as the greater the number of layers overlapping, the higher the resultant confidence.

Therefore a top range of 16 (the maximum score from layers that could theoretically overlap) was used in the analyses. The actual results only extend up to 12 as the 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.

3.2.3. 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 theoretical total maximum possible score i.e. a score from 13 up to 16 where data layers overlap. However it would be possible to apply this method to the data/results, then insert an additional upper category to extend the range of the 'heat' mapping upwards to the maximum possible score resulting from overlaps e.g. extend upwards from maximum achievable score of overlaps (with the existing data e.g. 12 overlaps) to include the score of 13-16. However, it is the view of the EIA WG that this approach lacks a level of scientific credibility.

Therefore intervals of 4 were chosen to develop the categorisation of 'heat' associated with mapping i.e. 1-4, 5-8, 9-12, 13-16. This ensures that any location with a single layer score of 5 (i.e. IHLS), is not included within the lowest category. Therefore use of categories of multiples of 4 (e.g. as opposed to 5) allows greater differentiation (i.e. 5 would results in only two categories showing data).

Therefore, the score range of 1-16 resulting from layers of data overlap is divided into four categories of 'heat' as presented in Table 3.3.

Table 3.3: 'Heat' map categorisation

Score of data-layers overlapping	'Heat' map category
1-4	**Low**
5-8	**Medium**
9-12	**High**
13-16	**Very high**

There were no results obtained for the 'very high' category, though this category is shown on the map legends to account for the maximum possible data layers score.

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

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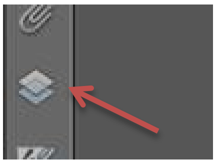
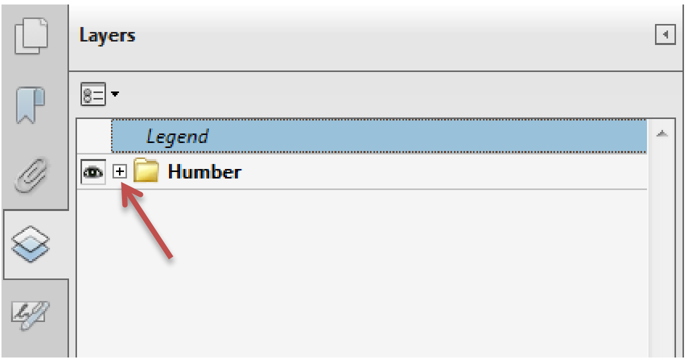
Instructions for using interactive PDF

The spatial datasets used to complete the analysis of herring and sand eel for each region has been presented as an interactive pdf (ipdf). An ipdf provides the user with the ability to switch on and off numerous data-layers, to allow them to observe the methodology used by the EIA working Group. By switching various layers on and off, the user can assess on an individual or cumulative basis the potential for interaction of various receptors, effects and pressures. The ipdf does not allow the user to manipulate the data.

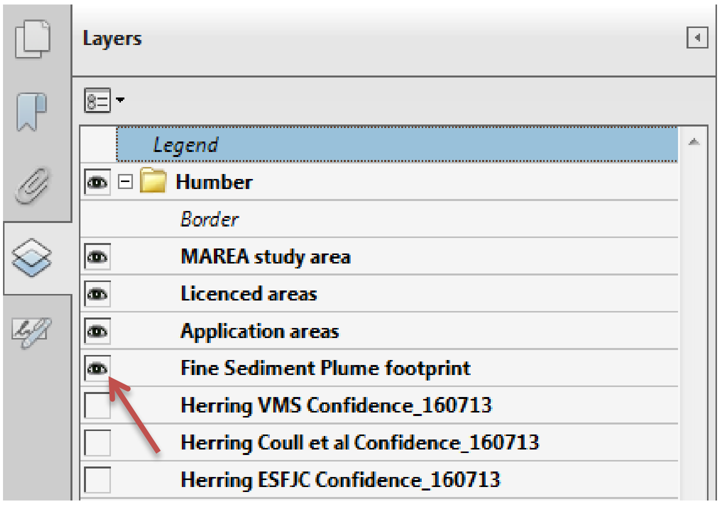
To view the available data layers, click on the layer icon on the left-hand menu bar

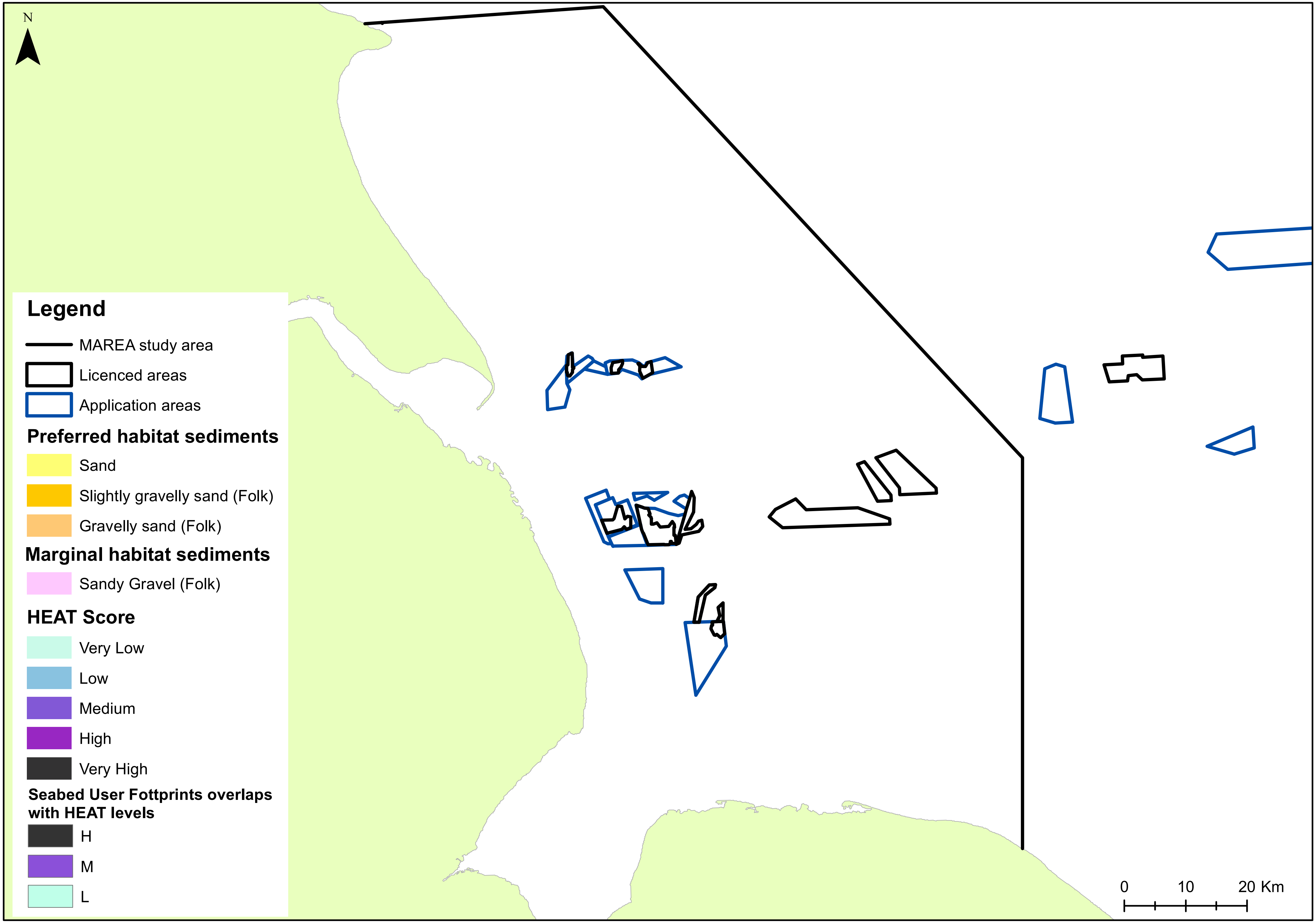


Next click on the + icon between the eye symbol and the region name folder (Humber region shown in example). This expands the folder and shows the data layers.



You can then switch on and off the various data layers by clicking on the appropriate eye icon. If the eye is present the layer is visible, if it is absent the layer is switched off.


Layers
Legend
Humber
Border
MAREA study area
Licenced areas
Application areas
Fine Sediment Plume footprint
Herring VMS Confidence_160713
Herring Coull et al Confidence_160713
Herring ESFJC Confidence_160713


N
Legend
MAREA study area
Licenced areas
Application areas
Preferred habitat sediments
Sand
Slightly gravelly sand (Folk)
Gravelly sand (Folk)
Marginal habitat sediments
Sandy Gravel (Folk)
HEAT Score
Very Low
Low
Medium
High
Very High
Seabed User Fottprints overlaps with HEAT levels
H
M
L
0
10
20 Km

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

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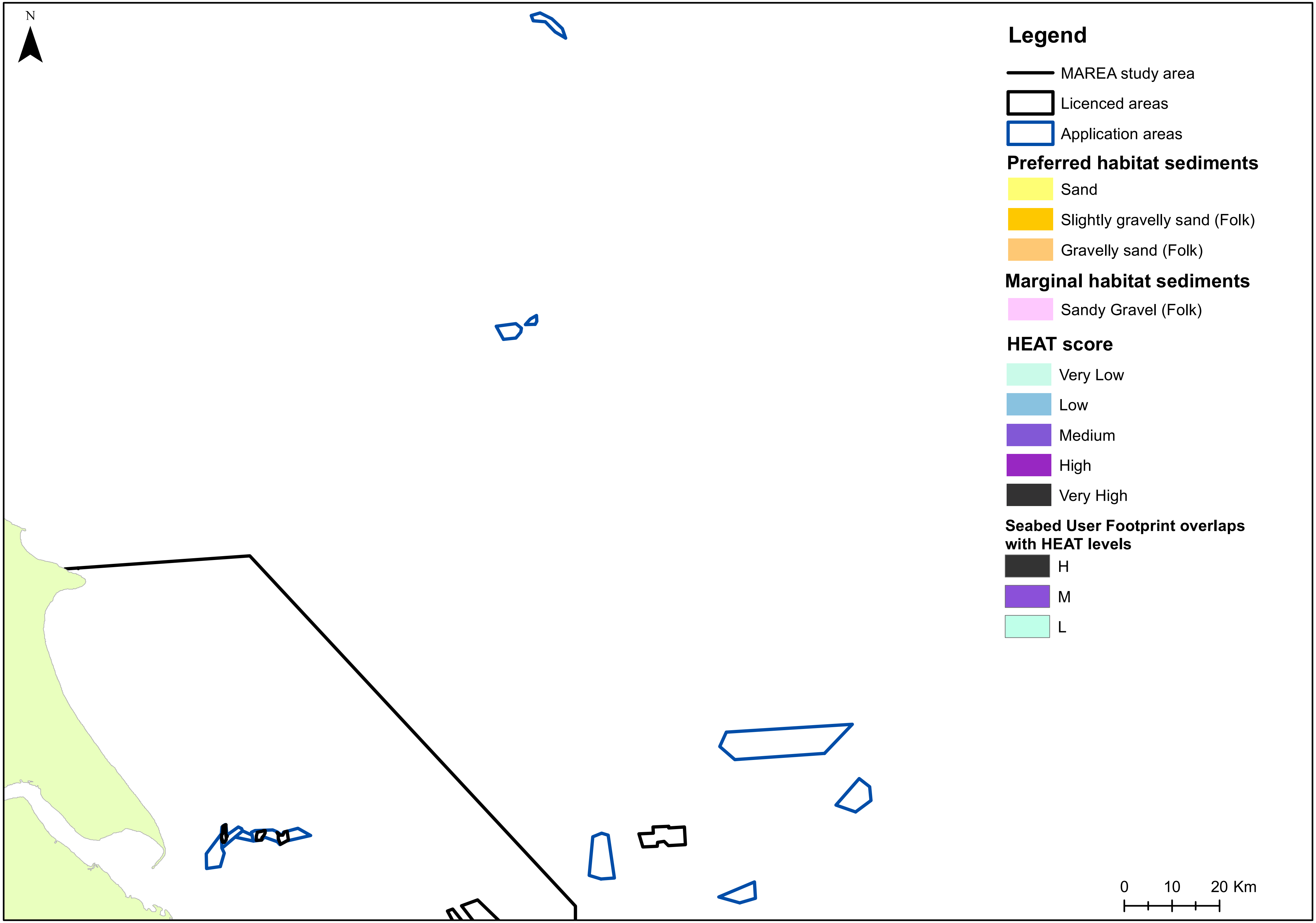
N
Legend
MAREA study area
Licenced areas
Application areas
Preferred habitat sediments
Sand
Slightly gravelly sand (Folk)
Gravelly sand (Folk)
Marginal habitat sediments
Sandy Gravel (Folk)
HEAT score
Very Low
Low
Medium
High
Very High
Seabed User Footprint overlaps with HEAT levels
H
M
L
0
10
20 Km

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

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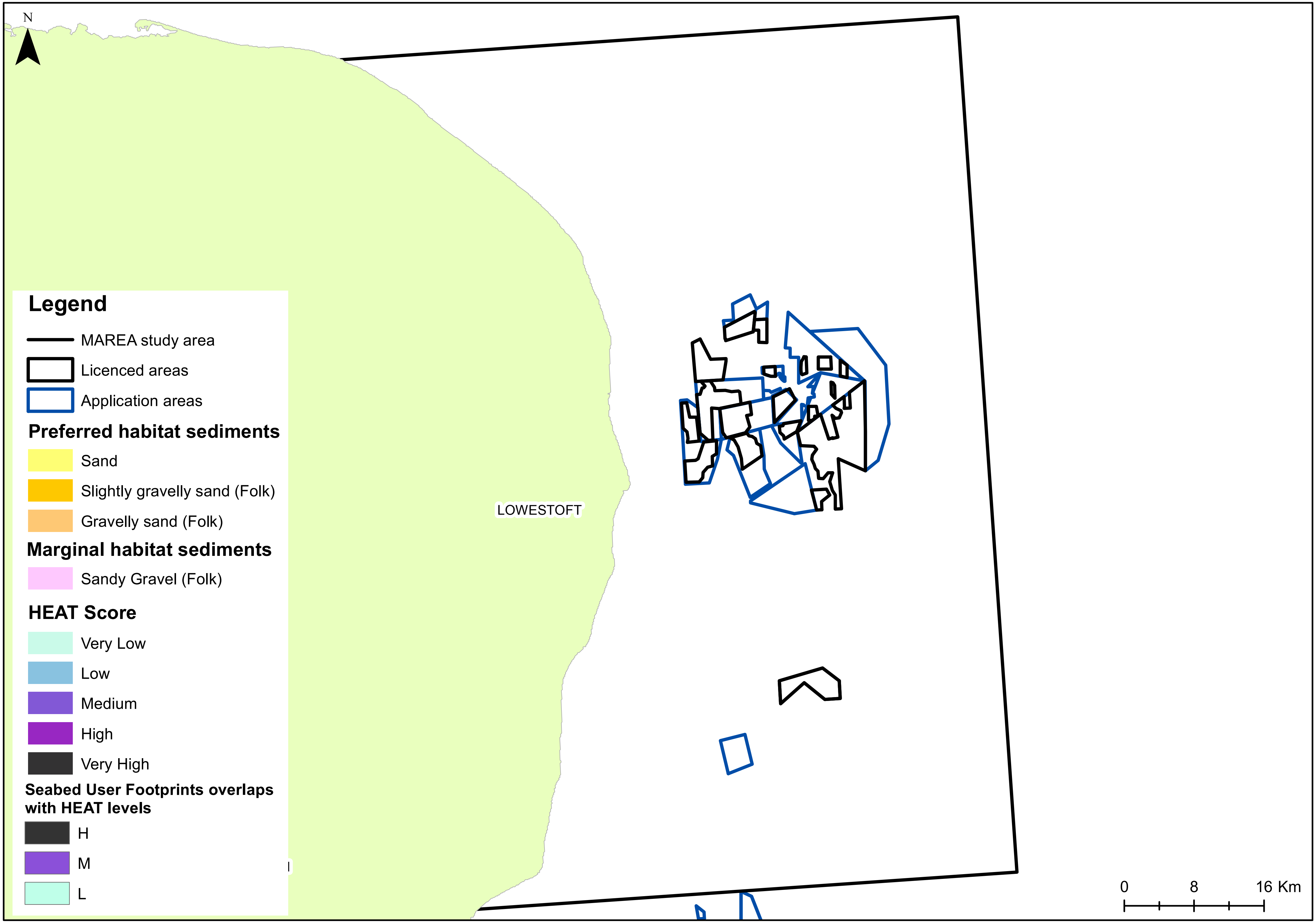
N
Legend
MAREA study area
Licenced areas
Application areas
Preferred habitat sediments
Sand
Slightly gravelly sand (Folk)
Gravelly sand (Folk)
Marginal habitat sediments
Sandy Gravel (Folk)
HEAT Score
Very Low
Low
Medium
High
Very High
Seabed User Footprints overlaps with HEAT levels
H
M
L
LOWESTOFT
0
8
16 Km

Appendix F: Data-layers used for screening Thames region licence and application areas

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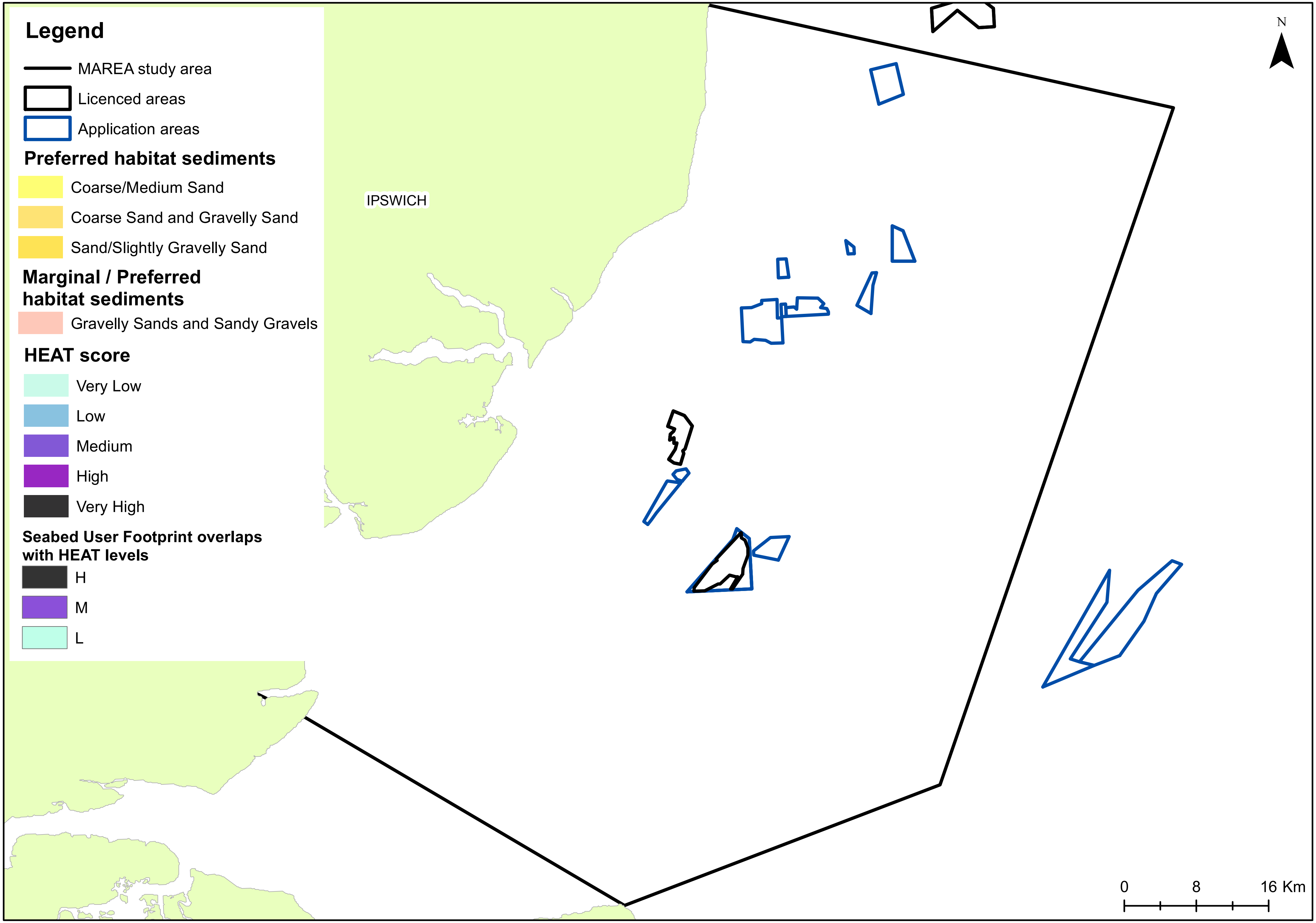
Legend
MAREA study area
Licenced areas
Application areas
Preferred habitat sediments
Coarse/Medium Sand
Coarse Sand and Gravelly Sand
Sand/Slightly Gravelly Sand
Marginal / Preferred habitat sediments
Gravelly Sands and Sandy Gravels
HEAT score
Very Low
Low
Medium
High
Very High
Seabed User Footprint overlaps with HEAT levels
H
M
L
IPSWICH
N
0
8
16 Km

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

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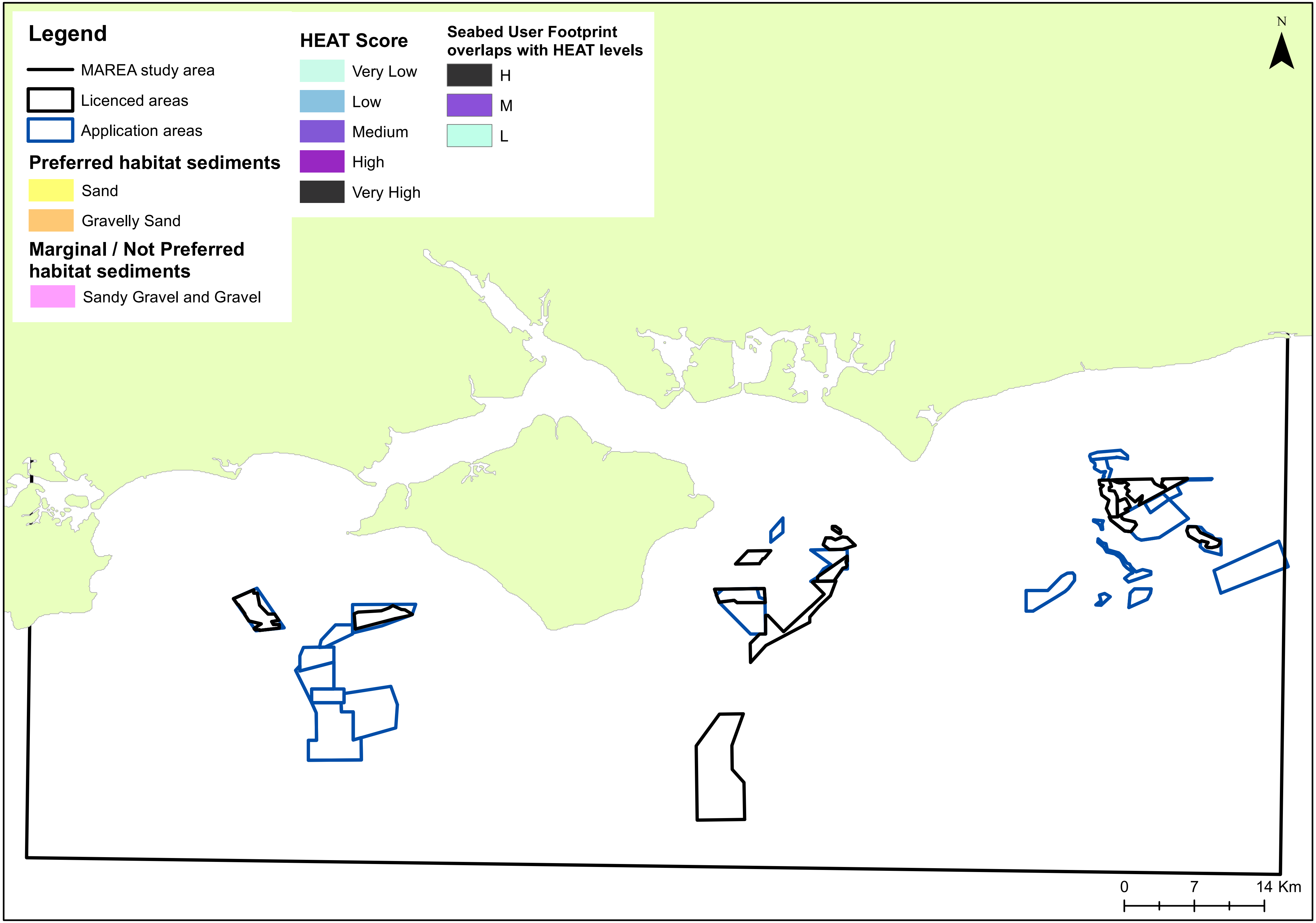
Legend
MAREA study area
Licenced areas
Application areas
Preferred habitat sediments
Sand
Gravelly Sand
Marginal / Not Preferred habitat sediments
Sandy Gravel and Gravel
HEAT Score
Very Low
Low
Medium
High
Very High
Seabed User Footprint overlaps with HEAT levels
H
M
L
N
0
7
14 Km

Appendix H: Humber Regional Cumulative Impact Assessment

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Assessment of Cumulative Impacts from Marine Aggregate Extraction on Potential Sandeel Habitat in the Humber MAREA Region

Contents

1.0. Introduction

Marine Ecological Surveys Limited (MESL) has been commissioned to undertake a cumulative impact assessment (CIA) of the effects of marine aggregate extraction on potential sandeel habitat in the Humber Region.

This report assesses the cumulative impacts of regional aggregate extraction upon sandeel habitat in the Humber MAREA region, provides context to marine aggregate extraction activities in the region with reference to other seabed users, and assesses the significance of the results, with regards to receptor sensitivity and magnitude of the potential effects.

This assessment encompasses three main steps:

1. The identification of current marine aggregate extraction areas and application areas in the Humber Region, with reference to potential sandeel habitat
2. The identification of other seabed users whose activities may interact with potential sandeel habitat, and the contextualisation of aggregate extraction within the cumulative impact assessment
3. An assessment of the impact significance of aggregate extraction in the Humber Region accounting for other seabed users, and based upon receptor sensitivity and magnitude of effects

The Humber Region is of noted importance for sandeel, with the region known to support a large sandeel population which is of importance to the many species of birds present along the coastline and in wider food webs (Engelhard *et al.* 2008; ERM, 2012). Sandeels favour sandy sediments as a habitat choice from which they may seek shelter if necessary, and are known to tolerate a specific range of substrate types including sand, slightly gravelly sand, gravelly sand, and to a lesser extent sandy gravel (Jensen, 2011; Greenstreet *et al*. 2010; Holland *et al*. 2005). Sandeel are predominantly active during the day, and take refuge in seabed sediments at night. As such, sandeel are potentially vulnerable to the impacts of aggregate extraction; specifically the removal of sediment or the alteration of habitat composition (Jensen, 2011).

Potential sandeel habitat has been identified within the Humber Region, based on sediment type, historic spawning areas and fishing fleet data (see Latto *et al*. 2013 for full methods). The data used in this assessment have been sourced from the EIA Working Group consortium as part of the wider herring and sandeel habitat assessment currently being undertaken to support the aggregates industry in licence renewals.

The Humber MAREA Region currently contains a total of 13 marine aggregate extraction licence areas, and 12 licence application areas. A map of the Humber MAREA current licences and application areas is shown in Figure 1.

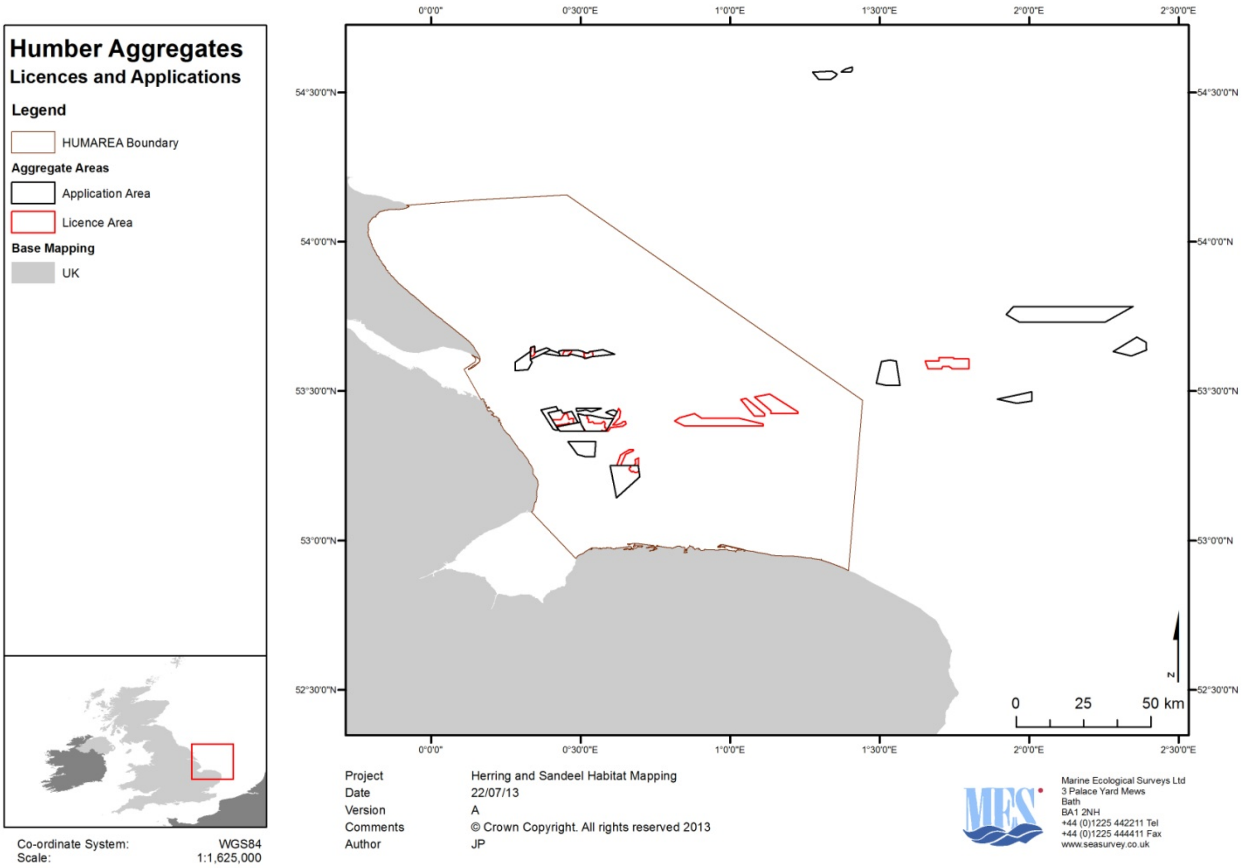

Figure 1. The location of current and application marine aggregate extraction licence areas in the Humber Region and the MAREA boundary.

2.0. Methodology and Data Sources

2.1. Potential Sandeel Habitat Data

The data used in the habitat assessment have been sourced from the EIA Working Group consortium as part of the wider sandeel habitat assessment currently being undertaken to support the aggregates industry in licence renewals. Data sourced included:

- Substrate Folk Classification: British Geological Society (BGS)
- Substrate Folk Classification: Marine Aggregate Regional Environmental Assessment (MAREA)
- Fishing Fleet: Vessel Monitoring Systems (VMS) 2007-2011
- Spawning Grounds: Eastern Sea Fisheries Joint Committee (ESFJC)
- Spawning Grounds: Coull *et al* (1998)

As detailed in the supporting confidence assessment report (MESL, 2013), each of the data layers were first processed to extract the part of the layer that indicated sandeel habitat (for example, the relevant substrate, gear types).

2.1.1. Confidence Assessment

As data were all required in the same format to inform the combined confidence assessment, any layers not in polygon format were converted. All analyses were conducted using ArcGIS 9.3.

Each dataset was then assigned a confidence score, based on both confidence in the data itself as well as its reliability as an indicator to sandeel habitat (each of equal weighting). By combining the different indicator layers together, the individual scores from each layer were combined (ultimately from 1 to 12) for any given location. Scores used throughout this report are classified as follows for ease of presentation:

- Confidence of 1-4 are categorised as 'low' confidence
- Confidence of 5-8 as 'moderate' confidence
- Confidence 9-12 as 'high' confidence
- Confidence 13-16 as 'very high' confidence

See Latto *et al.* (2013) and MESL (2013) for a full account of the confidence processing.

2.2. Impact Assessment

The cumulative assessment methods utilised in this report follow those presented in the Marine Aggregate Regional Environmental Assessment of the Humber and Outer Wash Region (Humber MAREA) (ERM 2012). The methods have been slightly adjusted where appropriate to suit the current assessment objectives, and to reflect the fact that only one receptor is being assessed in the case of sandeel habitats.

Effect-Receptor pathways have been identified by the EIA WG and agreed with the MMO and RAG for the impacts of aggregate extraction on sandeel habitat. Over the following sections, each impact pathway is assessed in terms of magnitude, which is combined with the receptor value and sensitivity to produce a significance classification. These individual significance classifications are then combined, which, along with consideration of the cumulative impacts from other industries, gives the regional significance of marine aggregate extraction on potential sandeel habitat in the Humber Region.

2.2.1. Predicting Effect Magnitude

In accordance with the Humber MAREA, the potential magnitude of each effect is assessed with reference to four variables: extent, duration, frequency and elevation above baseline conditions. A combination of assessments against these variables determines the magnitude of the effect. The components of magnitude are indicated in Figure 2. A detailed description and the definition of each magnitude factor is discussed in ERM (2012).

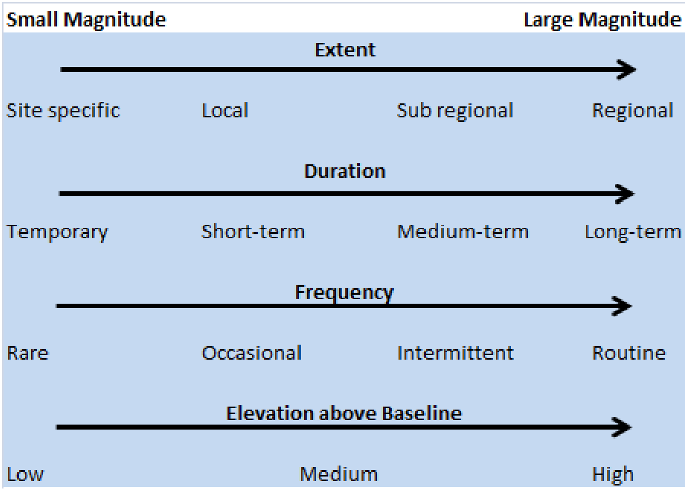

Figure 2. The components of magnitude used in this assessment (adapted from ERM, 2012).

Magnitude has been assigned using expert opinion and information regarding the likely impacts arising from aggregate extraction (e.g. ERM, 20112). As such, the assessment process is subjective, although a reasonable degree of consensus has been sought when classifying exposure pathways.

2.2.2. Determining Receptor Value and Sensitivity

The determination of receptor value and sensitivity adopts a similar approach as to that for magnitude of potential effects, taking receptor tolerance, adaptability and recoverability into account. The categories used for defining sensitivity are shown in Figure 3. Much of the information needed to inform this assessment has been collated as part of the sandeel habitat assessment methodology (Latto *et al*. 2013), or from the Humber MAREA (ERM, 2012).

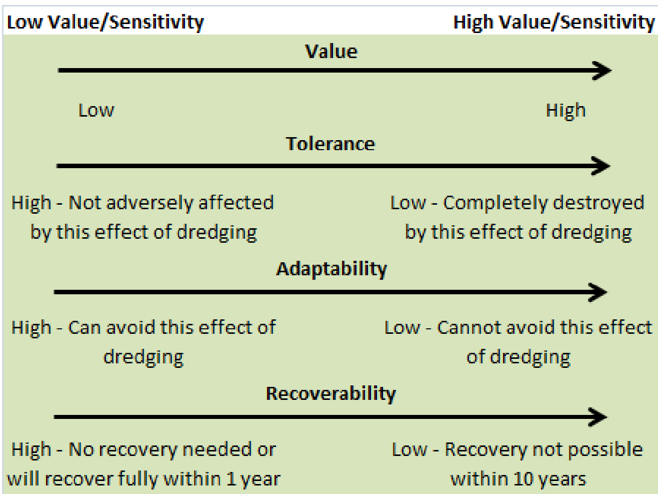

Figure 3. The components of sensitivity used in this assessment (adapted from ERM, 2012).

2.2.3. Determining Impact Significance

Following the assessment of the magnitude of potential effects and the receptor sensitivity and value for each impact pathway, overall impact significance is be assigned according to the classifications presented in Figure 4 and in Table 1. A level of the degree of interaction between the magnitude of effects and the receptors is also taken into account in assigning impact significance.

The assessment of impact significance is a subjective process, although is based on expert opinion and general consensus of the likelihood of the receptor suffering impact from the expected effects.

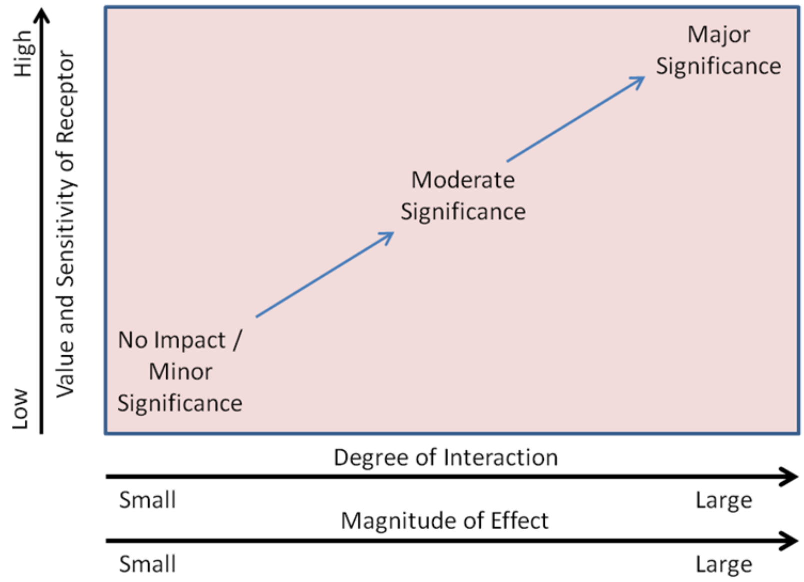

Figure 4. Scales used to define impact significance in this study (adapted from ERM, 2012).

Table 1. Definitions of Impact Significance (ERM, 2012).

Impact Significance	
Not Significant	Impacts that, after assessment, were found to be not significant in the context of the MAREA objectives
Minor Significance	Impacts that warrant the attention of particular stakeholders but no action is required if the impacts can be controlled by adopting normal good working practice
Moderate Significance	Regional impacts that should be recognised and addressed in consultation with particular stakeholders
Major Significance	Regional impacts that are not environmentally sustainable and compromise the continuation of extraction activity in the region

3.0. Cumulative Impact Assessment of Impacts on Potential Sandeel Habitat

3.1. Identification of Interactions between Marine Aggregate Extraction Areas/Application Areas and Potential Sandeel Habitat in the Humber MAREA Region

Current marine aggregate extraction areas and application areas in the Humber MAREA Region are shown with reference to potential sandeel habitat in Figure 5 (derived from the methods presented in Latto *et al*. (2013) and the associated confidence assessment (MESL, 2013). These have been plotted in conjunction with the 'worst-case scenario' secondary impact zones derived from those data layers provided to the EIA WG.

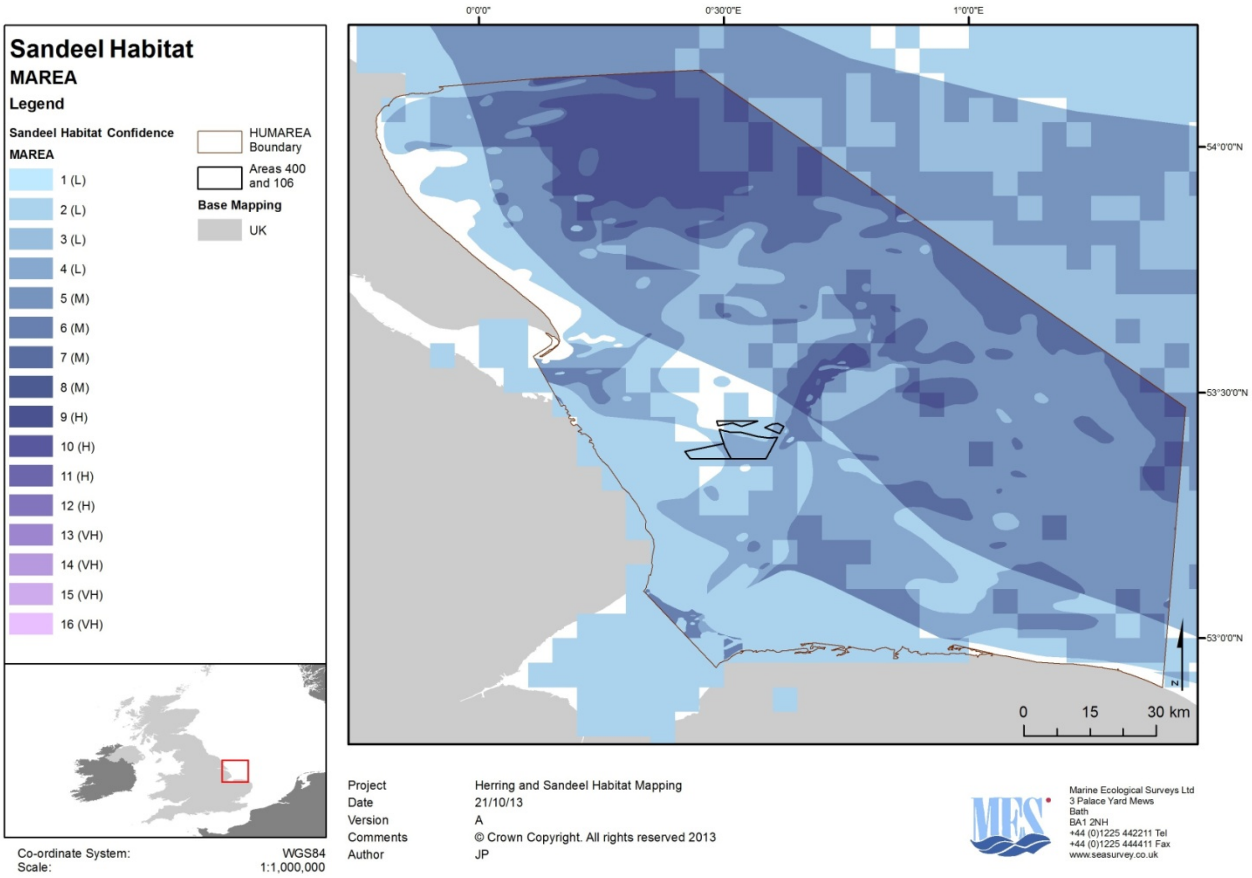

Figure 5. Current and application marine aggregate extraction areas in the Humber Region and their associated secondary impact zones overlain onto potential sandeel habitat (split by confidence) as derived from Phase 1 of the sandeel assessment, following the methods outlined in Latto *et al*. (2013) and MESL (2013).

From Figure 5, percentage calculations of the overlap between current and proposed aggregate extraction sites and potential sandeel habitat can be produced. These are shown in Table 2. The data are only provided for overlaps with the cumulative PIZ area, as it has been agreed with the MMO and RAG that only effects in the PIZ need to be considered for this sandeel assessment (MMO, 2013).

Table 2. The regional footprint of marine aggregate extraction areas (current, application and options) overlapping potential sandeel habitat in the Humber Region (as identified in Figure 5).

	Very high confidence habitat overlap as % of entire area	High confidence habitat overlap as % of entire area	Moderate confidence habitat overlap as % of entire area	Low confidence habitat overlap as % of entire area	Total percentage of potential habitat overlapped by marine aggregate extraction
Current Licences	0.00	0.00	1.22	0.62	1.84
Applications	0.00	0.00	0.42	1.98	2.40
Options	0.00	0.00	0.07	0.63	0.70

Table 2 indicates the interaction between the regional footprint of aggregate activity in the Humber Region and potential sandeel habitat. It can be seen that current aggregate licence areas in the Humber Region overlap with a 1.84% of the total available sandeel habitat, of which the majority moderate confidence habitat. Application areas overlap with 2.40% of the total sandeel habitat available in the Humber region (mostly low confidence habitat) and aggregate option areas overlap with 0.70% of the total sandeel habitat. No areas of very high or high confidence sandeel habitat are overlapped by any aggregate areas, existing or proposed.

3.2. Identification of Interactions between other Seabed Users and Potential Sandeel Habitat in the Humber MAREA Region

Following on from the assessment of the regional aggregate extraction footprint, this section identifies the interactions between other seabed users and potential sandeel habitat. The following benthic impacting sectors are considered in the assessment:

- Offshore Windfarms (current and proposed)
- Potential offshore windfarms corridors
- Cable and pipeline routes
- Disposal sites
- Commercial fishing (trawl and dredge)

It should be noted that cable and pipeline routes include predicted export cable route pathways for proposed windfarm developments which are assessed to be the worst case scenario, i.e. the route which encompasses the greatest sandeel habitat. Cable routes have been buffered by 300mm to produce polygons in GIS.

A map of all seabed users is presented with respect to potential sandeel habitat in Figure 6.

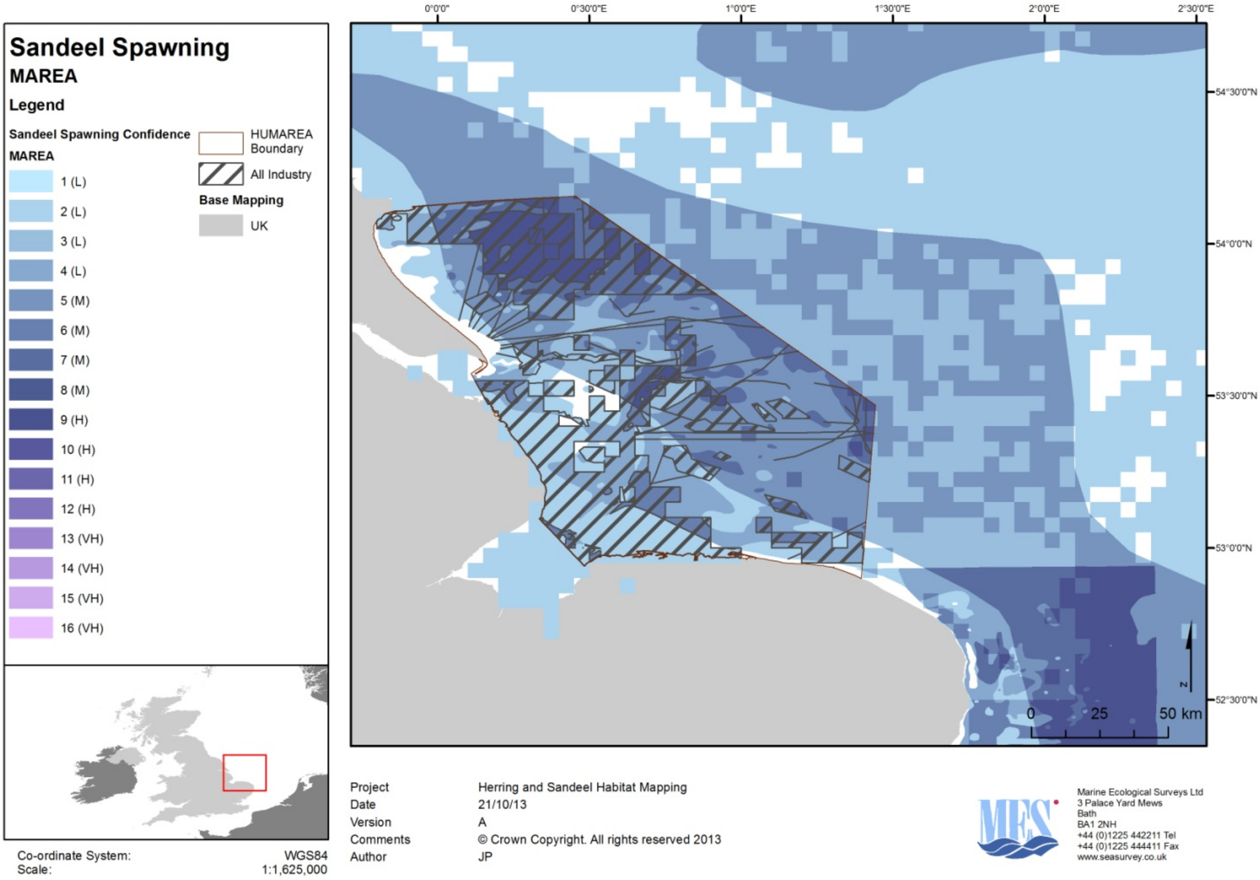

Figure 6. Thematic map of the footprint of all seabed users considered in this assessment in the Humber Region overlain onto potential sandeel habitat areas (split by confidence). Data are taken from the GIS layers compiled by the EIA WG during Phase 1 of the sandeel habitat assessment, following the methods outlined in Latto *et al*. (2013) and MESL (2013).

Percentage overlaps of each sector on potential sandeel habitat have been calculated, as for the aggregate extraction areas. These are presented in Table 3. The figures allow an insight to be gained into the regional footprint of each seabed user against which the footprint of regional aggregate extraction can be contextualised.

Table 3. The regional footprint of all seabed users considered in this assessment overlapping potential sandeel habitat in the Humber Region (as identified in Figure 6).

	Very high confidence overlap as % of entire area	High confidence overlap as % of entire area	Moderate confidence overlap as % of entire area	Low confidence overlap as % of entire area	Total percentage overlap regardless of confidence
Aggregate Options	0.00	0.00	0.07	0.63	0.70
Application Licence Areas	0.00	0.00	0.42	1.98	2.40
Current Aggregate Areas	0.00	0.00	1.22	0.62	1.84
Demersal Trawling Footprint	0.00	5.91	9.08	17.79	32.78
Disposal Sites	0.00	0.00	0.21	1.23	1.43
Fisheries Dredging Footprint	0.00	4.48	4.15	0.65	9.28
Operating Windfarm Turbine footprint	0.00	0.00	0.00	0.00	0.01
Pipelines	0.00	0.00	0.00	0.00	0.01
Power Cables	0.00	0.00	0.00	0.00	0.00
Proposed Windfarm Sites - Indicative Turbine Footprint	0.00	0.00	0.02	0.00	0.02
Telecommunications Cables	0.00	0.00	0.00	0.00	0.00
Windfarm Licence Areas Proposed	0.00	1.59	7.02	1.62	10.23
Windfarm Licence Areas under Construction	0.00	0.00	0.00	0.44	0.44
Worst-Case Proposed Power Cables	0.00	0.00	0.00	0.00	0.00
Total Industry Overlap Regardless of Confidence					**48.37**

It can be seen from Table 3 that the total combined footprint of all benthic impacting seabed sectors overlaps with 48.37% of the total sandeel habitat available in the Humber MAREA Region. The majority of the overlap occurs in areas of medium and low confidence sandeel habitat, with only a minor amount of overlap occurring in high confidence areas.

Commercial trawling, proposed wind farm areas and dredge fisheries contribute the greatest to total regional sandeel habitat overlaps (32.78%, 10.23% and 9.28% respectively).

In terms of contextualising the contribution of marine aggregate extraction to regional cumulative impacts, it can be seen that current aggregate extraction areas (PIZ only) overlap 1.84% of the total potential sandeel habitat in the Humber MAREA Region, application areas overlap 2.4% and option areas overlap 0.7%, compared to much larger totals from other impact sectors. Considering high confidence habitat areas in isolation, it can be seen that the cumulative aggregate impact footprint does not overlap any high confidence habitat, as opposed to other combined impact sectors.

3.3. Assessing Significance of Impacts upon Potential Sandeel Habitat in the Humber MAREA Region from Aggregate Extraction

This section utilises the methodology presented in Section 2.0. to assign significance to the regional impacts of aggregate extraction on sandeel habitat in the Humber Region.

For the purposes of this assessment, the potential effect-receptor pathways of aggregate dredging (or other sectors) on sandeel habitat were agreed with the MMO and RAG during the project conception stage (at a meeting held on 01 May 2013 (MMO, 2013). It was agreed that the effects on sandeels considered in this assessment would be limited to those which may occur in the PIZ. These were agreed to be as follows:

- Direct removal of suitable sediment
- Alteration of habitat structure
- Recovery of suitable habitat to support future populations (*re-colonisation*)

It has been agreed that potential effects of sediment plumes on sandeel, the entrainment of larvae and adults and any effects relating to the adult populations of both species outside those listed above are not to be considered in the context of this report (MMO, 2013)

3.3.1. Magnitude of Impacts

The magnitude of each marine aggregate extraction related effect-receptor pathway identified for this assessment is considered below with regard to potential sandeel habitat for marine aggregate extraction.

Direct removal of suitable sediment:

Sandeel habitat preference is sand, slightly gravelly sand, gravelly sand and sandy gravel (Holland *et al*, 2005; Greenstreet *et al*. 2010). The direct removal of sediment suitable is likely 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 in the Humber Region and the low-medium confidence habitats shown to be overlapped mean 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 considered to be **short-term**. Frequency is assessed to be **occasional**, given the size of the combined ADZ footprint, and the likely return time of dredgers. Elevation above the baseline in terms of this impact is considered to be **low** for the above reasons. The overall magnitude of the effects of direct removal of sediment on sandeel habitat is considered **low** at the regional scale.

Alteration of habitat structure

Alteration of habitat structure within the regional PIZ footprint is likely to be **site-specific** and **short-term**, the effects only occurring in the active dredging areas of each PIZ, with the effects lasting for not more than 1 year following the cessation of dredging (Hill *et al*. 2011). It is thought unlikely that seabed sediments will become coarser as a result of the dredging process. The frequency of this effect is therefore classified as **rarely**, and elevation above baseline is considered **low**. The overall magnitude of effects arising from the alteration of habitat structure on sandeel habitat is considered **low**.

Recovery of suitable habitat

The magnitude of the effects of regional aggregate extraction on potential sandeel habitat recovery is assessed to be **site-specific** and generally **short-term**, given the small areas involved (1.84% of potential habitat overlapped by current aggregate areas, 2.4% of habitat overlapped by application areas, 0% high confidence habitat by any current or proposed areas) and the low likelihood of significant negative impacts from aggregate extraction. Recovery of the seabed from the effects of aggregate dredging in the Humber is thought to be relatively short term (Hill *et al*. 2011). Only **occasional** effects are thought to be likely which impact a sites ability to recover, and a **low** elevation above the baseline recovery is anticipated. As such, the magnitude of effects impacting the ability of sandeel habitat to recover is considered **low** at the regional scale.

3.3.2. Sensitivity of Receptor

An assessment of the regional sandeel habitat sensitivity in the Humber area to the identified effect-receptor pathways is presented below.

Part of assigning receptor sensitivity is the definition of the receptor value. As a receptor, sandeel is considered to be **medium** in value. This reflects the importance of sandeel as a species in wider food-webs, the importance as a prey item for larger predators and seabirds along the Humber coast, and the economic value of the habitat in supporting the species.

Direct removal of suitable sediment

Sandeel habitat is likely to be sensitive to the direct removal of sediment, as habitat is largely defined according to distinct sediment types which fall within a certain range (Jensen et al. 2011). However, considering the exposure of regional aggregate licence areas to suitable habitat (especially high confidence habitat), this assessment considers that the overall tolerance is **medium**, as the distribution of highly suitable habitat at the regional level is limited, and overlap is low. 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. Overall sensitivity of sandeel habitat to the direct removal of sediment is considered to be **medium**.

Alteration of habitat structure

Sandeel habitat is likely to have a relatively low tolerance to the alteration of habitat structure, given the specific affinity to certain sediment types that sandeel have. However, the preferred habitat covers a range of sediment types, and impacts are unlikely to have negative effects on sandeel unless the thresholds in sediment composition are exceeded. Tolerance to alteration of habitat structure is therefore classified as **medium**, and adaptability as **high**, especially given the large extent of suitable habitat in the region, and the low 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 seabed in a similar state to which it was found following the cessation of dredging, and the low likelihood of significant negative impacts. Sensitivity of sandeel habitat to the alteration of habitat structure is therefore considered to be **medium** overall.

Recovery of suitable habitat

Sandeel habitat is considered to have **medium** tolerance, **high** recoverability and **medium** adaptability with regard to the potential for the habitat to recover and continue to support sandeels after the cessation of dredging. Overall sensitivity of sandeel habitat to impacts affecting the potential for recovery is considered **medium**.

3.3.3. Evaluating Impact Significance

Following assessment of the potential effects of regional aggregate extraction on sandeel habitat according to the magnitude of, and sensitivity to the individual impact pathways, the overall significance of the effects can be determined.

Based on the information presented in the above sections, an overall significance level has been assigned to each effect-receptor pathway in accordance with the determination matrix presented in Figure 4 and Table 1. The significance of each effect pathway is shown in Table 4.

Table 4. Summary of impact significance of regional aggregate extraction in the Humber Region on potential sandeel habitat areas.

Impact Pathway	Significance	Rationale
Direct removal of suitable sediment	**Minor Significance**	Based on the general low magnitude of effects, the medium receptor value, the medium receptor sensitivity, and the low levels of likely exposure given the wider habitat available, 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	**Minor Significance**	Based on the low magnitude of effects, the medium receptor value, the general medium receptor sensitivity, and the levels of likely exposure given the wider habitat available, the cumulative impact of the alteration of habitat structure on potential sandeel habitat is considered to be of minor significance in the regional context.
Recovery of suitable habitat	**Minor Significance**	Based on the general low magnitude of potential effects, the medium receptor value and the medium receptor sensitivity, the cumulative impact of aggregate extraction on the potential for the habitat to recover is assessed to be of minor significance at the regional scale.

Based on the above assessments and the information presented in Table 4, it can therefore be said that the cumulative impact of marine aggregate extraction on sandeel habitat in the Humber Region is of minor significance at the regional scale.

4.0. References

ERM 2012 Marine Aggregate Regional Environmental Assessment of the Humber and Outer Wash Region. Prepared for the Humber Aggregate Dredging Association.

Greenstreet S.P.R., Holland G.J., Guirey E.J., Armstrong A., Fraser H.M., and Gibb I.M., 2010.Combining hydroacoustic seabed survey and grab sampling techniques to assess "local" sandeel population abundance. ICES Journal of Marine Science, 67, 971-984.

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Appendix I: Anglian Regional Cumulative Impact Assessment

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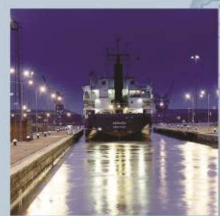
British Marine Aggregate Producers Association

Assessment of Cumulative Impacts on Sandeel from Marine Aggregates Extraction in the Anglian Region

Report R.2168

November 2013

Creating sustainable solutions for the marine environment





British Marine Aggregate Producers Association

Assessment of Cumulative Impacts on Sandeel from Marine Aggregates Extraction in the Anglian Region

Date: November 2013

Project Ref: R/4160/2

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Summary

As part of the Marine Aggregate Environmental Impact Assessment (EIA) Working Group, ABP Marine Environmental Research Ltd (ABPmer) was commissioned to undertake a cumulative assessment of the effects of marine aggregates dredging and other projects and activities on sandeel grounds off the Anglian coast of England. In addition to marine aggregates dredging, the following activities were also assessed: offshore renewables arrays; trawl and dredge fisheries; oil and gas pipelines; telecommunication cables; and dredge material disposal sites. The assessment found that marine aggregates extraction is generally not considered to lead to significant cumulative impacts requiring mitigation, as long as existing industry mitigation measures are continued. Of the other activities taking place in the region, trawl fisheries affect by far the largest area of potentially suitable habitat. Nevertheless, overall it is not thought that cumulative effects arising from all the activities combined are more than minor significant.

Abbreviations

ABPmer	ABP Marine Environmental Research Ltd
BAP	Biodiversity Action Plan
CIA	Cumulative Impact Assessment
ERM	Environmental Resources Management
ESFJC	Eastern Sea Fisheries Joint Committee
EIA	Environmental Impact Assessment
IFCA	Eastern Inshore Fisheries and Conservation Authority
JNCC	Joint Nature Conservation Committee
MAREA	Marine Aggregates Regional Environmental Assessment
MES	Marine Ecological Surveys
MMO	Marine Management Organisation
MMG1	Marine Minerals Guidance 1
NERC	Natural Environment and Rural Communities
ODPM	Office of the Deputy Prime Minister
PIZ	Primary Impact Zone
RAG	Regulatory Advisors Group
SIZ	Secondary Impact Zone
SSC	Suspended Sediment Concentrations
VMS	Vessel Monitoring System
%	Percent
km^2	Kilometre(s) squared
mg/l	Milligram(s) per litre

Assessment of Cumulative Impacts on Sandeel from Marine Aggregates Extraction in the Anglian Region

Contents

Tables

Figures

Images

1. Introduction

As part of the Marine Aggregate Environmental Impact Assessment (EIA) Working Group, ABP Marine Environmental Research Ltd (ABPmer) was commissioned by the British Marine Aggregate Producers Association (BMAPA) to undertake a cumulative impact assessment (CIA) of the effects of marine aggregates dredging and other projects and activities on sandeel (*Ammodytidae*) off the Anglian coast of England. Three other English dredging regions have been assessed by other members of the EIA Working Group (Environmental Resources Management (ERM), Fugro Emu and Marine Ecological Surveys (MES)).

As a demersal spawning fish species, and also a species which spends much of its life buried in sandy seabed sediment (particularly during night time and the cold months of autumn and winter), sandeel are considered to be sensitive to activities affecting the seabed which they preferentially use; including marine aggregates dredging. Lesser sandeel (*Ammodytes marinus*) are designated as a UK Biodiversity Action Plan (BAP) priority species, and are also considered to be a species of principal importance for the conservation of biodiversity in England under the 2006 Natural Environment and Rural Communities (NERC) Act. They are furthermore viewed as being of commercial importance, and are an important prey species for fish, seabirds and marine mammals (see, for example, Lynam *et al.*, 2013).

This report has been prepared based on a detailed method statement developed by the EIA Working Group, in consultation with the Marine Management Organisation (MMO) and the Regulatory Advisors Group (RAG) (Latto *et al.*, 2013) – 'Screening Spatial Interactions between Marine Aggregate Application Areas and Sandeel Habitat'. Following submission of draft CIAs in August 2013, comments were received from the Marine Management Organisation (MMO) and its advisors, and this final report takes account of the relevant change requests.

This report is intended to supplement the fish ecology impact assessment undertaken for the Anglian Offshore Marine Aggregates Regional Environmental Assessment (MAREA) (Emu, 2012).

Please note that ABPmer have also been commissioned to present the same type of assessment for (spawning) herring impacts. The herring CIA is presented in a separate report.

The report is structured in the following way:

Section 2: Background to the Anglian Dredging Region;

Section 3: Methodology;

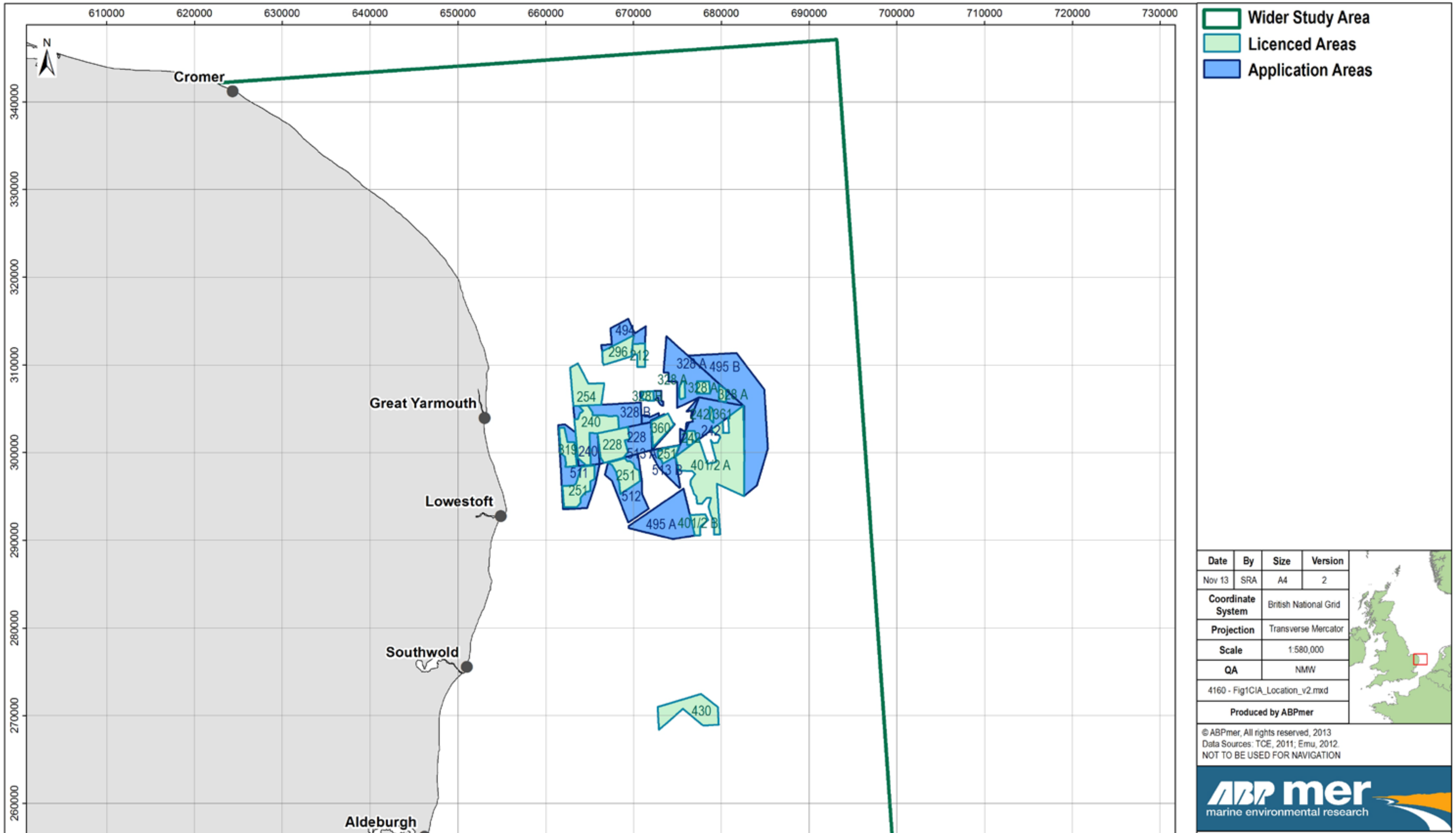
Section 4: Baseline Information; and

Section 5: Cumulative Impact Assessment.

2. Background to the Anglian Dredging Region

The marine aggregate licences within the Anglian / East Coast region of England have been an important source of aggregates for over 40 years. Offshore, the sands and gravels are of particularly high quality and, as a result, the supply of marine aggregates forms an important contribution to fulfilling local demand as well as supplying the markets of the south-east and the near continent (Emu, 2012).

The Anglian region currently has a total of 13 production licences for both sand and gravel, principally for use in the construction industry (BMAPA, 2013); these are being worked by five aggregates companies. Furthermore, several application / prospecting areas are currently being pursued. These areas are shown in Figure 1 below, which also depicts the extent of the MAREA region.



Aggregates Dredging Licences and Application Areas in the Anglian Region

Figure 1

3. Methodology

As outlined previously, the assessment approach and pathways to be applied for this Cumulative Impact Assessment (CIA) are outlined in the method statement by Latto *et al.* (2013). However, the impact evaluation methodology *per se* is to follow the respective MAREA methodology. Hence, the MAREA methodology applied by Emu for the 2012 Anglian MAREA is now firstly outlined in Section 3.1, before the Latto *et al.* (2013) CIA approach is briefly discussed in Section 3.2.

3.1 Cumulative Impact Assessment Structure Applied in the Anglian MAREA (Emu Methodology)

The Anglian MAREA assessed the cumulative and in-combination impacts of all aggregate dredging and other activities at the Anglian regional level. These types of assessment were defined as follows (Emu, 2012, Vol1, p.3.1):

- Cumulative: Impacts that arise from multiple marine aggregate extraction activities within a region and/or sub-region.
- In-combination: The total impacts of all industrial sectors operating within the same region in the context of natural variability or trends[1].

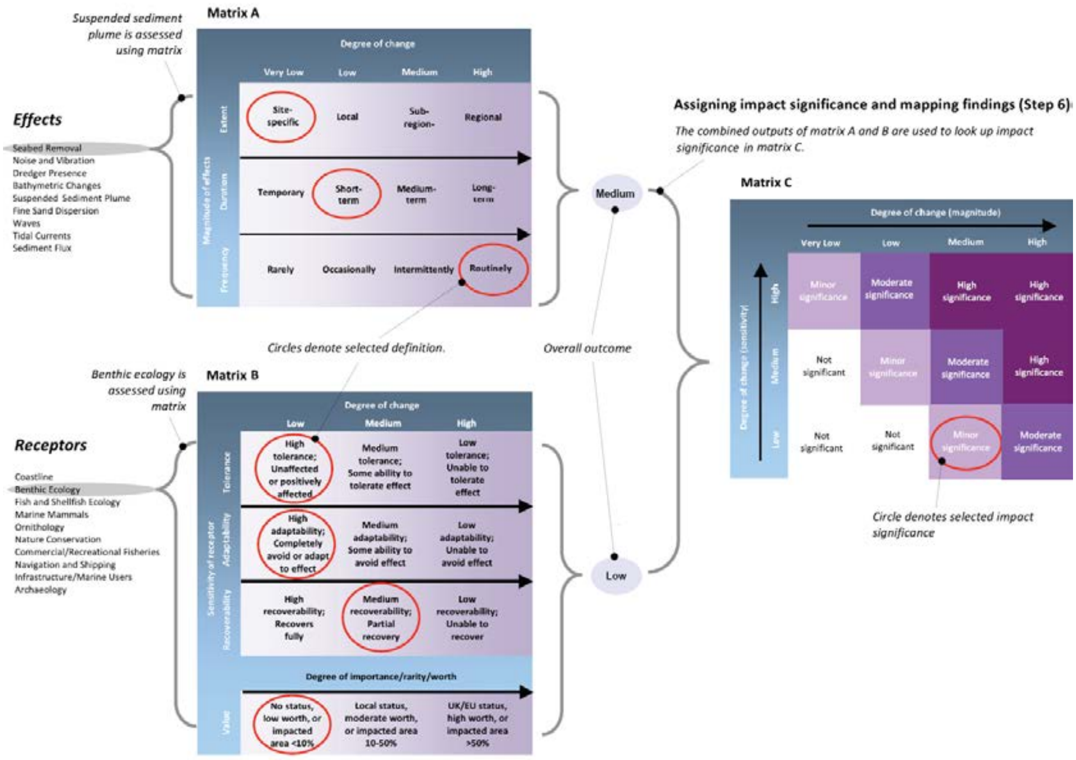
Emu's CIA methodology consisted of eight steps, which are as follows:

Step 1: Conceptualise effect-receptor relationship
Step 2: Quantify 'magnitude of effects'
Step 3: Map overlap between effects and receptors
Step 4: Characterise effect-receptor interactions
Step 5: Quantify 'sensitivity of receptor'
Step 6: Assign cumulative impact significance and map regionally and sub-regionally
Step 7: Determine in-combination impacts
Step 8: Conclusions and recommendations

With regard to Step 6 (Assigning Impact Significance), significance was defined as reflecting 'the level of importance placed on the impact in question and usually where it is acceptable to society'. For the purpose of determining significance, 'magnitude of effect' is assigned one of the following four categories; Very Low, Low, Medium and High (see matrix A in Image 1 below, which also shows an illustrated example), where 'sensitivity of receptor' is assigned either Low, Medium and High (see matrix B). A further matrix (C) combines the outcomes from the 'magnitude of effects' and 'sensitivity of receptor' matrices (A and B) to assign cumulative impact significance. Definitions of significance were as follows:

[1] Please note that the definition of 'in-combination' applied for the MAREA should not be confused with the 'in-combination' definition in relation to the Conservation of Habitats and Species Regulations 2010 (as amended), where 'in-combination' effects relate to those combined effects of plans or projects which could have significant effects on European designated sites or features.

- Not significant Impacts that, after assessment, were found to be not significant in the context of the MAREA objectives;
- Minor significance Impacts that warrant the attention of particular stakeholders but no action is required if impacts can be controlled by adopting normal good working practice;
- Moderate significance Impacts that should be recognised and addressed in consultation with particular stakeholders; and
- Major significance Impacts that are not environmentally sustainable and compromise the continuation of extraction activity in the region/sub-region.

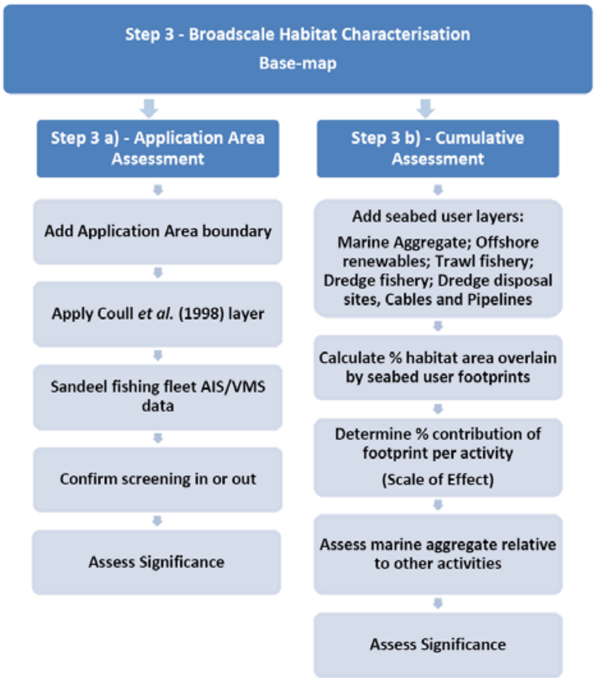


(Source: Emu, 2012, Figure 3.3)

Image 1. Illustrated example of assigning magnitude and sensitivity including assigning impact significance and mapping

3.2 Cumulative Assessment Approach

A detailed description of the iterative steps which are to be applied to the sandeel CIA was provided by Latto *et al.* (2013), and summarised in a chart shown below in Image 2. Step 3b describes the CIA approach, whereas Step 3a applies to the worked EIA approach (which is no longer presented). Please note that Steps 1 to 2 relate to screening and mapping levels which underpin this assessment, and which are discussed in the baseline section.



(Source: Latto *et al.*, 2013, Figure 4)

Image 2. Screening levels to enable application area and cumulative assessment between Marine Aggregate Application Areas and sandeel preferred and marginal habitat.

In summary, relevant activities are mapped, and overlapped with seabed and percentage contribution of footprint calculated (at a regional scale). The cumulative impacts are then assessed, and marine aggregates related to the following activities:

- Offshore renewables arrays;
- Trawl fisheries;
- Dredge fisheries;
- Oil and gas pipelines;
- Telecommunication cables; and
- Dredge material disposal sites.

It is worth noting that MES, in cooperation with EIA working group members, undertook a confidence assessment on each of the data layers described in this document (MES, 2013); conclusions reached are summarised in the baseline section of this report (see Section 4).

Within an aggregate assessment, two impact zones are considered; these are defined as follows. The boundary of the Primary Impact Zone (PIZ) is understood to coincide with that of the marine aggregates licence and application areas. Building on the Anglian MAREA (Emu, 2012), the Secondary Impact Zones (SIZs) are defined as those areas, wherein there could conceivably be an indirect impact due to either the suspended sediment released during dredging (causing plumes or changes in particle size distribution), or the screening undertaken by some dredgers (potentially creating bedforms). Particle size distribution changes could be observed as far as 4km away from a dredger, whereas it is thought that bedforms could occur as far as 2.5km distant from dredging activities. High suspended sediment concentration plumes exceeding 50mg/l are generally not observed further than 400m away from a dredging vessel (HR Wallingford, 2010). Please note however that for the purpose of the sandeel assessment, SIZ-related impacts need not be considered (they were however considered for the herring assessments mentioned above).

As mentioned in the introduction to this report, comments on the draft CIA reports produced based on this methodology (and also for herring) were received by the EIA working group in early September. A clarifying meeting was subsequently held between regulators and selected members of the working group on 19 September 2013. The key points agreed were as follows (quoting directly from MMO, 2013a):

a) *'Heat maps with low, medium and high boundaries will be used instead of the preferential/marginal habitat maps when screening Herring potential spawning habitat and Sandeel habitat in and out at a regional scale, and for the assessment of potential regional exposure resulting from site specific, cumulative and in-combination pressures;*
b) *The East Channel Region Herring spawning methodology will not be used as test of the Herring Potential Spawning Habitat Assessment methodology as it is not comparable;*
c) *The proposed worst case scenario (all suitable habitats present in all licence areas being impacted) is appropriate rather than adopting a realistic worst case scenario. However, a more realistic scenario (based on historic dredged area derived from Electronic Monitoring System data) could usefully be added to provide added context;*
d) *There is no requirement to undertake an assessment of possible direct effect pathways and resultant impacts on sandeel as a result of entrainment – this to be addressed in site specific Environmental Impact Assessment;*
e) *An update meeting has been scheduled at 4-4.30pm on 10 October 2013; and*
f) *A target of the end of October was agreed for formally signing-off the revised methodologies and final assessments.'*

The agreed actions from the follow up meeting on 10 October 2013 were as follows (quoting directly from MMO, 2013b):

a) *EIA WG to clearly signpost IHLS methodology from the appendices in the main report;*
b) *Cefas to confirm that the appendices provide enough information on the methodology used for the IHLS data (by 18 October 2013);*
c) *Cefas to provide regional narratives of where herring spawning occurs that can be considered and incorporated into the final assessment (by 18 October 2013);*
d) *MMO to contact IFCAs regarding the release of data where necessary for site specific assessments;*
e) *Cefas and NE to source DTU Aqua Data report (by 18 October 2013);*
f) *Cefas to provide additional information on the caveats detailed in response to Action e) from the 19 September 2013 meeting note (by 18 October 2013);*
g) *NE and Cefas to provide a steer on the level information required for the site specific herring spawning and sandeel habitat assessments (by 18 October 2013);*

h) *EIA WG to provide four case studies setting out the approach for assessing herring spawning and sandeel habitats at a site specific level.*

Cefas subsequently provided additional information on 18 October 2013 (Cefas, 2013); caveats and information provided in this document were included in this CIA as appropriate.

4. Baseline and Screening Information

This chapter presents baseline and screening information. Firstly, the extent of suitable sandeel habitat is detailed in Section 4.1. Section 4.2 then summarises what other layers and information indicative of sandeel presence are available for the Anglian region, before the screening outcome and confidence layer overlaps are presented in Section 4.3.

4.1 Sandeel Suitable Seabed Habitat

4.1.1 Introduction

Sandeels are a vital component of the North Sea food web, forming a crucial mid-trophic link between zooplankton production and top predators such as fishes, seabirds and marine mammals (Wanless *et al.*, 2004). They over-winter, overnight and rest buried in sandy sediment (normally within 4 to 6cm of the surface) (Haynes *et al.*, 2011). When not buried in sediment, sandeel are mostly found in mid-water or near the seabed (e.g. Wright and Bailey, 1993). Sandeel are demersal spawners, with eggs being laid as sticky clumps on sandy substrate; thereafter, sandeel larvae are pelagic for a period of 50 to 90 days (Rogers and Stocks, 2001; Wright *et al.*, 2000).

The distribution of sandeels is mostly dependant on sediment type, as sandeels do not maintain permanent burrow openings and hence rely on oxygen within the interstitial water (e.g. Holland *et al.*, 2005). *A. marinus* prefers sediments with a low silt/clay content, and also has a preference for gravel content of less than 10%, and ideally no more than 2 to 4%. Habitat preference experiments have also found that as the proportion of coarse sand and medium sand (between 0.25 and 2mm) in the sediment increases, sandeels show increased selection for the habitat, although slightly gravelly sand may also be suitable (e.g. Wright *et al.*, 2000; Holland *et al.*, 2005). Sandeels prefer to occupy sloping areas of sandbanks facing into currents (Greenstreet *et al.*, 2010), with current speeds being greater than 0.6m/s. Sandeels have also been shown to have a temperature preference (between 0ºC and 8.3ºC) as well as a preference for stratified saline waters (Wright *et al.*, 1998). Further information on the ecology of sandeel can be found in Latto *et al.* (2013).

Based on the available evidence, Latto *et al.* (2013) determined that sediment classed as 'Sand', 'slightly gravelly Sand' and 'gravelly Sand' on the Folk (1954) sediment classification scale should be viewed as 'preferred habitat', and 'sandy Gravel' as 'marginal habitat'. Aspects such as aeration and elevation are not to be considered in the analysis. As a consequence, not all areas described as suitable habitat will actually be likely to support sandeel.

4.1.2 Sandeel suitable habitat in the Anglian region

The Anglian MAREA seabed sediment layers were used to create sandeel habitat layers in order to facilitate the cumulative assessment. This mapping revealed that the following areas were present in the Anglian MAREA region:

- Preferred sandeel habitat: 3,800km^2, and
- Marginal sandeel habitat: 560km^2.

The combined area of 'preferred' and 'marginal' sandeel habitat accounts for 4.5% of the national seabed available to the Central North Sea and Southern North Sea sandeel populations.

MES assessed a high confidence (3 out of 3) in the MAREA preferred and marginal habitat layers; however, as an indicator of sandeel presence, a high and low score was given to the two layers respectively (4 and 2 out of 5) (MES, 2013).

4.2 Indicators of Sandeel Presence in the Anglian Region

The subsequent section presents other data layers which are indicative of sandeel presence, before other available information on sandeel presence in the Anglian region is summarised (Section 4.2.2).

4.2.1 Overlap with Other Spatial Information Indicative of Sandeel Presence

In 1998, a project led by the fisheries agencies mapped sensitivity areas (i.e. spawning and nursery areas) for the main commercial fish species. Coull *et al.* (1998)[2] mapped a wide zone where sandeel may spawn; this extends from ca. 13km from the coast to ca. 70 to 100km offshore. Furthermore, a sandeel fishery is present across most of Scroby Sands and South and Middle Cross Sands off Great Yarmouth, as well as on some sandbanks off Orford in the south of the MAREA region (according to an Eastern Sea Fisheries Joint Committee (ESFJC) mapping project[3]). These two layers are depicted in Figure 2.

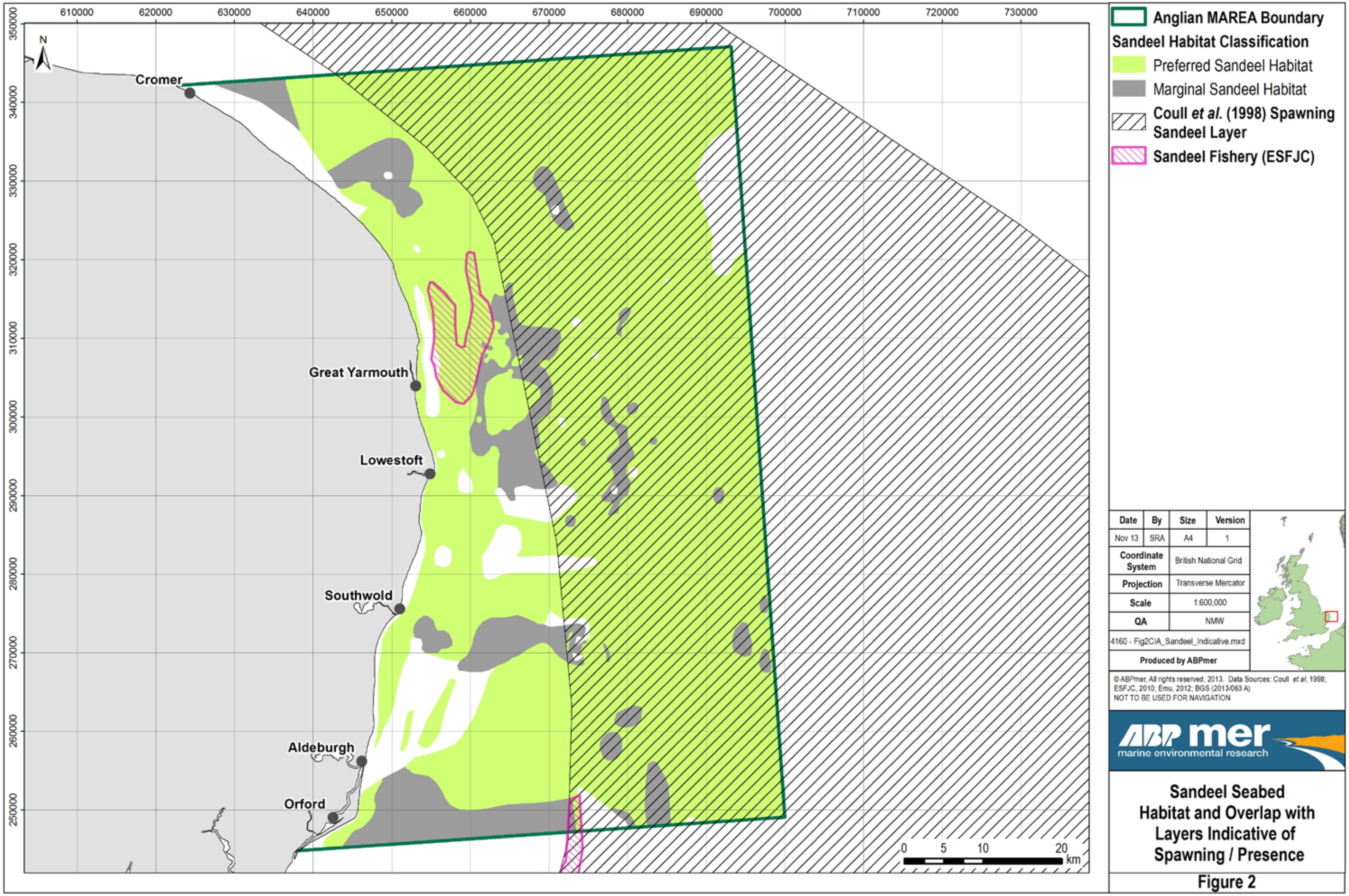
It is worth noting that MES assessed the confidence and 'indicativeness of sandeel presence' for these two layers as follows:

- Coull *et al.* (1998): low confidence (1 out of 3), medium indicator (3 out of 5); and
- ESFJC: low confidence (1 out of 3), medium indicator (3 out of 5).

---

[2] This identified spawning areas around England. Data was based on the collated distribution of eggs, larvae, young and commercially sized fish, seabed sediments and acoustic visualisation techniques (see MES (2013) for more detail). It remains unclear, whether the zone drawn straddling the East Anglian coastline is an actual spawning ground (and if so of what intensity) or a historic spawning ground, as the source data underlying Coull *et al*. has not been available for analysis.

[3] This 2010 mapping project aimed to describe, using best available data and fishermen's knowledge, the extent of the main fisheries within the ESFJC District. Please note that SFJCs are now called 'Inshore Fisheries and Conservation Authorities' (IFCAs).



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Sandeel Seabed Habitat and Overlap with Layers Indicative of Spawning / Presence

Figure 2

4.2.2 Information on Sandeel Presence from other Sources

Further information on sandeel presence in the Anglian region has been gleaned from the literature.

Firstly, fisheries landing data indicates that sandeel is not extensively targeted by fishermen in the MAREA region. An analysis of landings value undertaken for 2006 showed that ‘small pelagics’, which would include sandeel, accounted for 1.3% of the total landed value in 2006 in the Eastern District (which covers the Lincolnshire, Norfolk and Suffolk coastline from Donna Nook to Shotley) (Walmsley and Pawson, 2007). As outlined above, the ESFJC project also highlighted two small areas in the MAREA region where sandeel are targeted.

In the analysis of grab surveys for the Anglian MAREA (Emu, 2012), only single specimen were observed at eight survey stations (out of 543) (not surprising as these surveys are likely to have taken place during the daytime, when sandeel would be generally expected to be in the water column). Sandeel were however observed in a large percentage of the trawl samples analysed for the MAREA (110 out of 201)[4].

A Dutch study (van Damme *et al.*, 2011) undertook twelve monthly ichthyoplankton surveys between April 2010 and March 2011 in the southern North Sea. Four sandeel species were observed, namely smooth sandeel (*Gymnammodytes semisquamatus*), greater sandeel (*Hyperoplus lanceolatus*), small sandeel (*A. tobianus*) and lesser sandeel. During the May and April surveys, nearshore stations were also sampled along the Anglian coast. During the other months, including the crucial winter spawning months, only stations further offshore were surveyed. Lesser sandeel larvae were observed at many survey stations in the southern North Sea, including at some stations close to the Anglian coast; though the major aggregations were seen mainly to the south and north of the Anglian region, as can be seen in Image 3. Larvae of other sandeel species were also observed in the Southern North Sea, although only greater sandeel larvae were also observed in the Anglian nearshore and offshore region (in small numbers, at several stations).

Lynam *et al.* (2013) undertook a study analysing larval fish data from the Continuous Plankton Recorder (CPR) samplers present throughout the North and Irish Seas; where high level maps indicate that sandeel larvae have been captured in the Anglian region, particularly further offshore and generally in very low to low abundances.

Thus, overall, it appears that there is a sandeel presence in the Anglian region, although the distribution is likely generally not as high as in the adjacent areas (English Channel, Thames Estuary, Wash and Dogger Bank). Abundances appear to be higher towards the north of the region, and also further offshore.

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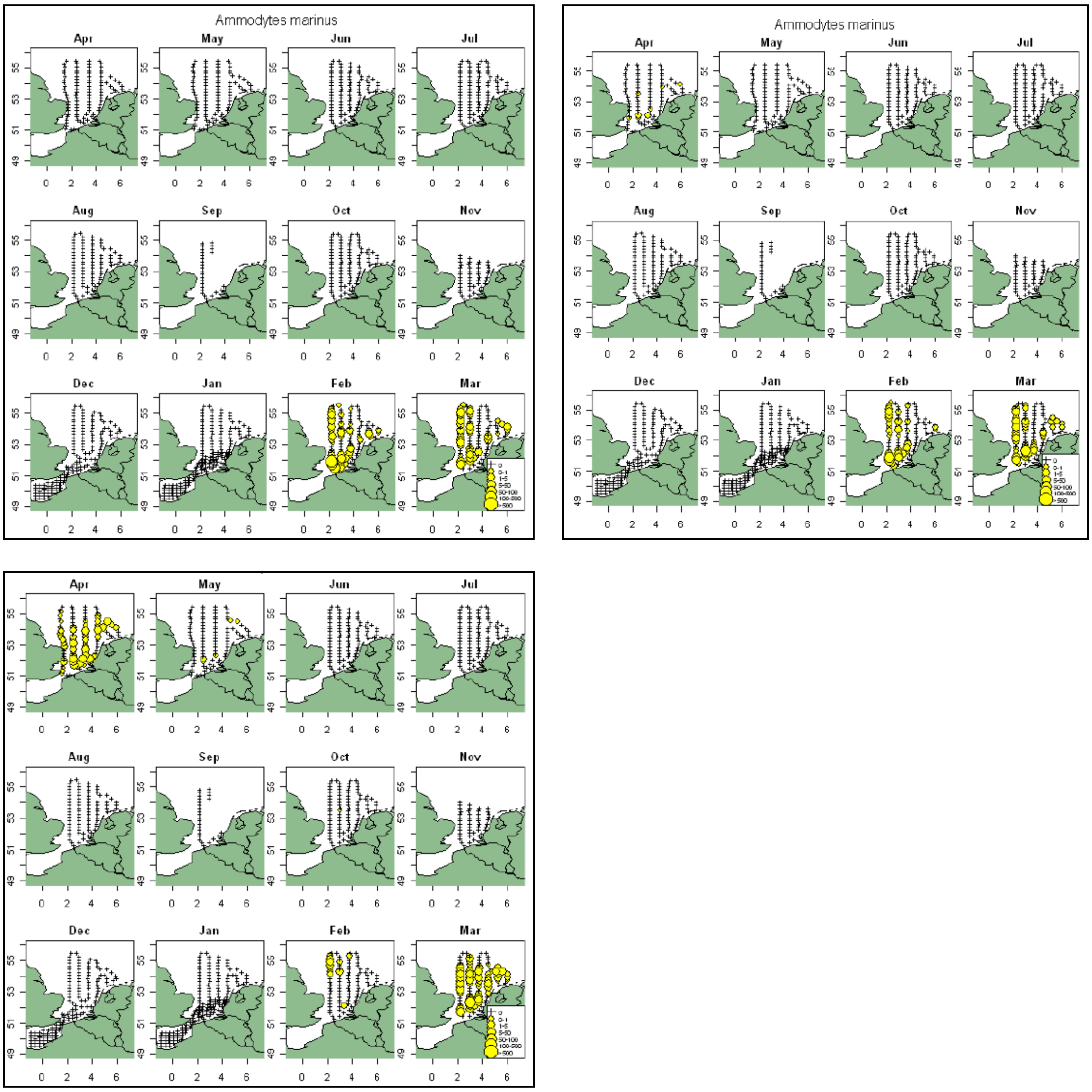
4 Please note that both grab and trawl surveys have significant limitations when it comes to surveying sandeel. In order to catch sandeel, a grab survey must be carried out when they are within the seabed; either at night time or between September and March when they undergo a period of dormancy. Trawl surveys only record epibenthos, and thus pelagic and adult demersal fish would have been underrepresented.



(Source: Figures 21a-c, Appendix A, van Damme *et al.*, 2011)

Image 3. Spatial and Temporal Distribution of Yolk Sac (top left), Non-yolk Sac (top right) and Notochord (bottom left) Stage Lesser Sandeel Larvae

4.3 Screening Results / Confidence Assessment

The screening outcome (based on the confidence layers produced by MES) is now firstly presented for the Anglian aggregates areas, before activity overlap with the same layers is presented for aggregates and other activities which could lead to cumulative effects.

4.3.1 Screening Outcome

In order to determine whether any of the aggregates areas in the Anglian MAREA region could be screened out of the CIA, the outcome of the screening exercise is presented in a heat diagram[5] in Figure 3, based on the MES (2013) confidence assessment. The score arrived at at any given location is the sum of the sediment type, ESFJC data, Coull *et al.* layers and VMS. Please note that VMS data (not previously discussed) is split into demersal gear types and pelagic gears, where demersal gears target sandeel as well as many other species. Thus, VMS data can be interpreted as providing a low (MES score of 2 out of 5) indicator to sandeel grounds. VMS data was scored as high (3 out of 3) for confidence in the data (MES, 2013).

Figure 3 presents a simplified categorisation of 'low', 'medium', 'high' and 'very high', as well as the more detailed numerical scale of 1 to 16. This heat map, which was generated from overall confidences, is not necessarily indicative of sandeel grounds; rather, higher confidences indicate that more layers of data were available for that particular area (irrespective of data content). It should not be assumed to be directly related to sandeel presence.

Figure 3 and Table 1 demonstrate that no 'very high' areas are present in / around the Anglian dredging areas. In fact, no such areas were found anywhere in the wider study area, or nationally; however, this category was included on the map legends to account for the maximum possible data layer score.

Regarding spatial interaction with aggregates activity, all the Anglian dredging areas overlap with at least one layer potentially indicating sandeel presence. Six (sub-) areas mostly or completely overlap with the 'high' categorisation, five with near-equal areas of 'high' and 'medium', six with 'medium', two with 'low' and 'medium', and one with 'low'[6].

Thus, all the Anglian aggregates areas were screened into this CIA.

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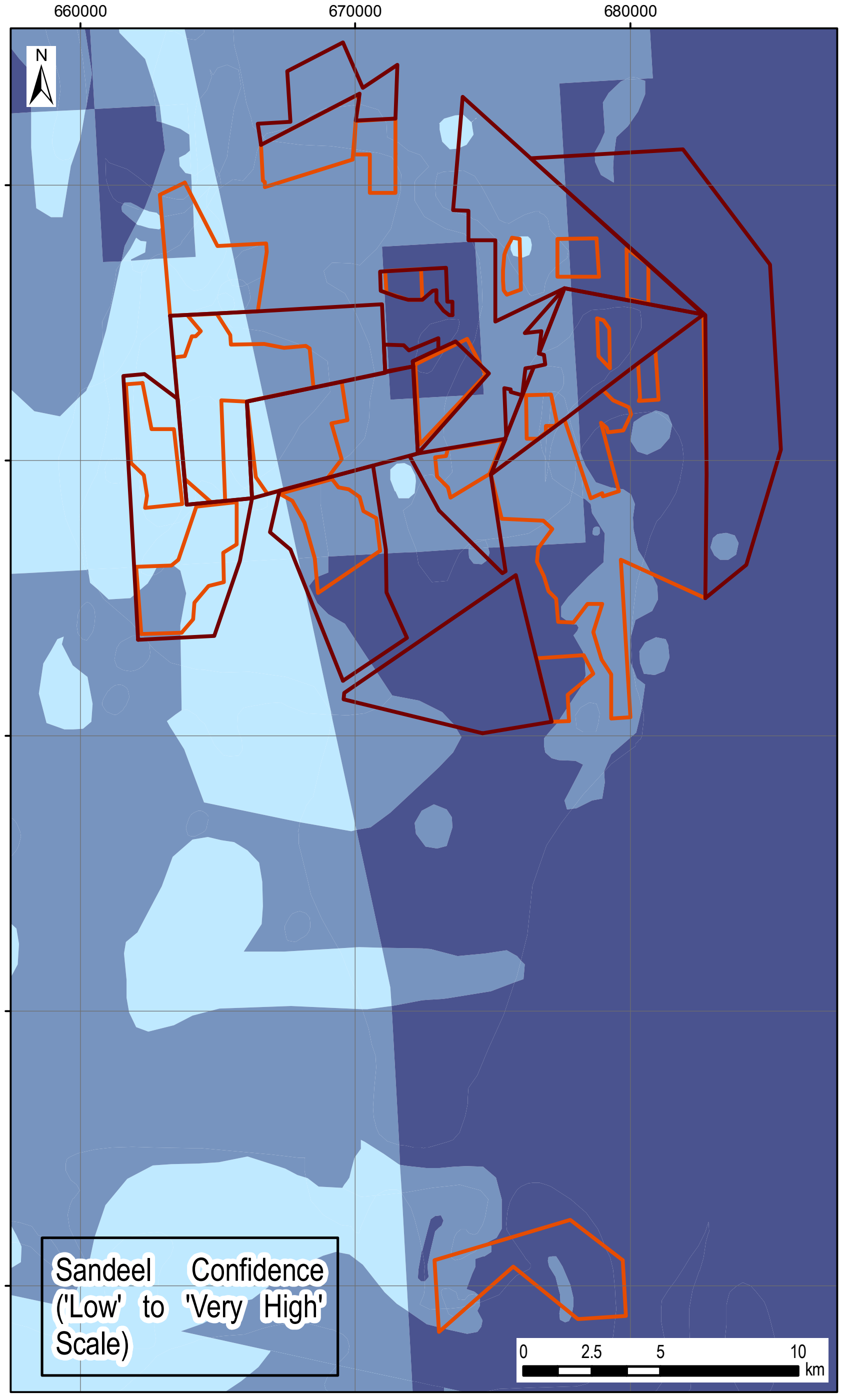
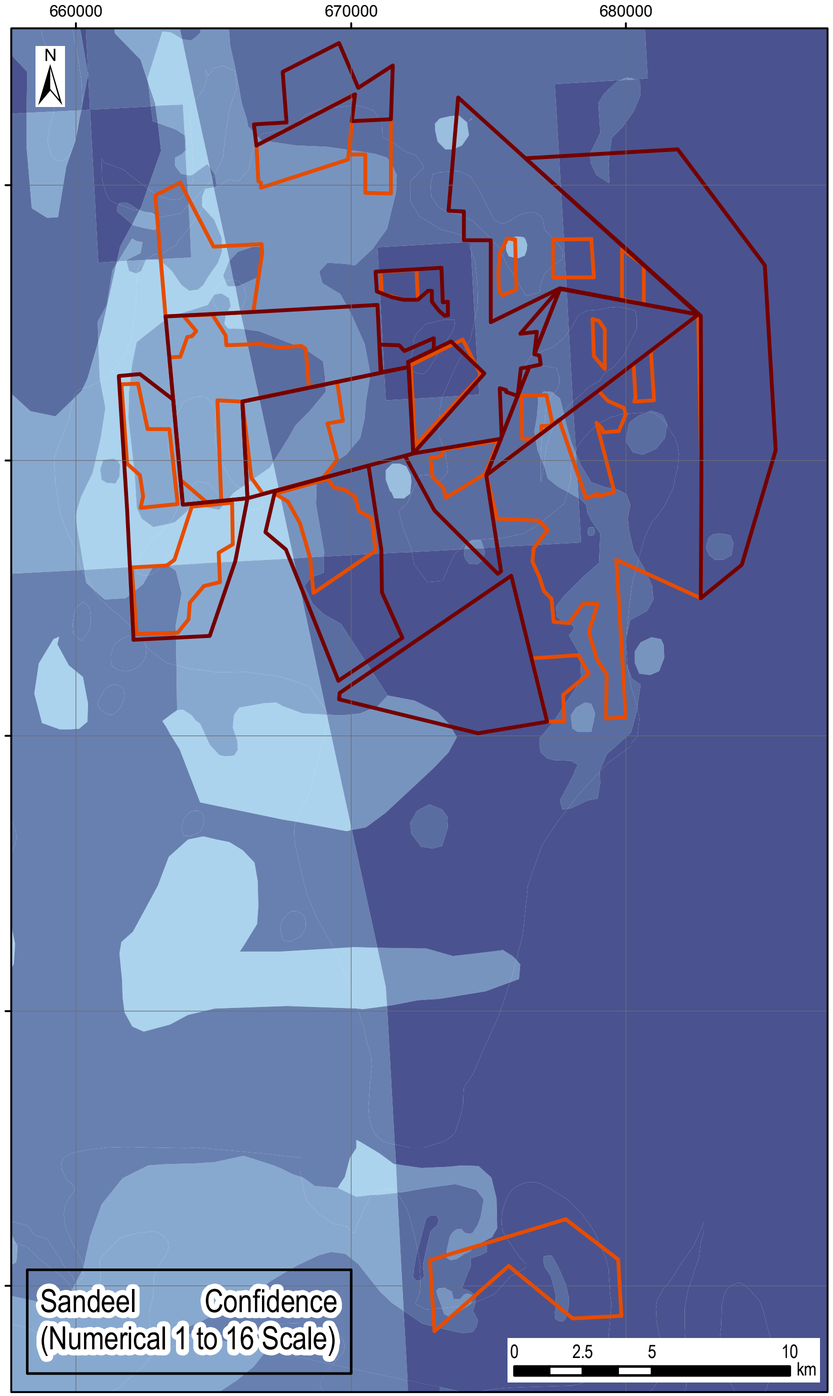
5 i.e. a colour gradient map where the larger values are represented by a darker colour to denote a greater number of variables

6 Numerical scores of '9' represent a VMS score of 2, a Coull et al. score of 3 and a preferred seabed habitat score of 4. Overall scores of '7' reflect the same scores, bar the VMS coverage. Scores of '5' are made up of 3 points for Coull et al. overlap, and 2 points for marginal habitat overlap. Lastly, scores of '4' or '2' are accounted for by either 4 points for preferred habitat overlap, or 2 points for marginal habitat overlap. For further explanation of the scoring system, please see MES 92013).

Table 1. Overlap of Anglian Aggregates Areas with Confidence Layers

Area	Predominant Confidence Category (Word)	Predominant Confidence Category (Number)	Area	Predominant Confidence Category (Word)	Predominant Confidence Category (Number)
212	Medium	5 & 7	401/2 A	Medium & High	7 & 9
228	Medium	5 & 7	401/2 B	High	9
240	Low & Medium	4 & 5, 7	430	High	9
242	Medium & High	7 & 9	494	Medium	7
254	Low & Medium	2, 4 & 7	495 A	High	9
296	Medium	5 & 7	495 B	High	9
328 A	Medium & High	7 & 9	511	Low	2, 4
328 B	High	9	512	Medium & High	7 & 9
328 C	High	9	513 A	Medium & High	7 & 9
361	Medium	7	513 B	Medium	7





Application Areas
Licenced Areas

Sandeel Confidence

- Low
- Moderate
- High
- Very High

Sandeel Confidence (1-16 scale)

1 (Low)	9 (High)
2 (Low)	10 (High)
3 (Low)	11 (High)
4 (Low)	12 (High)
5 (Med)	13 (Very High)
6 (Med)	14 (Very High)
7 (Med)	15 (Very High)
8 (Med)	16 (Very High)

Date	By	Size	Version
Dec 13	SRA	A4	2
Coordinate System	British National Grid		
Projection	Transverse Mercator		
Scale	1:275,000		
QA	NMW		
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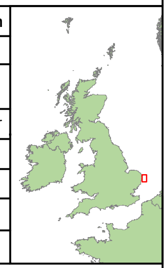

Data Sources: MES, 2013; TCE, 2013
NOT TO BE USED FOR NAVIGATION

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Sandeel Confidence Heat Maps

Figure 3

4.3.2 Overlap of Activities with the Confidence Layers

The percentage overlap of the activities listed in Section 3.2 and the sandeel confidence layers are given in Table 2[7], and a visual depiction of the overlap is provided in Figure 4. The percentages relate to the total area of the combined high/medium/low confidence layer coverage in the Anglian MAREA region.

The table demonstrates that marine aggregates rank third when overlapping activity/project footprint with any confidence layer (bearing in mind however that there is some double counting in this data, as some Application Areas contain current Licence Areas – in total this overlap accounts for 65km^2, or 1.7% of the total confidence layer area). By far the largest overlap is seen for demersal trawling[8], accounting for 25% of 'high' confidence areas, 14% of the 'medium' confidence areas, and 9% of the 'low' confidence areas. Trawling is followed by windfarm licence areas – this relates to the Round 3 licence area, wherein windfarms could be developed; the first of these, East Anglia ONE is currently going through the planning stages and only very marginally overlaps with the MAREA extent (which constitutes the boundary of this CIA). The overlap of the current and potential marine aggregates dredging licence areas with the sandeel confidence layers amounts to 3.3% of the 'high' category areas present, 3.6% of the 'medium' areas, and 1.7% of the 'low' grounds present. The footprints of other activities, most notably cables and pipelines and operating windfarm turbines, make relatively small contributions.

Trawler fishing and the Round 3 windfarm licence area frequently overlap with other pressures and therefore to arrive at a realistic cumulative total, the area not touched by any activity was calculated. It was found that some 27% of the confidence area showed no overlap with any of the cumulative activities or projects mapped.

It should be noted however that for several of the activities, the footprints applied represent very conservative / unrealistic worst case scenarios. For example, none of the dredging areas would be dredged across their whole extent at any one time. Similar limitations apply to disposal sites and also trawler fishing. Furthermore, they represent potential zones of impact, and not certain habitat change.

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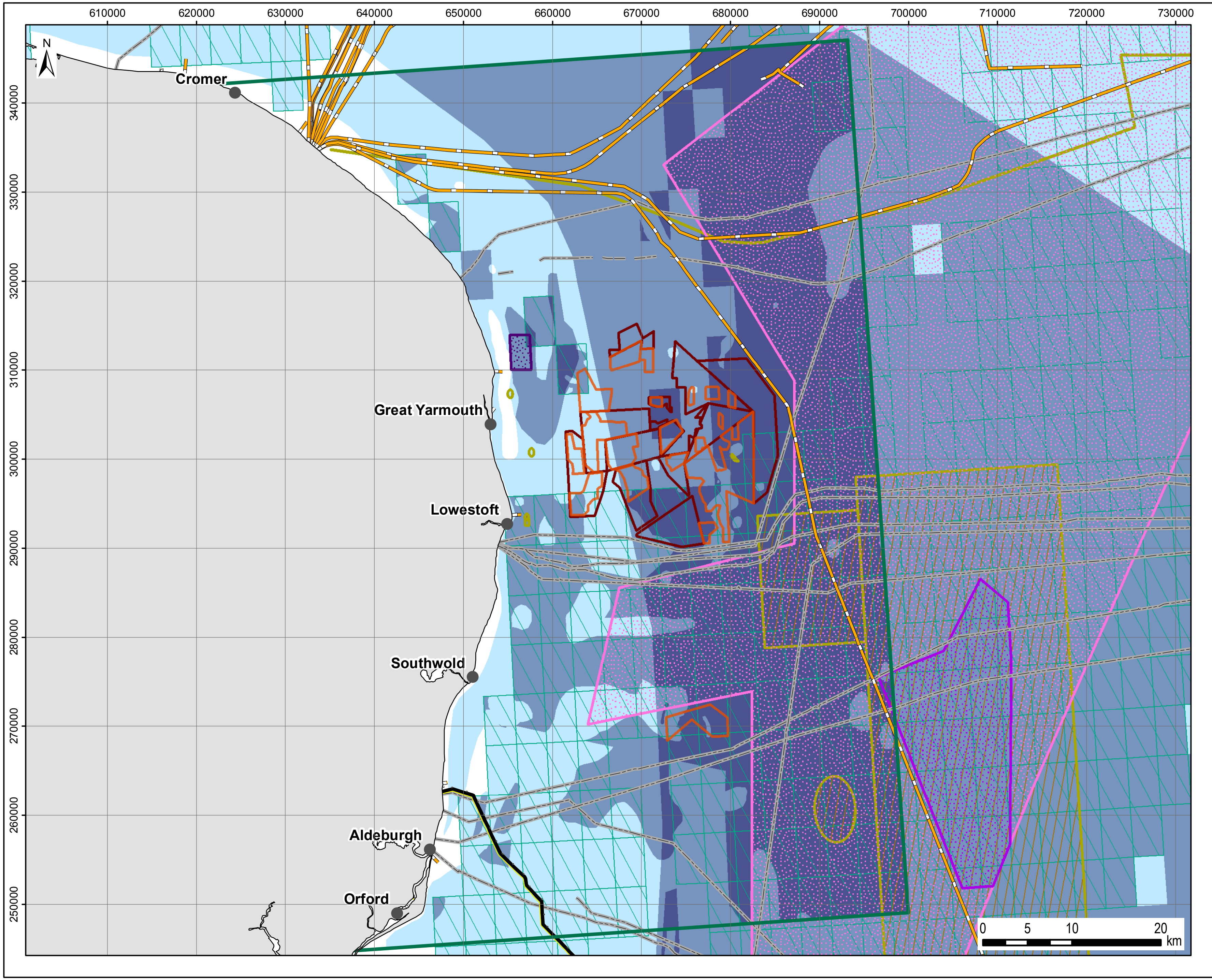
7 Where available, exact footprints were used by ERM to establish the spatial interaction. Where a seabed user footprint could only be established in outline (the standard footprint), a generic approach to establishing a realistic worst case detailed footprint was adopted to ensure that the full spatial footprint of interaction with the relevant grounds could be established. Therefore, where a standard footprint has been used, the worst case interaction was established.

8 Please note that the calculations were based on a merged 2007 to 2011 VMS layer mapped according to ICES sub-rectangles. Also, no dredge fishery was identified anywhere in the MAREA region according to VMS.

Table 2. Percentage Overlap of Cumulative Activities with Sandeel Confidence Layers

Confidence Score	Cables and Pipelines				Fisheries		Disposal Sites	Windfarms				Aggregates		Cumulative Total
	Pipelines	Power Cables	Telecommunications Cables	'Worst-Case' Proposed Power Cables	Demersal Trawling	Fisheries Dredging	Disposal Sites	Operating Windfarm Turbine Footprint	Operating Windfarm Licence Areas	Proposed Windfarm Sites - Indicative Turbine Footprint	Windfarm Licence Areas Proposed	Current Licence Areas	Application Areas	
High	0.0013	0	0.0003	0.0004	25.06	0	7.18	0	0.014	0.0709	29.98	1.08	2.20	37.04
Medium	0.0016	0.0001	0.0002	0.0002	14.1	0	0.33	0.0014	0.1683	0.01	4.15	1.48	2.08	21.87
Low	0.0015	0.0001	0.0001	0.0001	9.13	0	0.05	0	0.0053	0.0017	0.72	0.70	0.97	14.10



Date	By	Size	Version
Dec 13	SRA	A4	2

Coordinate System	British National Grid
Projection	Transverse Mercator
Scale	1:580,000
QA	MCE

4160 - Fig4CIA_SandeelOverlap_v2.mxd

Produced by ABPmer

Data Sources: TCE, 2011; Emu, 2012.
NOT TO BE USED FOR NAVIGATION

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Spatial Interaction of Potential Sandeel Grounds and Cumulative Activities

Figure 4

5. Cumulative Impact Assessment

5.1 Introduction

The MMO and the RAG have advised 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 Marine Works (EIA) (Amendment) Regulations 2011. Latto *et al.* (2013) clarified that marine aggregate licence applications in relation to an EIA of likely effects on potential sandeel habitat will specifically need to consider effect-receptor pathways for:

The Primary Impact Zone:

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

The Secondary Impact Zone:

- None

To clarify, in agreement with the RAG and the MMO, only impacts associated with the PIZ are to be assessed, in relation to direct removal of habitat, along with physical alteration of the structure of the sediments from direct contact with the draghead. Assessing SIZ related effects from the sediment plumes and sediment mobilisation was not considered necessary (see Latto *et al.* for more detail).

Also, it has been agreed with the RAG and MMO that entrainment effects of sandeels by the dredger draghead need not be considered for the purpose of this CIA. However, it should be noted that there is likely to be a potential effect pathway on adult sandeels (as they could be present in the substrate when it is extracted). Consequently, this effect pathway is to be considered and assessed during site specific EIA processes.

For the purpose of this CIA example, the only sandeel effect pathway assessed was 'seabed removal'.

The following effects are not discussed:

- Fine sand dispersion;
- Suspended sediments;
- Vessel displacement;
- Noise and vibration;
- Bathymetric changes;
- Wave changes;
- Tidal current changes; and
- Sediment flux (proxy for sediment erosion and accretion).

Please note that 'recovery of habitat' is not a pathway *per se*, but is an aspect informing sensitivity, and is hence incorporated into the relevant pathways.

Prior to the assessments being undertaken, the value assigned to sandeel for the purpose of the assessments is briefly outlined. In summary, based on the MAREA methodology (see Image 1), sandeel has been assigned a **medium value** (with value being a function of importance, rarity and worth). This is due to sandeel being listed as a nationally important species with regards to biodiversity conservation (BAP and NERC). It is a widespread species which is considered as being commercially important; however, it is not thought to be extensively targeted by fishermen in the MAREA region[9]. Furthermore, with regards to available seabed area, the total potential sandeel seabed area present in the MAREA region is less than 10% of the national total (4.5%; see Section 4.1).

The one effect scoped in for full impact assessment above is now assessed. The cumulative impacts of aggregates dredging are firstly assessed, before the contribution of other activities is considered.

5.2 Seabed Removal

5.2.1 Impacts from Marine Aggregates Dredging

5.2.1.1 Impact commentary

Within the PIZs, seabed removal could potentially lead to a change in seabed habitat (structure), whereby the dredging by draghead either exposes bedrock, or finer or coarser layers of sediment. Bedrock would not be considered suitable sandeel habitat. Bathymetric changes could also occur due to seabed removal, flows could be altered, and sediments disturbed.

It is thought that, after an initial larval dispersal period, sandeel display a degree of site fidelity (Haynes *et al.*, 2011; Jensen *et al.*, 2011). 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.

It is not thought that sandeels are sensitive to small scale depth changes, as they are typically found in a variety of depths ranging from 2m to 70m (Wright *et al.*, 2000). It is noteworthy that the depth of aggregate extraction in the MAREA region is typically at 15 to 40 metres below Chart Datum, and that worst case bathymetric changes in the licence and application areas are generally predicted to be in the region of 2 to 4m, though up to 10m could occur (see Appendix B to Emu, 2012).

Sandeels could be sensitive to significant flow changes; as they are known to preferentially occupy sloping areas of sandbanks facing into currents, with current speeds being greater than 0.6m/s (Greenstreet *et al.*, 2010). With regard to potential changes to tidal currents due to aggregate extraction in the Anglian MAREA region, the MAREA modelling found that, where

9 'Small pelagics' accounted for 1.3% of the total landed value in 2006 (Walmsley and Pawson, 2007).

localised dredging occurs related tidal current reductions are anticipated to occur, these are typically in the order of 5 to 10% (Emu, 2012; HR Wallingford, 2011). It is worth noting that flow speeds in the Anglian region are generally fairly high (HR Wallingford, 2011), and that related tidal current-induced bed shear stresses are equally relatively high throughout the region during normal tidal conditions; this leads to sand-sized material being mobile throughout most of the region (even gravel sized in some isolated areas during spring tide conditions) (ABPmer, 2013). Thus fine grained material deposited as a result of a plume or draghead seabed disturbance will be dispersed and generally kept in suspension.

Table 2 shows that Anglian licence and application aggregates dredging areas directly overlap with some 8.5% of the high/medium/low confidence areas present in the MAREA region – however some 1.7% of that is double counted (due to licence areas being located in application areas), and the accurate total percentage is thus 6.8%. As previously mentioned, assuming that all of this 6.8% itself will be impacted is however unrealistic, as relatively small percentages of licence areas tend to be dredged in any given year; for example, in 2009 only 17.7% of the overall area licensed in the Anglian region was dredged (BMAPA, 2009); whereas in 2012, 19.3% was dredged (BMAPA, 2013). On this basis, it may be more realistic to apply a conservative 'likely percentage of licensed area affected', which according to the last 10 years of annual BMAPA reports, would be around 20%. Applying 20% would mean that the combined area of potential sandeel grounds affected by aggregate dredging in any one year would be less than 1.4% of the regional total of high/medium/low areas present in the MAREA region. Over the course of the licence, the full percentage could be affected. However typically, significant proportions of licence areas are (hardly) ever dredged.

It is important to highlight that the British marine aggregates dredging industry is committed to a mitigation measure whereby the seabed post-dredging is to be returned to, or left in a similar physical condition to, that present before dredging. Sediments are furthermore not dredged completely (down to bedrock), but an adequate depth of suitable material (normally at least 50cm) is left after cessation of dredging as a 'capping layer'. These mitigation measures (detailed in Marine Minerals Guidance 1 (MMG1) (Office of the Deputy Prime Minister (ODPM), 2002)) primarily facilitate the re-colonisation and recovery of benthic communities (Joint Nature Conservation Committee (JNCC) and Natural England, 2011). These measures should enable the seabed in the Anglian dredging areas to be left in, or returned to, a similar state to that which it is currently in, once the licences have expired. A new monitoring approach to ensure that the composition of sediments within impacted areas remains within an acceptable range is currently being implemented, based on instructions by Cooper and Koch (2013). Thus, in summary, once a dredger has moved on, whilst the habitat the sandeel may have previously used for burrowing or spawning may have been dredged, there would generally still be an appropriate layer of suitable sediment remaining. Should a given licence area be changed too much with regard to seabed sediment, it is assumed that remedial measures would need to be taken by the licensee; this would also ensure that habitat preferred by sandeel would largely remain unchanged in extent. Consequently, it is not expected for there to be any significant long-term habitat change / sandeel habitat loss. It is expected that, provided the sediment composition has not changed significantly, sandeel would rapidly re-colonise an area which has recently been dredged.

Available data layers indicating sandeel presence imply that sandeel are present in the MAREA region; this was also borne out by trawl sampling undertaken for the Anglian MAREA, where sandeel were found in around half of the trawls (Emu, 2011).

5.2.1.2 Significance statement

The following PIZ-related pathways specified by Reach *et al.* (2013) are considered here:

- Direct removal of suitable sediment; and
- Alteration of habitat structure.

Direct Removal of Suitable Sediment
The direct removal of sediment suitable for sandeel in the PIZs of the Anglian MAREA region could affect up to 6.8% of the possibly present sandeel grounds (high/medium/low confidence areas) over the course of the 15 year licence terms. Without mitigation measures, the magnitude of this would be high in a regional context. However, due to the mitigation measures listed above, 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. With regard to *sensitivity* to habitat change of this magnitude, it is thought that sandeel have a medium tolerance, medium adaptability and high recoverability and consequently a medium sensitivity to such change. Coupled with a medium value/importance, a Minor Significant impact is assessed.

Alteration of Habitat Structure
The direct contact of the draghead with the seabed could lead to the physical alteration of the structure of the sediments that sandeel spawn on / reside in. However, it is not thought that areas affected by such changes would become immediately unsuitable. Fine materials would generally be dispersed / quickly re-suspended due to the high energy conditions within the MAREA region. A radical change in sandy/gravelly sediment composition would be required to make a given patch of seabed unsuitable for sandeel, given the range of sediment classes it appears to be able to inhabit (see Section 4.1.1). Should radical changes to the habitat structure occur, impacts could be long term in duration. However, it is considered that such radical change would be occasional in frequency (given the mitigation measures mentioned above), 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. Based on the evidence provided under the 'impact commentary' regarding bathymetry and anticipated flow changes, 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'. Due to the 'medium' value/importance assigned to sandeel, and the medium magnitude, an impact of 'Minor Significance' is recorded.

Uncertainty: There is some uncertainty with regard to the level of sandeel presence in the Anglian region. Confidence in the MAREA 'preferred'' sediment layer was considered to be high (MES, 2013), and sandeel habitat preference is considered to be a well researched field of science. VMS data, which in many cases contributed to areas being classed as 'high' confidence areas, is not thought to be a good indicator of sandeel grounds (having been given a 'low' indicator (2 out of 5) rating by MES (2013)). The Coull *et al.* layer, which also contributed to many areas being counted as 'high' or 'medium' received a 'low' data confidence rating (1 out of 3), as the source data underlying it has not been available for analysis.

5.2.2 Contribution of Other Activities

There are several other activities taking place in the Anglian region, which potentially affect sandeel in a similar fashion as seabed removal by the marine aggregates industry, specifically:

- Offshore renewables arrays (habitat loss);
- Trawl fisheries (habitat disturbance);
- Dredge fisheries (habitat disturbance, and potentially removal);
- Oil and gas pipelines (habitat loss);
- Telecommunication cables (habitat loss); and
- Dredge material disposal sites (habitat loss).

These activities constitute those which are considered to be the main activities which could affect sandeel habitat. It is beyond the cope of the CIAs to take into account all possible cumulative impacts from other activities both inside and outside of the MAREA regions from national and international sources, which could have further impacts on sandeels beyond the regional scale. Activities not considered include the operational phases of oil, gas and renewable infrastructure. It is also acknowledged that the buffered cable routes assessed above are approximations and do not capture all forms of cable protection.

Actual habitat changes would mainly be expected from the installation of windfarm foundations and the laying of cables and pipelines. As shown in Table 2, the latter account for very small percentages of potential seabed affected. By far the largest area of footprint is due to trawler fishing - 48% of the total high/medium/low confidence areas present in the Anglian MRAEA region, whereas aggregates account for some 6.8%. These footprints, as previously mentioned, are unrealistic worst case footprints. With regard to habitat change and habitat structure, it is not thought that cumulatively the effects of aggregates dredging and other activities would lead to a higher effect than the 'minor significant' effect already assessed for aggregates extraction, as aggregates extraction would be the main contributor in a regional context (provided previously mentioned marine aggregates industry mitigation measures are continued). Demersal trawling, whilst showing a large overlap, would be unlikely to lead to large scale habitat change. Recovery of seabed would not occur for windfarms, cables and pipelines; however, the cumulative footprint of these impacts in a regional context is very small for potential sandeel grounds.

Please note that the footprint of the Round 3 windfarm licensing area was disregarded for this assessment, as there is high uncertainty with regards to placement of future windfarms (excluding East Anglia ONE), and as the actual turbine footprint would only account for a very small percentage of the licence area.

5.2.3 Summary

In summary, marine aggregates extraction is generally not considered to lead to significant cumulative impacts requiring mitigation, as long as existing industry mitigation measures are continued. Of the other activities taking place in the region, trawl fisheries affect by far the largest area of potentially suitable grounds. Nevertheless, overall it is not thought that cumulative effects arising from all the activities combined are more than minor significant.

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Appendix J: Outer Thames Estuary Regional Cumulative Impact Assessment

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1 ASSESSMENT OF CUMULATIVE IMPACTS FROM MARINE AGGREGATE EXTRACTION ON SANDEEL HABITAT IN THE OUTER THAMES ESTUARY

1.1 *INTRODUCTION*

Sandeel species are an important part of marine food webs. The small fish are found in high densities and provide prey for numerous fish species, as well as for seabirds and marine mammals (Engelhard *et al.*, 2008). Sandeels feed on phytoplankton and zooplankton, which inhabit the water column, by filter-feeding during the daylight hours (Freeman *et al.*, 2004). Therefore, sandeels act as umbrella species linking primary productivity to the higher trophic levels and any notable reduction in biomass could have impacts throughout North Sea marine food webs. Sandeels have been found to display a high level of site fidelity making them potentially vulnerable at a sub-population level to direct habitat loss (Jensen *et al.*, 2011).

Based on current perspectives and knowledge it has been suggested by the Regulatory Advisory Group (RAG) that past aggregate extraction Environmental Impact Assessments (EIAs) have not sufficiently addressed cumulative and in-combination impacts [(1)] in relation to sandeel habitat and Atlantic herring spawning. As a result, the British Marine Aggregate Producers Association (BMAPA) and The Crown Estate approached MarineSpace Ltd to facilitate the delivery of a strategic protocol to address the environmental effects of marine aggregate extraction in relation to areas that have the potential to support sandeel habitat and Atlantic herring spawning habitat. The objective was for the study to support individual applications under the Marine Works Regulations (as amended 2011) (MWR), through the creation of four regional Cumulative Impact Assessments (CIAs).

MarineSpace Ltd in conjunction with four other UK marine environmental consultancies (ABPmer, ERM, Fugro Emu and MESL), the Marine Aggregate Environmental Impact Assessment Working Group (EIA WG), have developed a methodology (Reach *et al.*, 2013a) to assess the environmental effect pathways and significance of effects relevant to marine aggregate licence application areas and both sandeel habitat and Atlantic herring potential spawning habitat.

This CIA includes both the cumulative and in-combination effects of marine aggregate extraction on sandeel habitat within the Outer Thames Estuary Marine Aggregate Regional Environmental Assessment (MAREA) region (ERM, 2010).

[(1)] The terms cumulative impacts and in-combination impacts in this CIA have been used in the same context as in the Outer Thames Estuary Marine Aggregate Regional Environmental Assessment

This report will supplement the fish ecology impact assessment carried out in the Outer Thames Estuary MAREA (ERM, 2010) and should be used as a guide for future individual licence/application area EIAs in the MAREA region.

1.2 METHODOLOGY

1.2.1 *General Considerations*

This section outlines the Outer Thames Estuary MAREA (MAREA) methodology which has been used to conduct the CIA. The sandeel habitat assessment methodology (Reach *et al.*, 2013a) is also described.

1.2.2 *MAREA Methodology*

The MAREA was undertaken to assess the cumulative impacts of all aggregate dredging at a regional scale, and whilst the methodology employed was aligned as far as possible to the EIA methodology set out in the EIA Directive, due to the regional scale and the cumulative impact focus of the assessment the methodology and terminologies used are not always directly comparable. It is important to note that cumulative and in-combination impacts were the primary focus of the MAREA, but potential impacts arising from individual licence areas are highlighted for consideration in site-specific impact studies. This cumulative and in-combination impact assessment has applied the MAREA methodology which is outlined below.

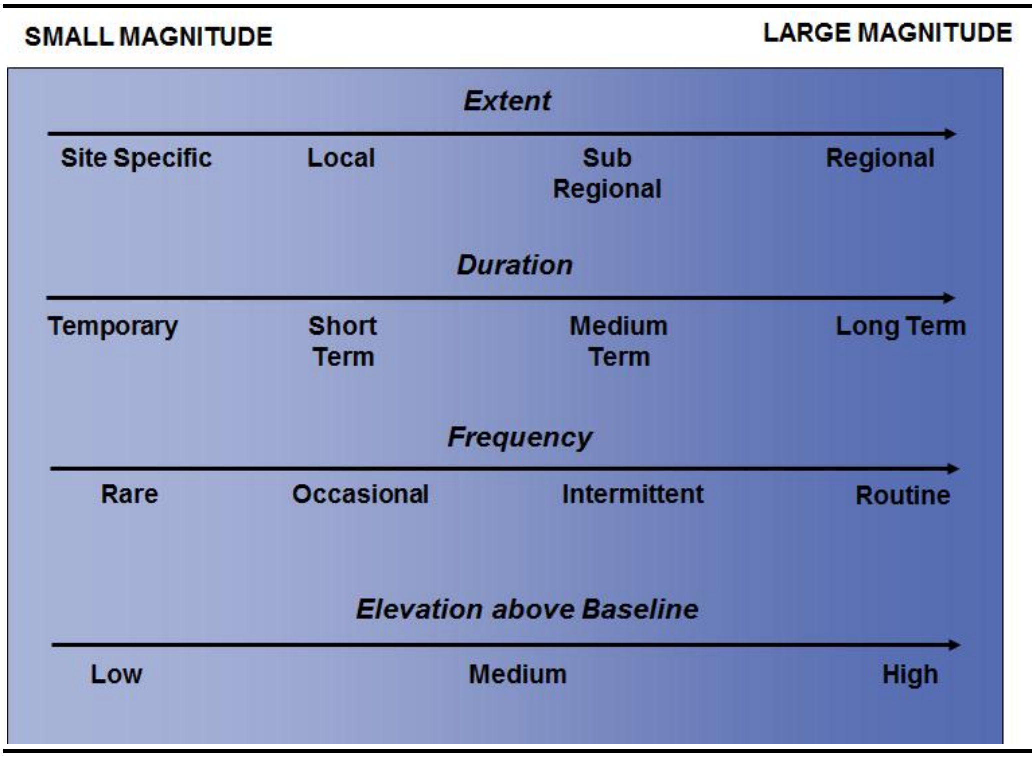
The MAREA assessment can be summarised as overlaying the extent of key physical effects which result from dredging with the extent of sensitive receptors within the Outer Thames region, including sediment removal and deposition, increased turbidity, changes to tidal current, wave and sediment transport regimes, and underwater noise. The assessment of impact significance within the MAREA applied specifically to impacts at a regional scale. An impact that had a low significance at the MAREA level may have a different level of significance for individual licence areas at the EIA stage.

For the purpose of the cumulative and in-combination impact assessment, the predicted effects from these studies are assessed in terms of three variables:

- extent (site specific, local, sub-regional, regional);
- duration (temporary, short-term, medium-term, long-term); and
- frequency (routine, intermittent, occasional, rarely).

The variables are quantified to the degree practicable. These variables collectively determine an effect's magnitude. Awarding a value to variables can be subjective in that the extent of change is difficult to define. The overall magnitude of the effect is then determined by considering a combination of elevation above baseline plus extent, duration and frequency and applying professional judgment/past experience. *Figure 1.1* shows how the components of magnitude are considered along a continuum and their individual contributions used to inform the overall prediction of effect magnitude.

Figure 1.1 *Components of Magnitude*



The assessment of value considers whether the receptor is rare, protected or threatened and in the case of biological receptors also considers whether the receptor provides an important ecosystem service (eg keystone species or important habitats). The sensitivity of each receptor was assessed according to three criteria, to the extent that they are applicable to the receptor in question:

- tolerance (low to high);
- adaptability (low to high); and
- recoverability (low to high).

Overall sensitivity is then determined by considering a combination of value, adaptability, tolerance and recoverability, as in *Figure 1.2*. The predicted degree of interaction between the receptor and dredging effects was also used to determine impact significance. This approach ensured that the assessment provided for a higher weighting to those receptors within the MAREA study area that will be exposed to a particular effect of dredging over much of their range, than to receptors that are only exposed to an impact in a small proportion of their range.

Figure 1.2 Receptor Value and Sensitivity

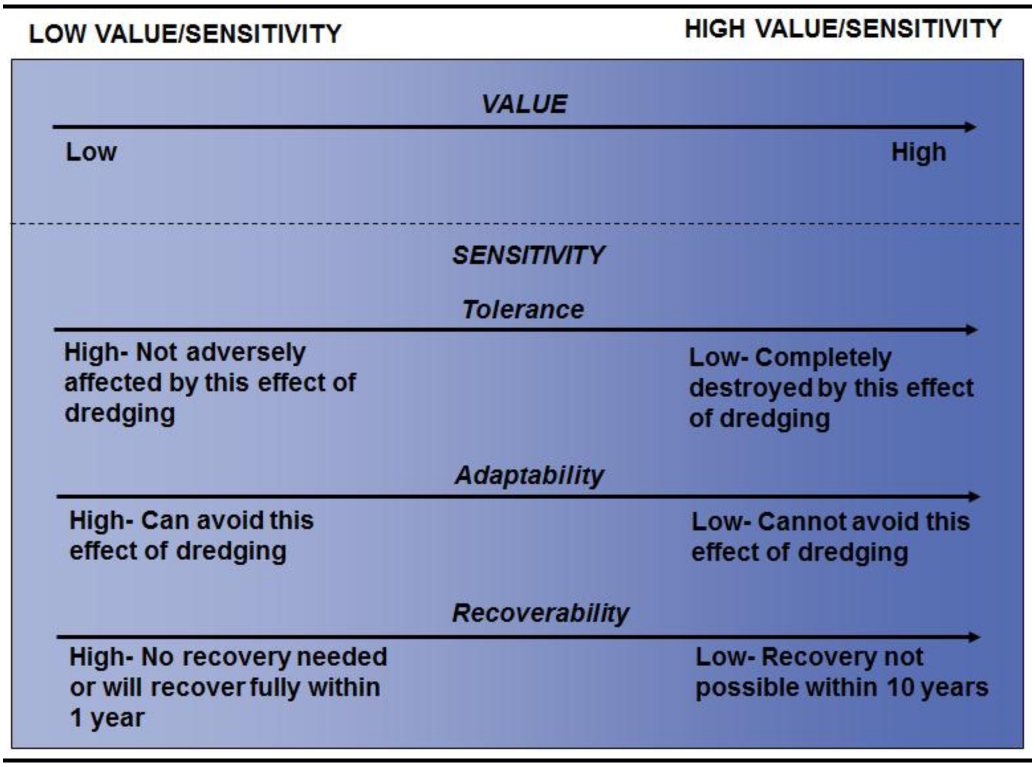
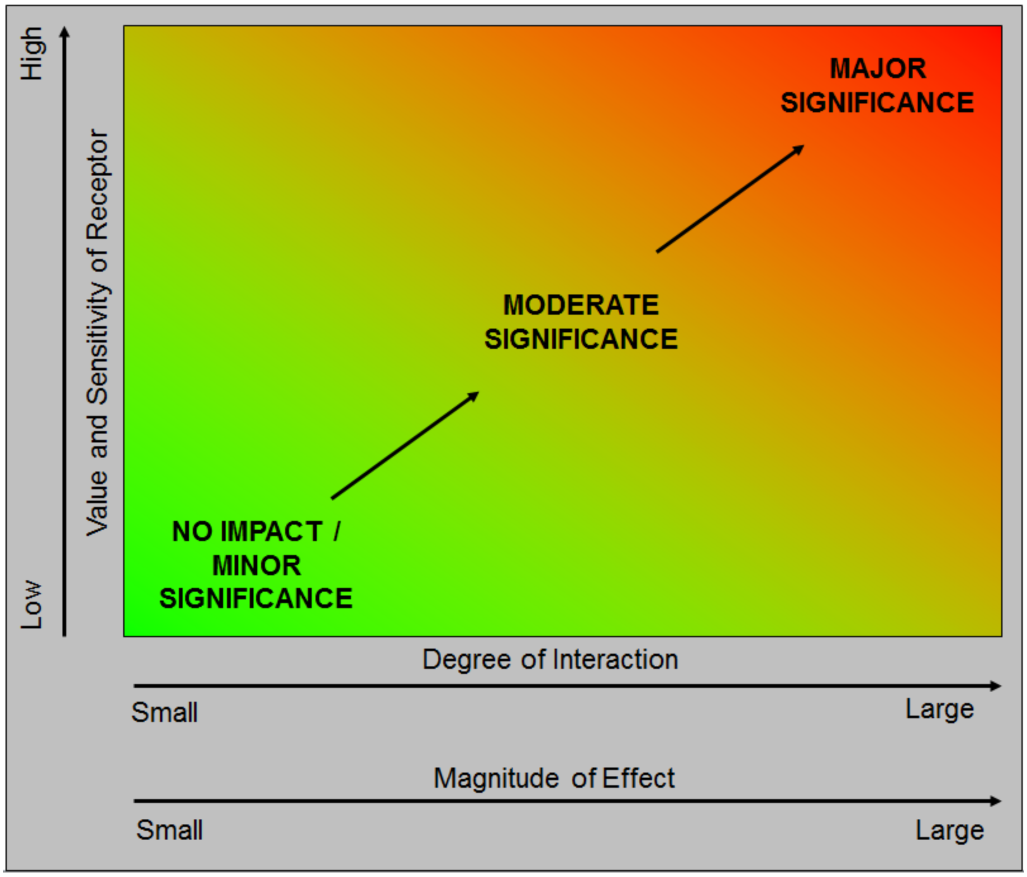


Figure 1.3 details the general relationship between the degree of interaction, effect magnitude and receptor sensitivity based on the descriptions and definitions provided in the sections above. The individual components of magnitude and sensitivity are taken into consideration together with the degree of interaction to identify the impact significance level for each effect-receptor combination.

Figure 1.3 Determination of Impact Significance



The final outputs from the cumulative assessment of all aggregate dredging at a regional scale are taken forward to the in-combination assessment which considers the interaction of aggregate extraction with other human activities in the study area to potentially create in-combination impacts. The in-combination impact assessment focuses on identifying areas where the predicted effects of dredging could interact with effects from other developments at the regional scale. This assessment uses the data presented in the EIAs for projects in other development sectors within the Outer Thames region, and the conclusions of scientific studies, to identify potential in-combination interactions.

It should be noted that the MAREA methodology adopts the rationale and metrics determined as fit-for-purpose for the MAREAs. The worst case scenario aligns with the rationale used to develop the MAREAs, ie that dredging may occur within all areas within the boundaries of licence and application areas, and that simultaneous dredging at all licence and application areas may take place.

1.2.3 *UK Aggregates Sandeel Habitat Assessment Methodology*

To determine the extent of available sandeel habitat the methodology developed by the sandeel aggregate working group was applied (Reach *et al*, 2013a). A summary of the methodology is outlined below.

The Marine Management Organisation (MMO) and the RAG advised (at a meeting held on 01 May 2013 (MMO, 2013)) on the types of effect and effect-receptor pathways that needed to be considered as part of the requirements of the EIA Directive as transposed to the MWR. For sandeel the environmental effects and effect-receptor pathways of potential impact are only associated with the PIZ and the direct removal of suitable habitat.

Habitat conversion as a result of removal of all suitable sediment leaving a completely unsuitable substrate in place (PIZ) could occur progressively over 15 years (and potentially prevail beyond that). However, the assessment that follows initially takes a worst case approach of conversion to a wholly unfavourable status within the PIZ footprint.

The MMO and RAG advised that population level effects of marine aggregate dredging on sandeel and entrainment of sandeels are not considered to be required to be assessed under the MWR application process (MMO, 2013).

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

- Stage 1 is habitat indicator and exposure pathway mapping and screening of spatial interactions for application areas and SIZ footprints.

- Stage 2 involves a regional CIA and case study EIA.

Stage 1 applies the spatial screening methodology from Reach *et al.* (2013a) and results in a screening of receptor-exposure-effect pathways between marine aggregate licence and application areas and seabed habitat areas with the potential to support sandeel. The pathways are analysed in a Geographical Information System (GIS) and a confidence assessment of the data used is applied. Licence and application areas which have overlap (exposure footprint) with receptor layers (potential habitat/areas) 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 CIA or subsequent EIA.

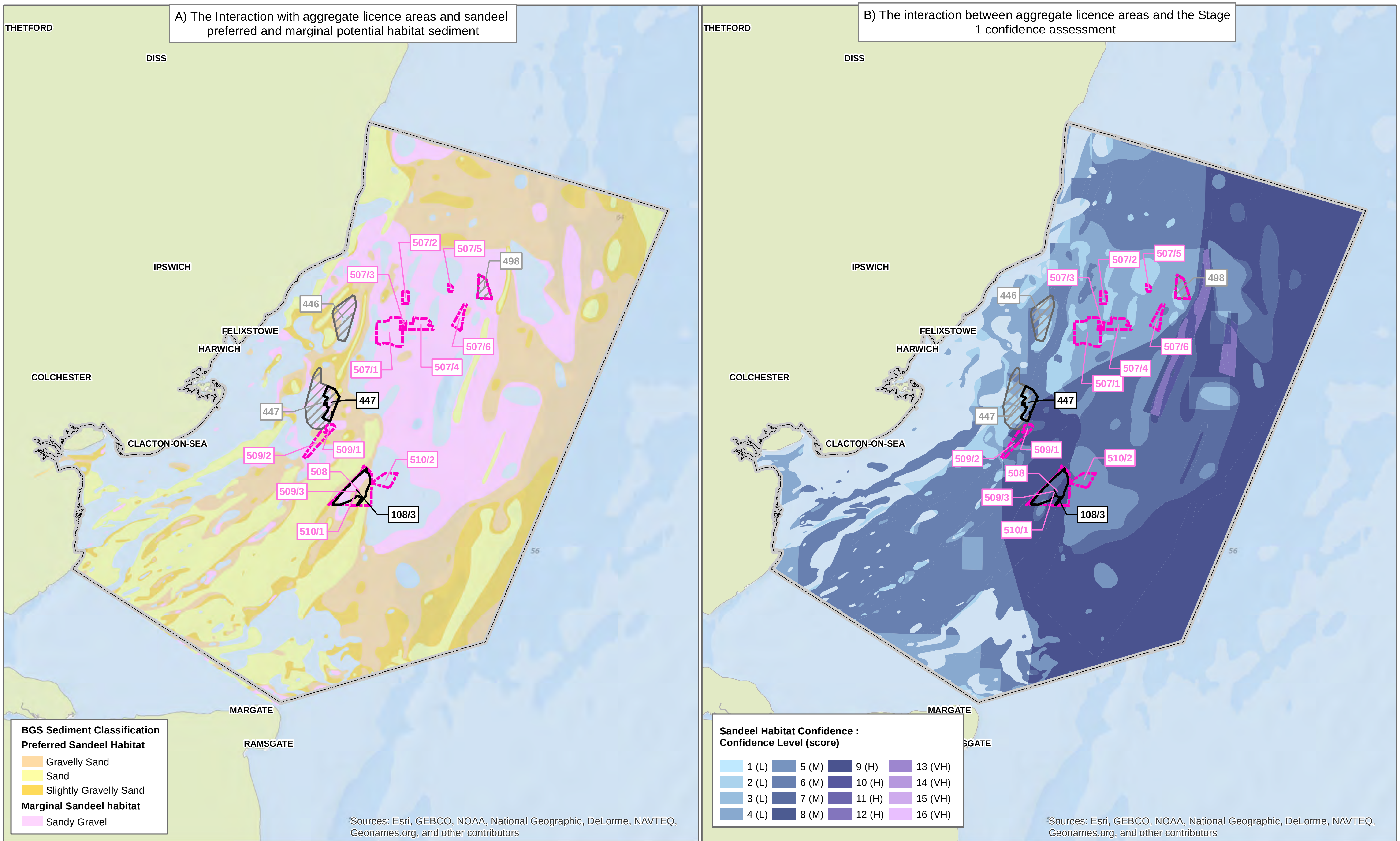
Stage 2 conducts a CIA for each of the marine aggregate strategic regions using the MAREA study area boundaries and the respective MAREA impact assessment protocols and methodologies (ERM, 2010). The rationale for this process means that the regional CIAs will act as supplements to each of the MAREAs regarding the characterisation of sandeel habitat and subsequent impact assessment. A case study EIA for a single application area per region is also conducted as part of Stage 2. These will be used to inform how the habitat assessment and CIA can be presented in an ES.

1.3 RESULTS OF SPATIAL INTERACTION SCREENING

Figure 1.4 presents the outcome of the stage 1 spatial interaction screening exercise for sandeel habitat in the Outer Thames Estuary MAREA area and the PIZ for all application areas within the MAREA area.

As detailed in the methodology developed by the sandeel aggregate working group (Reach *et al.*, 2013a), the potential sandeel habitat has been determined using a range of data which indicate the presence of potential sandeel habitat. The data that have been used include BGS, VMS, Coull *et al*. (1998), and fisheries data from the ESFJC. The assignment of confidence in the presence of potential sandeel habitat is based upon their spatial interaction across the Outer Thames MAREA. A higher level of confidence is assigned when multiple data supporting the presence of sandeel habitat are available in one area. The results are presented in *Figure 1.4*. The confidence levels applied to this assessment are as follows:

- very high;
- high;
- medium; and
- low.



MAREA Zone
Current Licences
Applications
Options

PROJECTION: WGS 1984 UTM Zone 31N

0 5 10 15 20 25
Kilometres

N

Figure 1.4
Distribution of potential sandeel habitat in the Outer Thames Estuary MAREA area

SCALE: See Scale Bar	VERSION: A01
SIZE: A3	DRAWN: AG
PROJECT: 0206159	CHECKED: KS
DATE: 12/12/2013	APPROVED: KJM

ERM

BMAPA & Crown Estates

SOURCE: The Crown Estates, BGS, CEFAS, MMO, EFJC, Esri, ALSF.

Path: C:\3_Temp\WorkingGISProjectFolders\0206159_FisheriesAssessment_AG_EB\Maps\Thames\Figure 1_4 - Distribution of Potential Sandeel Habitat in the Outer Thames Estuary.mxd

Following the application of the methodology developed by the EIA WG (Reach *et al*, 2013) all aggregate licence areas in the MAREA area were screened in to the CIA following the spatial interaction screening exercise. The majority of the licence areas overlap with medium and low confidence potential habitat.

1.4 *CUMULATIVE IMPACT ASSESSMENT*

1.4.1 *Impacts from Marine Aggregate Licence Areas*

General Considerations

As mentioned in *Section 1.2*, to assess the cumulative impacts of marine aggregate extraction on sandeel habitat it is necessary to consider the impacts from direct removal of suitable sediment (Reach *et al.*, 2013), which will potentially have a detrimental effect on sandeels through the removal of suitable habitat.

The ability of the seabed within the PIZ to recover and be used by sandeels at the cessation of dredging will also be considered because of the potential for long-term impacts on sandeel populations.

This remainder of this section will be structured as follows:

- value/importance of sandeel;
- impacts from direct removal of suitable habitat; and
- recovery of suitable habitat and potential recolonisation.

Value/Importance of Sandeel

Sandeels are preyed upon by numerous other fish species, seabirds such as black-legged kittiwake, and marine mammals (Englehard *et al.*, 2008). As a result, sandeels play a key role in marine food webs in the North Sea acting as conduit for energy transfer from primary production to higher trophic levels. In addition, sandeels are a commercially important species; in 2009 sandeels constituted the fourth largest catch by the European Union (European Union, 2012) although this species is not targeted by commercial fishing fleets in the MAREA area (ERM, 2010). Sandeel display a high level of site fidelity and the Thames contains suitable sandeel habitat which is important for maintaining healthy stocks. Taking this into account sandeel has been assigned a **medium** to **high value**.

Direct Removal of Suitable Sediment

The removal of suitable habitat considered to be site-specific in extent because it will only occur within the PIZ, will be short-term in duration, intermittent in frequency and a high change relative to baseline levels. Without mitigation measures the complete removal of the suitable sediment within the cumulative PIZ footprint could be considered a high magnitude effect but because the aggregate industry is required to leave a layer of sediment at the cessation of dredging that is similar to that which existed before dredging commenced, the suitable sediment is only unavailable during the licence duration, and as the sediment composition will be similar at the cessation of dredging it will be easier for sandeel to continue to use the sediment. As such it is assessed as being a **low - medium magnitude** effect [(1)].

Sandeels would have a low tolerance and adaptability to the removal all or most of the available suitable sediment because sandeel preferred habitat is sediment classified by the Folk classification is sand, slightly gravelly sand, gravelly sand and sandy gravel (Holland et al, 2005, Greenstreet *et al.*, 2010) and sandeels have high levels of site fidelity (Jensen *et al.* 2011). However, in the context of dredging activity in the MAREA area, only a proportion of the available habitat within the PIZ will be affected during dredging and this will not make the habitat immediately unavailable or wholly unsuitable; instead the habitat composition will alter over the 15 year licence period possibly making some areas gradually less suitable. Sandeels are therefore considered to have medium tolerance and adaptability to this effect; sandeels are considered to have a high recoverability because the entire PIZ will not become unavailable and there is suitable habitat present outside the cumulative PIZ area. Taking into account the tolerance, adaptability and recoverability the overall sensitivity of sandeels to removal of suitable sediment is **medium.**

There is no very high confidence potential habitat in the Outer Thames Estuary area and, therefore, the aggregate licence areas within the MAREA area do not overlap with any very high confidence habitat. The aggregate licence areas within the MAREA area overlap with 24.7 km^2 of high confidence potential habitat, and 58.7 km^2 of medium confidence potential habitat. Which constitutes an overlap of 0.4% and 1.1% of all available high and medium confidence potential sandeel habitat in the MAREA region, respectively. The degree of interaction is considered to be **small** because the calculations represent the worst case scenario of suitable habitat becoming wholly unsuitable habitat immediately. In reality the habitat will alter and potentially become less suitable over the 15 year licence period. Taking this into consideration the degree of interaction could be considered to be negligible.

Taking into account the medium - high value, low - medium sensitivity, small - medium magnitude of effect and small degree of interaction, the overall impact

([1]) The effect of dredging considered in this assessment differs from that presented in the MAREA. The MAREA considered the effect of sediment removal while this assessment considers the effect of removal of suitable habitat because it is specifically related to the impacts on sandeels.

of direct suitable sandeel habitat removal is of **minor significance** at most and possibly not significant.

Recovery of Suitable Habitat and Potential for Re-Colonisation

During aggregate extraction sandeel habitat within the PIZ (or a proportion thereof) may not be available as a result of physical disturbance by dredging. At the cessation of dredging the PIZ will become available again as all aggregate licence operators are required to leave a layer of sediment at the cessation of dredging that is similar to that which existed before dredging commenced. Leaving a layer of suitable habitat within the licence area ensures that potential habitat is only affected for the duration of extraction. Sandeels have high site fidelity (Jensen *et al.* 2011) and are expected to continue to use the habitat at the cessation of dredging. Therefore, the importance of operators maintaining suitable habitat on cessation of dredging will be key in ensuring the habitat will continue to be available.

1.4.2 Contribution of Other Seabed User Activities

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

- offshore renewable arrays;
- trawl fisheries;
- dredge fisheries;
- oil and gas pipelines;
- power cables;
- telecommunication cables; and
- dredge fines disposal sites.

Figure 1.5 shows the distribution of other seabed user activity with potential sandeel habitat in the Outer Thames Estuary as represented by the confidence assessment carried out at Stage 1 and preferred and marginal habitat (Reach *et al.*, 2013). The potential impacts of the other seabed user activities on the sandeel habitat vary according to the activity.

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.

Error! Reference source not found. quantifies the interaction between the other seabed user activities and potential habitat across the MAREA area as indicated by the confidence assessment carried out at Stage 1. The total footprint figures represent seabed user interaction with potential habitat with varying confidence levels (very high, high, medium and low) as explained in the methodology, albeit each sector interacting to a varying degree via different impact pathways.

The results show that there is no interaction between seabed users and very high confidence potential sandeel habitat (*Table 1.1*). Other seabed users interact with 38% and 46% of high and medium confidence potential habitat across the MAREA area, respectively. The overlap with low confidence potential habitat is 23%. Demersal trawl fisheries, offshore renewables arrays, and disposal sites have the largest footprint on potential sandeel habitat across the region.

Dredging activity constitutes 3.3 % of the interaction of the total seabed user activity with potential sandeel habitat across the MAREA area while trawl fisheries have the greatest footprint, but the least intense in terms of affecting sandeel habitat, contributing 57% of the overlap of high and medium confidence potential habitat. Noting the mitigation measures employed by the dredging industry, and the fact the impacts identified will only be present for the duration of the licence, the contribution of aggregate dredging to the long term loss or continued alteration of suitable habitat is negligible. The results of this in-combination assessment indicate that sandeel habitat within the Outer Thames Estuary MAREA is under some pressure from anthropogenic activity but aggregate dredging activity only contributes to a small proportion of this.

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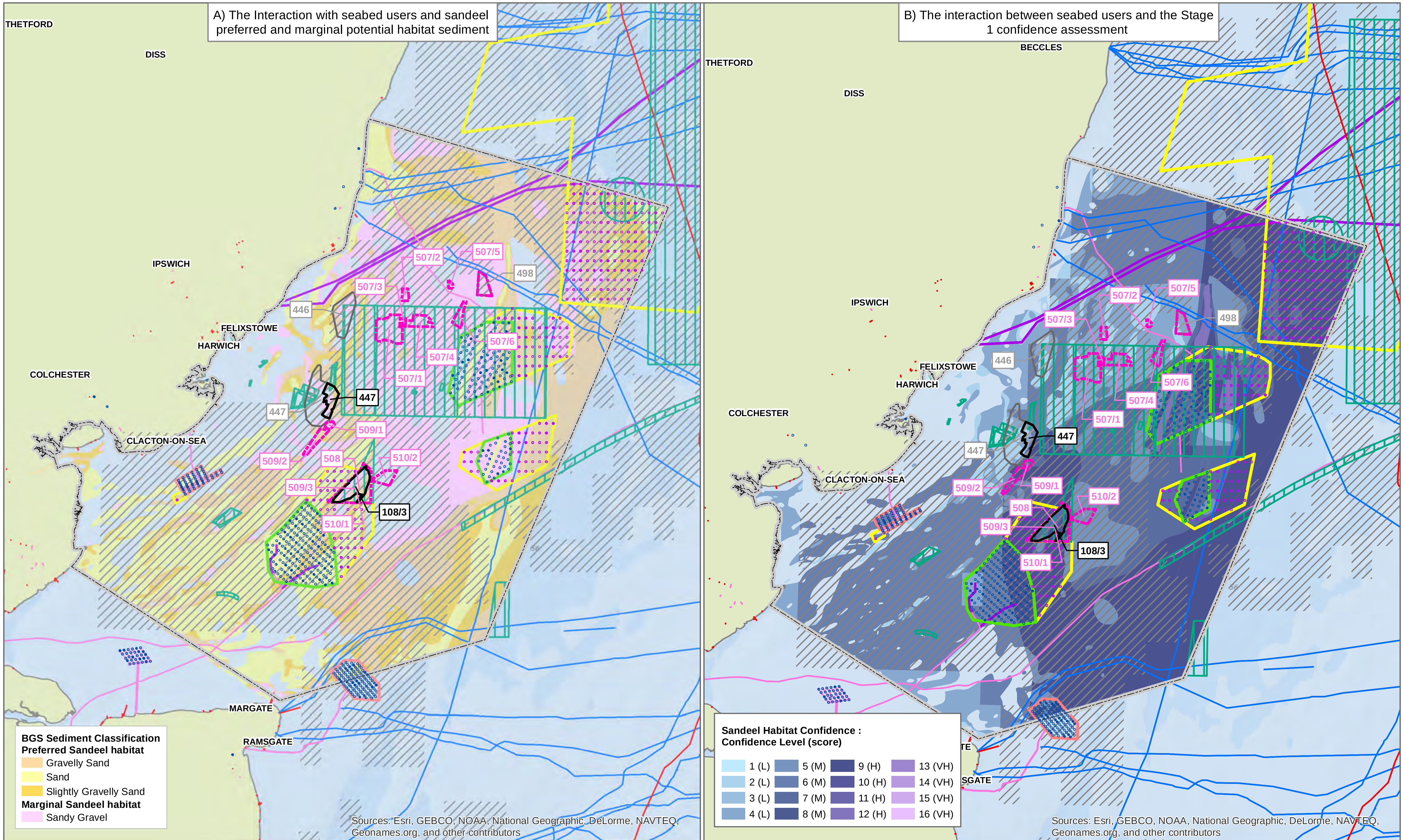
Table 1.1 *Footprint of Seabed User Activity on Potential Sandeel Habitat*

Seabed User Activity	**Very high confidence overlap with sandeel habitat (km²)**	**Very high confidence overlap with sandeel habitat (%)**	**High confidence overlap with sandeel habitat (km²)**	**High confidence overlap with sandeel habitat (%)**	**Medium confidence overlap with sandeel habitat (km²)**	**Medium confidence overlap with sandeel habitat (%)**	**Low confidence overlap with sandeel habitat (km²)**	**Low confidence overlap with sandeel habitat (%)**
Offshore renewables array	0.0	0.0	545.3135	10.5142	291.3866	5.6182	25.4145	0.49
Trawl fishery	0.0	0.0	1212.18234	23.37205	1812.48663	34.94650	953.87140	18.39157
Dredge Fishery	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
O&G pipelines*	0.0	0.0	0.0	0.0	0.0	0.0	0.00268	0.00005
Telecommunications cables*	0.0	0.0	0.00758	0.00015	0.00699	0.00013	0.00245	0.00005
Dredge fines disposal sites	0.0	0.0	235.8879	4.5482	329.065	6.3447	197.48519	3.80771
Power cables (existing and proposed)	0.0	0.0	0.2010	0.0004	0.0281	0.0005	0.0342	0.0007
TOTAL	0.0	0.0	**1992.4483**	**38.4163**	**2432.6313**	**46.9035**	**197.4852**	**22.69**
Dredging activity	0.0	0.0	24.7063	0.4764	58.7099	1.1319	91.8754	1.7714

* assumes that entirety of cable or pipeline is surface laid and not buried, and this therefore over represents footprint for these activities.

Note: Offshore renewables array footprint calculations include operational and proposed windfarms



MAREA Zone
Current Licences
Applications
Options
Disposal Sites
Pre-Planning / In-Planning & Consented
Operational
Under Construction
Pipeline Footprint
Telecommunication Cable Footprint
Power Cable Footprint
Proposed 'Worst Case' Power Cable Footprint for Herring
Dermersal Trawl Fisheries Footprint
Operating Windfarm Turbine Footprint (50m diameter)
Potential Windfarm Turbine Footprint (70m diameter)

NOTE:
There are no dredging gear fishing activity recorded in the Thames Region

0 5 10 15 20 25
Kilometres
N

Figure 1.5
Interaction between potential Sandeel spawning habitat and all Seabed Users in Outer Thames Estuary MAREA area

SCALE: See Scale Bar	VERSION: A01
SIZE: A3	DRAWN: AG
PROJECT: 0206159	CHECKED: KS
DATE: 12/12/2013	APPROVED: KJM

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BMAPA & Crown Estates

PROJECTION: WGS 1984 UTM Zone 31N

SOURCE: The Crown Estates, BGS, CEFAS, MMO, EFJC, Esri, ALSF.

Path: C:\3_Temp\WorkingGISProjectFolders\0206159_FisheriesAssessment_AG_EB\Maps\Thames\Figure 1_5 - Interaction between potential Sandeel spawning habitat and all seabed users in the MAREA area.mxd

1.5 SUMMARY OF IMPACTS

Table 1.2 summarises the cumulative assessment from marine aggregate extraction in the MAREA area. The MAREA assessment has direct removal of suitable habitat during dredging as having an impact of minor significance. As is standard industry practice dredging activity will not occur across the entire PIZ for the whole of the licence resulting in a much reduced footprint of impact from that assessed here.

Table 1.2 Summary of the Significance of Cumulative Impacts from Marine Aggregate Extraction

Effect	Significance
Direct removal of suitable habitat	Minor, possibly not significant
Recovery of suitable habitat post dredging	Not significant

2 *REFERENCES*

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Appendix K: South Coast Regional Cumulative Impact Assessment

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HERRING AND SANDEEL HABITAT MAPPING PROJECT

South Coast MAREA Region-
Cumulative Impact Assessment of Marine Aggregate Extraction on Sandeel Habitat

Report Number: 13/J/1/03/2381/1532

Prepared For:

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Making Sense of the Marine Environment ™

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On behalf of:

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sustainable solutions
bmapa

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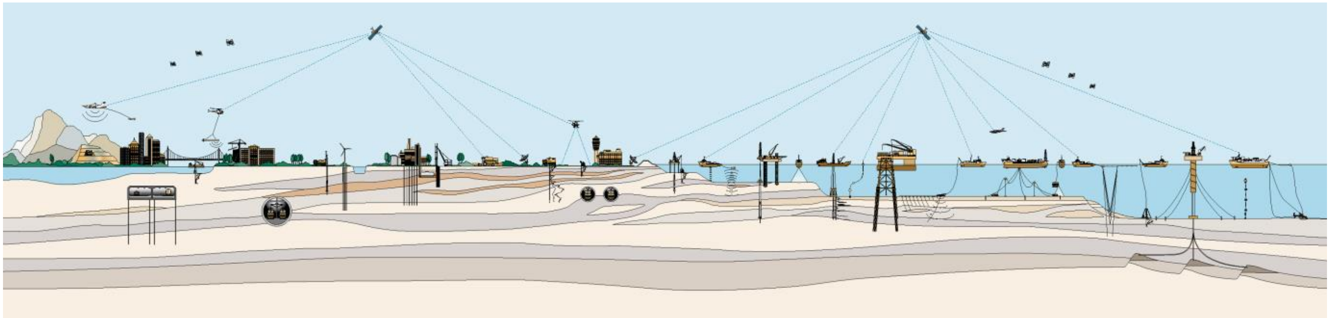
5	Final	KAB	RXP	JSD	11 November 2013
4	Final Draft	RXP	KAB	JSD	08 August 2013
Rev	Description	Prepared	Checked	Approved	Date



CONTENTS

TABLES

FIGURES

1. SOUTH COAST MAREA REGIONAL POTENTIAL SANDEEL HABITAT ASSESSMENT

1.1 Introduction

Fugro EMU Limited has been commissioned to conduct a Cumulative Impact Assessment (CIA) of the South Coast Marine Aggregates Regional Environmental Assessment (MAREA) region in order to assess the significance of effects arising from marine aggregate extraction on sandeel habitat.

All current marine aggregate extraction areas and application areas within the South Coast MAREA region are included in this assessment. Other seabed users that have the potential to interact with sandeel habitat are identified and aggregate extraction is contextualised with these seabed users. This information is used to assess the impact significance of aggregate extraction within the South Coast MAREA region accounting for other seabed users, and based upon the sensitivity and magnitude of the potential effects on sandeel habitat.

This assessment encompasses three main steps:

1. The identification of current marine aggregate extraction areas and application areas in the South Coast MAREA region, with reference to potential herring spawning habitat;

2. The identification of other seabed users whose activities may interact with potential herring spawning habitat, and the contextualisation of aggregate extraction with the cumulative impact assessment; and

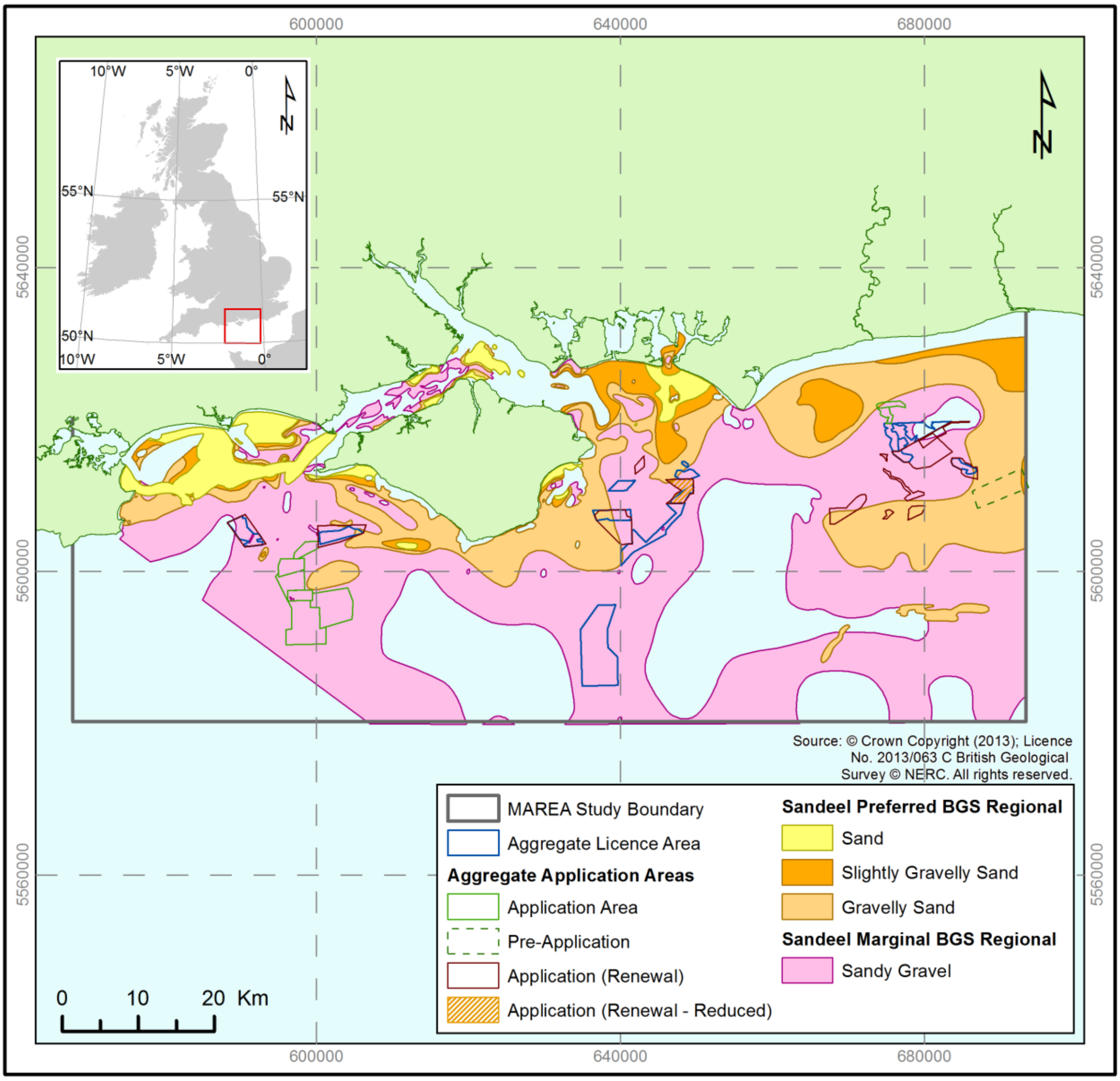
3. An assessment of the impact significance of aggregate extraction in the South Coast MAREA region accounting for other seabed users, and based upon receptor sensitivity and magnitude of effects.

Sandeel are assessed specifically here as they:

- Are a keystone species in the marine foodweb linking planktonic organisms, on which they feed, with the fish, marine mammals, seabirds and humans that predate upon them (Dickey-Collas *et al*., 2010; Latto *et al*., 2013). Therefore, sandeel form an important part of the marine foodweb and reductions in sandeel biomass can have impacts up the food chain.
- Have been found to display a high level of site fidelity making them potentially vulnerable at a sub-population level to direct habitat loss (Jensen *et al.,* 2011). As such the Marine Management Organisation (MMO) and the Regulatory Advisors Group (RAG) are keen to ensure that the impacts on habitats supporting sandeel, from marine aggregate extraction, are specifically considered by Environmental Impact Assessment (EIA).

Potential areas of sandeel habitat have been identified within the South Coast MAREA region based upon the presence of appropriate sediment type, historic spawning areas and Vessel Monitoring System (VMS) data of fishing vessels potentially targeting sandeel (see Latto *et al*. 2013 for full methods). The data used in this assessment have been sourced from the EIA Working Group consortium as part of the wider herring and sandeel assessments currently being undertaken to support the aggregates industry in licence renewals.

The South Coast MAREA region currently contains a total of 14 marine aggregate extraction licence areas and nine licence application areas. A map of the South Coast MAREA region licence and application areas is shown in Figure 1.1.



Map Document: (V:\J1132381_Herring_and_Sandeel_Mapping_Project\3_Plots\3_Final\Q2381_South_Coast_Region_Sandeel_BGS_Data_20131108.mxd) 11/11/2013 -- 10:16:01

Figure 1.1 Current and proposed aggregate areas in the South Coast MAREA region.

2. ASSESSMENT METHODOLOGY

2.1 Screening

The initial screening exercise and the data utilised for this purpose have been agreed and defined in the method statement produced by the EIA Working Group and referenced as Reach *et al*. (2013).

The method depends upon screening spatial interactions between the licence area and the potential sandeel habitat based on the Folk classification (Folk, 1954) (Sand and slightly gravelly Sand: preferred sandeel habitat, sandy Gravel: marginal sandeel habitat) and involves following steps.

- STEP 1 – Determination of the extent of habitat for sandeel at an international/national sea/basin scale;
- STEP 2 – Determination of the potential habitat for sandeel in a regional context; and
- STEP 3 – Compilation of a regional broadscale habitat characterisation layers basemap.

- The data utilised in the habitat assessment have been sourced from the EIA Working Group consortium, as part of the herring and sandeel spawning assessment currently being undertaken to support the aggregates industry in licence renewals. Data sourced included:Substrate Folk classification sourced from British Geological Survey (BGS);
- Licence and application area boundaries (Latto *et al*. (2013) method assumes that the boundary of the licence and application areas are representative of the primary impact zone (PIZ));
- Spawning grounds sourced from Coull *et al.* (1998) layer to capture known location of larvae and relationship with benthic habitats; and
- Sandeel fishing fleet AIS and VMS data (2006-2012).

2.2 Confidence assessment

As detailed in the supporting confidence assessment (MESL, 2013), each of the data layers was first processed to extract the part of the layer that indicated sandeel habitat, for example the relevant substrate or gear type.

- Each dataset was then assigned a confidence level, based upon the confidence in the data itself (e.g. the age, methodology used for collection etc) as well as its reliability to indicate herring spawning habitat (each of equal weighting). By combining the different indicator layers together, the individual scores from each layer were combined (ultimately from 1 to 16) for any given location. Scores used throughout this report are classified as follows for ease of presentation: Confidence of 1-4 is categorised as 'low' confidence;
- Confidence of 5-8 as 'moderate' confidence;
- Confidence 9-12 as 'high' confidence; and
- Confidence 13-16 as 'very high' confidence.

See Latto *et al*. (2013) and MESL (2013) for a full account of the confidence methodology.

2.3 Assessment methodology

The cumulative assessment methods utilised in this report follow those presented in the South Coast MAREA (EMU, 2012). The methods have been slightly adjusted where appropriate to suit the current assessment objectives, and to reflect the fact that only one receptor is being assessed in the case of sandeel habitats. The methodology is summarised below.

Central to the assessment of impacts is the conceptual 'source-pathway-receptor' model, which has been identified by the EIA Working Group and agreed with the Marine Management Organisation (MMO) and the Regulatory Advice Group (RAG) for the impacts of aggregate extraction on sandeel habitat. The model is effective at identifying potential impacts on the receiving environment and sensitive receptors resulting from the proposed extraction activities. It allows for a more transparent approach to conducting the assessment process by guiding assessors through the linkages between the source of the effects and the routes through the environment to potentially sensitive receptors.

The term 'source' describes the origin of the potential effect (e.g. the effects of aggregate extraction and plume dispersion, such as the draghead moving across the seabed) and the term 'pathway' as the means (e.g. deposition of sediment via the water column to the seabed, sediment transport processes and ingestion) by which the effect interacts with the receiving 'receptor' (e.g. benthic organisms, habitats, fisheries or maritime archaeology) (Figure 2.1).

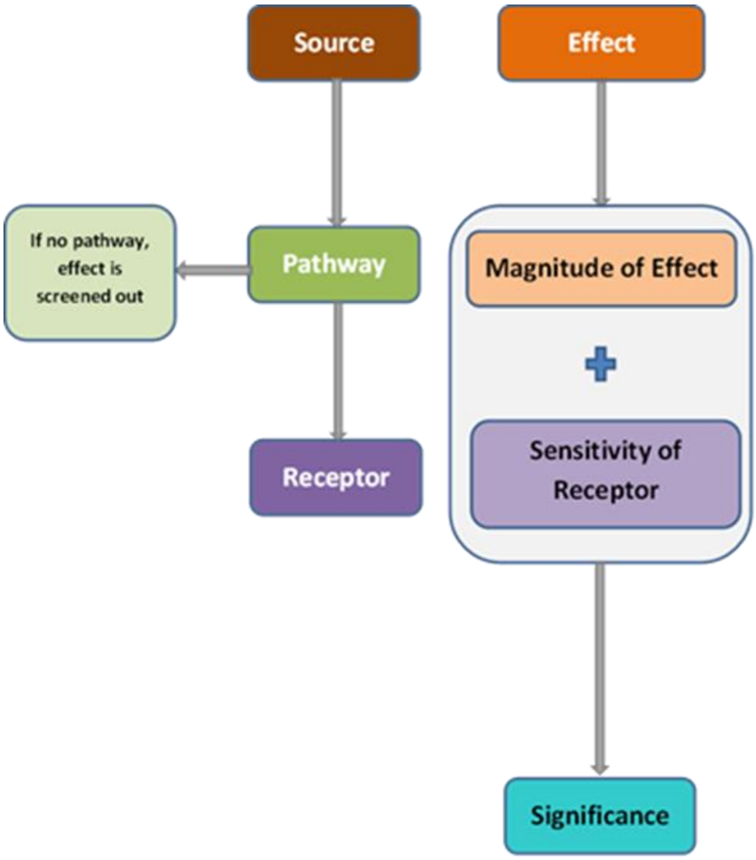


Figure 2.1 Conceptual 'source-pathway-receptor' impact assessment model

2.3.1 Determining magnitude of effect

In accordance with the South Coast MAREA (EMU, 2012), the potential magnitude of effect is assessed with reference to three variables: duration, frequency and extent, as shown in Table 2.1.

Table 2.1 Characteristics of magnitude of effect

Characteristic of magnitude of effect	Definitions
Duration	The temporal extent that the effect is noticeable against background variability. This can be temporary, short term, medium term or long term: • Temporary: Effects only occur during active dredging, are one off or last only a few hours or days after cessation of dredging; • Short-term: Effects are no longer observed after up to 1 year following cessation of dredging; • Medium-term: Effects that last between 1 and 10 years following cessation of dredging; or • Long-term: Effects that persist for >10 years following cessation of dredging. **Longer duration of effect ultimately results in higher overall magnitude.**

Characteristic of magnitude of effect	Definitions
Frequency	How often the effect occurs. This can be routine, intermittent, occasional, or rare: • Routine: Effect occurs during all normal dredging operations (95-100%); • Intermittently: Effect occurs regularly but not all the time during dredging operations (25-95%); • Occasionally: Effect only occurs during a small proportion (<25%) of routine dredging operations; or • Rarely: Effect only occurs very rarely as an unplanned event during dredging operations (e.g. emergency load dumping, oil spills). **Higher frequency of effect ultimately results in higher overall magnitude.**
Extent	The geographic area of influence where the effect is noticeable against background variability. Extent is defined through the following characteristics: • Primary impact zone: Effects that only occur where dredging occurs or is predicted to occur; • Localised: Extend beyond the immediate footprint of dredging but do not affect the receptor at a regional scale. Effects extending up to one tidal excursion beyond the licence area e.g. the SIZ • Sub-regional: Confined to an area associated with a group of licence areas that are distinct. Effects extending beyond the licence boundary (typically >10 km); and • Regional: Effects occurring across the entire South Coast MAREA region but do not extend outside it. **Greater spatial extent of effect ultimately results in higher overall magnitude.**

The characteristics of magnitude of effect are combined to provide an overall level of magnitude of effect as ‘very low’, ‘low’, ‘medium’ or ‘high’. Determination of the overall magnitude of an effect incorporates a degree of subjectivity, and quantifiable data are supported by expert judgement using previous experience of the aggregates sector, the region and consideration of elevation above baseline conditions, as outlined in MAREA approaches such as EMU (2012) and ERM (2010).

2.3.2 Sensitivity of receptor

The determination of receptor sensitivity adopts a similar approach to that for magnitude of potential effects. The sensitivity of a receptor is characterised by the following factors: adaptability, tolerance and recoverability as defined in Table 2.2. An understanding of the baseline conditions is critical to making an informed decision on sensitivity.

A further consideration in sensitivity of receptor and ultimately in determining overall significance of an impact is that of value. Value is an integral part of sensitivity and includes consideration of importance (e.g. level of conservation status and keystone species), rarity (e.g. how much of it exists relative to the potential area impacted) and worth (e.g. it’s socioeconomic, cultural and amenity value).

The exact determination of the level of sensitivity of each receptor will vary according to the receptor in question and as such, will be defined on a receptor by receptor basis using industry best practice, previous studies undertaken by the aggregate industry (e.g. EMU, 2012; ERM, 2010) and expert judgement. The overall sensitivity of the receptor is assessed as being ‘low’, ‘medium’ or ‘high’.

Table 2.2 Characteristics of sensitivity of receptor

Characteristic of sensitivity of receptor	Definitions
Adaptability	This refers to how well a receptor can avoid or adapt to an effect: • Low: Receptor unable to avoid or adapt; • Medium: Receptor has some ability to avoid or adapt e.g. by moving to other suitable areas; or • High: Receptor can completely avoid or adapt to this effect with no detectable changes. **Higher adaptability of a receptor ultimately results in lower overall sensitivity.**
Tolerance	This refers to the receptor's tolerance to the physical change: • Low: Receptor unable to tolerate effect resulting in permanent change in its abundance or quality; • Medium: Receptor has some ability to tolerate this effect but a detectable change will occur; or • High: Receptor unaffected or positively affected. **Higher tolerance of a receptor ultimately results in lower overall sensitivity.**
Recoverability	Recoverability refers to the receptors ability to recover given exposure to an effect, and has a temporal element to its characteristics (this temporal element is receptor dependent): • Low: Receptor recovers over the long term (typically >10 years); • Medium: Receptor partially recovers and/or recovers over the short term to medium term (typically 1-10 years); or • High: Receptor recovers fully, typically within weeks to 1 year. **Higher recoverability of a receptor ultimately results in lower overall sensitivity.**

2.3.3 Assigning significance of impacts

Following the assessment of the magnitude of potential effects and the receptor sensitivity for each impact pathway overall impact significance is assigned according to the classifications shown in **Error! eference source not found.**.

Table 2.3 Determination of overall significance of impact

		Overall Magnitude of Effect			
Overall Sensitivity of Receptor		Very low	Low	Medium	High
	High	Minor significance	Moderate significance	Major significance	Major significance
	Medium	Not significant	Minor significance	Moderate significance	Major significance
	Low	Not significant	Not significant	Minor significance	Moderate significance

The significance of impact (see Table 2.4) is therefore determined using the best available information from a range of sources including consultation, literature reviews, empirical evidence, numerical modelling and historical data analysis, in informing the magnitude of effect, sensitivity of receptor and overall impact significance. Where data gaps exist, informed scientific interpretation and expert judgement are used to present a transparent assessment of impact significance.

The determination of significance of an impact is presented in a significance statement. This provides a categorisation of an impact as being either 'not significant', or of 'minor', 'moderate' or 'major significance'.

Table 2.4 Descriptors for overall impact significance

• *Not significant:* An impact that, after assessment, was found not to be significant in the context of the objectives.
• *Minor significance:* Where an effect will be experienced, but the effect magnitude is sufficiently small (with or without mitigation) and well within accepted standards, and/or the receptor is of low sensitivity.
• *Moderate significance:* Moderate significance impacts may cover a broad range, although the emphasis remains on demonstrating that the impact has been reduced to a level that is as low as reasonably practical. This does not mean reducing to 'minor' but managing 'moderate' ones effectively and efficiently.
• *Major significance:* Where an acceptable limit or standard may be exceeded or large magnitude effects occur and highly valued/sensitive resources/receptors are affected.

2.3.4 Other considerations

Alongside magnitude of effects and sensitivity of receptors, there are some additional considerations that may be taken into account when assigning significance of impact. These may include the following, dependent on receptor and impact type:

- Reversibility of an impact. Whether the effect can be reversed i.e. conditions can be returned to that of the baseline prior to the effect occurring;
- Severity of an effect and resultant impact (e.g. the intensity of the physical change);
- Ecosystem interactions (e.g. the links between impacts on receptors having an indirect impact on other linked receptors). This also includes consideration that there are intrinsic links between various human, biological and physical receptors; and
- Certainty of impact. This considers whether an impact is likely to occur given the predictions outlined. For the purposes of this assessment this has been integrated with the confidence assessments undertaken on the data layers (see Section 2.2).

2.4 Cumulative impact assessment

Step 4b as defined in Latto *et al*. (2013) looks at a cumulative impact assessment to allow the characterisation of the seabed footprint of relevant seabed activities. The methodology has been developed to enable an assessment of the cumulative two dimensional footprints of seabed user activities that interact with the characterisation base map.

The methodology adopts the rationale and metrics determined as fit-for-purpose for the South Coast MAREA (EMU, 2012). It is assumed that the boundary of the application and licence areas are representative of the potential PIZ i.e. active dredging may occur anywhere within this boundary during the licence term. The cumulative assessment considers the footprint of all appropriate seabed users at the South Coast MAREA regional scale. This allows for the footprint of marine aggregate operations to be ranked with other seabed user groups and the values can be related to the potential habitat extents from the characterisation basemaps.

The seabed user activities likely to interact with potential sandeel habitat at a regional scale have been identified as:

- Marine aggregate activity;
- Offshore renewable;
- Trawl fisheries;
- Dredge fisheries;
- Disposal sites; and
- Cables and pipelines.

3. SANDEEL HABITAT CHARACTERISATION

There are five species of sandeel which commonly occur in UK waters. These are *Ammodytes marinus*, *A. tobianus, Gymnammodytes semisquamatus, Hyperoplus lanceolatus* and *H immaculatus*. For the purpose of this report these five species are referred to as sandeel and the term sandeel is used to denote one, some or all of these species. Sandeel are closely associated with sandy substrates in which they bury themselves. They over-winter buried in sediments and they are also known to bury themselves when threatened by predators or when feeding conditions are poor. Sandeel have specific requirements for sediments in which they burrow. The sediment divisions (based on the Folk Classification (Folk, 1954)) that best describe sandeel habitat for sandeel species in UK waters are:

- Sand;
- Slightly gravelly Sand; and
- Gravelly Sand.

These three sediment types are considered here to be preferred habitat of sandeel. A further sediment division, sandy Gravel is used to describe marginal habitat for sandeel in UK waters. Further information related to the specific sediment requirements of sandeel is provided by Latto *et al*. (2013).

It has been agreed with the MMO and RAG (MMO, 2013) that only the potential impacts upon sandeel preferred and marginal habitat associated with the PIZ and not the SIZ will be assessed in this methodology. The direct removal of habitat and the physical alteration (fining) of the sediments need to be addressed. These effect-receptor pathways relate to the PIZ. The secondary effects of aggregate extraction associated with the SIZ, i.e. sediment plumes and sediment mobilisation, are not considered necessary as sandeel have been shown to be tolerant to both increased suspended sediments within the water column, as well as sediment deposition (Perez-Dominguez and Vogel, 2010).

Further, the MMO and RAG have indicated that entrainment of sandeels by the dredger draghead, is not considered to be significant in the context of an EIA. Therefore entrainment effects will not be considered here.

The regional review specifically considers effect-receptor pathways from the PIZ:

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

3.1 STEP 1 – Determination of the extent of habitat for sandeel at an international/national sea/basin scale

The total extent of sandeel habitat in the central and southern North Sea including the English Channel has been derived from the BGS 1:250,000 scale seabed sediment maps. Nationally, a total area of 96,482.5 km^2 of seabed is considered to be suitable as sandeel habitat, this is comprised of

82,215.6 km^2 of preferred habitat (Sand, slightly gravelly Sand and gravelly Sand) and 14,266.9 km^2 of marginal habitat (sandy Gravel) (Figure 3.1).

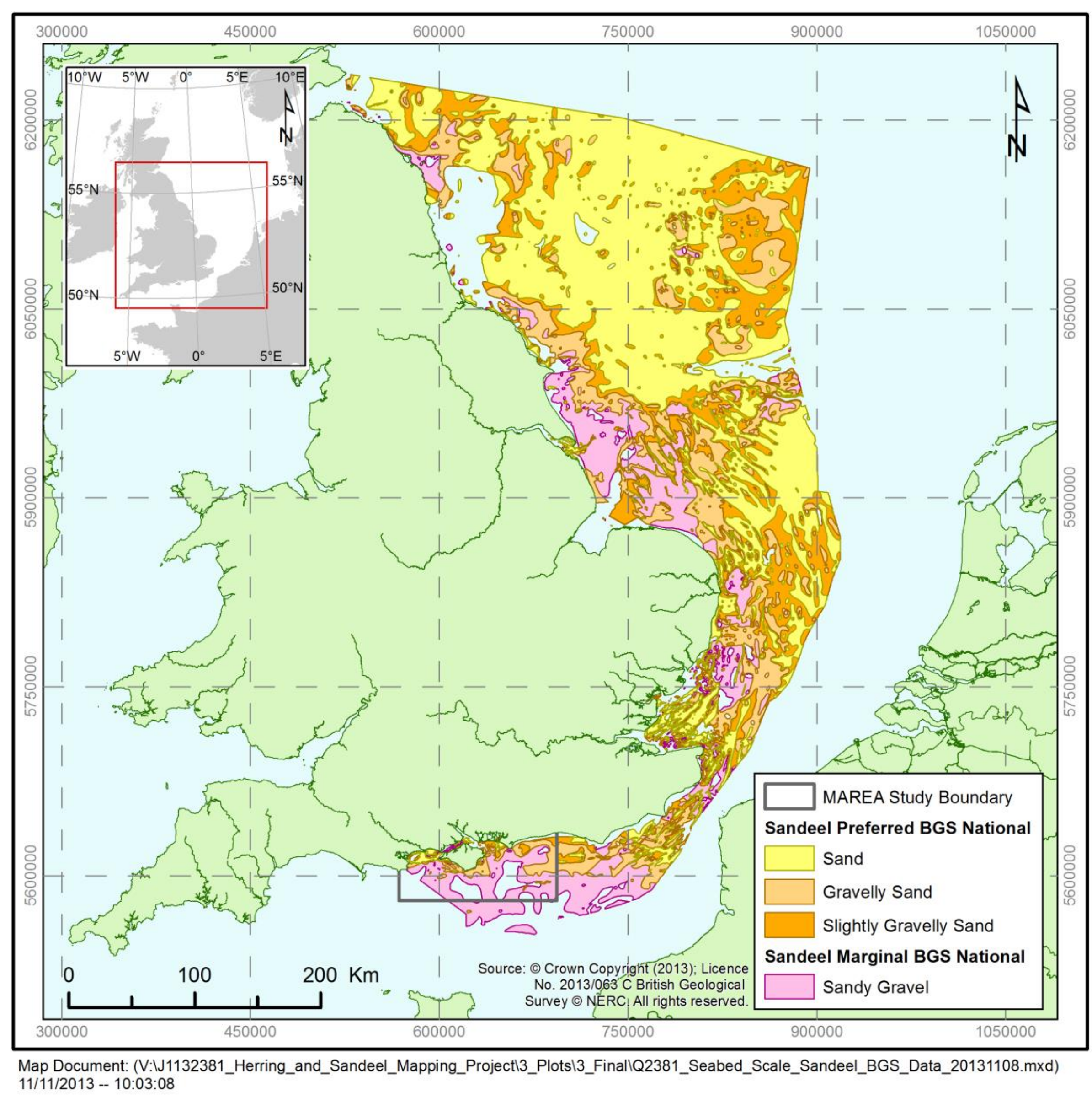


Figure 3.1 Boundary areas used to define the national and regional areas of sandeel habitat

3.2 STEP 2 – Determining the potential habitat for sandeel in a regional context

The habitat within the South Coast MAREA region has been assessed for its suitability for sandeel. The Folk sediment classifications of Sand, slightly gravelly Sand and gravelly Sand are considered herein to be the preferred habitat for sandeel (Latto *et al*., 2013). However, sandy Gravel is also a consideration as marginal habitat for sandeel. The preferred and marginal sandeel habitats have been quantified at a national and regional scale to highlight their extent within the region and to put them in the context of the nationally available habitat for sandeel.

The South Coast MAREA region has been used as the regional boundary for this assessment. A total area of 3,425.7 km^2 of seabed is considered to be suitable as potential sandeel habitat, comprising approximately 1,209.7 km^2 of preferred potential sandeel habitat (Sand, slightly gravelly Sand and gravelly Sand) and 2,216.0 km^2 of marginal potential sandeel habitat (sandy Gravel) (Figure 3.2). The potential sandeel habitat within the South Coast MAREA region comprises 3.6% of the total available habitat at the international/national sea scale (preferred and marginal). (Table 3.1)

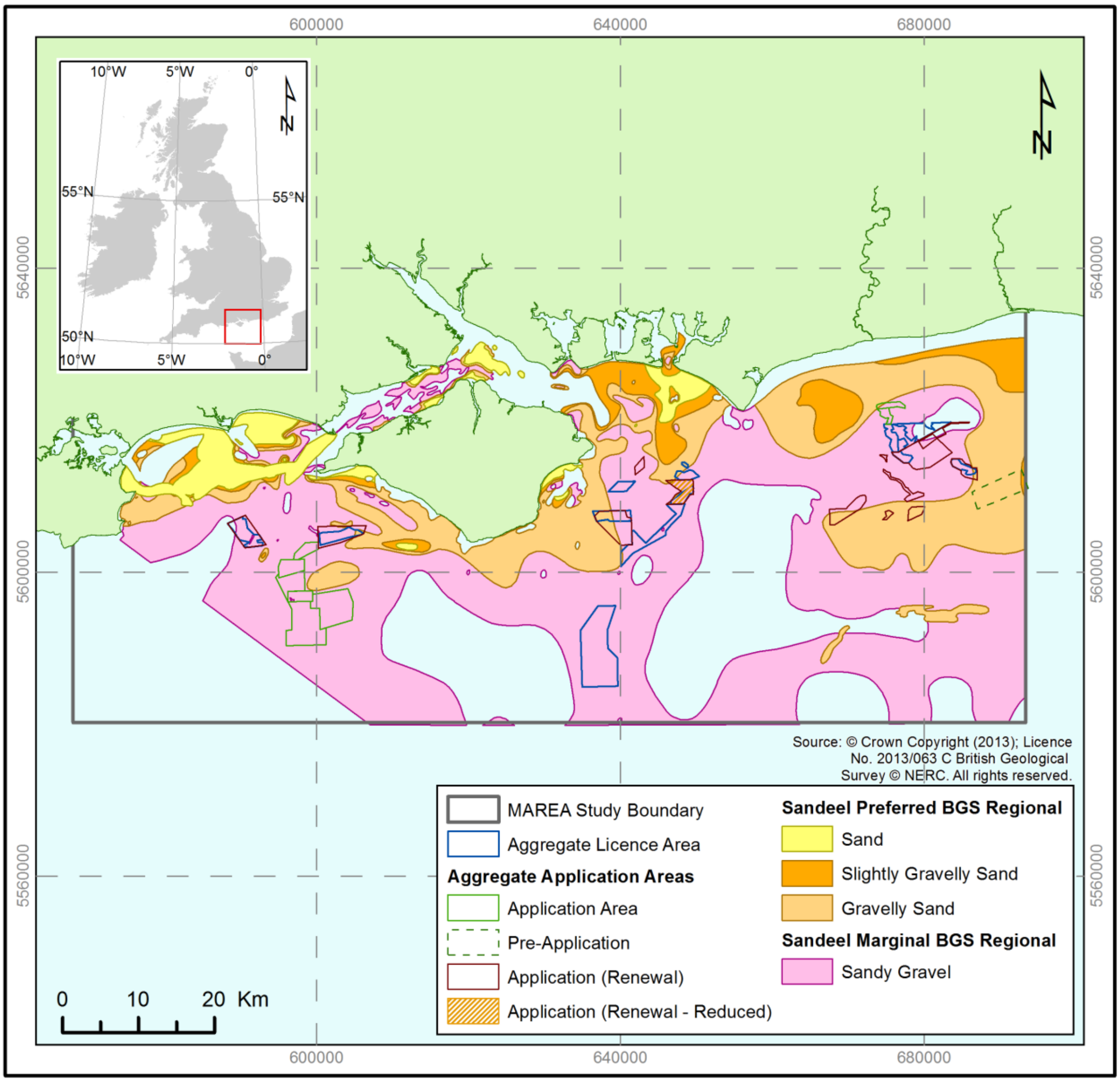


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Figure 3.2 Potential sandeel habitat within the South Coast MAREA region (Sand, slightly gravelly Sand and gravelly Sand = preferred habitat, sandy Gravel = marginal habitat)

3.3 STEP 3 – Regional broadscale habitat characterisation layers basemap

3.3.1 Regional assessment boundary

The regional assessment is synonymous with the 'cumulative' assessments undertaken in the South Coast MAREA region, and considers all aggregate extraction areas. See Figure 3.2 for the potential habitat for sandeel within the South Coast MAREA region.

3.3.2 Coull *et al.* (1998) layer

The next data layer incorporates the use of Coull *et al*. (1998) spawning maps for sandeel, which considered both the known location of larvae and the relationship with suitable benthic habitat (as per methods in Latto *et al.* (2013)). No overlap with the spawning map and the South Coast MAREA region occurs (Figure 3.3). The Coull *et al.* (1998) data layer is considered to be of low confidence because of the age of the data and the lack of detail on what underlying data was used to construct the spawning maps.

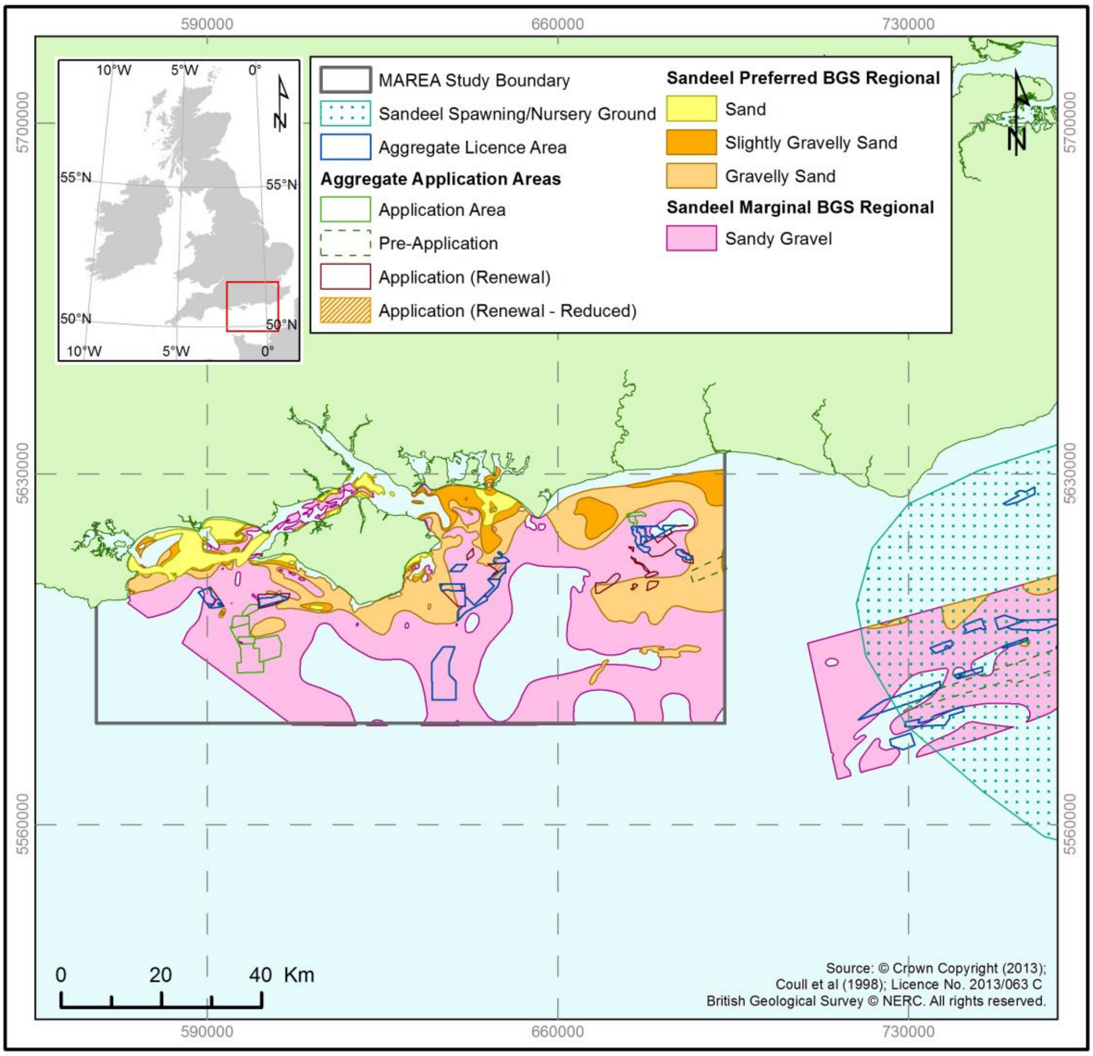

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Figure 3.3 Sandeel spawning grounds in the vicinity of the South Coast MAREA region. Source: Coull *et al.* (1998)

3.3.3 Regional sandeel fishing fleet VMS data

To further ascertain the presence of sandeel within the South Coast MAREA region, VMS data of demersal fishing gears (used to target sandeel) are presented below (Figure 3.4). There are limitations to this data layer as only commercial fishing vessels >15 m length are required to use VMS. Further, commercial fishing vessels using demersal fishing gears able to catch sandeel may not be targeting this species and could be targeting another species entirely. Therefore these data are not truly representative of the distribution of sandeel and confidence in the data will reflect this fact. The probability of this data informing sandeel habitat is therefore deemed as very low, however, demersal fishing gears are still considered here to be indicators of sandeel habitat.

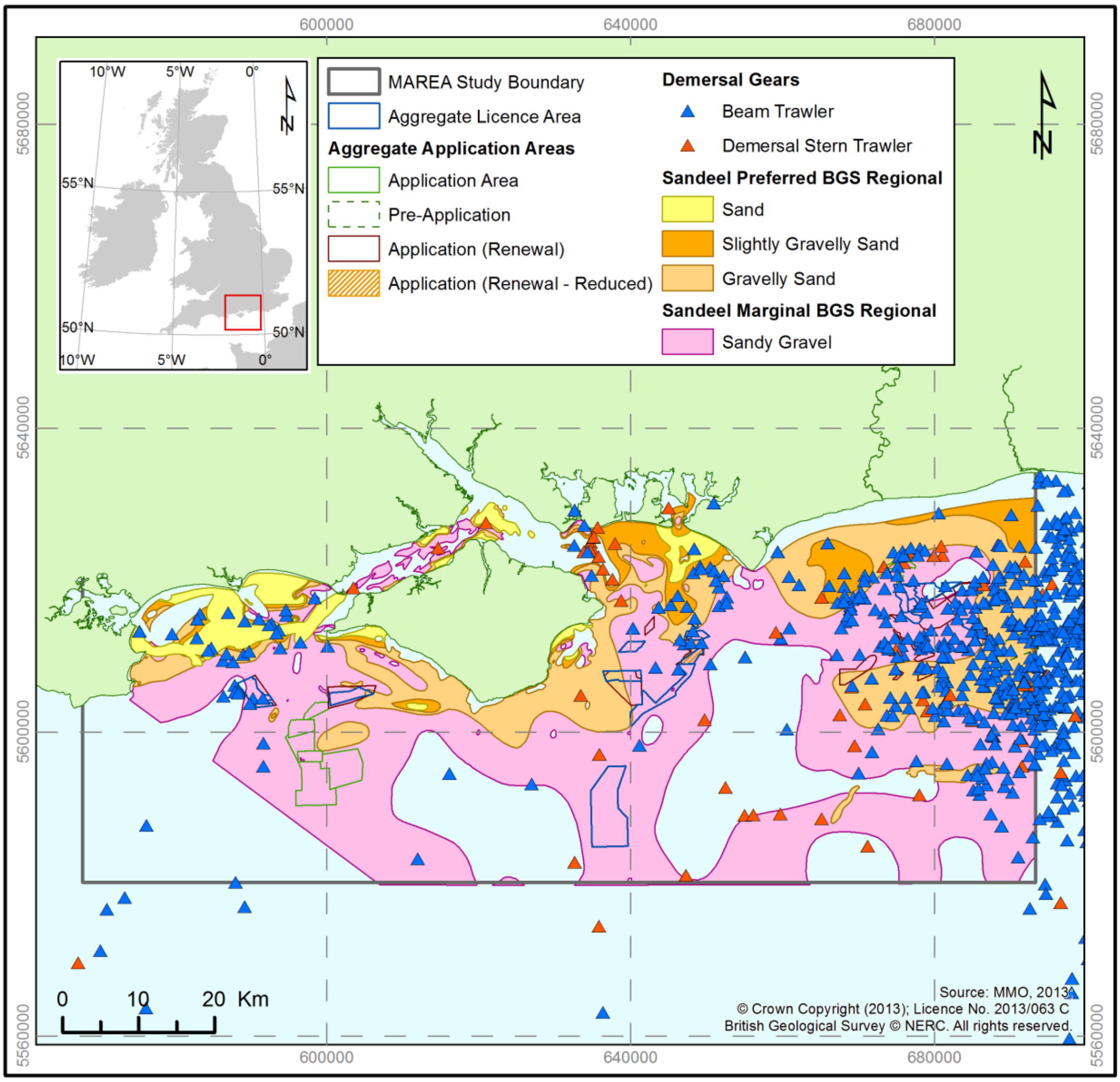

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Figure 3.4 VMS data showing demersal fishing gears of commercial fishing vessels >15 m length in the vicinity of the South Coast MAREA region

3.3.4 Regional screening

Current marine aggregate extraction areas and application areas in the South Coast MAREA region are shown with reference to potential sandeel habitat areas, derived using the methods presented in Latto *et al*. (2013) and the associated confidence assessment (MESL, 2013).

Each data layer has been awarded its own confidence scoring based on various parameters (such as accuracy, quality and age), which result in an overall map which includes confidence applied to this assessment for the South Coast MAREA region. The areas where the greatest number of data layers overlap one another results in a higher confidence that sandeel may occur there (Figure 3.5).

Low confidence in the data exists for the majority of the South Coast MAREA region. An area of moderate confidence exists to the east of the South Coast MAREA region as a result of the higher intensity of VMS data, although this is considered to be an over-representation of effort because although vessels were recorded using demersal fishing gear, they may not be targeting sandeel directly. There are no areas of high or very high confidence in the South Coast MAREA region.

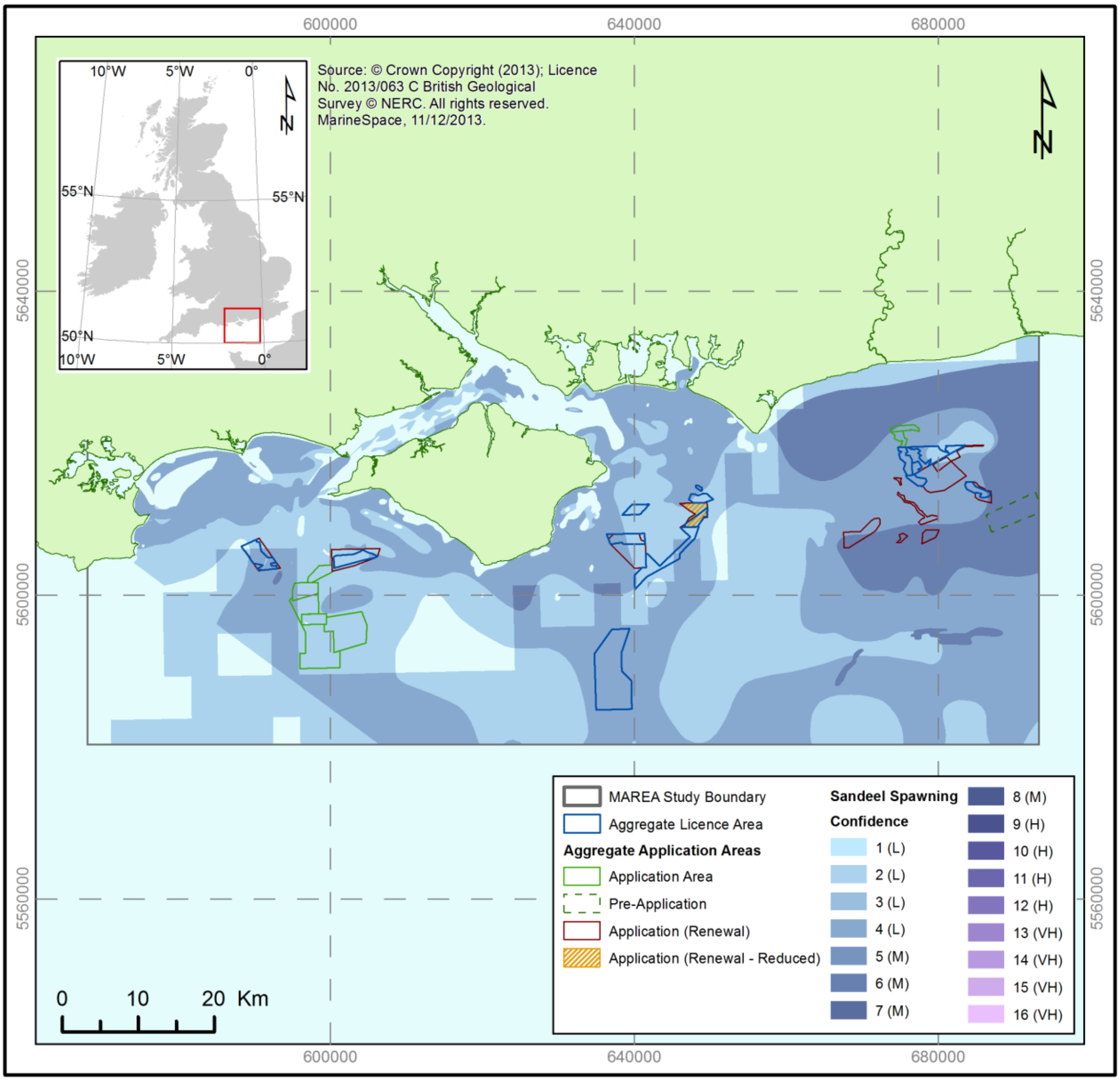

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Figure 3.5 Confidence assessment of the data layers used in the sandeel assessment for the South Coast MAREA region (1-4: low, 5-8: medium, 9-12: high, 13-16: very high)

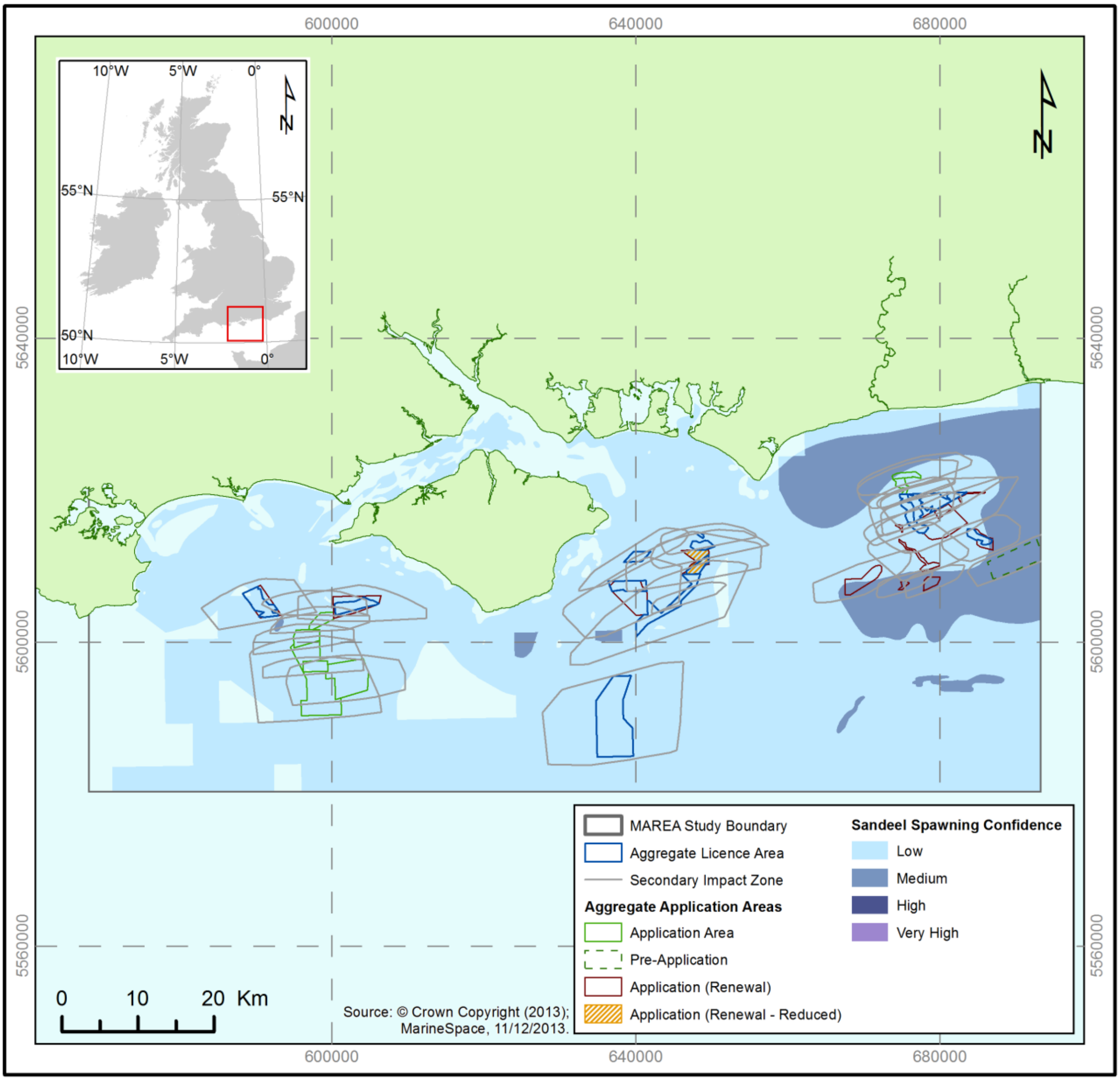

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Figure 3.6 Grouped confidence assessment of the data layers used in the sandeel assessment for the South Coast MAREA

3.3.5 Assessment of the south coast sandeel habitat

The percentage overlap between the current and proposed aggregate extraction areas and potential sandeel habitat, as shown in Figure 3.5, has been calculated as shown in Table 3.1.

There is generally low confidence in the South Coast MAREA region, as being able to support sandeel habitat, where overlap with aggregate area occurs. However, an area of moderate confidence exists to the east of the South Coast MAREA region, as a result of the presence of commercial fishing vessels utilising demersal fishing gears.

Table 3.1 indicates the regional footprint of aggregate activity in the South Coast MAREA region, and identifies the interaction overlap between dredging and potential sandeel habitat areas. It can be seen that the combined current and proposed aggregate area extraction overlap of sandeel habitat in the South Coast MAREA region is 7.51%, although the majority is made of low confidence area, where sandeel are less likely to occur. No high or very high confidence areas are included in the overlap.

Table 3.1 Regional footprint of marine extraction areas (current and proposed) overlapping with potential sandeel habitat in the South Coast MAREA region

Percentage of very high confidence sandeel habitat overlapped by cumulative aggregate footprint	Percentage of high confidence sandeel habitat overlapped by cumulative aggregate footprint	Percentage of moderate confidence sandeel habitat overlapped by cumulative aggregate footprint	Percentage of low confidence sandeel habitat overlapped by cumulative aggregate footprint
0.00	0.00	0.96	6.55

In addition, the South Coast MAREA boundary contains an area of 4,874.8 km^2 of seabed, with 70.3% of the total seabed habitat available for sandeel. Of this available habitat, 1,209.7 km^2 or 35.3% is preferred habitat and 2,216.0 km^2 or 64.7% is marginal habitat. There is lower confidence in the defined marginal habitat for supporting sandeel than in the smaller area of preferred habitat. This is because the sandy Gravel data layer derived from Folk (1954) may contain sediments with >50% gravel component which is considered unsuitable for sandeel. As such the extent of sandeel habitat may be over-represented within the region.

Broad scale sandeel sensitivity data (Coull *et al*., 1998) reveals no sandeel spawning or nursery grounds are directly located within the South Coast MAREA region. The nearest spawning grounds are approximately 34 km to the east of the South Coast MAREA region boundary, where there is a relatively large spawning ground.

Demersal fishing activity within the region is widespread. Much of the activity recorded between 2006 and 2012 by the MMO is shown to be trawlers located towards the east of the South Coast MAREA region. However demersal fishing gears target a numerous commercial species and this data is not considered to be representative of specific sandeel habitat within the region.

Much of the South Coast MAREA region is considered to be suitable habitat for sandeel but it is acknowledged that using the data available for this assessment, there is a low confidence in this conclusion. When contextualised further within a regional and national setting, the relative importance of the South Coast MAREA region for sandeel is reduced. This is because much of the area is supposed marginal habitat that is well distributed throughout the English Channel and wider North Sea. There is relatively little preferred habitat within the South Coast MAREA region, and where it is found, preferred habitat is distributed along the coast to the north of the region and away from the licence and application areas.

As sandeel are considered to show a degree of site fidelity (Jensen *et al.*, 2011), if they do occur within the licence and application areas of the South Coast MAREA region, they may undergo a reduction in abundance as a result of the direct removal of habitat, along with the physical alteration (fining) of the sediments. Based on the level of suitable habitat within and around the South Coast MAREA region, sandeel are screened into the assessment.

4. IMPACT ASSESSMENT OF THE SOUTH COAST REGION

It has been agreed with the MMO and RAG (MMO meeting note, 2013) that only the potential impacts upon sandeel preferred and marginal habitat associated with the PIZ and not the SIZ will be assessed. The direct removal of habitat and the physical alteration (fining) of the sediments need to be addressed. These effect-receptor pathways relate to the PIZ. The secondary effects of aggregate extraction associated with the SIZ, i.e. sediment plumes and sediment mobilisation, are not considered necessary as sandeel have been shown to be tolerant to both increased suspended sediments within the water column, as well as sediment deposition (Pérez-Dominguez and Vogel, 2010).

Further, the MMO and RAG have indicated that entrainment of sandeels by the dredger draghead, is not considered to be significant in the context of an EIA. Therefore, entrainment effects will not be considered here. It is assumed that the boundary of the licence areas within the South Coast MAREA region represent the PIZ and active dredging may occur anywhere within the boundary. The SIZ is not considered within the cumulative assessment as the secondary effects of aggregate extraction have been shown to be inconsequential to sandeel.

This assessment of likely effects on sandeel habitat will specifically considers the effect-receptor pathways for:

- Direct removal of suitable sediment; and
- Recovery of suitable habitat to support future possible spawning activity (re-colonisation).

It has been agreed with the MMO (2013) that the potential effects of sediment plumes and sediment mobilisation are not considered necessary in the context of this report. Therefore this assessment will only be conducted upon the PIZ footprint.

In addition, this section provides an assessment of the cumulative impacts of dredging within the South Coast MAREA region on sandeel habitat. Section 4.2 provides an assessment of the overlap of all industries within the South Coast MAREA region with sandeel habitat fulfilling Step 3 in the methodology (Latto *et al*., 2013).

4.1 Step 3a – Regional Impact Assessment

4.1.1 Direct removal of suitable sediment in the PIZ

Removal of the seabed will result in the direct removal of sandeel habitat. The effect of direct habitat disturbance/removal through dredging activities within the South Coast MAREA region is regarded as having a **medium magnitude** due to the medium term duration, routine frequency and extent limited to the PIZ.

The sandeel **sensitivity is medium to high** due to the low tolerance and adaptability and medium recoverability. It is recognised that the sediments identified in the PIZs are considered suitable for sandeel; however, no areas were identified as having high confidence in the potential used by sandeels. Despite the current low confidence levels, suitable habitats may be colonised over time, therefore an effect can be considered to occur to the integrity of the habitat.

In terms of the spatial overlap with the receptor, there is considered limited spatial overlap between the current and proposed aggregate areas and the total potential sandeel habitat in the South Coast MAREA region (7.51%), for which there is low confidence in their potential use.

The significance of the overall impact of seabed removal to the sandeel populations is, therefore, considered to be of ***minor significance***.

This significance differs from the impact of seabed removal that is identified within the South Coast MAREA region as sediment type has since been considered as a parameter for identifying potential sandeel presence, and was not previously considered as a sole indicator towards potential presence by the South Coast MAREA.

4.1.2 Recovery of suitable habitat to support future possible spawning activity (re-colonisation)

Following the cessation of dredging, the licence holders are required to leave a capping layer of aggregate resource of at least 0.5 m, which is similar in nature to that which existed before the commencement of dredging. The effect of leaving suitable habitat means that the effect of dredging is not permanent, and will allow re-colonisation of the areas that either become exclusion zones while the licences are is still in place, or are no longer dredged following the expiration of the licences.

The effect of leaving a layer of resource is considered mitigation for sandeels given the habitat still exists. The magnitude is **low to medium** due to the short term duration, routine frequency and extent within the PIZ. The sensitivity is considered **low to medium** given sandeels will have a greater degree of adaptability and recoverability should similar habitat exist post dredging. Therefore the overall impact is of ***not significant***.

4.1.3 Summary of impacts

Table 4.1 summarises the potential impacts on sandeel from marine aggregate extraction within the South Coast MAREA region.

Table 4.1 Summary of the significance of impacts on sandeel from marine aggregate extraction within the South Coast MAREA region

Effect	Significance	Rationale
Direct removal of suitable sediment in the PIZ	Minor significance	Based on the medium magnitude of effects, the medium to high sensitivity and the limited spatial overlap given the wider habitat available, the cumulative impact of direct removal of suitable sediment removal on potential sandeel habitat is considered to be of minor significance in the regional context.
Recovery of suitable habitat to support future possible	Not significant	Based on the low to medium magnitude of effects, the low to medium sensitivity and the limited spatial overlap given the wider habitat available, the cumulative impact of recovery of

Effect	Significance	Rationale
sandeel habitat within the PIZ		suitable habitat to support future possible sandeel communities within the PIZ is considered to be not significant in the regional context.

Based on the above assessments and the information presented above, the cumulative impact of marine aggregate extraction on potential sandeel habitats in the South Coast MAREA region is of **minor significance** at the scale of the South Coast MAREA region (EMU, 2012).

4.2 STEP 3b – Cumulative Assessment

4.2.1 Introduction

This section presents the findings of the Cumulative Impact Assessment (CIA) for potential impacts to potential sandeel habitat in the South Coast MAREA region. This assessment includes all industries that may cause effects that could interact with, or augment, the effects resulting from marine aggregate dredging. The following industries are considered in the CIA:

- All potential marine aggregate activity;
- Commercial fishing (trawl and dredge);
- Disposal sites;
- Offshore renewables; and
- Cables and pipelines.

It should be noted that the cable and pipeline routes include both current and predicted export cable route pathways for proposed wind farm developments, which are assessed as being worst case scenario footprints for future years, i.e. the route encompasses the greatest amount of sandeel habitat. Cable routes have been buffered by 300 mm to give an area to polylines in GIS.

4.2.2 Methodology and study area

The methodology aligns with the worst case rationale used within the South Coast MAREA (EMU, 2012). This rationale assumes that the application areas are representative of the PIZ, in that the Active Dredge Zone (ADZ) may be elected anywhere within the application area.

This approach has also been applied to potential projects for other industries:

- Offshore renewables: entire application areas;
- Cables and pipelines: 300 mm diameter along the entire proposed cable route; and
- Commercial fisheries: ICES sub-rectangle (each is approximately 3.5 x 5.5 km) in which the relevant fishing activity has been recorded using VMS data for the years 2007 to 2011.

The SIZs are not considered within the cumulative assessment as the secondary effects of aggregate extraction from increased concentrations of suspended sediments and smothering have been shown to be inconsequential to sandeel species (Pérez-Domínguez and Vogel, 2010).

The two dimensional extents (i.e. the footprints) of each industry/activity have been derived using Geographic Information Systems (GIS) software. The extent to which these overlap with sandeel preferred habitat (i.e. gravelly Sand/slightly gravelly Sand/Sand) and marginal habitat (i.e. sandy Gravel) have been calculated to give an estimate of the areas of potential habitat disturbance, proportional to the area of habitat available.

The study area is defined as the South Coast MAREA region. The footprints of the industries that fall within this area and overlap the habitat suitable for sandeel have been considered within this assessment. The total area of marginal habitat for sandeel within the South Coast MAREA region is estimated to be 2,216.0 km^2, and the total area of preferred habitat for sandeel in the South Coast MAREA region is estimated to be 1,209.7 km^2.

4.2.3 Assessment of industries

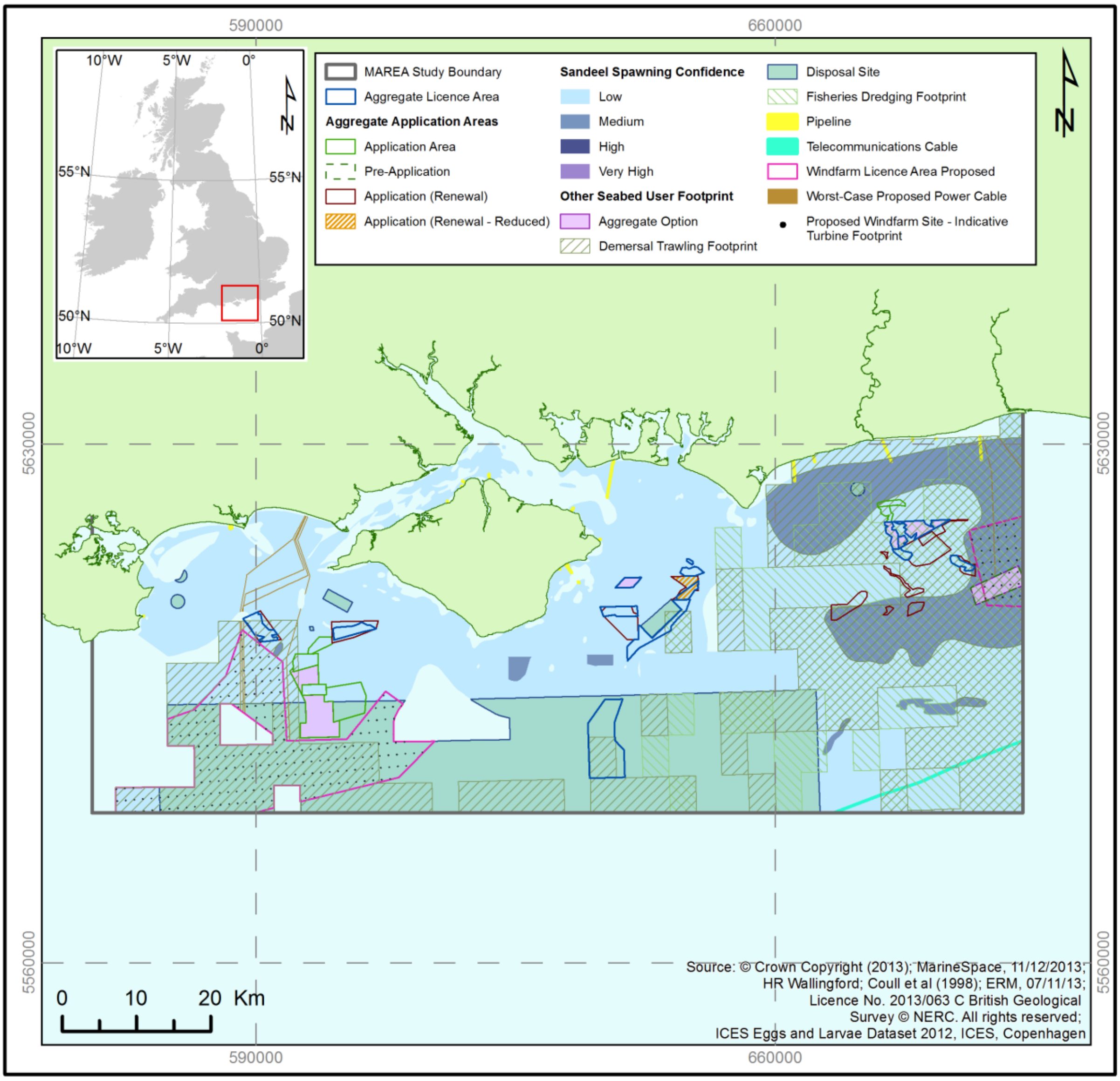
Percentage overlaps of each sector on potential sandeel habitat have been calculated, as for the aggregate extraction areas. These are presented in Table 4.2. These figures allow an insight to be gained into the regional footprint of each seabed user against which the footprint of regional aggregate extraction can be contextualised.

A map of all seabed users within the South Coast MAREA region is presented with respect to very high, high, moderate and low confidence areas of seabed to support sandeel, and is shown in Figure 4.1.

Table 4.2 Regional footprint of all seabed users considered in this assessment overlapping potential sandeel habitat areas in the South Coast MAREA region

	Percentage of area overlapped classified as very high confidence	Percentage of area overlapped classified as high confidence	Percentage of area overlapped classified as moderate confidence	Percentage of area overlapped classified as low confidence
Aggregate extraction (current and proposed) PIZ only	0.00	0.00	0.96	6.55
Commercial fishing (trawl gear types)	0.00	0.00	11.71	35.07
Commercial fishing (dredge gear types)	0.00	0.00	9.42	24.00
Disposal sites	0.00	0.00	0.06	27.67

Proposed wind farm option areas	0.00	0.00	1.48	8.79
Proposed wind farm sites (indicative turbine footprint)	0.00	0.00	<0.01	0.02
Proposed wind farm worst case cable route option	0.00	0.00	<0.01	<0.01
Telecommunication cables	0.00	0.00	0.00	<0.01
Pipelines	0.00	0.00	<0.01	<0.01



Map Document: (V:\J1132381_Herring_and_Sandeel_Mapping_Project\3_Plots\2_Draft\20131108 Updates\Q2381_South_Coast_Region_Sandeel_Cumulative_RJM_20131211.mxd) 11/12/2013 -- 14:25:27

Figure 4.1 Footprint of all industries within the South Coast MAREA region

4.2.3.1 Trawl fisheries

Trawl fisheries have an estimated overlap of 2,150.79 km^2 with moderate and low confidence areas of seabed within the South Coast MAREA region to support sandeel. This corresponds to 11.71% of moderate confidence areas of seabed and 35.07% of low confidence areas of seabed (Table 4.2). It should be noted that trawl fisheries are estimated to overlap with 42.4% of marginal sandeel habitat and 44.5% of preferred sandeel habitat within the South Coast MAREA region.

These figures are considered to be an over-estimate, because fishing activity is considered to take place over an entire ICES sub-rectangle if it has been recorded anywhere within it. However, VMS data are inherently an underestimate of fishing activity, as only vessels of >15 m are included within the data. Demersal trawl fisheries can cause direct disturbance to the seabed and cause depletion of adult, nursery and spawning stock by removal. This effect occurs regularly, on a seasonal basis, over a long duration.

4.2.3.2 Dredge fisheries

Dredge fisheries have an estimated overlap of 1,536.18 km^2 with moderate and low confidence areas of seabed within the South Coast MAREA region to support sandeel. This corresponds to 9.41% of moderate confidence areas of seabed and 24.00% of low confidence areas of seabed (Table 4.2). It should be noted that dredge fisheries are estimated to overlap with 35.6% of marginal sandeel habitat and 35.8% of preferred sandeel habitat within the South Coast MAREA region.

As with the trawl fishery approximations, these approximations may be considered as over-estimates, as fishing activity is considered to take place over an entire ICES sub-rectangle if it has been recorded anywhere within it. However, VMS data are inherently an underestimate of fishing activity, as only vessels of >15 m are included within the data.As with trawl fisheries, dredge can cause direct disturbance to the seabed and cause depletion of adult, nursery and spawning stock by removal. This effect occurs regularly, on a seasonal basis, over a long duration.

4.2.3.3 Disposal sites

There are five registered open disposal sites that are still operating within the South Coast MAREA region. These sites are generally used for the disposal of dredged material and are: Swanage Bay (WI110); West Wight (WI091); Needles (WI090); Hurst Fort; (WI080); and Nab Tower (WI060). Disposals are granted on a licence-by-licence basis, and the introduction of new or temporary disposal areas cannot be predicted.

Disposal sites have an estimated overlap of 1,275.00 km^2 with moderate and low confidence areas of seabed within the South Coast MAREA region to support sandeel. This corresponds to 0.06% of moderate confidence areas of seabed and 27.67% of low confidence areas of seabed (Table 4.2). It should be noted that disposal sites are estimated to overlap with 28.2% of marginal sandeel habitat and 0.5% of preferred sandeel habitat within the South Coast MAREA region.

It should be noted that these figures capture both open and closed disposal sites, however, only open sites have a potential for on-going cumulative impacts with aggregate extraction within the South Coast MAREA region. Excluding closed disposal sites from the assessment would significantly reduce the percentage overlap with moderate and low confidence areas of seabed which have the potential to support sandeel.

Dredge disposal will lead to a change in the existing sediment composition, dependant on the source location of the dredged sediments, though burial. This may alter the habitat suitability of the area. The effects of disposal are likely to be frequent; however, registered disposal areas are located in areas that are considered to have few influences on the surrounding human and biological environment.

4.2.3.4 Offshore renewables

Proposed wind farm option areas have an estimated overlap of 472.36 km^2 with moderate and low confidence areas of seabed within the South Coast MAREA region to support sandeel. This corresponds to 1.48% of moderate confidence areas of seabed and 8.79% of low confidence areas of seabed (Table 4.2). It should be noted that proposed wind farm option areas overlap with 7.8% of marginal sandeel habitat and 5.6% of preferred sandeel habitat within the South Coast MAREA region. It should be noted that these figures are likely to be an overestimate because consideration is given to the area of search rather than the actual areas of lease.

The indicative turbine footprints within the proposed wind farm option areas have an estimated overlap of 1.08 km^2 with moderate and low confidence areas of seabed within the South Coast MAREA region to support sandeel. This corresponds to 0.003% of moderate confidence areas of seabed and 0.02% of low confidence areas of seabed (Table 4.2). It should be noted that the indicative turbine footprints overlap with 0.06% of marginal sandeel habitat and 0.03% of preferred sandeel habitat within the South Coast MAREA region.

The worst case proposed power cables have an estimated overlap of 0.04 km^2 with moderate and low confidence areas of seabed within the South Coast MAREA region to support sandeel. This corresponds to 0.0002% of moderate confidence areas of seabed and 0.0008% of low confidence areas of seabed (Table 4.2).

Offshore renewables may cause direct loss of existing habitat due to the placement of infrastructure, or during ground preparation works for foundations and cables. Indirect impacts may occur as a result of smothering or sediment fining following the deposition of a sediment plume caused by the movement of seabed sediment. These effects are considered to occur during the construction of the development. During the operation of the development, occurrences of scour around installations may also contribute to a highly localised change in sediment type.

4.2.3.5 Cables and pipelines

Telecommunication cables have an estimated overlap of 0.001 km^2 with low confidence areas of seabed within the South Coast MAREA region to support sandeel. This corresponds to 0.00003% of low confidence seabed (Table 4.2). Pipelines have an estimated overlap of 0.014 km^2 with moderate and low confidence areas of seabed within the South Coast MAREA region to support sandeel. This corresponds to 0.00005% of moderate confidence areas of seabed and 0.00025% of low confidence areas of seabed (Table 4.2). It should be noted that the total area for all cables and pipelines within the South Coast MAREA region overlaps with 0.0003% of marginal sandeel habitat and 0.002% of preferred sandeel habitat within the South Coast MAREA region.

Potential maintenance to existing cables and pipelines, or proposed cables and that may be constructed, could cause effects that may also interact with habitat suitable for sandeel. Existing cables and pipelines may be buried to provide protection and avoid damage to and by fishing gears and vessel anchors. If maintenance is requires, the infrastructure will be required to be brought to the surface and replaced; causing direct disturbance to the seabed sediments. Also, proposed cables will require burial along the entire length. This effect does not occur over the entire cable route at one time, but depending in the burial method, may cause a plume that may lead to smothering of sediment fining.

4.2.4 Marine aggregates, relative to other activities

In terms of contextualising the contribution of marine aggregate extraction to the regional cumulative impacts, it can be seen that marine aggregate extraction overlap with 0.96% of moderate and 6.55% of low confidence areas of seabed to support sandeel. Ranking the percentage overlap with moderate and low confidence areas of seabed from each industry, from highest to lowest, leads to a standing of:

1. **Trawl fisheries** – overall, overlaps with 46.78% of moderate and low confidence areas of seabed within the South Coast MAREA region;
2. **Dredge fisheries** – overall, overlaps with 33.42% of moderate and low confidence areas of seabed within the South Coast MAREA region;
3. **Disposal sites** – overall, overlaps with 27.73% of moderate and low confidence areas of seabed within the South Coast MAREA region;
4. **Offshore renewables** – overall overlaps with 10.30% of moderate and low confidence areas of seabed within the South Coast MAREA region;
5. **Marine aggregates** – overall, overlaps with 7.51% (PIZ only) of moderate and low confidence areas of seabed within the South Coast MAREA region; and
6. **Cables and pipelines** – overall, overlaps with 0.0003% of moderate and low confidence areas of seabed within the South Coast MAREA region.

4.2.5 Assessment of cumulative significance

It is possible for cumulative impacts to occur outside the South Coast MAREA region, within the range of sandeel populations. Therefore, the impacts relating to any sandeel habitat distribution will require consideration within a site specific Environmental Impact Assessment, and as part of any Cumulative Impact Assessment.

Cables and pipelines are considered to have a negligible impact on sandeel habitat, due to the <0.01% spatial overlap and low duration and severity. The impact from offshore renewables and marine aggregates is considered to be minor due to the ~10% spatial overlap and taking account of the cumulative assessment for aggregates considered earlier. The effect of commercial fishing activity and disposal sites is also considered to be minor; although the extent is medium (i.e. approximately <50%) and frequency is high, the severity is low, as only the topmost sediments are changed, and to a small degree.

4.2.5.1 <u>Overall significance statement of impact of aggregate dredging:</u>

The licence and application areas within the South Coast MAREA region have the fifth lowest impact upon sandeel potential habitat. Regional aggregate extraction overlaps 7.51% of moderate and low confidence areas of seabed able to support sandeel.

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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 Marine Management Organisation and/or its statutory and technical advisors (the RAG)

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Cefas Caveat	EIA WG Response
For the purposes of this assessment preferred habitat for sandeel is based on substrate classification alone. It must be noted that there are other factors involved in establishing a ground as suitable for spawning. As a consequence not all areas described as preferred habitat will be suitable for spawning. **MMO Sandeel Comment 5.1.**	As noted in the assessment report, actual potential habitat will be dependent upon wider environmental parameters (physical, chemical and biotic) such water depth, sediment oxygenation and flanks of subtidal sandbanks and other geomorphological bedforms. These factors are made clear within the main report. Other site-specific evidence such as that provided by IFCA records of sandeelers who target sandeels would need to be sought in order to fully understand the location of specific habitats. The reference to preferred and marginal habitat has been amended to reference preferred and marginal habitat <u>sediments</u>. This acknowledges that they are only one data-layer that is considered with the overall 'heat' mapping assessment methodology. Amended text and sign-posts have been included in the report and an addendum has been provided at the beginning of Appendix A which contains the original methodology. Further, the direct reference to habitat sediment extents and determinations based on these areas of extent have been removed from the main body of the report and inserted into Appendix M. However, it is still important to acknowledge that habitat sediment type is an important mapping and assessment data-layer that underpins the other data-layers used in the assessments.
It is beyond the scope of the CIA carried out here to include all cumulative activities. However, it should be noted that there are potential cumulative impacts from other activities outside of the MAREA regions from national and international sources, and that these are likely to have further, additive,	All cumulative activities (Impacts that arise from multiple marine aggregate extraction activities) within each MAREA region have been assessed within this report. In addition, a spatial comparison of in-combination activities (all industrial sectors operating within the same region) has been carried out within this report, both for the MAREA regions and for the wider

impacts on some areas. **MMO Sandeel Comment 7.2**	regional sea area. It is however acknowledged that other in-combination activities may occur in some areas.
It is noted for CIA assessments that obstruction of sandeel habitat occurs from other activities i.e. during the operational phase of oil, gas and renewable infrastructure. In addition, it is acknowledged that the buffered cable routes are approximations and do not capture all forms of cable protection, which may result in greater areas of potential sandeel habitat being lost than has been assessed. **MMO Sandeel Comment 7.4 & 7.5 (caveat written as if from EIAWG for inclusion in the final document).**	Further explanation of the seabed user footprints and the way that these have been mapped and assessed is provided in Section 2.4.1 and Table 2.3. Specifically for cables routes: “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.” These parameters are in accordance with the Oceanwise data source. Further it should be noted that infrastructure that is at the plan or project stage has been mapped to overlap with areas of preferred habitat sediment rather than marginal sediments, thus establishing a precautionary envelope within the assessments.
Any new data sources concerning cumulative impacts should be included in the site level CIA.	Noted. This will also be done for in-combination impacts.
Sandeel distributions described by spawning and nursery maps sourced from Coull *et al.*, 1998, only cover the North Sea (and Scottish waters). There are no data for the Irish Sea, the western approaches or west English Channel.	Noted. This is reflected in the relevant text and is also part of the rationale for using multiple data layers as part of the ‘heat’ mapping assessment. There is nothing that the EIA WG is able to do to rectify the absence of a data layer where the spatial coverage does not extend across the full study area. The use of multiple data layers helps mitigate this to an extent, and this is reflected in the total combined ‘heat’ that is available for the South Coast region.

Heat maps generated from overall data confidences are not necessarily indicative of spawning areas. Higher confidence levels indicate that more layers of data are available for that area and do not relay any information about data contents. Hence should not be assumed to be directly related to spawning activity.	The assessment is to identify Atlantic Herring potential spawning habitat. The 'heat' map approach adopted in terms of confidence levels indicates varying degrees of likelihood that an area will be suitable for spawning or will contain spawning beds.
It is acknowledged that the methodology in this report will be subject to periodic review …, and subsequent revised versions may be released as new data become available.	Review and update may be a possibility. However once site-specific work at the licence area is undertaken to more fully determine presence or absence of potential spawning beds there will be little value to the marine aggregate companies in updating this study as it will no longer be relevant to management of their activities. The EIA Working Group will be happy to provide the data to any other party who may wish to continue the work.
It is not clear where the fisheries trawl data has been derived from and therefore its accuracy cannot be confirmed. These data needs to be referenced and caveated in terms of the limitations of these data by the EIAWG. The implications and assumptions attributed to the impacts from trawl fishing also need to be verified, referenced and discussed further in the report. **MMO Sandeel Comment 7.3**	The VMS data have been sourced from the MMO and accompanied by MEDIN standard metadata. No implications and assumptions attributed to the impacts from trawl fishing are made within the report, either the consultation version 0.8 that this comment 9.3 is based upon or within this final report. Statements made regarding trawl fisheries detail extent of footprint of the activity and relate this in comparison with the 'heat' map classes and other industrial seabed user sectors. Statements of assessment have been clarified within the relevant text in the report to preclude misinterpretation of the determinations and statements.

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. From January 2005 all UK fishing vessels over 15 metres in overall length were required to have installed on board a satellite tracking device. Since January 2012 vessels greater than or equal to 12 m have a requirement to install these systems.	Noted and the extent of the additional footprint of the less that 12 m fleet would need to be established by other means but that is beyond the scope of this study.

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

M1. Potential sandeel habitat sediment resource – Wider Geographical Region

As presented in Table M1 the spatial coverage for the wider geographical region sourced from the BGS SBS v3 data-layer covers a total of 134,549 km^2. Within this, the total area of preferred and marginal sediment habitats which have the potential to support sandeels (from the BGS SBS v3 data) covers an area of 96,482 km^2; just under 72% of the entire region. The area of seabed sediments which are considered to be preferential for sandeel occupation is 82,216 km^2 whereas the area of marginal sediments accounts for 14,267 km^2. This equates to 61% and 11% coverage of the total wider geographical region for preferable and marginal habitat sediments respectively.

Table M1: The extent of sandeel habitat sediments within the central and southern North Sea, the eastern English Channel and the south coast of England. (Data: The British Geological Survey 1:250,000 scale seabed sediment version 3)

BGS Seabed Sediment Data	Humber (km²)	Anglian (km²)	Thames (km²)	South Coast (km²)	Total Extent of Potential Habitat Sediment within MAREA Regions (km²)	Wider Regional Sea Extent of Potential Habitat Sediment (km²)
Preferred Habitat Sediment	3,279.57	3,650.33	3,138.83	1,209.69	11,278.42	82,215.57
Marginal Habitat Sediment	4,499.61	866.75	1,086.54	2,216.04	8,668.94	14,266.91
Total Potential Habitat Sediment	7,779.18	4,517.08	4,225.37	3,425.73	19,947.36	96,482.48

M1.1. Primary Impact Zone footprint – Wider Geographical Region

Considering the extent of the preferred habitat sediments at the wider geographic region scale (82,216 km^2) the area of influence of the PIZ associated with marine aggregate dredging activity can be set in context. The area of preferred habitat sediments within the PIZ footprint for all licence areas equals 163 km^2 with application areas adding another 502 km^2. Using these values the worst case total PIZ footprint[1] overlap with preferred habitat sediments equates to 665 km^2; or less than 1% of the total extent of the preferred habitat sediments present within the wider regional sea area.

The area of marginal habitat sediments in the wider geographic region accounts for 14,267 km^2 and interacts with a total licence area PIZ footprint of 360 km^2. Application areas overlap a further 594 km^2 of marginal habitat sediments resulting in a total overlap of 954 km^2 and an interaction with

[1] This assumes that the total area of seabed within the licence and application area boundaries will be exposed to dredging related habitat removal or abrasion pressures

just 7% of the marginal habitat sediments found in the wider geographic region. Therefore overall, the total PIZ footprint for all licence and application areas with potential sandeel habitat sediments equates to 1,619 km^2 or less than 2% of the total resource found within the wider geographic region.

M1.2. Potential sandeel habitat resource – MAREA-scale

Sub dividing the BGS SBS v3 data at a regional scale (based on the MAREA regional boundaries) indicates that preferential habitat sediment for sandeel occupies an area of 11,278 km^2 across all the MAREA regions, whereas the area of marginal sandeel habitat sediment accounts for 8,669 km^2. This is 8% and 6% of the total wider regional sea area (134,549 km^2) for preferable and marginal habitat sediments respectively.

Examination of the seabed sediment data extracted from each of the four MAREA reports considered in this study is represented in Table M2. The total area of preferred and marginal habitat sediments with the potential to support sandeel populations (for the four MAREA regions) covers an area of approximately 21,858 km^2. Of this 10,512 km^2 relates to preferred habitat sediments and approximately 11,347 km^2 to marginal habitat sediment (the actual total values of the marginal habitat sediment, and therefore the total habitat sediment, cannot be determined from the Thames and South Coast MAREA seabed sediment data due to grouping of sediment classifications). Approximately 78% of the seabed habitats found in the four MAREA regions have the potential to support sandeel populations. Contextually the potential sandeel habitat overlapping with a PIZ (assuming worst case i.e. all licence and application areas' PIZ delineated by the area boundary) equals 1388 km^2. This equates to a little over 6% of the potential habitat in the combined MAREA areas and is equivalent to more than 5.5% of the combined total extent of the MAREA regions.

Both the BGS, and the MAREA, seabed sediment data (Tables M1 and M2) show that the Humber region contains the largest extent of sandeel potential habitat out of the four regions assessed. The extent of potential habitat in the Thames and South Coast regions varies between the BGS and MAREA data. This is a result of the grouping of sediment classifications within the Thames and South Coast MAREAs to aid interpretation (ERM Ltd, 2010; EMU Ltd, 2012b). This has resulted in the differing representations of habitat in the context of this assessment. The significance of these differences is discussed in the following section.

Table M2: The extent of sandeel habitat sediments within the Humber, Anglian, Outer Thames Estuary and South Coast MAREA regions. (Data: ERM Ltd, 2010, 2012; EMU Ltd, 2012a, 2012b)

MAREA Seabed Sediment Data	Regional Extent of sandeel habitat sediments (km²)				Total from all MAREA Areas (km²)
	Humber	Anglian	Thames*	South Coast**	
Preferred Habitat Sediment	2,609.72	3,797.90	-	970.85	10,511.83
Marginal Habitat Sediment	4,348.56	562.48	-	~3,903.99	11,346.54
Total Potential Habitat Sediment	6,958.28	4,360.39	3,133.36	~4,874.83	21,858.37
Area of MAREA (km²)	9,600.00	4,800.00	5,400.00	5,000.00	24,800.00
% of MAREA Total Sandeel Habitat Sediments	72.48	90.84	58.03	~97.5	77.93

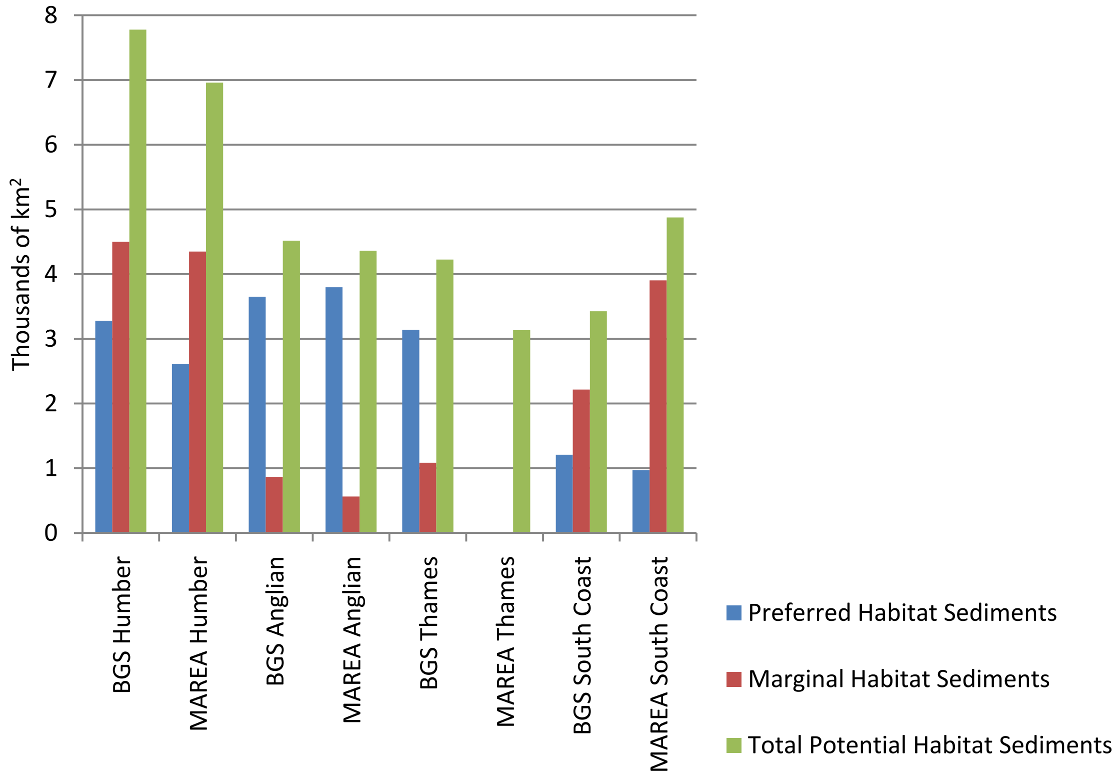
*The seabed sediments within the Thames MAREA have been mapped with sandy Gravels and gravelly Sands amalgamated into a single mapping unit. As this division represents both preferable and marginal sandeel habitat sediment this would result in the combined area of habitat calculated being duplicated in the table due to the inability to separate out the marginal from the preferable habitat sediments. This would over represent the preferable and marginal habitat sediment, and would lead to errors in interpretation of the data set. As such only the total extent of potential habitat is listed.
**The seabed sediments within the South Coast MAREA have been mapped with sandy Gravel and Gravel amalgamated into a single mapping unit. As Gravel is not considered potential habitat for sandeels this classification over represents the marginal habitat sediment. Due to the Gravel component not being able to be removed from this data layer only an approximate figure for marginal and total potential sandeel habitat sediments can be supplied in this instance.

M1.3. Comparison between the BGS and MAREA seabed sediment habitat data

The data sample density used to underpin both the BGS and MAREA seabed sediment data are comparatively similar, although with a slight bias towards marine aggregate areas in the MAREA data as expected due to the purpose of these studies; to characterise the marine and coastal environment with regard to marine aggregate operations and cumulative environmental effects.

In the Humber and Anglian regions comparison between the BGS and MAREA seabed habitat sediment extent data shows a degree of alignment, with broadly similar representations of total habitat, as well as the divide between preferred and marginal habitat sediments (Figure M1). In contrast there appears to be a level of disparity between the BGS and MAREA data for both the South Coast and Outer Thames Estuary regions. This was not unexpected due to the grouping of sediment classifications previously mentioned in Section 3.2.3. The MAREA sediment classifications were established for the purpose of the MAREA assessments and remain fit-for-purpose for these tasks. However, the presentation of the sediment data within the Thames and South Coast MAREAs assessments has meant they are not useable for the purposes of the sandeel habitat screening assessment.

Figure M1: 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.



The Outer Thames MAREA grouped sandy Gravels and gravelly Sands together, amalgamating preferable and marginal sandeel habitat sediment classes. As such only the total habitat extent is represented; this total extent is comparable with the preferable habitat sediment extent shown by the BGS data. The South Coast MAREA data grouped sandy Gravels with Gravels, bringing in a sediment classification which was not to be considered in this assessment; Gravel (Latto *et al.*, 2013). This has led to an unknown increase in the amount of marginal habitat sediment represented by the MAREA data in comparison with the BGS data. In contrast the preferable habitat sediment indicated in the South Coast MAREA remains at a comparable level to that shown by the BGS seabed sediment data.

It is likely that some of the discrepancies between the BGS and MAREA seabed sediment data could relate to data vintage and seabed bedform mobility e.g. the slight decrease in preferable habitat sediments 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 presentation of the seabed sediments data in each of the respective MAREA study reports has likely contributed the greatest discrepancies between the MAREA and BGS data. As already discussed, the Outer Thames Estuary and South Coast MAREAs amalgamated certain Folk sediment classification divisions to aid interpretation (ERM Ltd, 2010; EMU Ltd, 2012b). The Outer Thames Estuary MAREA combined the sandy Gravel and gravelly Sand divisions of the Folk classification together as a single mapping unit; whereas the South Coast MAREA combined the Gravel and sandy Gravel divisions. By grouping these sediment classes together meaningful analysis cannot be determined, in the case of the Outer Thames MAREA the data would over represent both the preferable and marginal sandeel habitat sediment extents whereas the South Coast MAREA over represents the marginal sandeel habitat sediment, by including the Gravel sediments. In these instances the Marine Aggregate EIA WG determined that the BGS data allowed more meaningful resolution for spatial analyses at the MAREA scale.

In the 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).

In addition, there was some difference in interpretation of seabed sediment type between overlapping MAREA regions, particularly between the Anglian and Outer Thames Estuary regions. Where this occurs the lowest confidence approach has been taken, e.g. if one MAREA predicts gravelly Sand where the overlapping MAREA predicts sandy Gravel then the lower confidence is adopted i.e. for marginal habitat sediment (sandy Gravel).

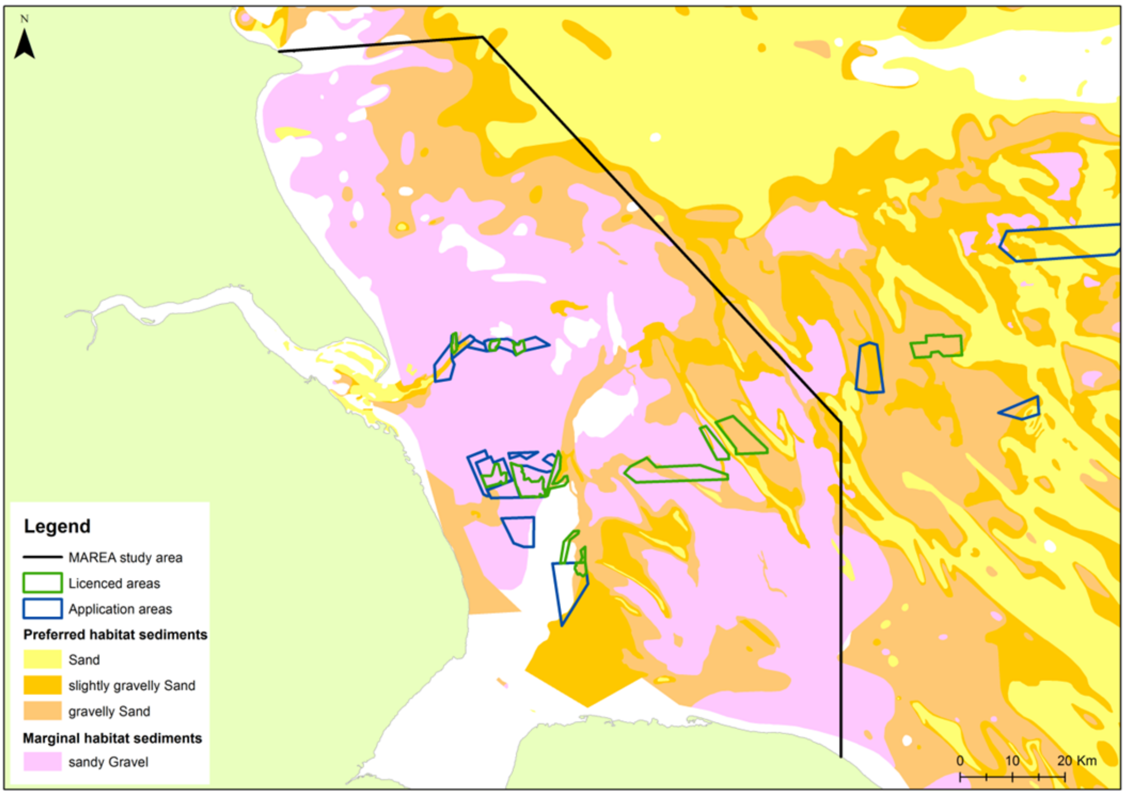
As it was not possible (or necessarily desirable) to combine both the BGS and MAREA seabed sediment data as an indicator of sandeel habitat, the EIA WG has advised that the best seabed sediment data deemed appropriate are used within the study (and for any application area specific ESs). Therefore the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

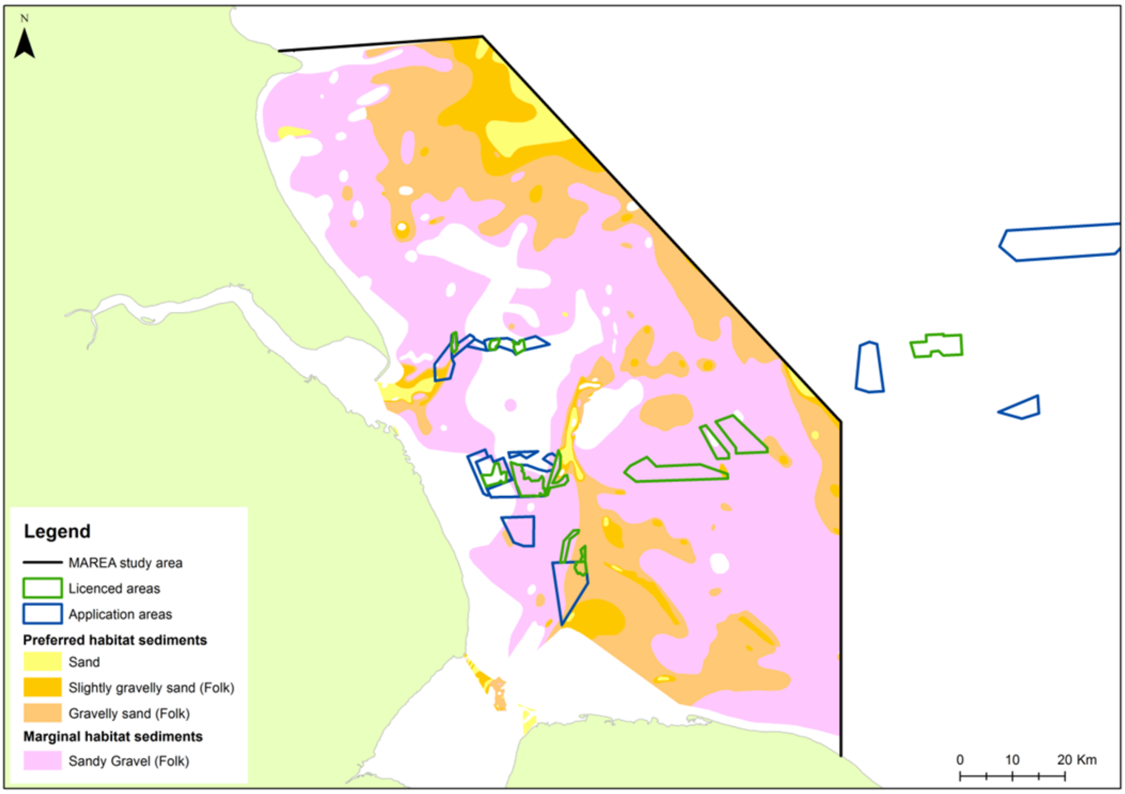
A comparison has been conducted per MAREA region, between the BGS and MAREA seabed sediment base-maps in order to ascertain the most appropriate spatial resolution to allow Stage 1 screening of application areas and Stage 2 CIA (see Figures M2-M5 below). Considerations of the issues discussed above, and the overall confidence in each of the datasets (see Appendix B) have been taken into account when determining the most appropriate base-map to use. The resolution of the seabed sediment 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 M6-M9), the following seabed sediment data have been used preferentially within this study:

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

Figure M2: Comparison of the mapped extents of potential sandeel habitat sediment using BGS (upper), MAREA (middle) and 'outlier' BGS (lower) data within the Humber region. (Derived from 1:250,000 scale BGS Digital Data under Licence 2013/063 British Geological Survey. ©NERC.; ERM Ltd, 2012)





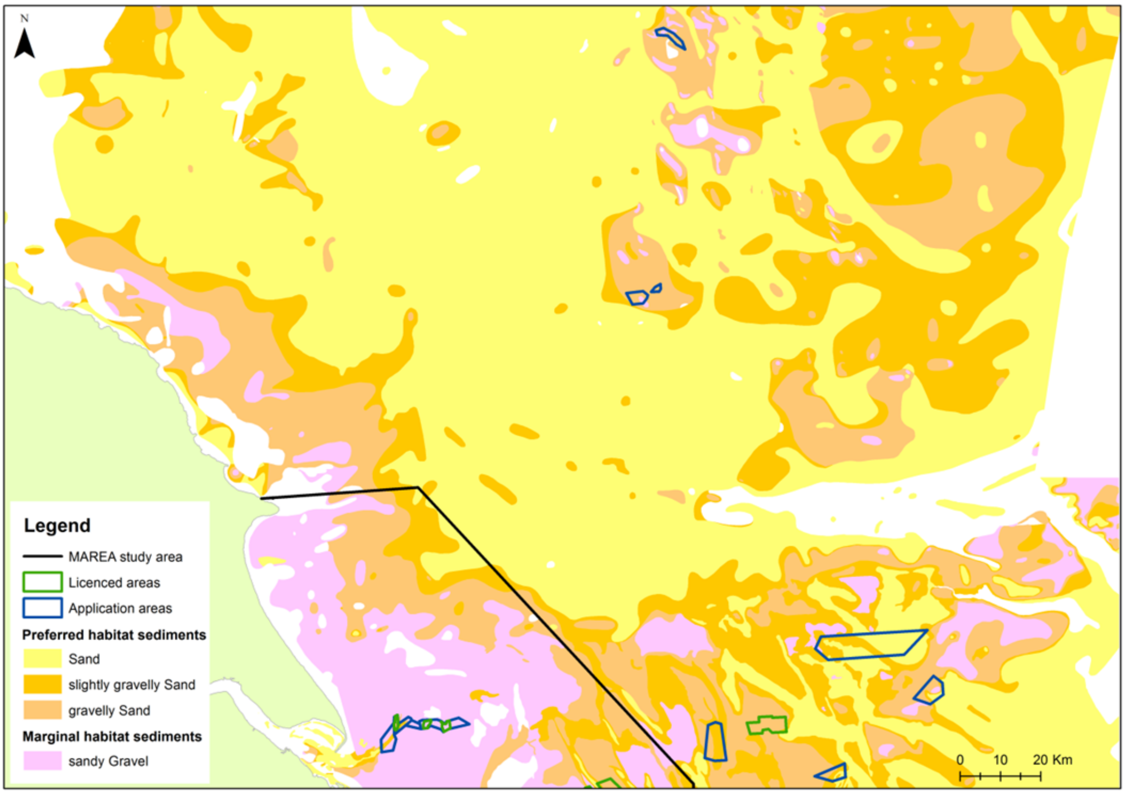

N
Legend
MAREA study area
Licenced areas
Application areas
Preferred habitat sediments
Sand
slightly gravelly Sand
gravelly Sand
Marginal habitat sediments
sandy Gravel
0
10
20 Km

Figure M3: Comparison of the mapped extents of potential sandeel habitat sediment using BGS (upper) and MAREA (lower) data within the Anglian region. (Derived from 1:250,000 scale BGS Digital Data under Licence 2013/063 British Geological Survey. ©NERC.; EMU Ltd, 2012a)

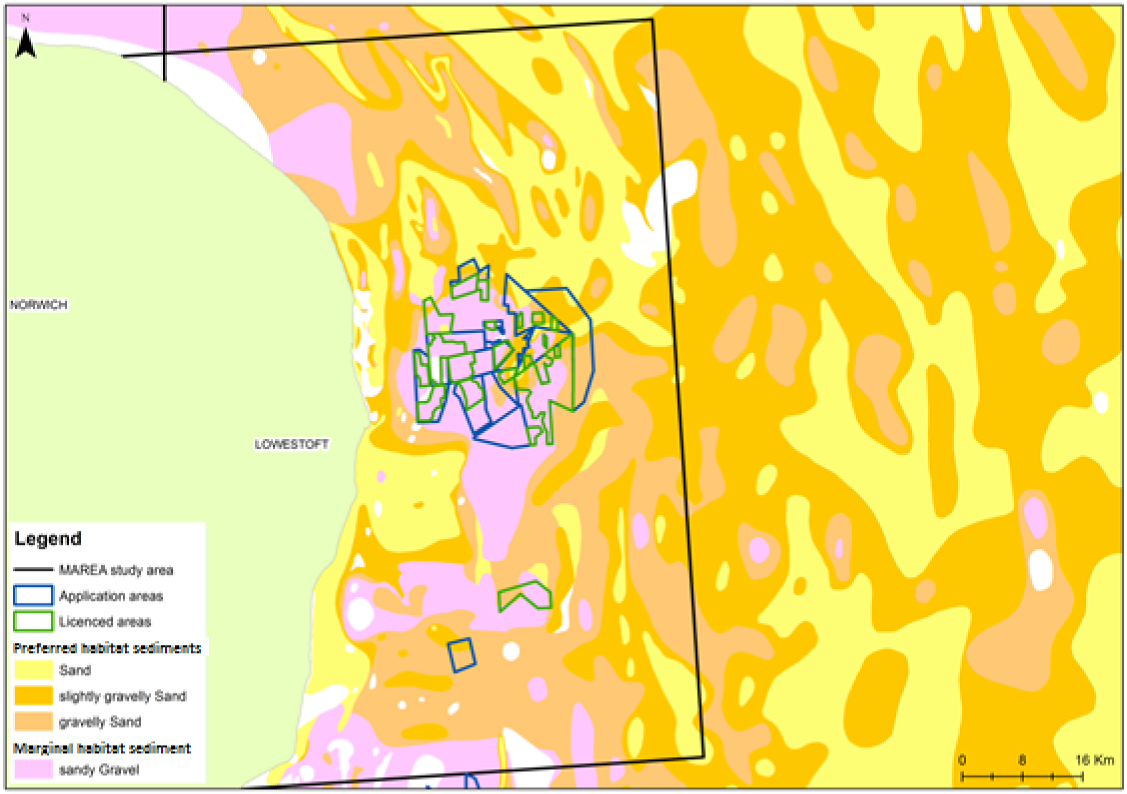


Figure M4: Comparison of the mapped extents of potential sandeel habitat sediment using BGS (upper) and MAREA (lower) data within the Outer Thames Estuary region. (Derived from 1:250,000 scale BGS Digital Data under Licence 2013/063 British Geological Survey. ©NERC.; ERM Ltd, 2010)

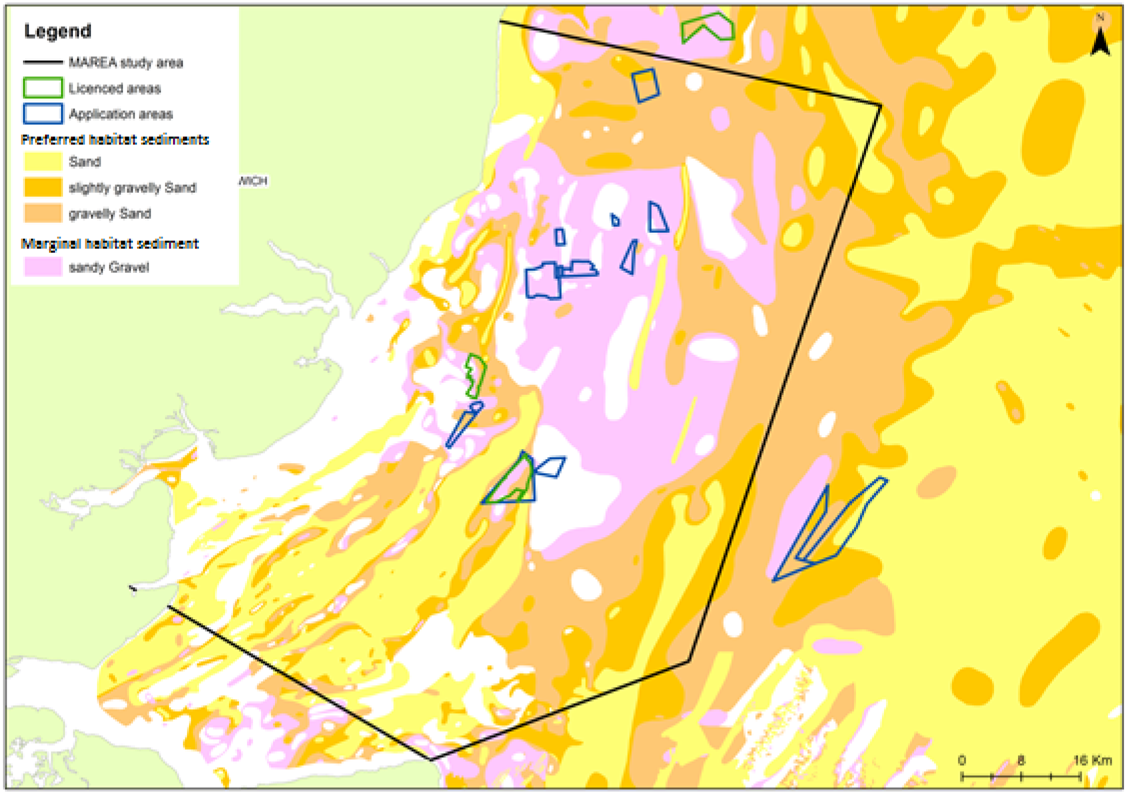
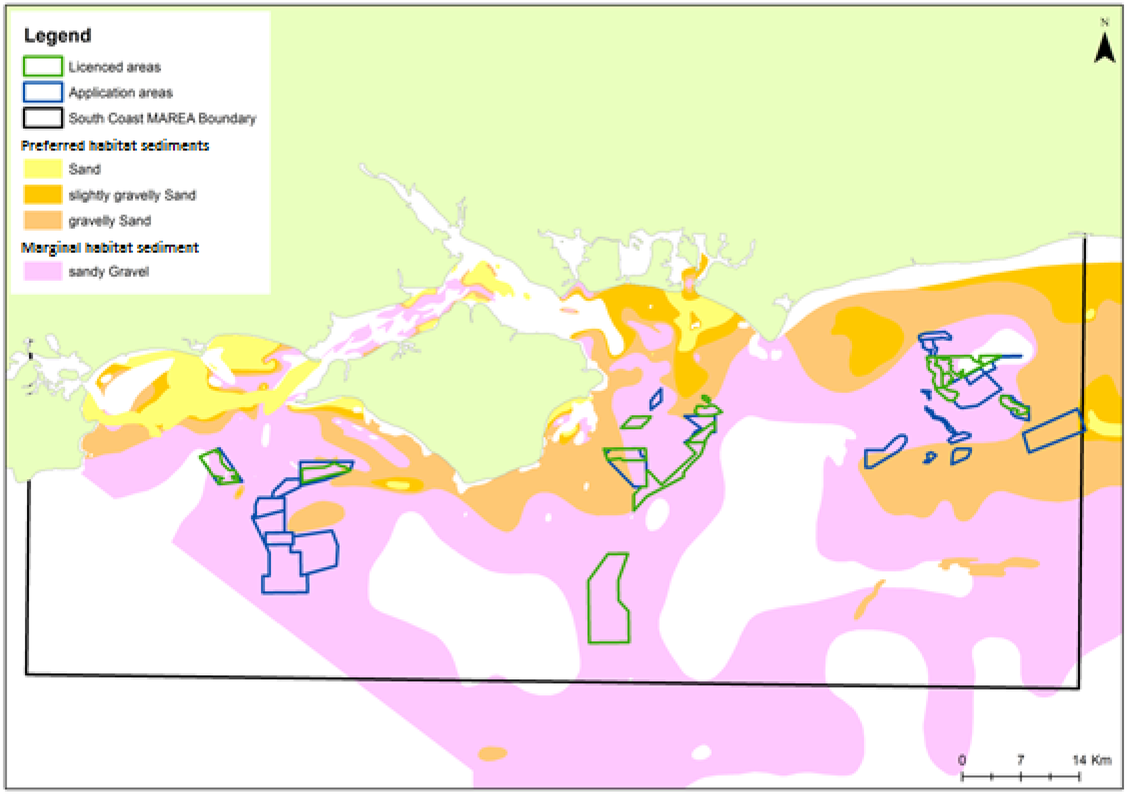
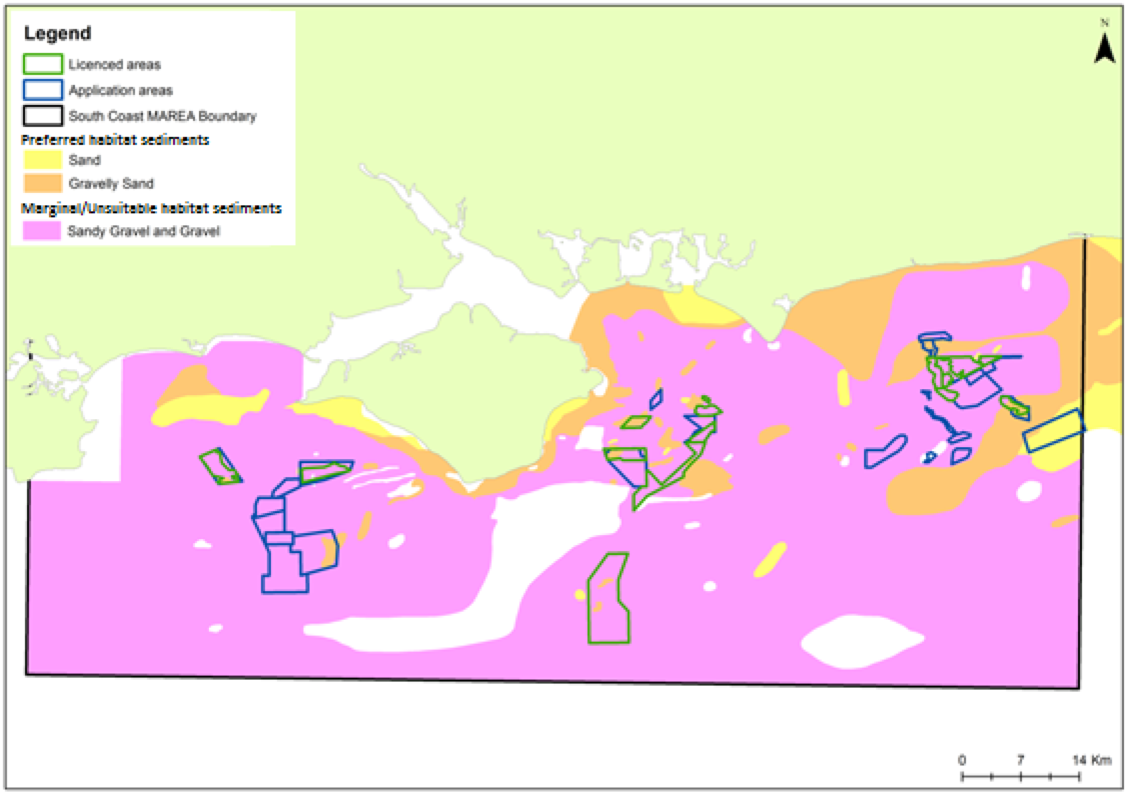


Figure M5: Comparison of the mapped extents of potential sandeel habitat sediment using BGS (upper) and MAREA (lower) data within the South Coast region. (Derived from 1:250,000 scale BGS Digital Data under Licence 2013/063 British Geological Survey. ©NERC.; EMU Ltd, 2012b)





Figures M6-M9 show the confidence attached, per MAREA region, to each of the BGS and MAREA seabed sediment maps. The confidence scoring reflects the preferred and marginal habitat sediment divisions with a higher confidence associated with preferred habitat sediment than that associated with marginal habitat sediment (Appendix B). The mapping layer confidence scores represent the Total Normalised Score and range from very low to very high (score of 1 to 5 with 1 = very low, 2 = low, 3= medium, 4 = high and 5 = very high).

No more than a score of low confidence (score of 2) for marginal habitat sediment and high confidence (score of 4) for preferred habitat sediment can be achieved (see Appendix B).

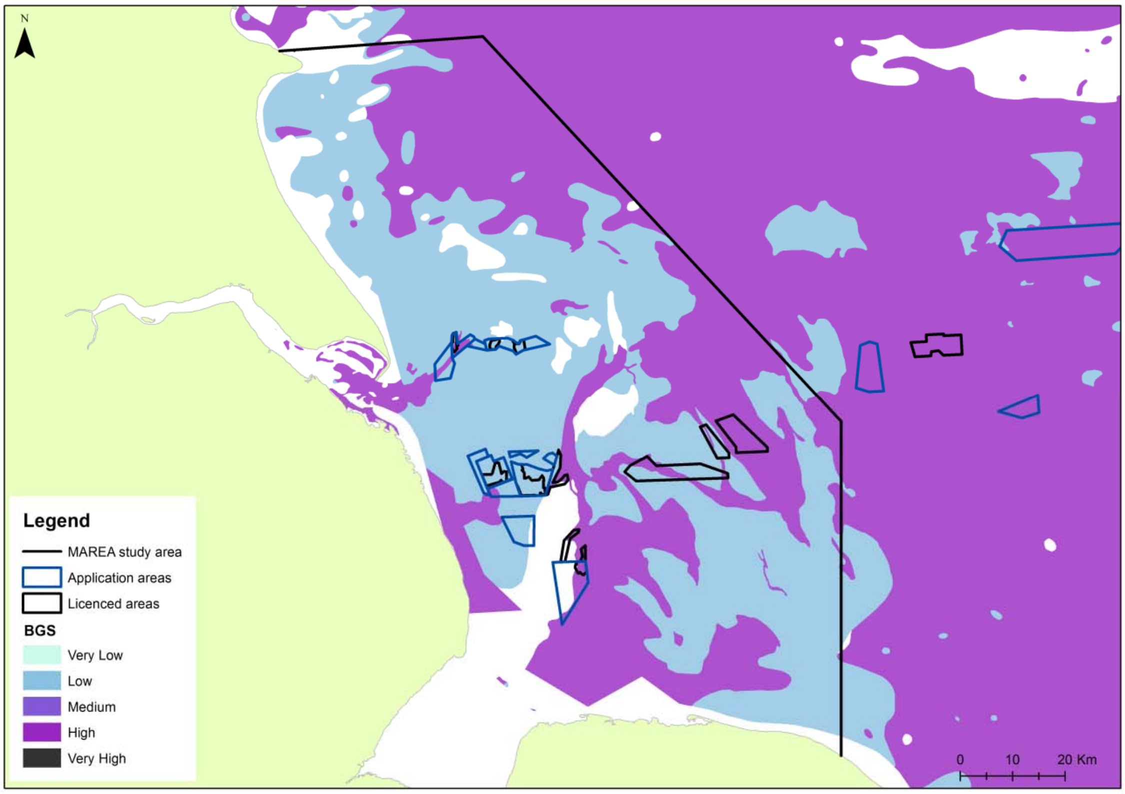
By comparing the confidence maps for the BGS data with the MAREA data it is evident that there are varying levels of confidence between using the data at the MAREA regional scale. For the Humber and Anglian regions it is evident that the confidences between the datasets are similar, but that the MAREA data provide an appropriate resolution of sediment distribution and coverage. Therefore as discussed in Section M1.3, the MAREA data have been used as the seabed sediment base-map for both the Humber and Anglian regions.

For the Outer Thames and South Coast regions the comparison between the MAREA and BGS confidence mapping shows that the BGS data provide higher resolution maps when compared with the MAREA data. For the Outer Thames region the BGS presents a much higher confidence in the BGS data due to the appropriate distinction between the preferred and marginal habitat sediment divisions. Further, the BGS data present a more detailed map of the bedforms and seabed sediment distribution. Therefore, as described Section M1.3, both the Stage 1 and 2 assessments within this study have used the BGS data for the Outer Thames region.

The South Coast region shows the highest variability between the data sets. The BGS data demonstrates higher confidence in the seabed sediments, particularly in relation to the marginal seabed habitat sediment as the Gravel component can be excluded. Despite the extent of the BGS data not covering the south western portion of the MAREA region, the division of the sediments and the exclusion of the Gravel classification has led to the BGS data being used for the Stage 1 and 2 assessments.

For the ‘outlier’ application areas (those outside the relevant MAREA region) the BGS seabed sediment data have to be used as no MAREA data are available. This is only applicable to the Humber and Outer Thames regions: all licence and application areas in the Anglian and South Coast regions fall within the relevant MAREA regional boundary.

Figure M6: Comparison of the confidence in the potential sandeel habitat sediment within the Humber region between the BGS (upper) and MAREA data (lower). (Derived from 1:250,000 scale BGS Digital Data under Licence 2013/063 British Geological Survey. ©NERC.; ERM Ltd, 2012)



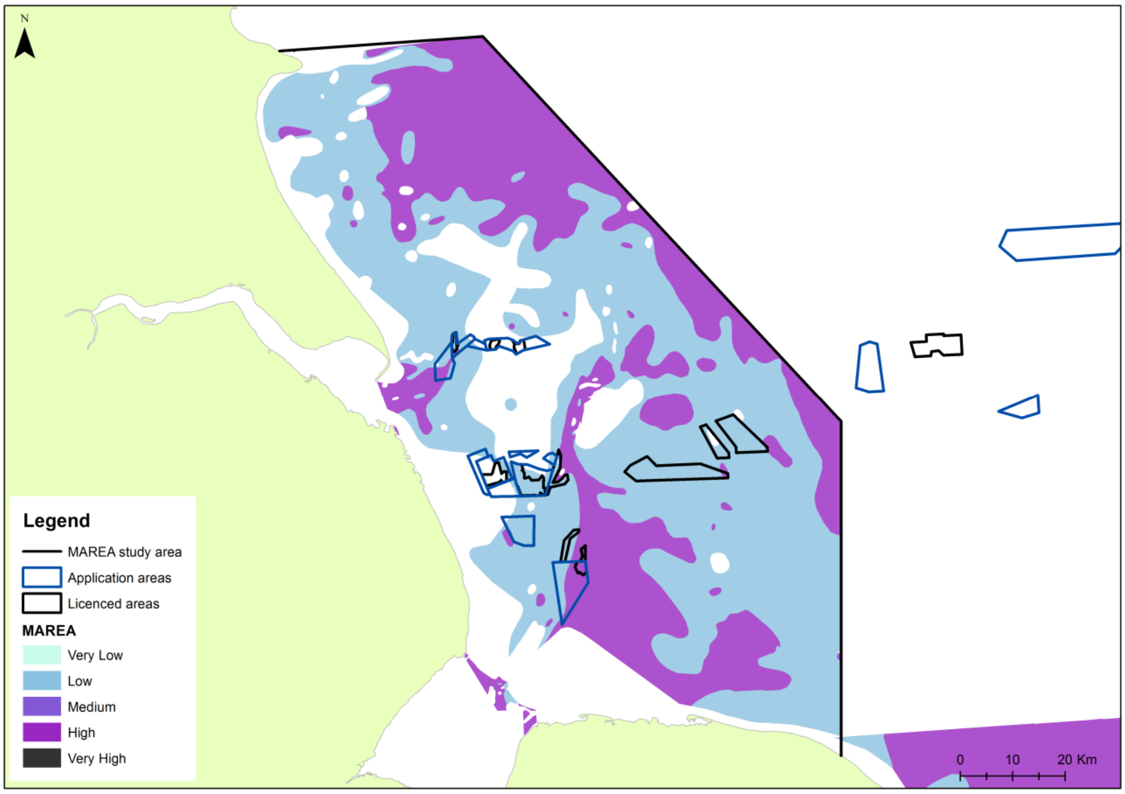
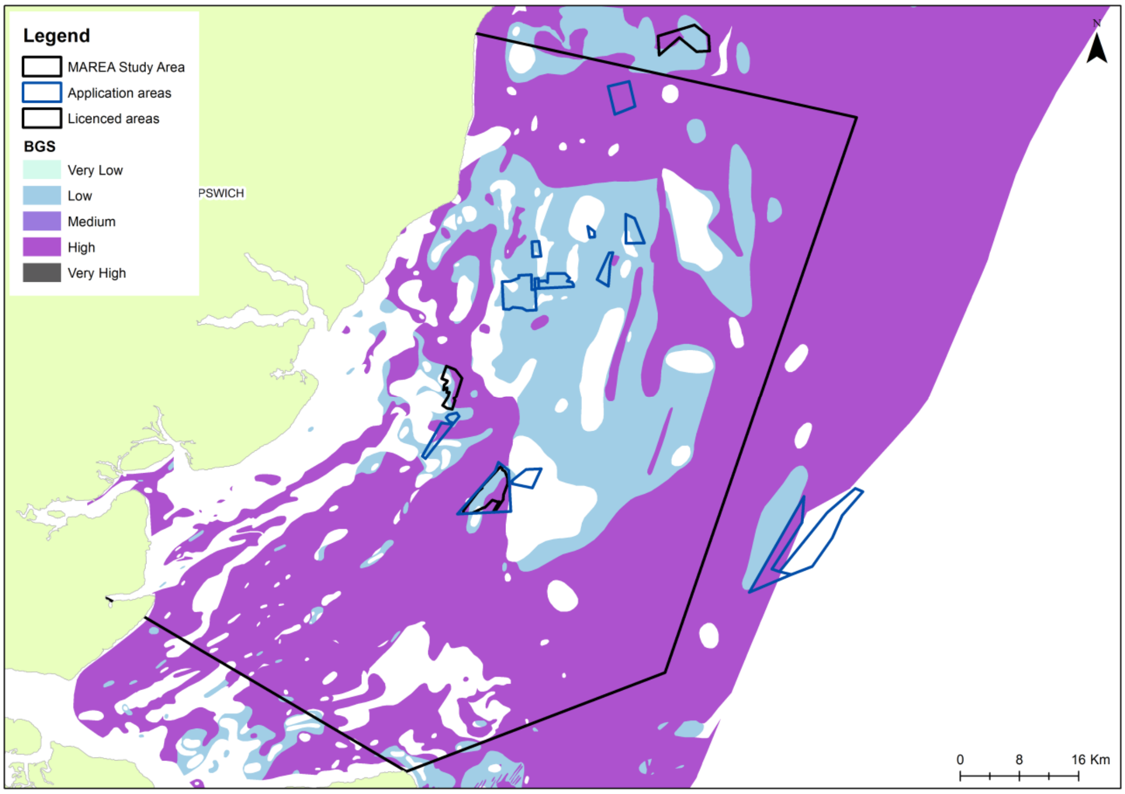


Figure M7: Comparison of the confidence in the potential sandeel habitat sediment within the Anglian region between the BGS (upper) and MAREA data (lower). (Derived from 1:250,000 scale BGS Digital Data under Licence 2013/063 British Geological Survey. ©NERC.; EMU Ltd, 2012a)

Figure M8: Comparison of the confidence in the potential sandeel habitat within the Outer Thames Estuary region between the BGS and MAREA data. (Derived from 1:250,000 scale BGS Digital Data under Licence 2013/063 British Geological Survey. ©NERC.; ERM Ltd, 2010)



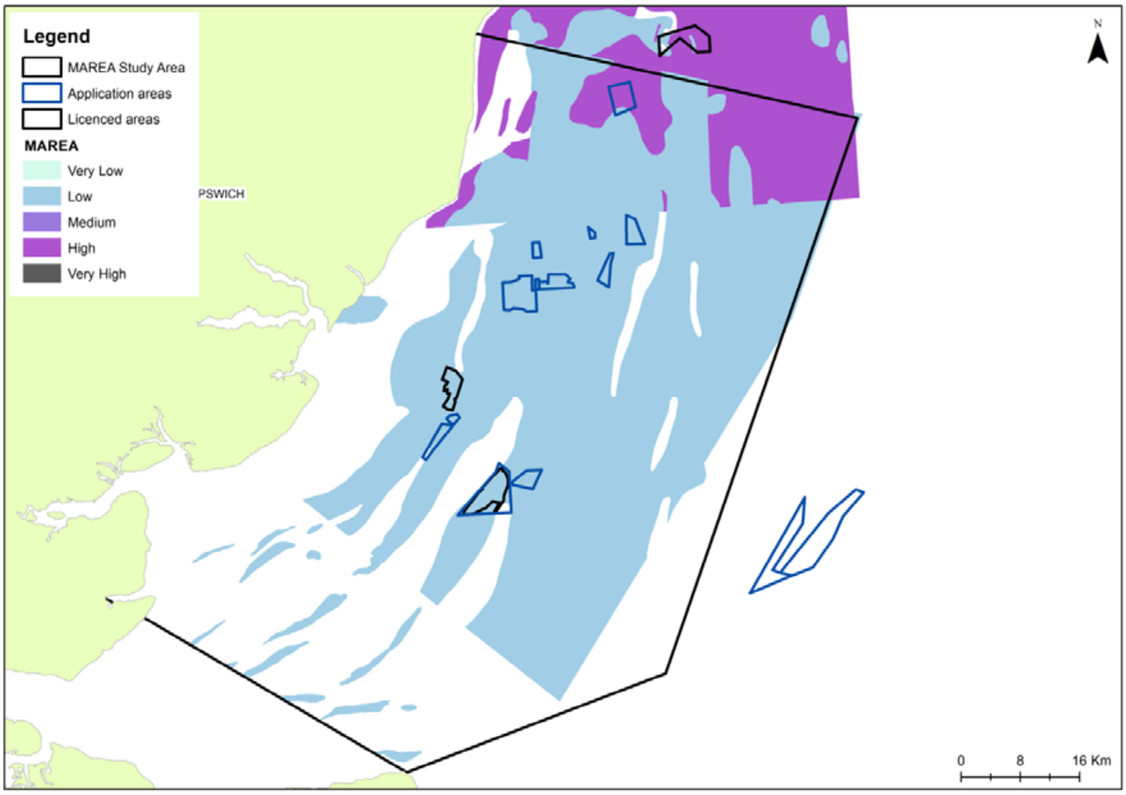
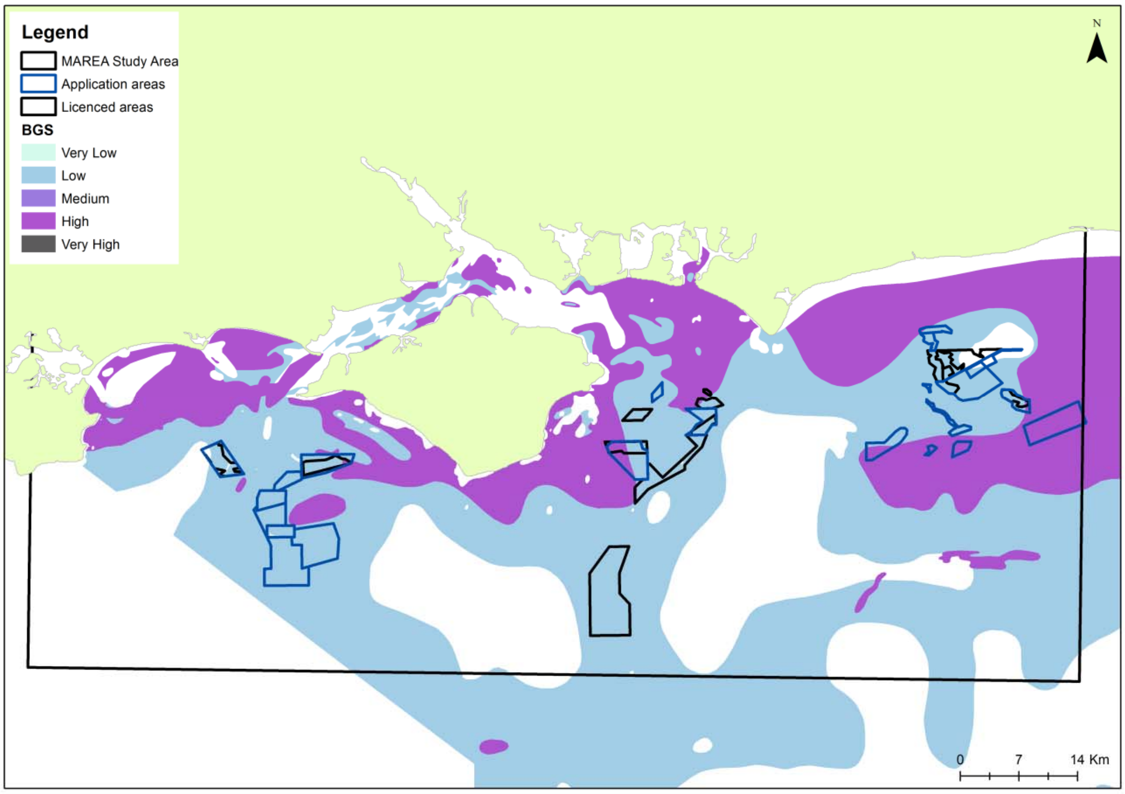
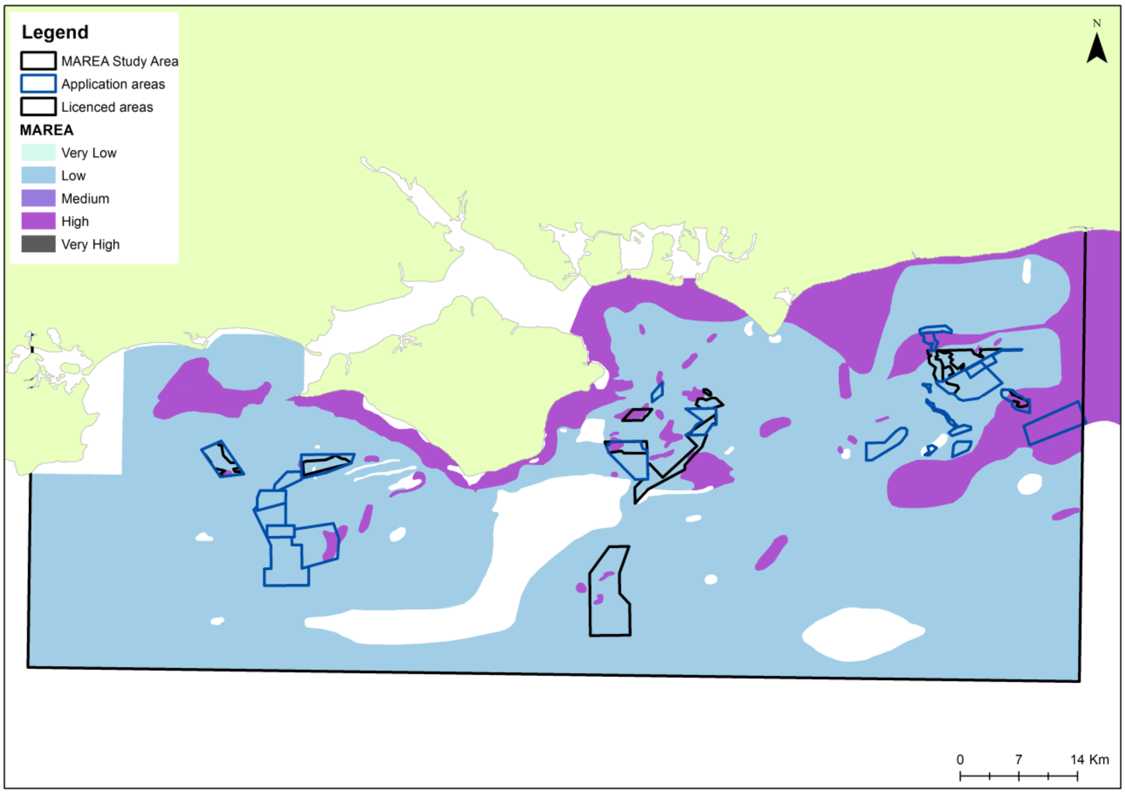


Figure M9: Comparison of the confidence in the potential sandeel habitat sediment within the South Coast region between the BGS and MAREA data. (Derived from 1:250,000 scale BGS Digital Data under Licence 2013/063 British Geological Survey. ©NERC.; EMU Ltd, 2012b)





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