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Vattenfall Wind Power Ltd

Thanet Extension Offshore Wind Farm

Biogenic Reef Mitigation Plan

June, 2018, Revision A

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Vattenfall Wind Power Ltd

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June, 2018

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Date of Approval	June 2018
Revision	A

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List of Abbreviations

Abbreviation	Definition
MMO	Marine Management Organisation
Thanet Extension	Thanet Extension Offshore Wind Farm
TOWF	Thanet Offshore Wind Farm
VWPL	Vattenfall Wind Power Ltd

1. Introduction

1.1. Overview

1.1.1. The proposed Thanet Extension Offshore Wind Farm (Thanet Extension) is in a region known to contain areas of potential biogenic reef formed mainly from *Sabellaria spinulosa* (Volume 2, Chapter 5: Benthic Subtidal and Intertidal Ecology (Doc Ref: 6.2.5)). Within the Benthic Subtidal and Intertidal Ecology chapter (Volume 2, Chapter 5 (Doc Ref: 6.2.5)) of the Thanet Extension Environmental Statement (ES) the impacts of the development of Thanet Extension have been assessed in cognisance of proposed mitigation.

1.1.2. The ES assessment determined that the development of a biogenic reef mitigation plan prior to the start of construction of Thanet Extension would ensure that the construction, operation and decommissioning would not have a significant effect on existing biogenic reefs.

1.1.3. Therefore, this document has been produced as an 'in-principle mitigation plan' outlining the principles and methodologies, inclusive of existing data, that will underpin the final pre-construction Thanet Extension Biogenic Reef Mitigation Plan. The final plan will be submitted for approval pre-construction and will detail buffers defined according to the methodologies presented herein.

1.1.4. The document will outline the method to be used for identifying and mitigating impacts on biogenic reefs. The Thanet Extension ES assessed a potential for *S. spinulosa* and Mytilus edulis biogenic reef being encountered. Due to evidence of *S. spinulosa* reefs forming within the proximity of the development and associated literature and appropriate reports outlining the core reef approach with respect to *S. spinulosa,* this document will focus on *S. spinulosa* reefs. However, this document is designed to be applicable to all forms of biogenic reef identified in the surveys associated with the construction of Thanet Extension.

1.2. Document structure

1.2.1. The remainder of this document is structured as follows:

- Background - a brief description of the ecology of the key biogenic reef forming species that may occur within the development area and an overview of the known biogenic reef habitat extent and classification within the relevant Thanet Extension zone of influence;
- Proposed mitigation measures – outlines the proposed mitigation measures that will be implemented for the construction of Thanet Extension; and
- Proposed methodology – a high level description of the proposed methodology to be used within the final Biogenic Reef Mitigation Scheme.

2. Background

2.1. Biogenic reef

2.1.1. Biogenic reefs are structures created by accumulations of organisms, usually rising from the seabed, or at least clearly forming a substantial, discrete community of habitat which is very different from the surrounding seabed (UK Marine SAC Project, 2001a; Gubbay, 2007).

2.1.2. The Benthic Subtidal and Intertidal Ecology chapter (Volume 2, Chapter 5 (Doc Ref: 6.2.5)) identified that the proposed development area has the potential to contain biogenic reefs formed from species such as *S. spinulosa* and *M. edulis*. Both forms of biogenic reef are listed as Annex I habitats under the EU Council Directive 92/ 43/ EEC on the conservation of natural habitats and of wild flora and fauna (the 'Habitats Directive') and designated as Biodiversity Action Plan (BAP) habitats under Section 42 (habitats of principle importance) of the Natural Environment and Rural Communities (NERC) Act 2006.

2.2. *S. spinulosa*

2.2.1. *S. spinulosa* is a tube-forming marine polychaete that can be found throughout UK waters and is known to be present within the wider region around Thanet Extension (Pearce *et al.*, 2014). One growth form of *S. spinulosa* aggregations is a biogenic reef structure.

2.2.2. *S. spinulosa* in its reef form is protected under both the Habitats Directive (EU Council Directive 92/ 43/ EEC) as an Annex I Habitat, and the Natural Environment and Rural Communities (NERC) Act 2008 as a feature of conservation interest. Therefore, it is necessary to ensure that any impacts are reduced as far as possible.

2.2.3. It is, however, important to note that the biogenic reef form of *S. spinulosa* is not an obligate growth form and *S. spinulosa* is known to exist throughout the region around Thanet Extension in non-reef crust and veneer forms. Furthermore, while biogenic reefs form within the surrounding area, the ephemeral reefs that are present are recognised to have limited longevity, particularly compared to those found in the Wash (Volume 2, Chapter 5: Benthic Ecology (Doc Ref: 6.2.5)).

2.2.4. *S. spinulosa* is a robust species, requiring only a few environmental conditions to be met and has a high tolerance to pollution. The most important physical factor for *S. spinulosa* in an area is a good supply of sand grains put into suspension for tube building. Larvae are strongly stimulated to settle on living or dead colonies of *S. spinulosa*, however, they will settle on any suitable substrate after 2 – 3 months. Additionally, once an initial small colony is established, more *S. spinulosa* larvae can attach to the existing tubes of the colony rather than requiring secondary anchor points, allowing the colony to extend over large areas of sediment (JNCC, 2016).

2.2.5. As noted above *S. spinulosa* may form reefs, however, this is not an obligate growth form. Itis the least common form and throughout most of its range is found in small groups encrusting pebbles, shells, kelp holdfasts and bedrock or as solitary individuals. More extensive crusts can form in favourable conditions; however, these tend to be thin and often only last for a season before being broken up by winter storms and reforming the next spring through new settlements (JNCC, 2016).

2.3. Mytilus edulis

2.3.1. *M. edulis* reefs are composed of layers of living and dead mussels at high densities, bound together by the byssus threads secreted by the mussels and sometimes overlaying a great deal of accumulated sediment. Subtidal beds have been reported to be up to 120 cm thick however, UK sites rarely exceed 30-50 cm. *M. edulis* reefs are comprised of three structural components:

- Living and dead shells;
- Accumulated sediments, mussel faeces and pseudofaeces, organic detritus and shell debris; and
- Assemblages of associated flora and fauna.

2.3.2. Accumulation of sufficient faecal and pseudo-faecal deposits together with dead shell to produce obvious mounds is largely restricted to those places, in estuaries or similar channels and flats, where there is a degree of shelter from wave action, but sufficient flow carrying seston for there to be good growth (UK Marine SAC Project, 2001b).

2.4. Reef habitat and classification

2.4.1. Baseline benthic surveys were undertaken in 2016 for the Thanet Extension site. These comprised of acoustic surveys to identify potential areas of interest. The areas of interest were then subject to ground truthing using video and grab sampling to identify whether these areas comprised biogenic reef habitat.

2.4.2. While no biogenic reef was identified in the baseline surveys for Thanet Extension (Volume 2, Chapter 5: Benthic Ecology (Doc Ref: 6.2.5)), the ephemeral nature of *S. spinulosa* reef means it is considered possible that reefs could form within the Thanet Extension proposed development boundary prior to the start of construction. This is particularly relevant for Thanet Extension as it is known that *S. spinulosa* reef has been present within the Thanet Offshore Wind Farm (TOWF) array area (Pearce *et al*., 2014).

2.4.3. Qualifying *S. spinulosa* reef is classified according to the protocol established for classifying assemblages as exhibiting 'high reefiness' as defined by the Gubbay (Gubbay, 2007) and the Hendrick and Foster-Smith (Hendrick & Foster-Smith, 2006) criteria.

2.4.4. The Gubbay (2007) criteria are more focused on the physical aspects of the potential reef (Figure 2.1), while the Hendrick & Foster-Smith (2006) criteria include the biological aspects of the reef system as well (Figure 2.2). Furthermore, the Hendrick & Foster-Smith reef assessment allows the 'reefiness' to be defined along a sliding scale, rather than relying on fixed categories.

Measure of 'reefiness'	NOT a REEF	LOW	MEDIUM	HIGH
Elevation (cm) (average tube height)	<2	2-5	5-10	>10
Area (m^2)	<25	25-10,000	10,000 – 1,000,000	> 1,000,000
Patchiness (% cover)	<10%	10-20	20-30	>30

Figure 2.1: Gubbay (2007) biogenic reef 'reefiness' assessment

		Characteristic score Low . . . . . Medium . . . . . High 0 . . . . . 50 100		
A.	*Elevation score.*			
	Average tube height	~10 cm	~15 cm	~20 cm
	Maximum tube height	~15 cm	~20 cm	~30 cm
	Indications from remote sensing	Undetectable	Colony produces an indistinct image	Colony produces a distinct image
B.	*Sediment consolidation score.*			
	Percentage cover of substratum by consolidated *Sabellaria* tubes	~30% cover	~45% cover	~60% cover
	Degree of consolidation	Consolidation of sediment primarily an encrusting veneer of *Sabellaria* tubes, little concretion of substratum	Sediment consolidation by upright *Sabellaria* tubes, some concretion of underlying substratum	Substratum well consolidated by intertwined matrix of *Sabellaria* tubes
C.	*Area score.*			
	Extent of total area	Area ~600 m^2	Area ~900 m^2	Area ~1200 m^2
	Extent of core area	Area ~200 m^2	Area ~350 m^2	Area ~500 m^2
	Extent of peripheral area	Area ~500 m^2	Area ~750 m^2	Area ~1000 m^2
D.	*Patchiness score.*			
	Percentage cover of consolidated tubes within overall spatial extent of reef	~10% cover	~20% cover	~30% cover
E.	Sabellaria spinulosa *density score.*			
	Average density of *S. spinulosa* ($/m^2$)	~800 individuals	~1500 individuals	~3000 individuals
	Maximum density ($/m^2$)	~500 individuals	~1700 individuals	~3500 individuals
F.	*Biodiversity score.*			
	Margalef's species richness	~5.0	~6.5	~8.0
	Shannon diversity index	~2.5	~2.7	~3.0
	Simpson's diversity index	~0.85	~0.87	~0.90
G.	*Biotope score.*			
	MNCR biotope code (see Table 3)	Other biotopes	CR.MCR.CSab.Sspi	SS.SBR.PoR.SspiMx
H.	*Longevity score.*	No evidence for longevity of colony	Evidence of dense *S. spinulosa* aggregations found *repeatedly* but not *persistently* over time	Evidence of dense *S. spinulosa* aggregations found *persistently* over time

MNCR, Marine Nature Conservation Review.

Figure 2.2 Hendrick & Foster-Smith (2006) *S. spinulosa* 'reefiness' assessment

2.4.5. While these assessment methods provide a robust classification of the reef at the time the survey is undertaken, neither of the methods focus on the temporal behaviour of the reef, nor identify the expected longevity of the reef. The Hendrick & Foster-Smith (2006) methodology includes a 'Longevity score' in the assessment, however this is only one aspect of the assessment and may still give a high reefiness score even in the absence of any evidence of longevity. Furthermore, the Hendrick & Foster-Smith methodology is dependent on the survey records to include information on any noted longevity, which has not necessarily been undertaken. It is also of note that to provide some of the requisite criteria under the Hendrick and Foster-Smith, such as the biodiversity score, it is necessary to take physical samples such as grabs; this method has been identified as not being preferred by conservation advisers as it inherently means destruction of part of the reef feature.

2.4.6. In light of the recognised need to incorporate some recognition of the longevity component of 'reefiness' and protect areas of reef representing high quality reef that is persistent over time Bussell and Saunders (2010) undertook an analysis of records of reef within the Wash region. This study presented a method of identifying areas of 'core reef' and under pinned the classification of management areas within the Inner Dowsing, Race Bank and North Ridge (IDRBNR) Special Area of Conservation (SAC), which were designated to protect core areas of *S. spinulosa* reef as defined across a number of datasets. In light of this approach having been used within an SAC, scientific literature confirming that within the existing array areas of biogenic reef there appears to be increasing in longevity, and there being confidence that the area surrounding Thanet Extension has an appropriate level of historic data available, it is proposed that the same approach be employed for the Thanet Extension biogenic reef mitigation plan. Therefore, it is proposed that a 'core reef' assessment is undertaken for Thanet Extension, following the Bussell & Saunders methodology (Bussell & Saunders, 2010).

3. Proposed mitigation measures

3.1.1. Thanet Extension propose to microsite all infrastructure associated with the construction around areas identified as core reef only as agreed with Natural England subject to a review of all available data sets (Evidence Plan Meeting 26/01/2018, see Evidence Plan Report (Document Ref: 8.18)). The method for identifying 'core reef' is outlined in the rest of this document.

4. Proposed methodology

4.1. Methodology outline

4.1.1. The core reef assessment methodology was first proposed and used by Bussell and Saunders (2010) before being updated and published in the public domain by Roberts *et al*. (2016) to assess the extent and distribution of core reef within the Wash and Norfolk Coast SAC and the IDRBNR SAC.

4.1.2. For the purposes of this in-principle mitigation plan (following the Bussell and Saunders (2010) methodology), core reef is defined as an area where biogenic reef is identified on repeat occasions in multiple surveys over multiple years (minimum two overlapping surveys). Following the Roberts *et al*. (2016) refinement to the Bussell and Saunders (2010) methodology, any reef classified as 'high reefiness', 'medium reefiness' or 'low reefiness' will be included within this assessment. As such, this methodology will identify those areas where conditions are favourable for consistent or repeat presence of biogenic reef over more than one year. Inclusion of 'low reefiness' reef will ensure that areas deemed to be 'low reefiness' at the time of the survey but may have been classed as 'medium' or 'high reefiness' if surveyed later in the season are not missed.

4.2. Data confidence

4.2.1. The Bussell & Saunders (2010)/ Roberts *et al*. (2016) methodology makes use of MESH confidence scores to assess the degree of confidence that can be applied to each dataset. This was necessary for the data used in those assessments due to the variety of methods used for data collection, the range of sources for the data and the format the data were provided in.

4.2.2. The data for the Thanet Extension assessment has been, or will be, sourced primarily from site specific surveys following standardised methodologies for marine surveys for offshore wind farms, and agreed with Natural England in advance and the results of the surveys also agreed. Therefore, it is not considered necessary to undertake this step of the assessment as confidence in all the data is consequently deemed to be high.

4.3. Reef index

4.3.1. The basis of the core reef assessment is the calculation of the 'reef index'. This number is used to identify if an area comprises core reef, reef that has been present for multiple years, or not. It is calculated using the total number of surveys of a specific area and the number of times reef was found there (Equation 1).

4.3.2. The reef index is calculated using the following equation:

Equation 1: Reef index

$$Reef\ Index = \left(\frac{Number\ of\ times\ reef\ found}{Number\ of\ times\ surveyed}\right) \text{X}\ Number\ of\ times\ reef\ found$$

4.3.3. Where no reef is found within an area, the above equation gives a reef index of 0. The negative reef index for these areas can then be calculated using the following equation:

Equation 2: Reef index score equation for areas where no reef is recorded

$$Reef\ Index = -1\ \text{X}\ Number\ of\ times\ surveyed$$

4.3.4. Thanet Extension propose to use a two-step process to identify core reef based on the likelihood for project infrastructure to impact the potential for reef to reform. Under this approach cable installation, which is proposed to result in burial of the infrastructure and therefore does not preclude the ability for reef to form over the top of the cable, is considered to trigger a lesser need to microsite when compared to foundation (and associated scour protection) installation. Bussell and Saunders (2010) used a reef index of ≥2, with a minimum of two surveys of that area and *S. spinulosa* reef being found on both occasions for The Wash and North Norfolk Coast SAC, while Roberts *et al*. (2014) used a more conservative value of ≥1.8 for the IDRBNR SAC due to lower confidence in the available data (i.e. core reef would be identified where reef was found in 3 out of 5 surveys of an area).

4.3.5. Different aspects of the construction of Thanet Extension will have different impacts on biogenic reef. Components such as foundation installation, scour and cable protection will result in long-term or permanent change of habitat. While it is recognised that the presence of foundations stops reef from re-forming, introduction of other types of hard substrate (i.e. scour or cable protection) does not preclude the ability of reef to reform. Other components, such as cable installation in the absence of cable protection, will have shorter term effects and while it may damage the seabed communities, these impacts will be recoverable, there will be no loss of reef potential, and it is possible that the reef will reform over the section of buried cable.

4.3.6. This difference in construction effects has been reflected in the different reef index thresholds proposed for the implementation of mitigation. For long-term/permanent infrastructure (foundations, scour/cable protection) it is suggested that a reef index of **≥1** is used to define areas of core reef to protect broader scale areas suitable to support core reef. For short-term/temporary impact infrastructure such as cables, it is proposed that a reef index of **≥2** is used to define core reef to ensure protection of areas where biogenic reef has been detected most consistently.

4.3.7. Using the equations above, the reef index for each area of identified reef will be calculated and the extent of those areas identified as core reef will be created in ArcGIS. These areas can then be used to inform the engineering design to ensure that there are no impacts during construction to these areas.

4.4. Data processing

4.4.1. ArcGIS will be used for the assessment to identify any regions of overlapping reef habitat. This will provide both a visual presentation of the extent of any reef identified in each of the relevant surveys but will also allow the delineation of the extent of any core reef. This core reef extent may be created using the existing tools within ArcGIS, based on the survey data, and can then be used for project design refinements and also by the regulators to ensure that these identified areas were not impacted by the construction works, post construction.

4.5. Survey data

4.5.1. Data used in this assessment is derived from two broad groups, survey data compiled specifically for Thanet Extension and survey data compiled for other projects which overlap the same area.

4.5.2. The primary survey data is that specifically compiled during pre-construction surveys for Thanet Extension. This is composed of interpreted geophysical data (side scan sonar and multibeam echosounder), ground truthed using drop down video (DDV). This results in the identification of potential core reef habitat area, rather than an explicit identification of core reef habitat extent, which would be gained from specific benthic surveys on the regions within this assessment.

4.5.3. The Thanet Extension pre-construction survey data will then be added to the data sets from other projects and the characterisation surveys for Thanet Extension. This combined layered data set will be used to identify core reef that will be microsited around.

4.5.4. If, using the full suite of data, it is identified that the extent of the area of potential core reef poses a risk to the final design of the development, additional benthic surveys could then be carried out to potentially further refine the delineation of the extents of the core reef.

4.5.5. Subsequently, all available data will be used to identify the final core reef extents to which mitigation will be applied and infrastructure will be microsited around. This would then both support the protection of this core reef habitat whilst also permitting the construction of Thanet Extension to take place.

4.5.6. Characterisation surveys have already been carried out for Thanet Extension and prior to the construction of the development, required pre-construction surveys will be carried out. In addition to this, site-specific data, encompassing parts of the Thanet Extension study area, have been collected as part of the baseline and post-construction monitoring for the existing Thanet Offshore Wind Farm. This will ensure that the core reef assessment will incorporate a minimum of two surveys across the full development boundary of Thanet Extension, thus meeting the minimum survey requirements. As a result of the existing Thanet OWF data the majority of the site will have more than two sets of survey data that can be used for the assessment. These data are presented in Table 4.1 and in Figure 4.1.

Table 4.1 Available and planned benthic datasets for use in the core reef assessment

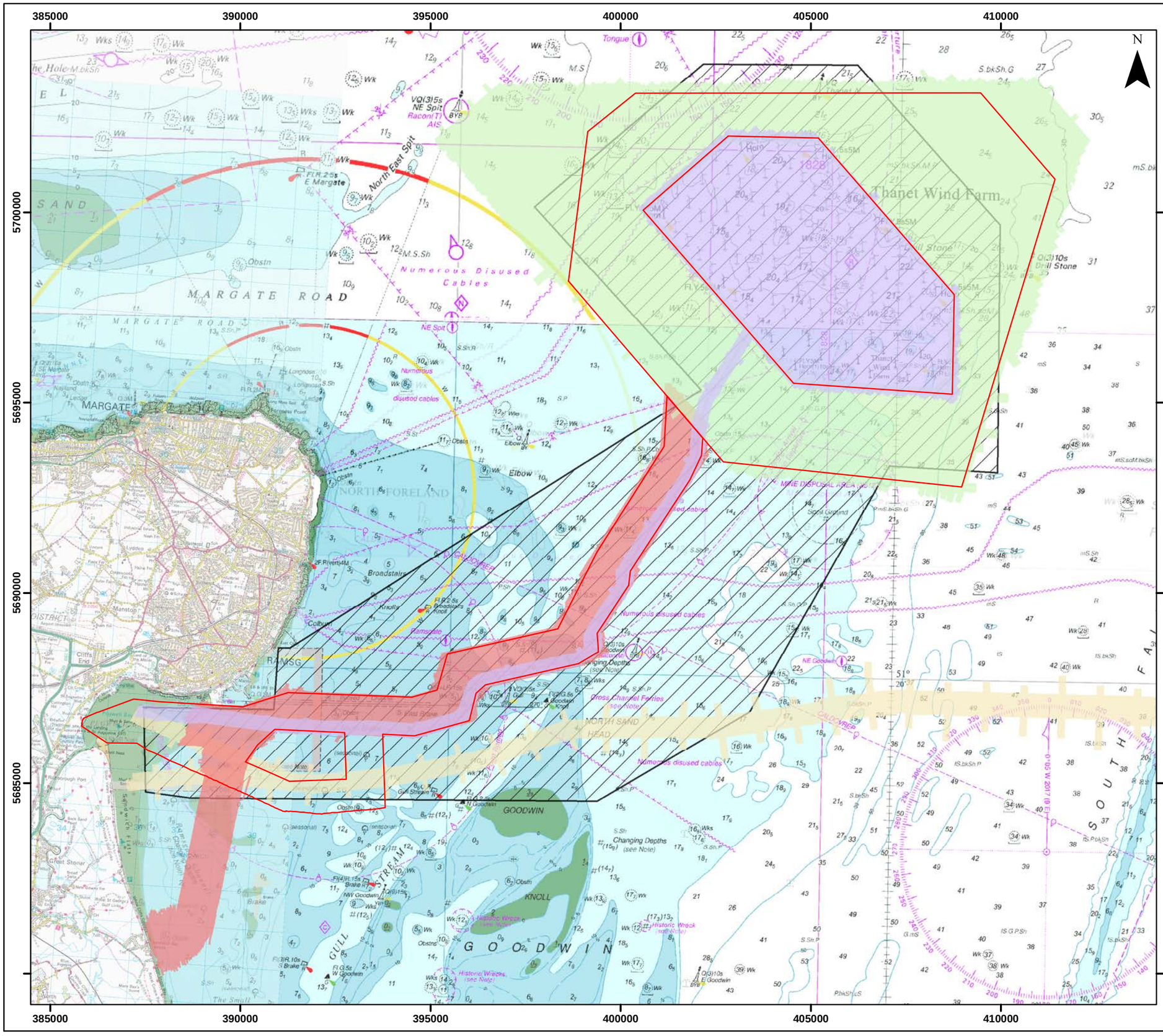
Dataset	Coverage	Year
TOWF Charcterisation Geophysical and Benthic and Intertidal Resource Surveys (Gardline Environmental Limited)	TOWF and export cable corridor	2005
TOWF Pre-Construction Benthic and Conservation Resources Survey (Gardline Environmental Limited)	TOWF and export cable corridor	2007
TOWF Post-Construction Benthic Resources Survey (Marine Ecological Surveys Limited)	TOWF and export cable corridor	2012
Thanet Extension Characterisation Survey (Fugro Group)	Thanet Extension proposed array and export cable corridor boundary	2016
Thanet Extension Pre-Construction Benthic Survey	Thanet Extension proposed array and export cable corridor route	2019[1]
Nemo Interconnector Characterisation Survey (MMT)	Nemo Interconnector cable corridor route	2010
Nemo Interconnector Pre-Construction Survey	Nemo Interconnector cable corridor route	2017[2]

[1]anticipated date

[2]datasharing currently under discussion

4.5.7. For the purposes of the core reef assessment, it is necessary to have data from at least two surveys over all areas of the final array area and offshore export cable corridor to ensure that areas of core reef can be accurately identified. Currently, the majority of the proposed offshore development boundary has been covered by at least two surveys. The exceptions being the outer edges of the array area and a few locations along the export cable corridor.

4.5.8. The extents of the currently available data are shown in Figure 4.1 below. The data collected for the Nemo Interconnector pre-construction surveys will be incorporated when these are made available to Vattenfall and pre-construction data for Thanet Extension would also be collected prior to the construction of the development. This additional data would then ensure that all areas of the proposed development boundary are covered by at least two surveys, with the exception of one area of cable corridor. If the final engineering design identifies this section of the export cable corridor as the optimal route, Vattenfall will discuss the most appropriate approach for data collection in this area with the relevant stakeholders at the time.



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THANET EXTENSION OFFSHORE WIND FARM

Figure 4.1

Available Benthic Datasets for use in the Core Reef Assessment

Legend

- Offshore Red Line Bounary
- TOWF Pre- and Post-construction Benthic Resources Survey 2007 and 2012
- Thanet Extension Characterisation Survey 2016 (array)
- Thanet Extension Characterisation Survey 2016 (export cable corridor)
- Nemo Interconnector Characterisation Survey 2010
- TOWF Baseline Benthic Resources Survey 2005

1:100,000 0 1 2 km 0 0.55 1.1 nm

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Rev	0.1	Date	25/05/2018
By	PN	Layout	N/A

Figure 4.1

4.6. Core reef – worked example using *S. spinulosa*

4.6.1. For the purposes of this worked example, three theoretical surveys have been carried out of the same survey area, with *S. spinulosa* recorded in all three surveys. Figure 4.2 show the survey area (green) and the extent of *S. spinulosa* reefs recorded in each survey (indicated by the different colours). Survey A found *S. spinulosa* at locations 1, 5 and 6; Survey B found *S. spinulosa* at locations 2 and 4; and Survey C found *S. spinulosa* at locations 3 and 7.

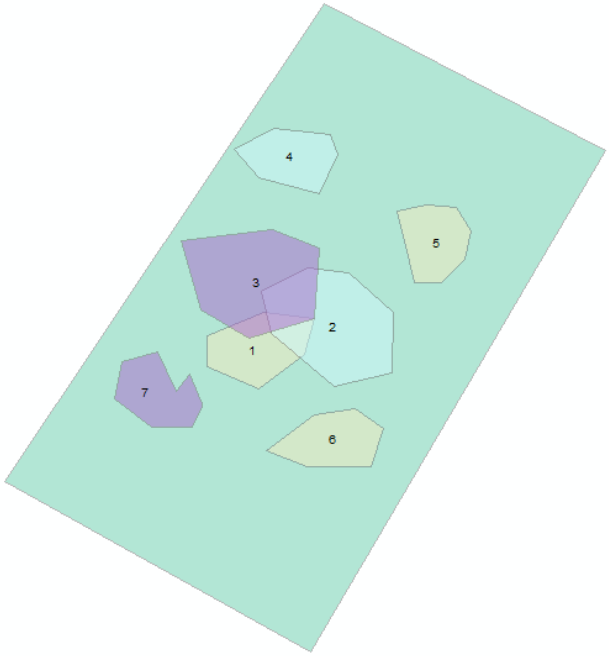

Figure 4.2: Theoretical Survey Area and *S. spinulosa* Reef Extents

4.6.2. As can be seen in Figure 4.2 the reef extents at locations 1, 2 and 3 partially overlap. Based on the known number of surveys, the reef index for each of the location can be calculated. It should be noted that each location can have a range of reef indexes. The reef index (or index range) for each location is presented in Table 4.2 below and based on the on calculation presented in section 4.3.

Table 4.2: Reef Indexes

Location	Reef Index
1	0.3, 1.3, 3
2	0.3, 1.3, 3
3	0.3, 1.3, 3
4	0.3
5	0.3
6	0.3
7	0.3

4.6.3. As identified in section 4.3, the reef index for defining core reef (and therefore the implementation of mitigation measures) for the installation of permanent structures is ≥1. As such, Locations 4 – 7 do not meet this requirement and would not be considered core reef for the purposes of this assessment.

4.6.4. However, Locations 1 – 3 have a range of reef indexes which is a result from the varying degrees of overlap between these three areas. The reef index of 0.3 for these areas is where there is no overlap and therefore, these areas would not be considered core reef. The reef index of 1.3 is where there is overlap between two of these locations (i.e. 1 and 2 or 1 and 3 or 2 and 3) and the reef index of 3 is where all three locations overlap. The areas where either two locations overlap or where all three areas overlap would consequently be defined as core reef. Figure 4.3 shows the area of core reef where these areas overlap.

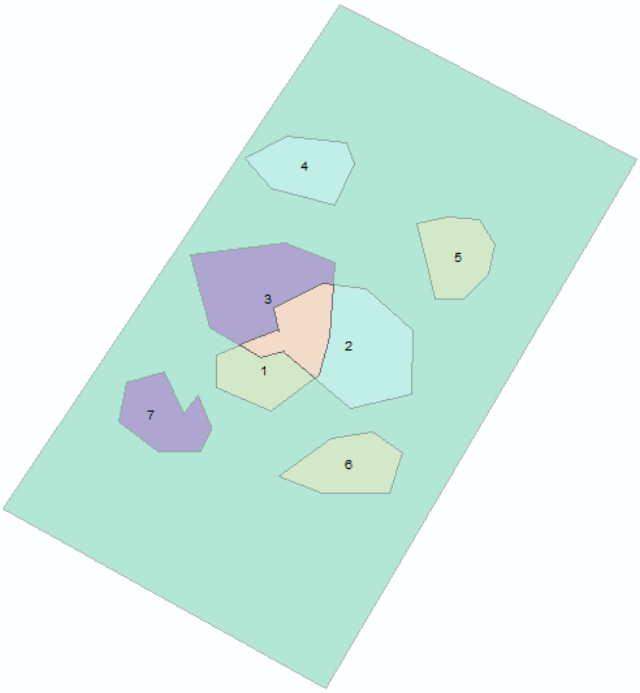

Figure 4.3: Core reef extent (pink)

5. Post-construction monitoring

5.1.1. Post-construction monitoring will consist of geophysical surveys of the whole development site. A comparison can then be made based on any change in reef extent and position between pre- and post-construction surveys and the success of micrositing mitigation measures assessed.

5.1.2. It is worth noting that the Pearce *et al*., (2014) study recorded that *S. spinulosa* biogenic reef within TOWF increased in extent post-construction. The study concluded that micrositing was effective in reducing the impact and that the increase in reef extent could have been caused by the de-facto marine reserve effect offshore wind developments have especially on reducing fishing/ trawling impacts on benthic features.

6. Summary

6.1.1. Figure 6.1 provides a summary of the process outlined in this biogenic reef mitigation plan.

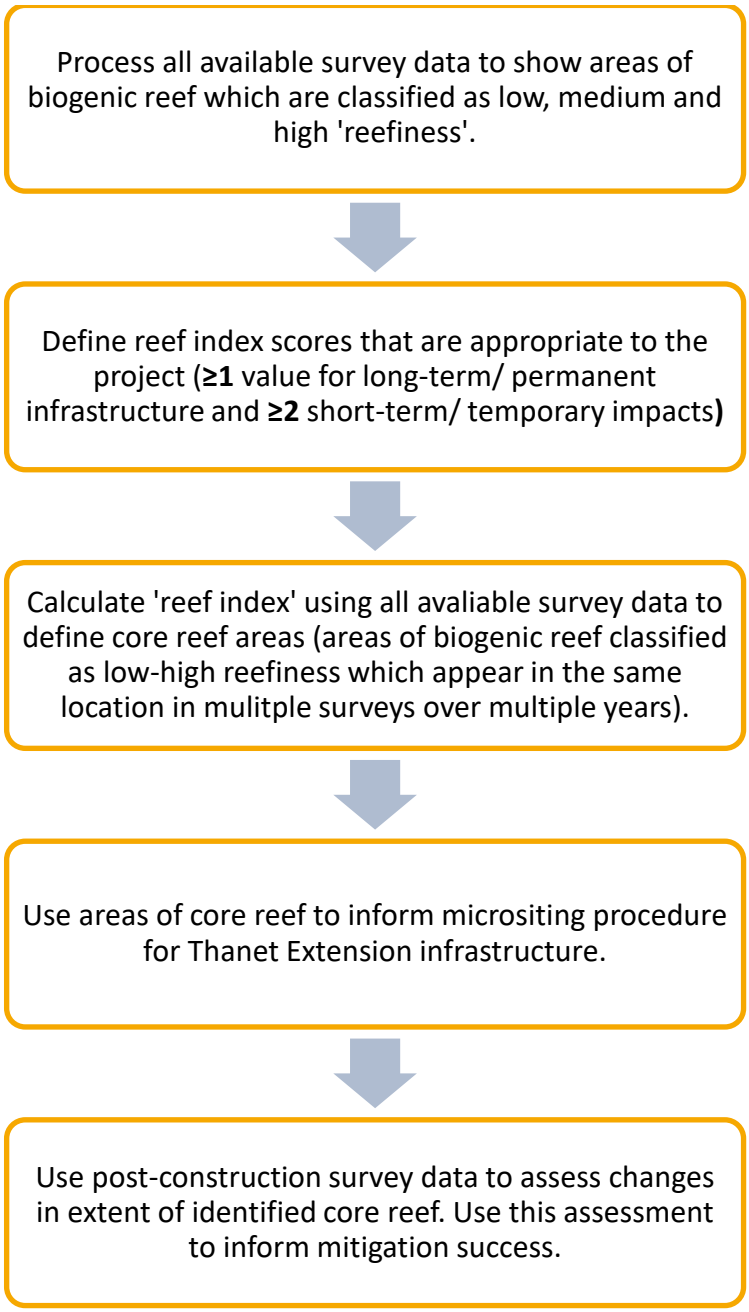

Figure 6.1: Summary of Biogenic Reef Mitigation Plan process

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