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Horns Rev 3 Offshore Wind Farm

Technical report no. 4

BENTHIC HABITATS AND COMMUNITIES

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SUMMARY

The benthic communities of the project area are typical for sandy substrates in the Horns Reef area and are common along the West Coast of Jutland. The benthic habitat contains species which are characteristic of the Venus, *Goniadella-Spisula* and *Lanice conchilega* communities. The benthic communities display large natural variations in spatial and temporal distribution across the Horns Reef area. The benthos is adapted to a dynamic environment and is generally tolerant to turbidity and redistribution of sediments. None of the invertebrate species are known to be particularly sensitive to noise, electromagnetic fields or heat.

Some benthic invertebrate species within the project area may be important food resources for vertebrate species, such as the red listed Common Scoter. Modelling of habitat suitability for two such prey species indicates that the offshore wind farm (OWF) area is well suited for American razor clam (*Ensis directus*), which has a distribution range extending throughout the whole Horns Reef area. Habitat modelling shows that the project area for wind turbines is less suited for cut trough shell (*Spisula subtruncata*), which is more common around the eastern project area, along the export cable corridor. The models show, that the Horns Rev 3 project area will only overlap with very small proportions of the overall distribution ranges of both species in the Horns Reef region.

The natural flora and invertebrate fauna species in the Horns Rev 3 project area are not considered vulnerable and are not protected under regional, national or international legislation. Environmental pressures on the flora and invertebrate fauna within the Horns Rev 3 project area are potentially present during the life stages of the OWF. However, impacts are considered minor and are not expected to have any significant effects on populations of flora and invertebrate fauna in the Horns Rev 3 project area.

SAMMENFATNING

Bunddyrssamfundene i projektområdet er typiske for sandede substrater i Horns Rev-området og som er almindelige langs den Jyske Vestkyst. Havbunden i området indeholder arter, der er karakteristiske for Venus, *Goniadella-Spisula* samt *Lanice conchilega* samfundene. Bunddyrssamfundene udviser store naturlige variationer i rumlig og tidsmæssig fordeling over hele Horns Rev-området. De bentiske arter er tilpasset et dynamisk miljø, og er generelt tolerante over for uklart vand med resuspenderet materiale. Ingen af de hvirvelløse dyr i området anses for at være særligt følsomme over for støj, elektromagnetiske felter eller varme.

Nogle hvirvelløse bunddyr i projektområdet kan være vigtige fødekilder for andre dyrearter såsom den rødlistede sortand. Habitatmodellering for to sådanne byttedyr indikerer dels, at projektområdet er velegnet til Amerikansk knivmusling (*Ensis directus*), som har en udbredelse der strækker sig over hele Horns Rev-området. Dels viser habitatmodellering at selve projektområdet er mindre velegnet til almindelig trugmusling (*Spisula subtruncata),* som er mere almindelig øst for projektområdet og langs kabelkorridoren. Modellerne viser, at Horns Rev 3 projektområdet kun vil overlappe med meget små dele af begge arters generelle fordeling i Horns Rev området.

Den naturlige flora og hvirvelløse fauna i Horns Rev 3 projektområdet betragtes ikke som sårbar og er ikke beskyttet i henhold til regional, national eller international lovgivning. Miljømæssige belastninger af flora og hvirvelløse dyrearter i Horns Rev 3 projektområdet kan potentielt forekomme under havvindmølleparkens forskellige livsstadier. Dog betragtes mulige virkninger på arterne som mindre og der forventes ikke nogen væsentlige negative indvirkninger på populationsniveau af flora og fauna i Horns Rev 3 projektområdet.

1. INTRODUCTION

1.1. Project background

In 2012 the Danish Government and a coalition of political parties passed a new energy plan, ”Energiaftale af 22. Marts 2012”, that stipulated the Danish government’s strategy to put Denmark on track for the 2050 target of the conversion of all energy supply to clean renewable energy; including an interim target of a 40% reduction by 2020 in all Danish greenhouse gas emissions (The Danish Ministry of Climate, Energy and Building, 2012 & 2013).

The number of offshore wind farms (OWFs) is steadily increasing in Denmark and the rest of Europe due to high demand, both economically and politically, for renewable energy. Denmark plans to establish OWFs with a total capacity of 4,400 MW (Energistyrelsen, 2011). The overall aim is that offshore wind will contribute as much as 50 % of the total national consumption of electricity in 2025. The energy generated from OWFs was approximately 665 MW in 2012 (www.offshorecenter.dk).

On the 22th of March 2011 a broad political majority agreed on the construction of two new OWFs:

- Horns Rev 3 (400 MW)
- Kriegers Flak (600 MW)

With orders from the Energy Agency, Energinet.dk has to perform and contract the preparation of background reports, impact assessments and environmental impact statements for the two wind farms.

1.2. Introduction to present report

The present EIS technical report comprises an assessment of the possible impacts from the establishment of Horns Rev 3 OWF on the benthic habitats and communities within the project area, including the turbines and interconnecting cables, as well as the transmission /export power cable from the transformer platform to land.

The present assessment is based on side scan sonar mapping and sediment samples collected in 2012 and on field surveys conducted in the spring of 2013. During the field surveys, an ROV was used to visually verify the substrate types and epifaunal communities present on the seafloor. Van Veen grab samples of the seafloor were also taken in order to sample benthic infauna and their correlated substrates, which were analysed for grain size distributions.

The available data are discussed in a context of available scientific knowledge and previous biological data from the area, as well as on experiences harvested in the demonstration project for Horns Rev 1 OWF and data collected in relation to the EIA for Horns Rev 2 OWF.

The baseline conditions in the project area are described in order to assess the impacts from establishment of the OWF. Assessment of the effects during preconstruction, construction, in the operational phase and during decommissioning of Horns Rev 3 OWF is included in the report along with an assessment of the cumulative effects of the establishment of a new wind farm in the Horns Reef area.

1.3. PSO-programmes

In 1998, an agreement was signed between the Danish Government and the energy companies to establish a large-scale demonstration programme. The development of Horns Rev 1 OWF and Nysted OWF was the result of this action plan (Elsam Engineering & ENERGI E2, 2005). The aim of this programme was to investigate the impacts on the environment before, during and after establishment of the wind farms. Environmental studies were conducted in the period 1999-2006 and were funded as a Public Service Obligation (PSO) of the Danish electricity consumers with a budget of 84 million DKK (Danish Energy Agency (DEA), 2005). A series of studies of the environmental conditions and possible impacts from the OWFs were undertaken for the purpose of ensuring that offshore wind power does not have damaging effects on the natural ecosystems. These environmental studies are of major importance for the establishment of new wind farms and extensions of existing OWFs like Nysted OWF and Horns Rev 1 OWF.

Prior to the construction of Nysted and Horns Reef OWFs, a number of baseline studies were carried out under the PSO-programme in order to describe the environment before the construction. The studies were followed up by investigations during and after the construction phase, and all environmental impacts were assessed. Data from the PSO-programmes has also been used in relation to the present report. Detailed information on methods and conclusions of these investigations can be found in the annual reports (www.hornsrev.dk; www.nystedhavmoellepark.dk).

1.4. Glossary of areas

Area name	Description of area
Horns Reef (Horns Rev)	A shallow reef 15-40 km off Blåvands Huk, on the west coast of Jutland
Horns Rev 1 OWF	Offshore wind farm (160 MW installed capacity) operational since 2002
Horns Rev 2 OWF	Offshore wind farm (209 MW installed capacity) operational since 2009
Horns Rev 3 OWF	Offshore wind farm (400 MW planned capacity) planned operation from 2020
Project area	The gross area within which the Horns Rev 3 OWF and export cable corridor is placed. Size of area: 160 km^2

Project area for wind turbines	The offshore area within which the Horns Rev 3 wind turbines can potentially be placed.
OWF Park layout (A,B,E)	Three different layout scenarios of the turbines; E) closest to the shore (easterly in project area for wind turbines), A) in the centre of the project area for wind turbines, and B) in the western part of the project area for wind turbines. The exact size will depend on the size/number of turbines installed, but will be a maximum of 88 km^2.
Export cable corridor	An area covering 500 m on each side of the 32.5 km long export cable.
Study areas	The different areas within which surveys have been conducted, can be larger than the project area
Pre-investigation area (for geo-investigations)	The gross area geo-surveyed within which the Horns Rev 3 project area for wind turbines and parts of the export cable corri-dor is placed. Size of area: 190 km^2.

2. HORNS REEF

Horns Reef is an extension of Blåvands Huk, extending more than 40 km to the west into the North Sea (Figure 2.1). Horns Reef is considered to be a stable landform that has not changed position since it was formed (DHI, 1999). The width of the reef varies between 1 km and 5 km.

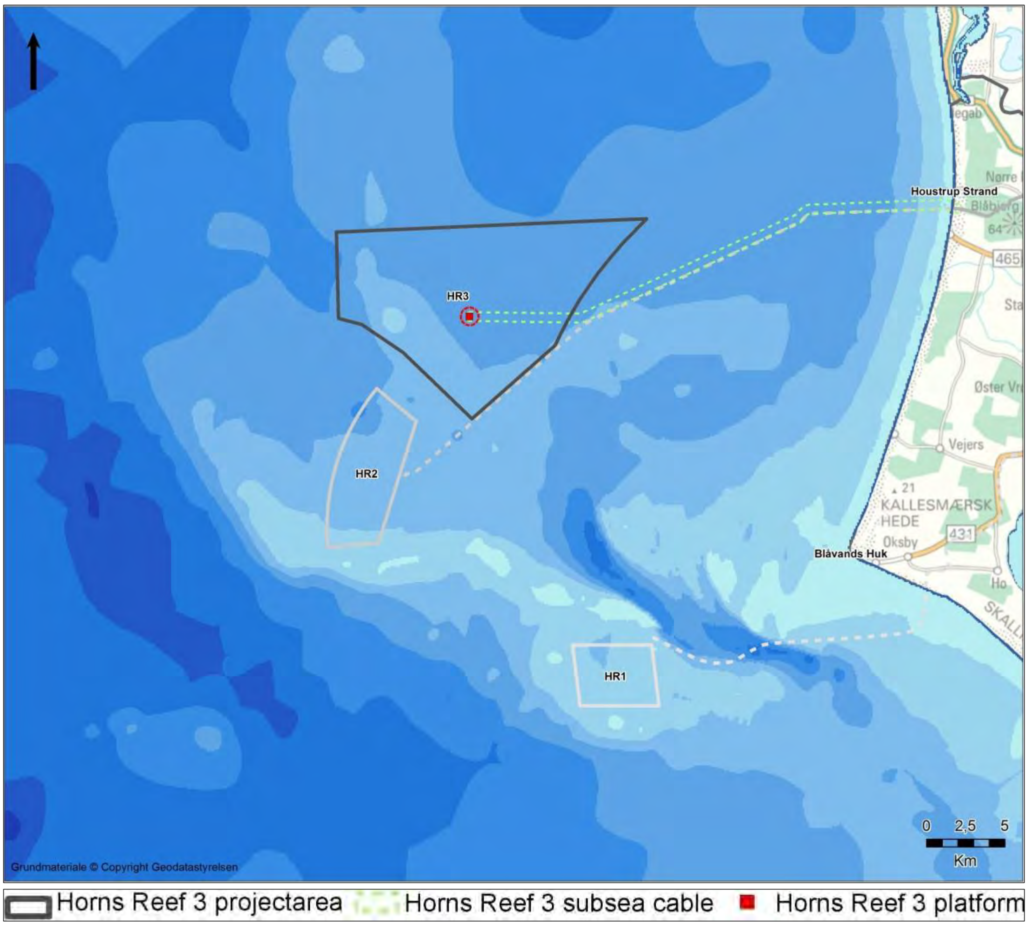


Figure 2.1 Map af the area around Blåvands Huk. Horns Rev 1 and 2 are marked with grey polygons, the Horns Rev 3 project area for wind turbinesis marked with a black polygon, the cable corridor with green dotted line.

Blåvands Huk is the western most point of Denmark and it forms the northern extremity of the European Wadden Sea, which covers the area within the Wadden Sea islands from Den Helder in Holland to Blåvands Huk.

2.1. Topography and sediment

Based on preliminary results from the geophysical survey carried out in 2012, and based on previous geophysical, geological and geotechnical investigations in the region, it can in short be concluded that the seabed in the Horns Rev 3 area exhibits marine sediments deposited during the Holocene with thicknesses up to approx. 40 m. These generally sandy sediments vary at the seabed surface from gravel to gravelly sand and sand in the southern and western parts of the area, but become finer in grain size towards the coast where the sand becomes silty and clayey (Figure 2.2, see Appendix 1 for details). Along the westernmost flank of the area, there are possible scatterings of stones and boulders in higher concentrations than is generally found in the rest of the project area. Just below the Holocene deposits, late Glacial (Weichselian), interglacial (Eemian) and Saalian meltwater deposits overlay the glacial Saale landscape (typically clay till) that forms a wide depression – a basin – in the area. The

Saale glacial surface may come relatively close to the seafloor to the west, which could explain the abundance of boulders in this area.

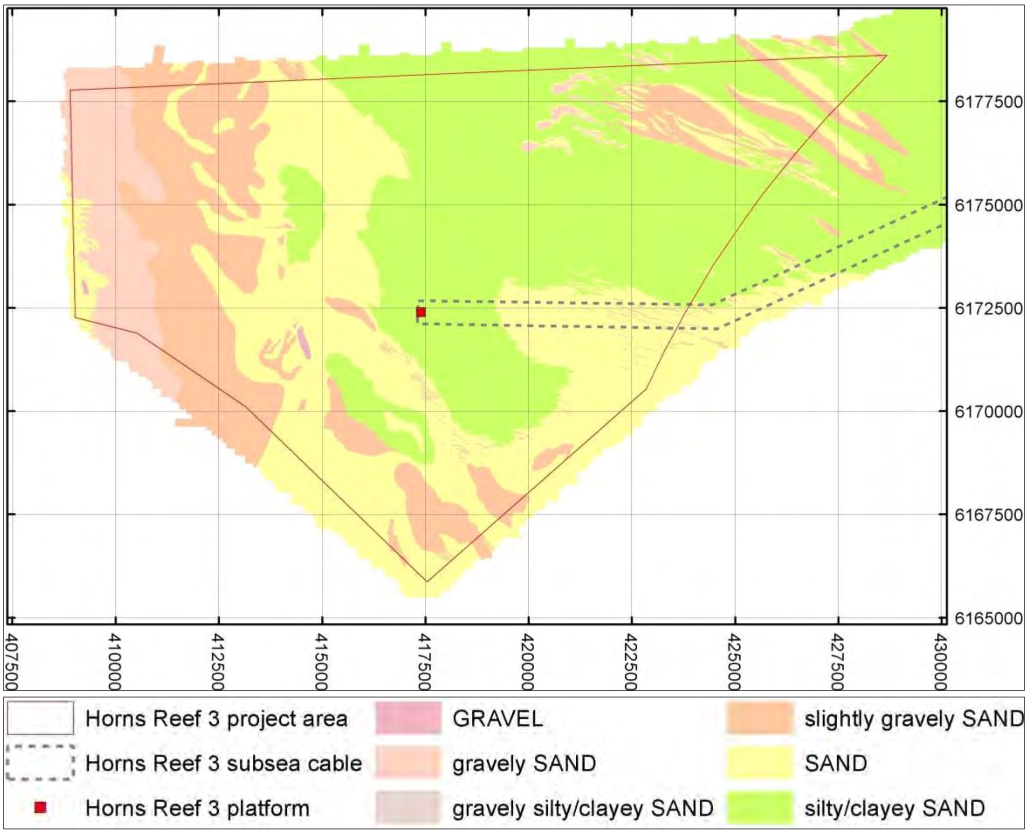


Figure 2.2. Seabed surface and feature map of project area for windturbines based on the geophysical survey in 2012.

2.2. Hydrography

In general, the salinity in this part of the North Sea is app. 32-35 PSU (3.2-3.5 %) with only minor spatial and temporal variations.

The area is subject to tide-induced, wind-induced and wave-induced currents, which vary in direction and magnitude according to time of the day and seasonal variations. During meteorologically calm periods, the tide-induced currents dominate with a magnitude of up to 0.5 m/s. Directions of the currents vary significantly in the area, but the net directions are north-south or vice versa, with a strong coherence between surface and bottom currents. The strongest currents naturally occur during storms causing currents considerably larger than the tide-induced.

Due to tidal currents, rough waves and water mixing, stratification does not develop in the Horns Reef area and thus oxygen deficiency is not likely to occur (DHI, 1999).

There is a net sedimentation accumulation in the Blåvands Huk - Horns Reef area. High turbidity due to the large amounts of re-suspended material in the water column is characteristic for the Horns Reef area. High temporal variability is found in the water turbidity due to the influence of tidal currents, wind induced currents and seasonal plankton dynamics. In general, the turbidity is high during spring and lower in autumn. Pronounced diel variations of turbidity can occur within a few hours and can be associated with changes in the direction of prevailing currents (Leonhard and Pedersen, 2006).

The wave sizes in the area are in general significantly influenced by the shallow water at Horns Reef. Waves can break on the reef and no waves higher than about Hs = 0.6 times the local water depth can pass over the reef. This means that Horns Reef significantly limits the near shore wave conditions in the leeward area of the reef, especially with waves coming in from southern and south-westerly directions.

However, in the Horns Rev 3 project area, the reef must be expected to have little to no influence on wave heights when wind directions are from the north, north-west or due west.

The tidal amphidromy along the Danish West Coast is anti-clockwise. The hydrographical effect of Horns Reef is a dampening of the northward travelling tidal wave, which has a drastic effect on the tidal ranges in the region. Spring Tidal Ranges vary between 0.8 m in Hvide Sande north of Horns Rev, to 1.8 m around Blåvands Huk, and 1.5-1.8 m in Esbjerg, south of the Horns Reef area.

The winds at Horns Reef are predominantly westerly and northwesterly throughout much of the year, but southeasterly directions are also frequent during winter. Rough wind and wave climates can occur during summer and winter, but especially occur during both autumn and winter. Winds are generally from westerly and northwesterly directions, but southeasterly directions are also frequent during winter. Average wind speeds are between 6 and 10 m/s, strongest during winter.

The metocean study presents data from the statistical analyses of normal and extreme conditions for site representative positions in the project area (Orbicon, 2014a). An overview of normal conditions are shown in Table 2.1.

Table 2.1 Overview of normal conditions for all positions (A, B and C in metocean study:(Orbicon, 2014a)).

Wind speed at 10 m [m/s]	Significant wave height [m]	Current [m/s]		Sea level [m]
		Surface	Bottom	
9.4 - 9.6	1.8 - 1.9	0.2 - 0.3	0.2 - 0.3	-0.4 - 0.3

3. THE WIND FARM AREA

3.1. Description of the wind farm area

The planned Horns Rev 3 OWF (400 MW capacity) is located north of Horns Reef in a shallow area in the eastern North Sea, about 20-30 km northwest of Blåvands Huk, the westernmost point of Denmark. The Horns Rev 3 pre-investigation area covered approx. 190 km^2, the present project area is approximately 160 km^2. To the west, the project area is delineated by gradually deeper waters, to the south/southwest by the existing Horns Rev 2 OWF, to the southeast by the export cable from Horns Rev 2 OWF, and to the north by oil/gas pipelines (Figure 3.1).

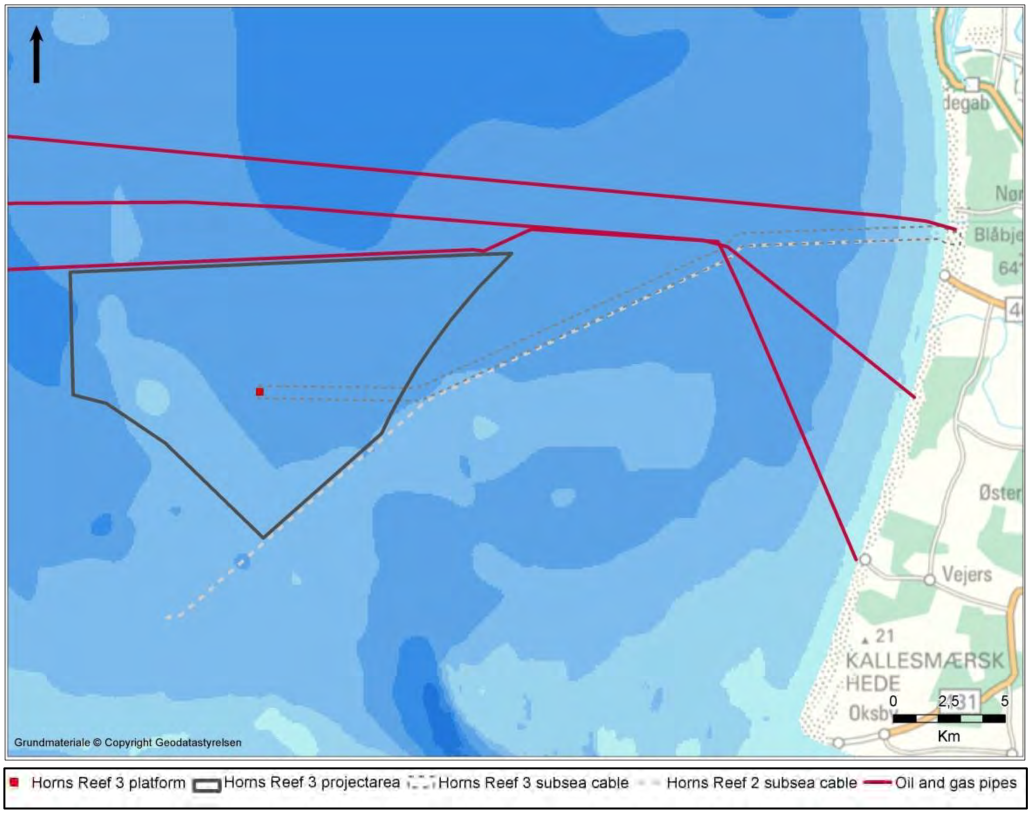


Figure 3.1 Location of the Horns Rev 3 OWF (400 MW) and the projected corridor for export cables towards shore. The project area enclosed by the polygons is approx. 160 km^2.

The water depths within the Horns Rev 3 project area for wind turbines vary between approx. 10-20 m (Figure 3.2). The minimum water depth is located on a ridge in the southwest of the site and the maximum water depth lies in the north of the area. Sand waves and mega-ripples are observed across the site.

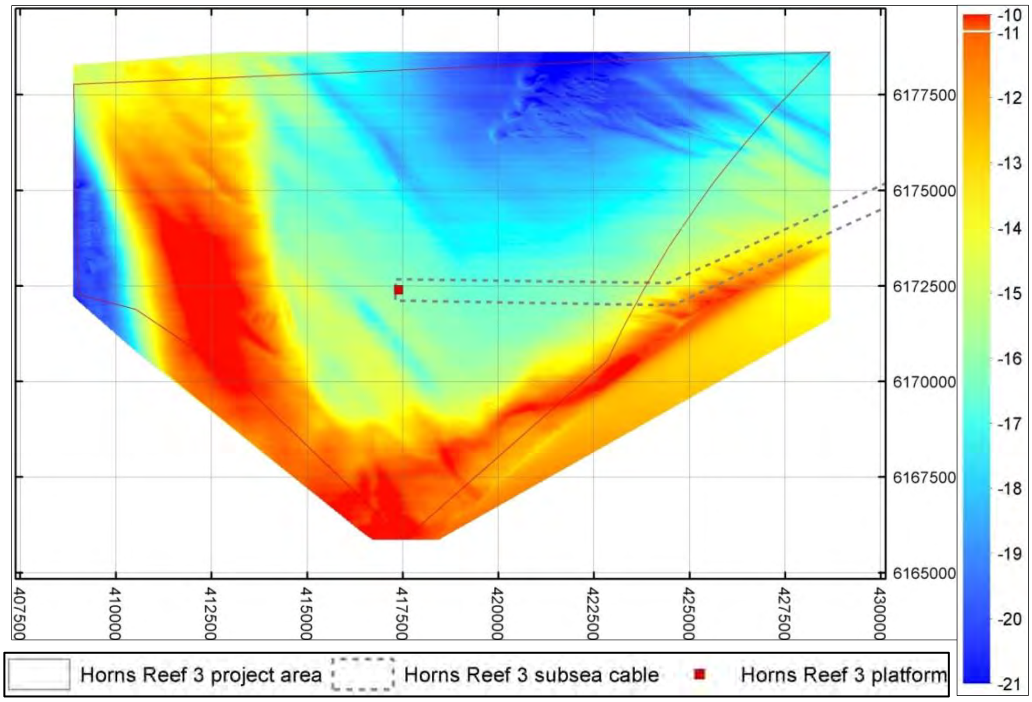


Figure 3.2. Bathymetric map of the Horns Rev 3 project area for wind turbines showing depths below DVR90 as graded colour. The map is based upon the Geophysical survey in 2012.

3.2. The turbines

The maximum rated capacity of the wind farm is limited to 400 MW. The type of turbine and foundation has not yet been decided. However, the farm will feature from 42 to 136 turbines depending on the rated power of the selected turbines, corresponding to the range of 3.0 to 10.0 MW.

It is expected, that turbines will be installed at a rate of one every one to two days. The work is planned for 24 hours per day, with lighting of barges at night, and accommodation for crew on board construction vessels. However, the installation is weather dependent, so installations may be delayed in unstable weather conditions.

Suggested OWF park layouts for different scenarios are presented in Figure 3.3 - Figure 3.11. The layouts are made for 3 MW, 8 MW and 10 MW turbines, respectively – and for three different locations of the turbines; ‘Layout E’ closest to the shore (easterly in the project area for wind turbines), ‘Layout B’ in the centre of the project area for wind turbines, and ‘Layout A’ in the western part of the project area for wind turbines.

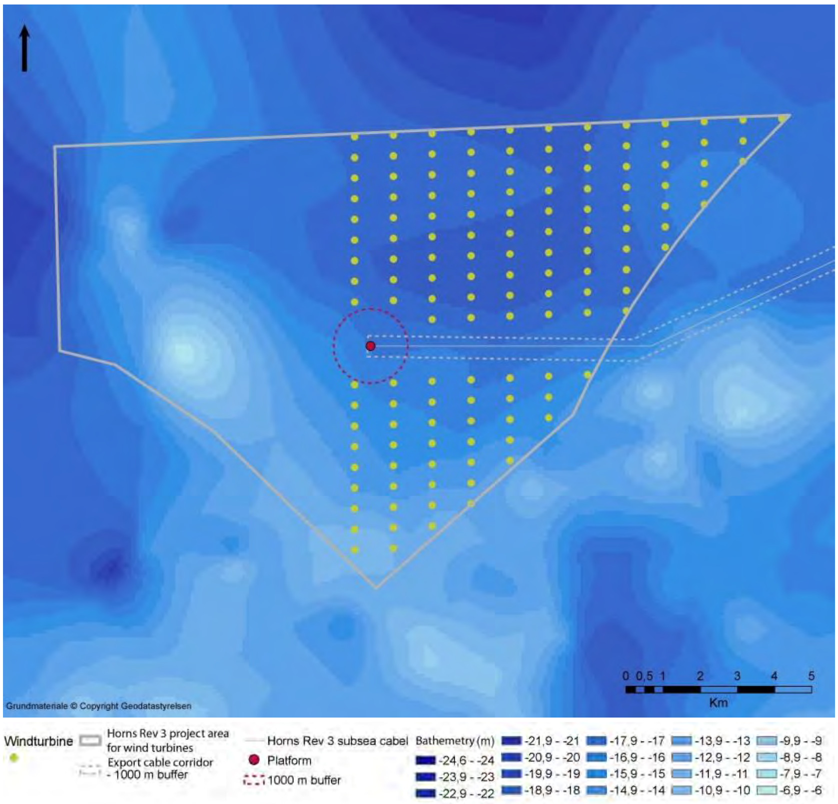


Figure 3.3 Suggested layout for the 3.0 MW wind turbine at Horns Rev3, closest to shore in the project area for wind turbines (OWF Park Layout E).

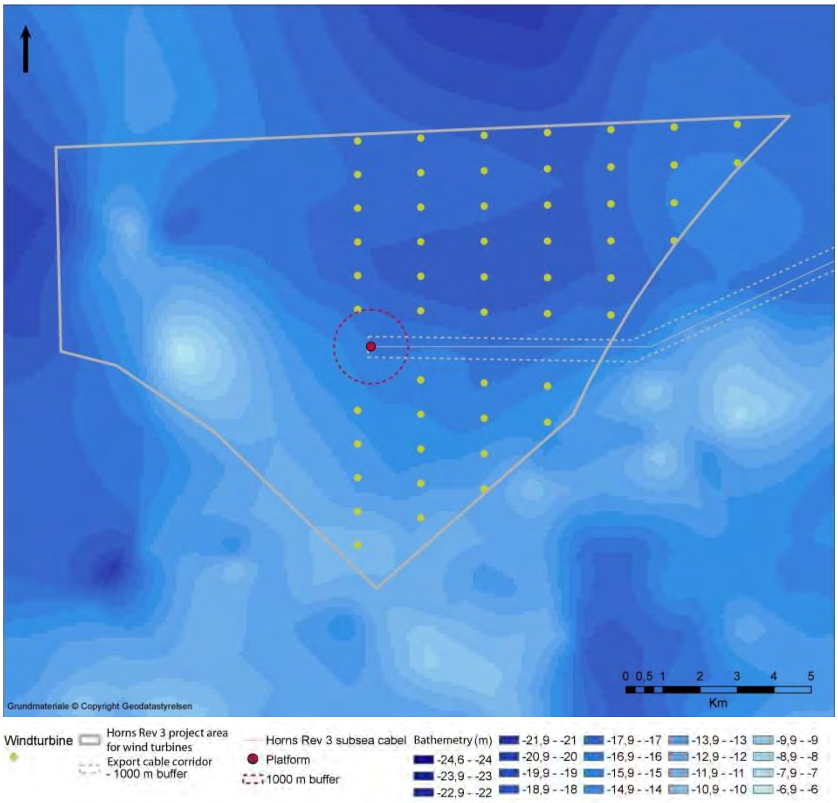


Figure 3.4 Suggested layout for the 8.0 MW wind turbine at Horns Rev3, closest to shore in the project area for wind turbines (OWF Park Layout E).

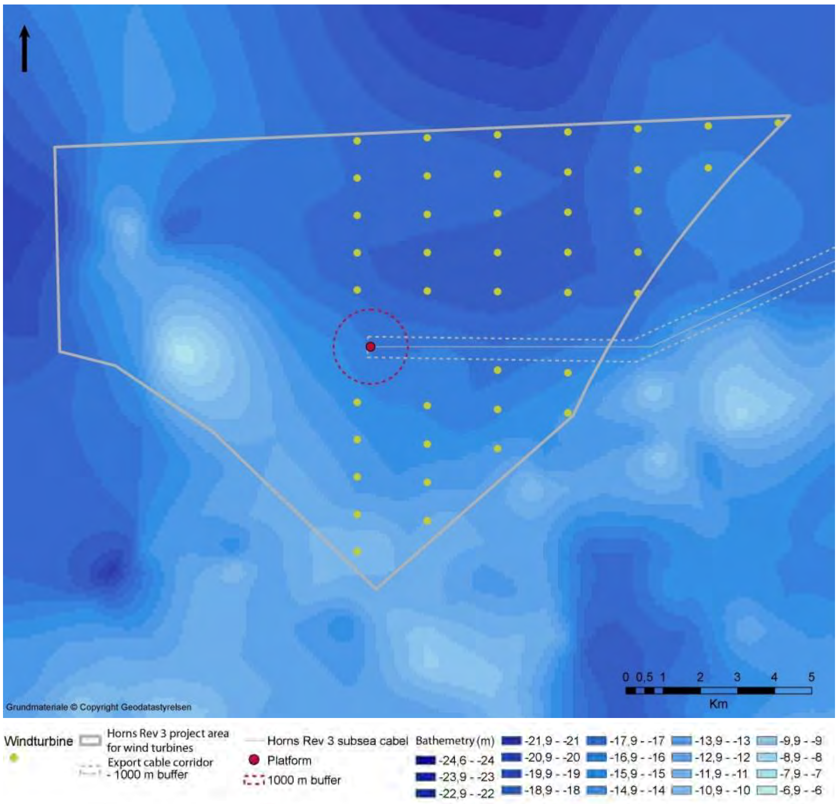


Figure 3.5 Suggested layout for the 10.0 MW wind turbine at Horns Rev3, closest to shore in the project area for wind turbines (OWF Park Layout E).

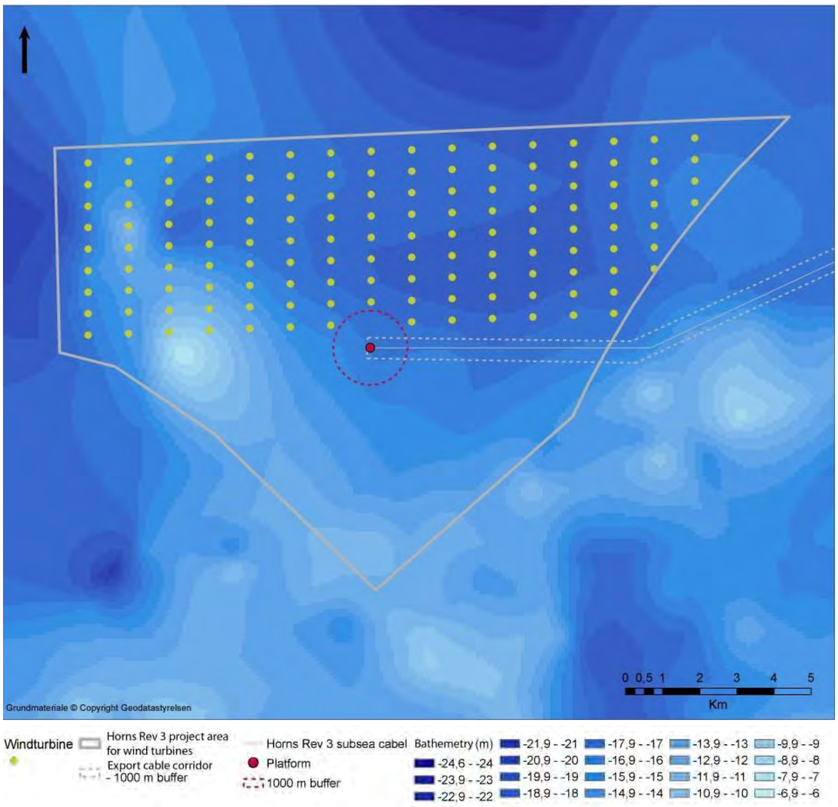


Figure 3.6 Suggested layout for the 3.0 MW wind turbine at Horns Rev3, located in the centre of the project area for wind turbines (OWF Park Layout A).

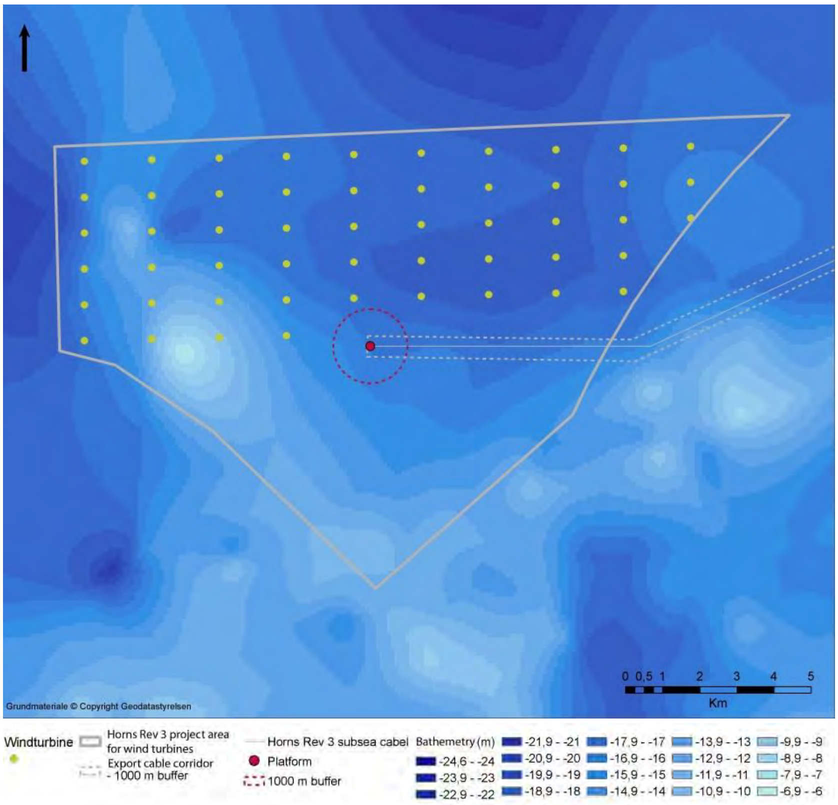


Figure 3.7 Suggested layout for the 8.0 MW wind turbine at Horns Rev3, located in the centre of the project area for wind turbines (OWF Park Layout A).

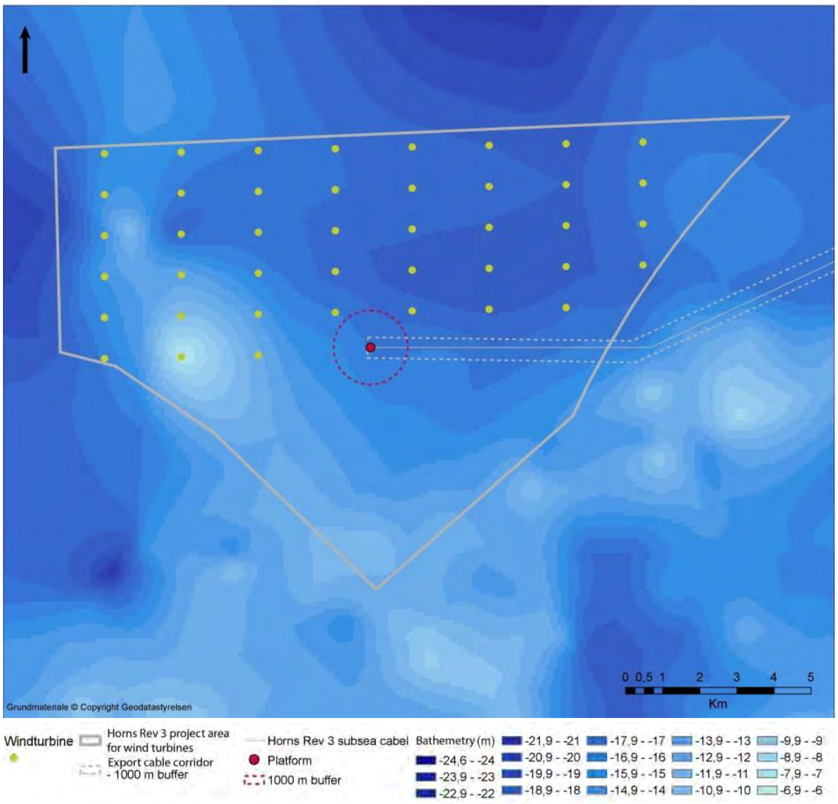


Figure 3.8 Suggested layout for the 10.0 MW wind turbine at Horns Rev3, located in the centre of the project area for wind turbines (OWF Park Layout A).

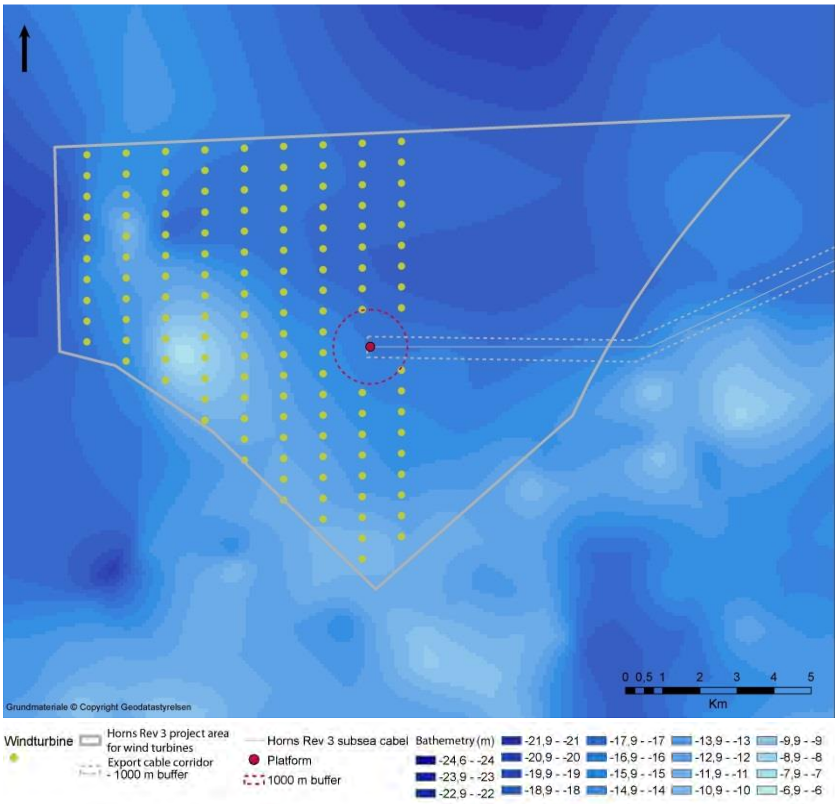


Figure 3.9 Suggested layout for the 3.0 MW wind turbine at Horns Rev3, located most westerly in the project area for wind turbines (OWF Park Layout B).

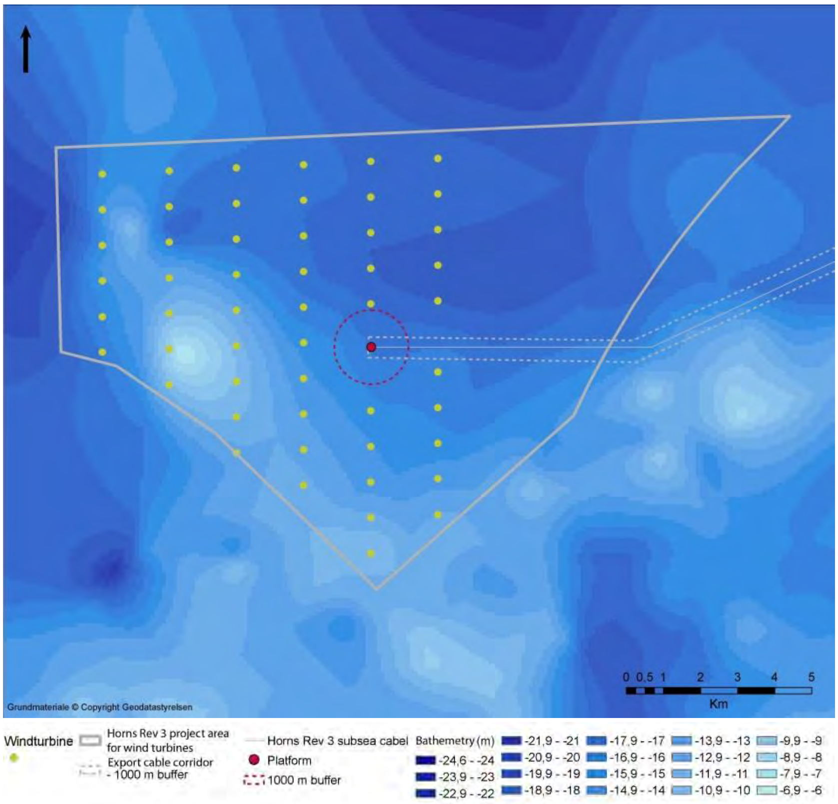


Figure 3.10 Suggested layout for the 8.0 MW wind turbine at Horns Rev3, located most westerly in the project area for wind turbines (OWF Park Layout B).

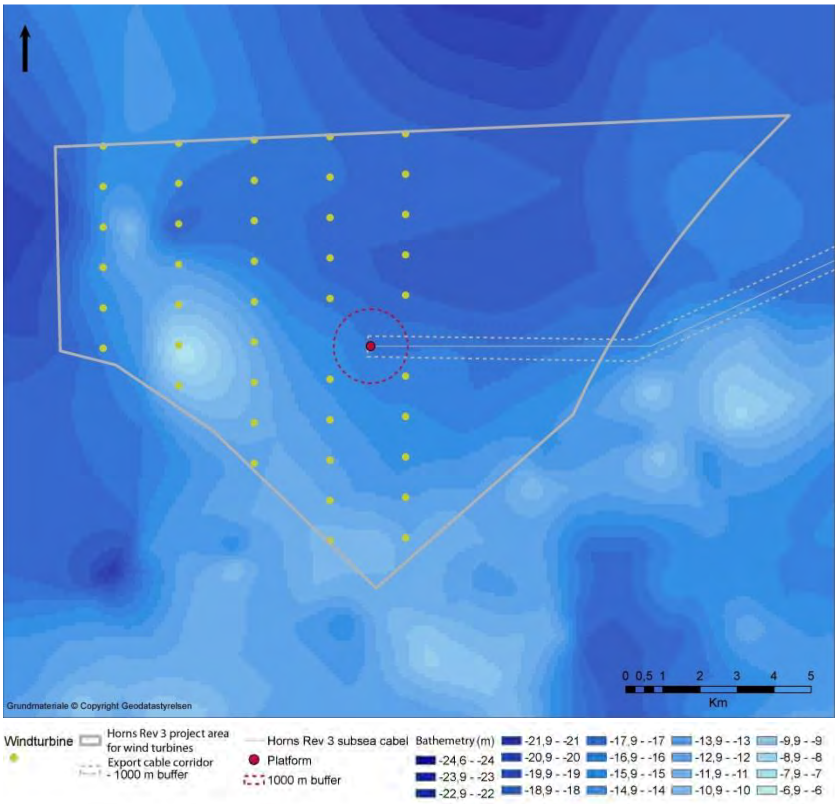


Figure 3.11 Suggested layout for the 10.0 MW wind turbine at Horns Rev3, located most westerly in the project area for wind turbines (OWF Park Layout B).

3.3. Foundations

The wind turbines will be supported by foundations fixed to the seabed. It is expected that the foundations will be one of the following types:

- Driven steel monopile
- Concrete gravity base
- Jacket foundation
- Suction bucket

3.3.1 Driven steel monopile

Monopiles have been installed at a large number of wind farms in the UK and in Denmark (e.g. Horns Rev 1, Horns Rev 2 and Anholt OWFs). The foundation consists of a hollow steel pile, which is driven into the seabed. Monopiles, for the relevant sizes of turbines (3-10 MW), are driven 25 – 35 m into the seabed and have diameters of 4.5 – 10 m. The pile diameter and depth of the penetration is determined by the size of the turbine as well as the local sediment characteristics.

The monopile concept is not expected to require much preparation work, but some removal of seabed obstructions may be necessary.

A filter layer for scour protection may be installed prior to pile driving, while a second layer of scour protection may be installed after installation of the pile. Scour protection of nearby cables may also be necessary. Scour protection is especially important when turbines are placed in turbulent areas with high flow velocities.

The noise level and emission under water will depend among other things on the pile diameter and seabed conditions. An indicative source level of pile driving operations would be in the range of 220 to 260 dB re 1 μPa at 1 metre.

3.3.2 Concrete gravity

These structures rely on their mass (including ballast) to withstand the loads generated by the offshore environment and the wind turbine.

The gravity base concept has been used successfully at operating wind farms such as Middelgrund, Nysted, Rødsand II and Sprogø in Denmark, Lillgrund in Sweden and Thornton Bank in Belgium.

Normally, seabed preparation is needed prior to installation. The top layer of seafloor material is removed and replaced by a stone bed. When the foundation is placed on the prepared seabed, the foundation base is filled with a suitable ballast material, and a steel “skirt” may be installed around the base, in order to penetrate into the seabed and to constrain the seabed underneath the base.

The ballast material is typically sand, which is likely to be obtained from an offshore source. An alternative to sand can be heavy ballast material, which has a higher density than natural sand. For a given ballast weight, using heavy ballast material will result in a reduction of foundation size, which may be an advantage for the project.

Noise emissions during construction are considered to be small.

3.3.3 Jacket foundations

Jacket foundation structures are three or four-legged steel lattice constructions. The jacket structure is supported by piles in each corner of the foundation construction.

The jacket foundation has been used successfully at wind farms operating in places such as the East Irish Sea, the North Sea and the Baltic Sea.

The construction itself is built of steel tubes with varying diameters depending of their location within the lattice structure. The three or four legs of the jacket are interconnected by cross bonds, which provide the construction with sufficient rigidity.

Anchoring the jacket in the seabed with piles can be done in several ways:

- Pilling inside the legs
- Pilling through pile sleeves attached to the legs at the bottom of the foundation structure
- Pre-pilling with a pile template

Scour protection of the foundation piles and cables may be applied depending on the seabed conditions. In sandy sediments, scour protection is normally considered necessary in order to protect the construction from bearing failure. Scour protection consists of natural, well graded stones.

3.3.4 Suction Bucket

The suction bucket foundation is a relatively new concept and is a quality proven hybrid design, which combines aspects of a gravity base foundation and a monopile in the form of a suction caisson.

The bucket foundation is said to be “universal”, in that it can be applied to and be designed for various site conditions. Homogeneous deposits of sand and silts, as well as clays, are ideal for the suction bucket concept.

The concept has been used offshore for supporting met masts at Horns Rev 2 and Dogger Bank. Bucket foundations are targeted for 2015/2016 in relation to wind turbines.

As a proven suction bucket design concept for the turbines involved in Horns Rev 3 does not yet exist, suction buckets are here assumed to have same plate diameter as gravity foundations for the respective turbines. However, it is expected that the maximum height of an installed bucket foundation will not protrude more than 1m above the surrounding seabed.

3.4. Scour protection

The foundations may lead to scour effects, which are removal of seabed sediments by hydrodynamic forces near the foundations. Scour can change the seabed morphology in the area and lead to increased suspension of seabed sediments as well as increases in water turbidity. To prevent this, scour protection can be used around the foundations to mitigate the effects of scouring. Nearby cables may also need to be protected with filter and armour stones.

3.4.1 Monopile solution

Depending on the hydrodynamic environment, the horizontal extent of the armour layer will, according to experience from former projects, be 10-15 metres. The vertical thickness will be between 1 and 1.5 metres. Filter layers are usually 0.8m thick and reach up to 2.5m further out than the armour layer. Expected stone sizes range between d_{50} = 0.30m to d_{50} = 0.5m. The total diameter of the scour protection is assumed to be 5 times the pile diameter.

3.4.2 Gravity base solution

Scour protection may be necessary, depending on the sediment properties at the installation location. The envisaged design for scour protection may include a ring of stones around the structure.

3.4.3 Jacket solution

Scour protection may be installed as appropriate by a Dynamically Positioned Fall Pipe Vessel and/or a Side Dumping vessel. The scour protection may consist of a two layer system comprising filter stones and armour stones. The effect of scour may be incorporated into the foundation design, in which case scour protection can be neglected.

3.4.4 Suction bucket solution

Scour protection of the bucket foundations and cables may be necessary, depending on the seabed conditions at the installation location. Scour protection may consist of natural well graded stones around the structure, but during detailed foundation design, it might be determined that scour protection is unnecessary.

3.4.5 Alternative scour protection solutions

Alternative scour protection systems such as the use of frond mats may be introduced by the contractor. Frond mats contain continuous rows of polypropylene fronds which project up from the mats and reduce scour.

Another alternative scour protection system is the use of sand filled geotextile bags around the foundations. This system is planned to be installed at the Amrumbank West OWF during 2013, where some 50,000t of sand filled bags will be used around the 80 foundations. Each bag will contain around 1.25t of sand. If this scour protection system is to be used at Horns Rev 3, it will employ around 31,000 to 84,000t of sand for approx. 50-133 turbine foundations.

3.5. Subsea cables

Medium voltage inter-array cables will be connected to each of the wind turbines and for each row of 8-10 turbines, a medium voltage cable is connected to the transformer station. The medium voltage is expected to be 33 kV (max. voltage 36 kV), but 66 kV (max. voltage 72 kV) is also considered.

After pulling the cables into the J-tubes on the foundation structure of the wind turbines, the cables are fixed to hang-off flanges. At the transformer station, the cables are fixed to a cable deck or similar.

The inter-array cables may be protected with bending restrictors at each J-tube. Scour protection is also considered for protecting the cables, if exposed.

A 220 kV transmission/export cable will be installed from the offshore transformer station and make landfall at the connection point on land at Blåbjerg Substation. The length of the transmission cable will be approx. 32.5 km. The cable will be aligned in parallel with the existing transmission cable from Horns Rev 2, with a distance of approx. 300 metres for most of the transect. Close to shore, the distance between the cables is expected to be approx. 40-50 metres

3.5.1 Electromagnetic fields

Transportation of the electric power from the wind farm through cables is associated with formation of electromagnetic fields (EMF) around the cables.

Electromagnetic fields emitted from the cables consist of two constituent fields: an electric field retained within the cables and a magnetic field detectable outside the cables. A second electrical field is induced by the magnetic field. This electrical field is detectable outside the cables (Gill et al., 2005).

In principle, the three phases in the power cable should neutralise each other and eliminate the creation of a magnetic field. However, as a result of differences in current strength, a magnetic field is still produced from the power cable. The strength of the magnetic field is, however, assumed to be considerably less than the strength from one of the conductors. Due to the alternating current, the magnetic field will vary over time.

At the offshore transformer station, the export cable and multiple inter-array cables will converge. There may occur electromagnetic interferrence patterns on a very local scale. This will, however, be dependent on several factors as well as the eventual metre-scale placement of individual cables and is very difficult to accurately assess.

Blåvands Huk

4. DATA SOURCES AND METHODS

This chapter gives a short overview of the data and information used in preparation of the present EIS technical report. Methods in relation to field surveys, sample treatment, laboratory work and modelling are also described.

4.1. Screening surveys

Several surveys were undertaken in order to screen the sediment characteristics, biota etc. Full coverage side scan sonar and 50 sediment sampling grabs were performed by GEMS in 2012 (Rambøll, 2013). The grain size distributions for the sediment samples were analysed by GEUS and formed the basis for the detailed sediment mapping (shown in Figure 2.2 and Figure 4.2), which was used for habitat modelling. As a basis for the assessment of benthic habitats and communities, data from side scan sonar, faunal Van Veen grabs and ROV-dives were employed and are described in this chapter.

4.1.1 Side scan sonar

Side scan sonar was applied in order to collect acoustic information on the types of surface sediments found in the study area. Side scan sonar was also supplemented with seismic data of the surface sediments. Side scan sonars are especially useful in describing the roughness of the seabed, and thereby mapping the surface character of the seabed. It is the differences in roughness, which makes it possible to identify and differentiate between objects such as sand banks, stones, cold seeps, wrecks etc. and between different types of substrate with differing surface characteristics, see Figure 4.1.

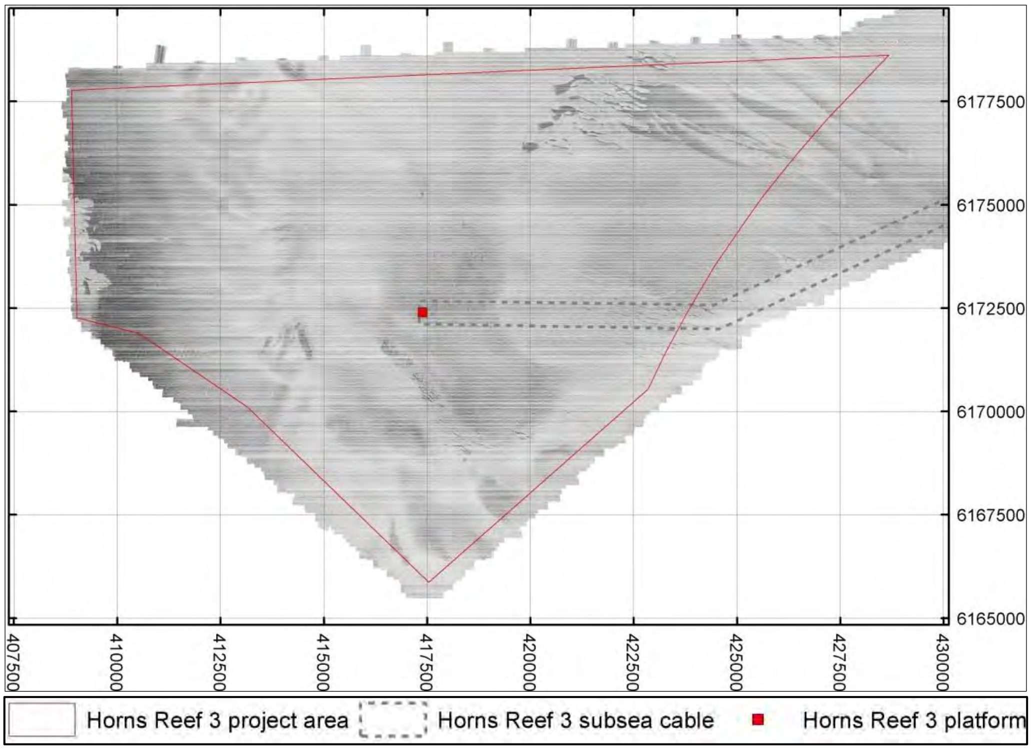


Figure 4.1 Side scan mosaic of the Horns Rev 3 project area for wind turbines (marked with red polygon).

4.1.2 ROV-verification

Visual documentation was carried out in March 2013 by ROV (Remote Operated Vehicle) verification at 20 sampling stations, see Figure 4.2.

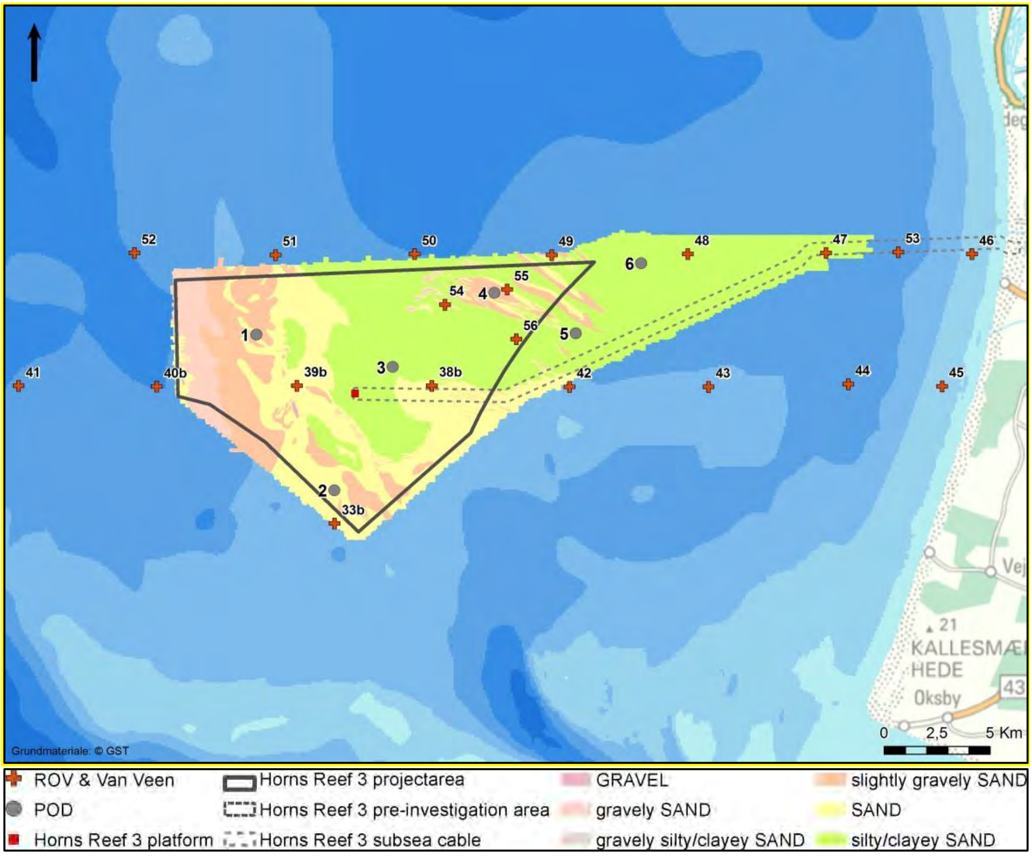


Figure 4.2 Overview of Van Veen grabs and ROV-verified sampling stations . At POD stations, concomitant fauna- and sediment sampling was carried out. The Horns Rev 3 project area for wind turbines is marked with a black polygon, the cable corridor is marked with a stippled polygon.

The ROV-stations coincided with 20 infaunal benthic sampling stations, which were placed in a pattern to continue the sampling layout from Horns Rev 1 & 2 OWFs.

Visual documentation of the seabed was conducted to verify and calibrate the bottom substrates identified on side scan data. During dives, epibenthic flora and fauna communities related to the different types of substrates were also described and recorded.

The visual documentation was carried out with an underwater video camera on-board the ROV. At each station, a local area (< 50 m around the selected station) was investigated, while substrate and biological conditions were documented on video sequences of 3 – 5 minutes duration.

The ROV model (Seabotix LBV200-4) has integrated underwater light and records video input to computer files. The ROV and video recordings were controlled from a control panel with a joystick and monitor. Generally, visibility was low during filming, however, it was possible to manoeuvre the ROV near the seabed with precision, yielding recordings of the seabed, which were satisfactory for visual verification.

The recordings were live-commented by experienced marine biologists and the audio speaks were recorded onto the video files. The underwater videos were supplemented with logbook listings.

4.1.3 Van Veen grab

Van Veen samples were collected at 26 stations to analyse the sediment composition and infauna, see Figure 4.2.

Of these, 20 stations are identical with the ROV verification stations, and only infaunal grab samples were taken. The remaining six van Veen samples were collected in combination with the deployment of C-PODS (Continious Porpoise Detector). These six stations were not verified with ROV, but grab samples for both infauna investigations and for sediment analysis were taken. From the grab samples, four sediment subsamples were taken according to specifications. Subsamples were transferred to Rilsan®-bags for subsequent analyses at selected laboratories.

4.2. Sample handling

4.2.1 ROV-video logbooks

A logbook from each station was completed and contains information on observed substrate type/composition and biological conditions, such as observed flora and fauna. Other relevant registrations, such as depth, weather conditions, QA-information etc. were also entered in the logbook. See Appendix 2 for details.

The logbooks were used for side scan verification in order to produce second generation side scan maps. Logbooks were also used in the description of the baseline conditions in relation to the epibenthic flora and fauna communities related to the different types of substrate.

4.2.2 Sediment

Apart from subsamples taken for contaminant analysis, sediment samples were characterised by analyses of grain size distribution, content of dry matter and amount of organic material measured by combustion loss. The content of dry matter was measured as a percentage of the wet weight. The combustion loss was measured as a percentage of the dry weight. The samples were treated according to DS 405.11 and DS 204. The sediment was pre-treated with hydrogen peroxide to remove organic material, and was washed in distilled water to remove any remaining salts and dried at 105°C until constant weight was obtained.

4.2.3 Benthos

Upon grab recovery, infauna samples were sieved through a 1 mm mesh sieve and the retained samples were fixed in 99 % ethanol for subsequent analysis in the laboratory. In the laboratory, the samples for identification of species composition, abundance and biomass were carefully washed over a 0.5 mm mesh sieve before sorting.

4.3. Data analyses

4.3.1 Sediment characteristics

At 20 stations the side scan mosaic of the surveyed seafloor was visually verified by ROV investigations. In 2013, grain size distribution analyses were carried out for six sediment sample stations (see placements in Figure 4.2). Data from 50 grain size distribution analyses of sediments collected in 2012 were also used.

Through the ROV and sediment verifications, the original side scan mosaic is used to generate a second generation side scan map, which is used in substrate and habitat mapping.

4.3.2 Benthos species composition

Epibenthic faunal species were recorded at the 20 ROV stations and identified to lowest possible taxon. Some of these species were partially retracted into the bottom, and their presence was inferred from siphon holes. General faunal coverage was assessed as a percentage of the substrate at each station.

Infauna species were recorded from 26 faunal grab samples. The fauna samples were sorted under a microscope and the animals were identified to lowest possible taxon level. The number of individuals of each taxon was determined and abundance (ind. m^{-2}) was calculated for the total fauna.

Molluscs are important prey items for Common Scoter and the distribution patterns were to be modelled. Therefore, dimensions, wet weight and dry weight for all taxa of molluscs were measured and the biomass (g wet weight [ww] m^{-2}/g; dry weight [dw] m^{-2}) was calculated.

4.3.3 Habitat modelling

Baseline studies in 2007-2008 in relation to Horns Rev 2 OWF modelled the distribution of prey species to Common Scooter (*Melanitta nigra*) (Skov et al., 2008) Later, as part of environmental monitoring programmes for large scale offshore wind farms in Denmark, The Environmental Group commissioned a special report on wind farm impacts on sea birds and their food resources (Leonhard & Skov, 2012). In these reports, a number of dependent models were developed for measuring the impacts of wind farms. The offshore wind farms covered in the 2012 report are Horns Rev 1 and 2. The original modelling framework in this report consisted of:

- A regional and local **hydrodynamic model**, which delivers input to →
- An **ecological model**, which delivers input to →
- A deterministic **filter-feeder model** and
- A **habitat suitability model**

In the present work at Horns Rev 3, the habitat suitability models are expanded to cover a geographical area, which now includes the planned Horns Rev 3 project area.

Habitat Suitability model

Habitat suitability models were developed on top of the filter-feeder models in order to estimate more precisely the distribution of cut trough shell *Spisula subtruncata* and American razor clams *Ensis directus*. This was done within the frame of habitat suitability modelling, using empirical samples of biomass (trough shells, ash-free dry weight) and abundance (American razor clams, number of individuals) as response variables; and modelled filter-feeder indices, sediment data and data on the depth and relief of the sea floor as predictor variables.

Suitability functions were computed using Ecological Niche Factor Analysis (ENFA) (Hirzel et al., 2002). In suitability functions, the distributions of American razor clams and trough shells in the multivariate oceanographic space encompassed by recorded abundance data are compared with the multivariate space of the whole set of cells in the modelled area (Hirzel, 2001). On the basis of differences in means and variances of the bivalve 'spaces' and the global 'space', marginality of bivalve records was identified by differences to the global mean and specialisation by a lower species variance than global variance. Thus, for large geographical areas like the Horns Rev area of the North Sea studied here, ENFA approaches the concept of ecological niche, defined as a hyper-volume in the multi-dimensional space of ecological variables, within which a species can maintain a viable population.

In the "Food Resources for Common Scoter. Horns Reef Monitoring 2009-2010" report (Leonhard & Skov, 2012), the following nine eco-geographical variables were found to be of significance for the model:

1. The modelled filter-feeder index for each of the two species (averages for the entire growth season from March to November);
2. Modelled sediment structure: median grain size (mm);
3. Modelled sediment structure: proportion (pct.) silt fraction;
4. Modelled sediment structure: proportion (pct.) fine sand fraction;
5. Modelled sediment structure: proportion (pct.) medium sand fraction;
6. Modelled sediment structure: proportion (pct.) coarse sand fraction;
7. Water depth;
8. Slope of the sea floor slope (in %);
9. Complexity of the sea floor calculated for 5x5 kernel: F = (n-1)/(c-1) where n=number of different classes present in the kernel, c= number of cells.

The main focus in relation to the Horns Rev 3 OWF is to expand the model to cover the new area, rather than document year-to-year changes. It was therefore decided not to run filter-feeding models isolated for the year 2013. Instead, index values from the original report were supplemented with values from 2011 and 2012 to calculate mean values for 2001-2012.

Marginality (M) was calculated as the absolute difference between the global mean (Mg) and the mean of the bivalve presence data (Ms) divided by 1.96 standard deviations of the global distribution (g):

$$M = \frac{|\mathrm{M}g - \mathrm{M}s|}{1.96\sigma g},$$

while specialisation (S) was defined as the ratio of the standard deviation of the global distribution to that of the species distribution:

$$S = \frac{\sigma g}{\sigma s}.$$

To take multi-colinearity and interactions among eco-geographical factors into account, indices of marginality and specialisation were estimated by factor analysis. The first component, being the marginality factor, was passed through the centroids of 1) all bivalve presence records and 2) all background cells in the study area. The index of marginality being a measure of the orthogonal distance between the two centroids. Several specialisation factors were successively extracted from the n-1 residual dimensions, ensuring their orthogonality to the marginality factor, while maximising the ratio between the residual variance of the background data and the variances of the bivalve occurrences.

A high specialisation would indicate restricted habitat usage compared to the range of conditions measured in the studied part of Horns Reef. This is obviously highly sensitive to the location and size of study area.

A habitat suitability index was computed on the basis of the marginality factors and the first four specialisation factors. A high proportion of the total variance was explained by the first few factors, by comparison to a broken-stick distribution. The habitat suitability algorithm allocated values to all grid cells in the study area. These values were proportional to the distance between the cells position and the position of the species optimum in factorial space. Habitat suitability computation was done using the medians algorithm.

<u>Sediment models</u>
Besides the 56 sediment samples and 26 infauna samples from the present study, data from a total of 262 samples from the sampling campaigns from Horns Reef 2001-2010 (Skov et al., 2008; Leonhard & Skov, 2012) and data from the Danish national environmental monitoring scheme was used in the models, see Figure 4.3.

Data layers showing the proportion of each seabed type (silt/clay/sand, etc.) were developed from the sediment samples using variogram-based kriging models.

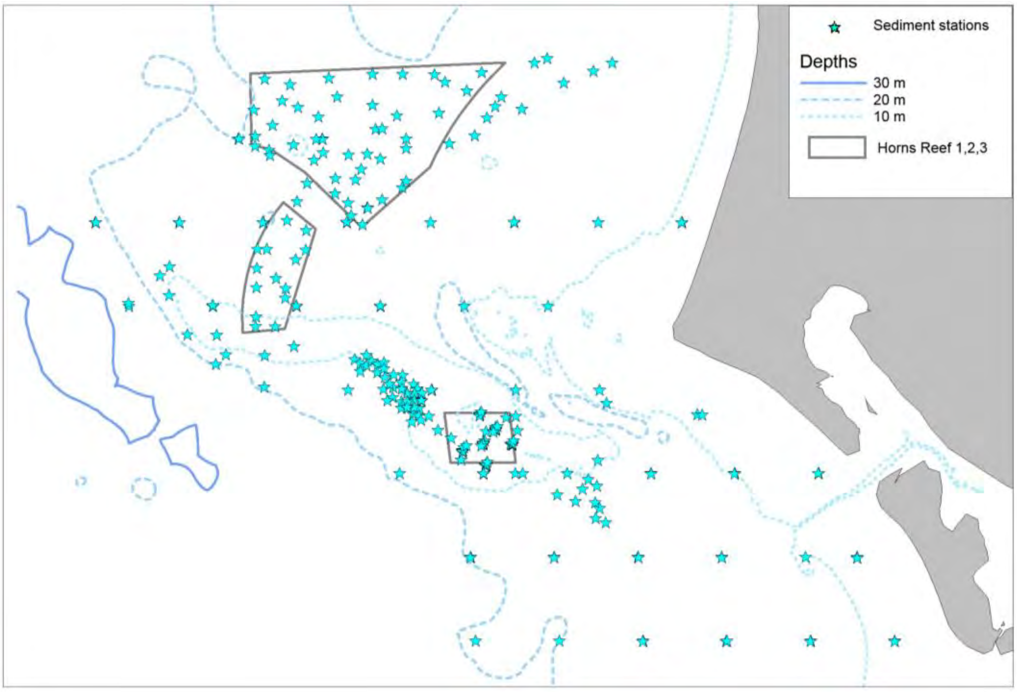


Figure 4.3 Positions of the sediment samples used in the habitat suitability modelling. The samples were taken in previous sample programmes 2001-2010 and in the present study 2012-2013.

The definitions for the seabed types characterised by grain size are shown in Table 4.1.

Table 4.1 Seabed type characterised by grain size.

Seabed type	Grain size (mm)
Silt and clay	< 0.063 mm
Sand, fine	0.063 mm – 0.200 mm
Sand, medium	0.2 mm – 0.6 mm
Sand, coarse	0.6 mm – 2 mm
Gravel	> 2 mm

4.4. Cumulative impacts

The assessment of cumulative impact in relation to the establishment of Horns Rev 3 Offshore Wind Farm are, by definition, impacts that may result from combined or incremental effects of past, present and future developments in the Horns Rev area in the benthic communities.

Past, present and future developments were identified from existing published information and potential impacts to the flora and fauna communities were described and evaluated. Special focus was made to existing OWFs (Horns Rev 1 and 2) and to existing marine sand and aggregate extraction sites, see Chapter 12.

5. EXISTING BENTHOS COMMUNITIES

The existing benthos communities in the Horns Rev 3 project area are presented and placed in a context with the sediment characteristics and biogeography of the study area.

5.1. Sediment characteristics

Within the survey areas, side scan images of the surveyed seafloor 'roughness', as well as 50 sediment samples carried out by GEMS and six combined fauna and sediment stations, indicate that sediments are predominantly sandy.

The sediment surface was visually verified by the ROV investigations, which recorded sandy substrates at all 20 ROV stations within the study area. The placement of ROV stations continued in the sampling grid originating with Horns Rev 1 & 2 OWFs. Some ROV stations were therefore placed outside the project area, and only five ROV stations were inside the current project area for wind turbines, with a further three within, or very close to, the cable corridor.

Presence of substrate subtype 1b (see Table 5.1) was visually verified by ROV at all stations, and the substrates were observed to consists of firm sandy substrates. At most of the verified stations, the seabeds were dynamic, with wave- and current induced sand ripples, sand waves etc.. At many stations, scattered empty shells of trough shells and razor clams were observed in varying densities.

At eight stations (HR3_39b, HR3_33b, HR3_38b, HR3_56, HR3_42, HR3_43 and HR3_55) the sediments were visually assessed to consist of 100 % pure sand. The remaining 12 stations were assessed to consist of 70-99 % sand mixed with other substrates. At 11 stations silt was assessed to compose between 1-30 % of the sediment surface. Inside the pre-investigation area, the two stations with the highest silt content (HR3_47 and HR3_48) were assessed to have 15% and 30% silt content, respectively. This silt content was higher than that any found during grain size analyses of Horns Rev 3 sediment samples. However, the two closest sediment grab samples (AQHR3GS033 and AQHR3GS047) were at respective distances of ~2600m and ~1200 m from HR3_47 and HR3_48. The silt content in the respective samples were analysed to be 1.65% and 1.8%, while the fractions of fine sand were 85% and 89%. Visual distinction between silt and very fine sand particles can be difficult, so it is expected, that the visually verified silt content sometimes overlaps the finer parts of the fine sand fraction.

At one location (HR3_54) in an area of large sand waves, on an otherwise 100% pure sand bottom (substrate type 1b), local areas of gravelly substrate was observed in the troughs. This was visually verified to be substrate type 2, consisting of 75 % sand, 20 % gravel and 5 % small stones and pebbles (2-10 cm).

In combination with the ROV- and sediment verifications, the original side scan mosaic was used to generate a second generation side scan map which is used in substrate- and benthic habitat mapping.

5.1.1 Substrate mapping at Horns Rev

The substrate of the Horns Rev 3 pre-investigation area is shown in Figure 5.1, classified according to a four-tier system described in Table 5.1.

Table 5.1 Substrate types and corresponding substrate descriptions.

Substrate type	Substrate description
1	Can be dynamic and is chiefly composed of fine-grained material from mud to firm sands. Subtypes 1A, 1B and 1C are dominated by silt, sand or clay, respectively. The substrate may contain some (<5%) gravel and very few (<1%) small and large stones (>20mm).
2	Composed chiefly of sand but with varying amounts of gravel (2-20mm) and pebbles/small cobbles (20-100 mm). The substrate may contain some (<1-10%) scattered larger stones (>100mm).
3	Composed of varying amounts of sand, gravel, pebbles/small cobbles as well as larger (>100mm) cobbles and boulders which cover 10-25% of the sea floor. Also includes pebble fields and scatterings of small cobbles.
4	Dominated by cobbles and boulders, from close scatterings to reefs rising from the sea floor, with or without cavity forming elements. Stones cover 25-100% of the bottom. Other substrates may be sand, gravel and pebbles in varying amounts.

The seabed in the Horns Rev 3 pre-investigation area exhibits marine sediments deposited during the Holocene with a thickness of up to approx. 40 m. These generally sandy sediments vary at the seabed surface from gravel to gravelly sand and sand in the southern and western parts of the area, becoming finer in grain size towards the north-east, where the sand also has minor fractions of silt and clay. An area in the central northern parts (northeastern parts of the Horns Rev 3 project area) contains large sand waves/ripples, where sediments are quite coarse.

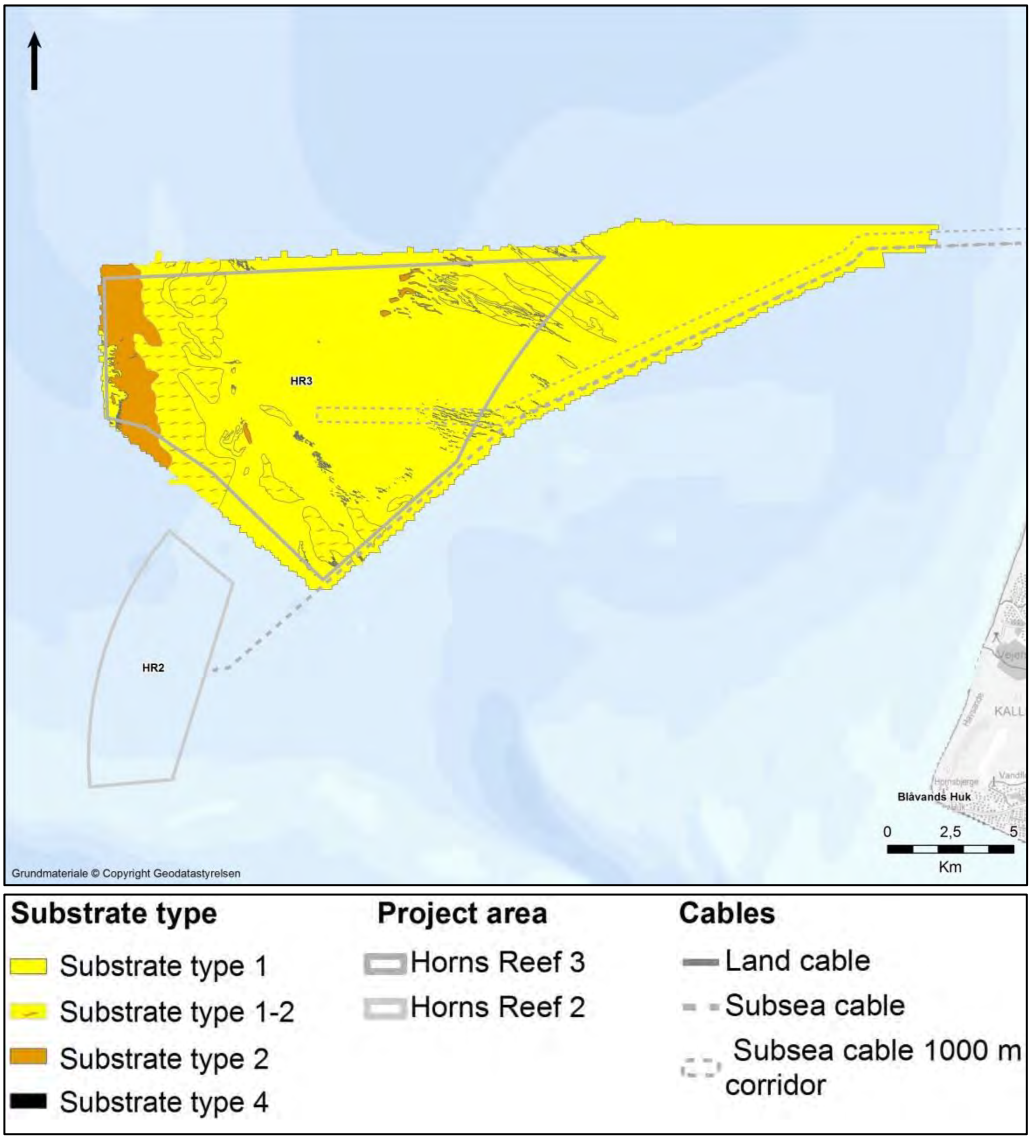


Figure 5.1 Substrate type mapping of the Horns Rev 3 pre-investigation area. The polygon showing the project area for wind turbines is solid grey overlay, the Horns Rev 2 subsea cable is shown with a stippled line and the Horns Rev 3 subsea cable corridor with a stippled polygon..

5.2. Benthic communities

An extensive amount of general literature exists on benthic surveys covering the North Sea, from the historical to the present (Kröncke and Bergfeld, 2001). The data sets from the DANA cruises 1932-1955 (Ursin, 1960; Kirkegaard, 1969; Petersen, 1977) and the results from the survey of Birkett (1953) are valuable historical baselines for community structures of the North Sea benthos. Newer studies also gather data from multiple collaborating parties in countries surrounding the North Sea (e.g. Greenstreet et al. 2007; Kröncke et al. 2011 and Reiss et al. 2010.

As a whole, the fauna in the North Sea is very variable and heterogeneous. It can therefore be difficult to directly compare areas such as Horns Reef with adjacent deeper areas or other sandbanks which are situated elsewhere in the North Sea (Vanosmael et al., 1982; Salzwedel et al., 1985; Degraer et al., 1999). Local faunal communities can also display high variability in spatial and temporal distribution patterns (Neumann et al. 2009).

Studies of species distributions and assemblages of North Sea benthic infauna have, however, separated the infauna into several assemblages, which occur over large spatial scales (Künitzer et al., 1992; Heip & Craeymeersch, 1995). In relation to the present study, it is notable that:

- Assemblages on fine sand (indicator species: *Amphiura filiformis*, *Pholoe* sp., *Phoronis* sp., *Mysella bidentata*, *Harpinia antennaria*, *Cylichna cylindracea*, *Nephtys hombergi*) can be separated from those on coarser sediment.
- Stations north-west of Denmark (indicator species: *Aonides paucibranchiata*, *Phoxocephalus holbolli*, *Pisione remota*) are separated from stations on coarser sediment (indicator species: *Nephtys cirrosa*, *Echinocardium cordatum*, *Urothoe poseidonis*).
- On fine sand, the species: *Aricidea minuta*, *Bathyporeia elegans* and *Ophelia borealis* occur all over the North Sea, while the species: *Bathyporeia guilliamsoniana*, *Fabulina fabula*, *Urothoe poseidonis* and *Sigalion mathildae* are only found in the southern North Sea on fine sand at depths less than 30 m

Infaunal and epifaunal species diversity is highest in the northern parts of the North Sea, and generally quite low in the area around Blåvands Huk, see Figure 5.2. While, the abundances of infauna and - particularly so - epifauna are generally higher in the southern parts of the North Sea, see Figure 5.3.

Large scale faunal community patterns and distributions are thus fairly well established, though little specific data is available from more regional shallow sand bank areas, such as Horns Rev. The Horns Rev 3 project area contains both fine sandy sediments and areas of coarser sands and gravel. This is also reflected in the composition of the benthic communities.

The communities show similarities, but also some differences, to the communities previously described at the Horns Rev 1&2 OWFs. Existing data from studies relating to these OWFs include comprehensive datasets on the benthos communities at Horns Rev. Data has been made available through the PSO programmes in connection with monitoring of impacts from the establishment of Horns Rev 1 OWF (Leonhard & Pedersen, 2006). Data was also collected in relation to the EIA for Horns Rev 2 OWF (Leonhard, 2006).

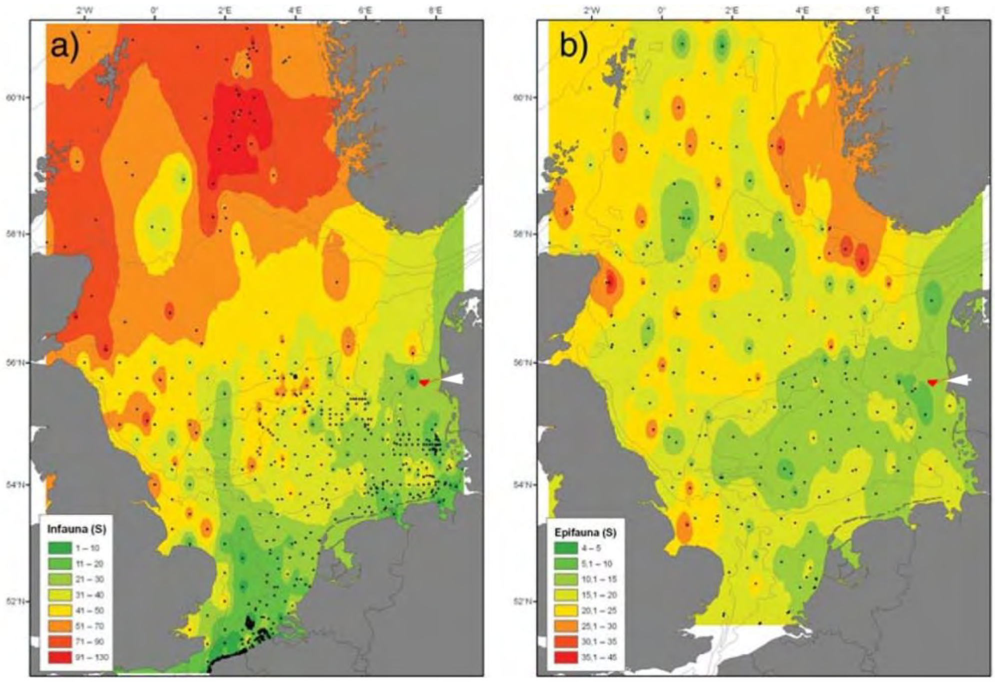


Figure 5.2 Number of species in parts of the North Sea. *Left::* Infaunal species, *Right::* Epifaunal species.Horns Rev 3 project area added in red next to white arrowhead (Modified from Reiss et al., 2010).

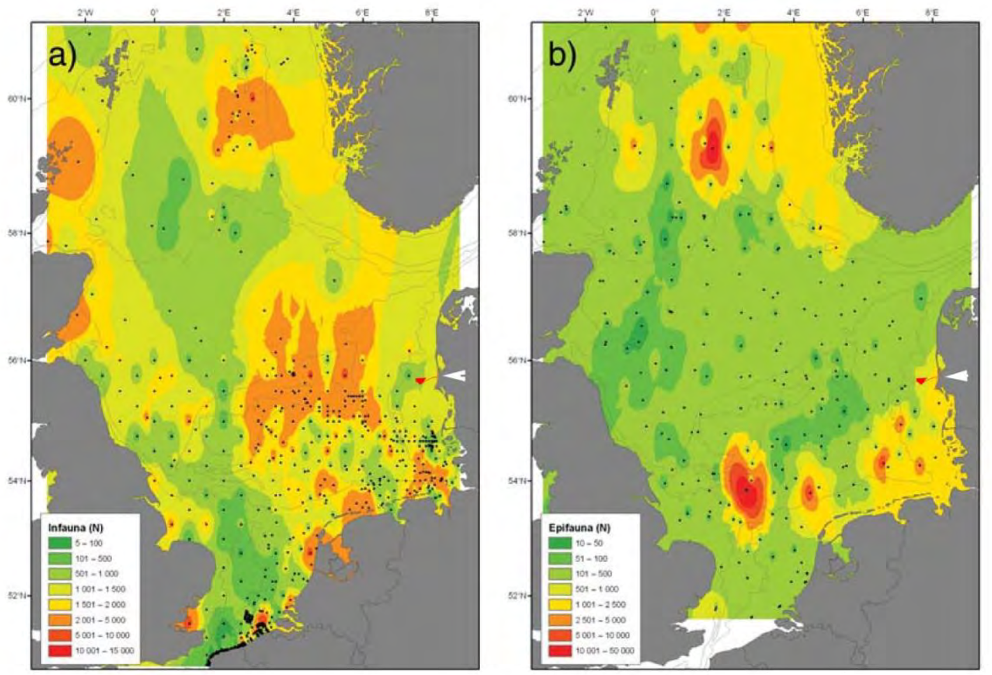


Figure 5.3 Abundance of infauna and epifauna in parts of the North Sea. *Left::* Infaunal species (ind./m^2), *Right::* Epifaunal species (ind./$500m^2$). Horns Rev 3 project area added in red next to white arrowhead (Modified from: Reiss et al. 2010).

5.2.1 Population ecology and habitat type distribution at Horns Reef

The native fauna composition at Horns Rev displays similarity to the fauna found on other sublittoral sandbanks in comparable areas the North Sea. The strongest similarity is to benthos communities described in shallow coastal waters, where sediments consist of pure medium-coarse sand with similar turbulent sea bottom conditions and low organic content in the sediment.

The benthic community at Horns Reef is generally characterised by lower diversity, abundance and biomass compared to adjacent areas where the bottom conditions are less unstable and the sediment has a higher content of fine sand and organic material (Leonhard, 2000). The faunal communities in areas such as Horns Reef can be described as the *Ophelia borealis* community (Dewarumez et al., 1992) or, as more commonly referred to, as the *Goniadella-Spisula* community (Kingston and Rachor, 1982; Salzwedel et al., 1985).

In the *Goniadella-Spisula* community, some of the characteristic species are the bristle worms *Goniadella bobretzkii* and *Ophelia borealis* as well as the bivalve thick trough shell (*Spisula solida*). The two latter species are important contributors to the collective biomass of the resident communities, mainly due to their relatively large body sizes.

In studies for the Horns Rev 2 OWF, the above-mentioned species together with other notable bristle worm species (*Pisione remota* and *Orbinia sertulata*) and the small mussel *Goodallia triangularis*, were found to be relatively uniform in terms of abundance and biomass dominance. These species were also used as indicator organisms for environmental changes in the established wind farm area at Horns Rev 1 Offshore Wind Farm (Leonhard and Pedersen, 2006).

In the Horns Rev 3 study area, indicator species for the *Goniadella-Spisula* community were abundant in the form of *Ophelia borealis*, *Spisula solida* (and *S. subtruncata*), while *Goniadella bobretzkii* was only recovered at a single station. Other common infaunal species in the area, which are indicative of the *Venus* (*Chamelea gallina*) community, were the bivalves *Angulus fabula*, *Chamelea gallina* and *Ensis directus*, the bristle worm *Magelona mirabilis* and the echinoderms *Echinocardium cordatum* and *Ophiura ophiura*. Many stations in the study area, also showed evidence of the *Lanice conchilega* community, indicated by presence of the sand mason worm (*L. conchilega*). More generalist species such as the crustacean *Bathyporeia* sp., and the bristleworms *Nephtys* spp. and *Scoloplos armiger* were also common.

5.2.2 Species distribution patterns in the wind farm area

Below, are given descriptions of the benthic infaunal and epifaunal species found in present study area.

<u>Infauna</u> species were recorded from 26 faunal grab samples. From these samples, 1579 recovered specimens were identified to lowest taxonomic level possible. In Fig-

ure 5.4 and Figure 5.5, the distributions of identified taxa and of individual specimens belonging to each grouping are shown.

The total number of taxa recovered in the samples was 64. As can be seen in Figure 5.4, the most diverse faunal groups were the bristle worms and the molluscs, which combined accounted for over 75 % of all recorded taxa.

Likewise in Figure 5.5, the same two faunal groups accounted for almost 75 % of the recovered specimens in the samples.

Individual taxa and number of specimens is listed in Table 5.2, and a detailed species list is available in Appendix 3.

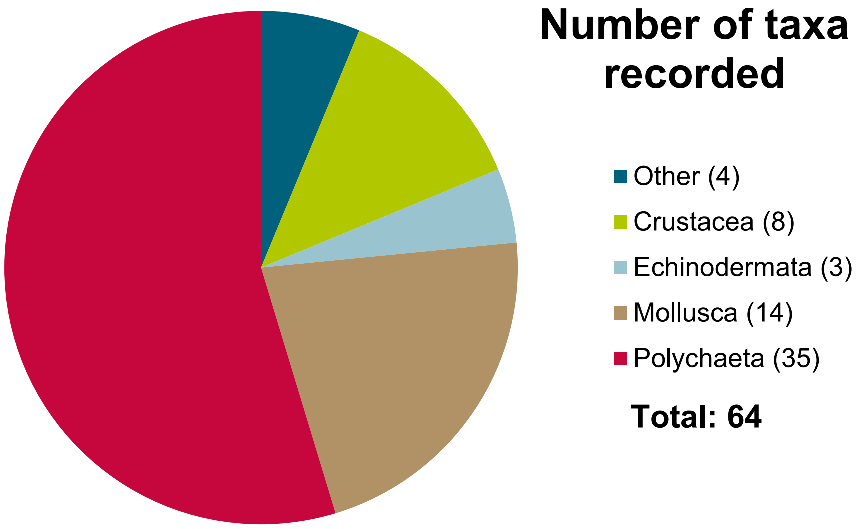


Figure 5.4 Distribution of faunal taxa in the grab samples.

Lanice conchilega and razor clams

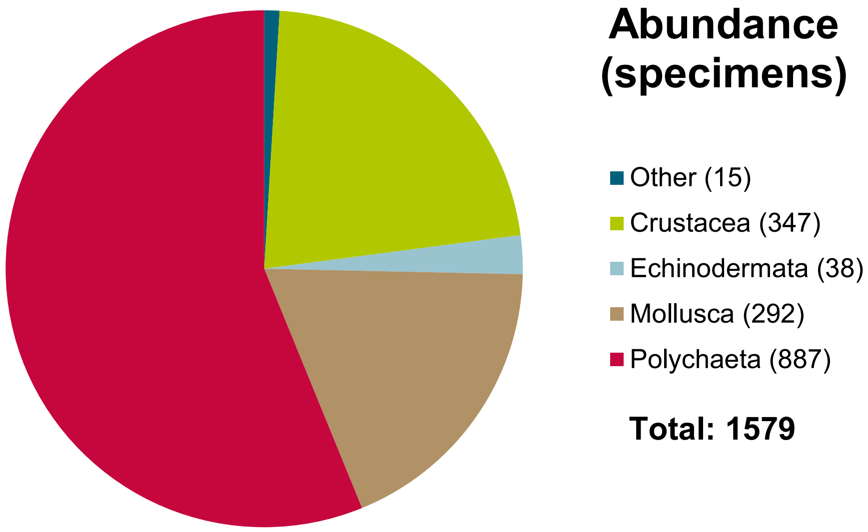


Figure 5.5 Distribution of individual specimens from the grab samples.

American razor clam

Table 5.2 Infaunal species and specimens in fauna samples from 26 stations.

Taxon name	Individuals	Taxon name	Individuals
Other taxa	**15**	**Polychaeta**	**887**
Anthozoa indet.	1	*Aonides paucibranchiata*	15
Branchiostoma lanceolatum	2	*Capitella* sp.	4
Nemertinea indet.	9	*Chaetozone* sp.	33
Phoronis sp.	3	*Eteone foliosa*	7
Crustacea	**346**	*Eteone longa*	1
Ampelisca sp.	17	*Eulalia* sp.	1
Bathyporeia sp.	274	*Eumida sanguinea*	4
Cumacea indet.	2	*Euzonus flabelligerus*	1
Liocarcinus sp.	2	*Goniada maculata*	17
Monoculodes carinatus	13	*Goniadella bobretski*	7
Pagurus bernhardus	2	*Harmothoe lunulata*	2
Urothoe grimaldii	36	*Lanice conchilega*	36
Echinodermata	**39**	*Magelona mirabilis*	243
Echinocardium cordatum	15	*Mediomastus* sp.	7
Ophiura sp.	19	*Nephtys assimilis*	11
Ophiura ophiura	5	*Nephtys caeca*	18
Mollusca	**292**	*Nephtys cirrosa*	33
Abra nitida	19	*Nephtys hombergi*	37
Angulus fabula	180	*Nephtys longosetosa*	1
Bivalvia indet.	1	*Nephtys* sp.	62
Chamelea gallina	4	*Notomastus latericeus*	45
Cylichna cylindracea	1	*Ophelia borealis*	106
Ensis directus	13	*Owenia fusiformis*	7
Kurtiella bidentata	20	*Pectinaria koreni*	6
Lunatia intermedia	6	*Pholoe baltica*	2
Mactra stultorum	2	*Phyllodoce rosea*	1
Nucula nitidosa	21	*Poecilochaetus serpens*	2
Spisula solida	1	*Polydora caeca*	1
Spisula subtruncata	17	*Scolelepis bonnieri*	6
Tellimya feruginosa	6	*Scoloplos armiger*	130
Thracia phaeseolina	1	*Sigalion mathildae*	5
		Spio armata	1
		Spio sp.	5
		Spiophanes bombyx	29
		Travisia forbesii	1
		Total	**1579**

Of the 26 faunal stations, six samples (HR3-1 to HR3-6, see placements in Figure 4.2) were taken at the same time as sediment samples for grain distribution analysis. The percentile distributions of size fractions for materials < 2 mm are shown below in Table 5.3 and Figure 5.6.

Table 5.3 Grain size distribution for six stations where faunal samples were also taken. Blue cells are most abundant fraction, brown cells are second-most abundant fraction.

Particle size fraction (mm)	Substrate description	HR 3-1 (%)	HR 3-2 (%)	HR 3-3 (%)	HR 3-4 (%)	HR 3-5 (%)	HR 3-6 (%)
<0.063	Silt and clay	0.57	0.58	1.07	0.42	0.62	1.36
0.063 - 0.200	Sand, fine	3.33	12.27	47.70	4.79	70.51	91.53
0.2 - 0.6	Sand, medium	89.57	85.71	49.51	72.50	28.31	6.90
0.6 – 2	Sand, coarse	6.37	1.44	1.55	22.03	0.56	0.18
>2	Gravel	0.16	0.00	0.17	0.27	0.00	0.03

While the number of concomitantly collected fauna and sediment data is too small for statistical analysis, some trends are noticeable regarding the sediment preferences of key species found in these six samples.

The bristle worm species, *Scoloplos armiger*, does not occur in the two samples with the coarsest grain size distributions (HR3-1 and HR3-4), which are the only two samples where coarse sand (0.6-2.0 mm) are among the two most common grain sizes. While *Scoloplos Armiger* does occur in clean, slightly coarser sandy substrates, the species is more common in the slightly finer mixed substrates. Another bristle worm, *Magelona mirabilis*, was found to be even less critical in sediment preference. It is most common in clean, slightly finer sandy substrates, but also occurs in slightly coarser sediments. This was also the case in the present study where *M. mirabilis* occurs in both fine-grained and coarse-grained substrates.

The bristle worm *Nephthys assimilis,* which is known to prefer fine sandy substrates with some silt and clay content, occurs only in the two samples with a predominance of fine grained (0.063-0.200mm) sediment and no coarse sand (Samples HR3-5 and HR3-6). The mussel *Angulus fabula* occurs only in the three samples which contain roughly 50% or more of fine sand, and were not found in the samples with coarse sands.

Conversely, bristle worms of the genus *Spio* and the species *Ophelia borealis*, which are indicators of clean, preferably coarse, sandy sediments, occur only in samples HR3-1 and HR3-4, which are the only two samples with substantial fractions of coarse sand.

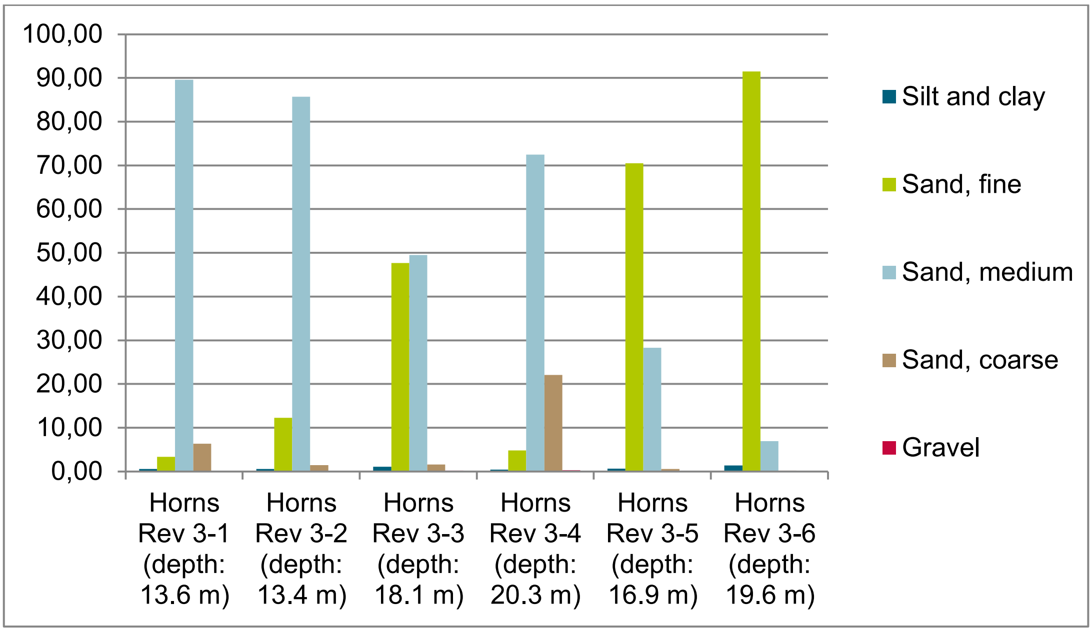


Figure 5.6 Sediment grain size distribution at the six sampled stations. As can be seen, the dominating sediment fraction is fine to medium sand.

These trends also hold when species data from all fauna grab samples containing the above species are compared to the mapped substrates in the vicinity of the sampling positions. All stations where at least one of the more mixed sediment indicating species *Scoloplos armiger* and *Magelona mirabilis* were found are plotted onto a map of the study area, see Figure 5.7. The species can be seen to occur on many stations in the study area spanning both fine and coarse substrates.

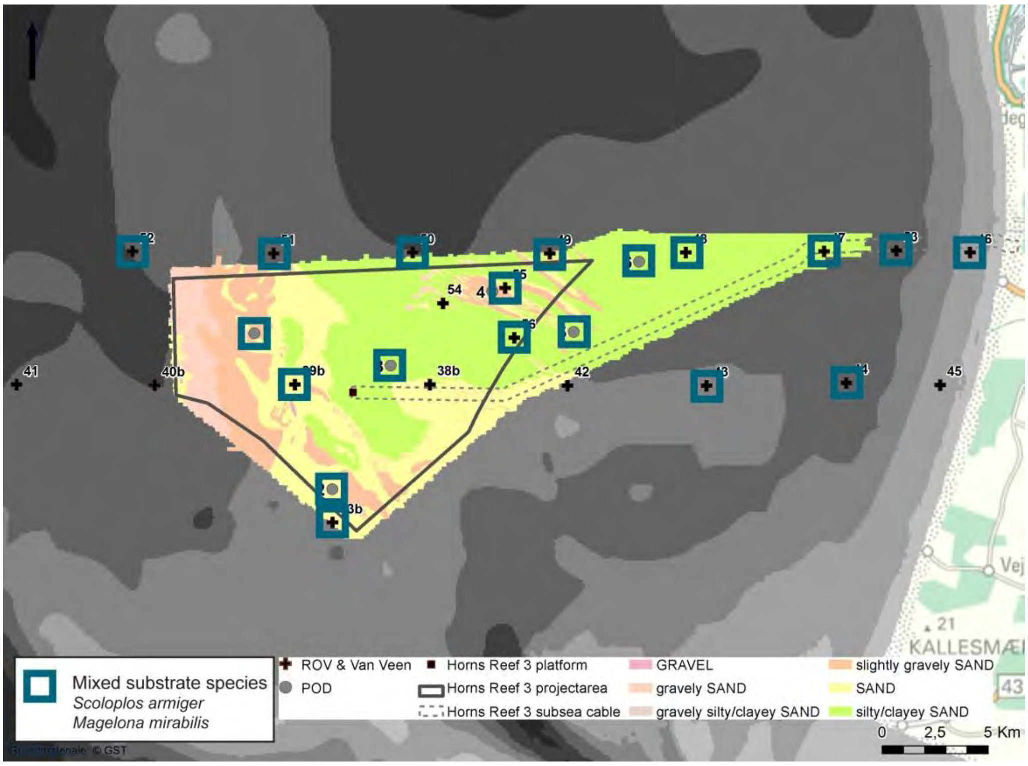


Figure 5.7 Distribution of faunal samples with the mixed sediment indicators *Scoloplos armiga* and *Magelona mirabilis* (petroleum blue boxes).

On the map of the study area in Figure 5.8, all stations are plotted where at least one of the fine sediment indicating species *Angulus fabula* and *Nephthys assimilis*, or the coarser sediment indicating *Ophelia borealis* and *Spio* sp. occur. Overall, *Angulus fabula* and *Nephthys assimilis* are shown to match the areas of silty/clayey sand well while *Ophelia borealis* and *Spio* sp. match the coarser sediments.

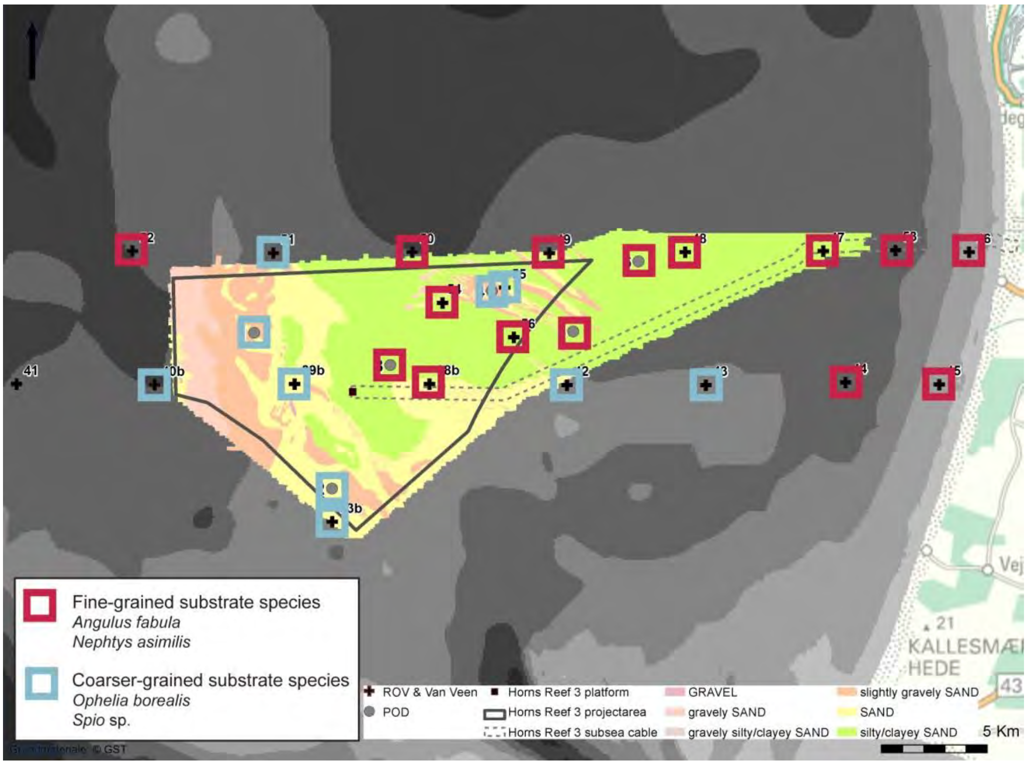


Figure 5.8 Distribution of faunal samples with the fine sediment indicators *Angulus fabula* and *Nephtys asimilis* (red boxes) and the coarser sediment indicators *Ophelia borealis* and *Spio* sp. (blue boxes).

Epifauna was recorded at 20 stations with ROV during the present survey. No flora was observed to be attached to the substrate during the ROV-investigations. However, several epibenthic faunal species were observed. General seafloor coverage of epifauna varied from <1% to 10% at individual stations, but was often within the interval 2-4%. The cover of fauna related to 100% pure sand was <1 -6 % which was slightly less than on the silty substrates.

Overall, the faunal assemblages were found to be quite homogenous across the 20 observed stations. Tubes from sand mason worms were observed at 13 out of 20 sites, and other frequently occurring epifaunal taxa included common hermit crab, common starfish, brittle stars and various gobies. Indirect evidence of the infaunal mollusc American razor clam was frequently seen in the form of empty shells, but was also observed by siphon holes and in a few cases; individuals on the sediment surface.

Vegetation was not observed at any of the stations, which is primarily considered to be due to lack of suitable hard substrates for adherence.

Overall, the benthic taxa observed by ROV were:

- **Cnidaria - cnidarians**
  - *Clava multicornis* – Club-headed hydroid
  - *Urticina felina* – Dahlia anemone
- **Crustacea - crustaceans**
  - *Pagurus bernhardus* – Common hermit crab
  - *Crangon crangon* – Brown shrimp
  - *Carcinus maenas* – Common shore crab (dead)
- **Echinodermata - echinoderms**
  - *Asterias rubens* – Common starfish
  - *Luidia sarsii*
  - *Ophiura* sp.
- **Mollusca - molluscs**
  - *Ensis directus* – American razor clam (shells, holes and clams)
- **Pisces - fish**
  - *Limanda limanda* – Common dab
  - Gobiidae spp. – Gobies (indeterminate)
  - *Ammodytes tobianus* – Lesser sand eel
  - Pleuronectidae spp. – flatfish (indeterminate)
- **Polychaeta - bristle worms**
  - *Lanice conchilega* – Sand mason worm (tubes)
  - *Phyllodoce groenlandica*

5.2.3 Habitat mapping at Horns Rev 3 project area

Differing proportions of fine, medium coarse and coarse sand within the study area does effect the distribution of some infaunal species. However, habitats are often viewed on a larger scale, where more pronounced differences in substrate composition can serve as habitats for very different faunal assemblages.

The various substrates indicated by the substrate mapping can be used to indicate which habitats are present in the study area, and which assemblages of species can be expected to occur within these habitats in the Horns Rev 3 project area. An overview of general benthic habitat types is given in Table 5.4.

Table 5.4 Habitat types and corresponding sediment descriptions.

Habitat type	Habitat description
1	The most common habitat type in the Horns Rev 3 project area is a habitat dominated by fine to coarse sand (substrate subtype 1B). Even in the photic zone, very few macro algae are present. If present, algae will mostly be annual species such as *Polysiphonia* sp. and *Ceramium* sp. The habitat is generally well suited for infauna, such as burrowing bivalves and polychaetes, but also contains generalist species such as *Pagurus bernhardus*, *Carcinus maenas* and *Asterias rubens*.
2	Contains species similar to habitat type 1, but also some species associated with coarser substrates. If within the photic zone, some macro algae, such as the annual species *Polysiphonia* sp. and *Ceramium* sp. as well as scattered brown algae may be present. Common invertebrate species found in the Horns Rev 3 project area could be: *Pagurus bernhardus*, *Carcinus maenas* and *Asterias rubens*, *Urticina felina, Ophelia borealis* and members of the genus *Spio*.
3	Not found in the Horns Rev 3 project area during present study. Contains species similar to above habitat types, but more species associated with hard substrates may be present. Within the photic zone, perennial macro algae species such as delesseriacids and kelps may be abundant. Invertebrate hard substrate species could be Porifera sp., *Balanus sp., Urticina felina*, *Metridium senile*, *Promatoceros triqueter* and *Cancer pagurus.*
4	Generally high diversity. Contains species similar to other habitat types, but may also have many species associated with hard substrates. If within the photic zone the hard substrates can be dominated by layered growths of perennial macro algae species such as delesseriacids and kelps, with an undergrowth of many red algae species. If below the photic zone, the hard substrate may be dominated by suspension feeders such as *Alcyonium digitatum*, *Urticina felina* and *Metridium senile.* Other invertebrate species could be *Promatoceros triqueter*, *Cancer pagurus*, Porifera sp., *Balanus sp.* and *Homarus gammarus*.

As can be seen in Figure 5.9, the habitats are predominantly habitat type 1 (sandy), with small areas along the northern and western borders, which contain habitat type 2 (slightly coarser).The species expected in the study area will be infaunal taxa connected to these habitats, as well as generalist epifaunal species.

The only occurrence of habitat type 4 is an ‘artificial reef’ in the south-western corner, which is formed by a sunken barge with a cargo of stones.

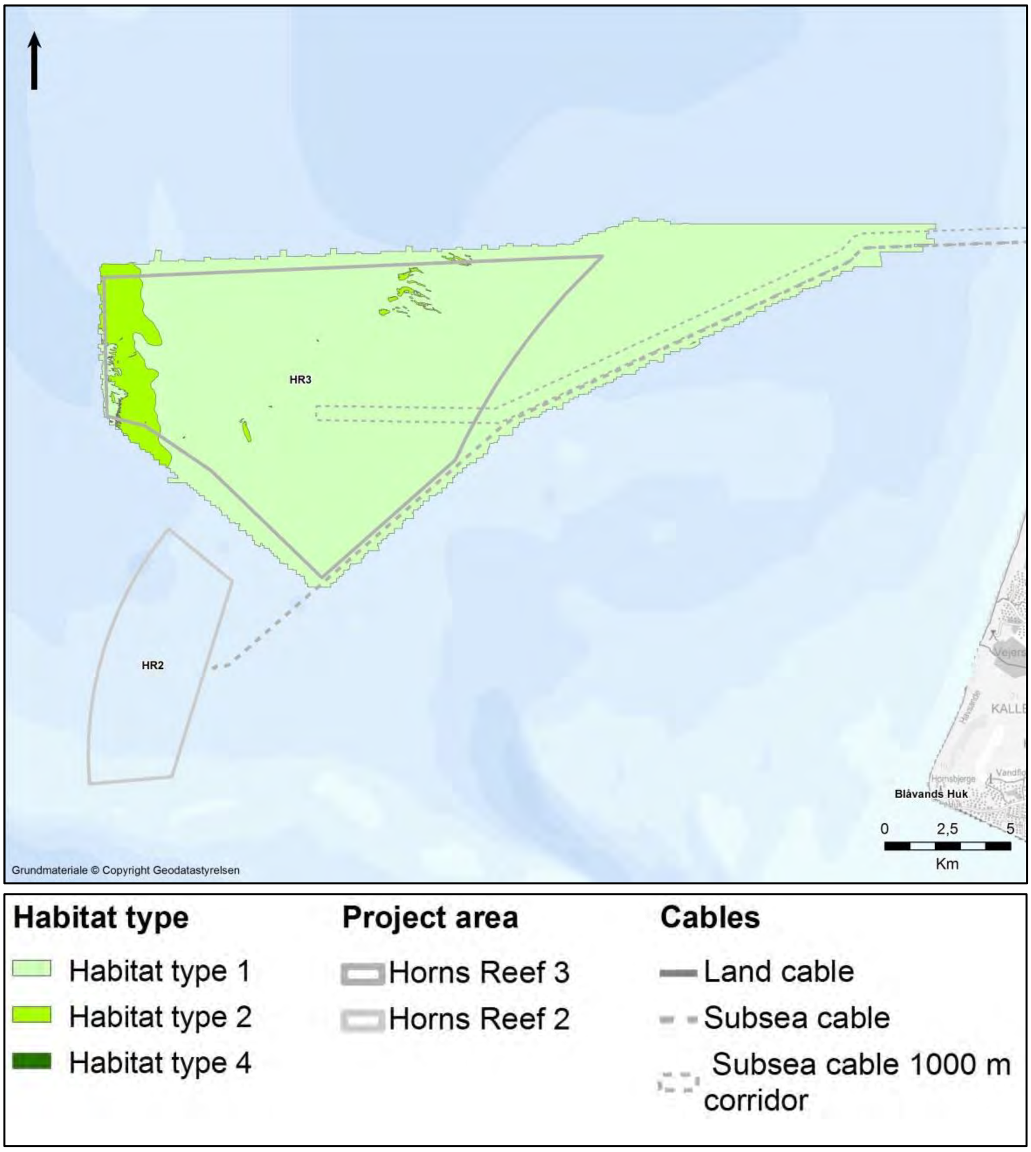


Figure 5.9 Habitat type mapping of the Horns Rev 3 pre-investigation area.

5.3. Influence of present fishing activities

At present, the Horns Rev 3 project area is used for some commercial fishery. At some times of the year, beam trawling and bottom trawling is quite common in the Horns Rev 3 project area. Bottom trawling primarily tagets sandeel and beam trawling primarily targets brown shrimp. Seine nets are used to a lesser extent west of Hvide Sande, but not within the project area. Gill nets are more common in the waters west and north of the project area, although a few have been recorded in the western parts hereof. Pelagic trawling occurs along the western part of Horns Reef, west of Hvide Sande and in the western parts of the project area. For further details of fisheries, consult the technical report (Orbicon, 2014b).

The fisheries most likely to influence the invertebrate communities of the Horns Rev 3 project area are bottom trawling and beam trawling. Intensity maps based on VMS-data (2005-2012) for vessels < 15m length (< 12m length since 2012) conducting beam trawling and bottom trawling are shown in Figure 5.10 and Figure 5.11.

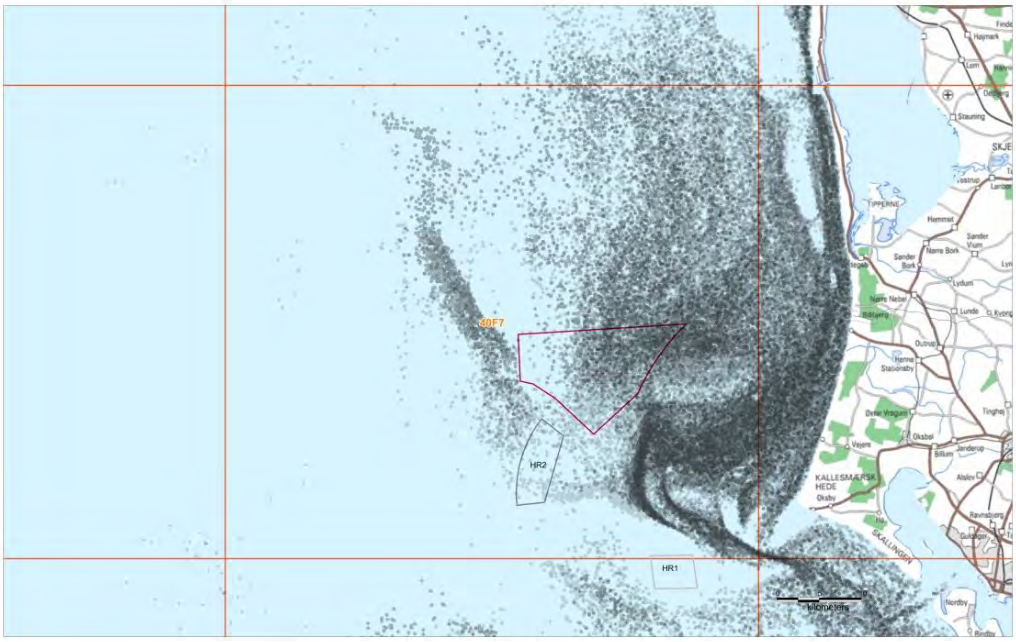


Figure 5.10 Beam trawling primarily targets brown shrimp in central and eastern parts of the Horns Rev 3 project area.

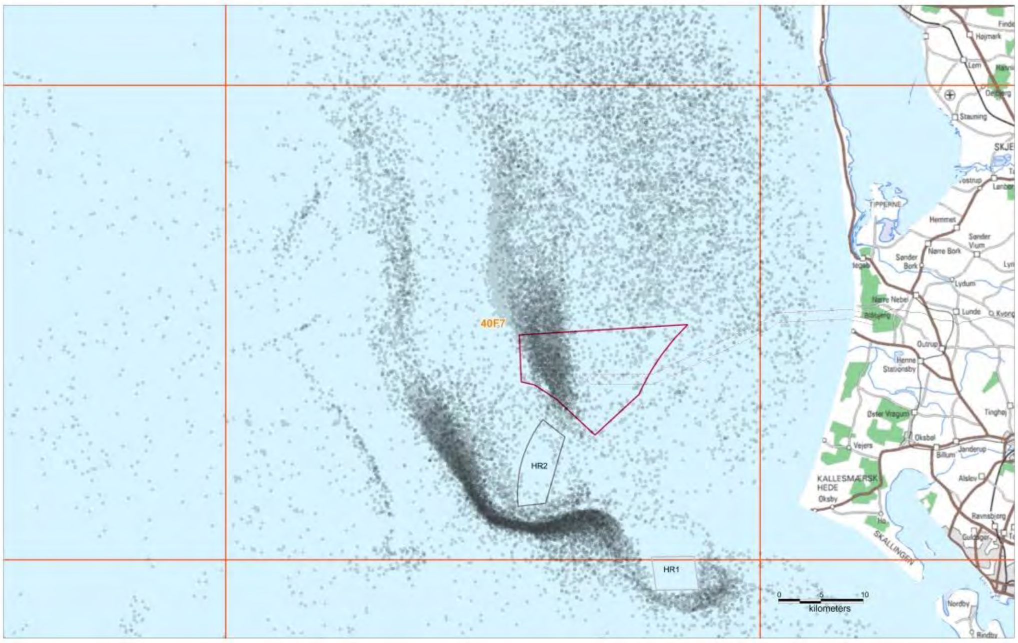


Figure 5.11 Bottom trawling primarily targets sandeels in the western parts of the Horns Rev 3 project area.

6. MODELLING OF BIVALVIA FOURAGING RESOURCES FOR COMMON SCOTER

6.1. Sediment

The Horns Reef area as a whole is generally characterised by fine to medium sand, see Figure 6.1. The finer sand fractions seem to be distributed toward the coast, whereas the coarser sediments are more frequently found in the western and northern parts of the area.

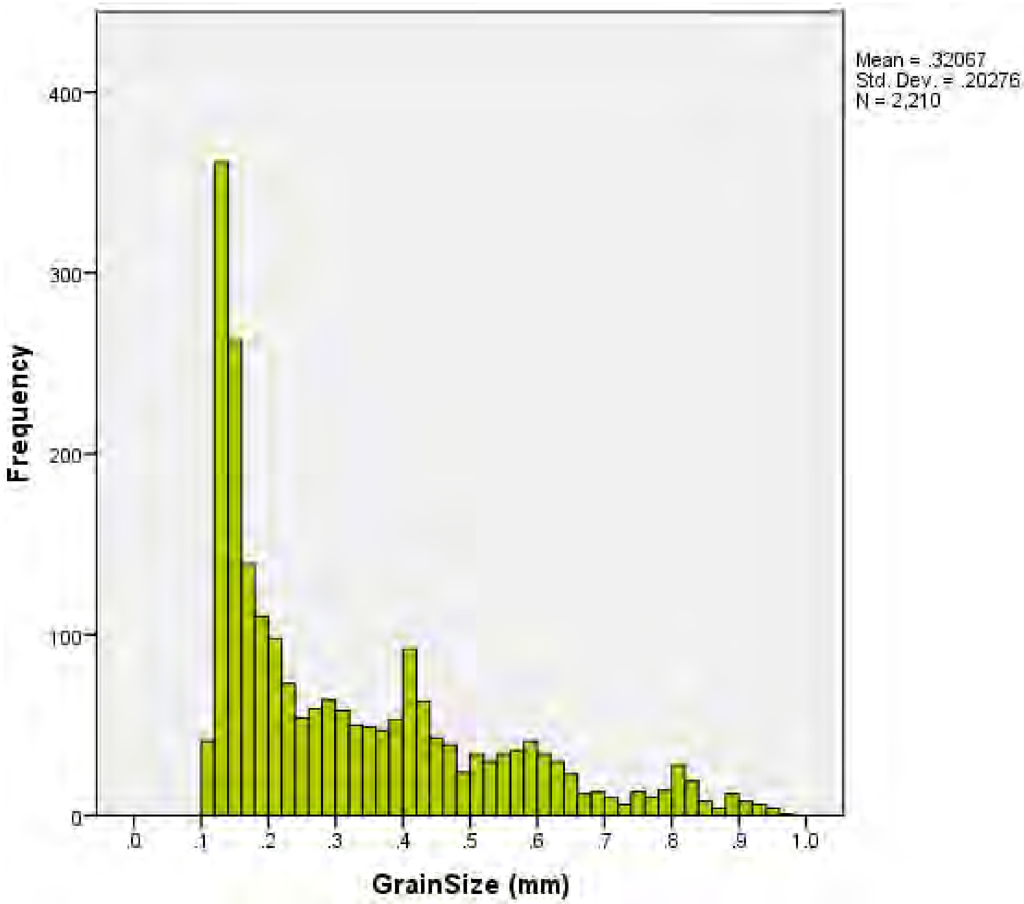


Figure 6.1 Median grain size frequencies based on modelled grain size distribution in the Horn Reef area.

The sediment in the Horns Rev 3 project area is generally a little coarser than many other parts of the modelled area. The average grain size for the whole modelled Horns Reef area is 0.32 mm versus 0.45 mm specifically in the Horns Rev 3 project area. In Figure 6.2 is shown a map of the median grain size (mm) of sediment for the Horns Reef area. It can be seen that median grain size increases in a north-westerly direction through the area.

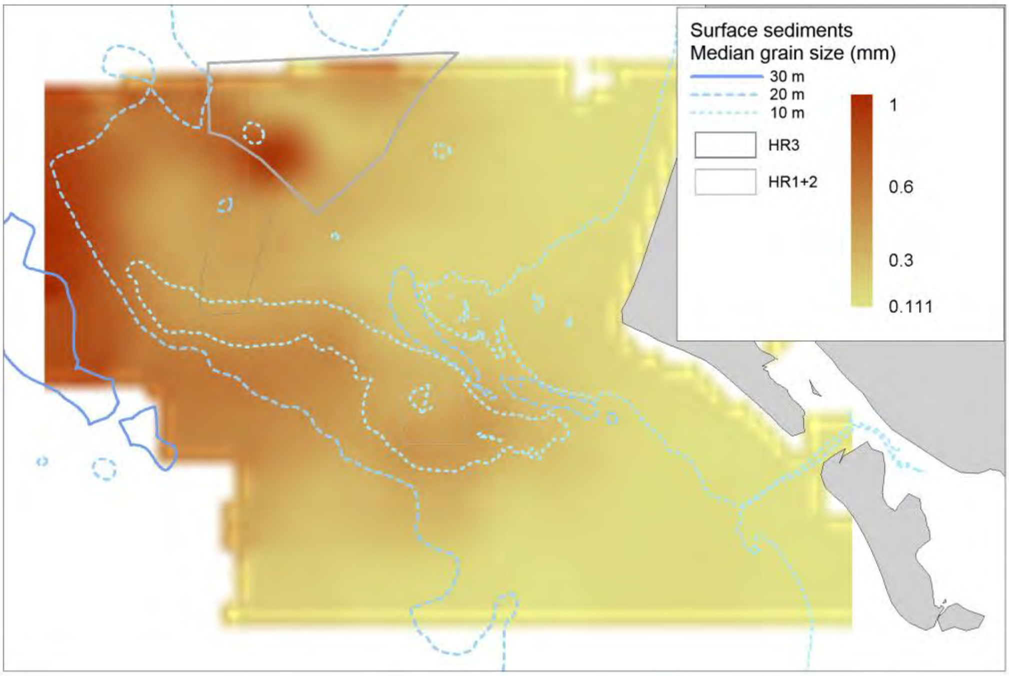


Figure 6.2 Modelled grain size distribution of sediments in the Horns Reef area. Data from 2000-2013

The fraction of silt and clay for Horns Reef sediments is shown as a percentage of the sediment in Figure 6.3. The highest percentages, at 3 – 4 %, are found close to the coast, while the fraction of silt and clay in the Horns Rev 3 project area is 1.1%-1.5%.

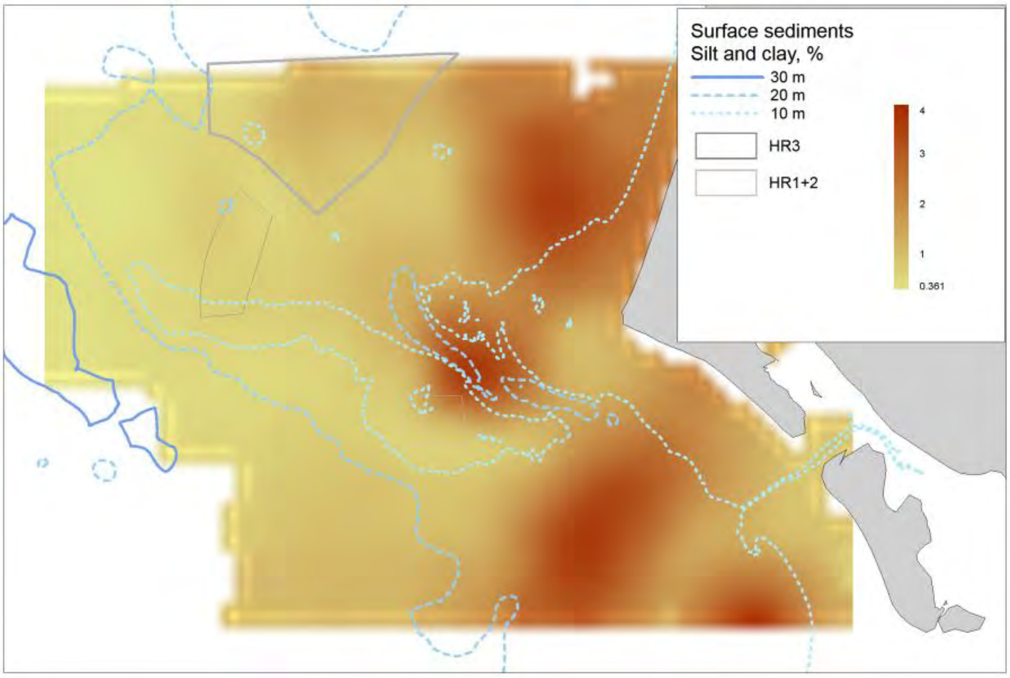


Figure 6.3 Modelled distribution of the silt & clay fraction in the Horns Reef area. Data from 2000-2013

6.2. Habitat suitability model for cut trough shell.

Cut trough shell *Spisula subtruncata*, the potential prey species for Common Scoter is highly patchy in terms of distribution and biomass in the Horns Reef area. This is partly a result of the high variability in seabed texture and morphology.

The cut trough shell appears to have a preference for more silty sediments with grain size of less than 0.15 mm. Areas with high trough shell biomasses and abundances were found further inshore of the Horns Reef area (Leonhard & Skov, 2012), where the sediments consist of sand with higher silt content. The highest abundance and biomass was found south of Horns Rev, see Figure 6.4.

The affinity of cut trough shells for silty, fine sediment, sloping seabed and low water depth is further strengthened by the habitat suitability model (Table 6.1). The model further showed an avoidance of areas with medium and coarse sand. Compared to seabed topography, the sediment characteristics were far more important than food supply (FF Index) in shaping the habitat of cut trough shells (Table 6.1).

Application of ENFA for data from 2001-2013 provided an overall marginality of m = 1.21 and an overall specialisation value of S = 16.22 for cut trough shells. This shows that the Horns Reef habitats for the species differed markedly from the mean conditions in the modelled part of the North Sea.

Table 6.1 ENFA results for cut trough shell (*Spisula subtruncata*). Coefficients of marginality and four first specialisation factors (2001-2013) are shown.

Environmental variable	Marginality	Specialisation Factor 1	Specialisation Factor 2	Specialisation Factor 3	Specialisation Factor 4
Water depth	0.279	-0.032	0.023	-0.153	0.686
Slope of bottom	-0.121	0.004	-0.046	-0.5	-0.218
FF index	-0.253	0.011	-0.083	-0.214	0.414
Median Grain size	-0.362	0.665	-0.116	-0.225	0.207
Pct. Coarse sand	-0.346	-0.702	-0.696	-0.272	0.142
Pct. Fine sand	0.493	-0.16	0.05	-0.715	-0.37
Pct. Medium sand	-0.49	-0.195	0.699	-0.21	-0.302
Pct. Silt and clay	0.33	-0.02	0.007	0.005	0.137

The five factors retained accounted for more than 99.8% of the sum of the eigenvalues (100% of the marginalisation and 98% of the specialisation). Marginality accounted for 87% in cut trough shells, indicating that the species is relatively restricted in the range of conditions it utilises in the study area.

The marginality and specialisation scores lead to habitat suitability scores ranging from 0-100, the upper 33 tiers reflecting a suitable habitat (Figure 6.4). The pixels indicating high habitat suitability for trough shells are confined to the area of silty and fine sediments in the south-eastern and eastern-most part. The areas closest to the coast are estimated as unsuitable primarily on account of lower carrying capacity index values.

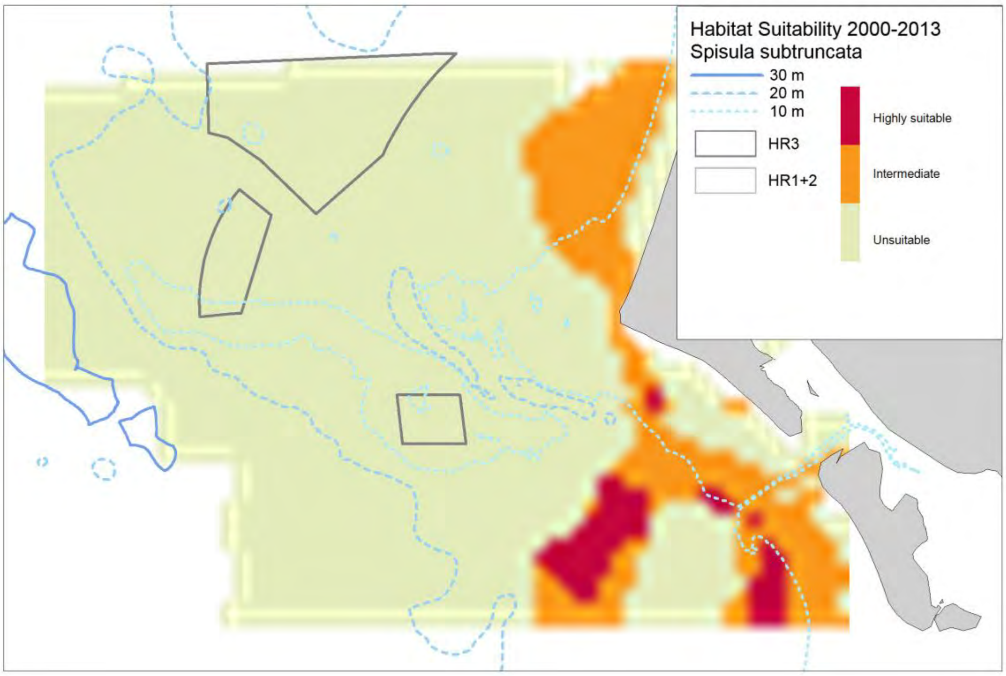


Figure 6.4 Modelled habitat suitability for cut trough shell (*Spisula subtruncata*) based on data from 2001-2013.

6.3. Habitat suitability model for American razor clam

American razor clam *Ensis directus*, another potential prey species for Common Scoter is also very patchy in terms of distribution and biomass in the Horns Reef area. This is partly a result of the high variability in seabed texture and morphology.

The American razor clam seems to be most abundant along the southern edge of Horns Reef, in areas with steep slopes, see Figure 6.5. The clams also seems to have a scattered distribution off the coast, along the 10 m depth curve (Leonhard & Skov, 2012).

A rather clear separation between the habitat preferences between the cut trough shell and the American razor clam seems to exist. The American razor clam appears to prefer sediment with grain sizes between 0.15mm and 0.6 mm, while no clear preferences for silty sediments were found. In general, the abundance and biomass of the American razor clam was higher in the northern part of the Horns Reef area (maximum values of 740 ind./m^2 and 732 g/m^2, respectively) compared to the southern part.

Areas with high habitat suitability were predicted far away from the coast in a well-defined region extending north-westwards from the Horns Rev 1 OWF to the Horns Rev 2 and 3 OWFs, out to the 20 m depth curve (Figure 6.5). The habitat suitability model documented that American razor clams have a strong affinity to medium coarse sediments (Table 6.2). The model also showed an avoidance of areas with silty and fine sand, which is almost a completely opposite habitat preference compared to cut trough shells.

Table 6.2 ENFA results for American razor clam (*Ensis directus*). Coefficients of marginality and four first specialisation factors 2001-2013 are shown.

Environmental variable	Marginal-ity	Speciali-sation Factor 1	Speciali-sation Factor 2	Speciali-sation Factor 3	Speciali-sation Factor 4
Water depth	0.025	-0.076	0.421	-0.352	0.012
Slope of bottom	0.181	0.027	-0.12	-0.099	0.117
FF index	0.218	-0.412	0.052	0.005	-0.054
Median Grain size	-0.372	0.685	0.226	-0.269	0.158
Pct. Coarse sand	0.159	0.22	0.097	-0.119	0.278
Pct. Fine sand	-0.476	0.66	0.752	0.768	0.538
Pct. Medium sand	0.738	0.564	0.352	0.413	0.538
Pct. Silt and clay	-0.341	0.129	-0.231	-0.287	0.522
Seafloor frag-mentation	0.043	-0.052	0.217	0.057	-0.212
Pct. Gravel	-0.069	0.046	0.074	-0.081	0.1

Application of ENFA in 2010 provided an overall marginality of *M* = 0.68 and an overall specialisation value of *S* = 2.21 for American razor clams, showing that Horns Reef habitats for these clams differed moderately from the mean conditions in the modelled part of the North Sea.

The five factors retained accounted for more than 92% of the sum of the eigenvalues (100% of the marginalisation and 75% of the specialisation). Marginality accounted for 46% in American razor clams, indicating that the species is less restricted than cut trough shells in the range of conditions it utilises in the study area.

Although the habitat preferences of American razor clams differ from the mean conditions, their distribution range extends throughout the whole area, and even overlaps with that of cut trough shells.

The proportion of medium sand was the most important factor shaping the marginality of the species. However, the proportion of coarse sand and steep slopes also played a role in specialisation within the region. The food supply (FF Index) was only of moderate importance for the species' marginality, and of no importance for its specialisation.

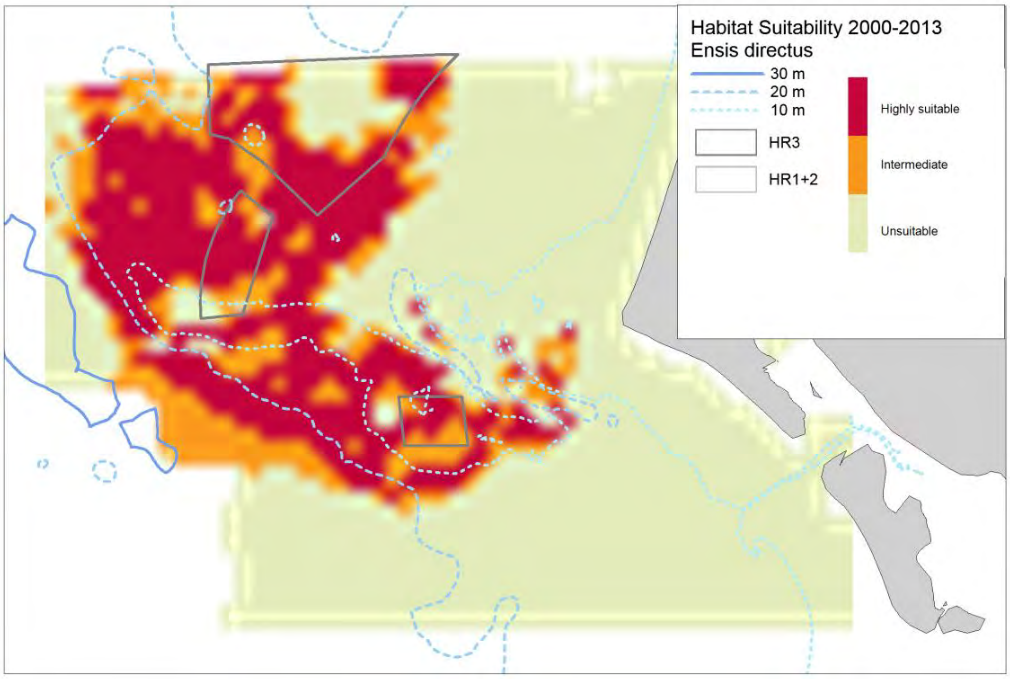


Figure 6.5 Modelled habitat suitability for American razor clam (*Ensis directus*) on Horns reef based on data from 2011-2013.

6.4. Habitat suitability models in relation to the project area

In the 26 infaunal samples in the present study, cut trough shell and American razor clam were represented by 17 and 13 specimens, respectively. However, the habitat suitability models for cut trough shell and American razor clam also include data from 2001-2010 samplings, and are able to show a clear separation between the habitat preferences of cut trough shells and American razor clams.

The models cover the greater Horns Reef area, including coast near areas north and south of Blåvands Huk. In relation to the Horns Rev 3 project area, the models cover the Horns Rev 3 project area for wind turbines (where turbines may be installed) and most of the export cable corridor, except the most eastern section of this.

The habitat suitability model for cut trough shell demonstrates an affinity to silty, fine sediments found in the more coastal parts of the Horns Reef area, and an avoidance of sloping areas with medium and coarse sand found in the more offshore parts of the Horns Reef area.

In relation to the Horns Rev 3 project area, this means that cut trough shell is not expected within the Horns Rev 3 project area for wind turbines. While the model does not cover the eastern parts of the cable corridor, it is considered likely that cut trough shell is present here, as the model shows intermediate habitat suitability just south of the area. Furthermore, infaunal samples from along the cable corridor showed presence of cut trough shells at three stations. Locations where cut trough shells were present are marked on an overlay of the habitat suitability model shown in Figure 6.6.

Only one sample within the Horns Rev 3 project area for wind turbines contained any cut trough shells, and only a single specimen was found in that sample.

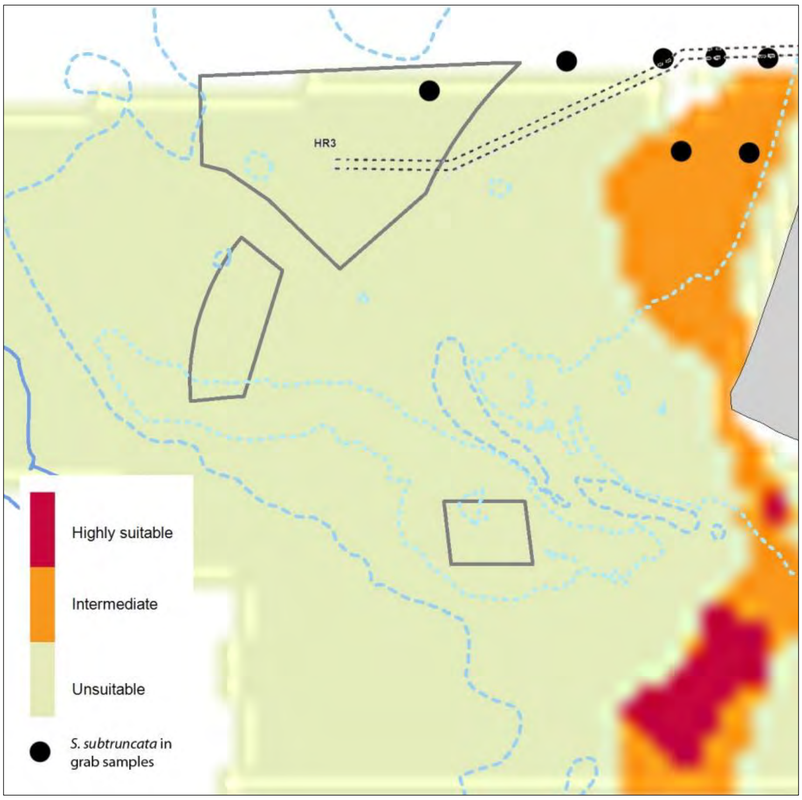


Figure 6.6 Modelled habitat suitability for cut trough shell (*Spisula subtruncata*) compared with present study Van Veen grab samples containing the species.

The habitat suitability model for American razor clams shows a habitat preference, which in effect is almost opposite to that of cut trough shells. The model demonstrates that American razor clam has a (somewhat patchy) main area of distribution which covers much of Horns Reef out to the 20 m depth curve. The model also indicates that American razor clams have a strong affinity to medium coarse sandy sediments with a sloping seabed, while displaying an avoidance of areas with silty and fine sand.

In relation to the Horns Rev 3 project area, American razor clam is expected to have a patchy distribution within the Horns Rev 3 project area for wind turbines, while being absent from most of the export cable corridor.

The predicted habitat suitability for American razor clam was also checked with the faunal Van Veen grab stations in which the species was present. Sampling locations where American razor clams were present are marked on an overlay of the habitat suitability model shown in Figure 6.7. Some sample locations are placed along the margins of the modelled area.

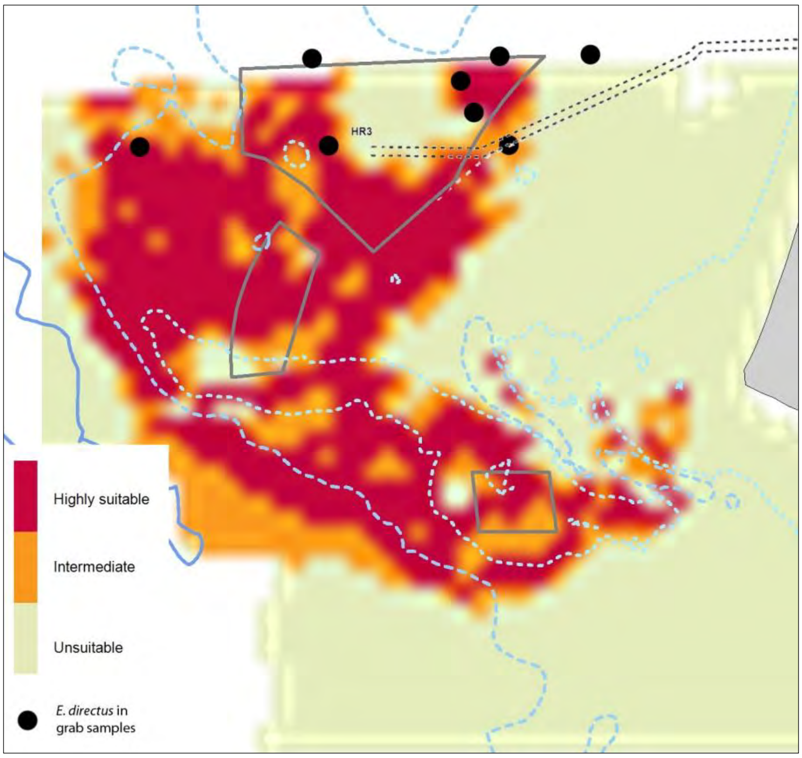


Figure 6.7 Modelled habitat suitability for American razor clam (*Ensis directus*) compared with present study Van Veen grab samples containing the species.

Spisula subtruncata

7. ASSESSMENT METHODOLOGY

To ensure a uniform and transparent basis for the overall EIA, a general impact assessment methodology for the assessment of predictable impacts has been prepared together with a list of terminology. The assessment methodology is described in greater detail in the supporting document designated HR3-TM-017. Below is a brief overview of the overall assessment scheme, as exemplified in Figure 7.1.

7.1. The Impact Assessment Scheme

The overall goal of the assessment is to describe the **Severity of Impact** caused by the project. The assessment comprises two steps; where the first step is an analysis of the magnitude of the pressure and an analysis of the sensitivity of the environmental factor. Combining the two analyses leads to the **Degree of Impact**. In the second step; the results from the **Degree of Impact** is combined with the importance leading to the **Severity of Impact**.

In some cases it is necessary to consider the risk of a certain impact occurring. In these cases, the **Severity of Impact** is considered against the Likelihood of the occurrence, giving the **Degree of Risk**.

As far as possible the impacts are assessed quantitatively, accompanied by a qualitative argumentation. The assessment steps are shown in Figure 7.1.

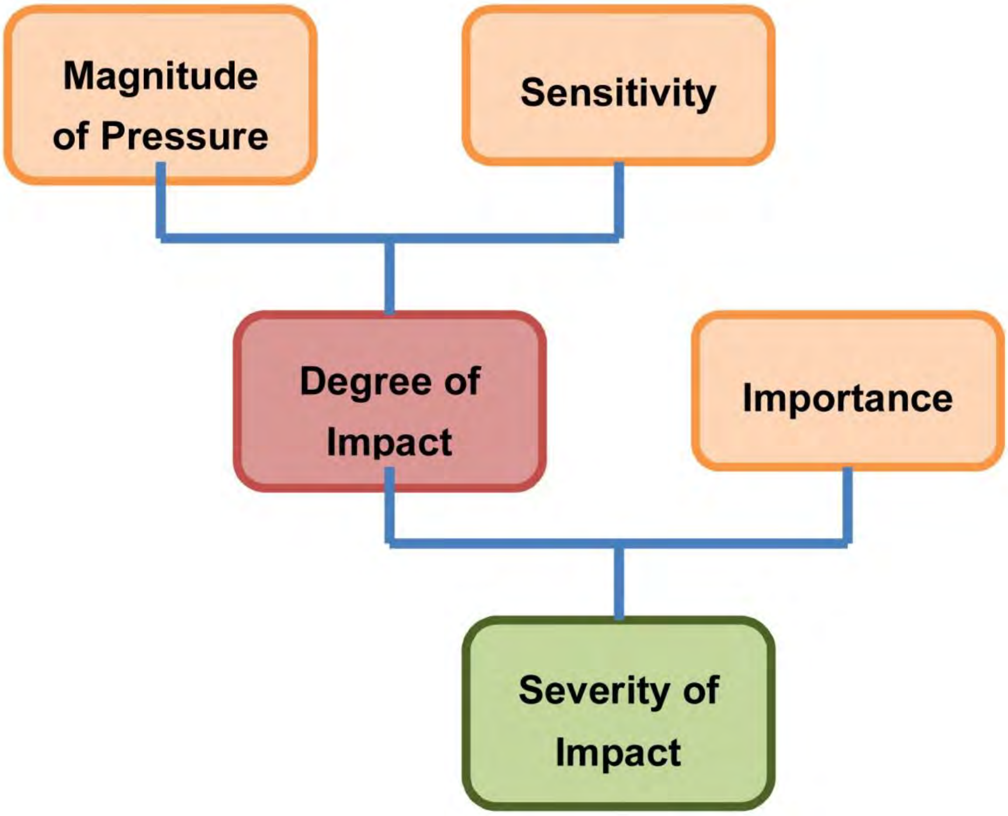


Figure 7.1. Drawing of the overall assessment approach.

Magnitude of pressure is described by pressure indicators, Table 7.1 These indicators are based on the modes of action on environmental factors in order to achieve most optimal descriptions of pressure for the individual factors; e.g. mm deposited sediment within a certain period and area.

Table 7.1 Aggregates included in the magnitude of pressure.

Magnitude of Pressure		
Intensity	**Duration**	**Range**
Very High	Recovery takes longer than 10 years or is permanent	International
High	Recovered within 10 years after end of construction	National
Medium	Recovered within 5 years after end of construction	Regional
Low	Recovered within 2 year after end of construction	Local

In order to determine the degree of impact; the magnitude of pressure and sensitivity are combined in a matrix Table 7.2. The degree of impact is the pure description of an impact to a given environmental factor without putting it into a broader perspective (the latter is done by including the importance in the evaluation, see Table 7.3 below).

Table 7.2 The matrix used for the assessment of the degree of impact.

	Sensitivity			
Magnitude of pressure	**Very high**	**High**	**Medium**	**Low**
Very high	Very High	Very High	High	High
High	Very High	High	High	Medium
Medium	High	High	Medium	Low
Low	Medium	Medium	Low	Low

The importance of the environmental factor is assessed for each environmental sub-factor. Some sub-factors are assessed as a whole, but in most cases, the importance assessment is broken down into components and/or sub-components in order to conduct a fulfilling environmental impact assessment. The importance criteria are graded into four tiers (Table 7.3).

Table 7.3 The definition of importance to an environmental factor.

Importance level	Description
Very high	Components protected by international legislation/conventions (Annex I, II and IV of the Habitats Directive, Annex I of the Birds Directive), or of international ecological importance. Components of critical importance for wider ecosystem functions.
High	Components protected by national or local legislation, or adapted on national “Red Lists”. Components of importance for far-reaching ecosystem functions.
Medium	Components with specific value for the region, and of importance for local ecosystem functions
Low	Other components of no special value, or of negative value

Severity of impact is assessed from the grading of degree of impact and importance of the environmental factor using the matrix in Table 7.4. If it is not possible to grade degree of impact and/or importance, an assessment is given based on expert judgment.

Table 7.4 The matrix used for the assessment of the severity of impact.

Degree of impact	Importance of the environmental component			
	Very high	High	Medium	Low
Very High	Very High	High	Medium	Low
High	High	High	Medium	Low
Medium	Medium	Medium	Medium	Low
Low	Low	Low	Low	Low

Based on the severity of impact, such an expert judgement can state the significance of the impact through the phrases given in Table 7.5. The contents of the table have been defined by Energinet.dk.

Table 7.5 The definition of Impact to an environmental factor. The column to the left is an attempt to include the overall assessment methodology to the scheme defined by Energinet.dk.

Severity of Impact	Relative Impact	Following effects are dominating
Very high	Significant negative impact	Impacts are large in extent and/or duration. Reoccurrence or likelihood is high, and irreversible impacts are possible.
High	Moderate negative impact	Impacts occur, which are either relative large in extent or are long term in nature (lifetime of the project). The occurrence is recurring, or the likelihood for recurrence is relatively high. Irreversible impact may occur, but will be strictly local, on e.g. cultural or natural conservation heritage.
Medium	Minor negative Impact	Impacts occur, which may have a certain extent or complexity. Duration is longer than short term. There is some likelihood of an occurrence but a high likelihood that the impacts are reversible.
Low	Negligible negative impact	Small impacts occur, which are only local, uncomplicated, short term or without long term effects and without irreversible effects
Low	Neutral / no impact	No impact compared to status quo
	Positive impacts	Positive impact occurring in one or more of the above statements

For further description of assessment methodology please refer to HR3-TM-003.

Edible crab – Cancer pagurus

8. IMPORTANCE

In this section the importance of marine flora, invertebrates and habitat types in the Horns Rev 3 project area is investigated. Importance criteria are graded into four tiers following the criteria in section 7.

8.1. Species

None of the invertebrate or algal species expected to be found naturally in the Horns Rev 3 project area are listed in Annex II and IV of the Habitats Directive, or are found on the national Danish 'red list' as curated by DCE/Aarhus University.

Several macrofaunal invertebrate species found in the Horns Reef area are on a red list covering the Danish, German and Dutch areas of the Wadden Sea (Petersen et al., 1996), for the complete list see Appendix 5. It should however be noted that the authors of the red list considered it problematic to compile a red list for Wadden Sea macrofaunal invertebrates. This was primarily attributed to the flexibility of the species' spatial distribution and the fact that many reproduce via larval stages, which can be widely dispersed and may not even be confined to the North Sea. The authors also noted that the general opinion in the Danish scientific community is that no macrofaunal invertebrates in the Danish Wadden Sea area qualify for a national red list, given the criteria at hand (Petersen et al., 1996).

While the Wadden Sea red list does not directly apply to the Horns Rev 3 project area, (closest distance to Wadden Sea MPA: ~19 km), it is within the same region and can be used to identify species of concern for subsequent assessments.

Horns Rev 1 OWF is closer to the Wadden Sea MPA (closest distance: ~9 km) than the Horns Rev 3 project area. In a study of the benthic communities at Horns Rev 1 OWF (Leonhard & Petersen, 2006), 14 species on the Wadden Sea red list were documented. These species were: the annelids: *Nereis pelagica*, *Sabellaria spinulosa*; the bivalves: *Angulus tenuis*, *Ostrea edulis*, *Spisula solida*, *Venerupis senegalensis*; the gastropod *Buccinum undatum*; the crustaceans: *Cancer pagurus*, *Caprella linearis*; the poriferan *Halichondria panicea*; the hydrozoan *Sertularia cupressina*; and the anthozoans: *Alcyonium digitatum*, *Metridium senile* and *Urticina felina*. However, the Horns Rev 1 study was conducted from 1999-2005 and many of the above listed species were either present throughout the study period, or were first registered in the latter part of the study period, indicating that they were either not affected by the presence of the OWF or were establishing themselves as part of the natural succession of fauna in the OWF (Leonhard & Petersen, 2006).

Within the Horns Rev 3 study area, four of the species found during present surveys are on the Wadden Sea red list: the bivalves *Abra nitida*, *Spisula solida* and *S. subtruncata*; and the anthozoan *Urticina felina*.

Apart from these four species, a number of invertebrate species, which can potentially be important to local ecosystem functions, have also been selected for further investigation in the subsequent assessments. Criteria for selection have been:

- Relative abundance in the study area
- Representatives for the three dominant benthic communities: *Goniadella-Spisula, Venus* and *Lanice*.
- Species which are important prey items for local species
- Invertebrate species which are important for local fisheries

The following species, which have been recorded during infaunal sampling and epi-faunal ROV-investigations, have been chosen for further assessment of the importance of their roles in the ecosystem of the Horns Rev 3 project area:

- *Polychaeta*
    - *Magelona mirabilis*
    - *Ophelia borealis*
    - *Scoloplos armiger*
    - *Lanice conchilega*
- *Mollusca*
    - *Angulus faubla*
    - *Abra nitida*
    - *Ensis directus*
    - *Spisula subtruncata*
    - *Spisula solida*
    - *Nucula nitidosa*
- *Crustacea*
    - *Bathyporeia sp.*
    - *Crangon crangon*
    - *Carcinus maenas*
- *Echinodermata*
    - *Echinocardium cordatum*
    - *Ophiura spp.*
    - *Asterias rubens*
- *Cnidaria*
    - *Urticina felina*

In Table 8.1 is given the relative importance of the selected species. Importance of a phylum is given as the importance of the most important species in the phylum.

Table 8.1 (Overleaf) Importance of selected species to the Horns Rev 3 project area. National distribution is given as **N)** North Sea, **K)** The Kattegat **B)** The Belts and Western Baltic. Basis for importance assignment is as follows: **A)** On the Wadden Sea red list. **B)** High abundance in the study area. **C)** Representatives for the three dominant benthic communities: Goniadella-Spisula, Venus and Lanice. **D1-3)** Species which are important prey items for **D1**:local invertebrates (e.g. starfish, green and brown crabs) **D2**: fish (e.g. cod, dab and plaice) and **D3**: bird species (e.g. Common Scoter and Eurasian Oystercatcher *Haematopus ostralegus*). **E)** Invertebrate species which are important for local fisheries. Information based on findings during present survey, listings on the Wadden Sea red list and on The Marine Life Information Network (MarLIN).

Species	National distribution	Basis	Importance species	Importance phylum
Polychaeta				
Magelona mirabilis	N,K,B	B,C,D2	Medium	Medium
Ophelia borealis	N,K,B	B,C	Medium	
Scoloplos armiger	N,K,B	B,D3	Medium	
Lanice conchilega	N,K	C,D1,D3	Medium	
Mollusca				
Angulus faubla	N,K	B,D1	Medium	Medium
Abra nitida	N,K	A,D2	Low	
Ensis directus	N,K,B	C,D3	Medium	
Spisula subtruncata	N,K	A,C,D2,D3	Medium	
Spisula solida	N,K	A,C,D2,D3	Medium	
Nucula nitidosa	N,K	D2	Low	
Crustacea				
Bathyporeia sp.	N,K,B	B,D3	Medium	Medium
Crangon crangon	N,K,B	D2,D3,E	Medium	
Carcinus maenas	N,K,B	D2	Low	
Echinodermata				
Echinocardium cordatum	N,K	C	Low	Low
Ophiura spp.	N,K	C,D2	Low	
Asterias rubens	N,K,B	D1,D2,D3	Low	
Cnidaria				
Urticina felina	N,K,B	A	Low	Low

8.2. Habitats

Denmark has many marine habitats protected under the Habitats Directive, however, the only habitat types listed in the Habitats Directive Annex 1, that can possibly be found in the Horns Rev 3 project area are H1110 ’Sandbanks which are slightly covered by sea water all the time’ and H1170 ’Reefs’.

<u>H1110 areas</u> consist of sandy sediments that are permanently covered by shallow sea water, typically at depths of less than 20m below chart datum - but sometimes including channels or other areas greater than 20m deep (JNCC, 2007a). As Horns Reef

consists of a large shallow area with sandbanks of glacial and marine sand deposits, H1110 can potentially be present in the Horns Rev 3 project area.

H1170 areas are rocky marine habitats or biological concretions that rise from the seabed. Reefs are very variable, both in form and in the communities that they support. Two main subtypes of reef can be recognised: those where animal and plant communities develop on rock or stable boulders and cobbles (rocky reefs), and those where structure is created by the animals themselves (biogenic reefs) (JNCC, 2007b). No natural areas of habitat type 1170 are found in the project area. However, at one site (Site:400110b-68 in the "Sites and Monuments" register of the Danish Agency for Culture) at the position E412081.47, N6171419.27 (UTM32, EURef 89) in the western part of the Horns Rev 3 area, a wreck of a barge carrying a cargo of boulders has formed an artificial 'rocky reef'.

The nearest areas of formally designated 1110 or 1170 habitats are found in two MPAs in the region. At respective closest distances of 19 km and 16 km from the Horns Rev 3 project area, the two areas are " Natura 2000 area No. 89 (The Danish Wadden Sea)" and "Natura 2000 area No. 246 (The southern North Sea)". An overview is shown on the map in Figure 12.1. The areas are also designated as marine habitat areas, with respective numbers H78 and H255. On the designation basis for H78 are the habitat types 1110 and 1170. On the designation basis for H255 is the habitat type 1110.

As no habitats formally classified as type 1110 or type 1170 have been designated within the Horns Rev 3 project area, the importance of the habitat types are not treated further.

9. PRESSURES

9.1. Main Pressures

During the lifetime of an offshore wind farm, potential pressures can impact marine habitats and organisms. Different pressures are expected to occur during various phases of the wind farm development. The life cycle of an offshore wind farm typically comprises three phases:

- **Construction phase** – Installation of foundations, turbines, cables, transformer platform etc.
- **Operational phase** – Daily operation of turbines, inspection & maintenance etc.
- **Decommissioning phase** – Removal of turbines, cabling, foundations

Each of these phases are associated with various pressures on the environment, which can be assigned to different physical factors:

- Noise and vibration
- Suspension and redistribution of sediment
- Physical disturbance of the seafloor
- Loss of sea-bed areas
- Introduction of hard substrate
- Electromagnetic fields and heat

In Table 9.1, an overview of which pressures are considered likely to occur during the individual phases is provided.

Table 9.1 An overview of the main pressures associated with the different stages/phases of Horns Rev 3 OWF. ”X” = potential presence of a pressure on the environment.

Source of pressure	Life cycle phase		
	Construction	Operation	Decommissioning
Noise and vibrations	X	X	X
Suspension and redistribution of sediments	X		X
Physical disturbance of seafloor	X		X
Loss of seabed area	X	X	X
Introduction of hard substrate		X	X
Electromagnetic fields and heat		X	

In describing pressures, it is considered to that they consist of:

- An *intensity* (quantitatively) evaluating the size of the pressure.
- A *duration* determining the time span of the pressure.
- A *range*, outside of which the pressure is considered negligible.

In the following chapters, these potential pressures are investigated.

9.2. Noise and vibrations

Underwater sound is a composite phenomenon, consisting of a sound pressure level component (SPL) and a frequency component. Sound pressure level in this report is given in dB re: 1μ Pa @ 1m, the unit normally used in underwater sound measurements. Sound frequencies are given in Hertz (Hz).

The acoustic background level in the North Sea is approximately 80 dB re 1 μPa. However, levels up to 100 dB re 1 μPa have been observed under effects from local shipping noise (Thiele 2002, DEWI 2004 in Keller et al. 2006).

The background noise levels in the sea are produced by different oceanic noise sources, both natural and man-made. The natural noise originates from mainly physical and biologic processes. Physically generated noise in the Horns Rev area includes wind, wave, and rain generated noise. The biological noise includes vocalisation by marine mammals and communication among individuals of various fish species, e.g. Atlantic cod. Noise generated by the wind is primarily related to wave action and is a product of speed, duration, water depth and proximity to the nearest coast. Wind introduced noise typically lies within the frequency band 0.001 - >30 KHz while wave-generated noise is typically located within the infrasonic spectra from 1 – 20 Hz.

Generally, anthropogenic noise from sources such as shipping, construction, dredging etc. is frequently emitted in the mid-low frequency range of 10-1000 Hz (Vella et al., 2001).

Many different sources of man-made underwater noise and vibration can be present at an offshore wind farm. Sources include pile driving, gravity foundation installation, vessels and machinery, turbine structure installation, drilling, cable trenching/jetting, rock laying, wind turbine operation etc. (Nedwell & Howell, 2004). An overview of the expected sound pressure levels (SPL) for the intensity of various wind farm related noises is presented in Table 9.2, below.

Table 9.2 Expected noise levels for various offshore wind farm activities, (Adapted from: Meißner & Sordyl, 2006)

SOURCE LEVELS* OF WINDFARM RELATED NOISE

*The Source Level is defined as the effective level of sound at a nominal distance of one metre, expressed in dB re1μPa @ 1 m.

Vessel and machinery	152 to 192 dB re 1 μPa @ 1 m	based on measurements of large vessels in deep water and small vessels in shallow water
Geophysical survey	215 to 260 dB re 1 μPa @ 1 m	measurements for airguns, often used in the offshore oil and gas industries
Pile driving	192 to 262 dB re 1 μPa @ 1 m	measurements from different localities worldwide, on average increase with increasing pile diameter
Drilling	145 to 192 dB re 1 μPa @ 1 m	deep water measurements of oil and gas facilities
Trenching	178 dB re 1 μPa @ 1 m	measurements at North Hoyle
Turbine noise	153 dB re 1 μPa @ 1 m	wind turbine capacity less than 1 MW

While anthropogenic noise is generated in all three phases of the OWF, differences in sound pressure level (dB) and frequencies are likely to exist between the phases.

Sound produced during the construction and decommission phase is expected to be more intense than the sound created during the operation phase. The most intense and thus most significant construction phase noise is generated by piling of foundations. The piling is expected to continue for several months and may mask all other noises during that period.

The underwater noise generated by pile driving during installation has been measured and assessed during construction of wind farms in Denmark, Sweden and England. The noise level and emission will depend among other things on the pile diameter and seabed conditions. An indicative source level of pile driving operations would be in the range of 220 to 260 dB re 1 μPa at 1 metre.

The SPL's emitted during the construction phase (piling) are the loudest expected during the OWF life cycle. SPL's are however not well suited to describe effects of short impulsive sounds such as pile driving. One measure often used in the literature is Peak Pressure (dB_{peak}). This value gives an indication of the maximum generated acoustic pressure an organism will be exposed to, at the peak of the sound pulse. For some audiological injuries, however, it is the effects of cumulative exposure which are harmful. For sources such as impact piling, it can therefore be more appropriate to calculate the energy in the pulse and expressing it as a Sound Exposure Level (SEL). The SEL is calculated by integrating the square of the pressure waveform over the duration of the pulse, which is defined as the region of the waveform containing the central 90% of the energy. It is also possible to calculate a total SEL (or cumulative SEL) for an entire sequence of marine piling blows by aggregating the SEL through summation of each noise pulse (Theobald et al., 2009).

The range of underwater noise also needs to be considered. As the Horns Rev 3 OWF is expected to be situated in shallow waters, noise from offshore wind turbines is likely to be channelled between the surface and the seabed, approximating a cylindrical divergence, equivalent to a 3 dB drop per doubling of distance (Westerberg, 1994). A modelled SEL and dB_{peak} at varying distances from pile driving a 10 metre diameter monopile with a hammer blow energy of 3000 kJ is shown in Figure 9.1, below.

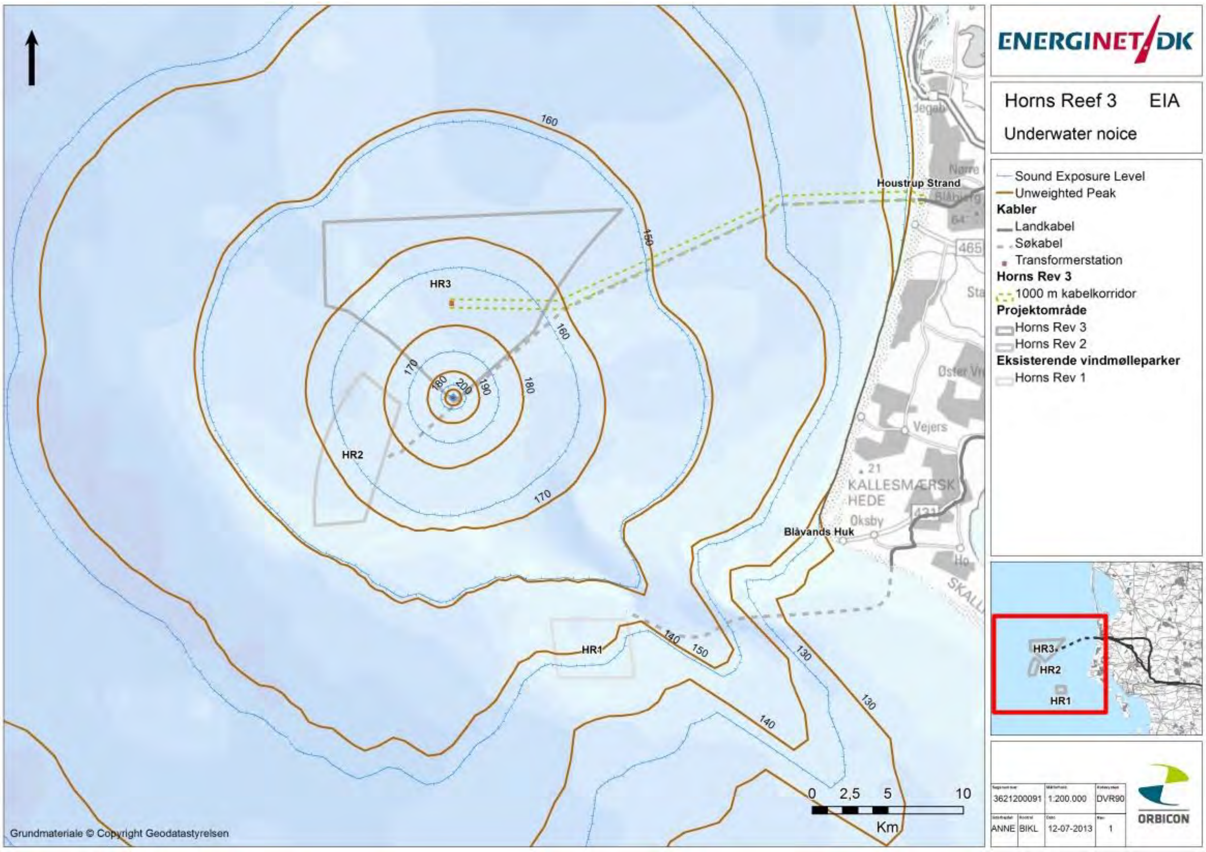


Figure 9.1 Modelling of SEL (blue contours) and dB_{peak} unweighted peak pressure (dun contours) for a 3000 kJ piling driving event at the southernmost point of the Horns Rev 3 project area. The shown contours are in 10 dB increments, starting with 180 dB for SEL and with 200 dB for dB_{peak}.

The underwater noise emitted during the operational phase will be dependent on the final construction solution, as well as on wind speeds at any given time.

Some operational underwater noise measurements of 3 and 5 MW turbines show similar source levels – also to the 1 MW turbine in Table 9.2. The type of foundation, however, has been found to be an important factor in transmission of turbine noise to the underwater environment. Field measurements have found, that 3 MW turbines mounted on mono-piles were approx. 20 dB re 1 µPa louder than 5 MW turbines mounted on gravity base foundations (Norro et al. 2011). Measurements of underwater noise emitted by 2.0 MW turbines at Horns Rev 1 OWF indicated that the noises emitted, even near maximum power was below 120 dB re 1 µPa (Betke, 2006). Measurements from four British OWFs (North Hoyle, Scroby Sands, Kentish Flats and Barrow) found that the noise levels inside the OWF areas were only 0-8 dB higher than outside. However, shipping noise was also registered at many of the measurement stations, and the ambient noise in the areas were 113-132 dB (Nedwell et al., 2007).

During decommissioning there will be some noise from vessels, machinery and disassembly of wind farm components, however, the noise will be short term and considerably less than that emitted during construction.

The duration of noises for construction and decommissioning work are expected to be transient, and only occur within a limited period of time (weeks to months), while the operational noise will be more or less continuous, and last throughout the operational phase of the OWF, which could be 20-25 years.

9.3. Suspension and redistribution of sediments

The Horns Rev 3 project area is subject to natural tide-induced, wind-induced and wave-induced currents, varying in direction and magnitude according to tidal cycles and seasonal variations. During meteorologically calm periods the tide-induced currents dominate with a magnitude of up to 0.5 m/s. The strongest currents occur during storm events, which cause currents considerably larger than the tide-induced. Directions of the currents vary significantly in the area, but the net directions are north-south or vice versa. There is a net sedimentation accumulation in the Blåvands Huk / Horns Rev area (Energinet.dk, 2014).

In relation to Horns Rev 3 OWF, suspension and redistribution of sediment will be most likely to occur during the construction and decommissioning phases.

Particularly the processes of dredging prior to installation of turbine foundations and cable jetting/trenching can cause suspension and redistribution of sediments.

When suspended, coarser sediments will settle close to the disturbance site, while finer sediment fractions may be carried away by local currents. Like natural sediment transport in the Horns Rev 3 project area, the deposition of redistributed sediment will be determined by the hydrodynamic conditions. In periods with rough weather and high currents, the finer sediment fractions will be kept in suspension and transported with the flow. In meteorologically calmer periods, the sediment will settle out closer to the disturbance. Irregular weather patterns in the Horns Reef area means that sediment transport will happen in a series of resuspension and redeposition events, until reaching a final deposition area, where the hydrodynamic forces, waves and currents are so weak that the sediments cannot be resuspended.

A dispersion scenario has been modelled for an installation of nine 3 MW turbines at the most north-westerly corner of the Horns Rev 3 area. Sediment composition in the model reflects typical sediments in the area, being largely composed of medium to coarse sand (67%). The remaining fraction of sediment is composed mostly of fine sand, with a silt content of 1.1%.

As a worst case scenario, the model is based on installation of gravitation foundations, which are considered the foundation type most likely to cause suspension and redistribution of sediment. For installation of gravitation foundations for 3 MW turbines, it is expected that 1,300m^3 of sediment need to be dredged to provide a suitable surface for the foundations to rest on. In the model scenario, 5% of all dredged material (65 m^3) was assumed to be released into the water column over a three day period for each turbine installation. This is a conservative estimate, as other OWFs often calculate with only 2% loss.

In the model, turbines were connected in groups with six inter-array cables. The distance between two turbines was set at 540m and the sediment release rate for cabling was 1.5m^3 per metre. Installing nine turbines takes 27 days and speed of cabling was estimated at 250m per hour, taking 12.96 hours to lay the 6 cables. In the model, cables were installed towards the end of the 27 days, so that installation of 9 turbines and 6 cables were completed at the same time, i.e. the end of Day 27.

In Figure 9.2 is shown a close up view of an approx. 2x4 km area around the nine installed turbines. The sediment suspension and redistribution patterns along the export cable is expected to be comparable to that of the inter-array cabling.

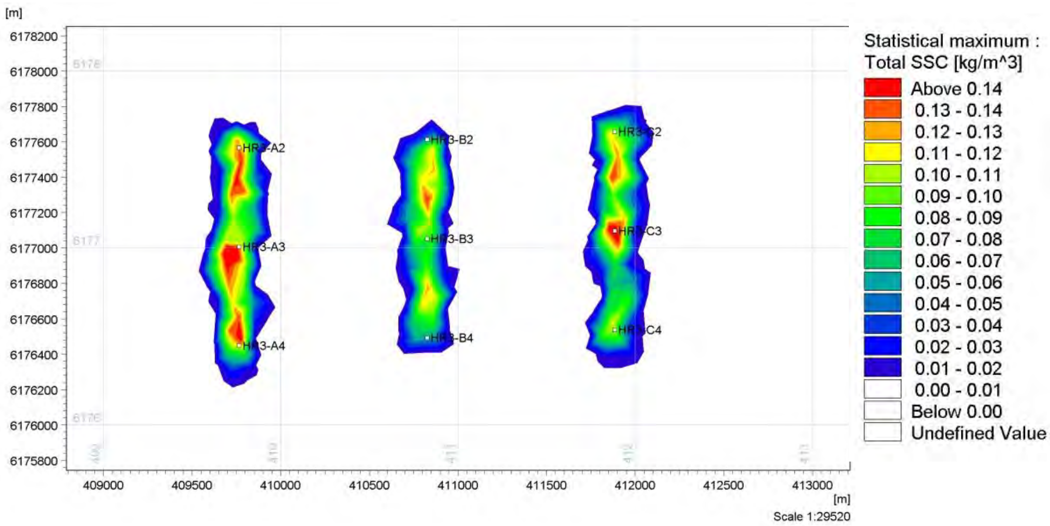


Figure 9.2 Modelled dispersion scenario for installation of nine turbines (3 MW) and cabling in the most north-westerly corner of the Horns Rev 3 project area.

The model shows that sediment plumes appear around the turbines and cabling routes, but not beyond, as the released sediment quickly resettles on the seabed. Maximum concentrations of resuspended material are calculated to be around 140 mg/l, and will extend less than 200 metres from work sites. As a comparison, studies of trawling fisheries have shown that resuspension can be 100-550 mg/l at distances up to 50 metres from the trawl (Rambøll, 2010).

During the operational phase, scouring of sediments around the turbine structures could, if unmitigated, also cause suspension and redistribution of sediment. However, scour protection is planned to be installed, and modelling has shown that the average increase in current velocities will only be in the order of 8 mm/s. When compared to the natural tide-induced currents of up to 500 mm/s, it is considered that the contribution to natural suspension and redistribution of sediments due to currents around the foundations will be negligible during the operational phase of the OWF.

During decommissioning, the potential for suspension and redistribution of sediments is dependent on the decommissioning plan to be followed. If substructures such as foundations are left *in situ*, or removed to natural seabed level, very little suspension is expected. If the substructures have to be completely removed, the suspension of sediment is assessed to be approximately equal to that of construction. This also applies for subsea cables, which is removed may have to be jetted out of the seafloor.

Further details of expected suspension and redistribution of sediment are discussed in ATR 5 ‘Sediment and water quality’.

9.4. Physical disturbance of seafloor

Physical disturbance of the seafloor involves a mechanical interference with the seabed. Benthic organisms may be physically damaged by crushing and scraping or may be dug up to the seabed surface, where they can become exposed to predation.

Disturbances of the seafloor are most likely during the construction and decommissioning phases, although minor disturbances may result from maintenance events during the operational phase. Disturbances will occur over a short time frame, and are then left to recover and fill-inn naturally. Areas of seabed that are subsequently covered by structures, scour protection etc. are dealt with under ’loss of seabed areas’.

Although offshore contractors have varying construction techniques, the installation and dismantling of wind turbines will typically require one or more jack-up rigs. These barge-like vessels extend large legs onto the seabed, and create a stable working platform by lifting themselves out of the water. The area of seabed disturbed by the spud cans on the legs is approximately 350m2 (in total) per deployment. Assuming one deployment per mill installed, the total area of seabed disturbed by installation of respectively 136/114/102/52/42 turbines will be as shown in Table 9.3.

Table 9.3 Area disturbed by jack-up rigs for different size turbines.

	3 MW	3.6 MW	4 MW	8 MW	10 MW
Combined footprint area (m^2)	47,600	39,900	35,700	18,200	14,700

Typical leg penetration into the seafloor is 2-15m (depending on seabed properties). Due to the firm sandy seabed in the Horns Rev 3 project area for wind turbines, leg penetration into the sediment is expected to be in the lower end of this range. Resultant foot prints will typically be left to fill-in naturally.

During decommissioning, comparable areas of seabed are expected to be disturbed by jack-up rigs for dismantling of turbines.

Another source of seabed disturbance during the construction phase is the laying of export and inter-array cables. Dependent on local seabed conditions, cables are either jetted into the seafloor (possibly in combination with trenching) or rock covered for protection. With the predominantly sandy substrates in the Horns Rev 3 project area, it is expected that all cables will be trenched/jetted into the seafloor.

The export cable will run from the offshore transformer station to land, making landfall at Blåbjerg Substation. The expected length of the export cable is approx. 32.5 km. If the required jetting/trenching physically disturbs an area of 1.5 metres to each side of the cable, the disturbed area of seabed will be 97,500 m^2.

The total length of inter-array cables will be dependent on the number and placement of turbines, as inter-array cables connect rows of 8-10 wind turbines in a 'daisy chain' to the transformer station. The precise placement and length of inter-array cables are not known at present. However, a rough calculation based on Figure 3.6 and Figure 3.8 would indicate, that inter-array cables could total a length of approx. 150 km for 3 MW turbines and approx. 100 km for 10 MW turbines – with values in between for the other turbine sizes. If the physical disturbances of the sea floor are also 1,5 metres to each side of the cables, the disturbed area of seabed will lie between 300,000 m^2 and 450,000 m^2

To a lesser extent, seabed disturbances will occur from anchoring vessels and machinery, but the scale is not considered to be of significance.

Overall, it is expected that approx. 0.60 km^2 seabed will be disturbed if 3 MW turbines are installed and that approx. 0.41 km^2 seabed will be disturbed if 10 MW turbines are installed. This should be seen in relation to the overall ~104 km^2 combined area of the OWF park layouts A,B or E in the Horns Rev 3 project area (max. 88 km^2), as well as the export cable corridor (which outside of the project area for wind turbines will be ~15.9 km^2). Consequently, the percentages of the project area for wind turbines which will be disturbed, will equate to 0.58% or 0.39%, respectively.

If subsea cabling is required to be removed during decommissioning, the disturbances to the seabed are expected to be approximately equal to those of the construction phase.

9.5. Loss of seabed areas

During the construction phase, some areas of previously untouched seabed will be covered by structures, scour protection etc. and will – at least for the operational lifespan of the OWF – be lost to the local biota. If decommissioning involves leaving foundations and scour protection, whole or partly, the seabed areas will be lost indefinitely.

The size of seabed areas lost will depend on the foundation type, and number of foundations installed (dependent on turbine sizes). In the top half of Table 9.4 is shown the areas lost for each type and size of foundation. In the lower half, the total area lost, including scour protection, is given for the total number of installed turbines.

Apart from areas lost to turbine foundations, an area will also be lost to the offshore transformer substation. This will be in the range of 600-1500 m^2, depending on the foundation type used for the platform.

Some areas may also be lost if subsea cables are protected with rock-dump. However, the seabed in the project area is well suited for jetting cables into the seafloor. It is therefore assessed, that only negligible areas, where cables exit the substrate to connect to turbines, will potentially be lost.

Table 9.4 Footprint areas (m^2) of seabed lost for each foundation type and turbine model (* Rough estimates. ** Areas used for gravity foundation, however scour protection may not be necessary for bucket foundations).

Turbine model	Foundation type	3 MW	3.6 MW	4 MW	8 MW	10 MW*
Foot print area per foundation (m^2)	Monopile	1,500	1,500	1,575	1,650	2,000
	Gravity	800-1,100	900-1,200	1,000-1,400	1,200-1,900	1,500-2,300
	Jacket	700	800	900	1,300	1,600
	Bucket**	800-1,100	900-1,200	1,000-1,400	1,200-1,900	1,500-2,300
Foundation and scour total area for 136/114/102/52/42 installed turbines (m^2)	Monopile	204,000	171,000	161,000	86,000	84,000
	Gravity	129,000	120,000	123,000	81,000	80,000
	Jacket	95,000	91,000	92,000	68,000	67,000
	Bucket**	129,000	120,000	123,000	81,000	80,000

The largest losses of seabed areas will invariably be due to turbine foundations and scour protection. Most seabed will be lost in a scenario of 3 MW turbines with monopiles, while least seabed will be lost in a scenario consisting of 10 MW turbines with jacket foundations.

As the area for Horns Rev 3 OWF park layouts A, B or E will cover a maximum of 88 km^2, the above worst case and best case scenarios will cause losses of seabed totalling respectively 0.23% and 0.08% of this area.

9.6. Introduction of hard substrate

On the areas of seabed lost, hard substrate will replace the previous seafloor substrate. The areas of hard substrate added will increase as construction progresses, and reach full magnitude upon completion. Hard substrate will remain present throughout the operational life of the OWF. Dependent on decommissioning plans, the hard substrate may remain, fully or in part, in the project area after decommissioning.

The area of hard substrate added to the project area, will depend on the number of turbines and the type of foundations. The lower half of Table 9.4, can be seen as a good indication of the areas of hard substrate added. Worst case and best case scenarios for introduction of hard substrate will total respectively 0.23% and 0.08% of the Horns Rev 3 OWF park layout A,B or E maximum areas.

The primary effect of the hard substrates will be the physical presence of hard structures, which may change water flow patterns, particularly near the seafloor. However, scour protection is expected and modelling has shown, that the average increase in current velocities will only be in the order of 8 mm/s. When compared to the natural tide-induced currents of up to 500 mm/s, it is considered that changes to flow rates due to introduction of hard substrates will be negligible during the operational phase of the OWF.

As a secondary effect, the hard bottom structures may act both individually and collectively as artificial reefs. This will provide habitats for hard substrate species, which were not previously present in the area. A potential secondary effect of introducing hard substrates is known as the ‘reef effect’, which is suspected of being able to induce changes in adjacent faunal communities, as well as changes to grain size composition and organic content of sediments in the vicinity (Schröder, 1995).

Investigations of artificial reefs in USA have demonstrated drops in previous benthic faunal communities at distances of up to 200 metres from the reefs (Davis et al., 1982; Lindquist et al., 1994). Adverse reef effects have also been demonstrated for meiofaunal communities close to artificial reefs (Danovaro et al., 2002).

It is difficult to directly compare effects from other climates and water masses with the North Sea, however, a tentative worst case assumption that a similar effect will be seen within a 200 metre radius from the centre of each turbine in the Horns Rev 3 OWF, would mean that an effect can be seen on approx. 125,000 m^2 seabed per turbine. For 136/114/102/52/42 installed turbines this will total between 5,3 km^2 and 17,0 km^2, see Table 9.5, which equates to between 6.0% and 19.3% of the Horns Rev 3 OWF park layout area.

Table 9.5 Area of seabed within 200 metres of a turbine, for various turbine sizes.

’Reef effect’ footprint area (m^2)	3 MW	3.6 MW	4 MW	8 MW	10 MW
	17,000,000	14,250,000	12,750,000	6,500,000	5,250,000

9.7. Electromagnetic fields and heat

9.7.1 EMF

There are three primary natural sources of electromagnetic fields (EMFs) in the marine environment: 1) The earth’s geomagnetic field, 2) Electric fields induced by the movement of charged objects (e.g. water currents and organisms) through a magnetic field and 3) Bioelectric fields produced by organisms (Normandeau et al., 2011). The term EMF covers two fundamental different types of field, the electrical field and the magnetic field. The strength of the electrical field is measured in volts pr. meter (V/m) and the unit of measurement of the magnetic field is tesla (T). The natural geomagnetic field of the earth varies with the latitude but it is approximately 50 μT whereas the natural occurring electrical field is expected to be around 25 μV/m (OSPAR 2008).

In relation to the Horns Rev 3 OWF, the foremost concern will be the submarine power cables, which can potentially generate heat as well as electric fields, magnetic fields and induced electric fields during the operational phase, see Figure 9.3.

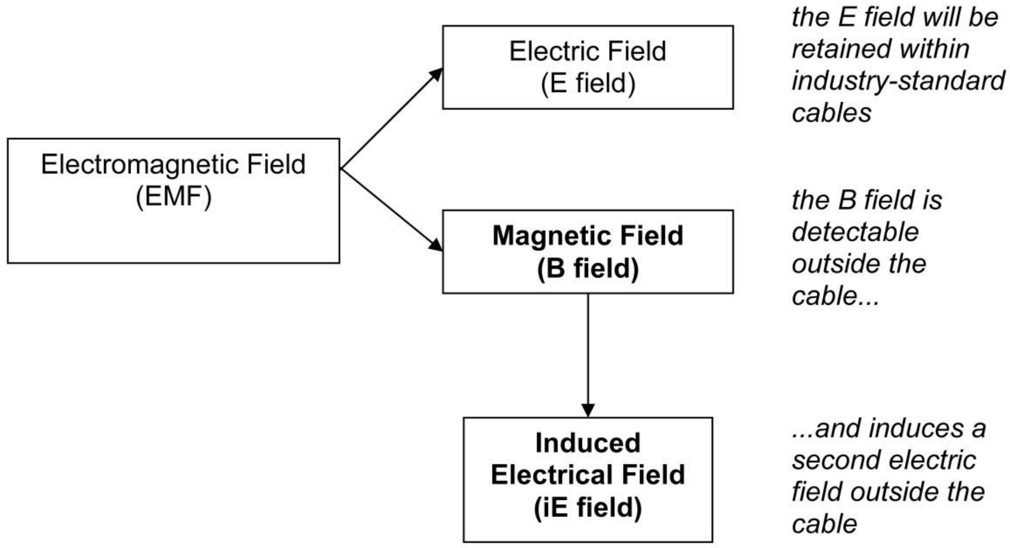


Figure 9.3 Simplified overview of the fields associated with industry-standard submarine power cables (From: Gill et al., 2005)

Anthropogenic electromagnetic fields in the marine environment are typically generated when electric energy is transmitted from one point to another, and are therefore generally related to operative submarine power cables. The expected EMF levels from undersea power cables are dependent on the source creating the field. The EMF from an AC cable will differ for the EMF from a DC cable.

Apart from the transmission system, the occurrence of electric and magnetic fields depends on the shielding of the cable. Cables with non-perfect shielding can generate electric fields outside the cable (Kramer, 2000; CMACS 2003). However, the directly generated electric fields are thought to be smaller than the electric field induced by the presence of the magnetic field in the surroundings of the cable (Meißner and Sordyl, 2006). Magnetic fields generated by the cable will be superimposed on any other magnetic field, such as the Earth´s geomagnetic field (CMACS, 2003).

In the Horns Rev 3 OWF, the inter-array cables and the export cable will be alternating current (AC) cables with three conductor cores of either aluminium or copper. Both types of cable are expected to use XLPE insulation. Individual inter-array Medium Voltage Alternating Current (MVAC) cables are expected to be either 33kV (max. voltage 36 kV) or 66 kV (max. voltage 72 kV) and the collective export cable is expected to be a 220 kV (max. voltage 245 kV) High Voltage Alternating Current (HVAC) transmission cable (Energinet.dk, 2014).

The inter-array cables are described as having an outer protection consisting of polyethylene, possibly with a radial water barrier of lead underneath. The outer diameter of the inter-array cables will, independent of the chosen voltage, be around 100 - 160 mm.

The export cable is expected to have three cores of 2000 mm^2 each. Available manufacturing options, as well as pricing, will decide the final specifications of the export cable type to be used. For evaluation in the current report, a similar construction, but of larger diameter, to the inter-array cables is expected.

Studies of the electromagnetic fields emitted by AC transmission lines show some differences depending on the specifications of cable construction and current drawn, but do give an indicative measure of the field strengths of electrical and magnetic fields produced under wind farm operation.

Magnetic fields

A modelling study describing the magnetic field along the seabed of existing and proposed power cables provided information of the characteristics of the fields (Normandeau et al., 2011).

The magnetic fields along the seabed perpendicular to the cables for 10 AC undersea cables including Horns Rev 2 Offshore Wind Farm are shown in Figure 9.4. Most of the 33 to 345 KV AC cables used in the modelling were designed to provide connection between land and offshore wind farms. The magnetic field levels are highest closest to the cables and decrease with distance from the cables. The intensity of the field increases in rough proportion to the current flow on the cables, but is also influenced by the separation and burial depth of the cables. Deeper burial below the seabed will increase the distance between the field source and the marine environment (Normandeau et al., 2011).

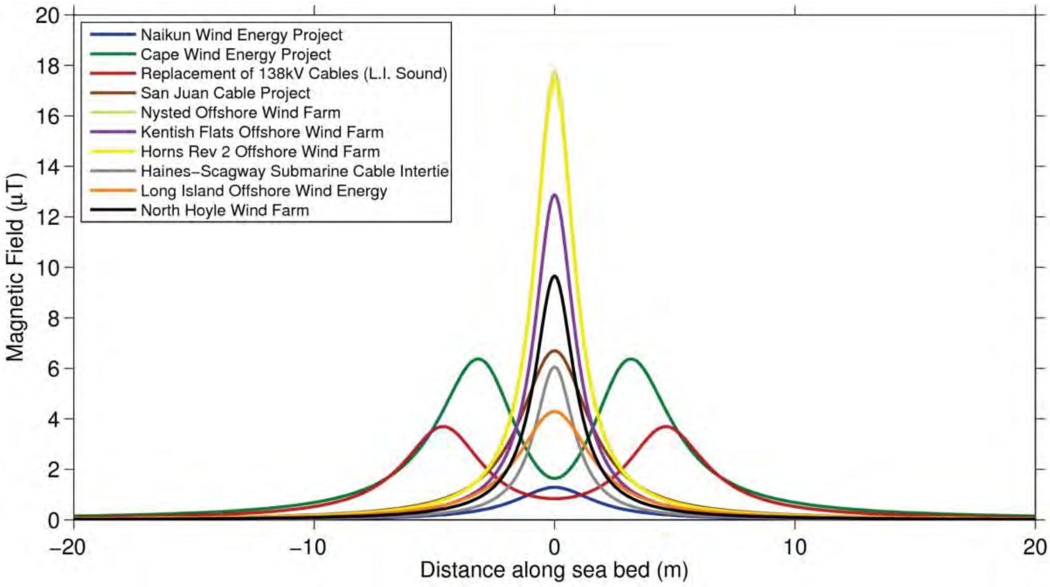


Figure 9.4 AC magnetic field profiles across the surface of the seabed for 10 submarine cable systems. Note that the profiles from Horns Rev 2 and Nysted offshore wind farm almost completely overlap each other (Normandeau et al., 2011).

The magnetic field in the water column above cables also varies with distance. The average values of the magnetic fields from the 10 AC cables are shown as a function of both horizontal and vertical distances to the cables in Table 9.6.

Table 9.6 Averaged magnetic field strength calculated at different vertical and horizontal distances to AC cables buried one meter in the seabed (Normandeau et al., 2011).

Distance (m) above seabed	Magnetic field strength (µT)		
	Horizontal distance (m) from AC cables		
	0	4	10
0	7.85	1.47	0.22
5	0.35	0.29	0.14
10	0.13	0.12	0.08

The strength of the magnetic field created by an AC cable will not reach the level of the geomagnetic field, and it will decrease rapidly with distance to the cable. Due to the low strength of the field generated by the AC cable it is unlikely that it can interfere with the local geomagnetic field (Normandeau et al., 2011).

<u>Electrical fields</u>

Movement through a magnetic field or the rotation of a magnetic field creates induced electric fields. This can occur from the movement of a water current or an organism through the field or from the asymmetric rotation of the AC field within the industry standard 3-phase cable. The speed and orientation of the current or the organism relative to the field will determine the strength of the induced field. A water current or organism moving parallel to a cable's magnetic field will not generate an induced electric field. A water current or organism moving perpendicular to cable's magnetic field will generate the maximum induced electric field.

The induced field strength will be a function of the current's or organism's speed, its exact orientation relative to the cable magnetic field, and the strength of the magnetic field (Normandeau et al., 2011). The induced electric field strength generated by a 5 knot current running perpendicular to a DC cable is shown in Table 9.7.

Table 9.7 Modelled average induced electric field from DC submarine cables (V/m) at distances above seabed and horizontally along seabed for cables buried 1 m below seabed for a 5 knot current (Normandeau et al., 2011).

Distance (m) above seabed	Field strength (µV/m)		
	Horizontal distance (m) from DC cables		
	0	4	10
0	194	31.5	78.5
5	17.5	16.2	13.9
10	8.80	8.52	7.13

The intensity of the electrical fields induced by DC cables are expected to be stronger than the natural electrical field within 1 to 5 m from the DC cables. At distances of more than 10 m to the cable, the induced electrical fields will be significantly lower than the naturally occurring field (Normandeau et al., 2011).

Magnetic fields from AC cables can also induce electric currents. In general, the induced electrical fields from AC cables are significantly lower than those arising from DC cables. The polarity of the induced current will also alternate at same frequency as that of AC magnetic field. This can potentially reduce the likelihood that the induced field from AC rotation will be detectable by organisms (Normandeau et al., 2011).

Another study modelling EMF strengths around 132 kV three-phase AC submarine cables predicted that electric fields in the surrounding water of around 25 µV/m could be induced by magnetic fields of 56 nT observed during field trials. The magnitude of the magnetic field in close vicinity to the cable (i.e. within millimetres) was found to be ~1.6 µT (CMACS, 2003). In the same study, information on the magnitudes of magnetic fields generated by 33 kV XLPE cables carrying AC currents was provided. These calculations yielded magnetic field strengths of 1.7 µT and 0.61 µT, at 0 m and 2.5 m respectively, for a current flow of 641 A.

Another study of a 33 kV cable (500 mm^2 conductors, current flow of 530A) approximated an induced electric field strength of 40µV/m. The induced electric field in the seabed was believed to dissipate rapidly to 1-2 µV/m within a distance of approximately 10 metres from the cable. The maximum current density at the interface between the seabed and seawater was determined to be about 10µA/m^2, which meant that the maximum induced electric field strength generated into the sea would be 2.5µV/m (Gill et al., 2005).

Field measurements of electric field strengths have been conducted around 36 kV cables at two British OWFs – North Hoyle and Burbo Bank (Gill et al., 2009). When normalised for load currents of 100A (to overcome fluctuations in wind farm generating status during the measurements), the maximum normalised electric field measured at North Hoyle was considerably larger than at Burbo (~110µV/m and 42µV/m, respectively), and larger than those predicted in the above mentioned studies. At Burbo Bank, the measured electric field generally varied from ~30µV/m close to the cable to ~15 µV/m approximately 150m to the west. This was a much slower rate of decay than theoretically anticipated. The reason for the persistence of the electric field was not clear, however the study acknowledged many factors that could have influence on the local electric fields, such as conductive water layers within the sediment, or variations in cable burial depth.

For Horns Rev 3, the magnitude of electrical and magnetic fields expected on the sea floor above the cables are difficult to predict precisely, but are expected to be in a range of 2.5-110 µV/m and 1.6 - 18 µT, respectively. The electromagnetic fields are expected to decrease rapidly with distance from the seabed.

9.7.2 Heat

When electric energy is transported in subsea cables, a certain amount gets lost as heat, warming the surrounding sediment. The temperature rise is influenced by a number of factors, such as the type of cable, transmission rates and characteristics of the surrounding environment (thermal conductivity, thermal resistance of the sediment etc.). In general, heat dissipation due to transmission losses can be expected to be more significant for HVAC cables than for High Voltage Direct Current (HVDC) cables at equal transmission rates (OSPAR, 2009).

Other than direct effects on the marine biota, a temperature rise of the sediment may also alter the physico-chemical conditions in the sediment and increase bacterial activity (Meißner & Sordyl, 2006).

A field study of 132 kV and 33 kV cables at the 166 MW Nysted OWF, measured a maximum temperature difference of 2.5 K between sites in the sediment 25 cm above the 132 kV cable (3x760 mm^2 copper cores with XLPE insulation) and the control seabed site (Meißner et al., 2007). The cables were buried at depths of approximately 1 metre below the seabed surface. The maximum temperature difference 20 cm below the seabed surface was 1.4 K and the temperature differences at the sediment surfaces were negligible. The coarse sediment of the study location were thought to allow for more heat loss through the interstitial water than would be the case with fine sandy or silty sediments (OSPAR, 2009). The sediment at Horns Rev 3 is also fairly coarse, so heat dissipation is expected to be good, particularly in the western parts.

The power generating capacity of Horns Rev 3 OWF will be larger than that of Nysted OWF. However, the export cable also has a comparably larger cross section. It is expected, that the amount of heat dissipated from the cables at Horns Rev will be similar, or a bit larger than at Nysted OWF.

10. SENSITIVITIES

Pressures exerted on the benthic environment by physical factors during the OWF life stages may affect benthic communities. Physical factors can have effects on benthic fauna, which will be specific to different species and life stages and will depend on the magnitude and duration of the environmental pressures. The sensitivity of a species to changes in physical factors depends on the intolerance of the species to such changes as well as the ability of the species to recover afterwards, through recruitment and immigration.

10.1. Sensitivity overview of selected species

In Table 10.1, sensitivities are given for a range of invertebrate species found in the Horns Rev 3 study area. The species shown in the table are those selected in Section 8.1. Worst case sensitivities for phyla are generated from the score of the most sensitive species for each physical factor.

The sensitivities to each potential pressure are expressed in relation to benchmarks, which could be encountered during the OWF life cycle. Sensitivity analyses are primarily based on information available through MarLIN (The Marine Life Information Network), which uses an approach described in Hiscock & Tyler-Walters, 2006. Electromagnetic fields are, however, not covered in the MarLIN sensitivity assessments, so benchmarks are compared to literature values for the most sensitive species within the same taxonomic groups, as listed in Normandeau et al., 2011. Sensitivity analyses for all selected species have not been available. In cases where specific species lack data, a suitable 'stand-in' species, which is found in the region and has a similar life-strategy, has been selected.

As benchmarks are wide in scope, and may be exceeded during some phases of the Horns Rev 3 OWF life cycle, the known general sensitivities of invertebrate species to the potential pressures are further discussed in the subsequent sections.

Table 10.1 (overleaf) Sensitivities of dominant and important invertebrate species found in the Horns Rev 3 study area. Sensitivity is a product of intolerance and recoverability to a physical factor. Sensitivity information is lacking in some species, here stand-in species which live under the same conditions and are expected to have similar sensitivities are used. Stand-in species are marked by parentheses. **Abbreviations**: **II)** insufficient information, **NS)** not sensitive, **VL)** very low, **L)** low, **M)** moderate, **H)** high, **VH)** very high. **Benchmarks: A)** Underwater noise levels e.g., the regular passing of a 30 metre trawler at 100 metres or a working cutter-suction transfer dredge at 100 metres for 1 month during important feeding or breeding periods. **B)** Acute change in background suspended sediment concentration e.g., a change of 100 mg/l for 1 month. **C)** All of the population of a species or an area of a biotope is smothered by sediment to a depth of 5 cm above the substratum for one month. **D)** A single event with a force equivalent to a standard scallop dredge landing on or being dragged across the organism. **E)** A single event of removal of an organism from the substratum and displacement from its original position onto a suitable substratum. Permanently attached species are not expected to re-attach and will likely die, whilst many burrowing species or sedentary species can re-burrow or re-attach **F)** All of substratum occupied by the species or biotope under consideration is removed. A single event is assumed for sensitivity assessment. Once the activity or event has stopped (or between regular events) suitable substratum remains or is deposited. **G)** A change of two categories in water flow rate for 1 year. For example from very weak (negligible) to moderately strong (1-3 knots). **H)** Exposure to 100 μv/m or 1 μT. **I)** A long term, chronic change in temperature e.g. 2 K change in the temperature range for one year. Sources:www.marlin.ac.uk and * Normandeau, 2011.

Pressure	Physical factors and benchmarks								
	Noise and vibrations	Suspension and redistribution of sediments		Physical disturbance of seafloor		Loss of seabed area	Introduction of hard substrate	Electromagnetic fields*	Heat
Physical factor	**Underwater noise**	**Suspended sediment**	**Smothering (burial)**	**Physical force**	**Displacement**	**Substrate loss**	**Change in water flow rate**	**EMF field strength***	**Increase in temperature**
Benchmark	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H***	**I**
Polychaeta	**NS**	**NS**	**L**	**L**	**L**	**M**	**M**	**II**	**L**
Magelona mirabilis	NS	NS	NS	L	L	M	L	II	II
Ophelia borealis (Spiophanes bombyx)	II	NS	L	L	VL	M	M	II	VL
Scoloplos armiger (Nephtys hombergii)	NS	NS	NS	L	NS	L	VL	II	NS
Lanice conchilega	NS	NS	L	L	L	M	L	II	L
Mollusca	**NS**	**VL**	**L**	**L**	**L**	**M**	**L**	**NS***	**L**
Angulus faubla	NS	NS	NS	L	L	M	L	NS*	VL
Abra nitida (Abra alba)	NS	NS	NS	L	VL	M	VL	NS*	VL
Ensis directus (Cerastoderma edule)	NS	NS	L	L	L	M	L	NS*	L
Spisula subtruncata (Spisula solida)	II	VL	L	L	L	M	L	NS*	NS
Nucula nitidosa	II	NS	VL	L	L	M	L	NS*	NS
Crustacea	**NS**	**VL**	**L**	**L**	**NS**	**L**	**M**	**NS***	**L**
Bathyporeia sp. (*B. pelagica*)	NS	VL	L	L	NS	L	M	NS*	L
Crangon crangon	NS	NS	L	VL	NS	L	NS	NS*	NS
Carcinus maenas	NS	NS	NS	L	NS	L	VL	NS*	NS
Echinodermata	**VL**	**L**	**M**	**M**	**L**	**M**	**L**	**NS***	**M**
Echinocardium cordatum	NS	L	NS	M	L	M	L	NS*	L
Ophiura spp. (*Ophiotrix fragilis*)	VL	VL	M	L	NS	M	VL	NS*	L
Asterias rubens	NS	L	VL	L	NS	M	L	NS*	M
Cnidaria	**NS**	**VL**	**VL**	**M**	**NS**	**M**	**NS**	**II**	**L**
Urticina felina	NS	VL	VL	M	NS	M	NS	II	L

The benchmark sensitivities operate with a finer gradation in the low sensitivity end. For assessment later in the report, the three lowest tiers are collected in the category Low, see Table 10.2.

Table 10.2 Translation of benchmark sensitivities to assessment methodology sensitivity.

Benchmark sensitivity	Assessment methodology sensitivity			
	Low	Medium	High	Very High
Not Sensitive	X			
Very Low	X			
Low	X			
Moderate		X		
High			X	
Very High				X

10.2. Noise and vibrations

Underwater noises and vibrations have the potential to disturb or even harm marine wildlife. Most studies of underwater noise address the impact on marine mammals, while studies on invertebrate impacts are scarcer.

Few marine invertebrates possess sensory organs that are believed to perceive sounds pressures directly. However, noise and vibration - particularly of lower frequencies in the 10-400 Hz range - have been demonstrated to have effects on invertebrates, and they do possess two classes of sensory organs (mechanoreceptors and statocyst organs), through which vibrations and sound waves may indeed be perceived as a physical force:

- For crustaceans, sounds of 30 dB above control levels in the 25-400 Hz range have been shown to negatively impact growth and reproduction rates of exposed Brown shrimp - *Crangon crangon* (Lagardère, 1982). The hearing threshold of American lobsters - *Homarus americanus* has been determined to be approximately 150 dB in the low frequency range, and sounds in the 10-75 Hz range can cause their heartbeat to slow down (Offutt, 1970).
- For echinoderms, the brittle star *Ophiura ophiura* is able to detect near-field vibrations down to a few Hertz, as well as far-field pressure waves (Moore & Cobb, 1986).
- In Molluscs, the cephalopod Common octopus - *Octopus vulgaris* is known to be sensitive to sound frequencies below 100 Hz (Packard et al., 1990). The threshold for hearing far-field sound waves in *O. bimaculoides* is estimated to be 146 dB (Budelmann & Williamson, 1994).

However, most invertebrates typically do not have delicate organs or tissues whose acoustic impedance is significantly different from water. So unlike, e.g. fish with swim bladders, the general consensus regarding underwater noise effects on invertebrates and planktonic larvae under field conditions, is that very few behavioural or physiological effects are expected unless the organisms are within a few metres of powerful (240 dB re 1 μPa) noise sources (Vella et al., 2001).

The direct colonisation of wind turbine structures in Horns Rev 1 and 2, also indicates that operational noise and vibration have no detrimental effects on the attached fauna (Leonhard, 2000).

10.3. Suspension and redistribution of sediments

Suspension of sediments into the water column, and subsequent redistribution can affect benthic communities and be a factor for species that are sensitive to clogging of respiratory or feeding apparatuses or species that require a supply of sediment for tube construction. If sediment is not redistributed over a large area, smothering may occur, in which local species and communities are physically covered by sediment. If the layer is sufficiently thick, and organisms are not able to relocate up to the new sediment surface, they may perish.

However, as the area around Blåvands Huk is often exposed to natural wind and current driven suspension and redistribution of sediment, species which are very sensitive to high concentrations of suspended matter (SPM) are not expected to be present in the area. Local populations of the same species may by also display adaptations to deal with SPM. This is the case with e.g. blue mussels (*Mytilus edulis*), where smaller gills and larger labial palps are found in Wadden Sea populations compared to Baltic Sea populations, as the former are exposed to higher SPM-levels (Essink, 1999).

If physically covered by sediment, smothering may kill organisms which are unable to reach the overlying water/sediment interface. The polychaete *Nephtys hombergii* (37 specimens in present study), has been found to successfully burrow to the surface of a 32–41 cm deposited sediment layer of till or sand/till mixture and restore contact with the overlying water (Powilleit et al., 2009). In a study of sensitivity to dumping of dredged sediments most benthic macro invertebrates were not expected to be seriously affected, as long as sediment deposition is restricted to 0.2 - 0.3 metres (Essink, 1999), see also Figure 10.1.

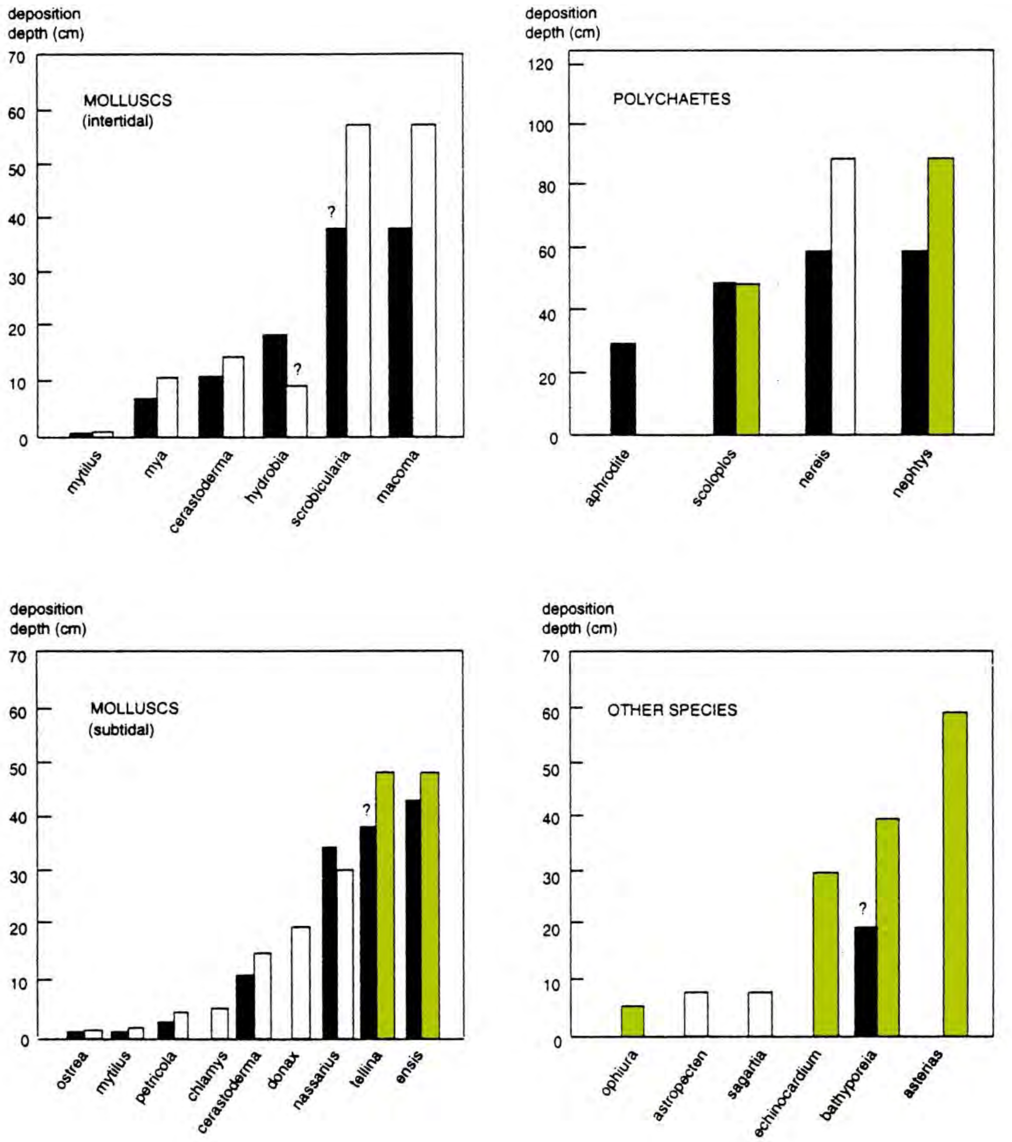


Figure 10.1 Fatal depth (cm) for macrozoobenthos at incidental deposition by mud (dark columns) or sand (light columns) Green columns are taxa for which species have been found in the Horns Rev 3 study area. Modified after R. Bijkerk in Essink, 1999.

10.4. Physical disturbance of seafloor

During disturbances, fragile organisms in the affected areas are expected to perish as a direct result of physical damage. Species which are not killed by the disturbances may become exposed on the seafloor, and if they are not able to rebury themselves in the sediment, they may be lost to predation.

However, recoverability of the each species is also part of the sensitivity analysis. After the short duration of the disturbance, it is therefore expected that species from the surrounding seabed will repopulate the disturbed areas. According to studies of benthic repopulation in coastal areas that undergo dredging, it is expected that re-establishing communities will occur within 2-3 years (Newell et al., 1998).

10.5. Loss of seabed areas

Newell et al. (1998) state that removal of the topmost 0.5 m of sediment is likely to eliminate benthos from the affected area. Likewise, denial of an area through placement of OWF-infrastructure on that area, will eliminate the species and communities within the affected areas. Intolerance to such loss will invariably be very high, but for most invertebrate species, the recoverability will also be high, if infrastructure is removed in the future.

10.6. Introduction of hard substrate

Introduction of hard structures may locally effect water flow rates. Some species are sensitive to changes in flow rate, if the change is sufficiently large to effect feeding strategy, oxygen uptake etc. As the seafloor in much of Horns Reef is dynamic, most species in the project area will be tolerant of changes in the water flow regime.

The sensitivities of the investigated species to the secondary ‘reef effect’ of introducing hard substrates will be variable. The sub-surface sections of turbine towers and scour protections will introduce new types of sub-littoral habitats and increase the heterogeneity in areas previously consisting only of relatively uniform sand.

Some local species are expected to be sensitive to increased predation pressures, while many will not be prey items for the species connected with the hard substrate. It should also be noted, that the benthic communities in the Horns Reef area show natural variations in spatial and temporal distribution (Leonhard & Birklund, 2006), and that most of the species investigated are already common prey items for other invertebrates, fish and birds in the area.

10.7. Electromagnetic fields and heat

10.7.1 EMF

Electro-sensitive organisms are known to be able to detect two types of electric field: localised polar and larger scale uniform electric fields (Gill et al., 2005).

The sensitivity to electric and magnetic fields by marine organisms is quite variable. The lowest known electrical field detectable by elasmobranchs (sharks, rays and skates) is 0.5 µV/m, and sharks have been shown to react to magnetic fields of 25-100 µT (Meyer et al., 2004).

Strong electrical fields, such as used for electrofishing have a pronounced effect on bony fishes and elasmobranchs, but can also affect invertebrates:

- Razor clams *Ensis* sp. have been observed to emerge from the seabed at minimum electrical field strengths of ~40-50 V/m (30 Hz pulsed) DC (Breen et al., 2011).
- In a study on side effects in benthic invertebrates when using a commercial electrofishing trawl system*, it was found that rag worms *Alitta virens*, green crabs *Carcinus maenas* and American razor clams *Ensis directus*, suffered a 3-7 % increase in mortality when subjected to simulated *in situ* exposure at

distances of 10-40 cm from the pulsed beam trawl electrodes (van Marlen et al., 2009). In the same study, no significant effect was found to occur in the species common prawn *Palaemon serratus*, cut trough shell *Spisula subtruncata* and common starfish *Asterias rubens*. (* The precise electrical field strength and specifics were not provided, as they are considered trade secrets. It is however assessed that they are comparable, or slightly less, to the field strengths reported by Breen et al., 2011).

Current knowledge on the impacts from power cables on electro-sensitive or magneto-sensitive invertebrate species is generally lacking and demonstrated sensitivities are quite variable, making informed assessments difficult. An overview in Normandeau et al., 2011 of conducted studies can be found in Appendix 4.

Weaker fields, such as those expected around the subsea cables of Horns Rev 3 OWF, are generally not believed to elicit strong effects in invertebrates. It is, however, possible that magnetic fields generated from submarine power cables may have an effect on some magneto-sensitive species like migratory crustaceans, which are thought to be sensitive to the Earth's magnetic fields (Gill et al., 2005).

Studies have investigated responses to lesser electric or magnetic fields in at least three marine invertebrate phyla: Echinodermata, Mollusca and Arthropoda:

- Exposure to 60 Hz magnetic fields (3.4-8.8 mT) and magnetic fields over the range DC-600 kHz (2.5-6.5 mT) can alter the timing of early embryonic development in embryos of the purple sea urchin *Strongylocentrotus purpuratus* (Levin & Ernst, 1995).
- No significant effects were found in survival rate and fitness of, amongst other species, brown shrimp *Crangon crangon* and blue mussels *Mytilus edulis*, in response to exposure to static magnetic fields of 3.7 mT for several weeks under laboratory conditions (Bochert & Zettler, 2004).
- Brown shrimp have been recorded as being attracted to magnetic fields associated with a wind farm cable (ICES, 2003)
- No significant effects were found on Dungeness crabs *Metacarcinus magister* in food detection when exposed to EMF as well as EMF-detection and avoidance/attraction (3 mT DC) (Woodruff et al., 2012).

Magnetic field emissions, of the orders above (mT) can potentially cause interactions from the cellular through to the behavioural level in coastal organisms (Gill et al., 2005). However, most invertebrates are not considered sensitive to EMF levels likely to be associated with the Horns Rev 3 OWF.

10.7.2 Heat

Benthic communities can be sensitive to increases of temperature (Hiscock et al., 2004) and warming of coastal water can increase the oxygen thresholds for hypoxia-driven mortality of benthic organisms (Vaquer-Sunyer & Duarte, 2001).

Most of the benthic organisms in Table 10.1, are not expected to be sensitive to potential increases of sea bottom temperature in the Horns Rev 3 project area. All but two of the species have large geographical distribution ranges, which extend to either South West European, Mediterranean, subtropical or tropical waters. Only the species *Ophelia borealis* and *Ophiura ophiura*, are restricted to more northern ranges. However, both species are found in The Limfjord, where bottom temperatures in the summer can become significantly higher than at Horns Reef. The bottom temperature variations in the Horns Reef area are also quite high, see Figure 10.2, and the organisms present are expected to be adapted to such variations.

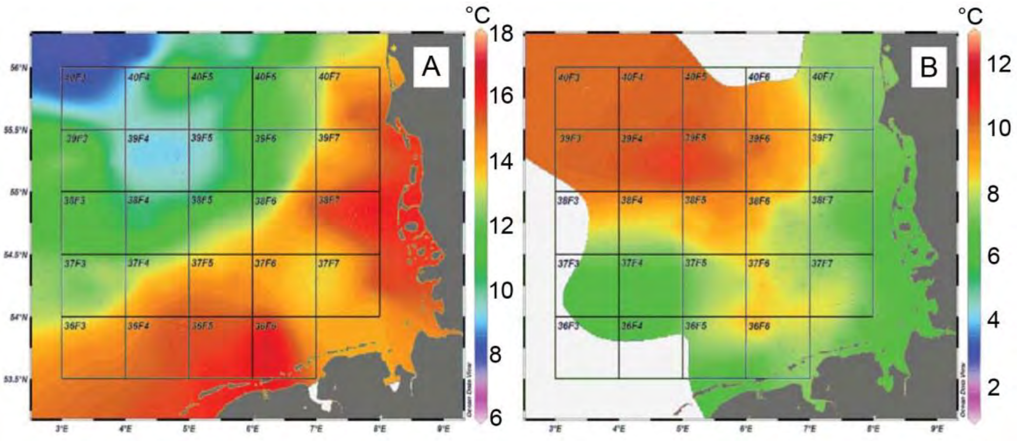


Figure 10.2 A) Mean summer and B) mean winter bottom temperatures (°C) from 1998 to 2007. (From Neumann et al., 2009)

Hermit crab

11. ASSESSMENT OF IMPACTS

11.1. Noise and vibrations

Noise levels from piling during the construction phase are expected to be the highest during the OWFs lifecycle. Peak SPLs are expected to be in the range 220-260 dB re 1 µPa at 1 metre, and the magnitude of pressure for underwater noise and vibrations is assessed to be High (although transient). During the operational phase, SPLs are expected to be in the range 113-150 dB re 1 µPa at 1 metre. These noise levels will depend on the wind speed and foundation type used, and will be mostly constant during the operational life of the OWF. Measurements at other operational OWFs indicate that the operational noise, even in the immediate vicinity of turbines, is very low and often not above background sea noise levels (Nedwell et al. 2007). The magnitude of pressure during operations is assessed to be Low. During decommissioning, noise levels are expected to be significantly lower than during construction, and will be transient. The magnitude of pressure is assessed to be Low.

In Table 10.1, the sensitivities of the selected phyla to underwater noise range from Not Sensitive to Very Low. In terms of overall sensitivity assessment, all invertebrate phyla investigated, and therefore the faunal communities in the Horns Rev 3 project area, are assessed to have Low sensitivity.

Some species are considered important for local ecosystem functions, or of value for the region. The importance of the listed phyla are given as the highest importance of the investigated species within each phylum. Based on the factors in Table 8.1, the phyla Polychaeta, Mollusca and Crustacea are considered of Medium importance for the Horns Reef area, while Echinodermata and Cnidaria are considered of Low importance.

In Table 11.1 to Table 11.3 below, are given Severity of Impact assessments for noise and vibrations for the three lifecycle phases of the Horns Rev 3 OWF.

Table 11.1 Degree of Impact on benthic habitats and communities for noise and vibrations during the construction phase.

Noise and Vibrations	Invertebrate phyla				
	Polychaeta	Mollusca	Crustacea	Echinodermata	Cnidaria
Magnitude of Pressure	High	High	High	High	High
Sensitivity	Low	Low	Low	Low	Low
Degree of impact	Medium	Medium	Medium	Medium	Medium
Importance	Medium	Medium	Medium	Low	Low
Severity of impact	**Medium**	**Medium**	**Medium**	**Low**	**Low**

Table 11.2 Degree of Impact on benthic habitats and communities for noise and vibrations during the operational phase.

Noise and Vibrations	Invertebrate phyla				
	Polychaeta	Mollusca	Crustacea	Echinodermata	Cnidaria
Magnitude of Pressure	Low	Low	Low	Low	Low
Sensitivity	Low	Low	Low	Low	Low
Degree of impact	Low	Low	Low	Low	Low
Importance	Medium	Medium	Medium	Low	Low
Severity of impact	**Low**	**Low**	**Low**	**Low**	**Low**

Table 11.3 Degree of Impact on benthic habitats and communities for noise and vibrations during the decommissioning phase.

Noise and Vibrations	Invertebrate phyla				
	Polychaeta	Mollusca	Crustacea	Echinodermata	Cnidaria
Magnitude of Pressure	Low	Low	Low	Low	Low
Sensitivity	Low	Low	Low	Low	Low
Degree of impact	Low	Low	Low	Low	Low
Importance	Medium	Medium	Medium	Low	Low
Severity of impact	**Low**	**Low**	**Low**	**Low**	**Low**

In summary, while the severity of impact is medium for three phyla in the construction phase, no invertebrates, algae or ecological components protected by international, national or local legislation are assessed to be impacted on population levels by noise and vibrations during the life-cycle of the Horns Rev 3 OWF.

11.2. Suspension and redistribution of sediments

During construction, the processes of dredging prior to installation of turbine foundations and cable jetting/trenching can cause suspension and redistribution of sediments and a change in the morphology of the seabed may induce resuspension. This can potentially impact biological components across the food web, as increased turbidity may cause shading of primary production, suspended solids in the water phase may clog respiratory tracts in benthic fauna and resettlement may smother benthic communities.

However, most of the sediments within the Horns Rev 3 project area are known to be fine, medium and coarse sands, which if suspended by wind farm activities, are expected to re-settle within a short range of the disturbances. Modelled maximum concentrations of resuspended material are calculated to be around 140 mg/l, and will extend less than 200 metres from work sites. The magnitude of pressure due to suspension and redistribution of sediments is assessed to be Medium during construction and, assuming a worst case scenario of complete foundation removal, also during decommissioning. During operation it is assessed to be Low.

The area around Blåvands Huk is dynamic and benthic communities within the Horns Rev 3 project area are often exposed to natural wind and current driven suspension and redistribution of sediment. In Table 10.1, the sensitivities of the selected species to suspension and redistribution of sediments range from Not Sensitive to Low for general effects of suspended sediment in the water phase and from Not Sensitive to Medium for effects of smothering. Overall, the phyla are assessed to have Low sensitivity to suspension and redistribution of sediment, with an exception of the phylum Echinodermata, as members of the genus *Ophiura* are noted as unable to reach the sediment surface if smothered by more than 5 cm of sediment. The phylum Echinodermata is considered to have Medium sensitivity.

Some species are considered important for local ecosystem functions, or of value for the region. The importance of the listed phyla are given as the highest importance of the investigated species within each phylum. Based on the factors in Table 8.1, the phyla Polychaeta, Mollusca and Crustacea are considered of Medium importance for the Horns Reef area, while Echinodermata and Cnidaria are considered of Low importance.

In Table 11.4 to Table 11.6 below, are given Severity of Impact assessments for suspension and redistribution of sediments for the three lifecycle phases of the Horns Rev 3 OWF.

Table 11.4 Degree of Impact on benthic habitats and communities for suspension and redistribution of sediments during the construction phase.

Suspension and redistribution of sediments	Invertebrate phyla				
	Polychaeta	Mollusca	Crustacea	Echinodermata	Cnidaria
Magnitude of Pressure	Medium	Medium	Medium	Medium	Medium
Sensitivity	Low	Low	Low	Medium	Low
Degree of impact	Low	Low	Low	Medium	Low
Importance	Medium	Medium	Medium	Low	Low
Severity of impact	**Low**	**Low**	**Low**	**Low**	**Low**

Table 11.5 Degree of Impact on benthic habitats and communities for suspension and redistribution of sediments during the operational phase.

Suspension and redistri-bution of sediments	Invertebrate phyla				
	Polychaeta	Mollusca	Crustacea	Echinodermata	Cnidaria
Magnitude of Pressure	Low	Low	Low	Low	Low
Sensitivity	Low	Low	Low	Medium	Low
Degree of impact	Low	Low	Low	Low	Low
Importance	Medium	Medium	Medium	Low	Low
Severity of impact	**Low**	**Low**	**Low**	**Low**	**Low**

Table 11.6 Degree of Impact on benthic habitats and communities for suspension and redistribution of sediments during the decommissioning phase.

Suspension and redistri-bution of sediments	Invertebrate phyla				
	Polychaeta	Mollusca	Crustacea	Echinodermata	Cnidaria
Magnitude of Pressure	Medium	Medium	Medium	Medium	Medium
Sensitivity	Low	Low	Low	Medium	Low
Degree of impact	Low	Low	Low	Medium	Low
Importance	Medium	Medium	Medium	Low	Low
Severity of impact	**Low**	**Low**	**Low**	**Low**	**Low**

In summary, no invertebrates, algae or ecological components protected by international, national or local legislation are assessed to be impacted on population levels by suspension and redistribution of sediments during the life-cycle of the Horns Rev 3 OWF.

11.3. Physical disturbance of seabed

Disturbances of the seafloor are most likely during the construction and decommissioning phases, although minor disturbances may result from maintenance events during the operational phase. Physical disturbances may physically damage or kill benthic organisms, however, the percentage of the Horns Rev 3 project area affected will amount to less than 0.4 % and is considered negligible. The magnitude of pressure is assessed to be Low during construction, operation and decommissioning.

In Table 10.1, the sensitivities of the selected species to physical force range from Not Sensitive to Medium and the sensitivities to displacement range from Not sensitive to Low. Overall, the phyla are assessed to have Low sensitivity to physical disturbance of the seafloor, with exceptions of the phyla Echinodermata and Cnidaria, as the species *Echinocardium cordatum* and *Urticina felina* are noted as sensitive to physical force. The phyla Echinodermata and Cnidaria are considered to have Medium sensitivities.

Some species are considered important for local ecosystem functions, or of value for the region. The importance of the listed phyla is given as the highest importance of the investigated species within each phylum. Based on the factors in Table 8.1, the phyla Polychaeta, Mollusca and Crustacea are considered of Medium importance for the Horns Reef area, while Echinodermata and Cnidaria are considered of Low importance.

In Table 11.7 to Table 11.9 below, are given Severity of Impact assessments for physical disturbance of the seabed for the three lifecycle phases of the Horns Rev 3 OWF.

Table 11.7 Degree of Impact on benthic habitats and communities for physical disturbance of seabed during the construction phase.

Physical disturbance of seabed	Invertebrate phyla				
	Polychaeta	Mollusca	Crustacea	Echinodermata	Cnidaria
Magnitude of Pressure	Low	Low	Low	Low	Low
Sensitivity	Low	Low	Low	Medium	Medium
Degree of impact	Low	Low	Low	Low	Low
Importance	Medium	Medium	Medium	Low	Low
Severity of impact	**Low**	**Low**	**Low**	**Low**	**Low**

Table 11.8 Degree of Impact on benthic habitats and communities for physical disturbance of seabed during the operational phase.

Physical disturbance of seabed	Invertebrate phyla				
	Polychaeta	Mollusca	Crustacea	Echinodermata	Cnidaria
Magnitude of Pressure	Low	Low	Low	Low	Low
Sensitivity	Low	Low	Low	Medium	Medium
Degree of impact	Low	Low	Low	Low	Low
Importance	Medium	Medium	Medium	Low	Low
Severity of impact	**Low**	**Low**	**Low**	**Low**	**Low**

Table 11.9 Degree of Impact on benthic habitats and communities for physical disturbance of seabed during the decommissioning phase.

Physical disturbance of seabed	Invertebrate phyla				
	Polychaeta	Mollusca	Crustacea	Echinodermata	Cnidaria
Magnitude of Pressure	Low	Low	Low	Low	Low
Sensitivity	Low	Low	Low	Medium	Medium
Degree of impact	Low	Low	Low	Low	Low
Importance	Medium	Medium	Medium	Low	Low
Severity of impact	**Low**	**Low**	**Low**	**Low**	**Low**

In summary, no invertebrates, algae or ecological components protected by international, national or local legislation are assessed to be impacted on population levels physical disturbance of the seabed during the life-cycle of the Horns Rev 3 OWF.

11.4. Loss of seabed areas

Placement of OWF structures in an area causes an absolute loss of original seabed in that area, however, the percentage of the Horns Rev 3 project area affected will amount to less than 0.2 % and is considered negligible. The magnitude of pressure is assessed to be Low during construction, operation and decommissioning.

In Table 10.1, the sensitivities of the selected species to substrate loss range from Low to Medium. Particularly, the assessed members of the phylum Crustacea are considered generalist species which are very mobile and have a Low sensitivity to loss of seabed areas. The remaining phyla are assessed to have Medium sensitivity.

Some species are considered important for local ecosystem functions, or of value for the region. The importance of the listed phyla are given as the highest importance of the investigated species within each phylum. Based on the factors in Table 8.1, the phyla Polychaeta, Mollusca and Crustacea are considered of Medium importance for the Horns Reef area, while Echinodermata and Cnidaria are considered of Low importance.

In Table 11.10 to Table 11.12 below, are given Severity of Impact assessments for loss of seabed areas for the three lifecycle phases of the Horns Rev 3 OWF.

Table 11.10 Degree of Impact on benthic habitats and communities for loss of seabed areas during the construction phase.

Loss of seabed areas	Invertebrate phyla				
	Polychaeta	Mollusca	Crustacea	Echinodermata	Cnidaria
Magnitude of Pressure	Low	Low	Low	Low	Low
Sensitivity	Medium	Medium	Low	Medium	Medium
Degree of impact	Low	Low	Low	Low	Low
Importance	Medium	Medium	Medium	Low	Low
Severity of impact	**Low**	**Low**	**Low**	**Low**	**Low**

Table 11.11 Degree of Impact on benthic habitats and communities for loss of seabed areas during the operational phase.

Loss of seabed areas	Invertebrate phyla				
	Polychaeta	Mollusca	Crustacea	Echinodermata	Cnidaria
Magnitude of Pressure	Low	Low	Low	Low	Low
Sensitivity	Medium	Medium	Low	Medium	Medium
Degree of impact	Low	Low	Low	Low	Low
Importance	Medium	Medium	Medium	Low	Low
Severity of impact	**Low**	**Low**	**Low**	**Low**	**Low**

Table 11.12 Degree of Impact on benthic habitats and communities for loss of seabed areas during the decommissioning phase.

Loss of seabed areas	Invertebrate phyla				
	Polychaeta	Mollusca	Crustacea	Echinodermata	Cnidaria
Magnitude of Pressure	Low	Low	Low	Low	Low
Sensitivity	Medium	Medium	Low	Medium	Medium
Degree of impact	Low	Low	Low	Low	Low
Importance	Medium	Medium	Medium	Low	Low
Severity of impact	**Low**	**Low**	**Low**	**Low**	**Low**

No invertebrates, algae or ecological components protected by international, national or local legislation are assessed to be impacted on population levels by loss of seabed areas during the life-cycle of the Horns Rev 3 OWF.

11.5. Introduction of hard substrate

Hard substrates will primarily be introduced in the form of turbine foundations and scour protection. Hard substrates will cover less than 0.3% of the Horns Rev 3 project area.

The physical presence of hard structures may change water flow patterns, particularly near the seafloor. However, scour protection is expected, and modelled increases in water flow rates are considered negligible in relation to the Horns Rev 3 project area for wind turbines.

While some modification to the character of sediment may occur locally around the turbines, it is the secondary 'reef effect' that potentially has the greatest impact on the local ecosystem, due to possible changes to communities and species present in the surrounding area (Hiscock et al., 2002; Meißner and Sordyl, 2006).

The habitats formed by introduction of hard substrate will be suitable for attachment by algae and colonisation by a variety of marine fauna. However, while the overall diversity of the biota in the area is expected to increase, the presence of e.g. reef fish can also have an adverse effect on the surrounding seafloor biota by increasing predation on existing local species.

International studies have demonstrated 'reef effects' on local benthic communities up to 200 metres away from artificial reefs. If similar effects were seen around Horns Rev 3 turbines, the percentages of the OWF park layout area affected could be between 6.0% and 19.3%, depending on the number of turbines installed. This is considered a very conservative assessment, as similar effects will not necessarily be as large for the North Sea biota. During the demonstration programme at Horns Rev 1 OWF, monitoring was carried out in order to assess the impact on the benthic communities from the introduction of artificial hard substrates into the pre-existing habitats of pure sand. During the studies, some changes of the benthic infauna community structure were found, with some species increasing in abundance within the OWF areas, while others decreased. However, the natural patchiness and species dynamics of Horns Reef meant that significant changes were not detectable (Leonhard & Birklund, 2006). Nonetheless, the International Advisory Panel of Experts on Marine Ecology (IAPE-ME), which reviewed the demonstration programme, did acknowledge the possibility of ‘feeding halos’ forming around each turbine.

Apart from the ‘reef effect’, another secondary effect of introducing the hard substrates of the Horns Rev 3 OWF is that any previous trawling fishery and dredging will have to cease within the project area. As disturbances of the seafloor will be heavily reduced, this will also have an effect on the benthic communities and allow species to mature to natural sizes and allow sensitive and long-lived species to establish populations. The Horns Rev 3 project area can potentially become a sanctuary area for vulnerable species (e.g. common oyster *Ostrea edulis*, ross worm *Sabellaria spinulosa* and white weed *Sertularia cupressina*), which are considered threatened or red listed in the Wadden Sea, southeast of the project area (Leonhard & Birklund, 2006; Petersen et al., 1996). The establishment of epifauna and flora on the hard substrates will increase the food available to fish, which again could lead to an increase in the food available to marine mammals and birds.

Overall, the introduction of hard substrate can potentially have effects on flora and fauna in the project area. The baseline benthic communities, which are in the area at present, can be negatively impacted, but the introduction of hard substrate will attract new species and increase the overall biodiversity of the area, while cessation of trawling activities will reduce disturbances of the benthos.

The areas covered by hard substrates will increase as construction progresses, and reach full extent upon completion of the OWF. The magnitude of pressure is assessed to be Low during construction, as natural succession will mean that the hard substrates will take a number of years before becoming fully colonised by marine organisms. During the operational phase, the effects on the surrounding benthic communities are expected to increase beyond just the areas covered by hard substrates. Compared to the pre-OWF seabeds, the magnitude of pressure is assessed to be Medium for the duration of the operational phase. Depending on decommissioning procedures, hard substrates may be removed or left *in situ* for the future. If left, the magnitude of pressure is assessed to be Medium.

In Table 10.1, the sensitivities of the selected species to changes in water flow due to introduction of hard substrate range from Not Sensitive to Medium. The phyla Polychaeta and Crustacea are assessed as having Medium sensitivities, while the remaining phyla are assessed as having Low sensitivities. The sensitivities to the secondary effects are more difficult to assess accurately. It is noted in Table 8.1 that 9 of the 17 investigated species are important prey items for fish. These species may experience increased predation in ‘feeding halos’ around hard substrates, however, the benthic invertebrate communities at Horns Reef are already subject to predation by fish, and are naturally patchy in distribution and have dynamic species compositions (Leonhard & Birklund, 2006). The sensitivity is assessed to be Low for the phylum Cnidaria and Medium for all phyla, which have species which are important prey items for fish.

Some species are considered important for local ecosystem functions, or of value for the region. The importance of the listed phyla are given as the highest importance of the investigated species within each phylum. Based on the factors in Table 8.1, the phyla Polychaeta, Mollusca and Crustacea are considered of Medium importance for the Horns Reef area, while Echinodermata and Cnidaria are considered of Low importance.

In Table 11.13 to Table 11.15 below, are given Severity of Impact assessments for introduction of hard substrates for the three lifecycle phases of the Horns Rev 3 OWF.

Table 11.13 Degree of Impact on benthic habitats and communities for introduction of hard substrate during the construction phase.

Introduction of hard substrate	Invertebrate phyla				
	Polychaeta	Mollusca	Crustacea	Echinodermata	Cnidaria
Magnitude of Pressure	Low	Low	Low	Low	Low
Sensitivity	Medium	Medium	Medium	Medium	Low
Degree of impact	Low	Low	Low	Low	Low
Importance	Medium	Medium	Medium	Low	Low
Severity of impact	**Low**	**Low**	**Low**	**Low**	**Low**

Table 11.14 Degree of Impact on benthic habitats and communities for introduction of hard substrate during the operational phase.

Introduction of hard substrate	Invertebrate phyla				
	Polychaeta	Mollusca	Crustacea	Echinodermata	Cnidaria
Magnitude of Pressure	Medium	Medium	Medium	Medium	Medium
Sensitivity	Medium	Medium	Medium	Medium	Low
Degree of impact	Medium	Medium	Medium	Medium	Low
Importance	Medium	Medium	Medium	Low	Low
Severity of impact	**Medium**	**Medium**	**Medium**	**Low**	**Low**

Table 11.15 Degree of Impact on benthic habitats and communities for introduction of hard substrate during the decommissioning phase.

Introduction of hard substrate	Invertebrate phyla				
	Polychaeta	Mollusca	Crustacea	Echinodermata	Cnidaria
Magnitude of Pressure	Medium	Medium	Medium	Medium	Medium
Sensitivity	Medium	Medium	Medium	Medium	Low
Degree of impact	Medium	Medium	Medium	Medium	Low
Importance	Medium	Medium	Medium	Low	Low
Severity of impact	**Medium**	**Medium**	**Medium**	**Low**	**Low**

In summary, while the severity of impact is medium for three phyla in the operation phase (and beyond, if hard substrates are not removed during decommissioning), no invertebrates, algae or ecological components protected by international, national or local legislation are assessed to be impacted on population levels by introduction of hard substrates during the life-cycle of the Horns Rev 3 OWF. Furthermore, the reduction in trawl fishing, as well as the hard substrates themselves, are also assessed to have positive effects on the diversity of marine life in the area, and the project area for wind turbines may serve as marine sanctuary for vulnerable species.

11.6. Electromagnetic fields and heat

Interarray- and export cables in the Horns Rev 3 project area will generate some electromagnetic fields (EMF) and heat when power is transmitted. This will only occur during the operational phase; accordingly the construction- and decommissioning phases are not assessed.

The strengths of electrical and magnetic fields expected above the sea floor depend on several factors, but are assessed to be in a range of 2.5-110 µV/m and 1.6 - 18 µT, respectively. The magnitude of pressure from EMF is assessed to be Low.

It is expected, that the amount of heat dissipated from the cables at Horns Rev will be similar, or a bit larger than have been measured at Nysted OWF, where a temperature rise of 0-1.4 K was found in the top 20 cm of sediment, which is the biologically most active layer. According to a guideline by the German Federal Agency for Nature Conservation (BfN), the temperature increase above cables buried in the seabed should, at a depth of 20 cm below the sediment surface, not exceed 2K. This is expected to be upheld. The magnitude of pressure due to heat is expected to be Low.

Sensitivity to EMF in the selected species is not a well understood, but by analogy to other invertebrate species, it is in Table 10.1, expected that the species in the Horns Rev 3 project area are Not Sensitive to electromagnetic fields. For some species there has been Insufficient Information to conduct the analysis.
In Table 10.1, the sensitivities of the selected species to a rise of sediment temperature range from Not Sensitive to Medium. Only the species *Asterias rubens* is recorded as having a Medium sensitivity to an increase in temperature. However, *Asterias rubens* (common starfish) is a motile epibenthic species, and will be quite able to move away from the localised area of potential temperature increase. The sensitivity of all phyla will therefore be assessed as Low.

In Table 11.16 below, is given Severity of Impact assessments for EMF and heat for the three lifecycle phases of the Horns Rev 3 OWF.

Table 11.16 Degree of Impact on benthic habitats and communities for electromagnetic fields and heat during the operational phase.

EMF and heat	Invertebrate phyla				
	Polychaeta	Mollusca	Crustacea	Echinodermata	Cnidaria
Magnitude of Pressure	Low	Low	Low	Low	Low
Sensitivity	Low	Low	Low	Low	Low
Degree of impact	Low	Low	Low	Low	Low
Importance	Medium	Medium	Medium	Low	Low
Severity of impact	**Low**	**Low**	**Low**	**Low**	**Low**

In summary, no invertebrates, algae or ecological components protected by international, national or local legislation are assessed to be impacted on population levels by electromagnetic fields and heat during the life-cycle of the Horns Rev 3 OWF.

12. CUMULATIVE EFFECTS

When several projects affect the same environmental conditions within a region at the same time, they are defined to have cumulative effects. Cumulative effects can potentially occur on a local scale, such as within the Horns Rev 3 project area, on a regional scale covering the entire Horns Reef / Blåvands Huk area as well as on a National/International scale; affecting general Danish environmental conditions or across borders.

The aim of assessing cumulative effects is to evaluate the extent of the environmental impact of the Horns Rev 3 OWF in terms of intensity and geographic extent, in relation to other projects in the area, as well as the vulnerability of the area to such cumulative impacts.

'Other projects' are defined as projects with existing utilised or unutilised permits or with approved plans, which have activities in the same area. A project is relevant to include in an assessment of cumulative impacts, if it meets one or more of the following requirements:

- The project and its impacts are within the same geographical area as the Horns Rev 3 OWF.
- The project effects the same or related environmental conditions as the Horns Rev 3 OWF.
- The project has permanent impacts in its operation phase interfering with impacts from the Horns Rev 3 OWF.

From these criteria, the assessments of cumulative impacts and effects from Horns Rev 3 OWF need to include:

- **Horns Rev 1 & 2 OWFs**
  - Operational noises from turbines.
  - Loss of seabed areas & introduction of hard substrate in the Horns Reef area.
  - Maritime traffic by service and maintenance vessels.
  - Decommissioning activities.
- **Raw material areas south of Horns Rev**
  - Underwater noise from shipping, aggregate extraction and dredging.
  - Suspension and redistribution of sediments during aggregate extraction.
- **Maritime traffic and shipping lanes**
  - Underwater noise from shipping lanes.
- **Fisheries**
  - Physical disturbance of the seabed due to beam trawls and bottom trawls.
  - Suspension and redistribution of sediments due to beam trawls and bottom trawls.
  - Underwater noise from vessels and fishing gear.

In Table 12.1 is shown a summary of potential overlapping effects between Horns Rev 3 environmental pressures and other pressures in the area.

Table 12.1 Potential overlaps in relation to environmental pressures during life-cycle phases of the Horns Rev 3 OWF. Overlaps in pressure possible during: **1**: Construction phase, **2**: Operational phase and **3**: Decommissioning phase (worst case decommissioning plan for the described pressure).

Source of pressure	Overlaps			
	Horns Rev 1&2	Raw materials areas	Maritime traffic	Fisheries
Noise and vibrations	1,2	1	1,2,3	1,3
Suspension and re-distribution of sediments		1		1,3
Physical disturbance of seafloor		1		1,3
Loss of seabed area	2,3			
Introduction of hard substrate	2,3			3
Electromagnetic fields and heat	2			

While overlaps of environmental pressures are present in the greater Horns Reef area, the distances involved will often eliminate the potential for cumulative effects.

In Figure 12.1 is presented an overview map showing closest distances from the Horns Rev 3 project area to: nearby Horns Rev 2 OWF (2.5 km), Horns Rev 1 OWF (15 km), the closest raw materials area (16 km) and, for reference, the two closest marine habitat AOCs (Areas Of Conservation); respectively 16 km and 19 km.

Bordering the Horns Rev 3 project area to the north, are several oil- and gas pipelines transporting hydrocarbons in from the North Sea oil and gas fields. The closest distance from to a pipeline from the edge of the Horns Rev 3 project area is 437 metres.

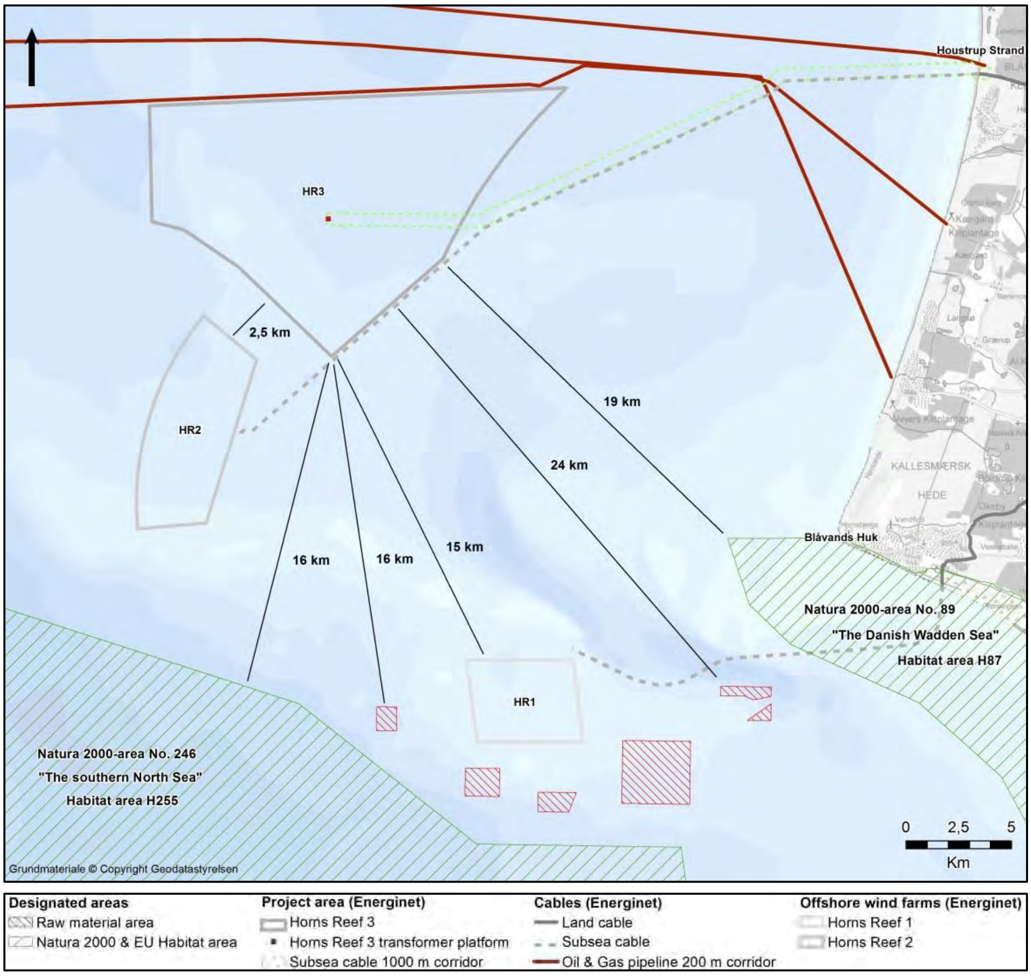


Figure 12.1 Mapping of Horns Rev 3 project area in relation to other OWFs, subsea cables & pipelines, Natura 2000-areas and designated raw material areas. Shortest distances to the latter two are drawn onto the map.

In relation to shipping, an overview of Automated Identification System (AIS) entries for maritime traffic in the Horns Reef area in the calendar year 2011 is shown in Figure 12.2. In the studied year, some vessels transited across the Horns Rev 3 project area, however, such traffic is less likely to occur once the OWF has been constructed. Heavier traffic occurs along shipping lanes following the coast of Jutland, west of the project area, as well as traffic serving the ports of Hvide Sande and Esbjerg. Some of the densest traffic appears to be inspection and maintenance craft serving the Horns Rev 1 and 2 OWFs, however, these vessels are likely to be of modest size.

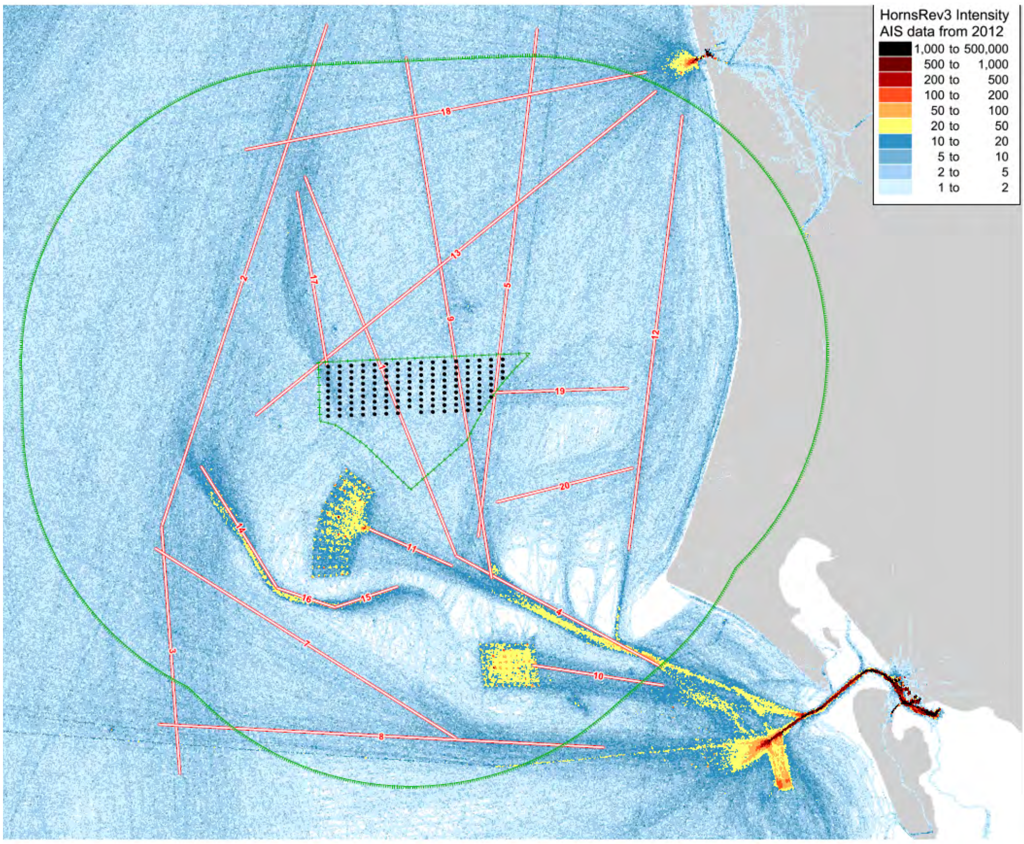


Figure 12.2 Maritime traffic and shipping lanes observed in the Horns Reef area. Based on AIS-data plots for the year 2011 (1/1-31/12). The intensity is given for 25x25m sections. From intensity analysis, often used shipping routes have been identified and are marked with orange lines. Turbine placement represents 3 MW central placement in Horns Rev 3 project area (Orbicon, 2014d)

The environmental pressures, which are considered to have potential for cumulative effects with other projects in the Horns Reef area, are presented in the life-cycle phases below.

12.1. Construction phase

Piling is the construction activity with the most far reaching environmental pressure, see Figure 9.1. While piling is not likely to occur simultaneously at several sites, the noise pressure can potentially have cumulative effects with all other projects over large parts of the Horns Reef area. However, the noise will be transient and the collective duration of piling activities will be relatively short. The potential for cumulative effects is considered Medium.

Suspension and redistribution of sediments and physical disturbance of the seabed due to Horns Rev 3 construction is expected to have very local effects, see Figure 9.2. Simultaneous dredging activities in the wind farm area and sand & aggregate extraction in the raw materials areas will (at distances >16km) therefore not generate cumulative effects. An increase in suspended sediments from fisheries could occur closer to the Horns Rev 3 project area, but will still have to occur outside of a 500 metre minimum safety distance to the construction work (Orbicon, 2014d). There will also be seasonal variations in the intensity of fisheries. The potential for cumulative effects is considered Low.

Potential cumulative effects concerning the pressures: Loss of seabed areas; Introduction of hard substrate and Electromagnetic radiation & heat and are only assessed to be possible during the operation phase of the Horns Rev 3 OWF, and are treated under that section.

Table 12.2 Significance of cumulative effects during preconstruction and construction of Horns Rev 3 OWF. **Severity of impact** is the result of assessments in previous sections. **Cumulative potential** is likelihood of cumulative effect based on range of environmental pressure and proximity with other projects. Overall assessment is translated into a **Significance** of cumulative effect.

Environmental pressures	Construction			
	Severity of impact from HR3 OWF	Cumulative potential	Duration	Significance
Noise and vibrations	Medium	Medium	Short term	Minor negative impact
Suspension and redistribution of sediments	Low	Low	Short term	No impact
Physical disturbance of seabed	Low	Low	Short term	No impact

12.2. Operation phase

Operational noise from Horns Rev 3 OWF will be orders of magnitude less than piling noise, but will be consistent throughout the operational life of the wind farm. The range of noise, which is measurably higher than background noise levels in the area, is assessed to be confined within the Horns Rev 3 project area, with possible overlap to operational noise from Horns Rev 2 OWF. The cumulative potential is assessed to be Low.

Suspension and redistribution of sediments and physical disturbance of the seabed is not assessed to be an issue during the operational phase of Horns Rev 3 OWF.

Loss of seabed areas from Horns Rev 3 will together with losses through the existence of Horns Rev 1 and 2 OWFs detract from the overall seabed areas on Horns Reef. However, the percentage of the overall area lost in comparison to the area of Horns Reef is negligible and the cumulative potential is assessed as Low.

Introduction of hard substrate from Horns Rev 3 can potentially have a cumulative effect through the existence of Horns Rev 1 and 2 OWFs. A faster colonisation of algae on the newly deployed hard substrates is considered a cumulative effect of more wind farms in the Horns Rev area. Interdiction of trawling activities inside the wind farm areas due to the presence of turbines (and subsea cables) is assessed to be beneficial to the benthic communities by enabling the species to mature to their natural sizes and enabling sensitive species to be established. There might be a cumulative effect from the establishment of Horns Rev 3 OWF within 2.5 km to Horns Rev 2 OWF if the proximity prevents or reduces effective trawling between the two OWFs.

Artificial hard substrate structures at Horns Rev 1 & 2 OWFs might contribute to a faster and more diverse faunal colonisation of hard substrates at Horns Rev 3 OWF as geographically close wind farms might function as stepping stones. Cumulative effects of the Horns Rev 1 & 2 OWFs may therefore accelerate the succession of species in the fouling communities. This can accelerate the intrusion of invasive and alien species, but might also benefit the establishment of vulnerable and threatened species like the ross worm (*Sabellaria spinulosa*) and the white weed (*Sertularia cupressina*). However, for mature community structures to appear may take up to 5-6 years after hard substrate deployment. 'Reef effects' might have an effect on the benthos species composition within the respective project area for wind turbines, but are not assessed to otherwise have cumulative effects. The cumulative potential is assessed as Medium.

The cable corridor from Horns Rev 3 follows that of Horns Rev 2. However, the pressures from electromagnetic radiation and heat are short ranged and the safety distances of 300 metres between parallel cables is assessed to large enough to negate potential cumulative effects. Close to shore, the safety distance between the cables is expected to be narrowed to 40-50 metres. Depending on sediment characteristics and burial depths, some cumulative effects might occur. However, the overall cumulative potential is assessed as Low.

Table 12.3 Significance of cumulative effects during operation of Horns Rev 3 OWF. **Severity of impact** is the result of assessments in previous sections. **Cumulative potential** is likelihood of cumulative effect based on range of environmental pressure and proximity with other projects. Overall assessment is translated into a **Significance** of cumulative effect.

Environmental pressures	Operation			
	Severity of impact from HR3 OWF	Cumulative potential	Duration	Significance
Noise and vibrations	Low	Low	Long term	No impact
Loss of seabed areas	Low	Low	Long term	No impact
Introduction of hard substrate	Medium	Medium	Long term	Positive impact
EMF and heat	Low	Low	Long term	No impact

12.3. Decommissioning phase

Decommissioning of the Horns Rev 3 OWF will generate impacts which are generally similar to the construction activities, although likely of lesser magnitude. The decommissioning work will generate noise and vibrations, but of lower intensity than piling. Noise from marine traffic and fishery activities in the area can occur at the same time as decommissioning, but is not assessed to be in the immediate proximity of the workforce. The cumulative potential is assessed as Low.

Likewise, pressures of suspension and redistribution of sediments as well as seabed disturbance can occur at the same time as fishery activities, but are not expected to be far ranging, and trawling will not occur in close proximity. The cumulative potentials are assessed as Low.

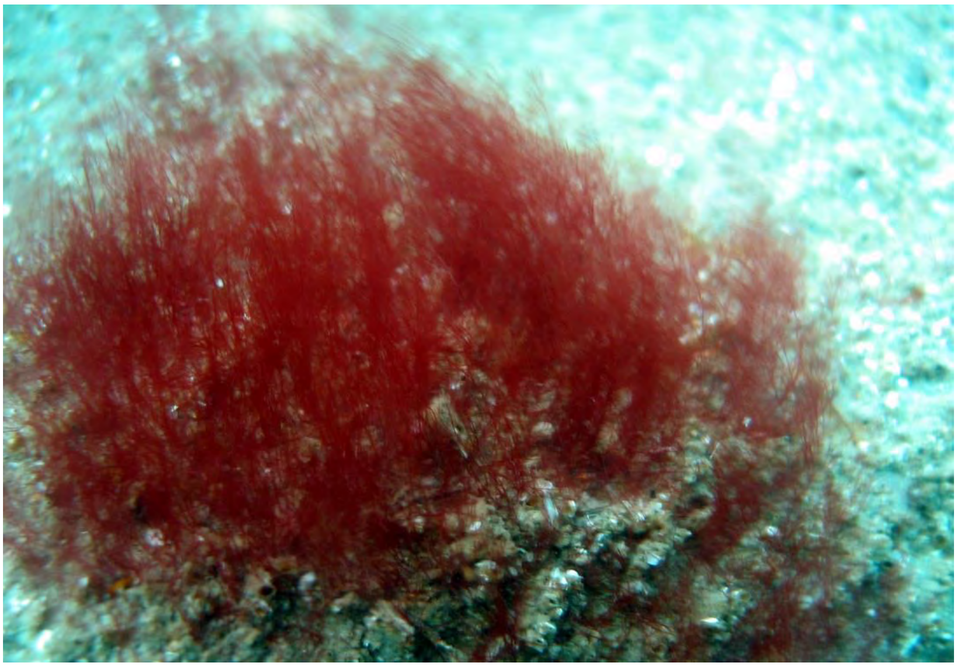
Loss of seabed areas from structures left on the seabed after decommissioning Horns Rev 3 can together with similar losses through the decommissioning of Horns Rev 1 and 2 OWFs detract from the overall seabed areas on Horns Reef. However, the percentages involved in comparison to the overall area of Horns Reef are negligible and the cumulative potential is assessed as Low.

Introduction of hard substrate can become permanent if structures and scour protection are left on the sea bed after decommissioning. The type of foundation used, will have an effect on the type of structures that are potentially left on the seabed. The effects of leaving hard substrate structures will then be similar to those under the operational phase, and are assessed to have Medium cumulative potential.

Sertulina cupressina

Table 12.4 Significance of cumulative effects during decommissioning of Horns Rev 3 OWF. **Severity of impact** is the result of assessments in previous sections. **Cumulative potential** is likelihood of cumulative effect based on range of environmental pressure and proximity with other projects. Overall assessment is translated into a **Significance** of cumulative effect.

Environmental pressures	Decommissioning			
	Severity of impact from HR3 OWF	Cumulative potential	Duration	Significance
Noise and vibrations	Medium	Low	Short term	Negligible negative impact
Suspension and redistribution of sediments	Low	Low	Short term	No impact
Physical disturbance of seabed	Low	Low	Short term	No impact
Loss of seabed areas	Low	Low	Long term	No impact
Introduction of hard substrate	Medium	Medium	Long term	Positive impact



Red algae on scour protection – Horns Rev 1

13. MITIGATION

A significant purpose of an EIA is to optimise the environmental aspects of the project applied for, within the legal, technical and economic framework.

Aspects concerning birds, fish and marine mammals are covered in other technical reports. The local algae and invertebrate species found within the project area are not protected or endangered and no environmental impacts from construction, operation and decommissioning of the Horns Rev 3 OWF, are assessed to significantly effect local flora or invertebrate fauna on population levels. The use of mitigation is therefore not assessed to be required to avoid significant impacts.

Nonetheless, in the sections below are discussed mitigation measures which would reduce the principal environmental pressures, for each life stage of the Horns Rev 3 OWF.

13.1. Construction phase

The noise from ramming piles can be mitigated by either:

- Reducing the sound generated by the pile, or by
- Reducing the transmission of sound into the environment (DOT-CA, 2009).

Regarding the first target of mitigation, the modelling of noise dispersion in this report is based on the largest turbine monopile presently conceivable, and very high ramming energies of 3000 kJ. Alternative methods for installing smaller piles into the seafloor can include using vibratory hammers as well as other oscillatory, rotary or press-in systems. It is also possible to lessen the sound generated by the piles through use of pile caps /cushion blocks of wood or synthetic materials. If such systems are used, or smaller diameter piles with less ramming energy, the noise generated by the piles are expected to be considerably less.

Regarding the second pathway of mitigation, it is possible to lessen the amount of noise transmitted through the water by using air bubble curtains or cofferdams. Bubble curtains have variable effectiveness, but can usually attenuate the sound by 0-20 dB. Some multistage designs have achieved up to 30 dB attenuation. If dewatered, coffer dams can be very effective at reducing the underwater noise, being equal or better to bubble curtains.

However, some of the sound energy is propagated through the sediment as vibrations, and will not be mitigated through water pathway measures. Invertebrates are not considered very sensitive to sound or vibrations, but very high amplitudes, such as are expected within a few metres of a pile driving can possibly cause mortalities. A possible mitigation could be to use ramp-up/slow start procedures, where the first hammer blows are at reduced impact energy. This would allow non-sessile species to vacate the immediate vicinity, and avoidance is indeed expected to be a common response by invertebrates. Even species such as American razor clam (*Ensis directus*), which are primarily known for burrowing deeper into the sediment when disturbed, are able to move short horizontal distances above the sediment by swimming, crawling or jumping (Leavitt, 2010).

13.2. Operation phase

During the operational life of offshore wind farms, scouring is known to be able to impact the surrounding seabed. This has been observed at e.g. Scroby Sands OWF (MMO, 2013). The scour protection planned into the design of the Horns Rev 3 turbine foundations is a mitigation measure, which during the operational life of the wind farm reduces the impacts of suspension and redistribution of sediments, as well as physical disturbance of the seabed. However, large areas of rock-fill for scour protection can increase the ‘reef effect’ by introducing hard substrates. On-going investigations are testing alternative methods of scour protection. One such technology is scour mattresses, such as the SSCS Frond Mat. Such technologies employ buoyant fronds of e.g. polypropylene, which reduce current velocity and cause sedimentation among the fronds, until a suspension/sedimentation equilibrium is reached. A description of the principle is available at: (http://www.resourcechurchill.com/sscs/frond_mats.html). Another alternative to rock-fill scour protection is using sandbags, which have a surface less suited to colonisation by hard substrate species. The use of such alternative scour protection, as opposed to rock-fill, is likely to reduce the ‘reef-effects’ of wind-turbine foundations resulting in a benthic environment, which more closely reflects the baseline conditions (Linley et al., 2007).

13.3. Decommissioning phase

The impacts from decommissioning will be similar to those of construction, with an exception of piling. As piling will not take place, the impact from this needs not be mitigated. At the time of decommissioning, other activities may require mitigation, however, as the details of a decommissioning plan are not known at present, and mitigation measures continually evolve, the implication of such measures during decommissioning is not considered in the present assessment.

14. SUMMARY OF IMPACT ASSESSMENT

The natural flora and invertebrate fauna species in the Horns Rev 3 project area are not considered vulnerable and are not protected under regional, national or international legislation. The benthic communities display large natural variations in spatial and temporal distribution across the Horns Reef area.

The benthic communities of the project area are typical for sandy substrates in the Horns Reef area and contain species which are characteristic of the Venus community, the *Goniadella-Spisula* community and the *Lanice conchilega* community. These communities are adapted to energetic environments and are generally tolerant to high turbidity and redistribution of sediments. None of the species are known to be particularly sensitive to noise, electromagnetic fields or heat.

Some benthic invertebrate species within the project area may be important food resources for bird species, such as the red listed Common Scoter and Oystercatcher. Modelling of habitat suitability for two such prey species indicates that the project area for wind turbines is well suited for American razor clam (*Ensis directus*), which has a distribution range extending throughout the whole Horns Reef area. Only very little of the export cable corridor is modelled to be suitable for American razor clam. Habitat modelling also shows that the project area for wind turbines is not suited for cut trough shell (*Spisula subtruncata*). This species is more common east of the project area for wind turbines and several faunal samples from eastern parts of the cable corridor contained cut trough shell. The models show that the Horns Rev 3 project area will only overlap with very small proportions of the overall distribution ranges of both species in the region.

Environmental pressures on the flora and invertebrate fauna within the Horns Rev 3 project area are present during the life stages of the OWF. An overview of the assessments is shown in Table 14.1.

The principal effects of these pressures are divided into temporary and permanent effects. The temporary effects are only predicted to occur within short timespans of the project and are expected to be recovered within the life time of the project. The effects within this category are primarily those connected with construction and decommissioning. The permanent effects can last for the life time of the project, or beyond, depending on decommissioning procedures.

Table 14.1 Summary of Impact assessment. For each pressure, the table shows assessment with the highest expected severity of impact. Abbreviations for Lifecycle phases: **C)** Construction, **O)** Operation and **D)** Decommissioning. Abbreviations for Phyla: **P)** Polychaeta, **M)** Mollusca, **Cr)** Crustacea, **E)** Echinodermata and **Cn)** Cnidaria.

Assessment Summary	Source of Pressure					
	Noise & vibrations	Suspension and redistribution of sediments	Physical disturbance of seafloor	Loss of seabed areas	Introduction of hard substrate	Electromagnetic fields and heat
	Lifecycle phases of highest pressure					
	C	C,D	C,O,D	C,O,D	O,D	O
	Most sensitive and/or important phyla					
	P,M,Cr	E	E,Cn	P,M	P,M	P,M,C
Magnitude of Pressure	High	Medium	Low	Low	Medium	Low
Sensitivity	Low	Medium	Medium	Medium	Medium	Low
Degree of impact	Medium	Medium	Low	Low	Medium	Low
Importance	Medium	Low	Low	Medium	Medium	Medium
Severity of impact	**Medium**	**Low**	**Low**	**Low**	**Medium**	**Low**

14.1. Temporary effects

Temporary noises and vibrations will be present during construction and decommissioning, but the largest effect is expected to be from piling. Modelling of noise propagation from a 10 metre diameter monopile being rammed with a 3000 kJ hammer have shown elevated Sound Exposure Levels (SELs) and dB_{peak} values in the project area. The impact on local biota is assessed to be medium as invertebrates are not considered to be particularly sensitive to noise. Only specimens within very short range of the pile driving are expected to be vulnerable to injuries.

Suspension and redistribution of the sediment has been modelled for installation of gravitation foundations and inter-array cabling. The sediment within the Horns Rev 3 project area consists of clean fine to coarse sand with a low content of silt and clay. The model shows that the seabed sediment is unlikely to contribute to significant increases in suspended sediment during construction activities. Along the cable corridor, sediments are slightly finer, but the area that is disturbed during cabling is very small and will not significantly impact cut trough shell populations. It is assessed, that no significant impacts on benthic communities will occur during construction and decommissioning.

Physical disturbances of the seabed during construction and decommissioning will equate to less than 0.6% of the Horns Rev 3 OWF park layout area and export cable corridor. The impact on the local biota is expected to be negligible, and repopulation of disturbed areas is not expected take more than 2-3 years.

14.2. Permanent effects

Operational noise and vibrations is assessed to have negligible effects on flora and invertebrate fauna, as the direct colonisation of wind turbine structures at Horns Rev 1 & 2 OWFs indicates that operational noise and vibration have no detrimental effects on the attached fauna.

Loss of seabed areas and introduction of hard substrate due to placement of wind farm infrastructure is expected to be 0.08%-0.23% of the Horns Rev 3 OWF park lay-out area, depending on the number of turbines installed. This is considered negligible.

However, hard substrates may have a secondary effect on the surrounding seabed due to the ‘Reef effect’, as the biota which colonises the hard substrate may cause ‘feeding halos’ on the surrounding seafloor. A conservative estimate, by analogy to artificial reefs on the United States Atlantic seaboard, indicates that the effect may cause impacts on 0.3%-10.6% of the Horns Rev 3 project area (depending on the number of turbines installed). The reef effect is not well documented in the North Sea, and not all local species are considered vulnerable to predation by hard substrate species. It is also noted that disturbances of the seafloor will be heavily reduced due to an interdiction of trawl fisheries within the OWF. This will have a positive effect on the benthic communities and allow species to mature to natural sizes and allow sensi-tive and long-lived species to establish populations. The overall effect of introducing hard substrates has been assessed to be a medium impact.

Electromagnetic fields and heat emissions along the subsea cables are not expected to impact the benthic fauna significantly.

15. KNOWLEDGE GAPS

The effects of many of the potential environmental pressures are not well known in invertebrates. Knowledge gaps noted in this report are:

- Effects of noise and vibrations on invertebrates
- Secondary impacts of the ‘Reef Effect’ on benthic communities in the North Sea /Horns Reef area
- Possible barrier effects of electromagnetic fields on benthic invertebrates in the area.
- Cumulative effects of operational noise and introduction of hard substrates when several OWFs are placed within the same geographical region.

16. CONCLUSIONS

The natural flora and invertebrate fauna in the Horns Rev 3 project area is not considered vulnerable and is not protected under regional, national or international legislation.

The important prey species American razor clam (*Ensis directus*) and cut trough shell (*Spisula subtruncata*) have been investigated through habitat modelling. The models show, that the Horns Rev 3 project area will only overlap with very small proportions of the overall distribution ranges of both species in the Horns Reef region.

Impacts from construction and operation activities are considered minor and are not expected to have any significant effects on populations of flora and invertebrate fauna in the Horns Rev 3 project area.

Physical disturbance of the seabed and loss of seabed areas to infrastructure is only expected to affect negligible percentages of the Horns Rev 3 project area. The overall effect of disturbances and loss is assessed to have no significant impacts on the local benthic communities.

Faunal communities in areas covered by wind farm infrastructure and scour protection areas will change from sandy substrate communities to hard substrate communities. Cumulative effects of the hard substrates in Horns Rev 1 & 2 OWFs may accelerate the natural succession of species in the fouling communities, however, mature community structures are still expected to take 5-6 years to develop.

Secondary 'Reef effects', in the form of predatory 'feeding halos' caused by hard substrate species may cause changes in the sandy substrate communities beyond the areas of hard substrate. The precise magnitude of potential 'reef effects' in the Horns Reef area is not known.

Reduced fishery within the project area may result in more diverse and more mature infaunal communities, as periodic disturbances of the seafloor from trawling will cease. The project area could potentially become a safe haven for vulnerable species not currently present in the project area. Some such species are not considered to qualify for a national Danish red list, but are nonetheless listed in Wadden Sea red list, which covers coastal regions to the east, south and south-east of the project area. Some species from the list, which might establish themselves in the project area, include: sea anemone *Urticina felina*, common oyster *Ostrea edulis*, ross worm *Sabellaria spinulosa* and white weed *Sertularia cupressina* – which are respectively listed as: critical, critical, endangered and vulnerable.

Overall severity of impacts on benthic communities during the life stages of Horns Rev 3 OWF, are assessed to be minor and none are assessed to have significant effects on the population levels of local communities. Further mitigation is therefore not assessed to be required in relation to the benthic flora and fauna communities.

17. REFERENCES

Betke K (2006). Measurement of underwater noise emitted by an offshore wind turbine at Horns Rev. Report. Institut für Technische und Angewandte Physik GMBH (ITAP). Pp.19.

Birkett L (1953). Changes in the compositions of the bottom faunaof the Dogger Banke area. Nature 171: 265.

Breen M, Howell T and Copland P (2011). A report on electrical fishing of razor clams (Ensis sp.) and its likely effects on the marine environment. Marine Scotland Science Report 03/11. 120 pp.

CMACS (2003). A baseline assessment of electromagnetic fields generated by off-shore wind farm cables. Collaborative Offshore Wind Energy Research into the Environment (COWRIE) Report EMF-01-2002 66.

Danovaro R, Gambi C, Mazzola A and Mirto S (2002). Influence of artificial reefs on the surrounding infauna: analysis of meiofauna. ICES Journal of Marine Science. Vol. 59: 356-362.

Danish Energy Agency (2005). Havvindmøller – Danske erfaringer og løsninger. ISBN: 87-7844-562-0.

Danish Ministry of Climate, Energy and Building (2012). Energy policy report 2012.

Danish Ministry of Climate, Energy and Building (2013). The Danish Climate Policy Plan – Towards a low carbon society 2012. Electronic publication ISBN: 978-87-93071-29-2

Davis N, Blaricom van GR and Dayton PK (1982). Man-made structures on marine sediments: effects on adjacent benthic communities. Marine Biology. Vol. 70: 295-303.

DEWI, Deutches Windenergie-Institut (2004). Standardverfahren zur Ermittlung und Bewertung der Belastung der Meeresumwelt durch Schallimmissionen von Offshore-Windenergieanlagen. -Abschlussbericht zum Forschungsvorhaben 0327528A an das BMU. Pages 123.

DHI (1999). Havvindmøllefundamenter ved Horns Rev – Hydrografiske data. ELSAMPROJEKT A/S.

Degraer S, Vincx M, Meire P and Offringa H (1999). The macrozoobenthos of an important wintering area of the common scoter (*Melanitta nigra*). J. Mar. Biol. Ass. UK, 79. 243-2251.

Dewarumez JM, Devoult D, Anorve LES and Frontier S (1992). Is the ‘muddy heterogenoussediment assemblage ‘ an ecotone between the pebbles community and the Abra alba community in the Southern Bight of the North Sea? Netherlands Journal of Sea Research, Vol. 30: 229-238.

DOT-CA, California Department of Transportation (2009). Technical Guidance for Assessment and Mitigation of the Hydroacoustic Effects of Pile Driving on Fish. Final Report. Pp. 298.

Energinet.dk (2014) Technical Project Description for the large-scale offshore wind farm (400 MW) at Horns Rev 3.

Essink K (1999). Ecological effects of dumping of dredged sediments: options for management. Journal of Coastal Conservation, Vol. 5: 69–80.

Gill AB, Gloyne-Phillips I, Neal KJ and Kimber JA (2005). COWRIE 1.5 Electromagnetic fields. Review. The potential effects of electromagnetic fields generated by sub-sea power cables associated with offshore wind farm developments on electrically and magnetically sensitive marine organisms – a review. Final report. COWRIE-EM FIELD 2-06-2004.

Gill AB, Huang Y, Gloyne-Philips I, Metcalfe J, Quayle V, Spencer J and Wearmouth V (2009). EMF-sensitive fish response to EM emissions from sub-sea electricity cables of the type used by the offshore renewable energy industry. COWRIE 2.0 EMF Final Report. COWRIE-EMF-1-06.

Greenstreet S, Robinson L, Reiss H, Craeymeersch J, Callaway R, Goffin A, Jorgensen L, Robertson M, Kröncke I, Bois I de, Jacob N and Lancaster J (2007). Species composition, diversity, biomass and production of the benthic invertebrate community of the North Sea. Fisheries Research Services Collaborative Report No. 10/07.

Heip C, Craeymeersch JA (1995). Benthic community structures in the North Sea. Helgoländer Meeresuntersuchungen, Vol. 49: 313-328.

Hirzel AH (2001). When GIS come to life. Linking landscape- and population ecology for large population management modelling: the case of Ibex (*Capra ibex*) in Switzer-land. Institute of Ecology, Laboratory for Conservation Biology , University of Lausanne. 2001. pp. 1-114, PhD thesis .

Hirzel AH, Hausser J, Chessel D and Perrin N (2002). Ecological-niche factor analysis: How to compute habitat- suitability maps without absence data? Ecology. 2002, 83, pp. 2027-2036.

Hiscock K, Tyler-Walters H and Jones H (2002). High level environmental screening study for offshow wind farm developments – marine habitats and species project. Report from the Marine Biological Association to DTI New & Renewable Energy Programme. AEA Technology, Environment contract: W/35/0632/00/00.

Hiscock K, Southward A, Tittley I and Hawkins S (2004). Effect of changing temperature on benthic marine life in Britain and Ireland. Aquatic Conservation:Marine and Freshwater Ecosystems, Vol.14: 333-362.

Hiscock K and Tyler-Walters T (2006). Assessing the sensitivity of seabed species and biotopes – the Marine Life Information Network (MarLIN). Hydrobiologia Vol. 555: 309-320.

Joint Nature Conservation Committee (2007a). Conservation status assessment for :

H1110: Sandbanks which are slightly covered by sea water all the time. Second Report by the UK under Article 17 on the implementation of the Habitats Directive from January 2001 to December 2006. Peterborough: JNCC. Available from: www.jncc.gov.uk/article17

Joint Nature Conservation Committee (2007b). Conservation status assessment for :

H1170: Reefs. Second Report by the UK under Article 17 on the implementation of the Habitats Directive from January 2001 to December 2006. Peterborough: JNCC. Available from: www.jncc.gov.uk/article17

Keller O, Lüdemann K and Kafemann R (2006). Literature review of offshore wind farms with regard to fish fauna. BfN-Skripten. 2006, Vol. 186. Page 47-130.

Kingston P and Rachor E (1982). North Sea level bottom communities. ICES CM 1982/L:41, 1-15.

Kirkegaard JB (1969). A quantitative investigation of the central North Sea. Polychaeta. Spolia 29: 1-284.

Kramer K (2000). Kabelbauarten sowie Verlegemethoden und ihre Auswirkungen auf magnetische und elektrische Felder im Meer. In: Merck T, von Nordheim H (Eds) Technische Eingriffe in Marine Lebensräume, BfN-Skripten 29: 77-87.

Kröncke I and Bergfeld C (2001). Synthesis and New Conception of North Sea Research (SYCON) 12. Working group 10. Review of the current knowledge on North Sea Benthos. Berichte aus dem Zentrum für Meeres und Klimaforschung dern Universität Hamburg: 1-138.

Kröncke I, Reiss H, Eggleton JD, Aldridge J, Bergman MJN, Cochrane S, Craeymeersch JA, Degraer S, Desroy N, Dewarumes JM, Duineveld GCA, Essink K, Hillewaert H, Lavaleye MSS, Moll A, Nehring S, Newell R, Oug E, Pohlmann T, Rachor E, Robertson M, Rumohr H, Schratzberger M, Smith R, Berghe E van, Dalfsen J van, Hoey G van, Vincx M, Willems W and Rees HL (2011). Changes in North Sea macrofauna communities and species distribution between 1986 and 2000. Estuarine, Coastal and Shelf Science. Vol. 94: 1-15.

Künitzer A, Basford D, Craeymeersch JA, Dewarumez JM, Dörjes J, Duineveld GCA, Eleftheriou A, Heip C, Herman P, Kingston P, Niermann U, Rachor E, Rumohr H and Wilde PAJ de (1992). The benthic infauna of the North Sea: species distribution and assemblages. ICES Journal of Marine Science. Vol 49: 127-143.

Lagardère JP (1982). Effects of noise on growth and reproduction of Crangon crangon in rearing tanks. Marine Biology. Vol. 71. 177-185.

Leavitt DF (2010). Biology of the Atlantic Jacknife (Razor) Clam (*Ensis directus* Conrad, 1843) NRAC (National Regional Aquaculture Center). 5 pp.

Leonhard SB (2000). Horns Rev Offshore Wind Power Farm. Environmental Impact Assessment of Sea Bottom and Marine Biology. 1-36. Report request. Commissioned by Elsam I/S.

Leonhard SB (2006). EIA report – Benthic communities. Horns Rev 2 Offshore Wind Farm. Prepared for ELSAM.

Leonhard SB and Birklund J (2006). Infauna, epifauna and vegetation – Change in diversity and higher biomass. Report. Danish Offshore Wind – Key Environmental Issues: 44-63.

Leonhard SB and Pedersen J (2006). Benthic communities at Horns Rev before, during and after construction of Horns rev Offshore Wind Farm. Report commissioned by ELSAM Engineering. Bio/consult: 1-23.

Leonhard SB and Skov H (Eds.) 2012. Food Resources for Common Scoter. Horns Reef Monitoring 2009-2010. Orbicon, DHI, Wageningen IMARES. Report commissioned by The Environmental Group through contract with DONG Energy, 48pp.

Levin M and Ernst SG (1995). Applied AC and DC magnetic fields cause alterations in the mitotic cycle of early sea urchin embryos. Bioelectromagnetics. Vol. 16: 231-240.

Lindquist DG, Cahoon LB, Clavijo LB, Posey IE, Bolden MH, Pike SK, Burk LA, and Cardullo PA (1994). Reef fish stomach contents and prey abundance on reef and sand substrata associated with adjacent artificial and natural reefs in Onslow Bay, North Carolina. Bulletin of Marine Science. Vol. 55: 308-318.

Linley EAS, Wilding TA, Black K, Hawkins AJS and Mangi S (2007). Review of the reef effects of offshore wind farm structures and their potential for enhancement and mitigation. Report from PML Applications Ltd and the Scottish Association for Marine Science to the Department for Business, Enterprise and Regulatory Reform (BERR), Contract No: RFCA/005/0029P.

Marlen van B, Haan de D, Gool van A and Burggraaf D (2009). The effect of pulse stimulation on marine biota – Research in relation to ICES advice – Progress report on the effects on benthic invertebrates, IMARES report No. C103/09. Pp. 49.

Meißner K and Sordyl H (2006). Literature review of offshore wind farms with regard to benthic communities and habitats. 1-46 in: BfN-Skripten 186 (2006) - "Ecological Research on Offshore Wind Farms: International Exchange of Experiences", Editors: Zucco C, Wende W, Merck T, Köchling I, Köppel J.

Meißner K, Bockhold J and Sordyl H (2006). Problem Kabelwärme? – Vorstellung der Ergebnisse von Feldmessungen der Meeresbodentemperatur im Bereich der elektrischen Kabel im dänischen Offshore-Windpark Nysted Havmøllepark (Dänemark). In: Meeresumwelt-Symposium 2006. Hrsg. Bundesamt für Seeschiffahrt und Hydrographie, Hamburg : 153-161.

Meyer CG, Holland KN and Papastamatiou YP (2004). Sharks can detect changes in the geomagnetic field, Journal of the Royal Society Interface, (DOI:10.1098/rsif.2004.0021 FirstCite): 2pp.

Moore A and Cobb JLS (1986). Neurophysiological studies on the detection of mechanical stimuli in Ophiura ophiura. Journal of Experimental Marine Biology and Ecology. Vol 104: 125-141.

MMO (2013). Evalutaion of the current state of knowledge on potential cumulative effects from offshore wind farms (OWF) to inform marine planning and marine licensing. A report produced for the Marine Management Organisation, pp. 71. MMO Project No: 1009 ISBN: 978-1-909452-07-7.

Nedwell J and Howell D (2004). A review of offshore windfarm related underwater noise sources. Report No. 544 R 0308. Collaborative Offshore Wind Energy Research into the Environment (COWRIE).

Newell RC, Seiderer LJ and Hitchcock DR (1998). The impact of dredging works in coastal waters: A review of the sensitivity to disturbance and subsequent recovery of biological resources on the sea bed. Oceanography and Marine Biology: an Annual Review 1998. Vol. 36: 127-78.

Nedwell JR , Parvin SJ, Edwards B, Workman R , Brooker AG and Kynoch JE (2007). Measurement and interpretation of underwater noise during construction and operation of offshore windfarms in UK waters. Subacoustech Report No. 544R0738 to COWRIE Ltd. ISBN: 978-0-9554279-5-4.

Neumann H, Reiss H, Rakers S, Ehrich S and Kröncke I (2009). Temporal variability in southern North Sea epifauna communities after the cold winter of 1995/1996, ICES Journal of Marine Science. Vol 66: 2233-2243.

Normandeau, Exponent, Tricas T and Gill A(2011). Effects of EMFs from Undersea Power Cables on Elasmobranchs and Other Marine Species. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Regulation, and Enforcement, Pacific OCS Region, Camarillo, CA. OCS Study BOEMRE 2011-09.

Norro A, Rumes B and Degraer S (2011) Characterisation of the operational noise, generated by offshore wind farms in the Belgian part of the North Sea. In: Offshore wind farms in the Belgian part of the North Sea: Selected findings from the baseline and targeted monitoring. Editors: Degraer, S.; Brabant, R.; Rumes, B. (2011). Royal Belgian Institute of Natural Sciences. Management Unit of the North Sea, Mathematical Models. Marine Ecosystem Management Unit: Brussels. 157 pp.

Offut GC (1970). Acoustic stimulus perception by the American *Lobster Homarus americanus*. Experentia. Vol. 26:1276-1278.

Orbicon. (2014a). Horns Rev 3 Offshore Wind Farm. Metocean. DMI; Orbicon A/S. Energinet.dk.

Orbicon. (2014b). Horns Rev 3 Offshore Wind Farm. Commercial Fisheries. Technical report no. 6. Orbicon A/S. Energinet.dk.

Orbicon. (2014c. Horns Rev 3 Offshore Wind Farm. Fish Ecology. Technical report no. 5. Orbicon A/S. Energinet.dk.

Orbicon. (2014d). Horns Rev 3 Offshore Wind Farm. Navigational Risk Analysis. Technical report no. 11. Cowi A/S; Orbicon A/S. Energinet.dk.

OSPAR (2008). Background document on potential problems associated with power cables other than those for oil and gas activities. Biodiversity series 2008.

OSPAR (2009). Assessment of the environmental impact of cables. Publication Number: 437/2009, 19 p.

Packard A, Kalsen HE and Sand O (1990). Low frequency hearing in cephalopods. Journal of Comparative Physiology. Vol. 166: 501-505.

Petersen GH (1977). The density, biomass and origin of the bivalves of the central North Sea. Meddr. Danm. Fisk.- og Havunders. N.S. Vol. 7: 221-273.

Petersen GH, Madsen PB, Jensen KT, Bernem van KH, Harms J, Heiber W, Kröncke I, Michaelis H, Rachor E, Reise K (1996). Red List of macrofaunal benthic invertebrates of the Wadden Sea. Helgoländer Meeresuntersuchungen, October 1996, Supplement, Vol. 50: 69-76.

Powilleit M, Graf G, Klein J, Riethmüller R, Stockmann K, Wetzel MA, Koop JHE (2009). Experiments on the survival of six brackish macroinvertebrates from the Baltic Sea after dredged spoil coverage and its implications for the field. Journal of Marine Systems Vol. 75: 441–451.

Rambøll (2010) Anholt Havmøllepark: Miljøredegørelse – Transformerplatform og ilandføringskabel. Final Report 2010.

Rambøll (2013). Horns Rev 3 Results Report – Geo investigation 2012. Rambøll og Energinet.dk, 28 pp, http://www.energinet.dk/SiteCollectionDocuments/Engelske%20dokumenter/Anl%C3%A6g%20og%20projekter/HR3_Results_Report_v1.pdf

Reiss H, Degraer S, Duineveld GCA, Kröncke I, Aldridge J, Craeymeersch J, Eggleton J, Hillewaert H, Lavaleye MSS, Moll A, Pohlmann T, Rachor E, Robertson M, Berghe vanden E, Hoey van G, Rees HL (2010). Spatial patterns of infauna, epifauna and demersal fish communities in the North Sea. ICES Journal of Marine Science. Vol. 67: 278-293.

Salzwedel H, Rachor E and Gerdes D (1985). N´Benthic macrofauna communities in the German Bight. Veröff. Inst. Meeresforsch. Bremerh. Vol. 20: 199-267.

Schröder A (1995). Das Makrozoobenthos am West-Gamma-Wrack in der äußeren Deutschen Bucht. Zum Fischereieinfluß auf eine Bodenfaunagemeinschaft der Nordsee. Dipl.-Arbeit Rheinische Friedrich-Wilhelm-Universität Bonn / Alfred-Wegener Institut für Polar- und Meeresforschung Bremerhaven, 115pp.

Skov H, Durinck J, Erichsen A, Kloster RM, Møhlenberg F, Leonhard SB (2008). Horns Reef II Offshore Wind Farm - Food Basis for common Scoter. Baseline Studies 2007-2008. Orbicon A/S, DHI Water Environment and Health A/S, Marine observers. s.l. : Dong Energy A/S, 2008, 48 pp.

Theobald PD, Lepper PA, Robinson SP and Hazelwood RD (2009). Cumulative noise exposure assessment for marine using sound exposure level as a metric. In: Proceedings of the 3rd International Conference Underwater Acoustic Measurement: Technologies & Results (UAM2009), 21-26 June 2009, Nafplion, Greece.

Thiele R (2002). Propagation loss values for the North Sea. Handout re experts' consultation: Offshore windmills sound emissions and marine mammals. - FTZ-Büsum, 15 Jan. 2002.

Ursin E (1960). Quantitative investigation of the Echinoderm Fauna of the central North Sea. Meddr. Danm. Fisk.- og Havunders. N.S. Vol. 2: 1-204.

Vanosmael C, Willems KA, Claeys D, Vincx M and Heip C (1982). Macrobenthos of a sublittoral sandbank in the southern Bight of the North Sea. J. Ma. Biol. Ass. UK, Vol. 62: 521-534.

Vaquer-Sunyer R and Duarte CM (2011). Temperature effects on oxygen thresholds for hypoxia in marine benthic organisms. Global Change Biology, Vol. 17: 1788-1797.

Vella G, Rushforth I, Mason E, Hough A, England R, Styles P, Holt T and Thorne P (2001). Assessment of the effects of noise and vibration from offshore wind frams on marine wildlife. ETSU W/13/00566/REP – DTI/Pub URN 01/1341. 107 pages.

Westerberg H (1994). Fiskeriundersökningar vid havsbaserat vindkraftverk 1990-1993. Rapport 5 – 1994 – Göteborgfilialen, Utredningskontoret I Jönköping. 44 pages.

Woodruff DL, Schultz IR, Marshall KE, Ward JA and Cullinan VI (2012). Effects of Electromagnetic Fields on Fish and Invertebrates. Task 2.1.3: Effects on Aquatic Organisms Fiscal Year 2011 Progress Report. Environmental Effects of Marine and Hydrokinetic Energy. Prepared for U.S. Department of Energy.

APPENDICES

MAPS:

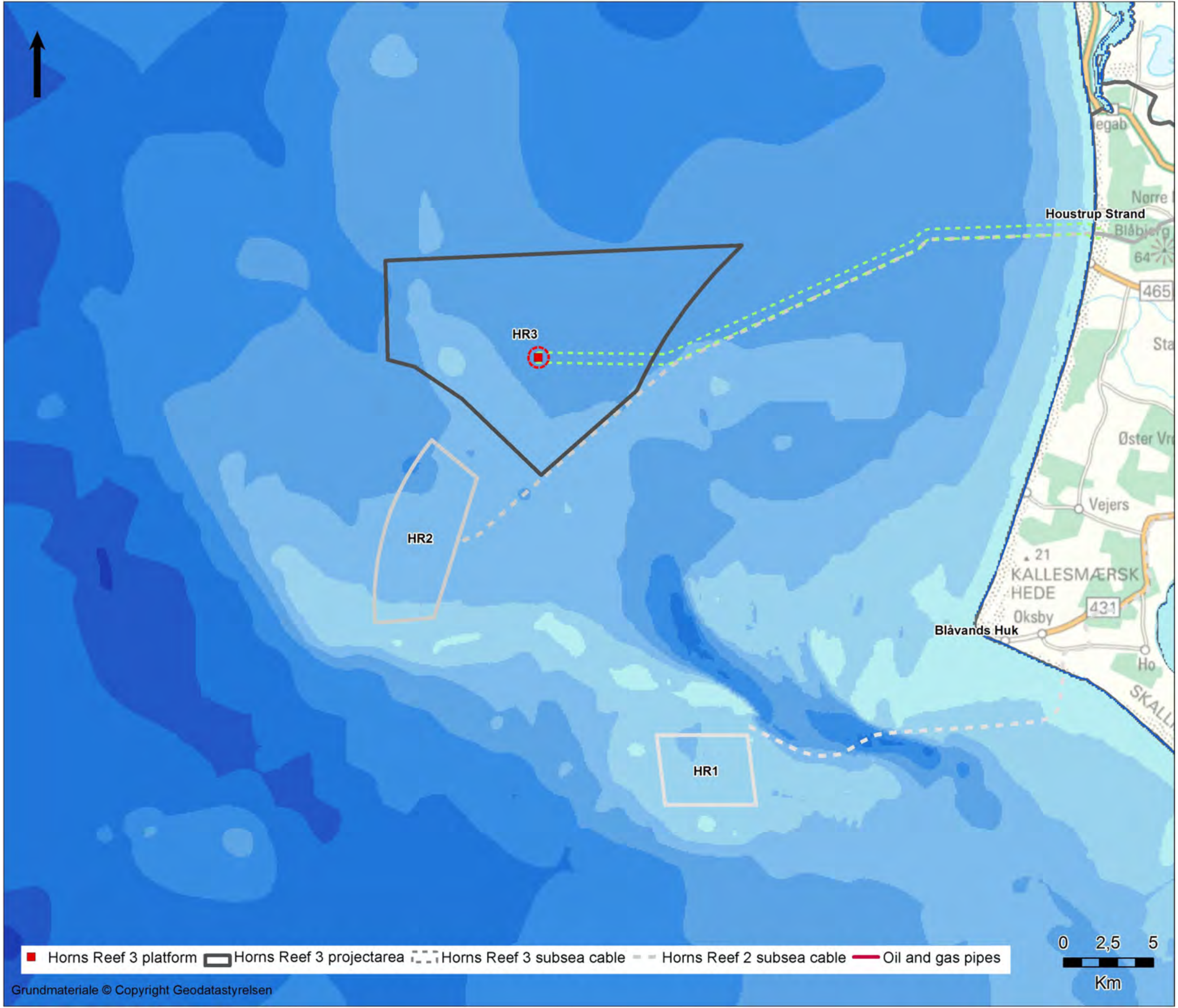
29: *Figure 36* Modelling of SEL (blue contours) and dBpeak unweighted peak pressure (dun contours) for a 3000 kJ piling driving event at the southernmost point of the Horns Rev 3 project area. The shown contours are in 10 dB increments, starting with 180 dB for SEL and with 200 dB for dBpeak.

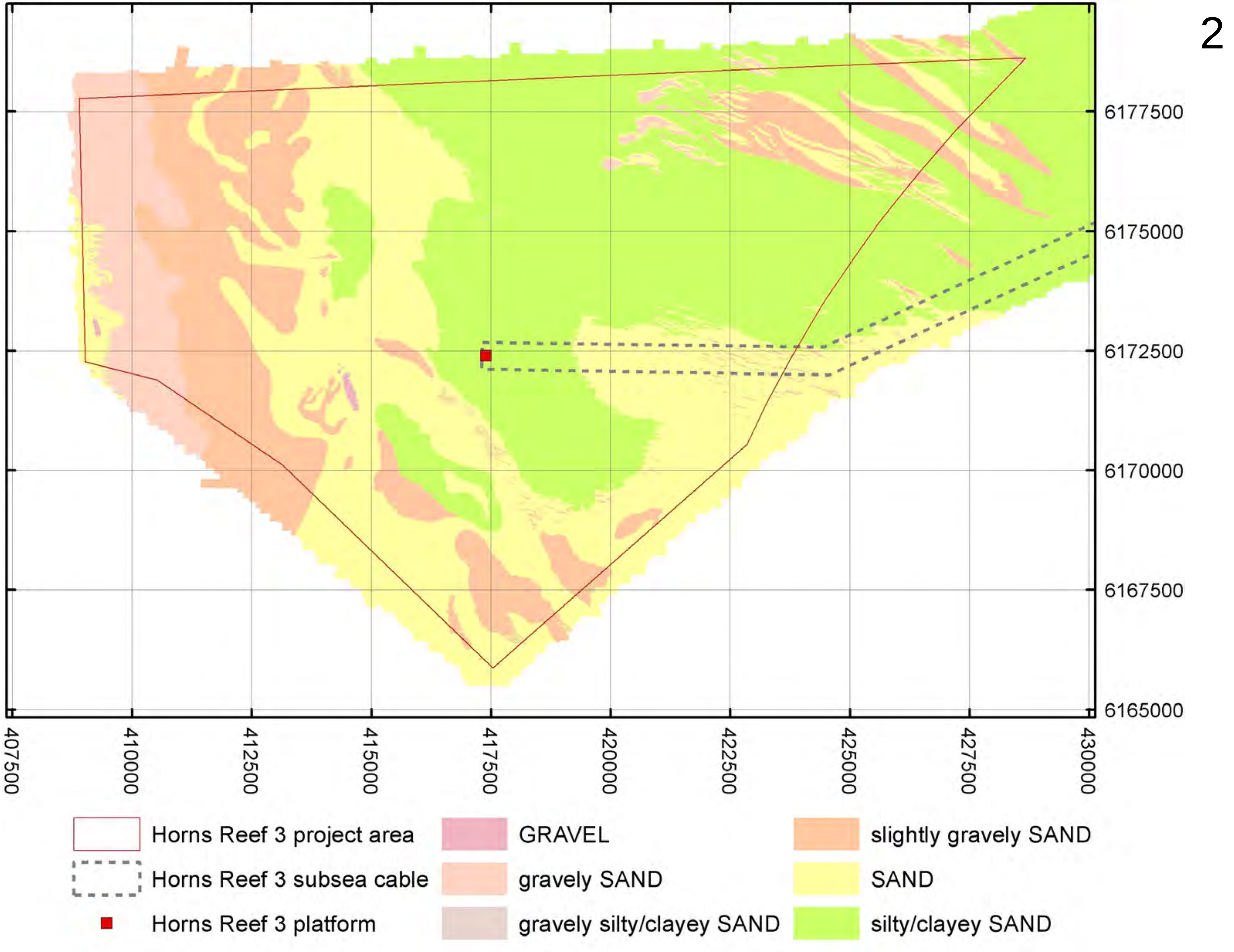
30: *Figure 37* Modelled dispersion scenario for installation of nine turbines (3 MW) and cabling in the most north-westerly corner of the Horns Rev 3 project area.

31: *Figure 39* A) Mean summer and B) mean winter bottom temperatures (°C) from 1998 to 2007. (From Neumann et al., 2009)

32: *Figure 41* Mapping of Horns Rev 3 project area in relation to other OWFs, subsea cables & pipelines, Natura 2000-areas and designated raw material areas. Shortest distances to the latter two are drawn onto the map.

33: *Figure 42* Maritime traffic and shipping lanes observed in the Horns Reef area. Based on AIS-data plots for the year 2011 (1/1-31/12). The intensity is given for 25x25m sections. From intensity analysis, often used shipping routes have been identified and are marked with orange lines. Turbine placement represents 3 MW central placement in Horns Rev 3 project area. From HR-TR-007 – Navigational Risk Analysis.


HR3
HR2
HR1
Houstrup Strand
Blåbjerg
Nørre
Øster Vr
Vejers
KALLESMÆRSK
HEDE
Oksby
Blåvands Huk
Ho
465
431
64
21
Horns Reef 3 platform
Horns Reef 3 projectarea
Horns Reef 3 subsea cable
Horns Reef 2 subsea cable
Oil and gas pipes
0
2,5
5
Km
Grundmateriale © Copyright Geodatastyrelsen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6172500
6170000
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6165000
407500
410000
412500
415000
417500
420000
422500
425000
427500
430000
Horns Reef 3 project area
Horns Reef 3 subsea cable
Horns Reef 3 platform
GRAVEL
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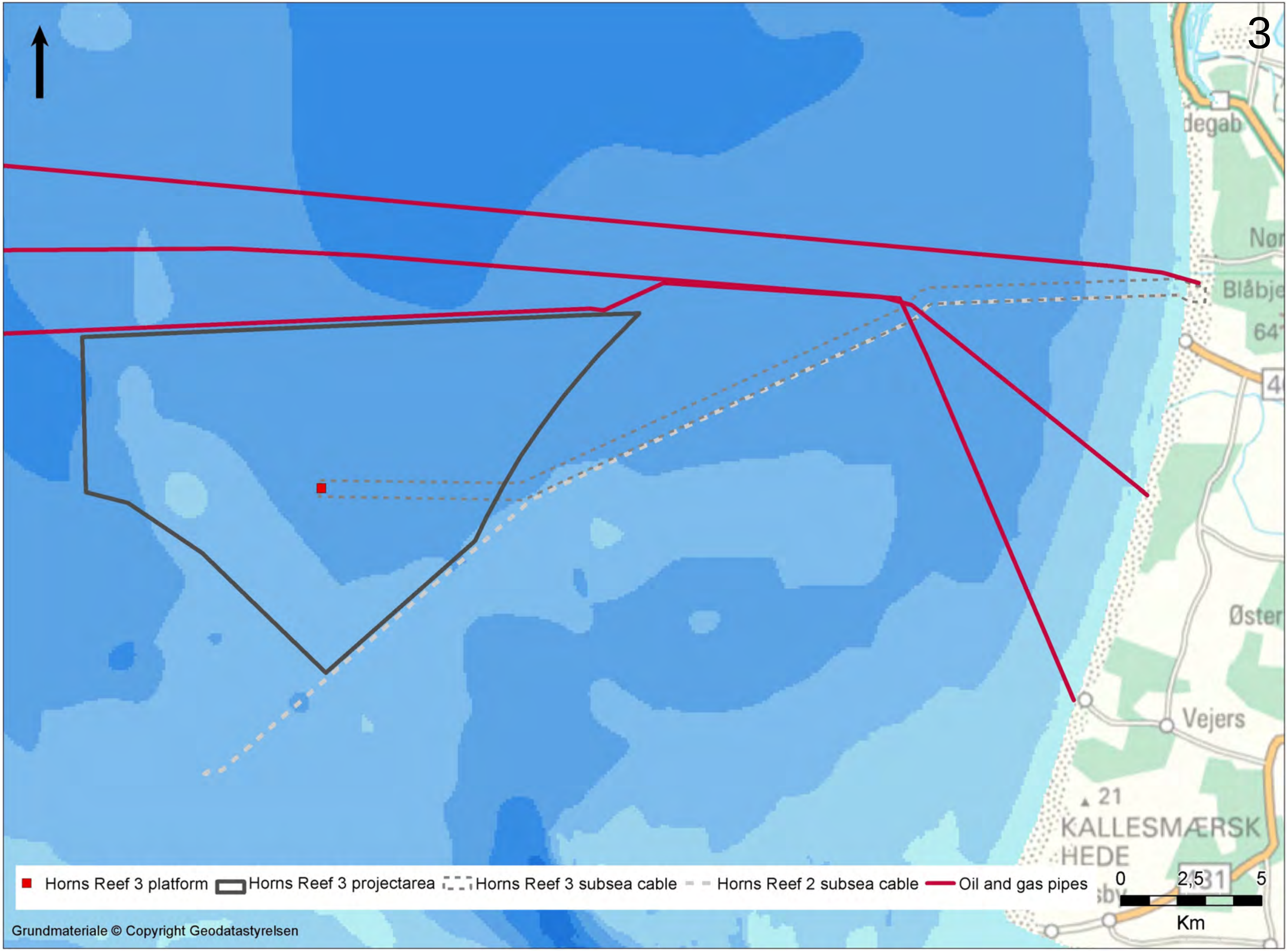
gravely silty/clayey SAND
slightly gravely SAND
SAND
silty/clayey SAND


3
degab
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Øster
Vejers
21
KALLESMÆRSK
HEDE
431
Horns Reef 3 platform
Horns Reef 3 projectarea
Horns Reef 3 subsea cable
Horns Reef 2 subsea cable
Oil and gas pipes
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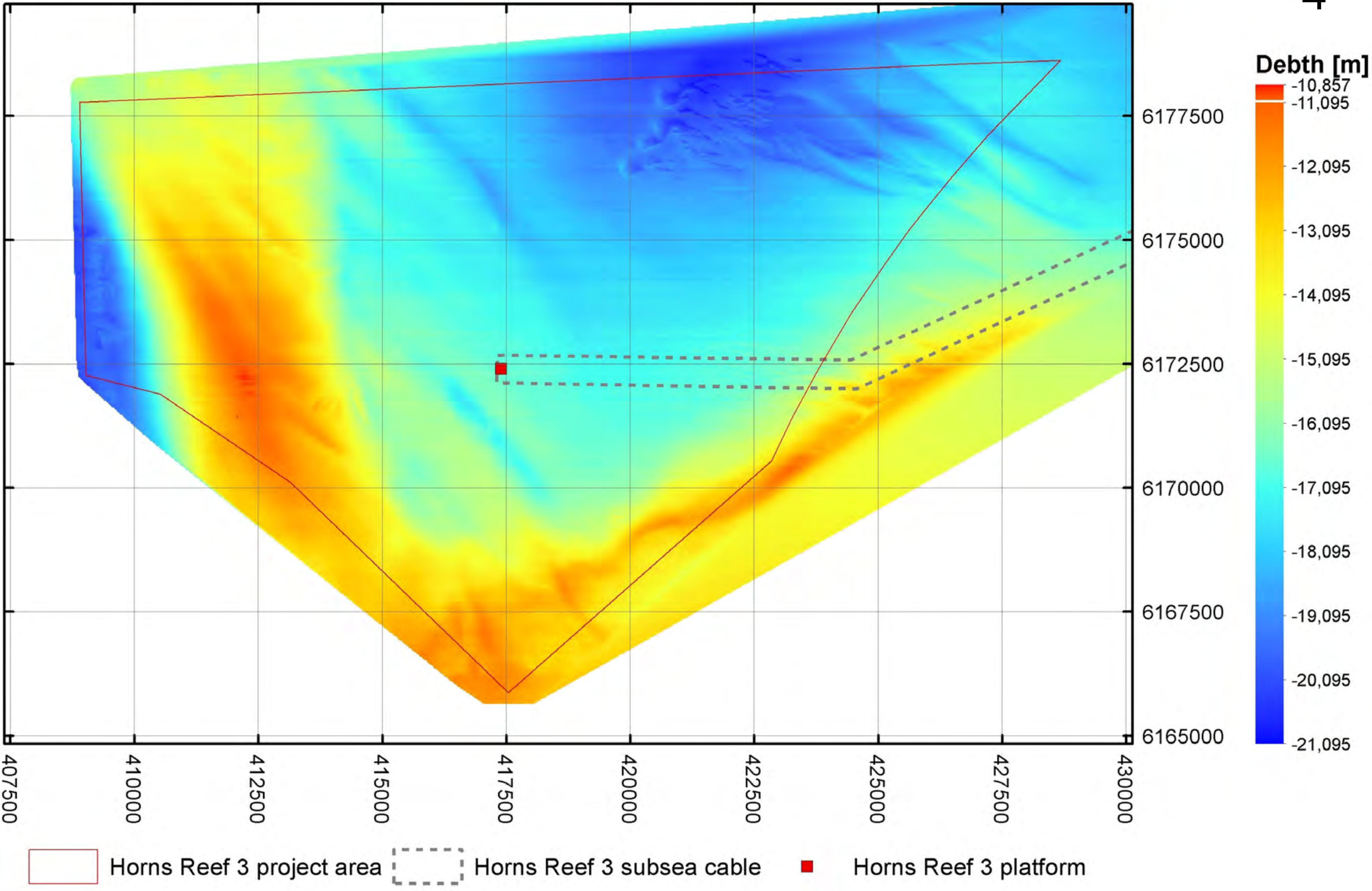
Grundmateriale © Copyright Geodatastyrelsen



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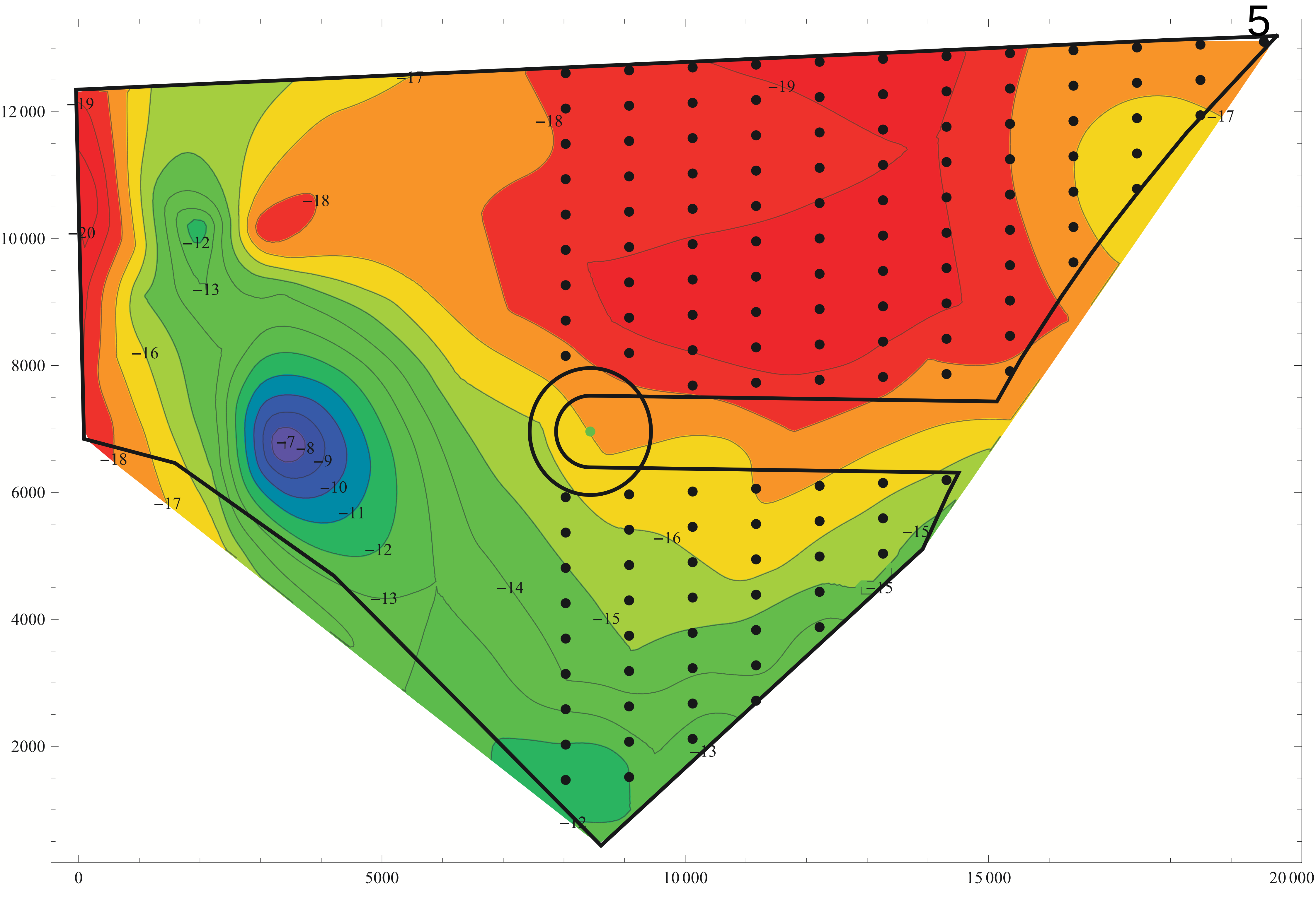
Horns Reef 3 project area
Horns Reef 3 subsea cable
Horns Reef 3 platform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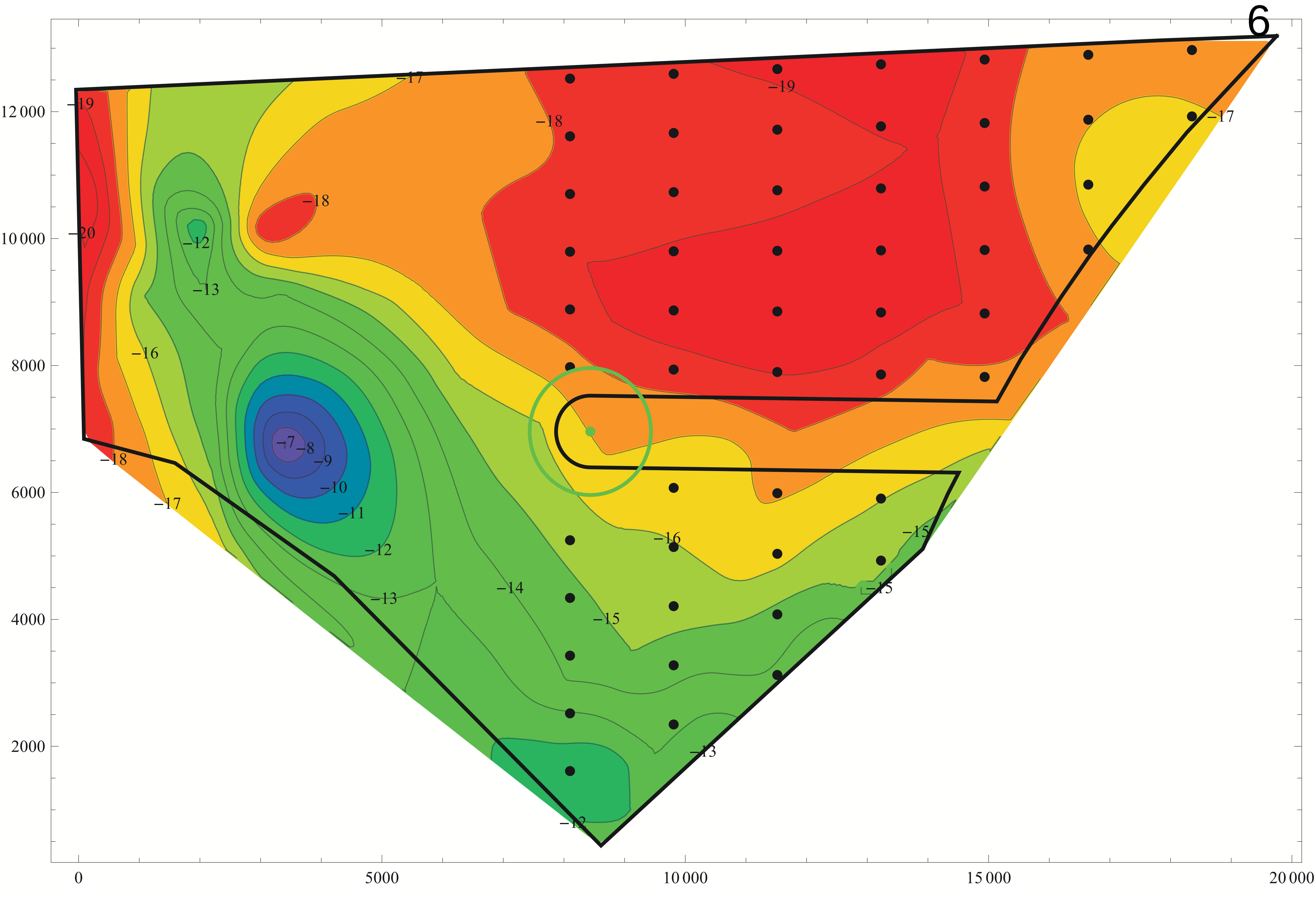

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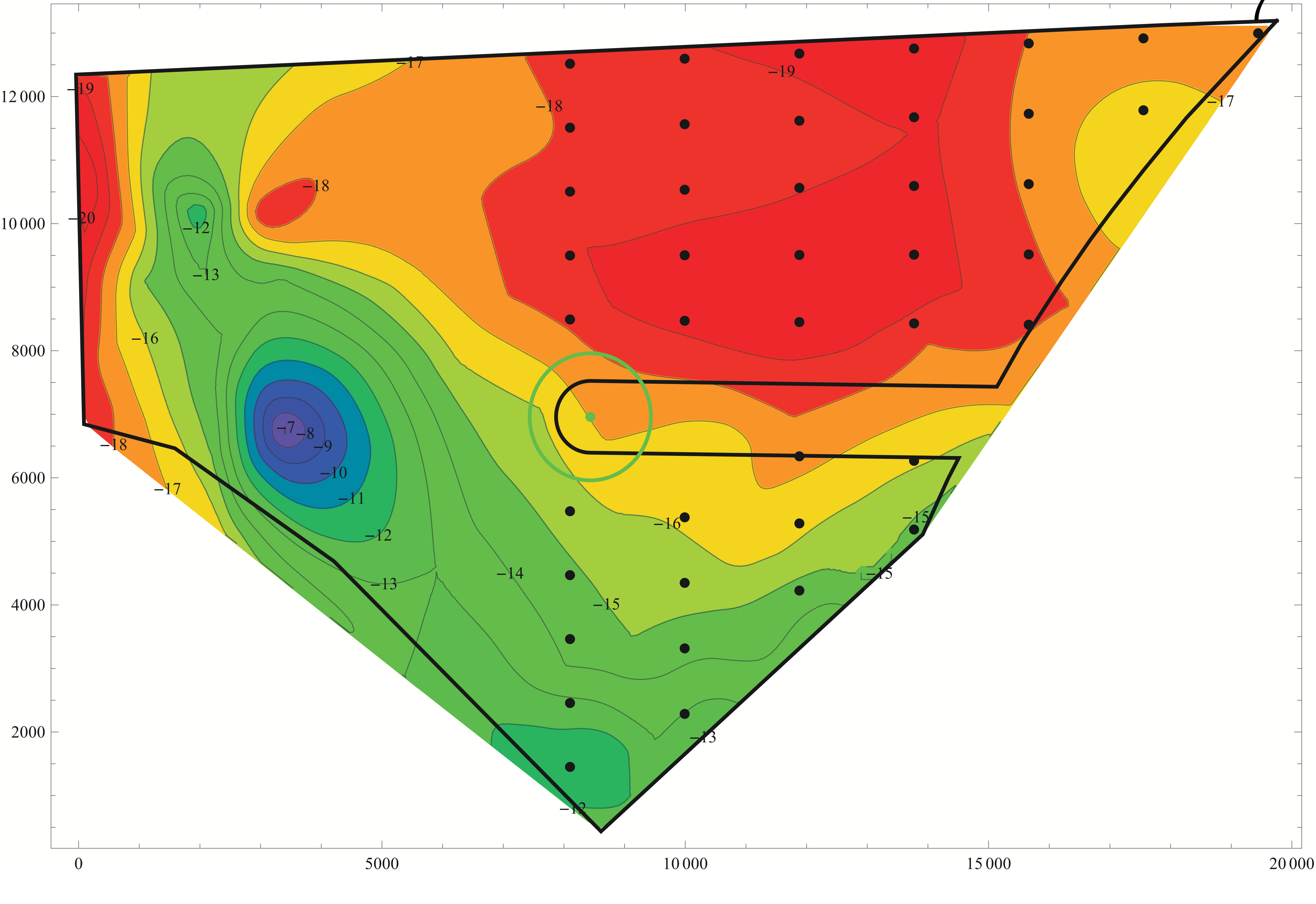

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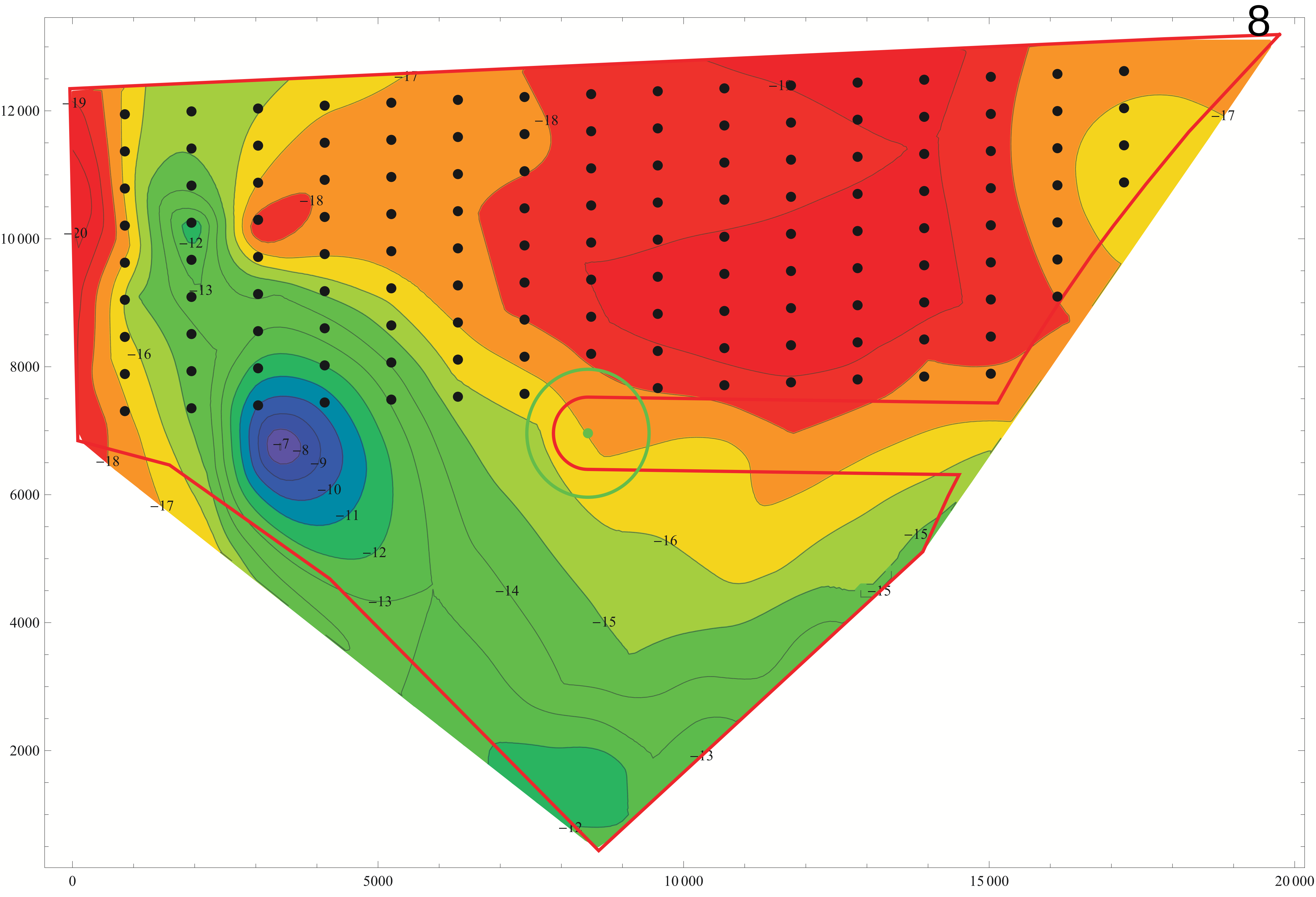
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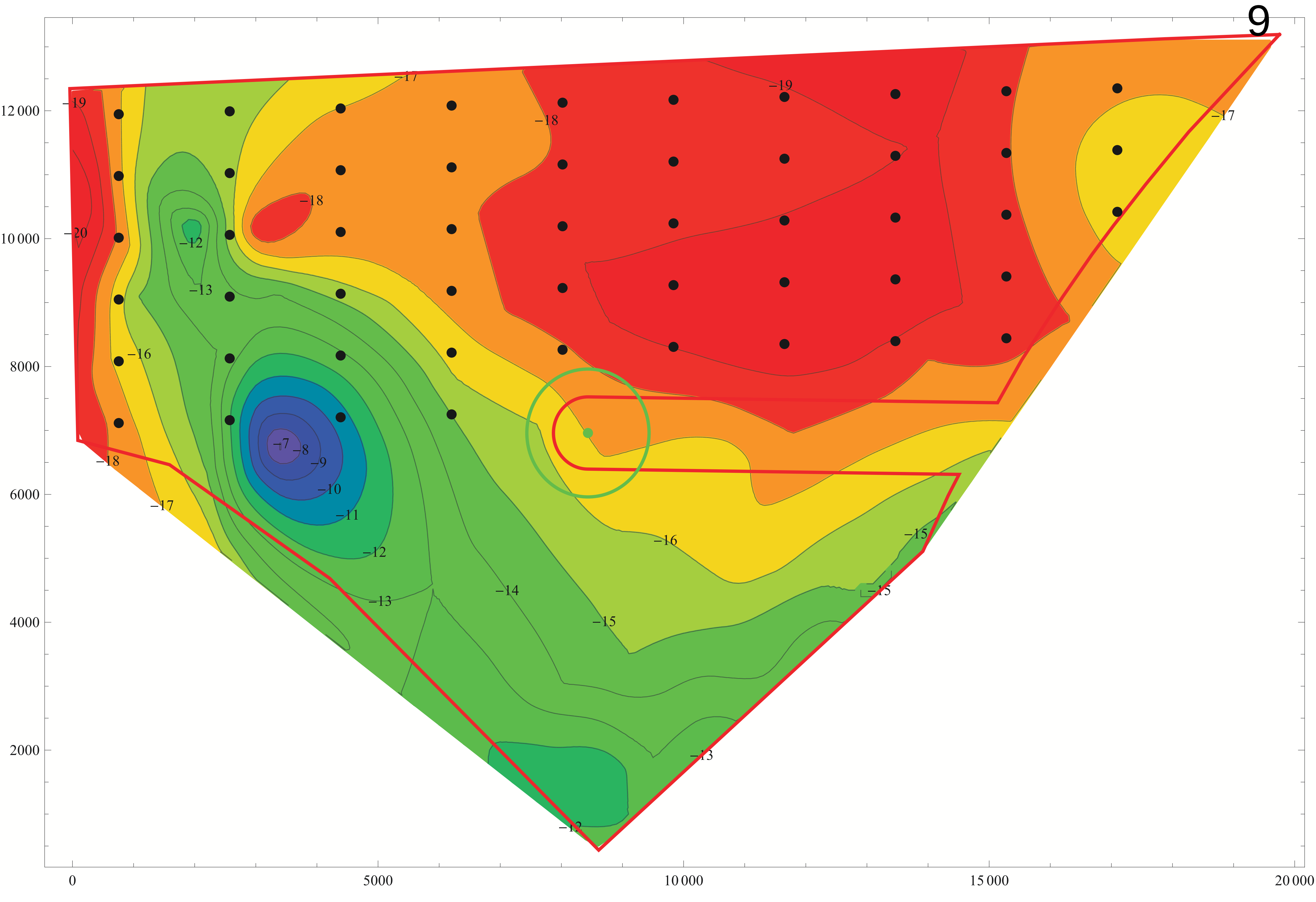

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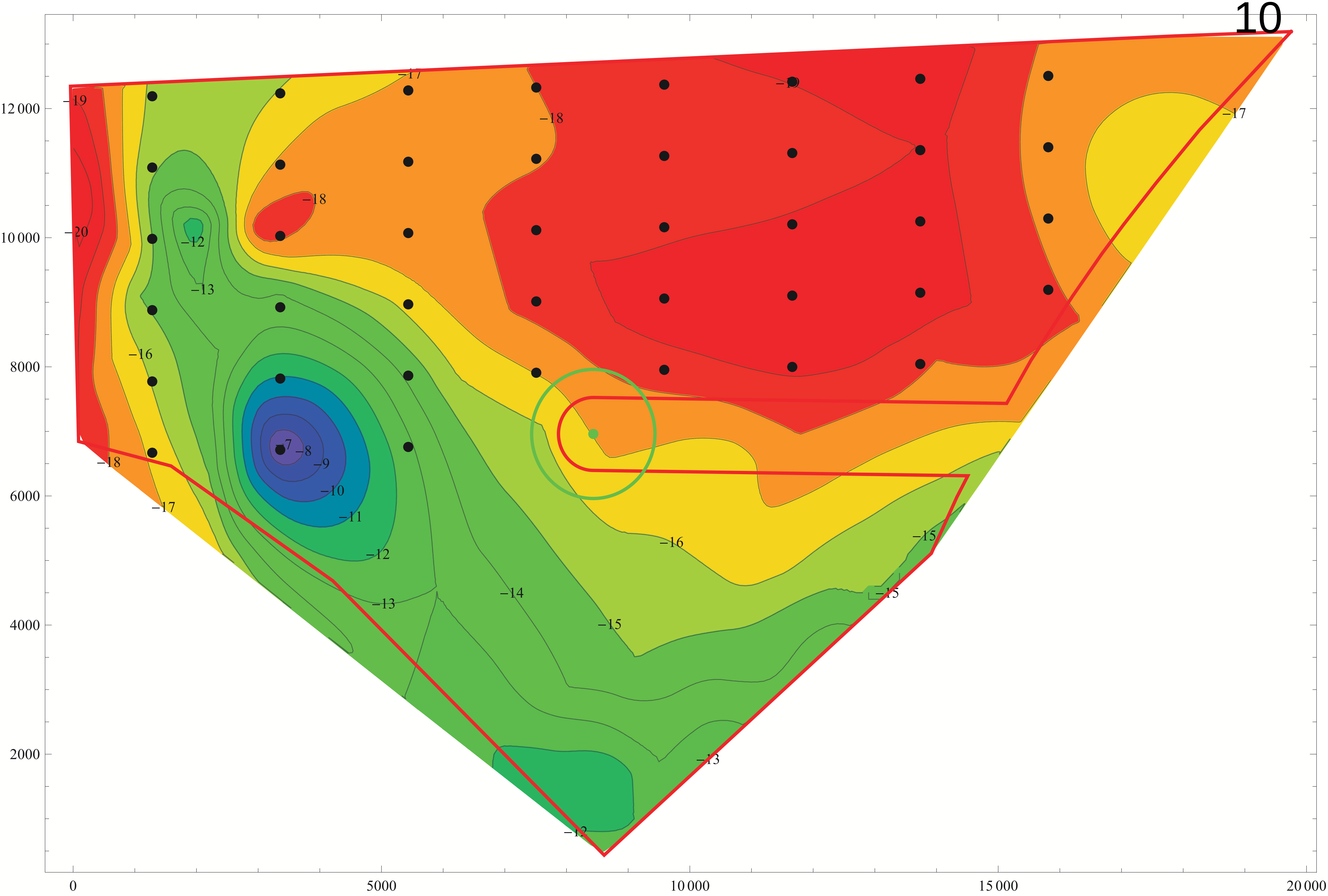
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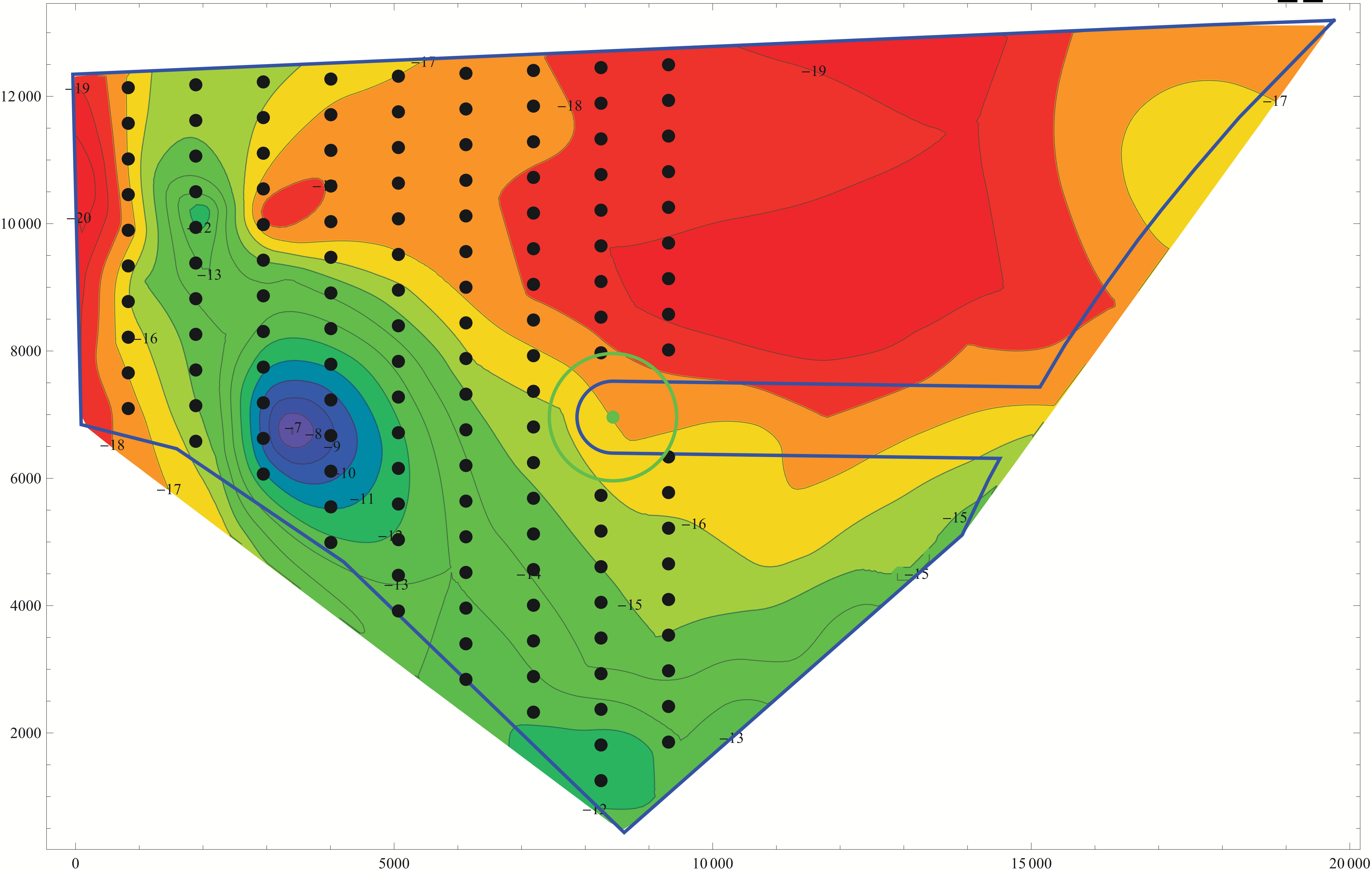

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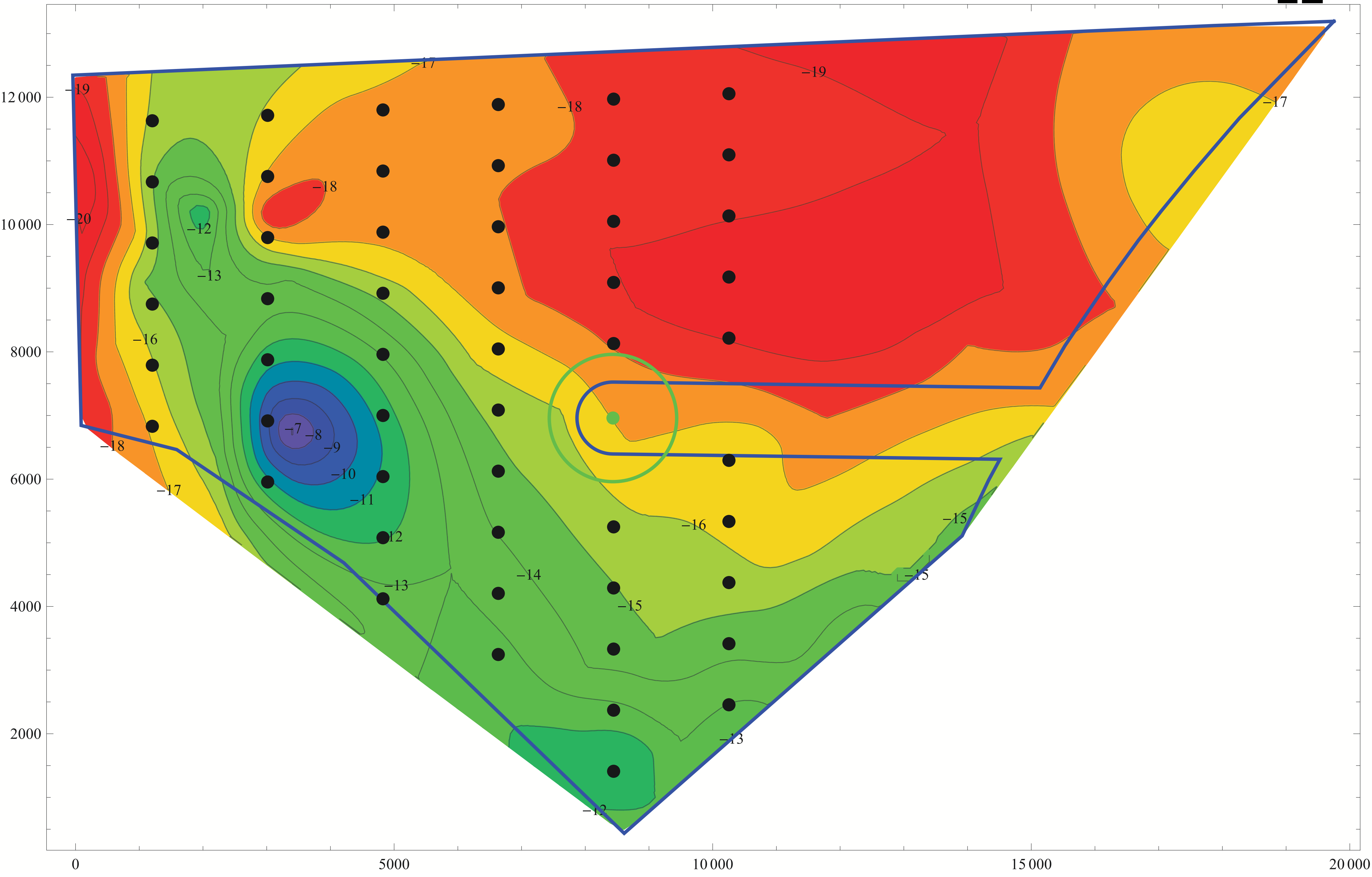

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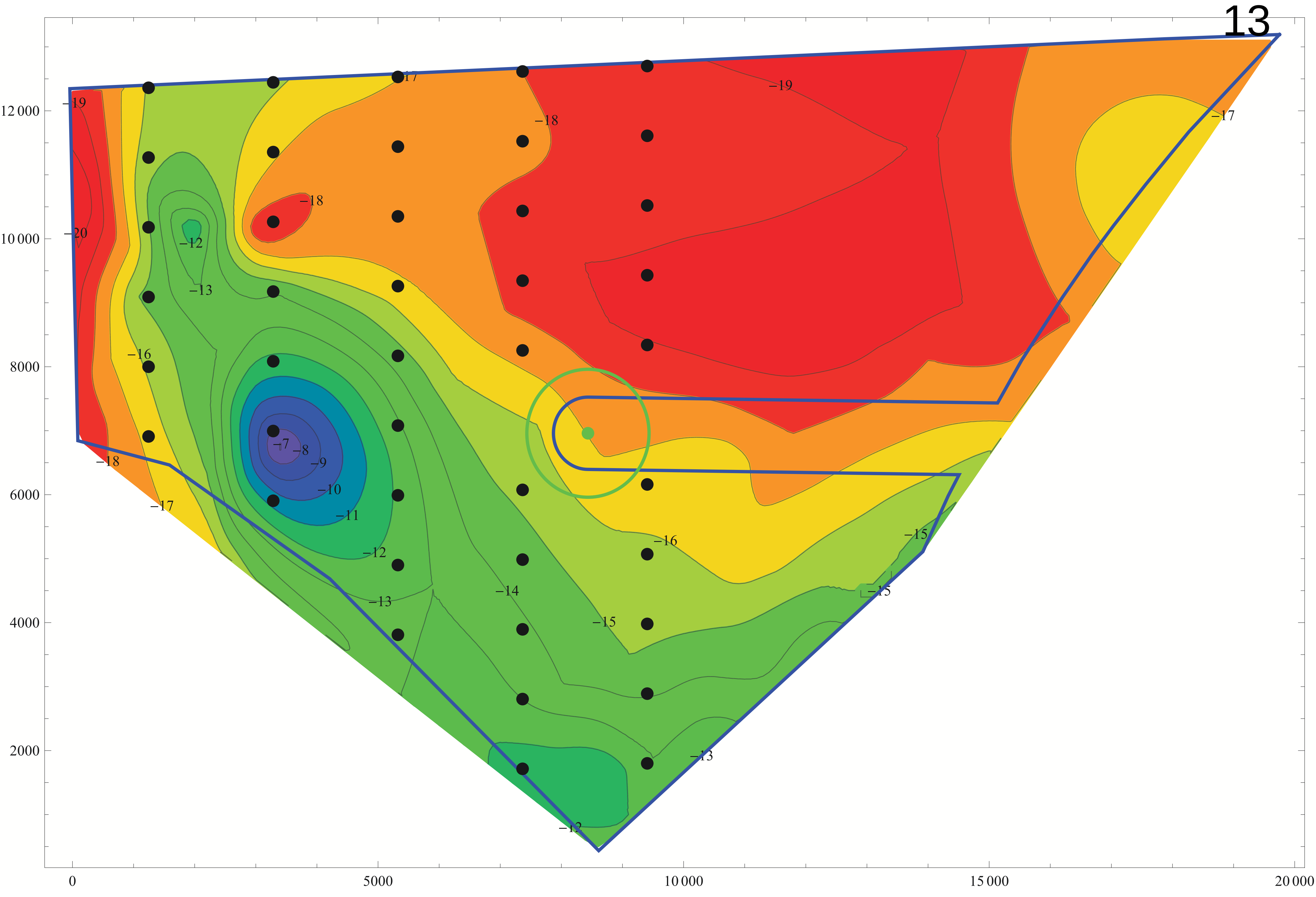
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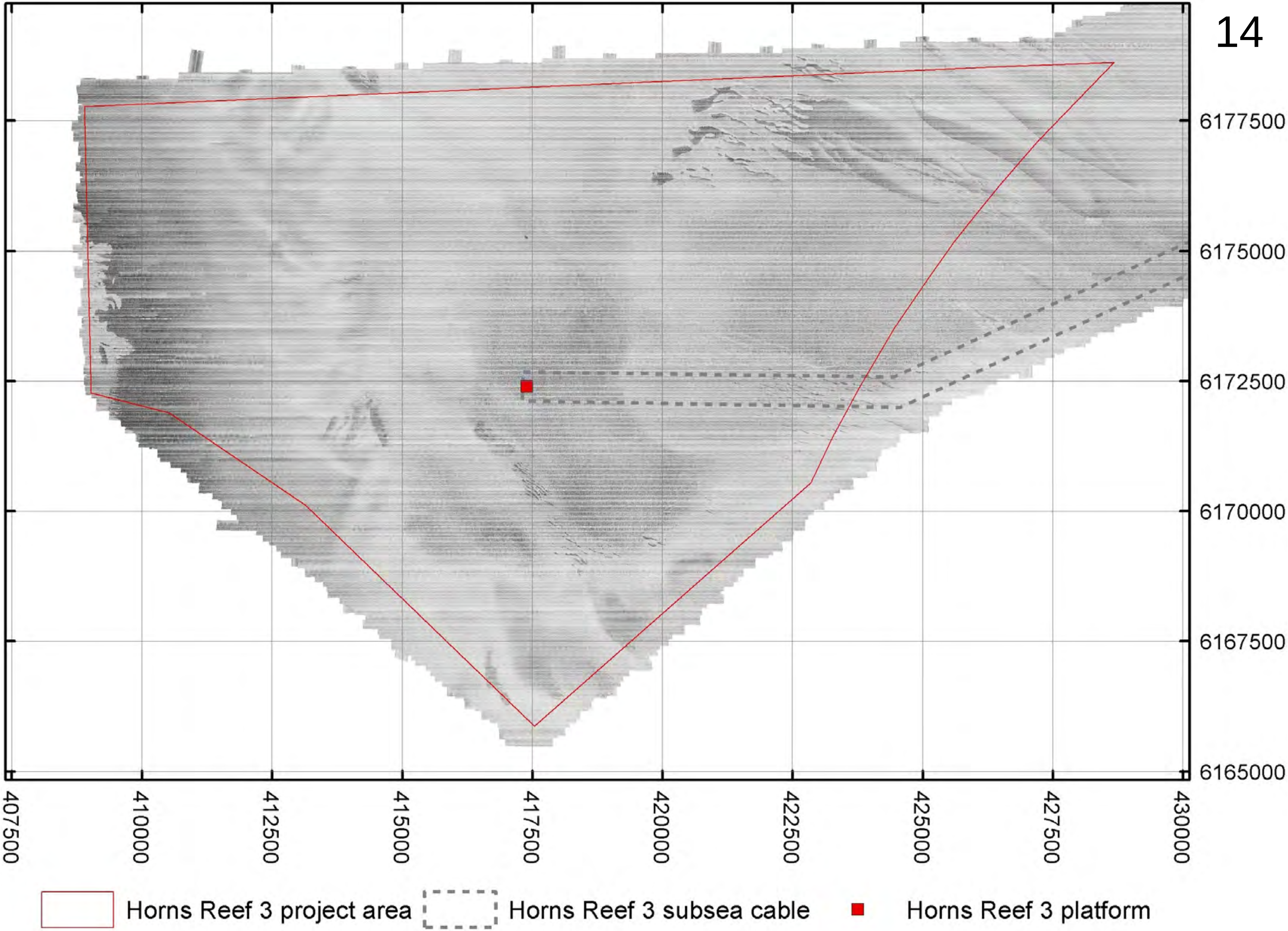
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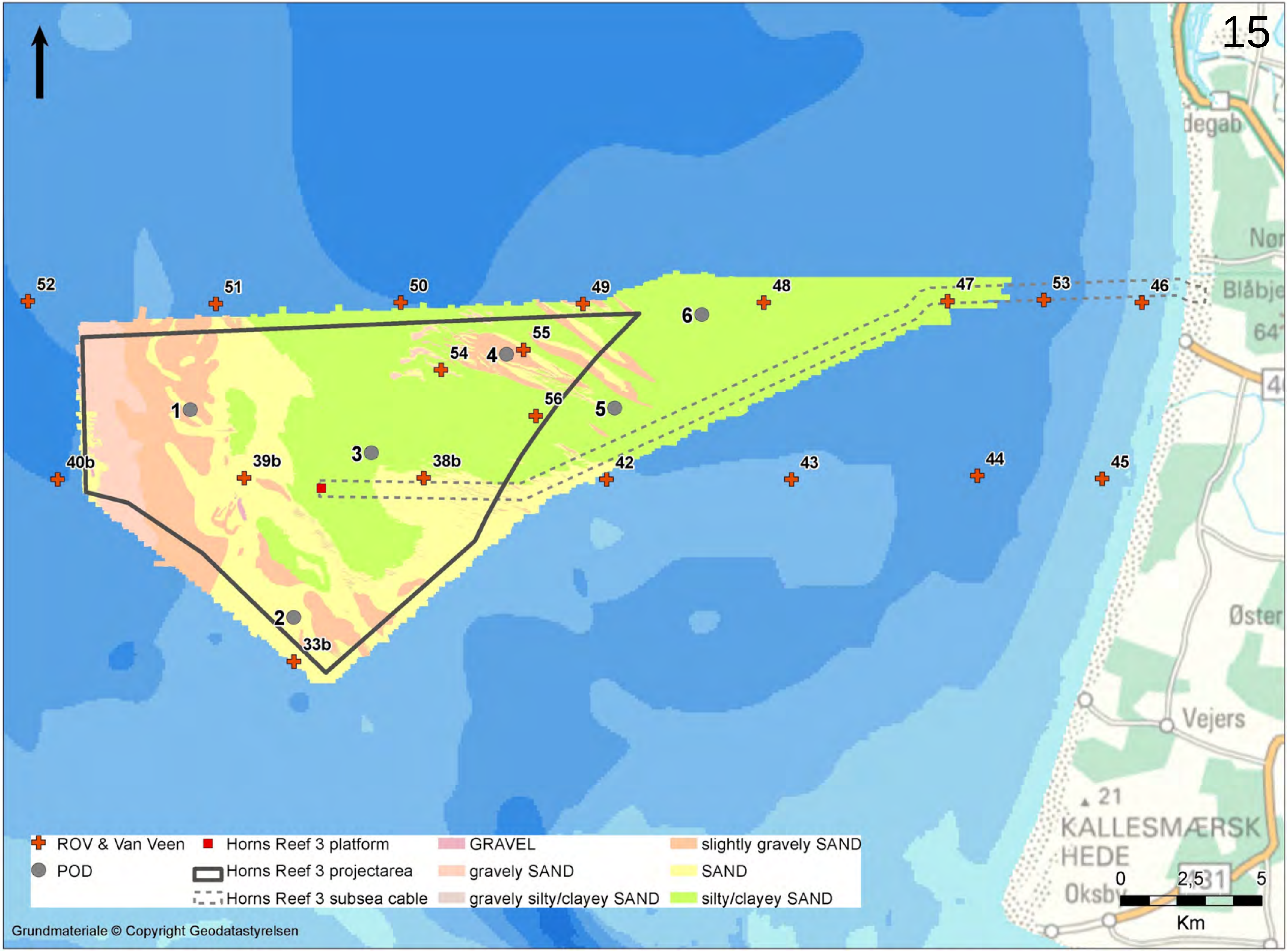
Horns Reef 3 project area
Horns Reef 3 subsea cable
Horns Reef 3 platform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4
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3
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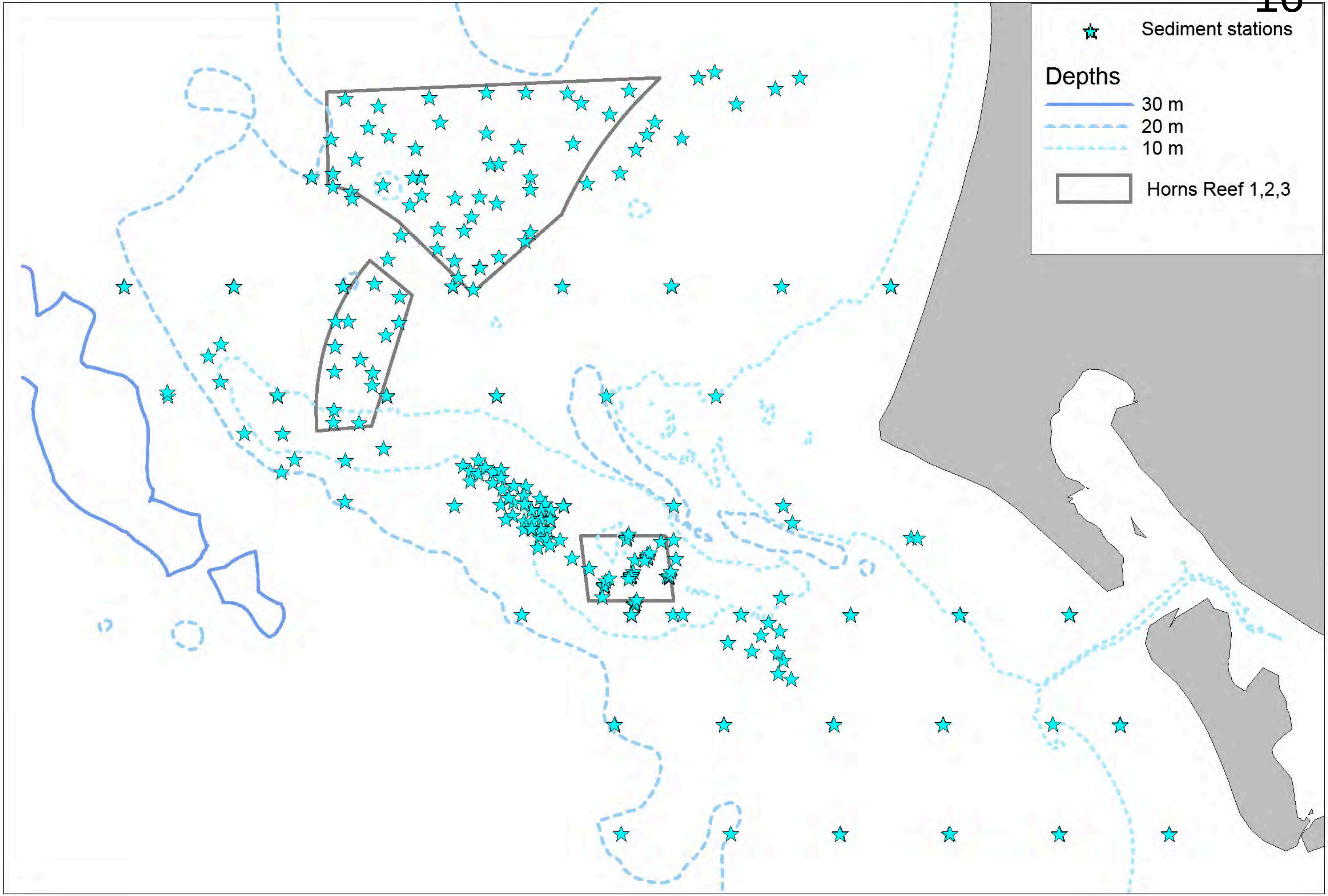
39b
38b
42
43
44
45
2
33b
degab
Nør
Blåbje
Øster
Vejers
21
KALLESMÆRSK
HEDE
Oksby
0
2,5
5
Km
ROV & Van Veen
POD
Horns Reef 3 platform
Horns Reef 3 projectarea
Horns Reef 3 subsea cable
GRAVEL
gravely SAND
gravely silty/clayey SAND
slightly gravely SAND
SAND
silty/clayey SAND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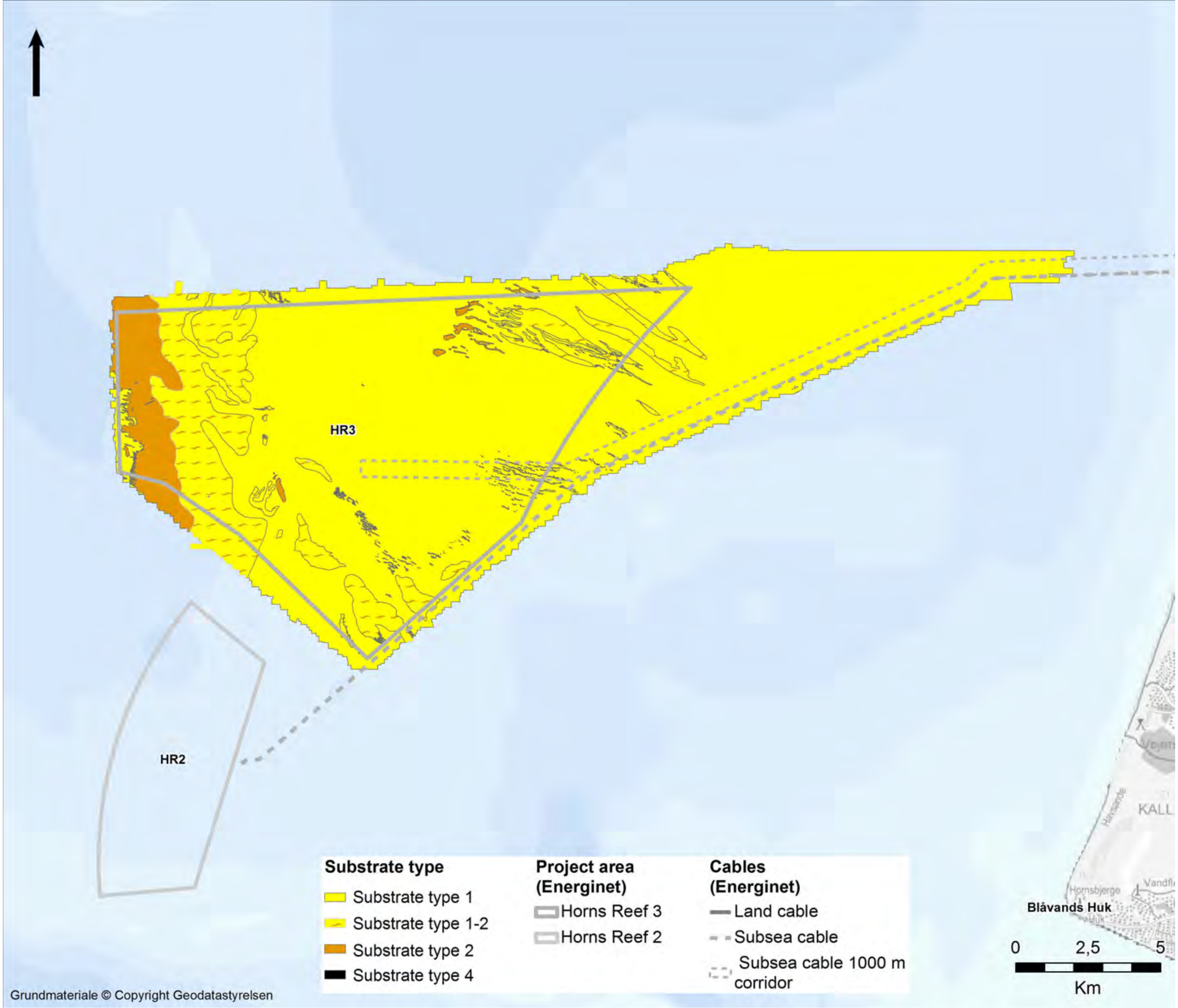
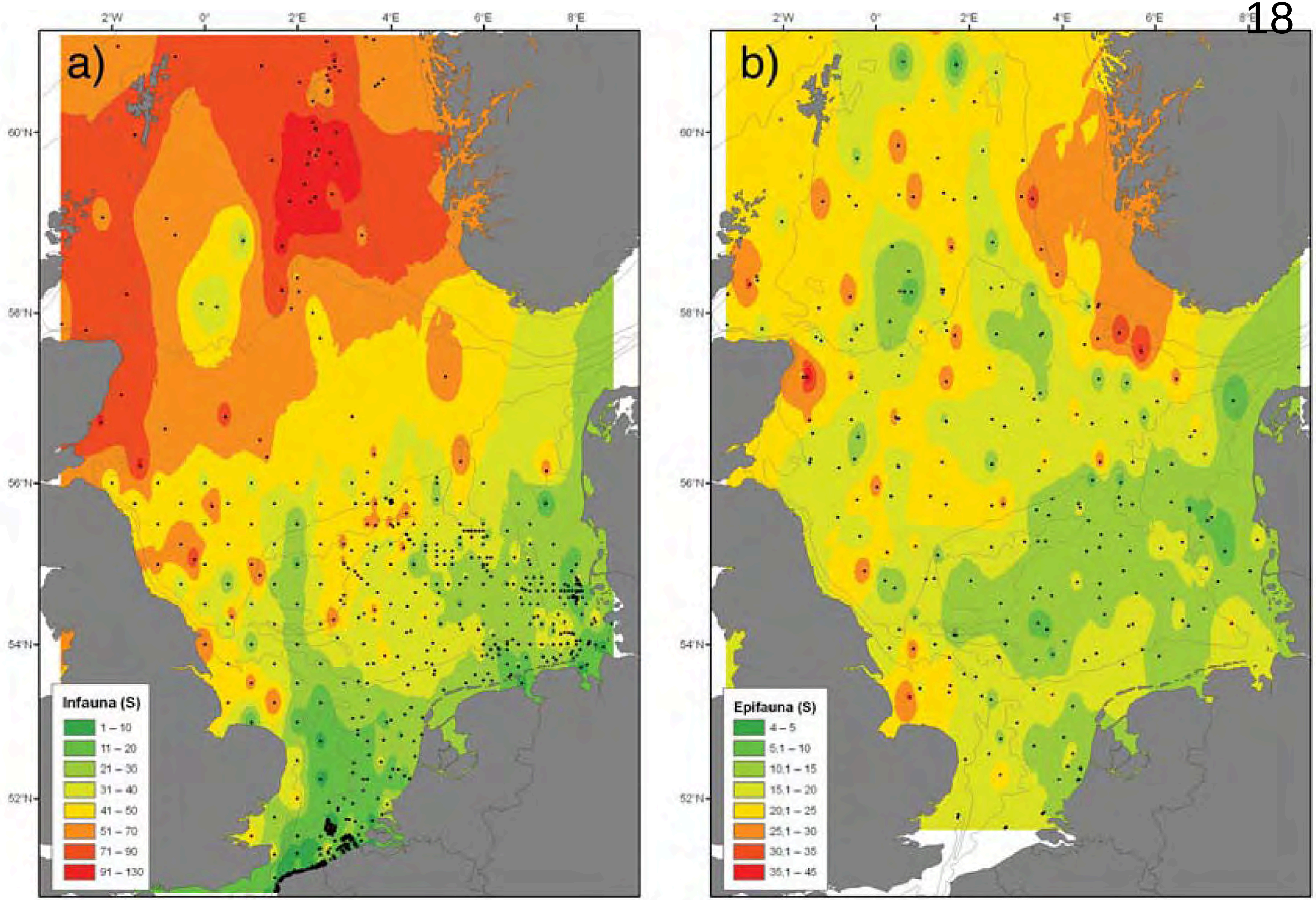
Depths
30 m
20 m
10 m
Horns Reef 1,2,3


HR3
HR2
Substrate type
Substrate type 1
Substrate type 1-2
Substrate type 2
Substrate type 4
Project area
(Energinet)
Horns Reef 3
Horns Reef 2
Cables
(Energinet)
Land cable
Subsea cable
Subsea cable 1000 m corridor
Blåvands Huk
0
2,5
5
Km
Grundmateriale © Copyright Geodatastyrelsen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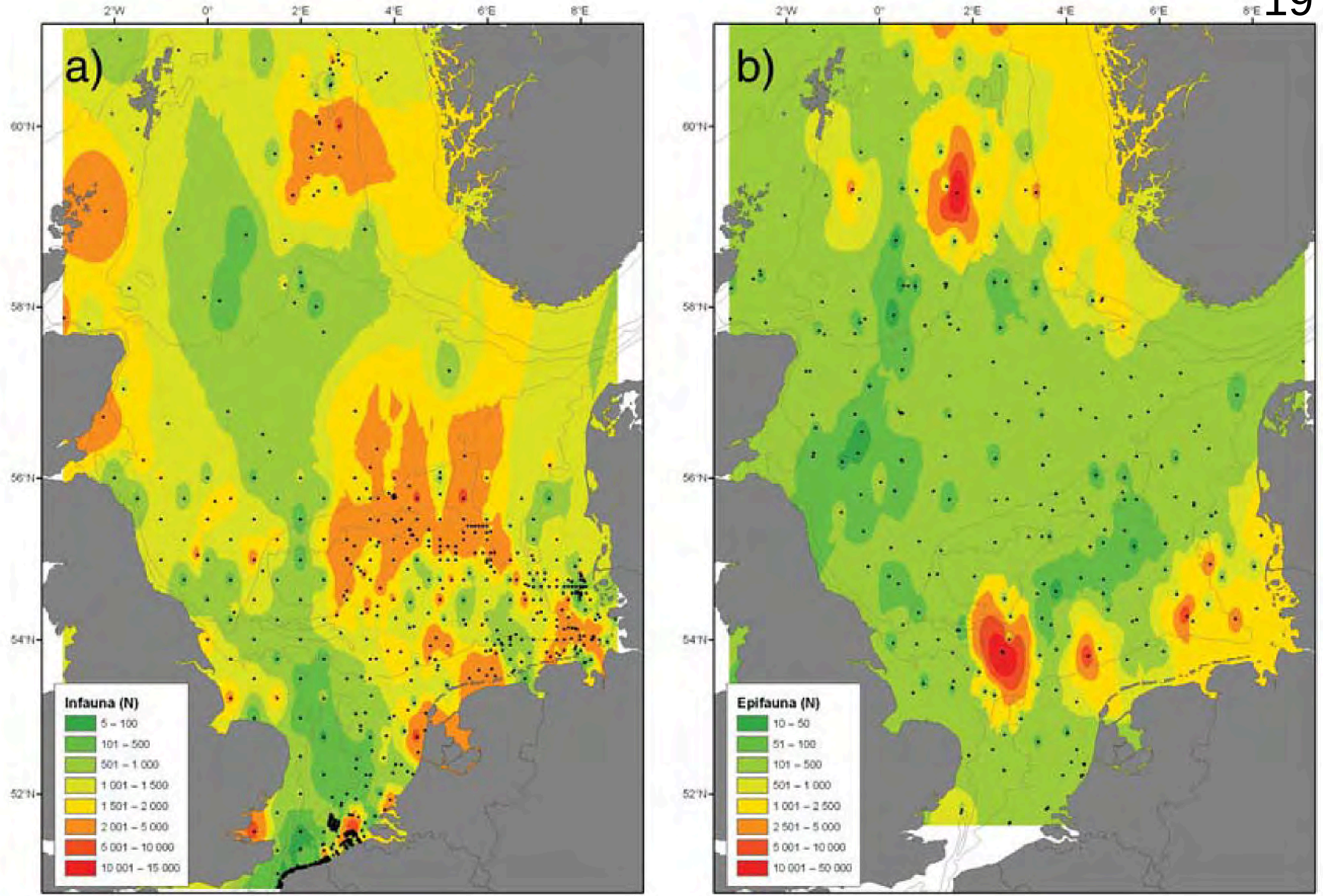
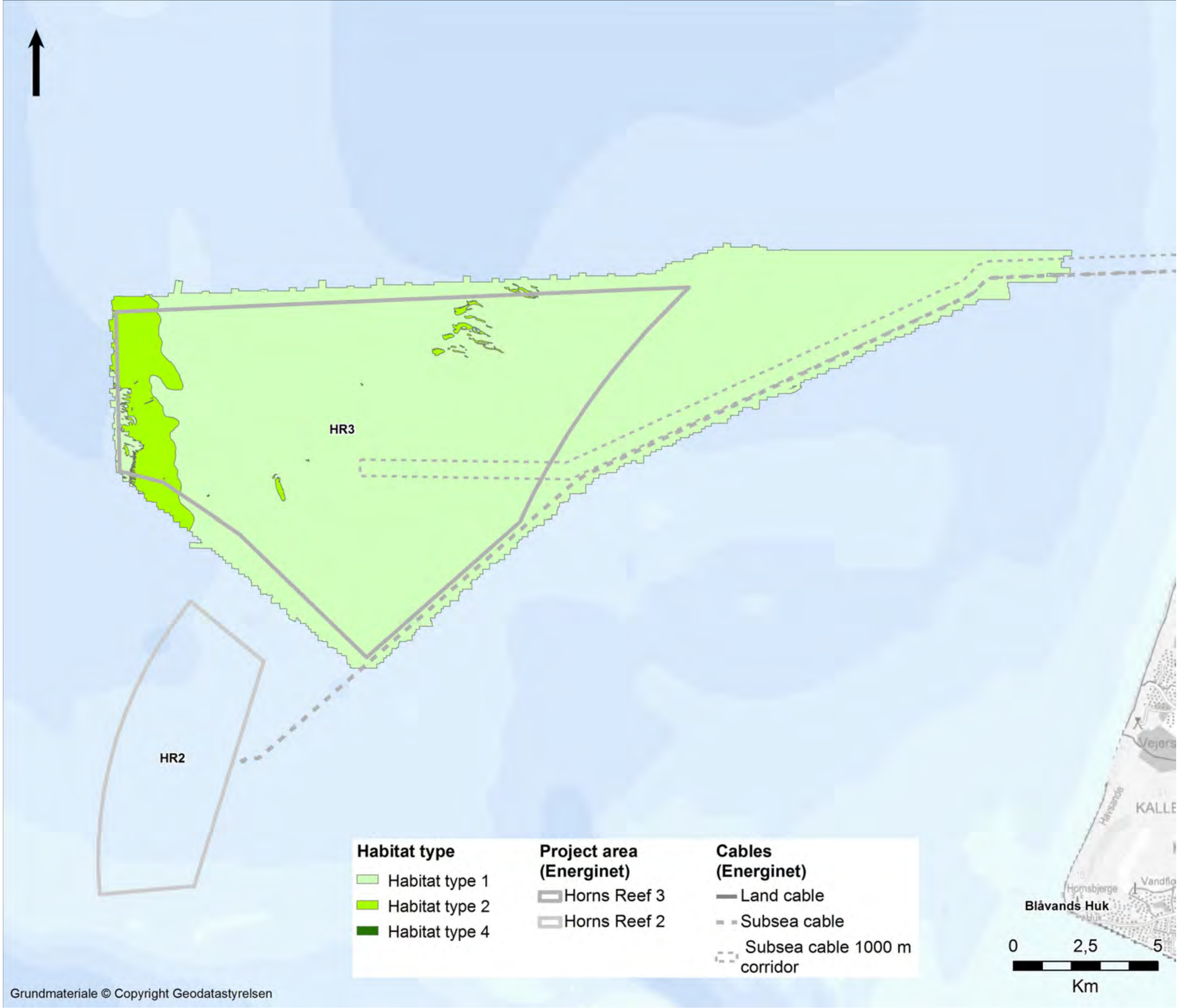
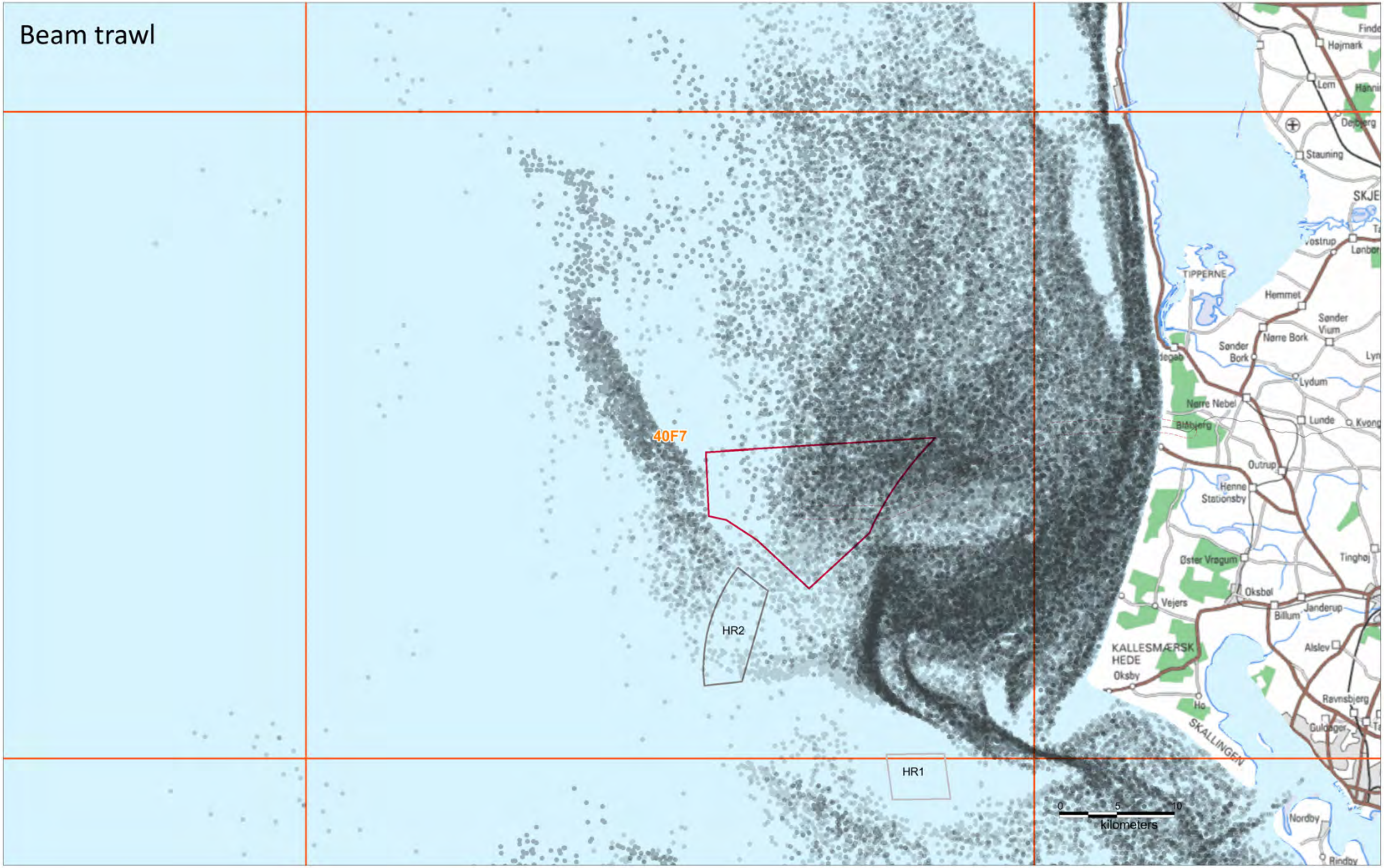
Infauna (S)
1 – 10
11 – 20
21 – 30
31 – 40
41 – 50
51 – 70
71 – 90
91 – 130
b)
Epifauna (S)
4 – 5
5.1 – 10
10.1 – 15
15.1 – 20
20.1 – 25
25.1 – 30
30.1 – 35
35.1 – 45
2°W
0°
2°E
4°E
6°E
8°E
60°N
58°N
56°N
54°N
52°N


a)
2°W
0°
2°E
4°E
6°E
8°E
60°N
58°N
56°N
54°N
52°N
Infauna (N)
5 – 100
101 – 500
501 – 1 000
1 001 – 1 500
1 501 – 2 000
2 001 – 5 000
5 001 – 10 000
10 001 – 15 000
b)
Epifauna (N)
10 – 50
51 – 100
101 – 500
501 – 1 000
1 001 – 2 500
2 501 – 5 000
5 001 – 10 000
10 001 – 50 000


HR3
HR2
Habitat type
Habitat type 1
Habitat type 2
Habitat type 4
Project area
(Energinet)
Horns Reef 3
Horns Reef 2
Cables
(Energinet)
Land cable
Subsea cable
Subsea cable 1000 m
corridor
Blåvands Huk
0
2,5
5
Km
Grundmateriale © Copyright Geodatastyrelsen


Beam trawl
40F7
HR2
HR1
TIPPERNE
Hemmet
Sønder Vium
Nørre Bork
Sønder Bork
Lydum
Nørre Nebel
Lunde
Outrup
Henne Stationsby
Øster Vrøgum
Tinghøj
Oksbøl
Vejers
Billum
Janderup
Alslev
KALLESMÆRSK HEDE
Oksby
Ho
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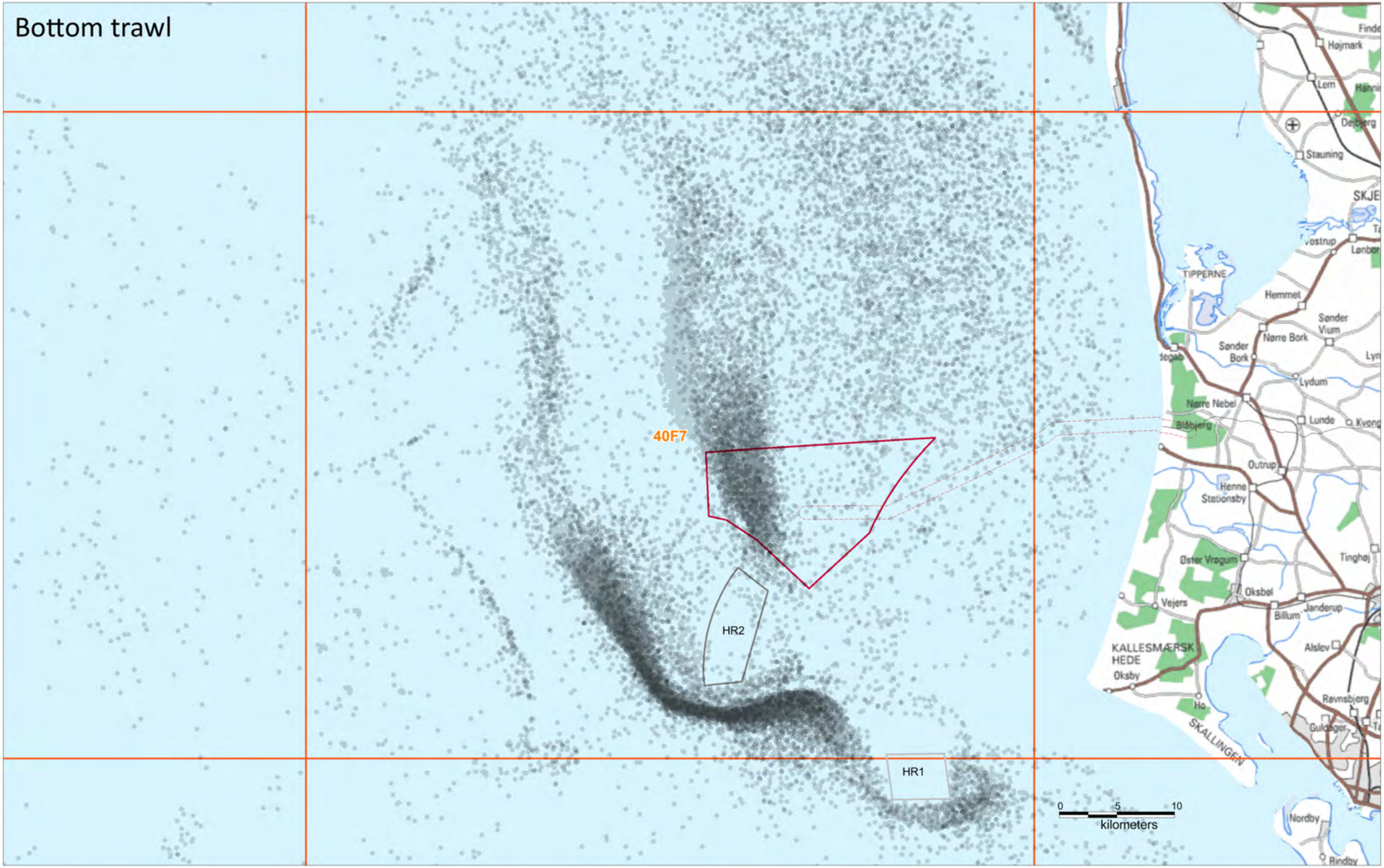
Nordby
Rindby
Højmark
Lem
Stauning
0
5
10
kilometers


Bottom trawl
40F7
HR2
HR1
0
5
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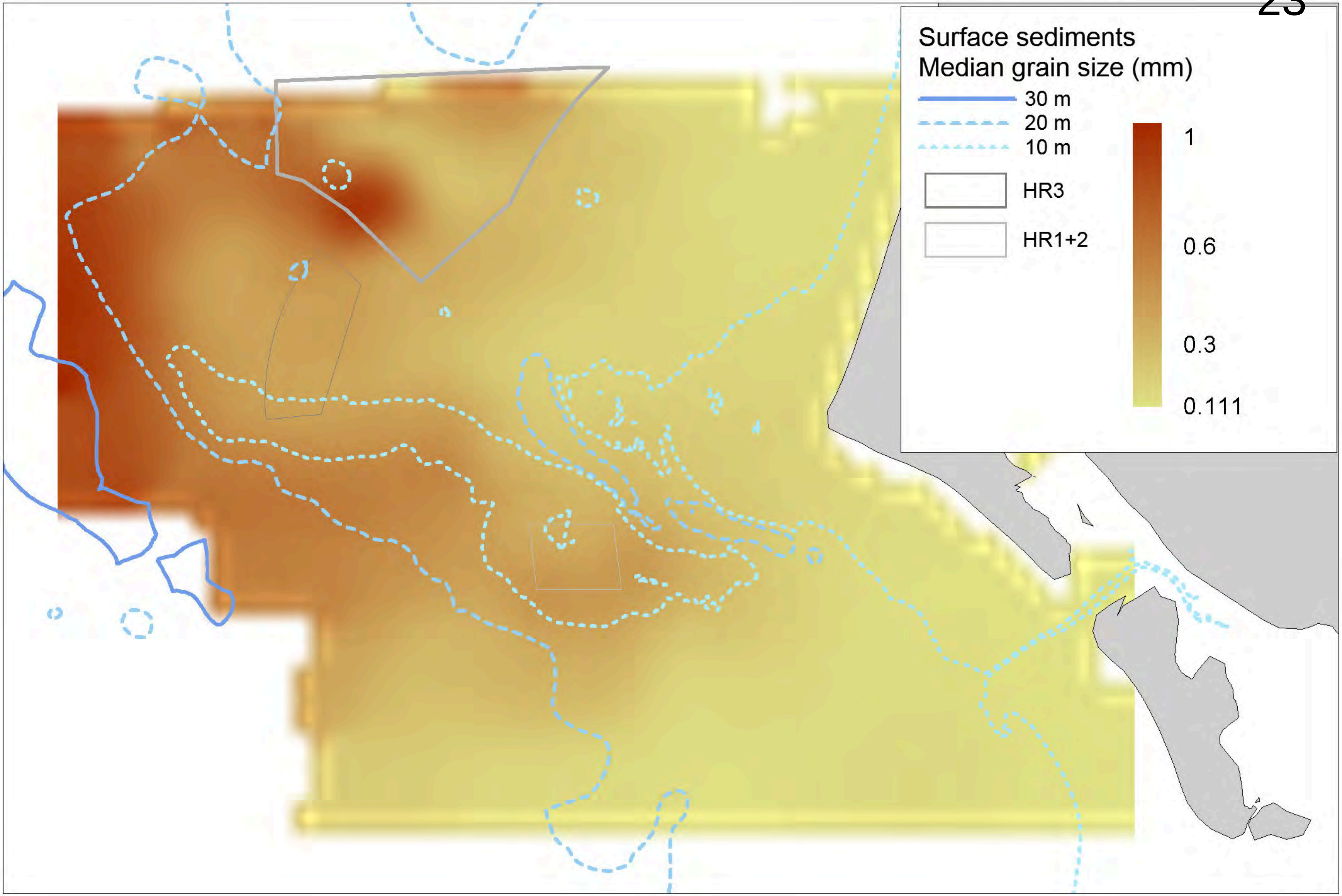
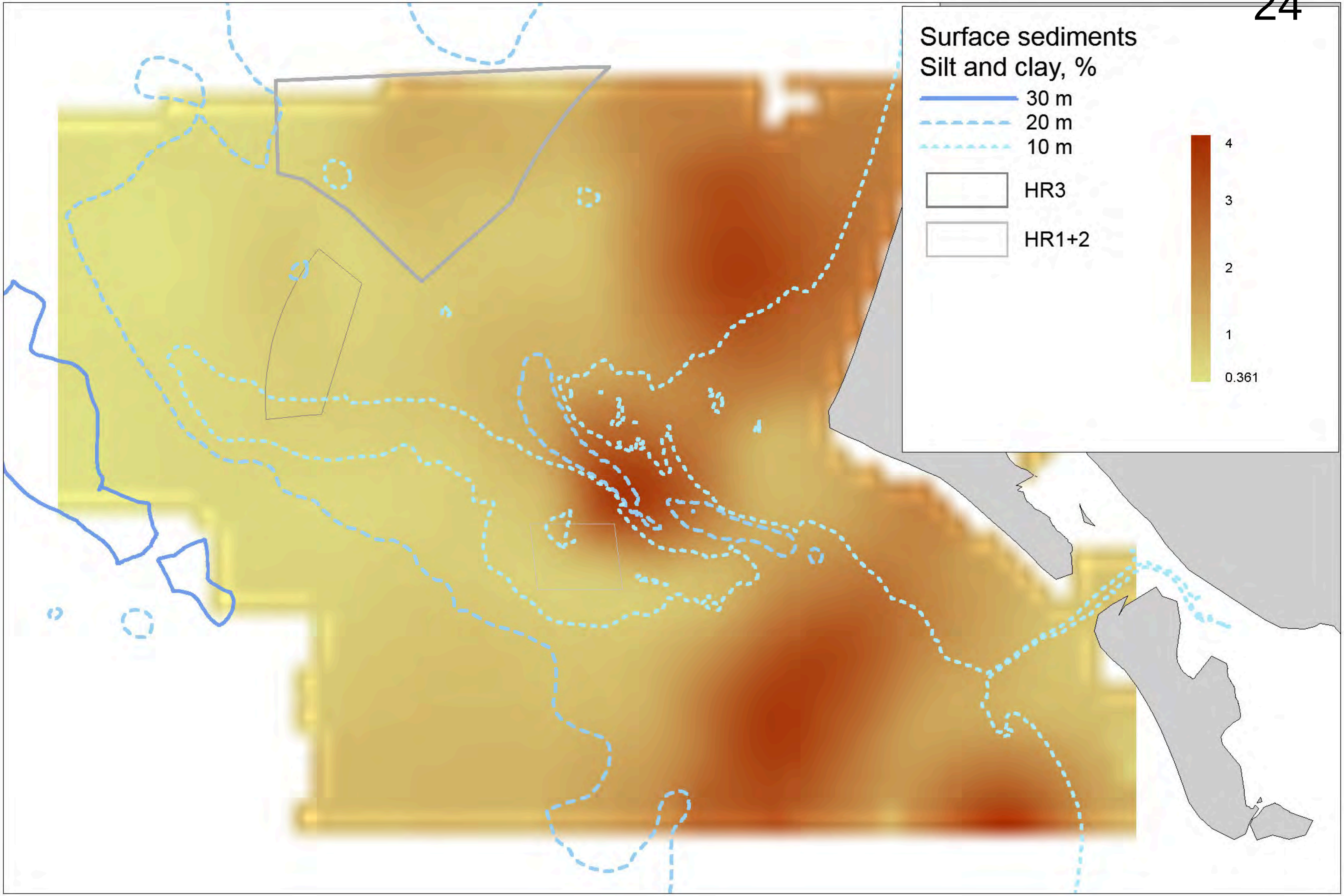
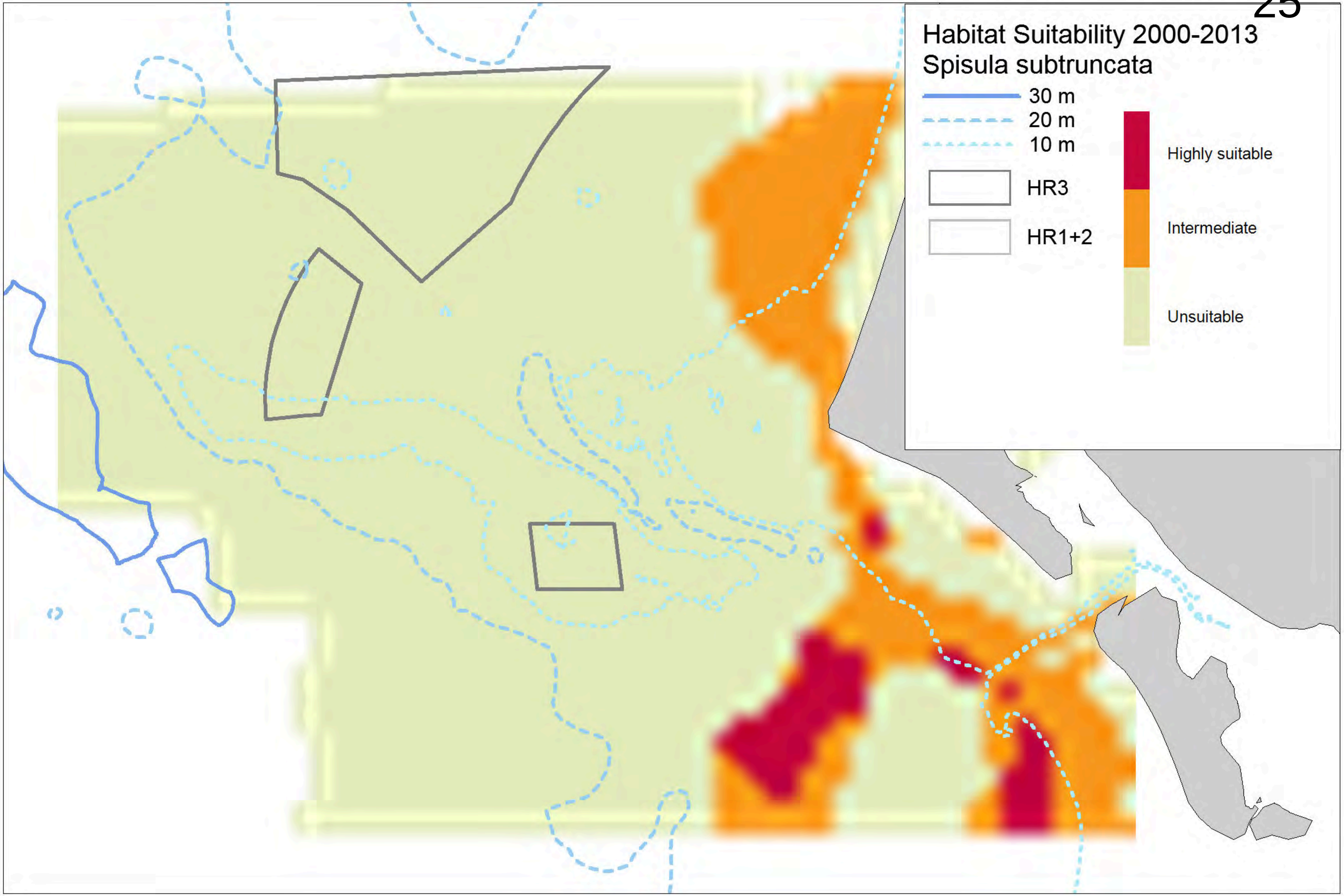
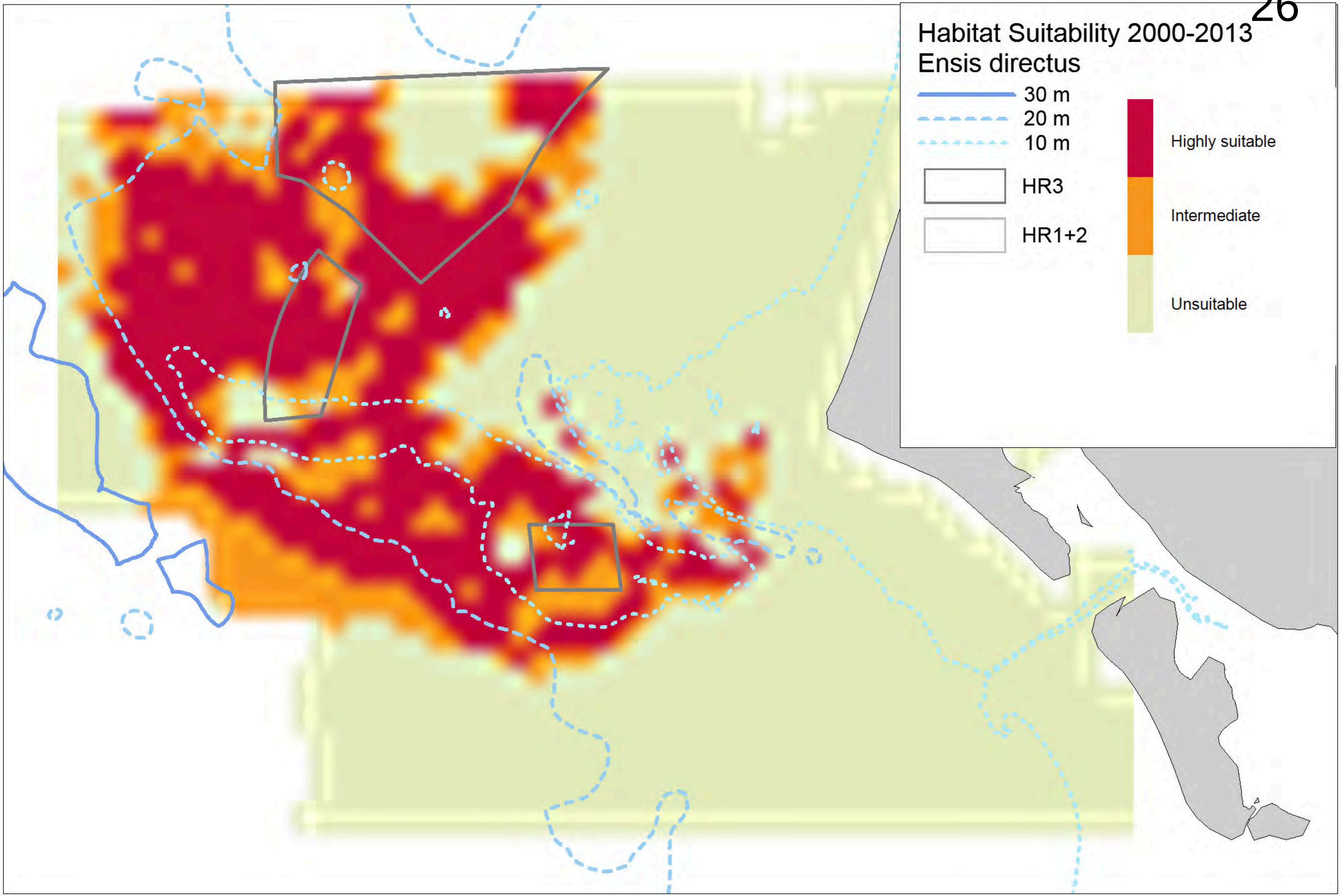
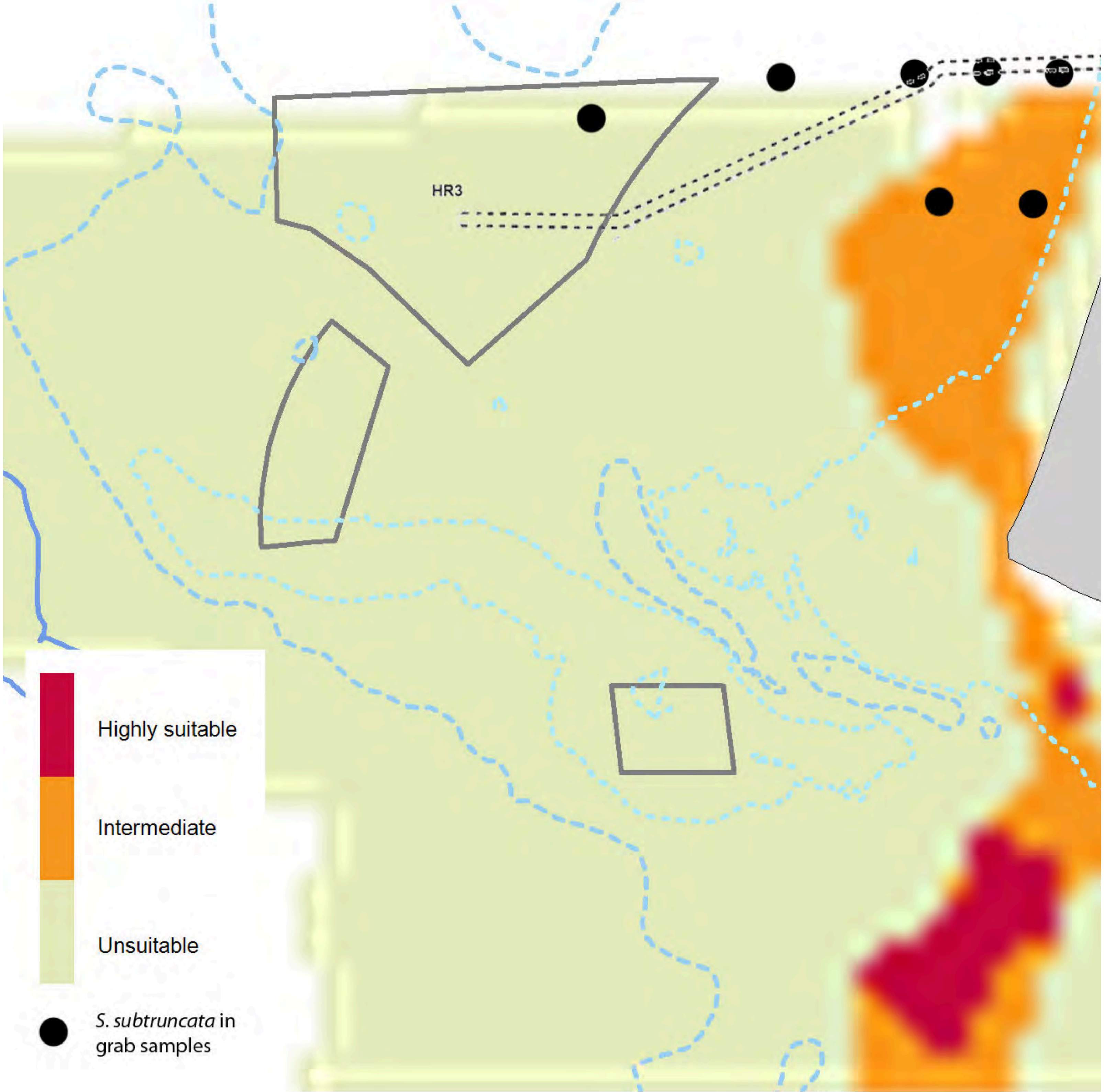
kilometers
Højmark
Lem
Stauning
TIPPERNE
Hemmet
Sønder Vium
Nørre Bork
Sønder Bork
Lydum
Nørre Nebel
Lunde
Outrup
Henne Stationsby
Øster Vrøgum
Tinghøj
Oksbøl
Vejers
Billum
Janderup
Alslev
KALLESMÆRSK HEDE
Oksby
Ho
SKALLINGEN
Nordby
Rindby

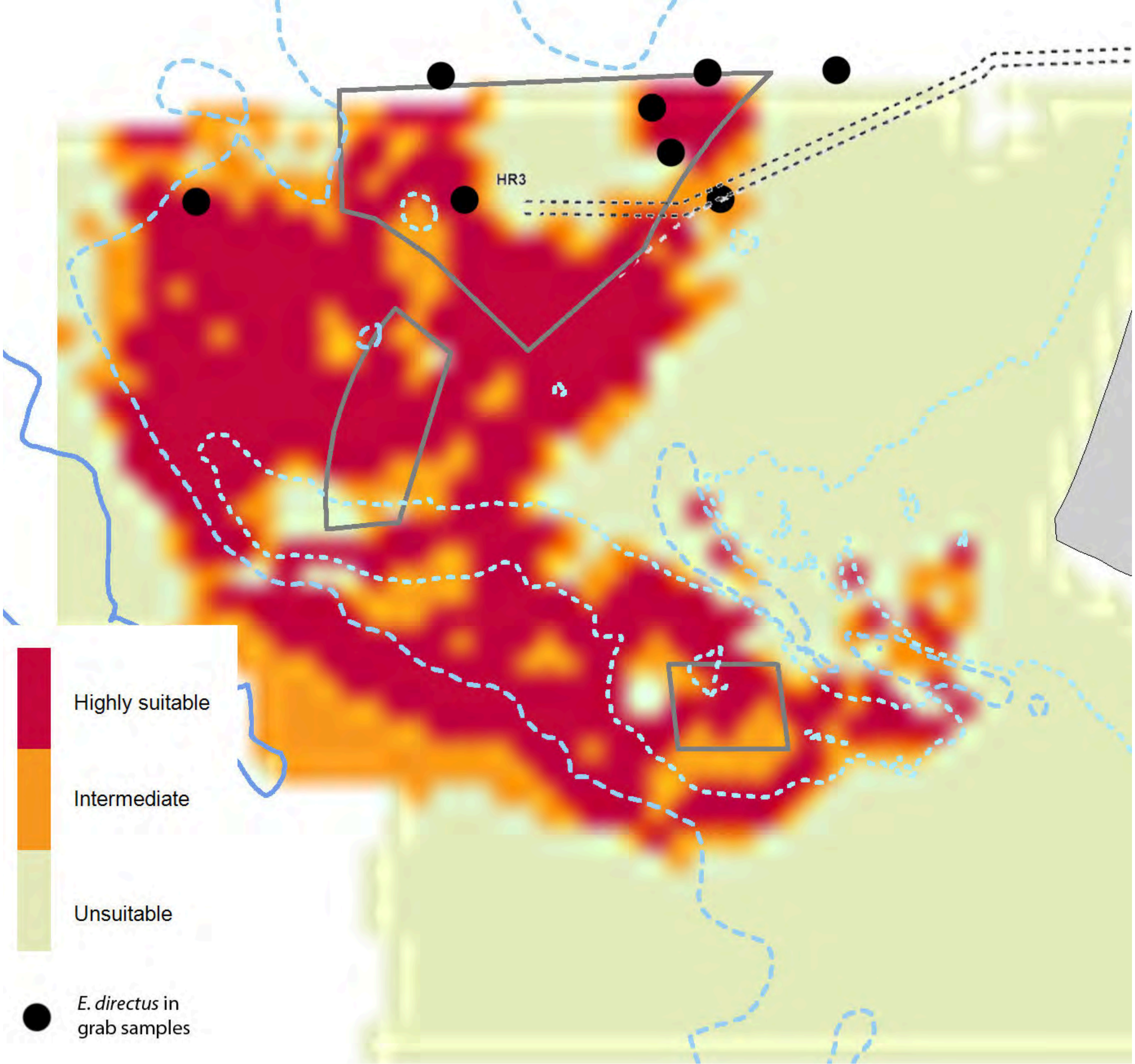

Surface sediments
Median grain size (mm)
30 m
20 m
10 m
HR3
HR1+2
1
0.6
0.3
0.111

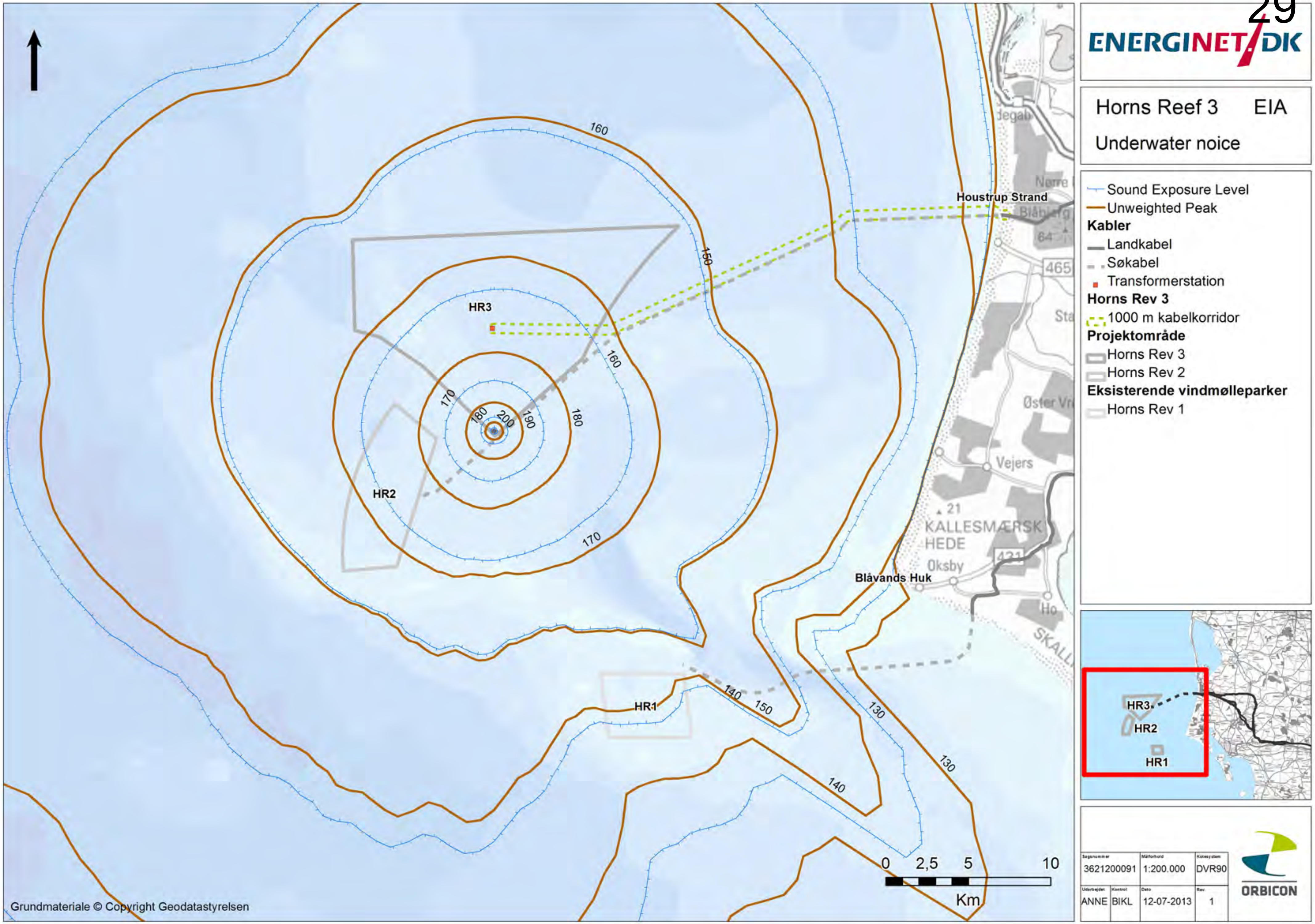

Surface sediments
Silt and clay, %
30 m
20 m
10 m
HR3
HR1+2
4
3
2
1
0.361


Habitat Suitability 2000-2013
Spisula subtruncata
30 m
20 m
10 m
HR3
HR1+2
Highly suitable
Intermediate
Unsuitable

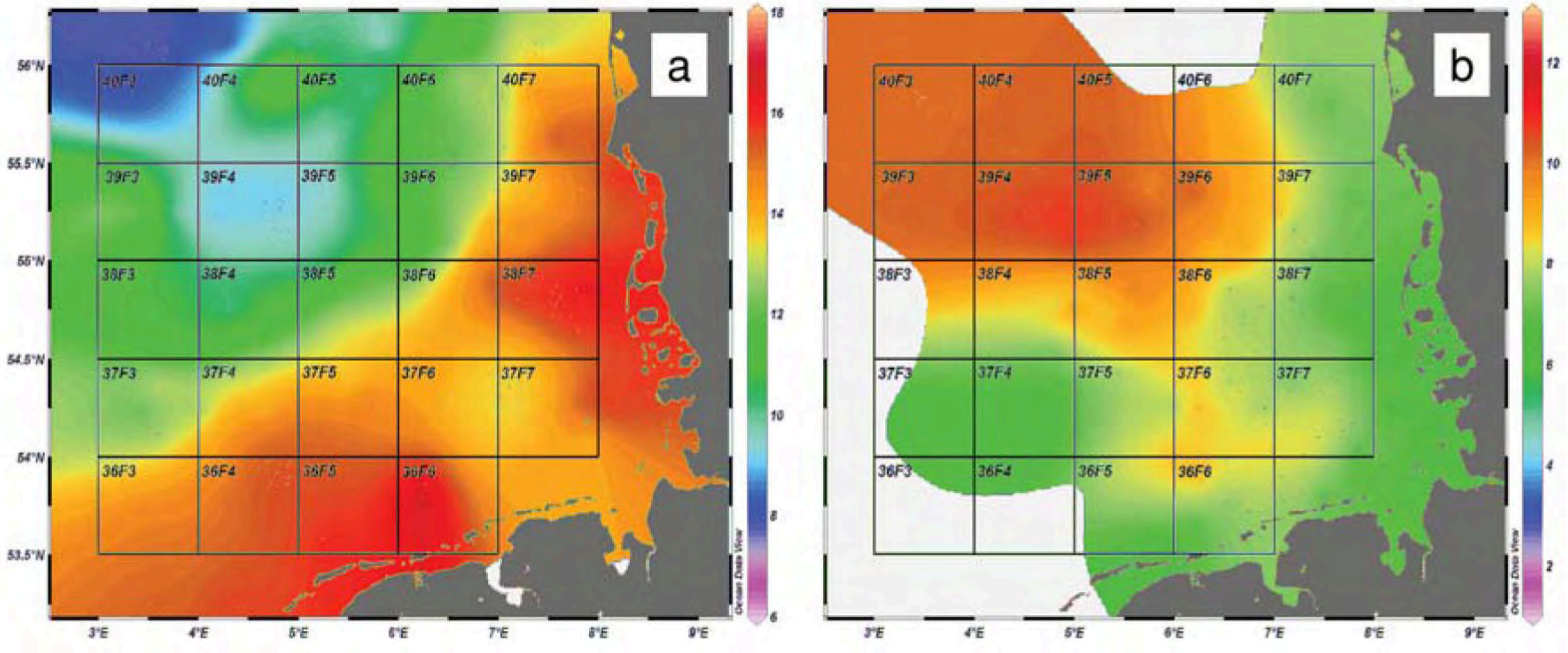

Habitat Suitability 2000-2013
Ensis directus
30 m
20 m
10 m
HR3
HR1+2
Highly suitable
Intermediate
Unsuitable


HR3
Highly suitable
Intermediate
Unsuitable
S. subtruncata in grab samples


HR3
Highly suitable
Intermediate
Unsuitable
E. directus in
grab samples


ENERGINET DK
Horns Reef 3 EIA
Underwater noice
Sound Exposure Level
Unweighted Peak
Kabler
Landkabel
Søkabel
Transformerstation
Horns Rev 3
1000 m kabelkorridor
Projektområde
Horns Rev 3
Horns Rev 2
Eksisterende vindmølleparker
Horns Rev 1
HR3
HR2
HR1
Houstrup Strand
Blåvands Huk
Vejers
KALLESMÆRSK HEDE
Oksby
160
150
170
180
190
200
140
130
0 2,5 5 10
Km
3621200091
1:200.000
DVR90
ANNE
BIKL
12-07-2013
1
ORBICON
Grundmateriale © Copyright Geodatastyrelsen


[m]
6178200
6178000
6177800
6177600
6177400
6177200
6177000
6176800
6176600
6176400
6176200
6176000
6175800
6178
6177
6176
409
410
411
412
413
HR3-A2
HR3-A3
HR3-A4
HR3-B2
HR3-B3
HR3-B4
HR3-C2
HR3-C3
HR3-C4
409000
409500
410000
410500
411000
411500
412000
412500
413000
[m]
Scale 1:29520
Statistical maximum :
Total SSC [kg/m^3]
Above 0.14
0.13 - 0.14
0.12 - 0.13
0.11 - 0.12
0.10 - 0.11
0.09 - 0.10
0.08 - 0.09
0.07 - 0.08
0.06 - 0.07
0.05 - 0.06
0.04 - 0.05
0.03 - 0.04
0.02 - 0.03
0.01 - 0.02
0.00 - 0.01
Below 0.00
Undefined Value


a
40F3
40F4
40F5
40F6
40F7
39F3
39F4
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39F6
39F7
38F3
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38F7
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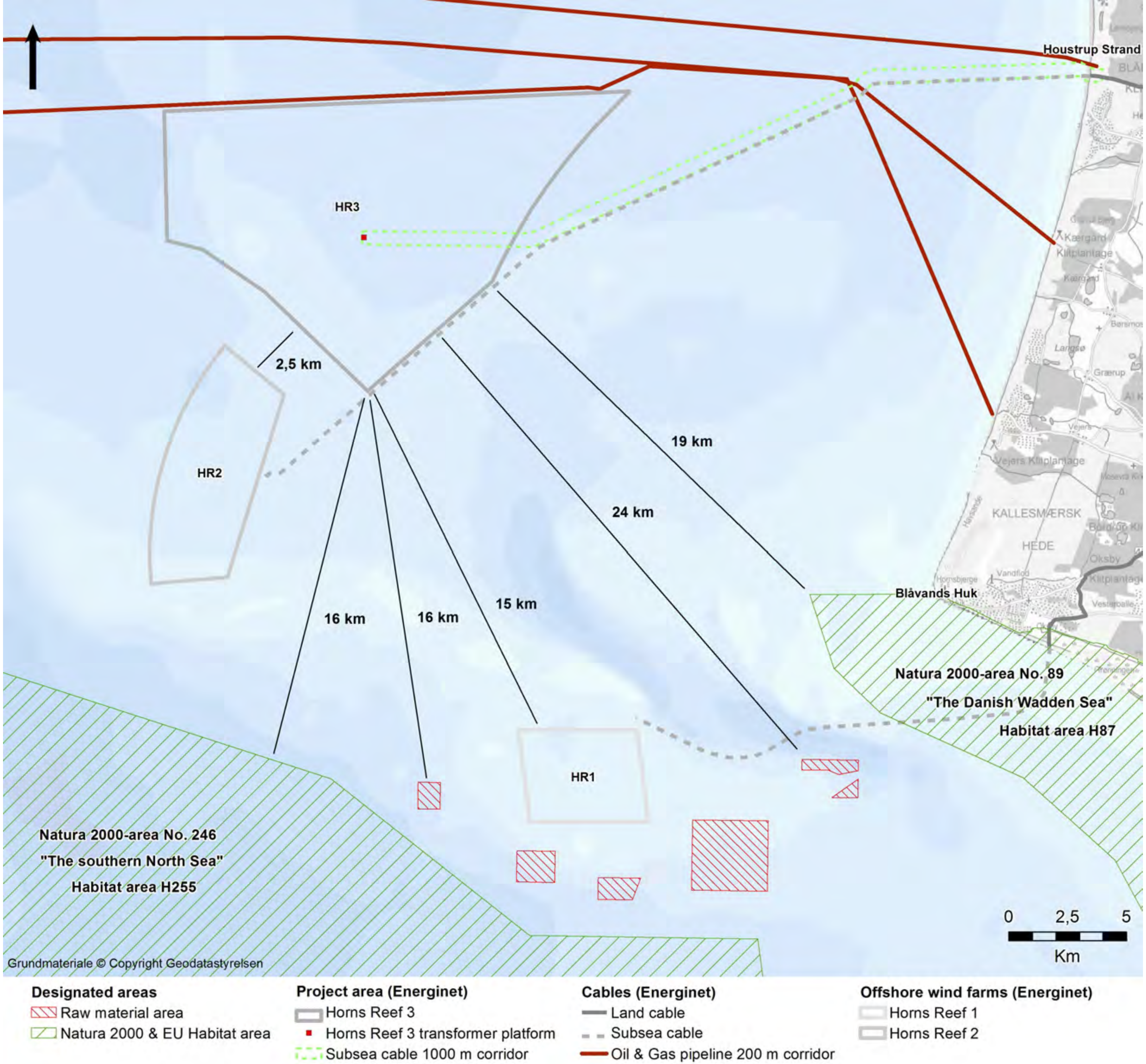
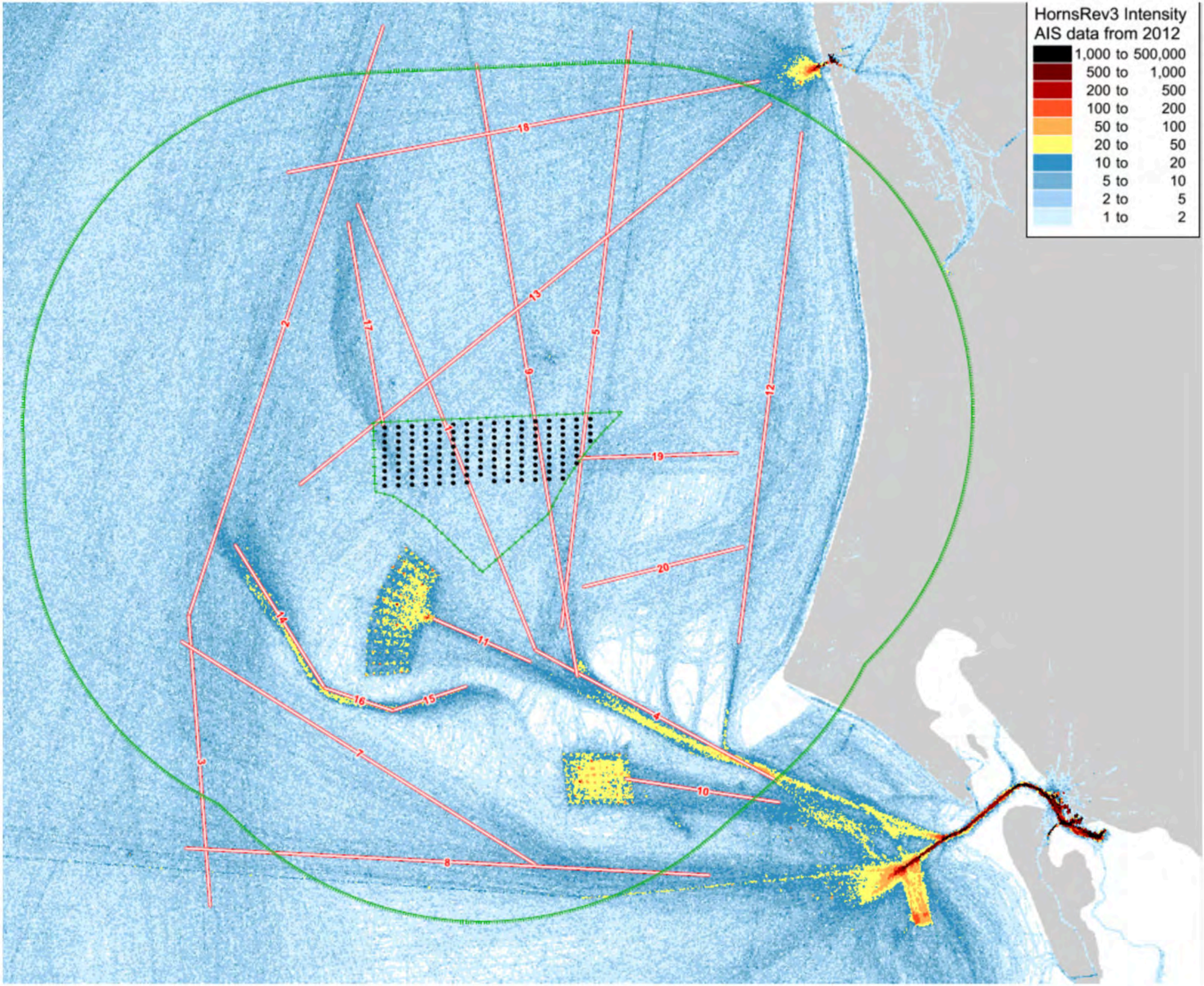
37F4
37F5
37F6
37F7
36F3
36F4
36F5
36F6
56°N
55.5°N
55°N
54.5°N
54°N
53.5°N
3°E
4°E
5°E
6°E
7°E
8°E
9°E
18
16
14
12
10
8
6
Ocean Data View
b
12
10
8
6
4
2


Houstrup Strand
HR3
2,5 km
HR2
19 km
24 km
16 km
16 km
15 km
HR1
Kærgård Klitplantage
Vejers Klitplantage
KALLESMÆRSK
HEDE
Oksby
Blåvands Huk
Natura 2000-area No. 89
"The Danish Wadden Sea"
Habitat area H87
Natura 2000-area No. 246
"The southern North Sea"
Habitat area H255
0
2,5
5
Km
Grundmateriale © Copyright Geodatastyrelsen
Designated areas
Raw material area
Natura 2000 & EU Habitat area
Project area (Energinet)
Horns Reef 3
Horns Reef 3 transformer platform
Subsea cable 1000 m corridor
Cables (Energinet)
Land cable
Subsea cable
Oil & Gas pipeline 200 m corridor
Offshore wind farms (Energinet)
Horns Reef 1
Horns Reef 2


HornsRev3 Intensity
AIS data from 2012
1,000 to 500,000
500 to 1,000
200 to 500
100 to 200
50 to 100
20 to 50
10 to 20
5 to 10
2 to 5
1 to 2

LOGBOOKS

Kunde:	Energinet		Dato:	05/03/2013	Område:	Horns Rev 3
Opgave:	Sedimentkortlægning		Tid:	10:12:00	Lokalitet:	HR3_41
Pos. N	Pos. E	Dybde m	Bølgehøjde m	Dyk / Rov	Pilot/Dykker	Speak
55°41,461	7°26,053	16.0 m	0,5-1	ROV	Mils	Ersp
55°41,442	7°25,995	m	Foto/Video	Skib	Tender	Assistent
Kurs 231°	Afst. 70 m	16 m	Video	Anette Christina	Ersp	Steffen
Pritet:	High	Udpegning:	Sand…..			
Bundtype	% mudder/silt	% sand	% grus	% sten <10 cm	% sten >10 cm	% rest:
Type 1b	1	99	0	0	0	0
Substrat:	Strømribber, groft sand, mere siltet mellem strømribber					
Fauna:	Søstjerner , lanicerør, knivmuslinger, enkelte hvide tomme muslingeskaller		Overordnet dækning: 3			Overordnet dækning
Flora:	Ingen		Substratspecifik dækning: 0%			Substratspecifik dækning
Bundtype	Prøvetager	Assistent	Bundprøveudstyr	Sigte	Bundprøve	Kvantitativ
Type 1b	ERSP	MILS/Steffen	VanVeen	1 mm	Ja	Ja
Bundprøve feltbeskrivelse	Middelstor sigterest, mest groft sand, enkelte knivmuslingeskaller, mange Ophelia borealis, og enkelte lancetfisk, (type 1b bund, sand)					
Bundprøve laboratorie-beskrivelse						

Kunde:	Energinet		Dato:	05/03/2013	Område:	Horns Rev 3
Opgave:	Sedimentkortlægning		Tid:	12:05:00	Lokalitet:	HR3_40b
Pos. N	Pos. E	Dybde m	Bølgehøjde m	Dyk / Rov	Pilot/Dykker	Speak
55°41,495	7°32,224	19.6 m	0,5-1	ROV	Mils	Ersp
55°41,496	7°32,221	m	Foto/Video	Skib	Tender	Assistent
Kurs 313°	Afst. 4 m	20 m	Video	Anette Christina	Ersp	Steffen
Pritet:	High	Udpegning:	Sand…..			
Bundtype	% mudder/silt	% sand	% grus	% sten <10 cm	% sten >10 cm	% rest:
Type 1b	1	99	0	0	0	0
Substrat:	Strømribber, silt mellem strømribber					
Fauna:	Søstjerner (alm og Luidia), mange Lanicerør, eremitkrebs,enkelte hvide skaller, kutling, hydroider		Overordnet dækning			Overordnet dækning
			3			
Flora:	Ingen		Substratspecifik dækning			Substratspecifik dækning
			0%			
Bundtype	Prøvetager	Assistent	Bundprøveudstyr	Sigte	Bundprøve	Kvantitativ
Type 1b	ERSP	MILS/Steffen	VanVeen	1 mm	Ja	Ja
Bundprøve feltbeskrivelse	Lille sigterest, groft sand/fint grus, enkelte skaller, der var enkelte Polychaeter (Ophelia borealis og Nephtys) (type 1b bund, fint sand)					
Bundprøve laboratorie-beskrivelse						

Kunde:	Energinet		Dato:	05/03/2013	Område:	Horns Rev 3
Opgave:	Sedimentkortlægning		Tid:	13:02:00	Lokalitet:	HR3_39b
Pos. N	Pos. E	Dybde m	Bølgehøjde m	Dyk / Rov	Pilot/Dykker	Speak
55°41,601	7°38,655	15.0 m	0,5-1	ROV	Mils	Ersp
55°41,598	7°38,537	m	Foto/Video	Skib	Tender	Assistent
Kurs 263°	Afst. 124 m	15 m	Video	Anette Christina	Ersp	Steffen
Pritet:	High	Udpegning:	Sand…..			
Bundtype	% mudder/silt	% sand	% grus	% sten <10 cm	% sten >10 cm	% rest:
Type 1b	0	100	0	0	0	0
Substrat:	Strømribber, turbulent					
Fauna:	Enkelte søstjerner, knivmuslingeskaller, enkelte hvide muslingeskaller		Overordnet dækning: 1			Overordnet dækning
Flora:	Ingen		Substratspecifik dækning: 0%			Substratspecifik dækning
Bundtype	Prøvetager	Assistent	Bundprøveudstyr	Sigte	Bundprøve	Kvantitativ
Type 1b	ERSP	MILS/Steffen	VanVeen	1 mm	Ja	Ja
Bundprøve feltbeskrivelse	Forholdsvis lille sigterest, enkelte knivmuslinger og Polychaeter, enkelte sten, ellers mest skaller, bundtype 1b med fint sand					
Bundprøve laboratorie-beskrivelse						

Kunde:	Energinet		Dato:	05/03/2013	Område:	Horns Rev 3
Opgave:	Sedimentkortlægning		Tid:	13:56:00	Lokalitet:	HR3_33b
Pos. N	Pos. E	Dybde m	Bølgehøjde m	Dyk / Rov	Pilot/Dykker	Speak
55°38,112	7°40,335	10.0 m	0,5-1	ROV	Mils	Ersp
55°38,100	7°40,349	m	Foto/Video	Skib	Tender	Assistent
Kurs 168°	Afst. 27 m	10 m	Video	Anette Christina	Ersp	Steffen
Pritet:	High	Udpegning:	Sand…..			
Bundtype	% mudder/silt	% sand	% grus	% sten <10 cm	% sten >10 cm	% rest:
Type 1b	0	100	0	0	0	0
Substrat:	Fint til mellemfint sand, mellemstore diffuse strømribber, fint sorteret sand					
Fauna:	Søstjerne, ellers meget lidt liv, fisk (sandsynligvis tobis), detritus.		Overordnet dækning			Overordnet dækning
			<1			
Flora:	Ingen		Substratspecifik dækning			Substratspecifik dækning
			0%			
Bundtype	Prøvetager	Assistent	Bundprøveudstyr	Sigte	Bundprøve	Kvantitativ
Type 1b	ERSP	MILS/Steffen	VanVeen	1 mm	Ja	Ja
Bundprøve feltbeskrivelse	Type 1b, fint sand, megetg lille sigterest, små skaller og fint grus, enkelte Ophelia borealis.					
Bundprøve laboratorie-beskrivelse						

Kunde:	Energinet		Dato:	05/03/2013	Område:	Horns Rev 3
Opgave:	Sedimentkortlægning		Tid:	14:43:00	Lokalitet:	HR3_38b
Pos. N	Pos. E	Dybde m	Bølgehøjde m	Dyk / Rov	Pilot/Dykker	Speak
55°41,693	7°44,602	16.0 m	0,5-1	ROV	Mils	Ersp
55°41,664	7°44,625	m	Foto/Video	Skib	Tender	Assistent
Kurs 175°	Afst. 59 m	16 m	Video	Anette Christina	Ersp	Steffen
Priritet:	High	Udpegning:	Sand…..			
Bundtype	% mudder/silt	% sand	% grus	% sten <10 cm	% sten >10 cm	% rest:
Type 1b	0	100	0	0	0	0
Substrat:	Strømribber, meget marin sne, store strømribber, men også område med små strømribber, fint sand					
Fauna:	Kutling, enkelte spredte hvide skaller, spisulaskaller, en del søstjerner, enkelte knivmuslinger, slangestjerner		Overordnet dækning: 2-3%			Overordnet dækning
Flora:	Ingen		Substratspecifik dækning: 0%			Substratspecifik dækning
Bundtype	Prøvetager	Assistent	Bundprøveudstyr	Sigte	Bundprøve	Kvantitativ
Type 1b	ERSP	MILS/Steffen	VanVeen	1 mm	Ja	Ja
Bundprøve feltbeskrivelse	Forholdsvis lille sigterest, mest små skaller, en smule fint grus, enkelte knivmuslinger, en enkelt sømus og en del Polychaeter (Nephtys, Ophelia)					
Bundprøve laboratorie-beskrivelse						

Kunde:	Energinet		Dato:	05/03/2013	Område:	Horns Rev 3
Opgave:	Sedimentkortlægning		Tid:	15:15:00	Lokalitet:	HR3_56
Pos. N	Pos. E	Dybde m	Bølgehøjde m	Dyk / Rov	Pilot/Dykker	Speak
55°42,914	7°48,352	16.0 m	0,5-1	ROV	Mils	Ersp
55°42,888	7°48,389	m	Foto/Video	Skib	Tender	Assistent
Kurs 176°	Afst. 62 m	16 m	Video	Anette Christina	Ersp	Steffen
Pritet:	High	Udpegning:	Sandbanker			
Bundtype	% mudder/silt	% sand	% grus	% sten <10 cm	% sten >10 cm	% rest:
Type 1b	0	100	0	0	0	0
Substrat:	Forholdsvis lave strømribber, meget marint sne, fint sand					
Fauna:	Enkelte søstjerner og lanicerør, tomme knivmuslingeskaller. Rigtig mange Lanicerør (lokalt 5-10%), eremitkrebs,		Overordnet dækning 6%			Overordnet dækning
Flora:	Ingen		Substratspecifik dækning 0%			Substratspecifik dækning
Bundtype	Prøvetager	Assistent	Bundprøveudstyr	Sigte	Bundprøve	Kvantitativ
Type 1b	ERSP	MILS/Steffen	VanVeen	1 mm	Ja	Ja
Bundprøve feltbeskrivelse	Forholdsvis lille sigterest, fine skaller og runde rør, en enkelt sømus, og en del Polychaeter, type 1b fint sand.					
Bundprøve laboratorie-beskrivelse						

Kunde:	Energinet		Dato:	05/03/2013	Område:	Horns Rev 3
Opgave:	Sedimentkortlægning		Tid:	15:46:00	Lokalitet:	HR3_42
Pos. N	Pos. E	Dybde m	Bølgehøjde m	Dyk / Rov	Pilot/Dykker	Speak
55°41,704	7°50,775	10.6 m	0.5-1	ROV	Mils	Ersp
55°41,694	7°50,829	m	Foto/Video	Skib	Tender	Assistent
Kurs 178°	Afst. 59 m	11 m	Video	Anette Christina	Ersp	Steffen
Pritet:	High	Udpegning:	Sand…..			
Bundtype	% mudder/silt	% sand	% grus	% sten <10 cm	% sten >10 cm	% rest:
Type 1b	0	100	0	0	0	0
Substrat:	Markante men ikke regelmæssige strømribber, homogen bund, meget marint sne					
Fauna:	Ikke meget fauna, enkelte hvide skaller, eremitkrebs,		Overordnet dækning <1%			Overordnet dækning
Flora:	Ingen		Substratspecifik dækning 0%			Substratspecifik dækning
Bundtype	Prøvetager	Assistent	Bundprøveudstyr	Sigte	Bundprøve	Kvantitativ
Type 1b	ERSP	MILS/Steffen	VanVeen	1 mm	Ja	Ja
Bundprøve feltbeskrivelse	Type 1b fint gult sand, lille sigterest, fine skaller og fint grus, en enkelt knivmusling og nogle enkelte Ophelia					
Bundprøve laboratorie-beskrivelse						

Kunde:	Energinet		Dato:	05/03/2013	Område:	Horns Rev 3
Opgave:	Sedimentkortlægning		Tid:	16:20:00	Lokalitet:	HR3_43
Pos. N	Pos. E	Dybde m	Bølgehøjde m	Dyk / Rov	Pilot/Dykker	Speak
55°41,747	7°57,129	10.5 m	0,5-1	ROV	Mils	Ersp
55°41,748	7°57,101	m	Foto/Video	Skib	Tender	Assistent
Kurs 70°	Afst. 29 m	11 m	Video	Anette Christina	Ersp	Steffen
Pritet:	High	Udpegning:	Sand…..			
Bundtype	% mudder/silt	% sand	% grus	% sten <10 cm	% sten >10 cm	% rest:
Type 1b	0	100	0	0	0	0
Substrat:	Fint sand, tydelige strømribber, marint sne, groft sand på kanten af strømribberne, homogen bund, lidt detritus					
Fauna:	Enkelte hvide skaller og tomme knivmuslingeskaller, slangestjerner, død strandkrabbe, eremitkrebs		Overordnet dækning			Overordnet dækning
			<1%			
Flora:	Ingen		Substratspecifik dækning			Substratspecifik dækning
			0%			
Bundtype	Prøvetager	Assistent	Bundprøveudstyr	Sigte	Bundprøve	Kvantitativ
Type 1b	ERSP	MILS/Steffen	VanVeen	1 mm	Ja	Ja
Bundprøve feltbeskrivelse	lille sigterest med fine skaller, enkelte Ophelia, 1b bund med fint gult sand.					
Bundprøve laboratorie-beskrivelse						

Kunde:	Energinet		Dato:	05/03/2013	Område:	Horns Rev 3
Opgave:	Sedimentkortlægning		Tid:	16:59:00	Lokalitet:	HR3_44
Pos. N	Pos. E	Dybde m	Bølgehøjde m	Dyk / Rov	Pilot/Dykker	Speak
55°41,899	8°03,403	15.0 m	0,5-1	ROV	Mils	Ersp
55°41,868	8°03,395	m	Foto/Video	Skib	Tender	Assistent
Kurs 177°	Afst. 58 m	15 m	Video	Anette Christina	Ersp	Steffen
Pritet:	High	Udpegning:	Sand…..			
Bundtype	% mudder/silt	% sand	% grus	% sten <10 cm	% sten >10 cm	% rest:
Type 1b	20	80	0	0	0	0
Substrat:	Ret meget detritus i overfladen af bølgeribber, fint sand en smule silt, meget marint sne					
Fauna:	Lanicerør, enkelte søstjerner, enkelte hvide skaller, Ophiurer, eremitkrebs		Overordnet dækning			Overordnet dækning
			10%			
Flora:	Ingen		Substratspecifik dækning			Substratspecifik dækning
			0%			
Bundtype	Prøvetager	Assistent	Bundprøveudstyr	Sigte	Bundprøve	Kvantitativ
Type 1b	ERSP	MILS/Steffen	VanVeen	1 mm	Ja	Ja
Bundprøve feltbeskrivelse	Lille til mellemstor sigterest, mest bestående af skaller. Svømmekrabbe, stor Ophiur, en del Polychaeter					
Bundprøve laboratorie-beskrivelse						

Kunde:	Energinet		Dato:	05/03/2013	Område:	Horns Rev 3
Opgave:	Sedimentkortlægning		Tid:	17:29:00	Lokalitet:	HR3_45
Pos. N	Pos. E	Dybde m	Bølgehøjde m	Dyk / Rov	Pilot/Dykker	Speak
55°41,849	8°07,647	6.0 m	0,5-1	ROV	Mils	Ersp
55°41,844	8°07,632	m	Foto/Video	Skib	Tender	Assistent
Kurs 141°	Afst. 18 m	6 m	Video	Anette Christina	Ersp	Steffen
Prioritet:	High	Udpegning:	Sand…..			
Bundtype	% mudder/silt	% sand	% grus	% sten <10 cm	% sten >10 cm	% rest:
Type 1b	5	95	0	0	0	0
Substrat:	Meget marint sne, strømribber, fint sand og silt, homogen bund					
Fauna:	Lanicerør, skaller af tallerkenmuslinger, slangestjerner		Overordnet dækning			Overordnet dækning
			4%			
Flora:	Ingen		Substratspecifik dækning			Substratspecifik dækning
			0%			
Bundtype	Prøvetager	Assistent	Bundprøveudstyr	Sigte	Bundprøve	Kvantitativ
Type 1b	ERSP	MILS/Steffen	VanVeen	1 mm	Ja	Ja
Bundprøve feltbeskrivelse	Lille sigterest, få skaller og del ormerør, en del Polychaeter og Amphipoder, en enkelt tallerkenmusling, meget finkornet sand, med ca 5% silt. 1b bund.					
Bundprøve laboratorie-beskrivelse						

Kunde:	Energinet		Dato:	05/03/2013	Område:	Horns Rev 3
Opgave:	Sedimentkortlægning		Tid:	18:03:00	Lokalitet:	HR3_46
Pos. N	Pos. E	Dybde m	Bølgehøjde m	Dyk / Rov	Pilot/Dykker	Speak
55°45,233	8°08,924	7.0 m	0,5-1m	ROV	Mils	Ersp
55°45,228	8°08,909	m	Foto/Video	Skib	Tender	Assistent
Kurs 140°	Afst. 18 m	7 m	Video	Anette Christina	Ersp	Steffen
Pritet:	High	Udpegning:	Sand…..			
Bundtype	% mudder/silt	% sand	% grus	% sten <10 cm	% sten >10 cm	% rest:
Type 1b	5	95	0	0	0	0
Substrat:	Meget lav sigtbarhed pga. marint sne, finkornet sandbund med strømribber, en smule silt					
Fauna:	Enkelte hvide muslingeskaller,		Overordnet dækning			Overordnet dækning
			1%			
Flora:	ingen		Substratspecifik dækning			Substratspecifik dækning
			0%			
Bundtype	Prøvetager	Assistent	Bundprøveudstyr	Sigte	Bundprøve	Kvantitativ
Type 1b	ERSP	MILS/Steffen	VanVeen	1 mm	Ja	Ja
Bundprøve feltbeskrivelse	Lille sigterest, mest skaller, søanemone, tre sømus og en del Polychaeter, type 1b finkornet sand					
Bundprøve laboratorie-beskrivelse						

Kunde:	Energinet		Dato:	05/03/2013	Område:	Horns Rev 3
Opgave:	Sedimentkortlægning		Tid:	18:30:00	Lokalitet:	HR3_53
Pos. N	Pos. E	Dybde m	Bølgehøjde m	Dyk / Rov	Pilot/Dykker	Speak
55°45,281	8°05,573	15.5 m	0,5-1	ROV	Mils	Ersp
55°45,252	8°05,570	m	Foto/Video	Skib	Tender	Assistent
Kurs 179°	Afst. 54 m	16 m	Video	Anette Christina	Ersp	Steffen
Pritritet:	High	Udpegning:	Sand…..			
Bundtype	% mudder/silt	% sand	% grus	% sten <10 cm	% sten >10 cm	% rest:
Type 1b	5	95	0	0	0	0
Substrat:	Fintkornet sandbund med strømribber, dårlig sigtbarhed pga. meget marint sne, detritus og silt					
Fauna:	Hvide muslingeskaller, knivmuslinger, søanamone, Lanicerør, tallerkenmusling, kutling, evt. tobis, Ophiurer,		Overordnet dækning 3-4%			Overordnet dækning
Flora:	Ingen		Substratspecifik dækning 0%			Substratspecifik dækning
Bundtype	Prøvetager	Assistent	Bundprøveudstyr	Sigte	Bundprøve	Kvantitativ
Type 1b	ERSP	MILS/Steffen	VanVeen	1 mm	Ja	Ja
Bundprøve feltbeskrivelse	lille sigterest, mest skaller, en hel del polychaeter, en del amphipoder, en enkelt sømus, type1b fin gult sand med ca. 5% silt					
Bundprøve laboratorie-beskrivelse						

Kunde:	Energinet		Dato:	05/03/2013	Område:	Horns Rev 3
Opgave:	Sedimentkortlægning		Tid:	18:58:00	Lokalitet:	HR3_47
Pos. N	Pos. E	Dybde m	Bølgehøjde m	Dyk / Rov	Pilot/Dykker	Speak
55°45,222	8°02,275	16.0 m	0,5-1	ROV	Mils	Ersp
55°45,204	8°02,306	m	Foto/Video	Skib	Tender	Assistent
Kurs 197°	Afst. 46 m	16 m	Video	Anette Christina	Ersp	Steffen
Priritet:	High	Udpegning:	Sand…..			
Bundtype	% mudder/silt	% sand	% grus	% sten <10 cm	% sten >10 cm	% rest:
Type 1b	15	85	0	0	0	0
Substrat:	Strømribber, fint sand, en hel del detritus					
Fauna:	En del Lanicerør, stor søanamone, søstjerne, ising, eremitkrebs, kutling, fladfisk, enkelte tomme knivmuslingeskaller, hestereje, slangestjerner, enkelte hvide muslingeskaller		Overordnet dækning			Overordnet dækning
			10%			
Flora:	Ingen		Substratspecifik dækning			Substratspecifik dækning
			0%			
Bundtype	Prøvetager	Assistent	Bundprøveudstyr	Sigte	Bundprøve	Kvantitativ
Type 1b	ERSP	MILS/Steffen	VanVeen	1 mm	Ja	Ja
Bundprøve feltbeskrivelse	Middelstor sigterest, skaller, enkelkte ormerør, mange Polychaeter, en del tallerkenmuslinger, 1b bund fint sand ca. 15% silt					
Bundprøve laboratorie-beskrivelse						

Kunde:	Energinet		Dato:	05/03/2013	Område:	Horns Rev 3
Opgave:	Sedimentkortlægning		Tid:	20:00:00	Lokalitet:	HR3_48
Pos. N	Pos. E	Dybde m	Bølgehøjde m	Dyk / Rov	Pilot/Dykker	Speak
55°45,125	7°56,087	17.0 m	0,5-1	ROV	Mils	Ersp
55°45,126	7°56,071	m	Foto/Video	Skib	Tender	Assistent
Kurs 53°	Afst. 17 m	17 m	Video	Anette Christina	Ersp	Steffen
Priritet:	High	Udpegning:	Sand…..			
Bundtype	% mudder/silt	% sand	% grus	% sten <10 cm	% sten >10 cm	% rest:
Type 1b	30	70	0	0	0	0
Substrat:	Fint sand, små strømribber, en del silt, detritus i overfladen					
Fauna:	En del slangestjerner, søstjerner og Lanicerør, eremitkrebs, kutlinger, spredte hvide skaller, masser af Ophiurer, knivmuslingeskaller, ising, små fladfisk, stor søanemone.		Overordnet dækning: 10			Overordnet dækning
Flora:	Ingen		Substratspecifik dækning: 0%			Substratspecifik dækning
Bundtype	Prøvetager	Assistent	Bundprøveudstyr	Sigte	Bundprøve	Kvantitativ
Type 1b/1a	ERSP	MILS/Steffen	VanVeen	1 mm	Ja	Ja
Bundprøve feltbeskrivelse	Mellemstor sigterest, skaller, en del polychaeter, en enket ophiur og en enkelt sømus, enkelte tallerkenmuslinger, 1b bund med fint sand og 30 % silt (begyndende overgang til 1a bund)					
Bundprøve laboratorie-beskrivelse						

Kunde:	Energinet		Dato:	05/03/2013	Område:	Horns Rev 3
Opgave:	Sedimentkortlægning		Tid:	20:46:00	Lokalitet:	HR3_49
Pos. N	Pos. E	Dybde m	Bølgehøjde m	Dyk / Rov	Pilot/Dykker	Speak
55°45,045	7°49,957	18.0 m	1	ROV	Mils	Ersp
55°45,048	7°49,928	m	Foto/Video	Skib	Tender	Assistent
Kurs 348°	Afst. 31 m	18 m	Video	Anette Christina	Ersp	Steffen
Pritet:	High	Udpegning:	Sand…..			
Bundtype	% mudder/silt	% sand	% grus	% sten <10 cm	% sten >10 cm	% rest:
Type 1b	2	98	0	0	0	0
Substrat:	Strømribber, fint sand, marint sne					
Fauna:	Lanicerør, slangestjerner, søstjerne, enkelte hvide skaller, kutling, fladfisk, knivmusling		Overordnet dækning			Overordnet dækning
			6%			
Flora:	Ingen		Substratspecifik dækning			Substratspecifik dækning
			0%			
Bundtype	Prøvetager	Assistent	Bundprøveudstyr	Sigte	Bundprøve	Kvantitativ
Type 1b	ERSP	MILS/Steffen	VanVeen	1 mm	Ja	Ja
Bundprøve feltbeskrivelse	Lille til middelstor sigterest, mest skaller, få ormerør, en del muslinger, Venus, Spisula og knivmuslinger, få Polychaeter, 1b bund, fint gult sand kun få procent silt.					
Bundprøve laboratorie-beskrivelse						

Kunde:	Energinet		Dato:	05/03/2013	Område:	Horns Rev 3
Opgave:	Sedimentkortlægning		Tid:	21:16:00	Lokalitet:	HR3_55
Pos. N	Pos. E	Dybde m	Bølgehøjde m	Dyk / Rov	Pilot/Dykker	Speak
55°44,150	7°47,980	19.0 m	0,5-1	ROV	Mils	Ersp
55°44,148	7°47,938	m	Foto/Video	Skib	Tender	Assistent
Kurs 229°	Afst. 44 m	19 m	Video	Anette Christina	Ersp	Steffen
Pritet:	High	Udpegning:	Sandbanker			
Bundtype	% mudder/silt	% sand	% grus	% sten <10 cm	% sten >10 cm	% rest:
Type 1b	0	100	0	0	0	0
Substrat:	Enkelte strømribber, fint til mellemfint sand, marint sne					
Fauna:	Søstjerner, lanicerør, fladfisk, knivmuslinger, kutling, eremitkrebs		Overordnet dækning			Overordnet dækning
			2%			
Flora:	Ingen		Substratspecifik dækning			Substratspecifik dækning
			0%			
Bundtype	Prøvetager	Assistent	Bundprøveudstyr	Sigte	Bundprøve	Kvantitativ
Type 1b	ERSP	MILS/Steffen	VanVeen	1 mm	Ja	Ja
Bundprøve feltbeskrivelse	Meget lille sigterest, få skaller, enkelte Polychaeter, en lille sømus, type 1b fint gult sand uden detritus eller silt.					
Bundprøve laboratorie-beskrivelse						

Kunde:	Energinet		Dato:	05/03/2013	Område:	Horns Rev 3
Opgave:	Sedimentkortlægning		Tid:	21:50:00	Lokalitet:	HR3_54
Pos. N	Pos. E	Dybde m	Bølgehøjde m	Dyk / Rov	Pilot/Dykker	Speak
55°43,743	7°45,145	19.0 m	0,5-1	ROV	Mils	Ersp
55°43,734	7°45,154	m	Foto/Video	Skib	Tender	Assistent
Kurs 174°	Afst. 19 m	19 m	Video	Anette Christina	Ersp	Steffen
Pritritet:	High	Udpegning:	Sandbanker			
Bundtype	% mudder/silt	% sand	% grus	% sten <10 cm	% sten >10 cm	% rest:
Type 1b	0	100	0	0	0	0
Type 2	0	75	20	5	0	0
Substrat:	Sandbund med strømribber, fint til mellemfint sand, mere normale sandribber, type 1b			Grovere sand, store voldsomme ribber, meget groft sand på toppen, småstenet, afblæsningsområde, type 2 med pletvise småsten		
Fauna:	Knivmuslingeskaller, spredte hvide skaller, søstjerner , rejerslangestjerne, knivmuslinger		Overordnet dækning: 3			Overordnet dækning: 2
Flora:	Ingen		Substratspecifik dækning: 0%			Substratspecifik dækning: 0

Bundtype	Prøvetager	Assistent	Bundprøveudstyr	Sigte	Bundprøve	Kvantitativ
Type 1b	ERSP	MILS/Steffen	VanVeen	1 mm	Ja	Ja
Bundprøve feltbeskrivelse	Meget lille sigterest, få skaller, nogen Polychaeter, enkelte tallerkenmuslinger, type 1b bund med fint gult sand uden silt					
Bundprøve laboratorie-beskrivelse						

Kunde:	Energinet		Dato:	05/03/2013	Område:	Horns Rev 3
Opgave:	Sedimentkortlægning		Tid:	22:22:00	Lokalitet:	HR3_50
Pos. N	Pos. E	Dybde m	Bølgehøjde m	Dyk / Rov	Pilot/Dykker	Speak
55°45,013	7°43,733	20.0 m	0,5-1	ROV	Mils	Ersp
55°45,012	7°43,738	m	Foto/Video	Skib	Tender	Assistent
Kurs 150°	Afst. 5 m	20 m	Video	Anette Christina	Ersp	Steffen
Pritritet:	High	Udpegning:	Sand…..			
Bundtype	% mudder/silt	% sand	% grus	% sten <10 cm	% sten >10 cm	% rest:
Type 1b	3	97	0	0	0	0
Substrat:	Strømribber, meget marin sne, fint sand					
Fauna:	Mange lanicerør, knivmuslinger, enkelte hvide skaller, søanemone, hestereje.		Overordnet dækning 8%			Overordnet dækning
Flora:	ingen		Substratspecifik dækning 0%			Substratspecifik dækning
Bundtype	Prøvetager	Assistent	Bundprøveudstyr	Sigte	Bundprøve	Kvantitativ
Type 1b	ERSP	MILS/Steffen	VanVeen	1 mm	Ja	Ja
Bundprøve feltbeskrivelse	Middelstor sigterest, skaller og ormerør, en del Polychaeter, enkelte venus- og tallerkenmuslinger, 1b bund, fint gult sand med få procent silt.					
Bundprøve laboratorie-beskrivelse						

Kunde:	Energinet		Dato:	05/03/2013	Område:	Horns Rev 3
Opgave:	Sedimentkortlægning		Tid:	23:03:00	Lokalitet:	HR3_51
Pos. N	Pos. E	Dybde m	Bølgehøjde m	Dyk / Rov	Pilot/Dykker	Speak
55°44,917	7°37,437	16.0 m	0,5-1	ROV	Mils	Ersp
55°44,916	7°37,458	m	Foto/Video	Skib	Tender	Assistent
Kurs 102°	Afst. 22 m	16 m	Video	Anette Christina	Ersp	Steffen
Pritet:	High	Udpegning:	Sand…..			
Bundtype	% mudder/silt	% sand	% grus	% sten <10 cm	% sten >10 cm	% rest:
Type 1b	0	100	0	0	0	0
Substrat:	Fint sand strømribber, marint sne.					
Fauna:	En del lanicerør og tomme muslingeskaller, søstjerner, kutlinger, Phyllodoce cf. groenlandica,		Overordnet dækning			Overordnet dækning
			2%			
Flora:	Ingen		Substratspecifik dækning			Substratspecifik dækning
			0%			
Bundtype	Prøvetager	Assistent	Bundprøveudstyr	Sigte	Bundprøve	Kvantitativ
Type 1b	ERSP	MILS/Steffen	VanVeen	1 mm	Ja	Ja
Bundprøve feltbeskrivelse	lille sigterest, ormerør, få skaller, enkelte Polychaeter og muslinger, 1b bund, fint gult sand, ingen silt.					
Bundprøve laboratorie-beskrivelse						

Kunde:	Energinet		Dato:	05/03/2013	Område:	Horns Rev 3
Opgave:	Sedimentkortlægning		Tid:	23:44:00	Lokalitet:	HR3_52
Pos. N	Pos. E	Dybde m	Bølgehøjde m	Dyk / Rov	Pilot/Dykker	Speak
55°44,900	7°31,110	21.0 m	0,5-1	ROV	Mils	Ersp
55°44,898	7°31,085	m	Foto/Video	Skib	Tender	Assistent
Kurs 256°	Afst. 27 m	21 m	Video	Anette Christina	Ersp	Steffen
Priritet:	High	Udpegning:	Sand…..			
Bundtype	% mudder/silt	% sand	% grus	% sten <10 cm	% sten >10 cm	% rest:
Type 1b	15	85	0	0	0	0
Substrat:	Sand, en smule silt, strømribber					
Fauna:	Søanemone, lanicerør, muslingeskaller, søstjerner, eremitkrebs, knivmuslingeskaller, hestereje		Overordnet dækning			Overordnet dækning
			2%			
Flora:	Ingen		Substratspecifik dækning			Substratspecifik dækning
			0%			
Bundtype	Prøvetager	Assistent	Bundprøveudstyr	Sigte	Bundprøve	Kvantitativ
Type 1b	ERSP	MILS/Steffen	VanVeen	1 mm	Ja	Ja
Bundprøve feltbeskrivelse	lille sigterest bestående af skaller, en del Polychaeter, enkelte tallerkenmuslinger, 1b bund: fint sand med ca 15 % silt.					
Bundprøve laboratorie-beskrivelse						

Kunde:	Energinet		Dato:	15/03/2013	Område:	#I/T
Opgave:	Sedimentkortlægning		Tid:	09.10	Lokalitet:	HR3_1
Pos. N	Pos. E	Dybde m	Bølgehøjde m	Dyk / Rov	Pilot/Dykker	Speak
88°42,889	7°36,517	13.6 m	1.5	Nej	-	-
#I/T	#I/T	#I/T	Foto/Video	Skib	Tender	Assistent
#I/T	#I/T	#I/T	Nej	Reykjanes	ERSP	-
Prioritet:	#I/T	Udpegning:	#I/T			
Bundtype	% mudder/silt	% sand	% grus	% sten <10 cm	% sten >10 cm	% rest:
Type 1b	0	92	5	3	0	0
Substrat:						
Fauna:			Overordnet dækning			Overordnet dækning
Flora:			Substratspecifik dækning			Substratspecifik dækning
Bundtype	Prøvetager	Assistent	Bundprøveudstyr	Sigte	Bundprøve	Kvantitativ
Type 1b	ERSP	0	VanVeen	1mm	Ja	ja
Bundprøve feltbeskrivelse	Fint til mellemfint sand. Lidt grus og enkelte smásten. Forholdsvis stor sigterest, mest bestående af grus og sten med enkelte skaller. En søanemone og enkelte Ophelia borealis					
Bundprøve laboratorie-beskrivelse						

Kunde:	Energinet		Dato:	15/03/2013	Område:	#I/T
Opgave:	Sedimentkortlægning		Tid:	08.30	Lokalitet:	HR3_2
Pos. N	Pos. E	Dybde m	Bølgehøjde m	Dyk / Rov	Pilot/Dykker	Speak
55°38,930	7°40,375	13.4 m	1 til 2	Nej	-	-
#I/T	#I/T	#I/T	Foto/Video	Skib	Tender	Assistent
#I/T	#I/T	#I/T	Nej	Reykjanes	ERSP	-
Pritritet:	#I/T	Udpegning:	#I/T			
Bundtype	% mudder/silt	% sand	% grus	% sten <10 cm	% sten >10 cm	% rest:
Type 1b	0	100	0	0	0	0
Substrat:						
Fauna:			Overordnet dækning			Overordnet dækning
Flora:			Substratspecifik dækning			Substratspecifik dækning
Bundtype	Prøvetager	Assistent	Bundprøveudstyr	Sigte	Bundprøve	Kvantitativ
Type 1b	ERSP	0	VanVeen	1mm	Ja	ja
Bundprøve feltbeskrivelse	Fint gult sand. Lille sigterest med få skaller og ormerør. Enkelte Polychaeta					
Bundprøve laboratorie-beskrivelse						

Kunde:	Energinet		Dato:	15/03/2013	Område:	#I/T
Opgave:	Sedimentkortlægning		Tid:	12.28	Lokalitet:	HR3_3
Pos. N	Pos. E	Dybde m	Bølgehøjde m	Dyk / Rov	Pilot/Dykker	Speak
55°42,064	7°42,785	18.1 m	1,5-2	Nej	-	-
#I/T	#I/T	#I/T	Foto/Video	Skib	Tender	Assistent
#I/T	#I/T	#I/T	Nej	Reykjanes	ERSP	-
Prioritet:	#I/T	Udpegning:	#I/T			
Bundtype	% mudder/silt	% sand	% grus	% sten <10 cm	% sten >10 cm	% rest:
Type 1b	1	99	0	0	0	0
Substrat:						
Fauna:			Overordnet dækning			Overordnet dækning
Flora:			Substratspecifik dækning			Substratspecifik dækning
Bundtype	Prøvetager	Assistent	Bundprøveudstyr	Sigte	Bundprøve	Kvantitativ
Type 1b	ERSP	0	VanVeen	1mm	Ja	ja
Bundprøve feltbeskrivelse	Fint gult sand. En anelse silt. Lille sigterest, mest bestående af skaller. En stor sømus. Enkelte Pectinaria, Nephtys og Scoloplus					
Bundprøve laboratorie-beskrivelse						

Kunde:	Energinet		Dato:	15/03/2013	Område:	#I/T
Opgave:	Sedimentkortlægning		Tid:	13.29	Lokalitet:	HR3_4
Pos. N	Pos. E	Dybde m	Bølgehøjde m	Dyk / Rov	Pilot/Dykker	Speak
55°44,062	7°47,393	20.3 m	1.5	Nej	-	-
#I/T	#I/T	#I/T	Foto/Video	Skib	Tender	Assistent
#I/T	#I/T	#I/T	Nej	Reykjanes	ERSP	-
Pritiet:	#I/T	Udpegning:	#I/T			
Bundtype	% mudder/silt	% sand	% grus	% sten <10 cm	% sten >10 cm	% rest:
Type 1b	0	99	1	0	0	0
Substrat:						
Fauna:			Overordnet dækning			Overordnet dækning
Flora:			Substratspecifik dækning			Substratspecifik dækning

Bundtype	Prøvetager	Assistent	Bundprøveudstyr	Sigte	Bundprøve	Kvantitativ
Type 1b	ERSP	0	VanVeen	1mm	Ja	ja
Bundprøve feltbeskrivelse	Mellemstor sigterest. Skaller og en smule grus. Fint til mellemfint sand med en smule grus. En del polychaeter og enkelte muslinger.					
Bundprøve laboratorie-beskrivelse						

Kunde:	Energinet		Dato:	15/03/2013	Område:	#I/T
Opgave:	Sedimentkortlægning		Tid:	15.13	Lokalitet:	HR3_5
Pos. N	Pos. E	Dybde m	Bølgehøjde m	Dyk / Rov	Pilot/Dykker	Speak
55°43,080	7°51,137	16.9 m	1.5	Nej	-	-
#I/T	#I/T	#I/T	Foto/Video	Skib	Tender	Assistent
#I/T	#I/T	#I/T	Nej	Reykjanes	ERSP	-
Pritet:	#I/T	Udpegning:	#I/T			
Bundtype	% mudder/silt	% sand	% grus	% sten <10 cm	% sten >10 cm	% rest:
Type 1b	0	100	0	0	0	0
Substrat:						
Fauna:			Overordnet dækning			Overordnet dækning
Flora:			Substratspecifik dækning			Substratspecifik dækning

Bundtype	Prøvetager	Assistent	Bundprøveudstyr	Sigte	Bundprøve	Kvantitativ
Type 1b	ERSP	0	VanVeen	1mm	Ja	ja
Bundprøve feltbeskrivelse	Fint gult sand. Lille sigterest. Få skaller. En Ophiur, enkelte polychaeter og tallerkenmuslinger.					
Bundprøve laboratorie-beskrivelse						

Kunde:	Energinet		Dato:	15/03/2013	Område:	#I/T
Opgave:	Sedimentkortlægning		Tid:	15.38	Lokalitet:	HR3_6
Pos. N	Pos. E	Dybde m	Bølgehøjde m	Dyk / Rov	Pilot/Dykker	Speak
55°44,923	7°53,994	19.9 m	2	Nej	-	-
#I/T	#I/T	#I/T	Foto/Video	Skib	Tender	Assistent
#I/T	#I/T	#I/T	Nej	Reykjanes	ERSP	-
Priritet:	#I/T	Udpegning:	#I/T			
Bundtype	% mudder/silt	% sand	% grus	% sten <10 cm	% sten >10 cm	% rest:
Type 1b	5	95	0	0	0	0
Substrat:						
Fauna:			Overordnet dækning			Overordnet dækning
Flora:			Substratspecifik dækning			Substratspecifik dækning
Bundtype	Prøvetager	Assistent	Bundprøveudstyr	Sigte	Bundprøve	Kvantitativ
Type 1b	ERSP	0	VanVeen	1mm	Ja	ja
Bundprøve feltbeskrivelse	Fint gult sand med silt som enkelte klumper. Lillte sigterest. Mest skaller. Enkelte Ophiuerer, tallerkenmuslinger og Polychaeter					
Bundprøve laboratorie-beskrivelse						

SPECIES LIST

Sample	Species	Phylum	Number of specimens	Wet Weight (g)	Dry Weight (g)	Danish vernacular name
HR3_3	Abra nitida	Mol.	1	0.1362	0.0492	Skinnende pebermusling
HR3_44	Abra nitida	Mol.	3	0.5135	0.2277	Skinnende pebermusling
HR3_47	Abra nitida	Mol.	2	0.3223	0.1224	Skinnende pebermusling
HR3_48	Abra nitida	Mol.	6	0.4208	0.1665	Skinnende pebermusling
HR3_52	Abra nitida	Mol.	1	0.117	0.0474	Skinnende pebermusling
HR3_53	Abra nitida	Mol.	6	1.211	0.5188	Skinnende pebermusling
HR3_33B	Ampelisca sp.	Crusta.	1	0	0	Ampelisca
HR3_44	Ampelisca sp.	Crusta.	3	0	0	Ampelisca
HR3_47	Ampelisca sp.	Crusta.	2	0	0	Ampelisca
HR3_48	Ampelisca sp.	Crusta.	1	0	0	Ampelisca
HR3_53	Ampelisca sp.	Crusta.	6	0	0	Ampelisca
HR3_56	Ampelisca sp.	Crusta.	3	0	0	Ampelisca
HR3_6	Ampelisca sp.	Crusta.	1	0	0	Ampelisca
HR3_3	Angulus fabula	Mol.	11	0.6257	0.2992	Stribet tallerkenmusling
HR3_38B	Angulus fabula	Mol.	1	0.0067	0.0032	Stribet tallerkenmusling
HR3_44	Angulus fabula	Mol.	29	2.7384	1.2712	Stribet tallerkenmusling
HR3_45	Angulus fabula	Mol.	10	0.3057	0.1454	Stribet tallerkenmusling
HR3_46	Angulus fabula	Mol.	7	0.2558	0.1168	Stribet tallerkenmusling
HR3_47	Angulus fabula	Mol.	33	4.271	2.0926	Stribet tallerkenmusling
HR3_48	Angulus fabula	Mol.	23	6.2232	2.8663	Stribet tallerkenmusling
HR3_49	Angulus fabula	Mol.	6	0.6981	0.3693	Stribet tallerkenmusling
HR3_5	Angulus fabula	Mol.	4	1.3512	0.6807	Stribet tallerkenmusling
HR3_50	Angulus fabula	Mol.	10	1.5639	0.6916	Stribet tallerkenmusling
HR3_52	Angulus fabula	Mol.	15	3.0507	1.4366	Stribet tallerkenmusling
HR3_53	Angulus fabula	Mol.	15	0.7564	0.3409	Stribet tallerkenmusling
HR3_54	Angulus fabula	Mol.	2	1.0009	0.4935	Stribet tallerkenmusling
HR3_56	Angulus fabula	Mol.	9	1.3214	0.6094	Stribet tallerkenmusling
HR3_6	Angulus fabula	Mol.	5	0.511	0.2635	Stribet tallerkenmusling
HR3_46	Anthozoa indet.	Andet	1	0	0	Koraldyr
HR3_4	Aonides paucibranchiata	Poly.	10	0	0	
HR3_41	Aonides paucibranchiata	Poly.	4	0	0	
HR3_42	Aonides paucibranchiata	Poly.	1	0	0	
HR3_1	Bathyporeia sp.	Crusta.	1	0	0	Bathyporeia
HR3_2	Bathyporeia sp.	Crusta.	2	0	0	Bathyporeia
HR3_3	Bathyporeia sp.	Crusta.	1	0	0	Bathyporeia
HR3_33B	Bathyporeia sp.	Crusta.	1	0	0	Bathyporeia
HR3_39B	Bathyporeia sp.	Crusta.	4	0	0	Bathyporeia
HR3_4	Bathyporeia sp.	Crusta.	2	0	0	Bathyporeia
HR3_40b	Bathyporeia sp.	Crusta.	7	0	0	Bathyporeia
HR3_44	Bathyporeia sp.	Crusta.	1	0	0	Bathyporeia
HR3_45	Bathyporeia sp.	Crusta.	164	0	0	Bathyporeia
HR3_46	Bathyporeia sp.	Crusta.	38	0	0	Bathyporeia
HR3_47	Bathyporeia sp.	Crusta.	1	0	0	Bathyporeia
HR3_49	Bathyporeia sp.	Crusta.	9	0	0	Bathyporeia
HR3_5	Bathyporeia sp.	Crusta.	4	0	0	Bathyporeia
HR3_50	Bathyporeia sp.	Crusta.	1	0	0	Bathyporeia
HR3_51	Bathyporeia sp.	Crusta.	19	0	0	Bathyporeia
HR3_52	Bathyporeia sp.	Crusta.	3	0	0	Bathyporeia
HR3_53	Bathyporeia sp.	Crusta.	10	0	0	Bathyporeia
HR3_54	Bathyporeia sp.	Crusta.	2	0	0	Bathyporeia
HR3_55	Bathyporeia sp.	Crusta.	4	0	0	Bathyporeia
HR3_33B	Bivalvia indet.	Mol.	1	0.6852	0.4648	Musling
HR3_41	Branchiostoma lanceolatum	Andet	2	0	0	Lancetfisk
HR3_45	Capitella sp.	Poly.	1	0	0	Capitella
HR3_48	Capitella sp.	Poly.	2	0	0	Capitella
HR3_53	Capitella sp.	Poly.	1	0	0	Capitella
HR3_3	Chaetozone sp.	Poly.	1	0	0	Chaetozone
HR3_33B	Chaetozone sp.	Poly.	4	0	0	Chaetozone
HR3_39B	Chaetozone sp.	Poly.	1	0	0	Chaetozone
HR3_45	Chaetozone sp.	Poly.	1	0	0	Chaetozone
HR3_48	Chaetozone sp.	Poly.	2	0	0	Chaetozone
HR3_49	Chaetozone sp.	Poly.	2	0	0	Chaetozone
HR3_5	Chaetozone sp.	Poly.	1	0	0	Chaetozone
HR3_50	Chaetozone sp.	Poly.	1	0	0	Chaetozone
HR3_52	Chaetozone sp.	Poly.	10	0	0	Chaetozone
HR3_54	Chaetozone sp.	Poly.	2	0	0	Chaetozone
HR3_55	Chaetozone sp.	Poly.	3	0	0	Chaetozone
HR3_56	Chaetozone sp.	Poly.	5	0	0	Chaetozone
HR3_47	Chamelea gallina	Mol.	2	2.1517	1.7302	
HR3_49	Chamelea gallina	Mol.	1	0.6476	0.521	
HR3_50	Chamelea gallina	Mol.	1	2.341	1.8012	
HR3_4	Cumacea indet.	Crusta.	1	0	0	Kommakrebs
HR3_56	Cumacea indet.	Crusta.	1	0	0	Kommakrebs

Sample	Species	Phylum	Number of specimens	Wet Weight (g)	Dry Weight (g)	Danish vernacular name
HR3_47	Cylichna cylindracea	Mol.	1	0.0419	0.0294	Cylindersnegl
HR3_3	Echinocardium cordatum	Echino.	1	0	0	Alm. sømus
HR3_33B	Echinocardium cordatum	Echino.	1	0	0	Alm. sømus
HR3_44	Echinocardium cordatum	Echino.	4	0	0	Alm. sømus
HR3_46	Echinocardium cordatum	Echino.	4	0	0	Alm. sømus
HR3_48	Echinocardium cordatum	Echino.	1	0	0	Alm. sømus
HR3_52	Echinocardium cordatum	Echino.	1	0	0	Alm. sømus
HR3_53	Echinocardium cordatum	Echino.	1	0	0	Alm. sømus
HR3_55	Echinocardium cordatum	Echino.	1	0	0	Alm. sømus
HR3_56	Echinocardium cordatum	Echino.	1	0	0	Alm. sømus
HR3_38B	Ensis directus	Mol.	1	4.8247	2.4747	Amerikansk knivmusling
HR3_39B	Ensis directus	Mol.	1	1.622	0.8802	Amerikansk knivmusling
HR3_4	Ensis directus	Mol.	1	0.0169	0.0031	Amerikansk knivmusling
HR3_41	Ensis directus	Mol.	2	6.6044	3.7138	Amerikansk knivmusling
HR3_42	Ensis directus	Mol.	1	1.2135	0.6913	Amerikansk knivmusling
HR3_48	Ensis directus	Mol.	1	0.6366	0.3355	Amerikansk knivmusling
HR3_49	Ensis directus	Mol.	2	8.0865	3.9463	Amerikansk knivmusling
HR3_51	Ensis directus	Mol.	3	0.3513	0.142	Amerikansk knivmusling
HR3_56	Ensis directus	Mol.	1	1.8762	1.2772	Amerikansk knivmusling
HR3_33B	Eteone foliosa	Poly.	1	0	0	
HR3_39B	Eteone foliosa	Poly.	1	0	0	
HR3_47	Eteone foliosa	Poly.	1	0	0	
HR3_51	Eteone foliosa	Poly.	4	0	0	
HR3_53	Eteone longa	Poly.	1	0	0	
HR3_52	Eulalia sp.	Poly.	1	0	0	
HR3_45	Eumida sanguinea	Poly.	2	0	0	
HR3_50	Eumida sanguinea	Poly.	2	0	0	
HR3_2	Euzonus flabelligerus	Poly.	1	0	0	
HR3_40B	Goniada maculata	Poly.	1	0	0	Krølleorm
HR3_44	Goniada maculata	Poly.	1	0	0	Krølleorm
HR3_47	Goniada maculata	Poly.	4	0	0	Krølleorm
HR3_48	Goniada maculata	Poly.	3	0	0	Krølleorm
HR3_49	Goniada maculata	Poly.	3	0	0	Krølleorm
HR3_50	Goniada maculata	Poly.	2	0	0	Krølleorm
HR3_52	Goniada maculata	Poly.	1	0	0	Krølleorm
HR3_6	Goniada maculata	Poly.	2	0	0	Krølleorm
HR3_4	Goniadella bobretski	Poly.	7	0	0	
HR3_45	Harmothoe lunulata	Poly.	1	0	0	
HR3_6	Harmothoe lunulata	Poly.	1	0	0	
HR3_45	Kurtiella bidentata	Mol.	9	0.0143	0.0073	
HR3_47	Kurtiella bidentata	Mol.	6	0.0262	0.0137	
HR3_53	Kurtiella bidentata	Mol.	5	0.0115	0.0065	
HR3_44	Lanice conchilega	Poly.	4	0	0	Lanice
HR3_45	Lanice conchilega	Poly.	13	0	0	Lanice
HR3_46	Lanice conchilega	Poly.	5	0	0	Lanice
HR3_47	Lanice conchilega	Poly.	4	0	0	Lanice
HR3_48	Lanice conchilega	Poly.	1	0	0	Lanice
HR3_50	Lanice conchilega	Poly.	5	0	0	Lanice
HR3_51	Lanice conchilega	Poly.	1	0	0	Lanice
HR3_53	Lanice conchilega	Poly.	2	0	0	Lanice
HR3_56	Lanice conchilega	Poly.	1	0	0	Lanice
HR3_4	Liocarcinus sp.	Crusta.	1	0	0	
HR3_44	Liocarcinus sp.	Crusta.	1	0	0	
HR3_3	Lunatia intermedia	Mol.	1	0.0841	0.0654	
HR3_50	Lunatia intermedia	Mol.	4	0.067	0.0745	
HR3_56	Lunatia intermedia	Mol.	1	0.0914	0.0699	
HR3_49	Mactra stultorum	Mol.	1	7.3149	3.9614	Smuk trugmusling
HR3_51	Mactra stultorum	Mol.	1	2.3993	1.1607	Smuk trugmusling
HR3_1	Magelona mirabilis	Poly.	1	0	0	Magelona
HR3_3	Magelona mirabilis	Poly.	26	0	0	Magelona
HR3_33B	Magelona mirabilis	Poly.	1	0	0	Magelona
HR3_33B	Magelona mirabilis	Poly.	23	0	0	Magelona
HR3_4	Magelona mirabilis	Poly.	1	0	0	Magelona
HR3_44	Magelona mirabilis	Poly.	2	0	0	Magelona
HR3_46	Magelona mirabilis	Poly.	24	0	0	Magelona
HR3_47	Magelona mirabilis	Poly.	7	0	0	Magelona
HR3_48	Magelona mirabilis	Poly.	2	0	0	Magelona
HR3_49	Magelona mirabilis	Poly.	10	0	0	Magelona
HR3_5	Magelona mirabilis	Poly.	5	0	0	Magelona
HR3_50	Magelona mirabilis	Poly.	4	0	0	Magelona
HR3_51	Magelona mirabilis	Poly.	2	0	0	Magelona
HR3_52	Magelona mirabilis	Poly.	102	0	0	Magelona
HR3_53	Magelona mirabilis	Poly.	10	0	0	Magelona

Sample	Species	Phylum	Number of specimens	Wet Weight (g)	Dry Weight (g)	Danish vernacular name
HR3_56	Magelona mirabilis	Poly.	22	0	0	Magelona
HR3_6	Magelona mirabilis	Poly.	1	0	0	Magelona
HR3_47	Mediomastus sp.	Poly.	3	0	0	
HR3_49	Mediomastus sp.	Poly.	2	0	0	
HR3_53	Mediomastus sp.	Poly.	1	0	0	
HR3_56	Mediomastus sp.	Poly.	1	0	0	
HR3_45	Monoculodes carinatus	Crusta.	4	0	0	
HR3_46	Monoculodes carinatus	Crusta.	4	0	0	
HR3_53	Monoculodes carinatus	Crusta.	4	0	0	
HR3_55	Monoculodes carinatus	Crusta.	1	0	0	
HR3_1	Nemertinea indet.	Andet	1	0	0	
HR3_44	Nemertinea indet.	Andet	1	0	0	
HR3_47	Nemertinea indet.	Andet	3	0	0	
HR3_48	Nemertinea indet.	Andet	1	0	0	
HR3_52	Nemertinea indet.	Andet	1	0	0	
HR3_53	Nemertinea indet.	Andet	2	0	0	
HR3_47	Nephtys assimilis	Poly.	2	0	0	
HR3_48	Nephtys assimilis	Poly.	1	0	0	
HR3_5	Nephtys assimilis	Poly.	1	0	0	
HR3_50	Nephtys assimilis	Poly.	1	0	0	
HR3_52	Nephtys assimilis	Poly.	2	0	0	
HR3_53	Nephtys assimilis	Poly.	1	0	0	
HR3_56	Nephtys assimilis	Poly.	2	0	0	
HR3_6	Nephtys assimilis	Poly.	1	0	0	
HR3_33B	Nephtys caeca	Poly.	2	0	0	
HR3_44	Nephtys caeca	Poly.	2	0	0	
HR3_45	Nephtys caeca	Poly.	3	0	0	
HR3_46	Nephtys caeca	Poly.	3	0	0	
HR3_47	Nephtys caeca	Poly.	1	0	0	
HR3_48	Nephtys caeca	Poly.	3	0	0	
HR3_50	Nephtys caeca	Poly.	2	0	0	
HR3_53	Nephtys caeca	Poly.	1	0	0	
HR3_54	Nephtys caeca	Poly.	1	0	0	
HR3_1	Nephtys cirrosa	Poly.	3	0	0	
HR3_33B	Nephtys cirrosa	Poly.	3	0	0	
HR3_33B	Nephtys cirrosa	Poly.	1	0	0	
HR3_39B	Nephtys cirrosa	Poly.	5	0	0	
HR3_40B	Nephtys cirrosa	Poly.	5	0	0	
HR3_41	Nephtys cirrosa	Poly.	2	0	0	
HR3_49	Nephtys cirrosa	Poly.	1	0	0	
HR3_50	Nephtys cirrosa	Poly.	1	0	0	
HR3_51	Nephtys cirrosa	Poly.	3	0	0	
HR3_52	Nephtys cirrosa	Poly.	1	0	0	
HR3_54	Nephtys cirrosa	Poly.	8	0	0	
HR3_3	Nephtys hombergi	Poly.	1	0	0	Nephtys
HR3_33B	Nephtys hombergi	Poly.	1	0	0	Nephtys
HR3_44	Nephtys hombergi	Poly.	1	0	0	Nephtys
HR3_45	Nephtys hombergi	Poly.	5	0	0	Nephtys
HR3_46	Nephtys hombergi	Poly.	5	0	0	Nephtys
HR3_47	Nephtys hombergi	Poly.	2	0	0	Nephtys
HR3_48	Nephtys hombergi	Poly.	2	0	0	Nephtys
HR3_49	Nephtys hombergi	Poly.	1	0	0	Nephtys
HR3_5	Nephtys hombergi	Poly.	2	0	0	Nephtys
HR3_50	Nephtys hombergi	Poly.	1	0	0	Nephtys
HR3_52	Nephtys hombergi	Poly.	5	0	0	Nephtys
HR3_53	Nephtys hombergi	Poly.	9	0	0	Nephtys
HR3_56	Nephtys hombergi	Poly.	2	0	0	Nephtys
HR3_2	Nephtys longosetosa	Poly.	1	0	0	
HR3_2	Nephtys sp.	Poly.	5	0	0	
HR3_3	Nephtys sp.	Poly.	1	0	0	
HR3_4	Nephtys sp.	Poly.	7	0	0	
HR3_44	Nephtys sp.	Poly.	2	0	0	
HR3_45	Nephtys sp.	Poly.	4	0	0	
HR3_46	Nephtys sp.	Poly.	3	0	0	
HR3_47	Nephtys sp.	Poly.	7	0	0	
HR3_49	Nephtys sp.	Poly.	4	0	0	
HR3_5	Nephtys sp.	Poly.	2	0	0	
HR3_53	Nephtys sp.	Poly.	5	0	0	
HR3_54	Nephtys sp.	Poly.	6	0	0	
HR3_55	Nephtys sp.	Poly.	9	0	0	
HR3_56	Nephtys sp.	Poly.	5	0	0	
HR3_6	Nephtys sp.	Poly.	2	0	0	
HR3_3	Notomastus latericeus	Poly.	1	0	0	

Sample	Species	Phylum	Number of specimens	Wet Weight (g)	Dry Weight (g)	Danish vernacular name
HR3_33B	Notomastus latericeus	Poly.	2	0	0	
HR3_44	Notomastus latericeus	Poly.	9	0	0	
HR3_47	Notomastus latericeus	Poly.	10	0	0	
HR3_48	Notomastus latericeus	Poly.	10	0	0	
HR3_49	Notomastus latericeus	Poly.	1	0	0	
HR3_50	Notomastus latericeus	Poly.	2	0	0	
HR3_53	Notomastus latericeus	Poly.	4	0	0	
HR3_55	Notomastus latericeus	Poly.	2	0	0	
HR3_56	Notomastus latericeus	Poly.	4	0	0	
HR3_44	Nucula nitidosa	Mol.	5	0.2154	0.1597	Skinnende nøddemsling
HR3_47	Nucula nitidosa	Mol.	8	0.4465	0.3577	Skinnende nøddemsling
HR3_53	Nucula nitidosa	Mol.	8	0.5442	0.4144	Skinnende nøddemsling
HR3_1	Ophelia borealis	Poly.	8	0	0	Alm.ophelia
HR3_2	Ophelia borealis	Poly.	6	0	0	Alm.ophelia
HR3_33B	Ophelia borealis	Poly.	2	0	0	Alm.ophelia
HR3_39B	Ophelia borealis	Poly.	17	0	0	Alm.ophelia
HR3_4	Ophelia borealis	Poly.	13	0	0	Alm.ophelia
HR3_40B	Ophelia borealis	Poly.	5	0	0	Alm.ophelia
HR3_41	Ophelia borealis	Poly.	36	0	0	Alm.ophelia
HR3_42	Ophelia borealis	Poly.	5	0	0	Alm.ophelia
HR3_43	Ophelia borealis	Poly.	3	0	0	Alm.ophelia
HR3_51	Ophelia borealis	Poly.	3	0	0	Alm.ophelia
HR3_55	Ophelia borealis	Poly.	8	0	0	Alm.ophelia
HR3_40B	Ophiura sp.	Echino.	1	0	0	Slangestjerne
HR3_44	Ophiura sp.	Echino.	3	0	0	Slangestjerne
HR3_45	Ophiura sp.	Echino.	1	0	0	Slangestjerne
HR3_47	Ophiura sp.	Echino.	1	0	0	Slangestjerne
HR3_5	Ophiura sp.	Echino.	1	0	0	Slangestjerne
HR3_53	Ophiura sp.	Echino.	9	0	0	Slangestjerne
HR3_56	Ophiura sp.	Echino.	2	0	0	Slangestjerne
HR3_6	Ophiura sp.	Echino.	1	0	0	Slangestjerne
HR3_44	Ophiura texturata	Echino.	1	0	0	
HR3_48	Ophiura texturata	Echino.	2	0	0	
HR3_5	Ophiura texturata	Echino.	1	0	0	
HR3_6	Ophiura texturata	Echino.	1	0	0	
HR3_44	Owenia fusiformis	Poly.	1	0	0	Owenia
HR3_47	Owenia fusiformis	Poly.	1	0	0	Owenia
HR3_50	Owenia fusiformis	Poly.	5	0	0	Owenia
HR3_43	Pagurus bernhardus	Crusta.	1	0	0	Alm. eremitkrebs
HR3_56	Pagurus bernhardus	Crusta.	1	0	0	Alm. eremitkrebs
HR3_3	Pectinaria koreni	Poly.	1	0	0	Lige kambørsteorm
HR3_33B	Pectinaria koreni	Poly.	1	0	0	Lige kambørsteorm
HR3_48	Pectinaria koreni	Poly.	1	0	0	Lige kambørsteorm
HR3_53	Pectinaria koreni	Poly.	1	0	0	Lige kambørsteorm
HR3_56	Pectinaria koreni	Poly.	2	0	0	Lige kambørsteorm
HR3_47	Pholoe baltica	Poly.	1	0	0	
HR3_53	Pholoe baltica	Poly.	1	0	0	
HR3_50	Phoronis sp.	Andet	2	0	0	
HR3_53	Phoronis sp.	Andet	1	0	0	
HR3_53	Phyllodoce rosea	Poly.	1	0	0	
HR3_4	Poecilochaetus serpens	Poly.	1	0	0	
HR3_52	Poecilochaetus serpens	Poly.	1	0	0	
HR3_4	Polydora caeca	Poly.	1	0	0	
HR3_33B	Scolelepis bonnieri	Poly.	2	0	0	
HR3_39B	Scolelepis bonnieri	Poly.	1	0	0	
HR3_41	Scolelepis bonnieri	Poly.	2	0	0	
HR3_49	Scolelepis bonnieri	Poly.	1	0	0	
HR3_2	Scoloplos armiger	Poly.	2	0	0	Scoloplos
HR3_3	Scoloplos armiger	Poly.	30	0	0	Scoloplos
HR3_33B	Scoloplos armiger	Poly.	9	0	0	Scoloplos
HR3_39B	Scoloplos armiger	Poly.	9	0	0	Scoloplos
HR3_43	Scoloplos armiger	Poly.	1	0	0	Scoloplos
HR3_44	Scoloplos armiger	Poly.	17	0	0	Scoloplos
HR3_46	Scoloplos armiger	Poly.	2	0	0	Scoloplos
HR3_47	Scoloplos armiger	Poly.	15	0	0	Scoloplos
HR3_48	Scoloplos armiger	Poly.	12	0	0	Scoloplos
HR3_49	Scoloplos armiger	Poly.	6	0	0	Scoloplos
HR3_5	Scoloplos armiger	Poly.	2	0	0	Scoloplos
HR3_50	Scoloplos armiger	Poly.	4	0	0	Scoloplos
HR3_53	Scoloplos armiger	Poly.	6	0	0	Scoloplos
HR3_55	Scoloplos armiger	Poly.	2	0	0	Scoloplos
HR3_56	Scoloplos armiger	Poly.	10	0	0	Scoloplos
HR3_6	Scoloplos armiger	Poly.	3	0	0	Scoloplos

Sample	Species	Phylum	Number of specimens	Wet Weight (g)	Dry Weight (g)	Danish vernacular name
HR3_48	Sigalion mathildae	Poly.	2	0	0	
HR3_52	Sigalion mathildae	Poly.	1	0	0	
HR3_6	Sigalion mathildae	Poly.	2	0	0	
HR3_52	Spio armata	Poly.	1	0	0	
HR3_1	Spio sp.	Poly.	2	0	0	
HR3_4	Spio sp.	Poly.	1	0	0	
HR3_42	Spio sp.	Poly.	1	0	0	
HR3_55	Spio sp.	Poly.	1	0	0	
HR3_1	Spiophanes bombyx	Poly.	2	0	0	
HR3_33B	Spiophanes bombyx	Poly.	1	0	0	
HR3_44	Spiophanes bombyx	Poly.	1	0	0	
HR3_45	Spiophanes bombyx	Poly.	3	0	0	
HR3_49	Spiophanes bombyx	Poly.	1	0	0	
HR3_50	Spiophanes bombyx	Poly.	4	0	0	
HR3_52	Spiophanes bombyx	Poly.	2	0	0	
HR3_53	Spiophanes bombyx	Poly.	8	0	0	
HR3_56	Spiophanes bombyx	Poly.	7	0	0	
HR3_4	Spisula solida	Mol.	1	0.5949	0.4537	Tykskallet trugmusling
HR3_4	Spisula subtruncata	Mol.	1	0.0182	0.011	Alm. trugmusling
HR3_44	Spisula subtruncata	Mol.	1	0.0239	0.0156	Alm. trugmusling
HR3_45	Spisula subtruncata	Mol.	5	0.082	0.0513	Alm. trugmusling
HR3_46	Spisula subtruncata	Mol.	2	0.0357	0.0224	Alm. trugmusling
HR3_47	Spisula subtruncata	Mol.	4	0.0942	0.0579	Alm. trugmusling
HR3_48	Spisula subtruncata	Mol.	1	0.0295	0.0183	Alm. trugmusling
HR3_53	Spisula subtruncata	Mol.	3	0.0681	0.0437	Alm. trugmusling
HR3_46	Tellimya ferruginosa	Mol.	5	0.0703	0.0799	
HR3_48	Tellimya ferruginosa	Mol.	1	0.0075	0.0035	
HR3_49	Thracia phaeseolina	Mol.	1	0.1476	0.0554	
HR3_42	Travisia forbesii	Poly.	1	0	0	Løgorm
HR3_33B	Urothoe grimaldii	Crusta.	2	0	0	
HR3_44	Urothoe grimaldii	Crusta.	4	0	0	
HR3_45	Urothoe grimaldii	Crusta.	3	0	0	
HR3_46	Urothoe grimaldii	Crusta.	3	0	0	
HR3_47	Urothoe grimaldii	Crusta.	1	0	0	
HR3_48	Urothoe grimaldii	Crusta.	2	0	0	
HR3_49	Urothoe grimaldii	Crusta.	4	0	0	
HR3_5	Urothoe grimaldii	Crusta.	1	0	0	
HR3_50	Urothoe grimaldii	Crusta.	4	0	0	
HR3_52	Urothoe grimaldii	Crusta.	1	0	0	
HR3_53	Urothoe grimaldii	Crusta.	8	0	0	
HR3_56	Urothoe grimaldii	Crusta.	3	0	0	

EMF SENSITIVITY IN AQUATIC INVERTEBRATES

Listing of marine invertebrates for which information on sensitivity to electric or magnetic fields has been reported (From Normandeau, 2011).

Table 4.2-17

Listing of marine invertebrates for which information on sensitivity to electric or magnetic fields has been reported.

Species[a]	Common Name	US?[b]	Sensitivity[c]	Sensory Range	Evidence Basis	Citation
Phylum Mollusca, Class Gastropoda, Order Opisthobranchia, Family Tritoniidae						
Tritonia diomedea	sea slug	US	M	geomagnetic field	behavioral: orientation	Cain et al 2006, Lohmann and Willows 1987, Lohmann et al 1991, Popescu and Willows 1999, Wang et al 2003, Wang et al 2004, Willows 1999
Phylum Mollusca, Class Bivalvia, Order Mytiloida, Family Mytilidae						
Mytilus edulis	blue mussel	US	None	n/a	none: toxicity study - no lethal effects from exposure to 3.7 mT DC fields for 7 weeks	Bochert and Zettler 2004
Mytilus galloprovincialis	Mediterranean mussel	Not in US	M	300-700 µT	physiological	Malagoli et al 2003, Malagoli et al 2004, Ottaviani et al 2002
Phylum Arthropoda, Subphylum Crustacea, Class Malacostraca						
Order Isopoda, Family Chaetiliidae						
Saduria entomon	glacial relict isopod	US	None	n/a	none: toxicity study - no lethal effects from exposure to 3.7 mT DC fields for 7 weeks	Bochert and Zettler 2004
Order Isopoda, Family Idoteidae						
Idotea baltica basteri	marine isopod	Not in US	M	geomagnetic field	behavioral: orientation	Ugolini and Pezzani 1995
Order Amphipoda, Family Talitridae						
Talorchestia martensii	sandhopper	Not in US	M	geomagnetic field	behavioral	Ugolini 2006
Order Decapoda, Infraorder Caridea, Family Crangonidae						
Crangon crangon	North Sea prawn	Not in US	None	n/a	none: toxicity study - no lethal effects from exposure to 3.7 mT DC fields for 7 weeks	Bochert and Zettler 2004
Order Decapoda, Infraorder Astacidea, Family Nephropidae						
Homarus vulgaris	European lobster	Not in US	none	n/a	none: No neural response to 500 Hz 0.2 T or a 50 Hz 0.8 T magnetic field	Ueno et al 1986

Table 4.2-17. Listing of marine invertebrates for which information on sensitivity to electric or magnetic fields has been reported (continued).

Species[a]	Common Name	US?[b]	Sensitivity[c]	Sensory Range	Evidence Basis	Citation
Order Decapoda, Infraorder Astacidea, Family Cambaridae						
Order Decapoda	Crayfish	Not in US	M	1-400 µT, 0.001-100 Hz	physiological: neural response	Uzdensky et al 1997
Procambarus clarkii	freshwater crayfish (Southeastern US)	Not in US	E	20 mV/cm; 8.08 mT	behavioral/ physiological	Delgado 1985, Steullet et al 2007, Ye et al 2004
Order Decapoda, Infraorder Astacidea, Family Parastacidae						
Cherax destructor	Australian freshwater crayfish	Not in US	E	current densities of 0.4 $\mu A/cm^2$	behavioral	Patullo and Macmillan 2007
Order Decapoda, Infraorder Palinura, Family Palinuridae						
Panulirus argus	Caribbean spiny lobster	US	M	geomagnetic field	behavioral/ anatomical	Boles and Lohmann 2003, Lohmann 1984, Lohmann 1985, Lohmann et al 1995
Order Decapoda, Infraorder Brachyura, Family Panopeidae						
Rhithropanopeus harrisii	round crab	US	None	n/a	none: toxicity study - no lethal effects from exposure to 3.7 mT DC fields for 7 weeks	Bochert and Zettler 2004
Phylum Echinodermata, Class Echinoidea, Order Temnopleuroida, Family Toxopneustidae						
Lytechinus pictus	sea urchin	US	M	30 mT	physiological: embryonic development	Levin and Ernst 1997
Phylum Echinodermata, Class Echinoidea, Order Echinoida, Family Strongylocentrotidae						
Strongylocentrotus purpuratus	purple sea urchin	US	M	30 mT	physiological: embryonic development	Cameron et al 1993, Levin and Ernst 1997

[a]Species listed alphabetically within family
[b]US = species occurs in US waters; Not in US = species does not occur in US waters
[c]M = magnetosensitivity; E = electrosensitivity; none = study found no indication of sensitivity

RED LIST OF MACROFAUNAL BENTHIC INVERTEBRATES OF THE WADDEN SEA*

EX - Extinct:
Alcyonium digitatum
Corambe obscura
Doridiella batava
Dodecaceria concharum
(?) *Helcion pellucidum*
Lacuna vincta
(?) *Rissoa membranacea*

CR - Critical:
Alkmaria romijni
Amphitrite cirrata
Echiurus echiurus
Facelina coronata
Monacha cantiana
Ostrea edulis
Quickella arenaria
Urticina felina
Mya truncata

EN - Endangered:
(?) *Boccardia (Polydora) redekei*
Buccinum undatum
Candidula gigaxii
(?) *Cerastoderma glaucum =C. lamarcki*
Clione celata
Gyraulus laevis
Homarus gammarus
Limapontia capitata
Limapontia depressa
Littorina neritoides
Modiolus modiolus
(?) *Rhithropanopeus harrisii*
Sabellaria spinulosa

VU - Vulnerable:
Alderia modesta
Amphitrite figulus
Archidoris tuberculata
Assiminea grayana
Candidula intersecta
Corbula (Varicorbula) gibba
Corophium lacustre
Cuthona nana
Eudendrium rameum
Facelina auriculata =F. drummondi
(?) *Gammarus duebeni*
Halichondria panicea
Hydrallmannia falcata
Hydrobia ventrosa
Idotea chelipes
Idotea linearis
Limnoria lignorum
Nereis pelagica
Ovatella (Myosotella) myosotis
(?) *Palaemon longirostris*
Psammechinus miliaris
Sagartiogeton viduatus
Sertularia cupressina
Tenellia pallida =Embletonia pallida
Venerupis (Tapes) senegalensis =V. pullastra

SU - Susceptible:
Abra nitida
Amphipholus squamata
Amphithoe helleri =Paramphithoe bicuspis
Cancer pagurus

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* Question-marks indicate that in one of the subregions the status of threat is uncertain.

LIST OF THREATENED MACROFAUNAL BENTHIC INVERTEBRATES OF THE WADDEN SEA

	Red List (trilateral)	Threats	Status of threat in the subregions of the Wadden Sea Area			
			NL	Nds	SH	DK[1]
PORIFERA						
Clione celata Grant, 1826	**EN**	HAB	VU	CR	EX	(*)
Halichondria panicea (Pallas, 1766)	**VU**		SU	VU	VU	(*)
CNIDARIA						
Hydrozoa						
Eudendrium rameum (Pallas, 1766)	**VU**		-	-	VU	(*)
Hydrallmannia falcata (Linnaeus, 1758)	**VU**		EN	-	VU	(*)
Sertularia cupressina (Linnaeus, 1758)	**VU**		SU	VU	VU	(*)
Anthozoa						
Alcyonium digitatum (Linnaeus, 1758)	**EX**	EXL	-	-	EX	(*)
Metridium senile (Linnaeus, 1761) (=*Metridium dianthus* Johnston, 1847)	*	EXL?	*	SU	*	(*)
Sagartiogeton undatus (O.F. Müller, 1788)	*	EXL?	*	SU	VU	(*)
Sagartiogeton viduatus (Gosse, 1860)*	**VU**		-	-	VU	(*)
Urticina eques (Gosse, 1860) (=*Tealia felina* (Linnaeus, 1758) =*T. crassicornis* (Johnston, 1847))	*		-	SU	-(?)	*
Urticina felina (Linnaeus, 1761)	**CR**		CR	SU	CR	(*)
MOLLUSCA						
Polyplacophora						
Lepidochitona cinerea (Linnaeus, 1767)	*		VU	*	*	*

* Possibly confused with *S. undatus.*

	Red List (trilateral)	Threats	Status of threat in the subregions the Wadden Sea Area			
			NL	Nds	SH	DK
Prosobranchia						
Assiminea grayana (Flemming, 1928)	**VU**	HAB, AGR, WAT, PAR	VU	VU	VU	(*)
Buccinum undatum Linneaus, 1758	**EN**	POL	CR	EN	SU	(*)
Crepidula fornicata (Linnaeus, 1758)	*		SU	SU	*	*
Epitonium clathrus (Linnaeus, 1758)	**SU**		-	SU	-	(*)
Helcion pellucidum (Linnaeus, 1758)	**EX?**		-	EX?	-	(*)
Hydrobia ventrosa (Montagu, 1803)	**VU**	HAB, WAT	VU	VU	VU	(*)
Lacuna vincta (Montagu, 1803)	**EX**	HAB	EX	-	-	(*)
Littorina saxatilis (Olivi, 1792)	*	HAB, WAT	VU	SU	*	(*)
Littorina neritoides (Linnaeus, 1758)	**EN**		CR	VU	-(?)	(*)
Rissoa membranacea (J.Adams, 1800)	**EX?**	HAB, WAT	EX	(*)	EX	(*)
Opisthobranchia						
Aeolidia papillosa (Linnaeus, 1761)	*		SU	SU	*	(*)
Alderia modesta (Loven, 1844)	**VU**	HAB, AGR, WAT	SU	SU	EN	(*)
Archidoris tuberculata (Cuvier, 1804)	**VU**		VU	VU	-(?)	(*)
Corambe obscura (Verrill, 1870)	**EX**	HAB	EX	-	-	(*)
Cuthona nana (Alder & Hancock, 1842)	**VU**		VU	-(?)	SU	(*)
Dendronotus arborescens (Ascanius, 1774)	**SU**		SU	SU	-(?)	(*)
Doridiella batava (Kerbert, 1886)	**EX**		EX	-	-	(*)
Facelina coronata (Forbes & Goodsir, 1839)	**CR**		CR	SU	-(?)	(*)
Facelina auriculata (Müller, 1776) (=*F. drummondi* Thompsen, 1844)	**VU**		VU	SU	-(?)	(*)
Limapontia capitata (O.F.Müller, 1774)	**EN**	HAB, AGR, WAT,	CR	VU	VU	(*)
Limapontia depressa (Alder & Hancock, 1862)	**EN**	HAB, AGR, WAT,	SU	EN	EN	(*)
Tenellia pallida (Alder & Hancock, 1842) =*Embletonia pallida* (Alder & Hancock, 1854)	**VU**	HAB, WAT	VU	VU	-(?)	(*)
Pulmonata						
Candidula gigaxii (L. Pfeiffer, 1850)	**EN**	WAT	VU	-(?)	EX	(*)
Candidula intersecta (Poiret, 1801)	**VU**	WAT	VU	-(?)	SU	(*)
Gyraulus laevis (Adler, 1838)	**EN**	HAB, WAT	EN	-(?)	EN	(*)

	Red List (trilateral)	Threats	Status of threat in the subregions of the Wadden Sea Area			
			NL	Nds	SH	DK[1]
Monacha cantiana (Montagu, 1803)	**CR**	WAT, HAB, AGR	VU	CR	EX	(*)
Ovatella (Myosotella) myosotis (Draparnaud, 1801)	**VU**	HAB, AGR, WAT	SU	VU	EN	(*)
Quickella arenaria (Boucjard-Chantereaux, 1837)	**CR**	HAB, WAT, AGR, DIS	CR	CR	-	(*)
Bivalvia						
Abra nitida (Müller, 1776)	**SU**	EUT	-	SU	-(?)	(*)
Cerastoderma glaucum (Poiret, 1789) = *Cerastoderma lamarcki* Reeve, 1843	**EN?**	HAB, WAT	EN	CR	EN	?
Corbula (*Varicorbula*) *gibba* (Olivi, 1792)	**VU**	EUT	-	VU	-	*
Ensis ensis (Linnaeus, 1758)	*	POL, EUT	-	SU	-	*
Modiolus modiolus (Linnaeus, 1758)	**EN**	POL, EXL	-	-	EN	(*)
Mya truncata (Linnaeus, 1758)	**CR**		CR	SU	EX	(*)
Ostrea edulis (Linnaeus, 1758)	**CR**	HAB, EXL, PAR?	EX	EX	EN	EX
Petricola pholadiformis (Lamarck, 1818)	*		*	SU	VU	*
Scrobicularia plana (Da Costa, 1778)	*	HAB, POL	*	*	VU	*
Spisula solida (Linnaeus, 1758)	**SU**	POL	-	SU	-	-
Spisula subtruncata (Da Costa, 1778)	*	POL	*	SU	VU	*
Tellina (*Angulus*) *tenuis* (Da Costa, 1778)	*		*	SU	VU	*
Venerupis (*Tapes*) *senegalensis* (Gmelin, 1791) (=*V. pullastra* Montagu, 1803)	**VU**		EN	VU	VU	*
ANNELIDA						
Polychaeta						
Alkmaria romijni Horst 1919	**CR**	HAB	EX?	-	SU	(*)
Amphitrite cirrata O.F. Müller, 1771	**CR**		- (?)	-	CR	(*)
Amphitrite figulus (Dalyell, 1853)	**VU**		SU	SU	VU	*
Boccardia (Polydora) redekei Horst 1920	**EN?**	HAB	CR?	SU?	SU	(*)
Dodecaceria concharum Orsted, 1843	**EX**		- (?)	-	EX	(*)
Nereis pelagica Linnaeus, 1761	**VU**		SU	SU	EN	(*)
Sabellaria spinulosa Leuckart, 1849	**EN**	EXL?, HAB	EX?	VU	EN	(*)
Streblospio shrubsolii (Buchanan, 1890)	*	HAB	SU	SU	*	*
Oligochaeta						
Monopylephorus irroratus (Verril)	**SU**		- (?)	SU	-(?)	
Tubificoides heterochaetus (Michaelsen)	**SU**		- (?)	SU	-(?)	

	Red List (trilateral)	Threats	Status of threat in the subregion the Wadden Sea Area			
			NL	Nds	SH	DI
CHELICERATA						
Pantopoda						
Nymphon rubrum Hodge, 1865	**SU?**		SU	SU	-(?)	?
Pycnogonum littorale (Ström, 1762)	**SU**		SU	SU	-(?)	(*
CRUSTACEA						
Decapoda						
Cancer pagurus Linnaeus, 1758	*	EXL	SU	SU	*	*
Homarus gammarus (Linnaeus,1758)	**EN**	EXL, POL, HAB	EX	-	EN	(*
Palaemon longirostris (H.Milne-Edw., 1837)	**VU?**	HAB, EUT?, POL?	VU?	SU?	-	(*
Palaemonetes varians (Leach, 1814)	**SU?**	HAB	SU?	-	-	(*
Processa nouveli holthuisi Al-Adhub & Williamson 1975 (=*P. canaliculata*, part., Nouvel & Holthuis 1957)	**SU?**		-	SU	?	(*)
Rhithropanopeus harrisii (Gould, 1841)	**EN?**	HAB	CR?	(*)	SU	(*)
Isopoda						
Armadillidium album = dillidium (Dollfus, 1887)	**?**	DIS, EUT?, POL?	VU	(*)	(*)	(*)
Cyathura carinata (Krøyer, 1848)	**?**	HAB, EUT?, POL?	SU?	(*)	(*)	(*)
Eurydice pulchra Leach,1815	*		*	*	SU	(*)
Idotea baltica (Pallas, 1772)	*		VU	SU	*	*
Idotea chelipes (Pallas, 1766)	**VU**	HAB, WAT	VU	SU	SU	*
Idotea granulosa Rathke, 1843	**SU?**		?	SU	-	(*)
Idotea linearis (Linnaeus, 1767)	**VU**		VU	SU	SU	(*)
Ligia oceanica (Linnaeus, 1767)	*	HAB, WAT	SU	SU	*	(*)
Limnoria lignorum (Rathke, 1799)	**VU**	HAB	SU	SU	VU	*
Sphaeroma hookeri (Leach, 1814)	**?**	HAB, WAT	VU	(*)	(*)	(*)
Amphipoda						
Amphithoe helleri Karaman 1975 (=*Paramphithoe bicuspis* (Heller 1967))	**SU**		- (?)	SU	SU	(*)
Caprella linearis (Linnaeus, 1767)	*		*	SU	SU	*
Cheirocratus sundevalli (Rathke, 1843)	**SU?**		?	SU	-	(*)
Corophium lacustre Vanhöffen 1911	**VU**	HAB	VU?	VU	VU	(*)

	Red List (trilateral)	Threats	Status of threat in the subregions of the Wadden Sea Area			
			NL	Nds	SH	DK[1]
Corophium bonelli Milne Edwards, 1830	*		?	SU	SU	*
Dexamine spinosa (Montagu, 1813)	**SU**		- (?)	SU	SU	(*)
Ericthonius difformis Milne Edwards, 1830	**SU**		?	SU	SU	(*)
Gammarus duebeni (Lilljeborg, 1851)	**VU?**	WAT	VU?	VU?	VU?	(*)
Phoxocephalus holbölli (Krøyer, 1842)	*		-	SU	SU	*
ECHINODERMATA						
Ophiuroidea						
Ophiothrix fragilis (Abildgard,1789)	*		*	SU	-	(*)
Echinoidea						
Amphipholus squamata (Delle Chiaje, 1829)	**SU**	WAT	SU	SU	(*)	(*)
Psammechinus miliaris (Gmelin, 1778)	**VU**	WAT, EXL	VU	VU	VU	*
ECHIURA						
Echiurus echiurus (Pallas)	**CR**		CR	CR	CR	(*)