Kriegers Flak Offshore Wind Farm

Benthic Flora, Fauna and Habitats
EIA - Technical Report
June 2015

NIRAS

MARILIM

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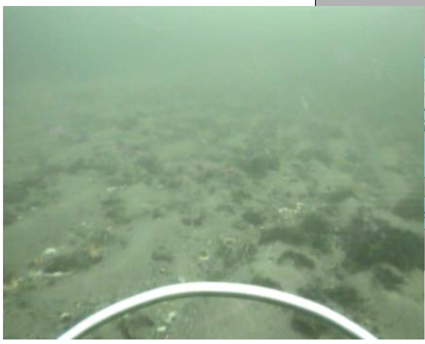
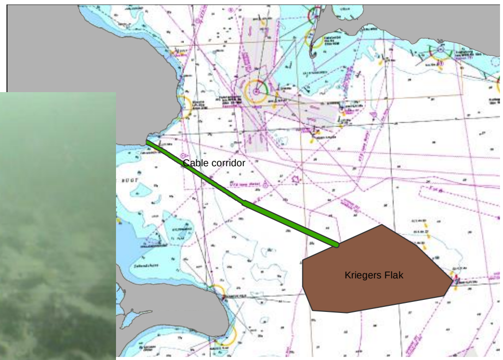
Baseline/EIA study





Kriegers Flak Offshore Wind Farm Baseline and EIA report on benthic flora, fauna and habitats

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Content

1 Non-technical summary

The establishment of a 600 MW offshore wind farm (OWF) and grid connection at Kriegers Flak is being planned, producing electrical power for about 600,000 households. Energinet.dk must conduct an environmental impact assessment (EIA) before the OWF and the grid connection to land in Denmark can be approved and constructed. This report documents the aspects of the benthic flora and fauna communities and the benthic habitats in the area where the OWF shall be established.

Baseline investigations have been undertaken in two subareas: the OWF subarea (Kriegers Flak) and at the cable corridor subarea including the landfall. The investigations included grab sampling, underwater video recording and diving. On the basis of the obtained data and supplemented with data from e.g. the geophysical survey (Rambøll 2013, GEO 2014), **benthic habitats** have been mapped throughout the complete investigation area. At Kriegers Flak, three benthic habitats have been identified. The dominant habitat is "Sand with infauna" where the bivalves *Macoma balthica* and *Mya arenaria* contribute with over 50 % of the fauna biomass. "Mixed substrate with infauna" is less dominant and includes areas with boulders and other hard substrates. Benthic vegetation is, however, scarce and the Blue mussel *Mytilus edulis* is dominating the biomass of this habitat. The north-western corner of Kriegers Flak is "Mud dominated by *Macoma balthica*" and characterises the transition to areas surrounding Kriegers Flak and having greater water depths and more fine-grained sediments.

Accordingly, "Mud dominated by *Macoma balthica*" is the predominant benthic habitat along the deeper part of the cable corridor (up to around 26 m water depth). The shallower part of the cable corridor up to the 15 m depth contour is largely dominated by the habitat "Sand with infauna", followed by "Mixed substrate with infauna". Macrophyte communities only occur in the nearshore region within the habitat complex "Reef".

Four **pressures** resulting from construction, operation and decommissioning activities of the project were regarded relevant for the EIA: Suspended sediments, sedimentation, foundation footprints and introduction of hard substrates. Nutrients and toxic substances have been excluded as pressures due to their proved low concentrations. Pressures were assessed in their impact on the benthic flora, fauna and habitats using worst case scenarios. As worst cases, scenarios have been chosen resulting in maximum concentrations of suspended sediments and maximum sedimentation (according to NIRAS 2014), producing largest footprints and solid substrates (steel driven monopiles or gravity based foundations depending on the number of turbines).

During the **construction phase**, a minor impact is expected from suspended sediments along the cable corridor. The concentrations are above the defined threshold value of 10 mg l^{-1} (threshold concentration above which reactions like interruption of feeding or otherwise reduced activity can be observed) in most regions of the corridor and also further away. Only at the corridor subarea, concentrations above 50 mg l^{-1} occur. However, the exceedance time for 10 mg l^{-1} is below 24 hours for 99.99 % of the affected area. On the Kriegers Flak subarea, the duration of such events is below half an hour and thus no impact results from this. Sedimentation above the threshold of 3 mm occurs only very near the substation platforms and in a larger "sediment trap" area east of Kriegers Flak that also is a natural sedimentation area. The sedimentation rates (including resuspension) are, however, so low that only a minor disturbance is expected locally and for a very short time leading to a negligible impact on the benthic flora and fauna. Along the cable corridor, sedimentation is only above the threshold within a narrow band in the subarea close to the modelled cable trench and reaches values above 3 mm (and mostly below 40 mm) in 8.2 % of the whole cable corridor subarea. The footprint areas from foundations are very small compared to the overall habitat areas (below 1 %) but since the disturbance is permanent, a minor impact is expected. Also the amount of additional solid substrate is small compared to the existing amount of hard substrate but due to the permanent nature of the solid substrate, a minor impact is expected.

During the **operation phase**, only the added solid substrate in the Kriegers Flak area is relevant as a pressure. On this substrate, stable hard substrate communities will develop and stay. This cannot be regarded a negative impact since it leads to a higher local species diversity. The overall character of Kriegers Flak is not altered because hard bottom communities already occur throughout the area and only 0.1 % of the soft bottom community area is changed into hard bottom. The impact is thus considered minor.

In the **decommissioning phase**, part of the footprint and the solid substrate is removed from Kriegers Flak. The amount is, however, small and the project structure at seafloor level will be left in-situ. Also, the removal of submarine cables will result in minor sediment spill but with a degree of disturbance less than during the construction phase. Accordingly, no significant disturbance is expected.

No impact of the project is expected on the implementation of the Water Framework Directive (WFD) and the Marine Strategy Framework Directive (MSFD). Cumulative impacts are considered from none of the four specifically analysed projects (Femern sand extraction area, Baltic II OWF, Swedish OWF at Kriegers Flak, German Baltic I OWF). Either, they are too far apart from the Kriegers Flak OWF or their impact is not happening at the same time or the same location as the impacts from the Kriegers Flak OWF. Thus, no relevant cumulative impacts have been identified.

2 Introduction

In 2012, the Danish parliament ("Folketinget") passed an agreement to reduce greenhouse gases by 40 % until 2020 and ultimately develop Denmark into a low-carbon society with greenhouse gas emissions reduced to an absolute minimum. On this background, the establishment of a 600 MW offshore wind farm (OWF) at Kriegers Flak is being planned, producing electrical power for about 600,000 households. Energinet.dk must conduct an environmental impact analysis before this offshore wind farm and grid connection can be approved and constructed.

This report documents the aspects of the benthic flora and fauna communities and the benthic habitats in the area where the OWF "Kriegers Flak" shall be established. The existing conditions in the wind farm area Kriegers Flak, the cable corridor including the landfall region are documented together with an assessment of the impacts that are expected on these benthic components when the OWF is constructed, operated and disseminated. Further, cumulative effects are evaluated, and the impact on the implementation of the Water Framework Directive and the Marine Strategy Framework Directive are described.

The existing baseline conditions are described on the basis of geophysical surveys undertaken by Rambøll (2013) and GEO (2014) and by supplementary sampling of the benthic components throughout the project area.

The report is divided into three major parts. The first part (chapters 1 to 4) presents the introduction, documents the part of the technical project description relevant for the benthic components and describes the methods applied in this study. The second part (chapter 5) documents the existing conditions and status (the baseline) of the benthic flora, fauna and habitats in the complete investigation area. The third part (chapters 6 to 13) describes the project pressures and potential impacts, defines the worst case scenarios applied and documents the impact assessment done on the three phases of the project (construction, operation and decommissioning phase) as well as impacts on the WFD and MSFD, cumulative impacts, the zero alternative and mitigation measures. The report ends with a description of knowledge gaps, the used reference literature and data appendices.

3 Technical project description

This chapter outlines the proposed technical aspects encompassed in the offshore-related development of the Kriegers Flak Offshore Wind Farm (OWF). This includes all aspects important towards the environmental impact assessment of benthic flora, fauna and habitats: wind turbines foundations, internal site array cables, transformer station and submarine cable for power export to shore. The text is extracted from the full technical project description (Energinet.dk 2014).

3.1 General description

The planned Kriegers Flak OWF is located approximately 15 km east of the Danish coast in the southern part of the Baltic Sea close to the boundaries of the exclusive offshore economic zones (EEZ) of Sweden, Germany and Denmark (Figure 3-1). It will have a power output of 600 MW. In the neighbouring German territory an OWF Baltic II is currently under construction, while pre-investigations for an OWF have already been carried out at Swedish territory, however further construction is currently on standby.

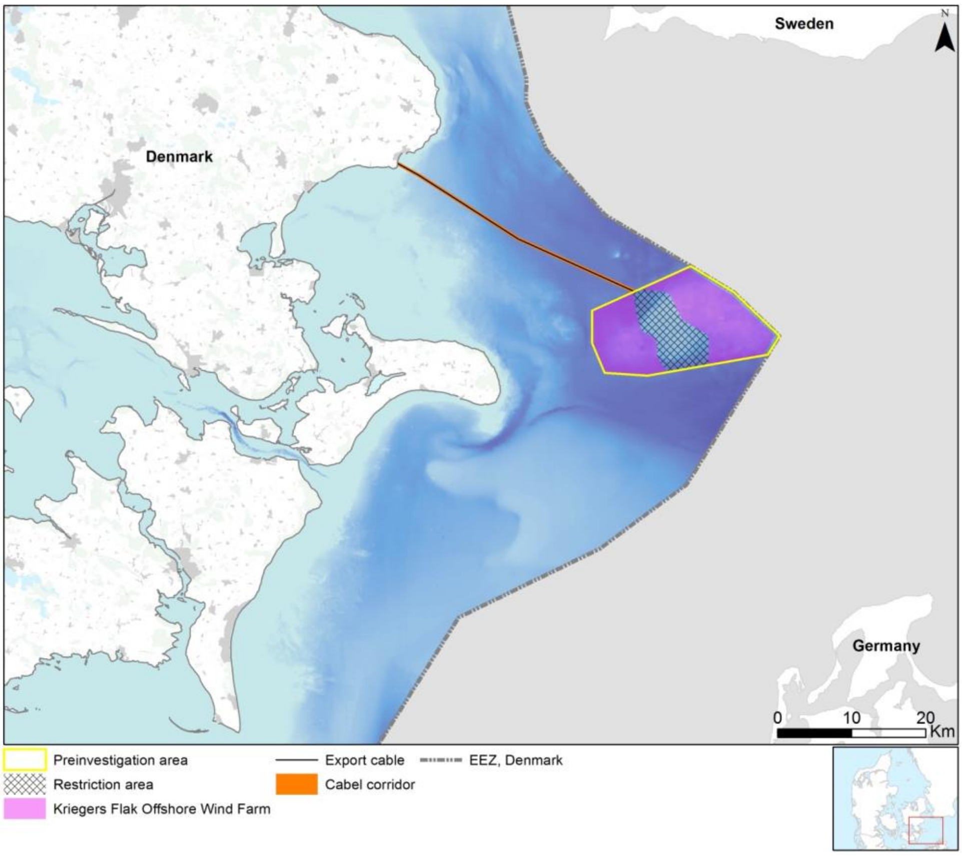


Figure 3-1 **The planned location of Kriegers Flak Offshore Wind Farm (600 MW) in the Danish territory. Approximately in the middle of the pre-investigation area an area (ca. 28 km²) is reserved for sand extraction with no permission for technical OWF components to be installed (hatched area). The cable corridor shown on the figure contains two export cables. The final positions of the cables within the cable corridor have not yet been determined.**

The area delineated as pre-investigation area covers an area of approximately 250 km² and encircles the bathymetric high called “Kriegers Flak” which is a shallow region of approximately 150 km². Central in the pre-investigation area an area reserved for sand extraction with no permission for technical OWF components to be installed. Hence, wind turbines will be separated in an Eastern (110 km²) and Western (69 km²) wind farm (200 MW on the western part, 400 MW on the eastern part). According to the permission given by the Danish Energy Agency (DEA), a 200 MW wind farm is allowed to use up to 44 km². Where the area is adjacent to the EEZ border between Sweden and Denmark, and between Germany and Denmark, a safety zone of 500 m will be established between the wind turbines on the Danish part of Kriegers Flak and the EEZ border.

Two possible layouts of wind turbines are used in this environmental impact study for the Kriegers Flak area: 3 MW turbines or 10 MW turbines. Based on the span of individual turbine capacity (from 3.0 MW to 10.0 MW) the farm will feature from 60 (+4 additional turbines) to 200 (+3 additional turbines) turbines. Extra turbines can be allowed (independent of the capacity of the turbine), in order to secure adequate production even in periods when one or two turbines are out of service due to repair. The exact design and appearance of the wind turbine will depend on the manufactures (Figure 3-2 and Figure 3-3).

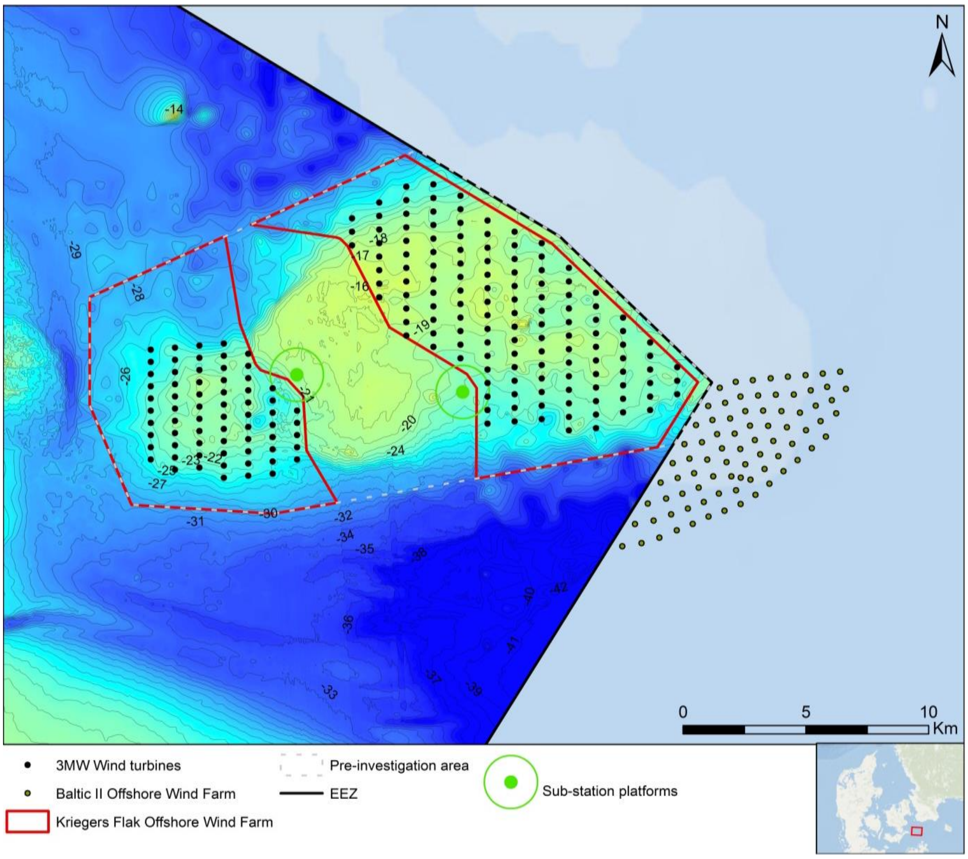


Figure 3-2 Layout of 203 wind turbines on Kriegers Flak using 3 MW turbines only.

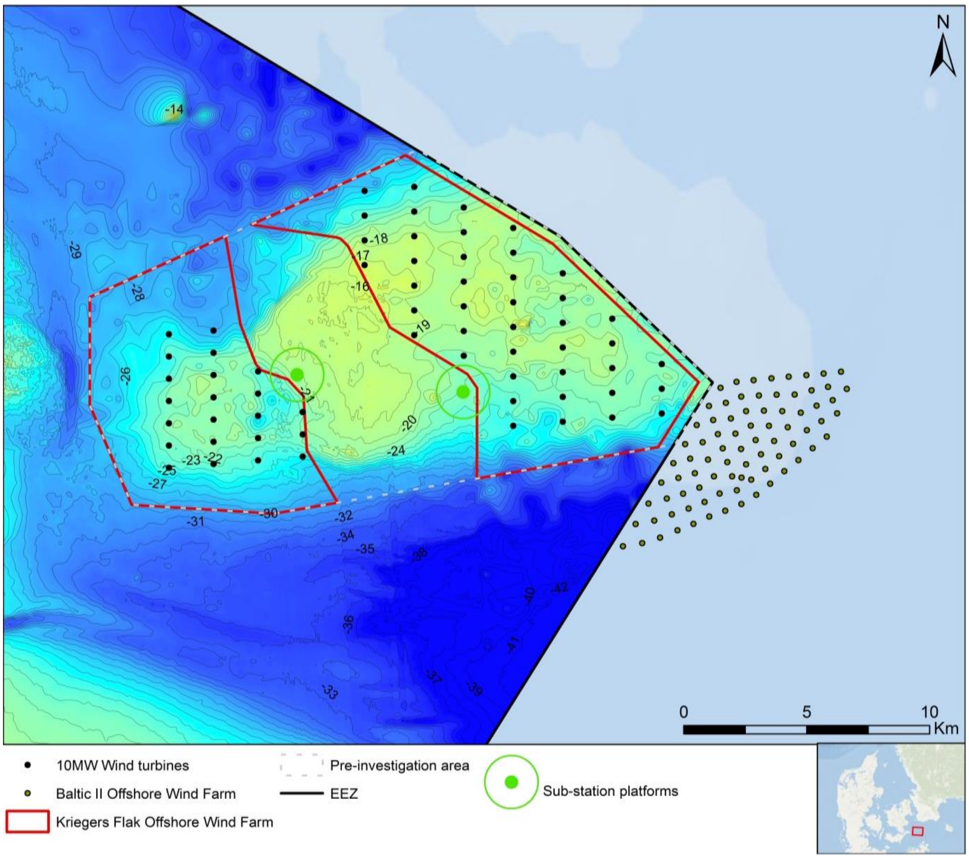


Figure 3-3 Layout of 64 wind turbines on Kriegers Flak using 10 MW turbines only.

3.2 Turbines

The installation of the wind turbines will typically require one or more jack-up barges. These vessels will be placed on the seabed and create a stable lifting platform by lifting themselves out of the water. The total area of each vessel's spud cans is approximately 350 m^2. The legs will penetrate 2–15 m into the seabed depending on seabed properties. These footprints will be left to in-fill naturally.

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

- Driven steel monopile
- Concrete gravity base
- Jacket foundations
- Suction buckets

3.2.1 Driven steel monopile

This solution comprises driving a hollow steel pile into the seabed. Pile driving may be limited by deep layers of coarse gravel or boulders, and in these circumstances the obstruction may be drilled out. A transition piece is installed to make the connection with the wind turbine tower. This transition piece is generally fabricated from steel, and is subsequently attached to the pile head using grout. The grouting material is described in section 3.2.5.3.

3.2.1.1 Dimensions

The dimensions of the monopile will be specific to the particular location at which the monopile is to be installed. The results of some very preliminary monopile and transition piece design for the proposed Kriegers Flak OWF, are presented in Table 3-1 and Figure 3-4.

Table 3-1 Dimensions of monopole and scour protection for driven steel monopiles. The numbers for 10 MW turbines are very rough estimates.

MONOPILE	**3.0MW**	**3.6MW**	**4.0MW**	**8.0MW**	**10.0MW**
*Outer Diameter at and below seabed level	4.5-6.0m	4.5-6.0 m	5.0-7.0 m	6.0-8.0m	7.0-10.0m
Ground Penetration (below mud line)	25-32m	25-32m	26-33m	28-35m	30-40m
Total pile weight (203/170/154/79/64 monopiles)	60,900-142,100 t	51,000-136,000 t	61,600-138,600 t	55,300-79,000 t	57,600-89,600 t
Scour Protection	**3.0MW**	**3.6MW**	**4.0MW**	**8.0MW**	**10.0MW**
Foot print area (per foundation)	1,500m^2	1,500m^2	1,575m^2	1,650m^2	2,000m^2
Total foot print scour area (203/170/154/79/64 monopiles)	304,500 m^2	255,000 m^2	242,550 m^2	130,350 m^2	128,000 m^2

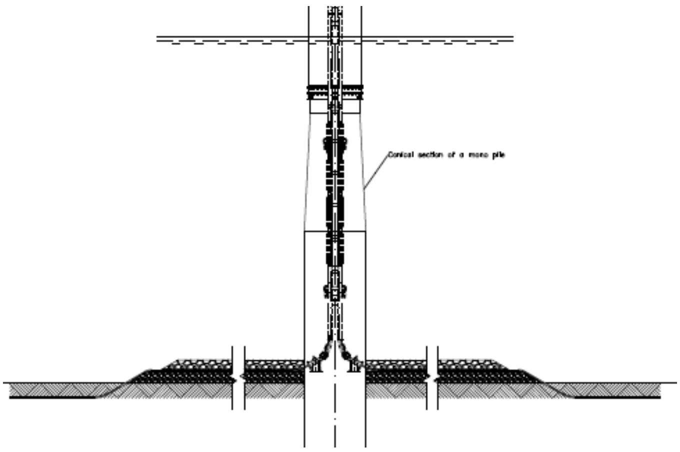


Figure 3-4 Schematic illustration of a driven steel monopile.

3.2.1.2 Installation

Seabed preparation

The monopile concept is not expected to require much preparation works, but some removal of seabed obstructions may be necessary. Scour protection filter layer may be installed prior to pile driving, and after installation of the pile a second layer of scour protection may be installed (armour layer). Scour protection of nearby cables may also be necessary.

Installation sequence

The installation of the driven monopile will take place from either a jack-up platform or floating vessel, equipped with 1–2 mounted marine cranes, a piling frame, and pile tilting equipment. In addition, a small drilling spread, may be adopted if driving difficulties are experienced. A support jack-up barge, support barge, tug, safety vessel and personnel transfer vessel may also be required.

Driving time and frequency

The expected time for driving each pile is between 4 and 6 hours. Installation of one pile and grouting of the transition piece will take 1-2 days.

3.2.2 Concrete gravity base

Normally the seabed preparations are needed prior to installation, i.e. the top layer of material upon the seafloor is removed and replaced by a stone bed. When the foundation is placed on the seabed, the foundation base is filled with a suitable ballast material, and a steel "skirt" may be installed around the base to penetrate into the seabed and to constrain the seabed underneath the base.

The gravity based foundation structure is placed in an excavation on a layer of gravel stones for primary secure a horizontal level. The required depth of the excavation is a result of the foundation design. After placing the foundation, scour protection is installed around the foundation slab and up to seabed level. In the design phase it will be determined if a part of the existing seabed also needs to be protected for preventing scour.

The extent of excavation at foundation level might be out to 2 m from the edge of the foundation structure and from here a natural slope up to existing seabed level. A scour protection design for a gravity based foundation structure is shown in Figure 3-5. The quantities to be used will be determined in the design phase. The design can also be adopted for the bucket foundation. Upon finalization of the installation, the substation will turn into operation. In the case that scour holes develop over time around the substation structure, additional scour protection may be placed.

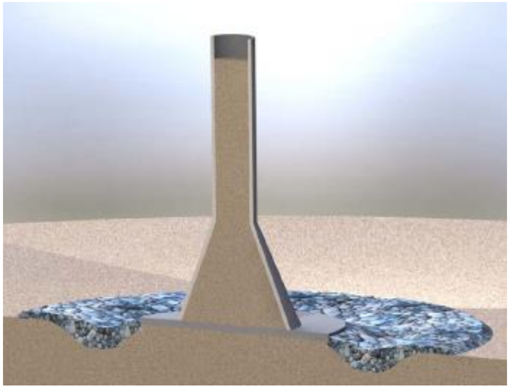


Figure 3-5 Example on scour protection for a concrete gravity base (drawing: Rambøll).

3.2.2.1 Ballast

The ballast material is typically sand, which is likely to be obtained from an offshore source. An alternative to sand could be heavy ballast material (minerals) like Olivine, Norit (non- toxic materials). Heavy ballast material has a higher weight (density) that natural sand and thus a reduction in foundation size could be selected since this may be an advantage for the project. Installation of ballast material can be conducted by pumping or by the use of excavators, conveyers etc. into the ballast chambers/shaft/conical section(s). The ballast material is most often transported to the site by a barge.

3.2.2.2 Dimensions

The results of the preliminary gravity base design for the proposed Kriegers Flak OWF are shown in Table 3-2.

Table 3-2 Estimated dimensions for concrete gravity bases. The numbers for 10 MW bases are very rough quantity estimates (depending on loads and actual geometry/layout of the concrete gravity foundation).

GRAVITY BASE	3.0MW	3.6MW	4.0MW	8.0MW	10.0MW*
Shaft Diameter	3.5-5.0m	3.5-5.0m	4.0-5.0m	5.0-6.0 m	6.0-7.0m
Width of Base	18-23m	20-25m	22-28m	25-35 m	30-40m
Concrete weight per unit	1,300-1,800t	1,500-2,000t	1,800-2,200t	2,500-3,000t	3,000-4,000t
Total concrete weight (t)	263,000-364,000t	254,000-338,000t	274,000-335,000t	193,000-230,000t	186,000-248,000t
Ballast	**3.0MW**	**3.6MW**	**4.0MW**	**8.0MW**	**10.0MW***
Type	Infill sand	Infill sands	Infill sands	Infill sands	Infill sands
Mass per unit (m^3)	1,300-1,800 m^3	1,500-2,000m^3	1,800-2,200m^3	2,000-2,500m^3	2,300-2,800m^3
Total volume (m^3) (203/170/154/79/64 turbines)	263,900-365,400 m^3	255,000-340,000 m^3	277,200-338,800 m^3	158,000-197,500 m^3	147,720-179,200 m^3

3.2.2.3 Seabed preparation

The seabed will require preparation prior to the installation of the concrete gravity base. This is expected to be performed as described in the following sequence, depending on ground conditions:

- The top surface of the seabed is removed to a level where undisturbed soil is encountered, using a back-hoe excavator aboard a barge, with the material loaded aboard split-hopper barges for disposal
- Gravel is deposited into the hole to form a firm level base

The quantities for the seabed preparation depend on the ground conditions. Below is given the quantities for an average excavation depth of 2 m, however large variations are foreseen, as soft ground is expected in various parts of the area. Finally the gravity structure (and maybe nearby placed cables) will be protected against development of scour holes by installation of a filter layer and armour stones.

Table 3-3 Quantities of excavation material for concrete gravity bases. The "total material excavated" is given for excavation depths of further 4 to 8m at 20 % of the turbine locations where the total excavated material would be increasing by around 100%. The numbers for 10 MW turbines are very rough quantity estimates.

	3.0MW	3.6MW	4.0MW	8.0MW	10.0MW**
Size of excavation (approx.)	23-28m	23-30m	27-33m	30-40m	35-45m
Material Excavation (per base)	900-1300m³	1,000-1,500m³	1,200-1,800m³	1,500-2,500m³	2,000-3,200m³
Total Material Excavated (203/170/154/79/64 turbines)*	182,700-263,900m³	170,000-255,000m³	184,800-277,200m³	118,500-197,500m³	128,000-204,800m³
Stone Replaced into Excavation (per base) – stone bed	90-180m³	100-200m³	130-230m³	200-300m³	240-400m³
Total Stone Replaced (202/169/152/77/62 turbines)	18,500-37,000m³	17,000-35,000m³	20,000-35,000m³	15,500-23,000m³	15,000-25,000m³
Scour protection (per base)	600-800m³	700-1,000m³	800-1,100m³	1,000-1,300m³	1,100-1,400m³
Foot print area (per base)	800-1,100m²	900-1,200m²	1,000-1,400m²	1,200-1,900m²	1,500-2,300m²
Total scour protection (203/170/154/79/64 turbines)	121,800-162,400m³	119,000-170,000m³	123,200-169,400m³	79,000-102,700m³	70,400-89,600m³
Total foot print area (203/170/154/79/64 turbines)	160-223,300m²	153,000-204,000m²	154,000-215,600m²	94,800-150,100m²	96,000-147,200m²

The approximate duration of each excavation of average 2 m is expected to be 3 days, with a further 3 days for placement of stone. The excavation can be done by a dredger or by an excavator placed on barge or other floating vessels.

3.2.2.4 Installation sequence

The installation of the concrete gravity base will likely take place using a floating crane barge, with attendant tugs and support craft. The bases will either be floated and towed to site or transported to site on a flat-top barge or a semi-submergible barge. The bases will then be lowered from the barge onto the prepared stone bed and filled with ballast.

3.2.2.5 Physical discharges of water

There is likely to be some discharge to the seawater from the material excavation process. A conservative estimate is 5 % material spill, i.e. up to 200 m³ for each base, over a period of 3 days per excavation.

3.2.3 Jacket foundations

A jacket foundation structure is basically a three or four-legged steel lattice construction with a shape of a square tower. The jacket structure is supported by piles in each corner of the foundation construction.

On top of the jacket, a transition piece constructed in steel and mounted on a platform. The transition piece connects the jacket to the wind turbine generator. The platform itself is assumed to have a dimension of approximately 10 x 10 meters and the bottom of the jacket between 20 x 20 meters and 30 x 30 meters between the legs.

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

- Piling inside the legs
- Piling through pile sleeves attached to the legs at the bottom of the foundation structure
- Pre-piling by use of a pile template

The jacket legs are then attached to the piles by grouting with well-known and well-defined grouting material used in the offshore industry. One pile will be used per jacket leg.

For installation purposes the jacket may be mounted with mudmats at the bottom of each leg. Mudmats ensure bottom stability during piling installation. Mudmats are large structures normally made out of steel and are used to temporary prevent offshore platforms like jackets from sinking into soft soils in the seabed. The functional life span of these mudmats is limited, as they are essentially redundant after installation of the foundation piles. The size of the mudmats depends on the weight of the jacket, the soil load bearing and the environmental conditions. As mudmats are steel structures it is expected that the effect on the environment will be the same as jackets and piles. Mudmats are not considered to be of environmental concern.

Scour protection at the foundation piles and cables may be applied depending on the soil conditions. In sandy soils scour protection is necessary for preventing the construction from bearing failure. Scour protection consists of natural well-graded stones or blasted rock.

3.2.3.1 Dimensions

The dimensions of the jacket foundation will be specific to the particular location at which the foundation is to be installed (see Table 3-4).

Table 3-4 Dimensions of jacket foundations. Numbers for 10 MW turbines are very rough estimates of quantities.

Jacket	3.0MW	3.6MW	4.0MW	8.0MW	10.0MW*
Distance between legs at seabed	18 x 18m	20 x 20m	22 x 22m	30 x 30m	40 x 40m
Pile Length	40 - 50m	40 - 50m	40 - 50m	50-60m	60-70m
Diameter of pile	1,200 - 1,500mm	1,200 - 1,500mm	1,300 - 1,600mm	1,400 - 1,700mm	1500 - 1800mm
Scour protection volume (per foundation)	800m^3	1,000m^3	1,200m^3	1,800m^3	2,500m^3
Foot print area (per foundation)	700m^2	800m^2	900m^2	1,300m^2	1,600m^2
Total scour protection (203/170/154/79/64 turbines)	162,400m^3	170,000m^3	184,800m^3	142,200m^3	160,000m^3
Total foot print area in m^2 (203/170/154/79/64 turbines)	142,100m^2	136,000m^2	138,600m^2	102,700m^2	102,400m^2

3.2.3.2 Installation

Depending of the seabed pre-dredging maybe considered necessary due to very soft soil and/or due to sand dunes. In case of an area with sand dunes dredging to stable seabed may be required. Dredging can be done by trailing suction hoper dredger or from an excavator placed on a stable plat form (a jack-up) or from a floating vessel with an excavator on board. The dredged material can be transported away from the actual offshore site by a vessel or barge for deposit. Minor sediment spill may be expected during these operations.

Normally a jack-up rig will be tugged to the site for doing the piling. The jack-up also places mudmats/pile template as appropriate.

3.2.4 Suction Buckets

The bucket foundation combines the main aspects of a gravity base foundation, a monopile and a suction bucket.

3.2.4.1 Dimensions

As the concept can be considered as a mix of a gravity based structure and a monopile, it is assumed that the impact will be less than the impact from a gravity base structure. The plate diameter from the gravity based structure will be used as foundation area. It is further anticipated that the maximum height of the bucket including the lid will be less than 1 m above seabed. For this project the diameter of the bucket is expected to be the same as for the gravity based foundation structures.

3.2.4.2 Installation

The foundations can be tugged in floated position directly to its position by two tugs where it is upended by a crane positioned on a jack-up. The concept can also be installed on the jack-up directly at the harbour site and transported by the jack-up supported by tugs to the position. Installation of the bucket foundation does not require seabed preparations and divers.

Additionally, there are reduced or no need for scour protecting depending on the particular case.

3.2.5 Offshore foundation ancillary features

3.2.5.1 Corrosion protection

Corrosion protection on the steel structure will be achieved by a combination of a protective paint coating and installation of sacrificial anodes on the subsea structure.

The anodes are standard products for offshore structures and are welded onto the steel structures. Anodes will also be implemented in the gravity based foundation design. The number and size of anodes would be determined during detailed design.

The protective paint should be of Class C5M or better according to ISO 12944. Some products in Class C5M, contain epoxy and isocyanates which is on the list of unwanted substances in Denmark. Further it can be necessary to use metal spray (for metallization) on exterior such as platforms or boat landings. The metal spray depending on product can be very toxic to aquatic organisms. It is recommended, that the use of protective paint and metal spray is assessed in relation to the usage and volume in order to evaluate if the substances will be of concern to the environment.

3.2.5.2 Scour protection

The decision on whether to install scour protection, in the form of rock, gravel or frond mats, will be made during a detailed design.

Where the seabed consists of erodible sediments there will be a risk for the development of scour holes around the foundation structure(s) due to impact from waves and current. Development of scour holes can cause an impact to the foundation structures stability. To prevent serious damages the seabed can be secured and stabilized by installation of scour protection (stones, mats, sand backs etc.).

The design of the scour protection depends upon the type of foundation design and seabed conditions.

If scour protection is required the protection system normally adopted consists of rock placement. The rocks will be graded and loaded onto a suitable rock-dumping vessel at a port and deployed from the host vessel either directly onto the seabed from the barge, via a bucket grab or via a telescopic tube.

Monopile solution

The scour protection consists of a two-layer system comprising a filter layer and an armour layer. Depending on the hydrodynamic environment the horizontal extent of the armour layer can be between 10 and 15 meter having thicknesses between 1 and 1.5 m. Filter layers are usually of 0.8 m thickness and reach up to 2.5 m further than the armour layer. Expected stone sizes range between d_{50} = 0.30 m to d_{50} = 0.5 m. The total diameter of the scour protection is assumed to be 5 times the pile diameter.

Gravity base solution

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

Jacket solution

The scour protection may consist of a two-layer system comprising filter stones and armour stones. Nearby cables may also be protected with filter and armour stones. The effect of scour may also be a part of the foundation design so scour protection can be neglected.

Bucket Foundation

Scour protection may be necessary depending on the soil properties at the installation location. The envisaged design for scour protection may include a ring of rocks around the structure. During detailed foundation design scour protection may not be needed.

Alternative Scour Protection Measures

Alternative scour protection systems such as the use of mats may be introduced by the contractor. The mats are attached in continuous rows with a standard frond height of 1.25 m. The installation of mats will require the use of standard lifting equipment.

Another alternative scour protection system is the use of sand filled geotextile bags around the foundations. This system planned to be installed at the Amrumbank West OWF during 2013, where some 50,000 t of sand filled bags will be used around the 80 foundations. Each bag will contain around 1.25 t of sand. If this scour protection system is to be used at Kriegers Flak, it will add up to around 47,000 to 125,000 t sand in geotextile bags for the 60–200 turbine foundations.

3.2.5.3 Grouting

Grout material is used for structural grouted connections in wind turbine foundations (e.g. to connect the foundation of a monopile to the actual monopile of the turbine). Grout material is similar to cement and according to CLP cement is classified as a danger substances to humans (H315/318/335). Cement is however not expected to cause effect on the environment. The core of grout material (example Ducorit®) is the binder. The binder are mixed with quartz sand or bauxite in order to obtain the strength and stiffness of the product. The use of grout material (here Ducorit®) does not require special precautions with respect to environmental or personal hazards. Grout is not considered as an environmental problem.

3.3 Offshore substation at Kriegers Flak

For the grid connection of the 600 MW offshore wind turbines on Kriegers Flak, two HVAC platforms will be installed, one (200 MW) on the western part of Kriegers Flak and one (400 MW) on the eastern part of Kriegers Flak. The planned locations of the platforms are shown on Figure 3-2 and Figure 3-3. The HVAC platforms are expected to have a length of 35–40 m, a width of 25–30 m and height of 15–20 m. The highest point is of a HVAC platform is expected to be 30–35 m above sea level. The array cables from the wind turbines will be routed through

J-tubes onto the HVAC platforms, where they are connected to a Medium Voltage (MV) switch gear (33 kV) which also is connected to High Voltage (HV) transformers.

A 220 kV export cable will run between the two HVAC sub-station platforms.

The Kriegers Flak platforms will be placed on locations with a sea depth of 20-25 metres and approximately 25-30 km east of the shore of the island of Møn.

3.3.1 Foundations for substation platforms

The foundation for the HVAC platforms will be either a jacket foundation consisting of four-legged steel structure or a gravity based structure (hybrid foundation) consisting of a concrete caisson with a four-legged steel structure on the top of the caisson.

The foundation will have J-tubes for both array cables with diameter of 300-400 mm and export cables where the steel tubing may have a diameter up to 700-800 mm.

3.3.1.1 Jacket foundation

For installation purposes the jacket will be mounted with mud mats at the bottom of each leg. Mud mats ensure bottom stability during piling installation to temporary prevent the jacket from sinking into soft soils in the seabed. The functional life span of these mud mats is limited, as they are essentially redundant after installation of the foundation piles. The size of the mud mats depends on the weight of the jacket, the soil load bearing and the environmental conditions.

Figure 3-6 Substation installed with a jacket foundation.

The dimensions of the platform jacket foundations will be specific to the location at which the foundation is to be installed (see Table 3-5).

Table 3-5 Dimensions of substation installed with jacket foundations.

Jacket	HVAC platform
Distance between corner legs at seabed	20 x 23m
Distance between legs at platform interface	20 x 23m
Height of jacket	depth of the sea plus 13m
Pile length	35-40m
Diameter of pile	1,700-1,900mm
Weight of jacket	1,800-2,100t
Scour protection area	600-1,000m^2

Installation

The installation of a platform with jacket foundation will be one campaign with a large crane vessel with a lifting capacity of minimum 2000 tonnes. The time needed for the installation of jacket plus topside will be 4-6 days with activities on-going day and night.

In case of an area with sand dunes dredging to stable seabed may be required. Minor sediment spill (a conservative estimate is 5 %) may be expected during these operations.

3.3.1.2 Gravity based structure (Hybrid or GBS)

The Gravity Based Structure is constructed as one or two caissons with an appropriate number of ballast chambers.

Two different designs can be predicted for the Kriegers Flak project:

- Hybrid foundation. One self-floating concrete caisson with a steel structure on tope, supporting the topside.
- (GBS) Steel foundation with two caissons integrated into the overall substation design.

The gravity based foundation will be placed on a stone bed prepared prior to the platform installation, i.e. the top layer of sea bed material is removed and replaced by a layer of crushed stones or gravel. After the gravity based foundation is placed on the store bed a layer of stones will be placed around the caisson as scour protection. The cables going to the platform may also be protected against scour (see Figure 3-7).

Figure 3-7 Substation installed with a hybrid foundation.

The dimensions of the hybrid foundations will be specific to the location at which the foundation is to be installed.

Table 3-6 Dimensions of substation installed with hybrid foundation.

Hybrid foundation	HVAC platform
Caisson length x width	21 x 24m
Caisson height	15-16m
Caisson weight	3,300-3,600t
Distance between corner legs of steel structure	20 x 23m
Location of interface caisson/steel structure	3-5 m below sea level
Height of steel structure	16-18m
Diameter of structure legs	1,700-1,900mm
Weight of steel structure	600-800t
Ballast volume	1,600-1,800m3
Total weight of foundation incl. ballast	9,000-10,000t
Scour protection area	600-1,200m2

Installation

The installation of a platform with jacket foundation will be one campaign with a large crane vessel with a lifting capacity of minimum 2000 tonnes. The time needed for the installation of jacket plus topside will be 4–6 days with activities ongoing day and night.

In case of an area with sand dunes dredging to stable seabed may be required. Minor sediment spill (a conservative estimate is 5 %) may be expected during these operations.

The seabed preparation will start with removal by an excavator aboard a vessel or by a dredger of the top surface of the seabed to a level where undisturbed soil is encountered. The excavated material is loaded aboard a split-hopper barge for disposal at appointed disposal area.

After the top soil has been removed crushed stones or gravel is deposited into the excavated area to form a firm level base. In Table 3-7 the quantities for an average excavation depth of 2 m. Finally the foundation is protected against development of scour holes by installation of filter and armour stones.

Table 3-7 Quantities used to install a gravity based structure for the HVAC substation.

	HVAC platform
Size of Excavation (approx.)	30 x 40m
Material Excavation	2,400m³
Stone Replaced into Excavation (approx.)	2,000m³
Scour protection	1,800-3,000m³

When the seabed preparation has finished the hybrid foundation or the Gravity Based Substation will be tugged from the yard and immersed onto the prepared seabed. This operation is expected to take 18-24 hours. When the hybrid foundation is in place it will be ballasted by sand, the ballasting process is expected to take 8-12 days.

3.4 Submarine cables

3.4.1 Inter-array cables

A medium voltage inter-array cable will be connected to each of the wind turbines and for each row of 8-10 wind turbines a medium voltage cable is connected to the offshore substation platform.

Inter-array cables will be installed at the HVAC platform in J-tubes which lead the cables to the platforms where the medium voltage cables will be connected to the high voltage part of the platform.

The length of the individual cables between the wind turbines depend on the size of the turbines or the configuration of the site. It is expected that the larger turbine/rotor diameter the larger the distance is between the wind turbines.

3.4.1.1 Installation of inter-array cables

The inter array cables are transported to the site after cable loading in the load-out harbour. The cables will be placed on turn-tables on the cable vessel/barge (flat top pontoon or anchor barge). The vessel is assisted by tugs or can be self-propelling.

The installation of the array cables are divided into the following main operations:

- Installation between the turbines
- Pull in – substation platform
- Pull in – wind turbines

Depending on the seabed condition the cable will be jetted or rock covered for protection. Jetting is done by a ROV (Remote Operate Vessel) placed over the cable. As the jetting is conducted the ROV moves forwards and the cable falls down in the bottom of the trench.

The array cables will be buried to provide protection from fishing activity, dragging of anchors etc.

A burial depth of approximately one metre is expected. The final depth of burial will be determined at a later date and may vary depending on a more detailed soil condition survey and the equipment selected.

The submarine cables are likely to be buried using a combination of two techniques:

1. Pre-trenching the cable route using a suitable excavator.
2. Post lay jetting by either Remote Operated Vehicle (ROV) or manual trencher that utilises high-pressure water jets to fluidise a narrow trench into which the cable is located.

After the cables are installed, the sediments will naturally settle back into the trench assisted by water currents.

3.4.2 Export cables

Two 220 kV export submarine cables will be installed from the offshore transformer stations to the landfall at Rødvig. In addition to the two export cables to shore, a 220 kV submarine cable will be installed between the platforms. The total length of the export cables will be approx. 100 km.

The export cables from the platforms to the landing at Rødvig will on the main part of the route be aligned in parallel with a distance of approximately 100–300 m. Close to the shore (approx. the last 500 m), the distance between the cables will be approx. 30–50 m.

3.4.2.1 Cable installation

The Kriegers Flak area where the cables are to be installed is partly consisting of soft (sand) and hard (clay and chalk) sediments.

It is expected that the export cables are installed in one length on the seabed and after trenching the cable is protected to the depth of one meter.

To prevent the cables from getting exposed as a result of sediment mitigation in near shore zone, the protection of the cables are done via an HDD (Horizontal Directional Drilling). The exact type of installation will be based on the actual conditions.

The jetting will be conducted in one operation and independent of the operation were the cables are laid on the seabed. It is expected that the route can be planned around possible big boulders. If boulders are to be moved they will be placed just outside the cable route, but inside the area of the geophysical survey.

It is expected that a significant amount of hard soil conditions are present along the trace – up to 50 %. Here the pre-excavated trench will have a depth of approx. 1–2 metres with a width of approx. 0.7–1.5 metres.

The excavation may be conducted by an excavator placed upon a vessel or a barge or by cutting or by ploughing. The soil will be deposited near the trench. The pre-trenching is aimed to be conducted one year prior to the cable installation.

After trenching, the export cable will be installed by a cable laying vessel or barge, self-propelled or operated by anchors or tugs. It may then be necessary to clear up the trench just before the cable is installed, still, after installation the cable will often have to be jetted down in the sediments that have been deposited in the period after trenching or clearing. The trench will thereafter be covered with the deposited material from the trenching operation.

During jetting very fine-grained seabed material will tend to get washed away and have an impact on the degree of volume back filling. A re-filling may be applied as appropriate with natural seabed friction materials. Basically the jetting will be conducted in one continuing process. Hence, there can be areas where the jetting may be conducted more than one time due to the soil conditions. On Kriegers Flak project it is estimated that the jetting will last for approximately 3–4 months excluding weather stand-by.

It shall be noted that the jetting also can be conducted by hand/diver in case of special conditions (environmental etc.). The depth of the jetting can here be lowered to a range of below 1 metre coverage, exact coverage is subject to the specific situation and the surrounding seabed conditions.

3.5 Wind farm decommissioning

The lifetime of the wind farm is expected to be around 25 years. It is expected that two years in advance of the expiry of the production time the developer shall submit a decommissioning plan. The method for decommissioning will follow best practice and the legislation at that time.

It is unknown at this stage how the wind farm may be decommissioned; this will have to be agreed with the competent authorities before the work is being initiated.

The following sections provide a description of the current intentions with respect to decommissioning, with the intention to review the statements over time as industry practices and regulatory controls evolve.

3.5.1 Extent of decommissioning

The objectives of the decommissioning process are to minimize both the short and long term effects on the environment whilst making the sea safe for others to navigate. Based on current available technology, it is anticipated that the following level of decommissioning on the wind farm will be performed:

1. Wind turbines – to be removed completely.
2. Structures and substructures – to be removed to the natural seabed level or to be partly left in situ.
3. Array and export cables– to be removed completely.

4. Cable shore landing – to be removed.
5. Scour protection – to be left in situ.

3.5.2 Decommissioning of wind turbines

The wind turbines would be dismantled using similar craft and methods as deployed during the construction phase. However the operations would be carried out in reverse order.

3.5.3 Decommissioning of offshore substation platform

The decommissioning of the offshore substation platforms is anticipated in the following sequence:

1. Disconnection of the wind turbines and associated hardware.
2. Removal of all fluids, substances on the platform, including oils, lubricants and gasses.
3. Removal of the substation from the foundation using a single lift and featuring a similar vessel to that used for construction.

The foundation would be decommissioned according to the agreed method for that option.

3.5.4 Decommissioning of buried cables

Should cables be required to be decommissioned, the cable recovery process would essentially be the reverse of a cable laying operation, with the cable handling equipment working in reverse gear and the cable either being coiled into tanks on the vessel or guillotined into sections approximately 1.5 m long immediately as it is recovered. These short sections of cable would be then stored in skips or open containers on board the vessel for later disposal through appropriate routes for material reuse, recycle or disposal.

3.5.5 Decommissioning of foundations

Foundations may potentially be reused for repowering of the wind farm. More likely the foundations may be decommissioned through partial of complete removal. For monopiles it is unlikely that the foundations will be removed completely, it may be that the monopile may be removed to the level of the natural seabed. For gravity foundations it may be that these can be left in situ. At the stage of decommissioning natural reef structures may have evolved around the structures and the environmental impact of removal therefore may be larger than leaving the foundations in place. The reuse or removal of foundations will be agreed with the regulators at the time of decommissioning. The suction bucket can fully be removed by adding pressure inside the bucket.

3.5.6 Decommissioning of scour protection

The scour protection will most likely be left in situ and not be removed as part of the decommissioning. It will not be possible to remove all scour protection as major parts of the material are expected to have sunk into the seabed. Also it is expected that the scour protection will function as a natural stony reef. The removal of this stony reef is expected to be more damaging to the environment in the area than if left in situ. It is therefore considered most likely that the regulators at the time of decommissioning will require the scour protection left in situ.

4 Methods and material

4.1 Definitions

Construction activity: All activities connected to the construction of the OWF.

Construction phase: The time period when the project is installed including permanent and provisional structures. The construction phase ends when all project structures are in place and the operation phase begins.

Decommissioning phase: The time after the operation phase ends and in which the project structures are removed from the marine environment.

Environmental factor: The environmental factors are defined in the EU EIA Directive (EU 1985) and comprise: human beings, fauna and flora, soil, water, air, climate, landscape, material assets and cultural heritage.

Footprint: The area of the seafloor that is either temporarily or permanently occupied by the project structure (e.g. piles, fundaments, rocks, scour protections).

Importance: The importance is defined as the functional value of the environmental factor.

Key species: Species or taxa groups playing a critical role in maintaining the structure of a community. In this report the term key species refers to habitat forming epibenthic species or taxa groups.

Macrophytes: The sum of benthic algae and angiosperms

Magnitude of pressure: The magnitude of pressure is described by the intensity, duration and range of the pressure.

Operation phase: The period from end of construction phase until the decommissioning phase.

Project: This term refers to the whole process of planning, installing and operating the Kriegers Flak Offshore Wind Farm (OWF).

Project pressure: All influences deriving from the project due to construction activities (see there). The same construction activity may cause several different pressures (e.g. dredging activity, leading to increase in both suspended sediments and sedimentation). The pressures are classified according to their relation to the different project phases: construction, operation or decommissioning phase or as being structure-related.

Project structure: All physical parts of the project placed in the marine environment during the construction phase and staying in the area over the complete operation phase (e.g. wind turbines with their fundaments, cables, transformer stations).

4.2 Investigation area

The area of investigation is defined by the requirements set by the objectives of the baseline and EIA study, i.e. it must ensure that it is possible to

a) determine the basic characteristics of benthic flora, fauna and habitats in the subareas

- Kriegers Flak (250.024902 km^2)
- Cable corridor including landfall at Rødvig (27.434726 km^2)

b) determine and fully describe impacts of the chosen EIA scenario

The extent of the investigation area has been defined based on existing knowledge on local conditions and impacts from physical structures and the anticipated sediment spill area. The investigation area and its specific geographical subareas are shown in Figure 4-1.

The cable corridor crosses the southern edge of the Natura 2000 site DK00VA305 “Stevns Rev”.

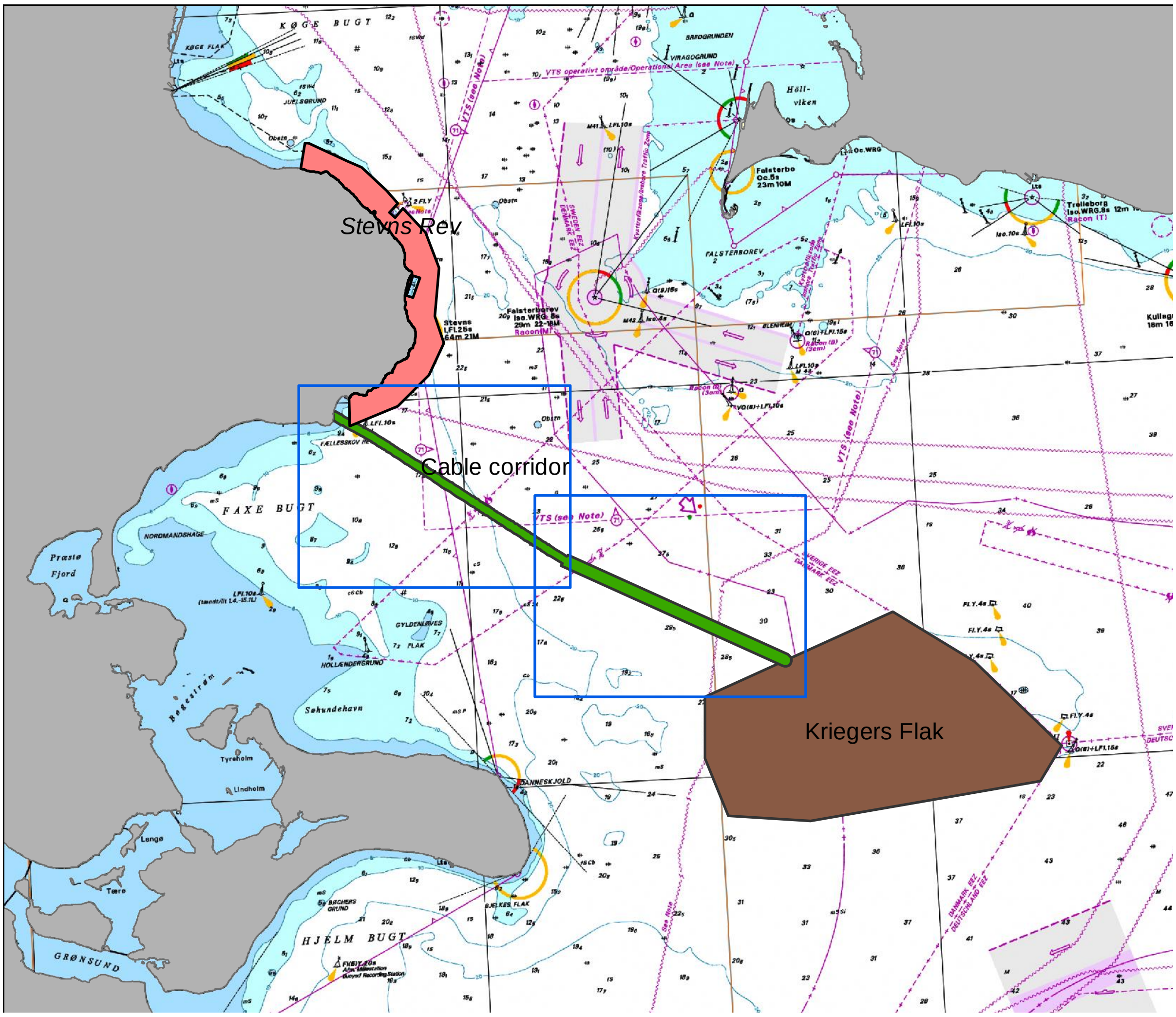


Figure 4-1 **Outline of the investigation area, including the OWF subarea (Kriegers Flak; brown) and the cable corridor subarea (green). The Natura 2000 site “Stevns Rev” (red) is crossed by the cable corridor. The two blue rectangles show the western (at the shoreline) and the eastern (at the OWF) parts of the cable corridor as used in the following figures.**

4.3 Field programme and survey methods

The baseline field study was performed in 2013 for the OWF area (Figure 4-2) and the eastern part of the cable corridor (Figure 4-4). Sampling was carried out between 3rd May and 5nd May 2013. For the western part of the cable corridor (Figure 4-3), sampling was done between 11th and 12th October 2014 (benthic fauna and video) and 20th November 2014 (diving and shallow water macrophyte sampling). The field programme varied between the different subareas of the investigation area and consisted of the following investigations:

a) Kriegers Flak

- video recording: spatial distribution and cover of substrate, total vegetation and key species (e.g. *Zostera, Mytilus*) along six transects
- grab sampling: species composition (flora and fauna), abundance and biomass (fauna), shell length (only blue mussels) with video still images and grab content images at 15 stations
- abiotic measurements: temperature, salinity and oxygen concentration in surface and bottom layer at three stations

b) Cable corridor

- video recording: spatial distribution and cover of substrate, total vegetation and key species (e.g. *Zostera, Mytilus*) along eleven transects
- grab sampling: species composition (flora and fauna), abundance and biomass (fauna), shell length (only blue mussels) with video still images and grab content images at 14 stations
- diver mapping: cover of substrate, total vegetation and key species (e.g. *Zostera, Mytilus*) as well as species composition of phytobenthos and photos of habitat characteristics at eight nearshore stations
- abiotic measurements: temperature, salinity and oxygen concentration in surface and bottom layer at six stations

Table 4-1 gives an overview of the field programme. The methods used are described in the following chapters. Figure 4-2 to Figure 4-5 show the distribution of transects and stations per subarea.

Table 4-1 Overview of the sampling programme in the different geographical subareas of the investigation area

Geographical subarea	Sampling program			
	Video transects	**Grab stations**	**Diving stations**	**Abiotic stations**
Kriegers Flak	6	15	0	3
Cable corridor	11	14	8	6
Variables measured	Spatial distribution and cover of sediment, total vegetation and key species (e.g. *Zostera, Mytilus*)	Species composition, abundance, biomass, length measurements (only bivalves), video still images	Cover of substrate, total vegetation, key species and species composition of phytobenthos, photos of habitats	Temperature, salinity and oxygen concentration of surface and bottom layer

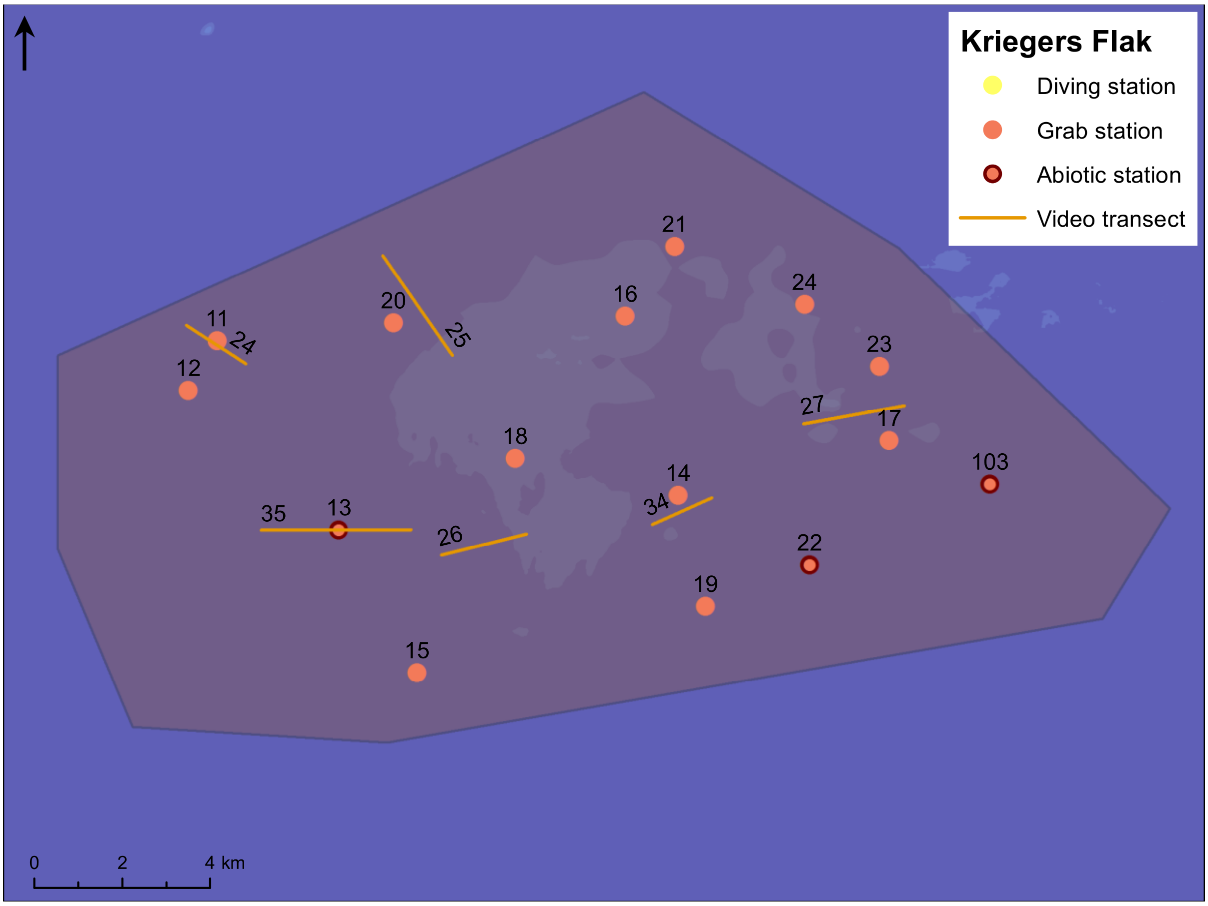


Figure 4-2 Sampling programme at the Kriegers Flak subarea in 2013.

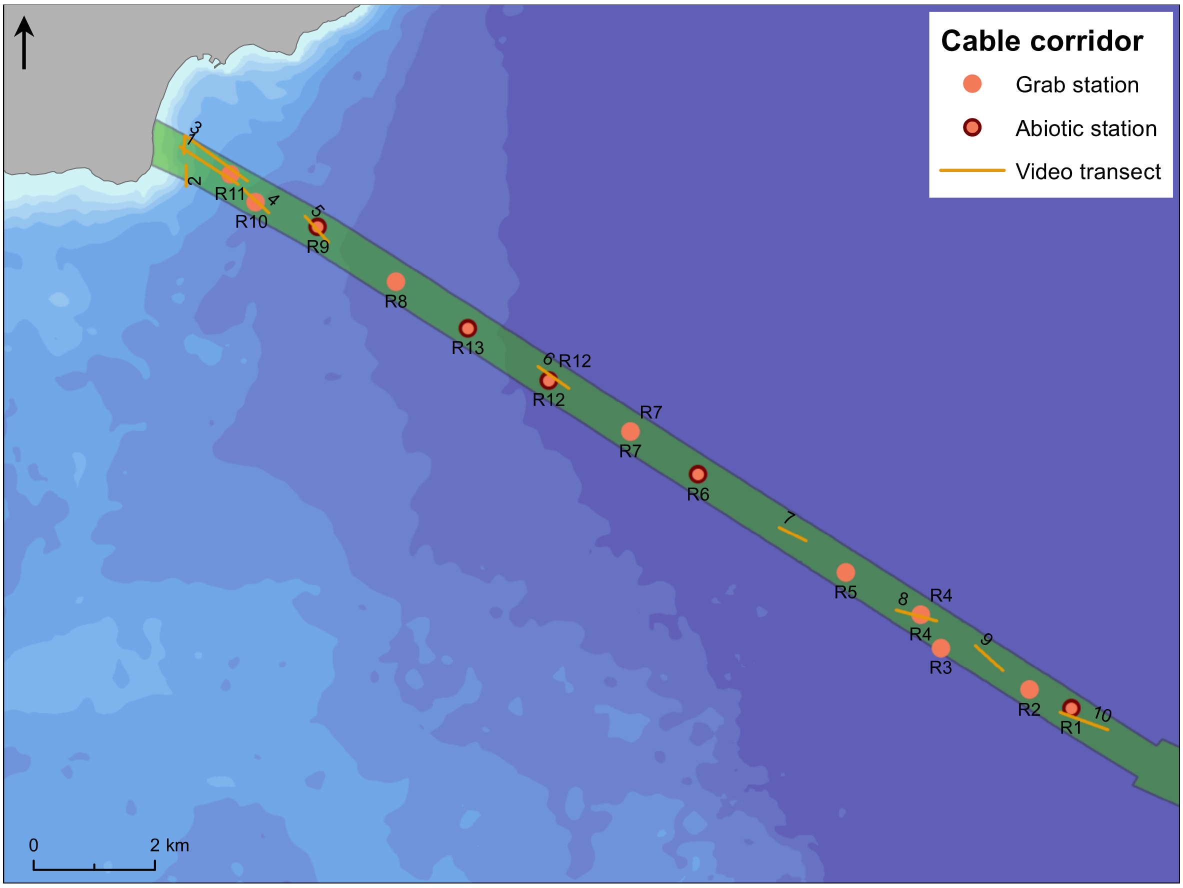


Figure 4-3 **Sampling programme at the western part of the cable corridor in 2014.**

Figure 4-4 Sampling programme at the eastern part of the cable corridor in 2013.

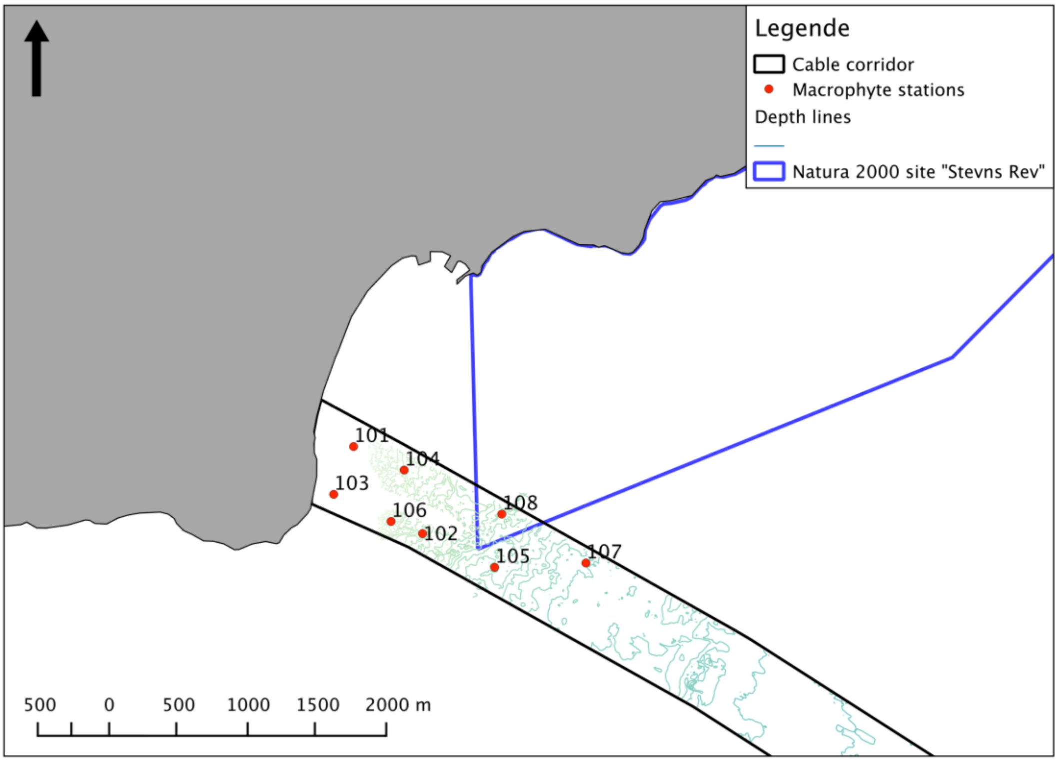


Figure 4-5 Sampling programme for macrophytes at the landfall area near Rødvig in 2014.

In deeper areas video transects and grab stations were distributed such that a complete coverage of all different morphological structures of the seabed identified by the geophysical data could be assured. In shallow areas either aerial photos were used in exchange to geophysical data or transects and grabs were distributed as evenly as possible over the respective subarea to achieve a full coverage of habitat structures.

Video recording

Video recordings along transects were carried out in both hard and soft bottom areas. The purpose of the video recordings was to establish and document the spatial distribution of marine benthic habitats and/or epibenthic key species to define suitable sampling sites.

The video system was a drop-down system towed by boat at low speed and connected with the on-board recording systems by a data transfer cable. The under water camera was mounted on a specific video sledge allowing movement above the bottom with least disturbance of sea bottom habitats.

Important track information (coordinates, depth, transect name etc.) was faded into the video sequence. The video recordings were, if possible, coupled with synchronised GPS- and depth-data storage in a log file, in order to simplify video processing. Video tracks were recorded continuously (if possible) with very low cruising speeds of 1–2 knots to assure high quality recording.

The start and end coordinates, depth ranges and the approximate length of video transects are shown in the appendix.

Video analysis

Coverage of specific vegetation elements as well as rough sediment characteristics and mussel coverage were estimated along each transect. Coverage of the following biotic and sediment categories was estimated: eelgrass, *Fucus*, *Laminaria* (*Saccharina latissima* is included), red algae, green algae, drifting algae, blue mussels, tasselweed (*Ruppia*) and pondweed (*Potamogeton*), sand and stones.

The following coverage scale (adapted Brown-Blanquet-scale, 1951) was used: 0: not present; 1: < 10% coverage; 2: ≥ 10–25% coverage; 3: ≥ 25–50% coverage; 4: ≥ 50–75% coverage; 5: ≥ 75–100% coverage; 6: 100% coverage.

Position and depths, where changes in coverage occurred, were noted manually. No image analysis software could be used as vegetation structures were too complex to allow effective and correct analysis. But, if possible, data of position and depth was stored in a log file and combined with manually assignment of coverage estimations. This was done by importing the logged data into a spread sheet (Figure 4-6). This allowed the calculation of transect length and distance between two coordinates.

Gr-S-E02

Time	Latitude	Longitude	E1	E2	Depth	Total	Zos	Myt	Fuc	Lami	Red	Green	Drift	Pot	Rup	Sand	Stone	Remark
11:53:27	54°22,801'N	11°07,852'E	0	0	2,3	4	4	1	0	0	2	0	1	0	0	5	2	
11:52:23	54°22,808'N	11°07,895'E	53,5	53,5	2,4	3	3	2	1	0	1	1	2	0	0	5	2	
11:48:41	54°22,825'N	11°08,038'E	173,9	227,4	2,9	3	3	3	1	0	1	1	1	0	0	5	2	
11:47:21	54°22,837'N	11°08,084'E	61,4	288,8	3	3	3	4	1	0	1	1	1	0	0	4	3	
11:46:21	54°22,844'N	11°08,122'E	48,4	337,2	2,5	4	4	4	1	0	1	1	1	0	0	4	3	
11:45:45	54°22,849'N	11°08,142'E	26,6	363,8	2,8	4	4	4	0	0	1	1	1	0	0	4	3	
11:45:41	54°22,850'N	11°08,145'E	3,9	367,7	2,8	4	4	4	0	0	1	1	0	0	0	4	3	
11:43:49	54°22,866'N	11°08,207'E	86,1	453,8	2,5	4	4	4	0	0	1	0	0	0	0	4	3	

Figure 4-6 **Example of Excel file for video analysis with positions, depth, distances (E1 = distance in m between single coordinates, E2 = added distances in m to define transect length or width of macrophyte belts or mussel banks) and coverage values of the different vegetation components (Zos = Zostera, Myt = Mytilus, Fuc = Fucus, Lami = Laminaria, Red = red algae, Green = green algae, Drift = drifting algae, Pot = Potamogeton, Rup = Ruppia).**

4.3.1 Grab stations

Sampling

The purpose of the grab sampling was to establish and document the species composition of the benthic invertebrates and the spatial distribution of specific benthic taxa as well as to analyse the biomass distribution and population dynamics of blue mussels via shell length-abundance measurements. Sampling was conducted in accordance with national and international guidelines (Danish NOVANA technical instructions for marine monitoring, German standard operational procedures (SOP), WFD, MSFD, HELCOM guidelines). This includes sampling by a Van Veen grab (Figure 4-7) with the following basic parameters: weight 70–100 kg, 0.1 m^2 sampling surface, net covered lid, warp-rigged. At each grab station the following parameters were recorded:

- Geographical position (WGS84)
- Date and time
- Weather and wind conditions (ICES codes)
- Water depth
- Sediment type (macroscopic, visual description)
- Presence of phytobenthos
- Video still images of the location
- Grab content images

The grab content was sieved in dispersion over 1 mm mesh size. In case of large proportion of coarse and medium-grained sand or gravel, the sample was decanted through a sieve and rinsed at least five times. Sieve residues were transferred to labelled sampling bottles and fixed in 4 % buffered formalin for later analysis in the laboratory. Phytobenthos included in the grab content was stored in separate sampling bags and frozen for later analysis.

Figure 4-7 Van Veen grab

Laboratory analysis

Grab analysis was conducted in accordance with national and international guidelines (German SOP, WFD, MSFD, HELCOM guidelines). This includes a standardized species list, QA management, a monitoring handbook and standard operational procedures (SOP). For each grab sample the following parameters were determined in the laboratory:

- Benthic fauna and flora species composition: nomenclature according to World Register of Marine Species, WoRMS, (date: 01.01.2013) and assignment to broader taxonomic groups (polychaetes, amphipods, bivalves, gastropods, etc.).
- Benthic fauna abundance: number of individuals per species/taxa. Values were recalculated to a surface area of 1 m^2.
- Benthic fauna biomass: total wet weight per species/taxa. Values were recalculated to a surface area of 1 m^2.
- Shell length of blue mussels

Sorting, counting and determination

The samples were sieved in small portions under running water. The mesh size of the sieve was 1 mm. The samples were sorted by the use of a stereomicroscope. The type of the remaining sediment (sand, stones, shells, wood, turf etc.) was documented in the sorting protocol for each sample. After sorting, the specimens were put into bins containing the same labelling as the sample container (station, date, replicate etc.). The specimens were fixated in ethanol. Sorting may be facilitated using dye (methylene blue).

In principle, the determination was done with the highest possible accuracy, i.e. to the species level. Taxa not determined to species level, carry the following suffixes:

- sp. = a single species, but only determined to genus level
- spp. = several different species, but only determined to the common genus level
- juv. = juvenile individuals, that can not be determined to species level

The following taxa were counted, but not routinely determined to species level:

- plathelminthes
- nemertean
- insecta (e.g. chironomids)
- hemichordata
- oligochaeta

In general, only individuals having a head/front part were counted (e.g. polychaete posterior ends are not counted). For bivalves, only individuals with hinges were counted. Not countable colonies (e.g. hydrozoa, bryozoa, porifera) were determined but not counted.

Biomass – wet weight
The procedure started by determining the tare weight, i.e. the weight of the empty bin. This weight was documented in the protocol. The animals were weighted at room-temperature by removing them from the preservation jar with tweezers, drying them on absorbent paper (under an extractor hood), and putting them onto the scale in a weighting bin. Shells of echinoids (e.g. *Echinocardium cordatum*) and bivalves were opened, so the surplus water can run off. All taxa with hard shells (e.g. bivalves, gastropods, barnacles) were weighted with the shells, if not specified otherwise. Tubes from polychaetes were removed as much as possible. As soon as the weighting bin has been placed on the scale, the biomass value is read and written in the protocol. Afterwards the material was immediately returned to the original preservation jar to avoid drying-out.

Shell length
Total shell length of *Mytilus edulis* individuals was measured by using a slide gauge, taking the longest possible length from the shell. Each specimen was measured with one mm accuracy. If necessary, e.g. very high abundances, mussels could be sieved via different mesh sizes to built size groups as pre-treatment. Only complete mussel shells were measured.

4.3.2 Diving stations

Mapping and sampling
The purpose of the diving was to document the habitat distribution in the very shallow parts of the investigation area and to achieve macrophyte coverage and species composition data as well as sediment characteristics.

At each station the cover of substrate (boulders, cobbles, pebbles, gravel, sand, clay/mud/silt and clay reef) was estimated. Total vegetation cover, blue mussel cover and the cover of several macrophyte key species (e. g. *Chorda filum*, *Fucus* spp., *Coccotylus/Phyllophora*, *Furcellaria lumbricalis*, *Delesseria sanguinea*, *Saccharina*, other perennial red algae, *Zostera*, tasselweed, pondweed and filamentous algae) were assessed. The coverage estimates were performed within an area of 20–25 m^2 at each site in % coverage. Habitat characteristics were documented by several photos per station.

The qualitative macrophyte samples to determine the species composition were transferred in a net bag and transported to the surface. The samples were then labelled and kept cool on board the ship until they were frozen by the end of the day.

At each diving station the following parameters were recorded additionally to the above described parameters:

- Geographical position (WGS 1984)
- Date and time
- Weather and wind conditions (ICES codes)
- Water depth

Macrophyte analysis
In the laboratory, samples were defrosted, sorted and identified to species level, if possible. In cases that identification of species was not possible after freezing, a higher taxonomic level was listed (e. g. *Aglaothamnion/Callithamnion*, *Ulva* sp.).

4.4 Supplementary Data

Background information on abiotic parameters (substrate, hydrography) or benthic communities (e. g. spatial or depth distribution, species composition) were also available from other sources. The data are listed and briefly described in Table 4-2.

Table 4-2 Supplementary data from other sources and used in this study

Data type	Subarea	Description of data source	Application in this study
Aerial photos	Cable corridor, Rødvig	Aerial photos covering the cable corridor in shallow waters up to the shore, provided by Energinet.dk	Habitat and substrate delineation in shallow water
Bathymetry data	Kriegers Flak, Cable corridor	Isobath lines from every 2 m, compiled from HELCOM and other sources	Background layer in several maps, also used for habitat delineation and characterisation in shallow water
Geophysical data	Kriegers Flak, Cable corridor	Sidescan data from Rambøll (2013) & GEO (2014)	Habitat and substrate delineation in deeper water
Baltic I OWF EIA	Kriegers Flak	Macrozoobenthos samples, provided by IOW Warnemünde, Germany	Comparison material for characterisation of Kriegers Flak

4.5 Analysis methods

4.5.1 Species Diversity

Species diversity at the sampling sites was described by the number of species (species richness), Shannon Index and Evenness (after Pielou).

The number of species is a basic measure of diversity, but the communities can be very different depending on the relative abundance of the species in the community, also called evenness.

The Shannon-Wiener Index (H) combines species richness (number of species within the community) and species evenness:

$$H = -\sum_{i=1}^{S} p_i \ln p_i$$

Where S = species richness (total number of species present), p_i = proportion of total sample belonging to the i^{th} species. Given a very large sample size, with more than 5 species, the S-W value (H) can range from 0 to ~ 4.6 using the natural log (ln). A value near 0 would indicate that every species in the sample is the same. A value near 4.6 would indicate that the species abundance is evenly distributed between all the species.

Evenness is a measure of the equality of individuals among species. The higher the value the more evenly the individuals are distributed among the species of a given sample. The evenness value can range between 0 and 1. The nearer to one the evenness is, the lower the abundance differences between the species of the sample. Evenness (J) was measured after Pielou (1966, 1984)

$$J = \frac{H}{log_2 S}$$

with S = species richness and H = Shannon index.

4.5.2 Abundance, biomass and shell length

Abundances and biomass have been extrapolated to 1 m^2 for each taxa and station. Mean absolute abundances and biomasses have been calculated for each subarea. Relative abundance and biomass have been calculated for each station but also as mean for each subarea. The proportion of taxa groups and the presence of taxa (expressed as proportion of stations at which the taxa occurs) has been analysed for each subarea. Shell lengths have been analysed and illustrated in size-frequency plots without nesting of size classes and extrapolating abundance/class to 1 m^2.

4.5.3 Habitat classification and mapping

There are various European classification systems in use, e.g. EUNIS (European Nature Information System), EU-Habitat types (Annex I of the Habitats Directive) and HELCOM HUB (HELCOM Underwater Biotopes and habitat classification). Some systems offer a classification of all existing habitats in an area (e. g. EUNIS, HELCOM HUB), others list only certain protected habitats (EU-Habitat types). Some of the classifications are only providing habitat terms without clear definitions or delineation criteria, which makes expert judgement necessary for habitat mapping.

HELCOM HUB is based on EUNIS. It has been developed recently and forms the only transnational classification system available for the Baltic Sea. It represents a full classification system for all occurring biotopes and was thus chosen as basic habitat classification system for this study. For legally protected habitats the EU-Habitat types of Annex I are used parallel to HELCOM HUB biotopes.

HELCOM HUB (HELCOM Underwater biotope and classification system)

The first 'Red List of Marine and Coastal Biotopes and Biotope Complexes of the Baltic Sea, Belt Sea and Kattegat' was published in 1998 (HELCOM, 1998). It included a description and classification system for Baltic marine and coastal habitats. In 2008, the Helsinki Commission was tasked with creating an updated Red List of Baltic Sea species and habitats/biotopes using the criteria defined by the IUCN (International Union for the Conservation of Nature). As a result of this project the existing HELCOM Red Lists (BSEP 109 and BSEP 75) have been updated in November 2013 (BSEP 138, BSEP 140).

A "by-product" of the RED LIST project was to prepare a biologically meaningful Baltic sea wide habitat/biotope classification system based on the EUNIS classification, called HELCOM HUB. The technical report about HELCOM HUB was published in November 2013 (BSEP 139).

In the sense of the HUB classification, biotopes are defined as a combination of an abiotic environment (= habitat) and an associated community of species (Connor et al. 2004, Olenin & Ducrotoy 2006). HELCOM HUB uses a hierarchical structure with six different levels of classification. Each biotope level is coded by using letters or numbers. Table 4-3 gives an overview of the different classification levels, the number of classes for each level (only for benthic biotopes) and examples (with codes) for each category. For each level specific split rules have been developed to delineate the different classes within one level of the classification. A HELCOM HUB biotope using all levels of classification would for example be coded as: AA.J1B7 – Baltic photic sand with eelgrass.

Table 4-3 Structure of the HELCOM HUB classification

Level	No. of benthic classes	Examples (and Code)
Level 1: Region	1 (letter code: A)	Baltic (A)
Level 2: Vertical zone	2 (letter code: A, B)	Photic benthos (A), Aphotic benthos (B)
Level 3: Substrate type	13 (letter code: A-M)	Rock (A), Sand (J), Mixed substrate (M)
Level 4: Functional characteristic	4 (number code: 1-4)	Macroscopic epibenthic structures (1), Sparse macroscopic epibenthic structures (2), Macroscopic infaunal biotic structures (3)
Level 5: Characteristic community	23 (letter code: A-W)	Emergent vegetation (A), Submerged rooted plants (B), Epibenthic bivalves (E), epibenthic moss animals (H)
Level 6: Dominating taxon	61 (number code: 1-61)	Eelgrass (7), Mytilidae (1), ocean quahog (3),

Apart from these individual biotopes, also biotope complexes can be defined. These consist of a number of different biotopes that occur together and are affected by the same specific environmental gradients. Examples are the habitat types of the EU Habitats Directive, like reefs and sandbanks.

Mapping is carried out methodically by a separate assessment of specific descriptors, which are used to define and delineate certain habitats. Which descriptors have to be used is an input requirement of the habitat classification in use.

Descriptors/data for HELCOM HUB

The investigation area is located completely within the Baltic Sea. The differentiation in photic and aphotic zones is not applicable as the depth at which the surface irradiance (100 %) is reduced to 1 % as measure for the photic/aphotic boundary is not available for the investigation area. Also, there are no macrophyte-dominated habitats on Kriegers Flak, making this distinction important. Therefore only the lower levels 3-6 of HELCOM HUB are relevant and have been used. Descriptors necessary for the habitat mapping are:

- substrate type,
- epibenthic biotic structures and
- dominating taxa

The available data and how they have been used for the habitat definition are listed in Table 4-4. To define the dominating taxa of a certain substrate or within a certain area a high frequency sampling is required as abundances and biomass are very variable over space and time. Level 6 was therefore only assigned, if all available samples allow a clear assignment of the dominating taxa. If results differ too much in terms of dominance between species/taxa the next possible higher levels were assigned.

Table 4-4 Descriptors and classes used for habitat definition

Substrate type		
Data basis/methods	**Specification**	**Classes assigned**
Geophysical investigations = Sidescan data	Spatial distribution of six different substrate classes (glacial till, glacial till with boulders, sand, sandy gravel, slightly gravelly sand, silty clayed sand)	Due to the variable data basis in terms of spatial availability and delineation of substrate classes only the differentiation of three classes was possible: mixed substrate, sand and mud.
Aerial photos (only nearshore area at Rødvig)	Spatial distribution of hard bottom and sand	
Video analysis	Cover of stones and sand in %	
Grab samples	Visual sediment description + species composition (absence/presence of key species for certain substrate types)	
Diving sites (only in vegetation areas off Rødvig)	Cover of boulders, stones, gravel, sand, mud in %	
Epibenthic biotic structures		
Data basis/methods	**Specification**	**Classes assigned**
Aerial photos (only nearshore area at Rødvig)	Spatial distribution of algae, rooted plants and mussel beds	Differentiation into biotopes dominated by macroscopic epibenthic biotic structures or macroscopic infaunal biotic structures (Level 4) Differentiation into biotopes dominated by epibenthic bivalves, submerged rooted plants, macroalgae and infaunal bivalves (Level 5)
Video analysis	Cover of specific taxa (*Zostera*, *Fucus*, *Mytilus*, …) and taxa groups (red algae, drift algae) in %	
Grab samples	Species composition	
Diving sites (only in vegetation areas off Rødvig)	Cover of boulders, stones, gravel, sand, mud in %	
Dominating taxa		
Data basis/methods	**Specification**	**Classes assigned**
Aerial photos (only nearshore area at Rødvig)	Spatial distribution of macroalgae, eelgrass and *Mytilus*	Differentiation into biotopes dominated by eelgrass, perennial algae, Mytilidae, Macoma balthica (Level 6)
Video analysis	Cover of specific taxa (*Zostera*, *Fucus*, *Mytilus*, …) and taxa groups (red algae, drift algae) in %	
Grab samples	Absolute and relative abundance and biomass values	
Diving sites (only in vegetation areas off Rødvig)	Cover of specific taxa (*Zostera*, *Fucus*, *Mytilus*, …) in %	

4.6 Assessment methods

The impact assessment aims at describing the potential impacts of the project on benthic flora, fauna and habitats in the three project phases: **construction** phase (section 6), **operation** phase (section 8) and **decommissioning** phase (section 9). For each phase, the potential environmental impacts are described individually for the different parts of the project, i.e. within the defined subareas: the wind farm (Kriegers Flak), the cable corridor and the landfall. For each of these subareas, the different relevant pressures and their impacts are evaluated. Pressures that have impacts spanning over more than one of the three project phases (in terms of duration) are typically only discussed once, namely for the project phase where the pressure is initiated.

In addition, the potential impacts on the Water Framework Directive (WFD), the Marine Strategy Framework Directive (MSFD) are described and also cumulative impacts and possible mitigation measures (sections 0 to 13).

As the technical implementation of the project depends on various variables and can be done in different ways (see the technical project description in section 3), all assessments have been done using a worst case approach, assuming that the technical method that would result in the most severe impact on the benthic organisms is used. The worst case scenarios are described in detail in section 6.2. These different scenarios result in certain *activities* which are performed within the three project phases, e.g. dredging or piling activities during the construction phase or excavation of export cables in the decommissioning phase. The activities lead to a number of potential *pressures* that act upon the benthic organisms (see section 6 for a detailed description of the relevant pressures). Depending on the *sensitivity* of the organisms towards these pressures and the *magnitude of the pressure* itself (in terms of e.g. type, duration), a *disturbance* is resulting that potentially affects the viability or even the survival of organism, communities or habitats. This impact is classified into three different classes of **degree of disturbance**: *high*, *medium* and *low*, and is typically the result of an expert judgement of the impact done by the disturbance.

The *degree of disturbance* is then assessed together with the *importance* of the corresponding topic (e.g. the importance of the effect of sedimentation onto benthic habitats on regional or national interests), the *likelihood of occurrence* and the *persistence* of the disturbance (temporal duration). These four criteria result in the final assessment of the **magnitude of the impact**.

In general, the impact assessment will be based on the habitat level. Individual species can typically not be evaluated in terms of their reaction on pressures because they do not live isolated from the other species in the community and habitat. All species interact with each other (e.g. through competition for food or living space) and with other biodiversity components (e.g. fish). Consequently, a pressure acting on the species in a habitat and changing e.g. the abundance of a species, typically leads to changes in the interaction between this species other species in the community. Consequently, the whole community changes according to the pressure and no individual species alone. This again leads to a change in the habitat, especially when the pressure is changing the abiotic properties of the habitat (like solid substrate or footprint). Only in special cases and for dominant species, like e.g. areas dominated by *Mytilus edulis* (both in terms of abundance and biomass), the remaining species in the community can be ignored in the first place an evaluation on species level is reasonable.

5 Baseline conditions

5.1 Abiotic conditions

The general abiotic conditions are described by using supplementary data (references listed in 4.4) for bathymetry and seabed morphology in combination with substrate and hydrography information surveyed during the field campaign.

5.1.1 Kriegers Flak

The Kriegers Flak area covers about 250 km^2. Water depth varies between 17 m and 30 m with the shallowest parts in the centre of the area and the deepest parts at the north-western edge at the transition to the cable corridor.

Sand is the dominant substrate component. Sidescan data as well as video analysis also gave information about areas with boulders (mixed substrate, boulders > 10 % cover). The deepest parts are characterised by mud (Figure 5-1).

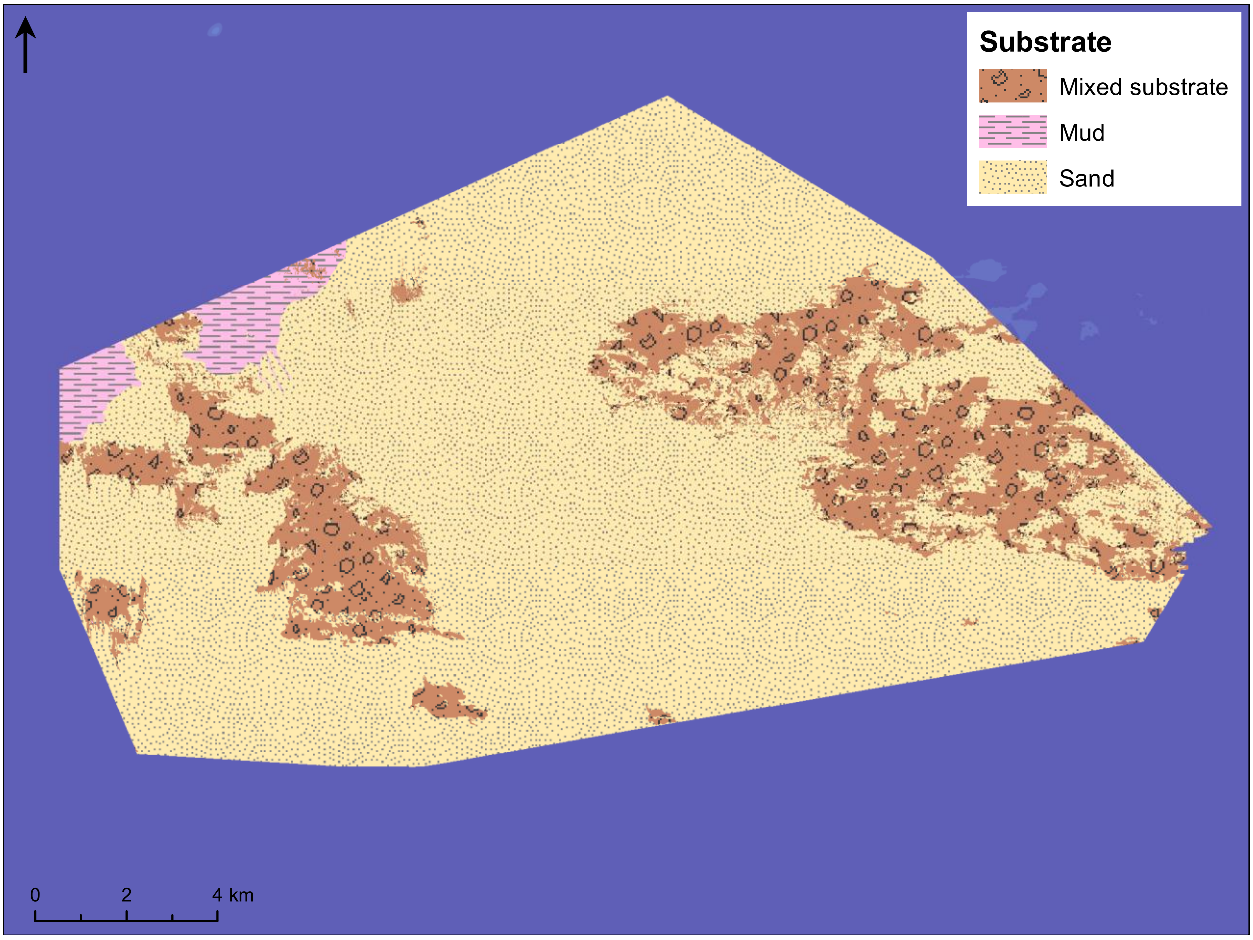


Figure 5-1 Substrate distribution at Kriegers Flak based on sidescan data (Rambøll 2013) and video analysis (this study).

Hydrographical conditions during the field campaign (3rd to 5th May 2013) were measured at three random stations distributed across the subarea (Figure 5-2). No considerable gradient between surface and bottom layer for salinity or oxygen concentration was evident. Salinity ranged between 7.1 and 7.5 psu which is close to the typical salinity of approximately 10 psu in this region of the Baltic Sea (ENDK 2014). Oxygen concentration varied between 13.2 and 13.8 ml/l, the water column was saturated with oxygen throughout the complete water column. Temperature was slightly higher at the surface at two stations with around 7 °C in the surface layer and 3.6 to 4.1 °C at the bottom. This is the typical situation for late spring/early summer, when the higher air temperature starts to heat the upper most water layer. This temperature gradient was not sufficient to cause stratification; the water column was thoroughly mixed.

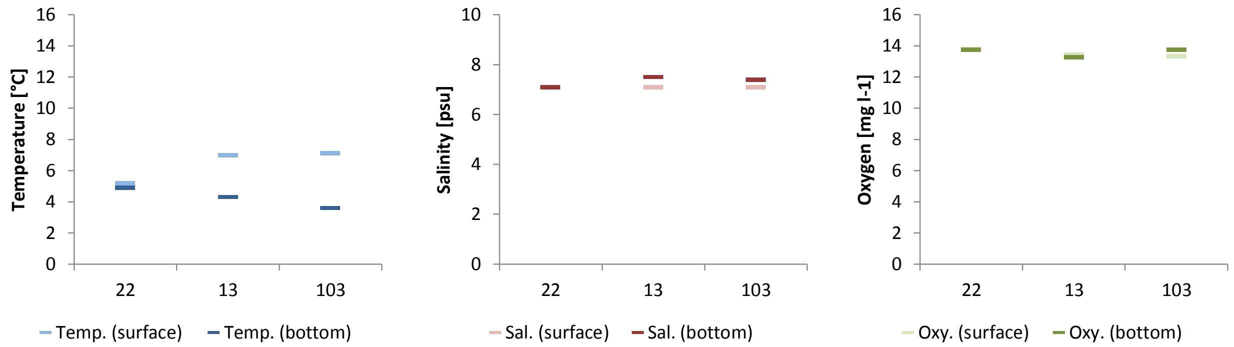


Figure 5-2 Hydrography parameters in Kriegers Flak OWF subarea at three of the sampling stations (see Figure 4-2 for the locations of these stations).

5.1.2 Cable corridor

The cable corridor covers about 27.4 km². Water depth varies strongly between 0 m at the shoreline and 30 m at the southern edge at the transition to Kriegers Flak OWF.

Mud characterises most of the area in the deeper, eastern part of the corridor. Sandy areas are primarily located closer to the coast of the Stevns peninsula at depths between 16 and 20 m, while the remaining part is characterised by mixed sediments and sand. Sidescan data and video analysis also gave information about areas with boulders (mixed substrate, boulders < 25 % cover) located mainly within the mixed substrate regions (Figure 5-3).

Hydrographical conditions during the field campaigns were measured at six stations (Figure 5-4) with Station R9 representing the shallowest section of the cable corridor. No considerable gradient between surface and bottom layer for temperature or oxygen concentration was evident. Temperature was around 6–7 °C in May 2013 and around 15 °C in October 2014. The oxygen concentration was around 10 mgl^{-1} in May 2013. In October 2014 the value ranged from 12.3 to 13.4 mgl^{-1}. Hence, the water column was saturated with oxygen throughout the complete water column. Salinity was around 8.25 psu in October 2014 without a gradient between surface and bottom water, but showed a gradient with a lower surface salinity of 7.1

and a higher bottom salinity of 9.2 psu in May 2013. This shows the well-mixed conditions in autumn 2014 against the slight stratification of the water layers in spring 2013.

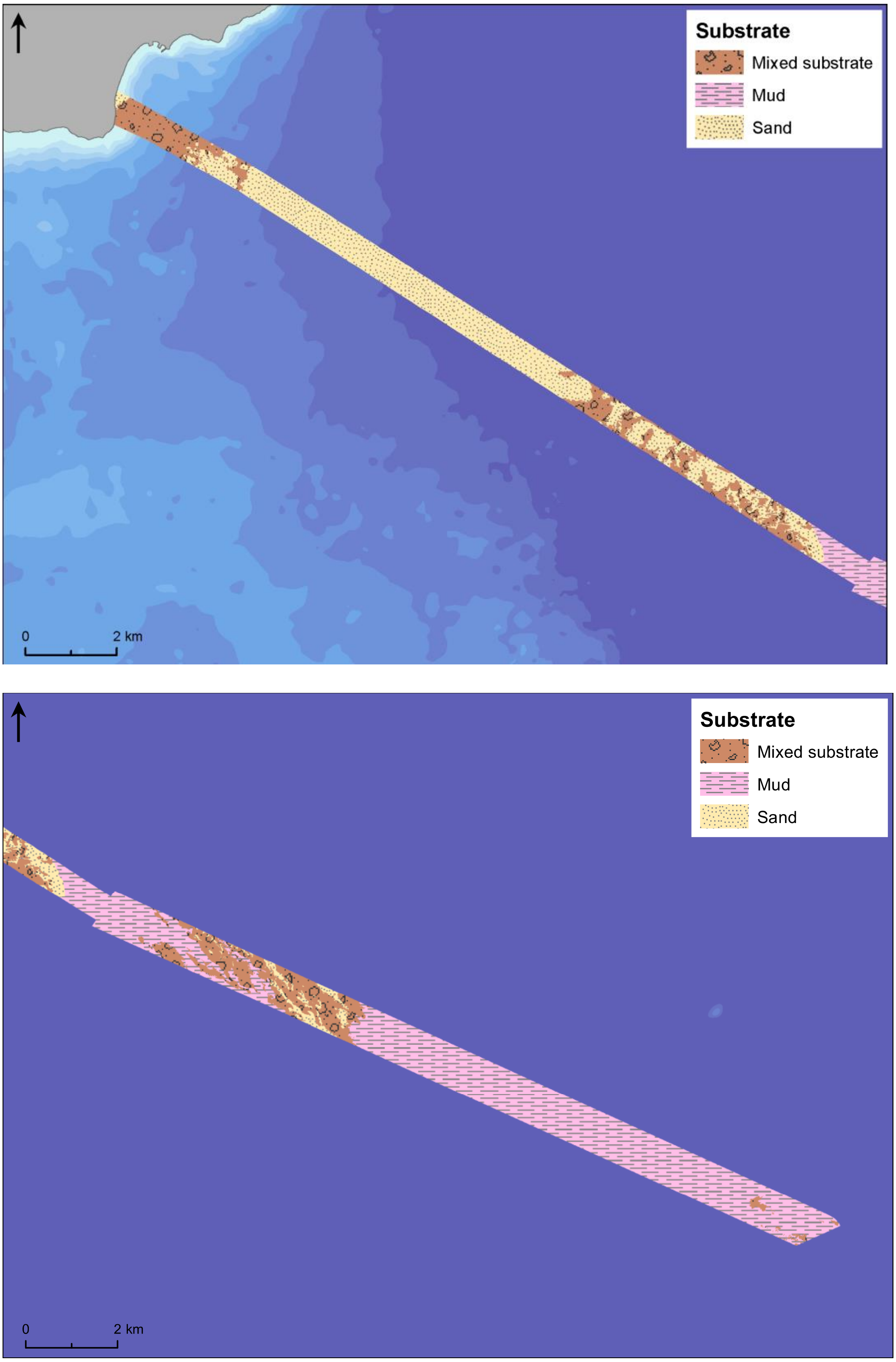


Figure 5-3 **Substrate distribution at the cable corridor based on sidescan data.**

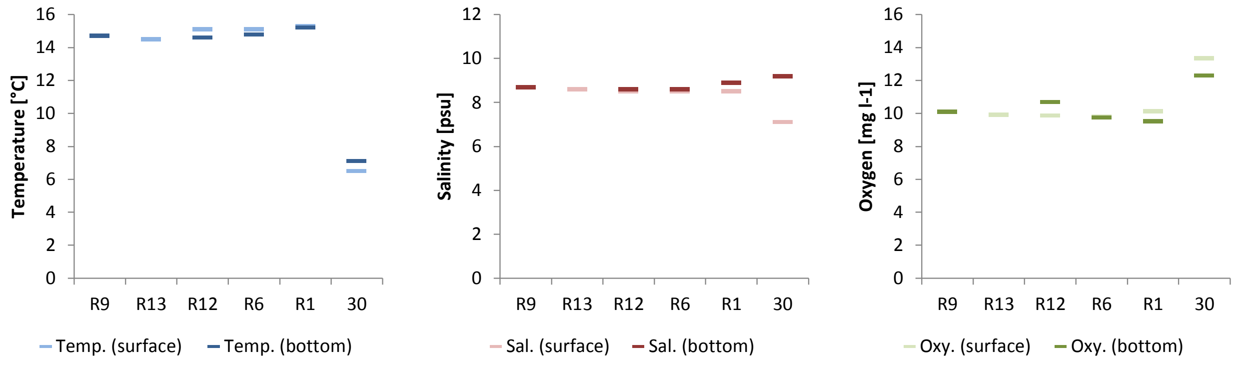


Figure 5-4 **Hydrography parameters at the cable corridor with stations arranged from west to east (see Figure 4-3 and Figure 4-4 for the locations of these stations).**

5.2 Macrozoobenthic communities

5.2.1 Kriegers Flak

Table 17-3 in the appendix gives an overview of the most relevant parameters of the benthic communities at Kriegers Flak. Overall 33 benthic taxa were identified, distributed over the different taxonomic groups.

The abundance distribution of the benthic taxa (Figure 5-5) was characterised by a strong dominance of *Mytilus edulis*. The blue mussel *Mytilus edulis* had the highest mean relative abundance (85 %), followed by the small epibenthic snail *Peringia ulvae* (7 %), the infaunal bivalve *Macoma balthica* (2 %) and the small polychaete *Pygospio elegans* (1 %). Due to the high dominance of *Mytilus edulis* the relative abundances of most taxa were less than 1 %.

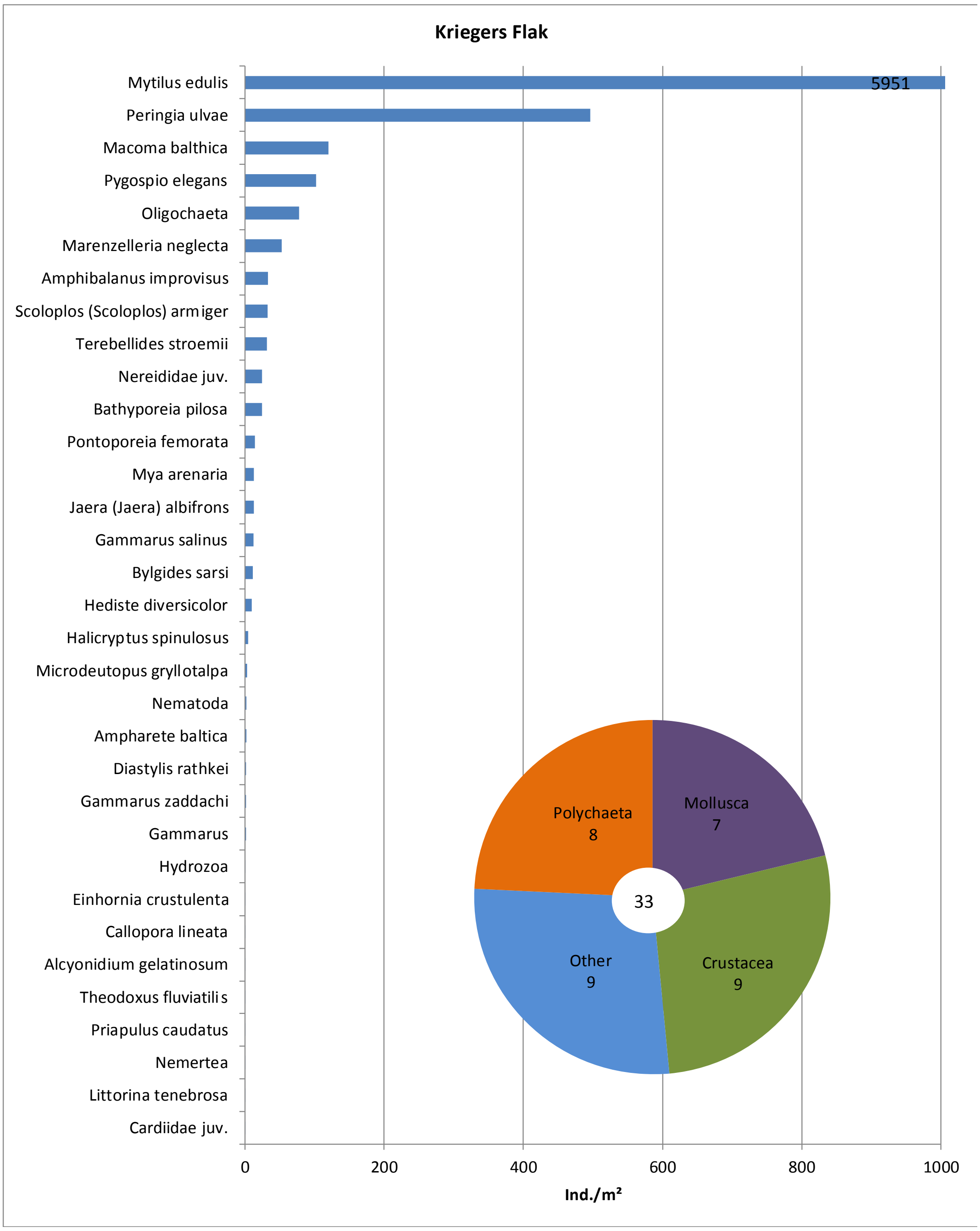


Figure 5-5 **Abundance distribution of benthic taxa at Kriegers Flak.**

The spatial distribution of the four most abundant taxa at Kriegers Flak (Figure 5-6) revealed no preferences for either shallower or deeper parts; all of them were distributed in the whole area. *Mytilus* dominated the benthic community at many stations with the highest absolute abundances at Station 15 and 17. Both stations are located within the mixed substrate area, where boulders (even in low density) form a suitable settling ground for blue mussels. At stations where the snail *Peringia ulvae* dominated, the blue mussel occurred with lower abundance. Although *Macoma balthica* was present at nearly all stations higher abundances occurred only at station 11. This is the deepest station at the Kriegers Flak area and comprises mud. The polychaete *Pygospio elegans* is distributed in sandy and muddy areas and also occurs in mussel beds (Hartmann-Schröder 1996). Therefore the species was distributed all over the area.

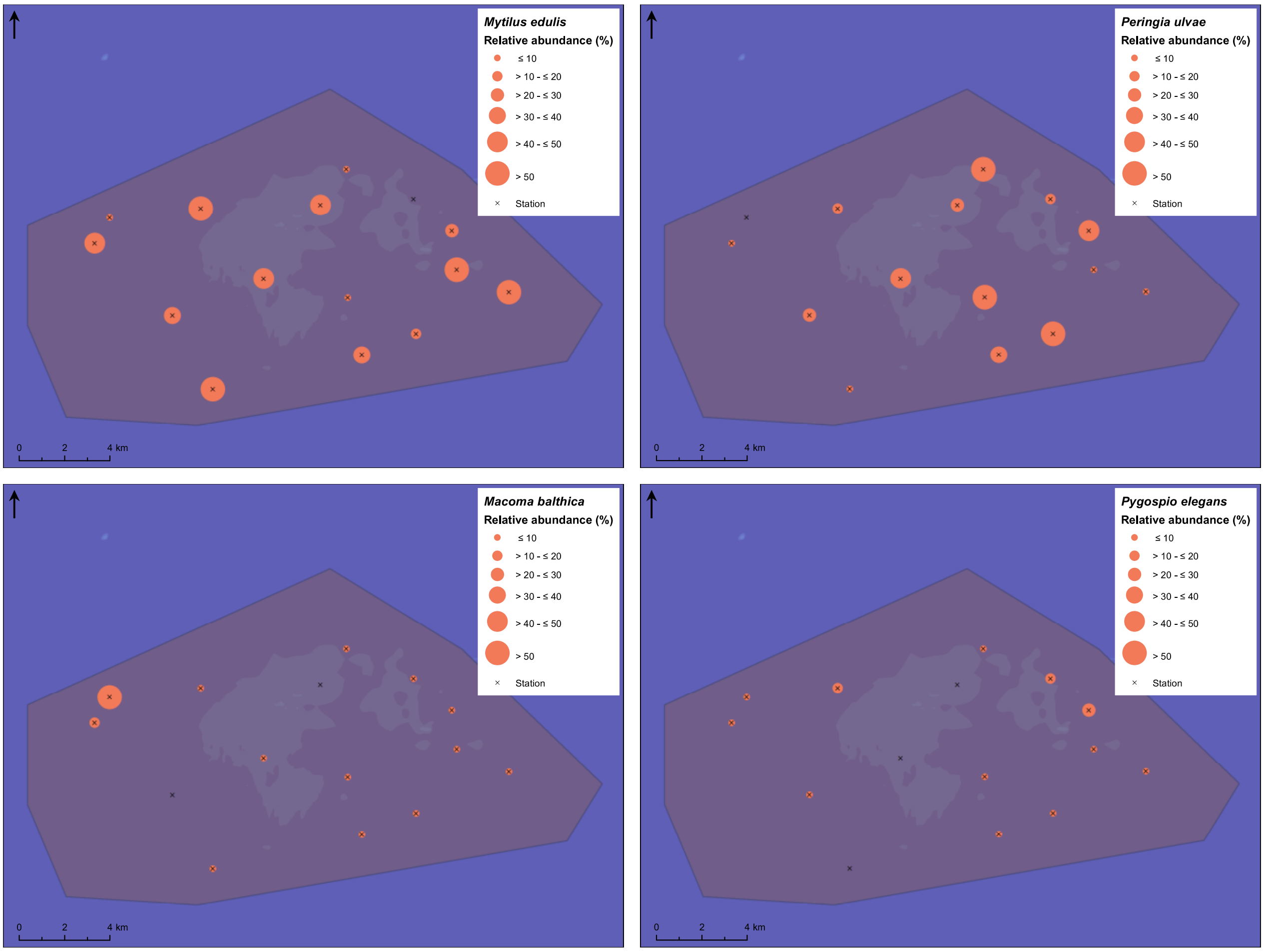


Figure 5-6 Relative abundances of the four most abundant species at Kriegers Flak OWF.

Species richness was higher in areas dominated by blue mussels than in other areas. The presence of an epibenthic habitat forming species like *Mytilus* offers additional living space between the shells. However the high relative abundances of blue mussels resulted in an unevenly distribution of abundances across taxa/species and as described for the Shannon and Evenness principles in chapter 4.5.1 accordingly very low Shannon index and Evenness values (e.g. H=0,15, J=0,04 at Station 15) at those stations compared to stations without high *Mytilus* dominance (e.g. H=2,25, J=0,75 at Station 21).

Mytilus edulis was distributed across the whole area and occurred locally with very high biomass (Figure 5-7). However, only two video transects showed relatively high *Mytilus* cover on longer sections. The *Mytilus* population was dominated by small specimens of 2-6 mm length (Figure 5-8). All stations had the same appearance in terms of the length-frequency distribution: many small specimens, only few individuals between 20 and 30 mm and no individuals larger than 30 mm. The abundances within the different length classes differed between stations with Station 15 and (partly) 17 as outliers with very high abundances within all length classes. The many small individuals revealed a spawning event from early 2013. The lack of large specimens could indicate that *Mytilus* does not form a stable population at Kriegers Flak and is dependent on inflow of larvae from neighbouring areas.

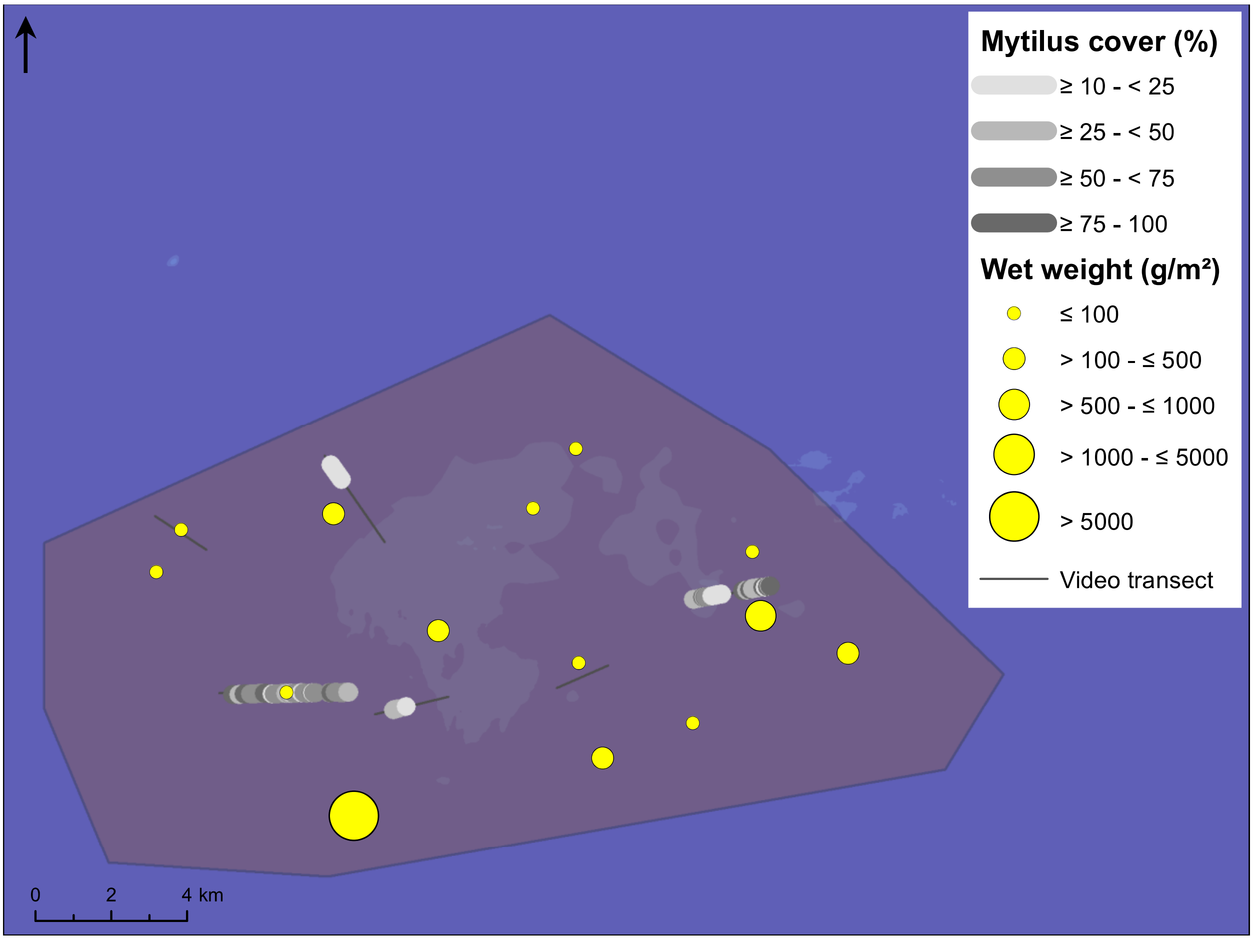


Figure 5-7 ***Mytilus edulis*** **cover and wet weight distribution at Kriegers Flak.**

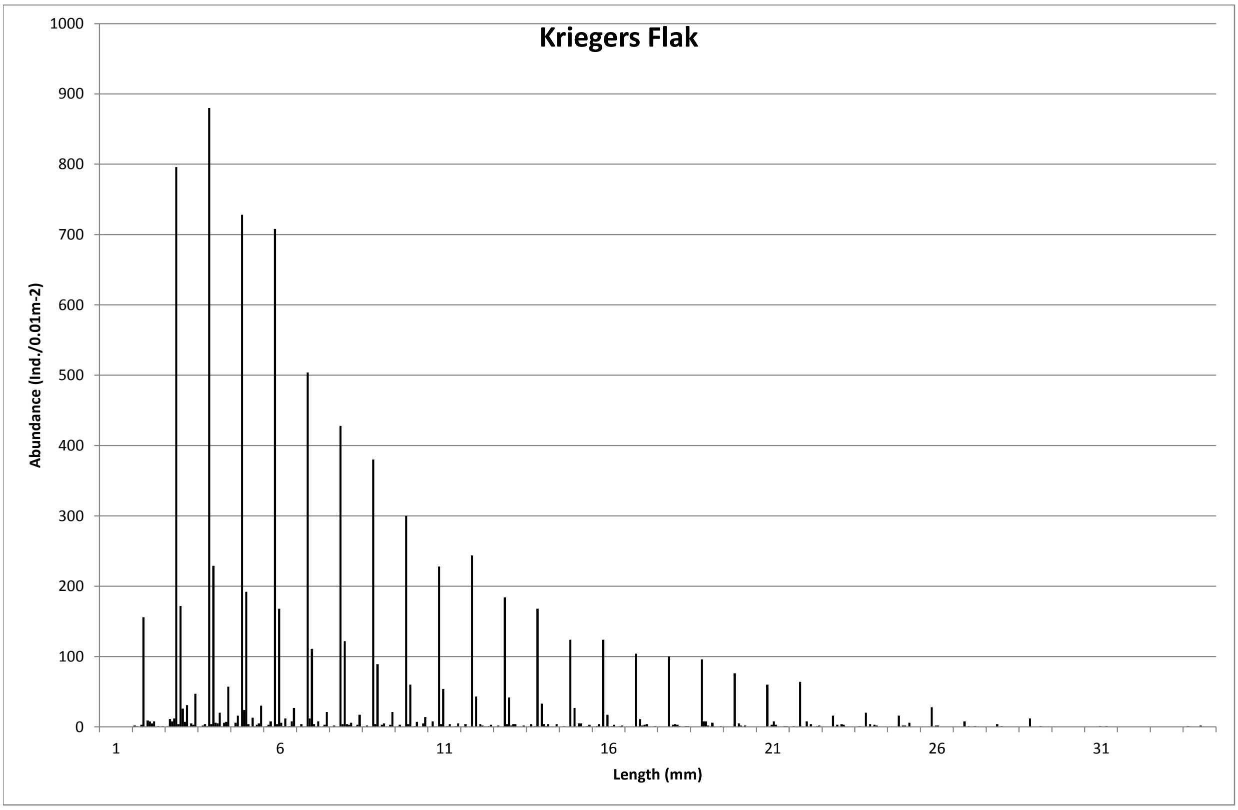


Figure 5-8 Length-Frequency distribution of *Mytilus edulis* at Kriegers Flak.

5.2.2 Cable corridor

Table 17-4 in the appendix gives an overview of the most relevant parameters of the benthic communities at the cable corridor. Overall 42 benthic taxa were identified. Polychaetes were the dominant taxa group at the cable corridor with 17 species identified. 11 mollusc species were found and five crustacean species. The remaining taxonomic groups (e.g. oligocheates, bryozoans, hydrozoans) amounted to nine species. The high overall species richness compared to the OWF subarea can be explained by the fact that the cable corridor comprises more different habitats and water depths, thus resulting in complementary species assemblages from these different habitats.

The abundance distribution of the benthic species (Figure 5-9) was characterised by a dominance of only three species: the mudsnail *Peringia ulvae* (27 % relative abundance) plus the polychaetes *Scoloplos armiger* and *Pygospio elegans* (both with 18 % relative abundance and occurring at every sampled station). The next abundant group was the oligochaetes with a relative abundance of 7 %. Most other taxa had only less than 1 % relative abundance. All these dominant species are typical for the sandy sediments that have been sampled at most of the stations. Only at the station 30, located at the eastern part of the corridor and on glacial till, the mudsnail was not observed.

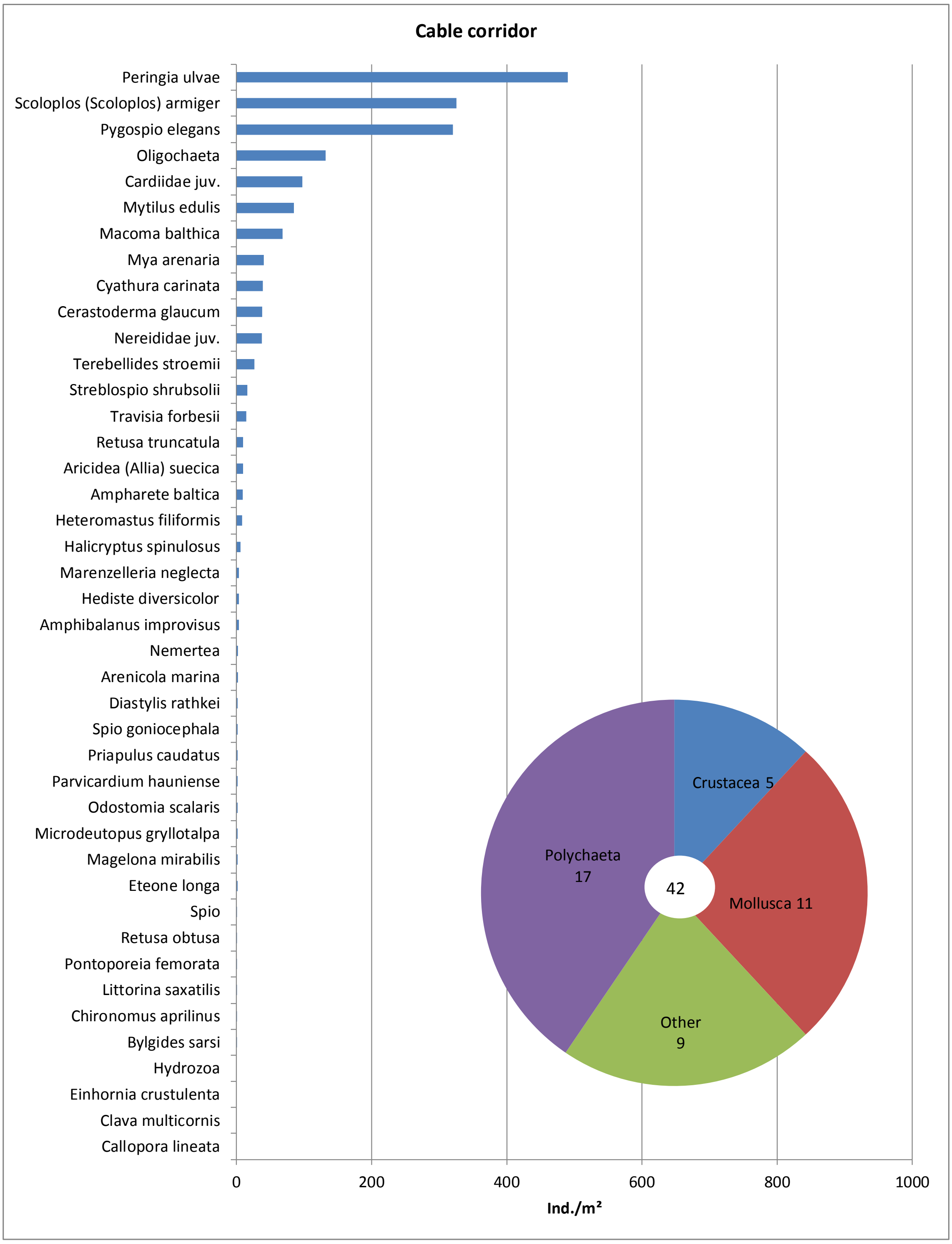


Figure 5-9 Abundance distribution of benthic taxa at the cable corridor.

The spatial distribution of the four most abundant taxa at the cable corridor is shown in Figure 5-10. The snail *Peringia ulvae* showed highest relative abundances at the nearshore part of the cable corridor and in the mixed substrate regions. The polychaete *Scoloplos armiger* was distributed in the whole subarea with no special preference towards sandy or mixed sediment. The polychaete *Pygospio elegans* was distributed relatively evenly along the whole cable corridor with slight preference for mixed substrates. The oligochaetes were correlated largely to substrate with a higher organic content due to epifauna and macrophyte vegetation.

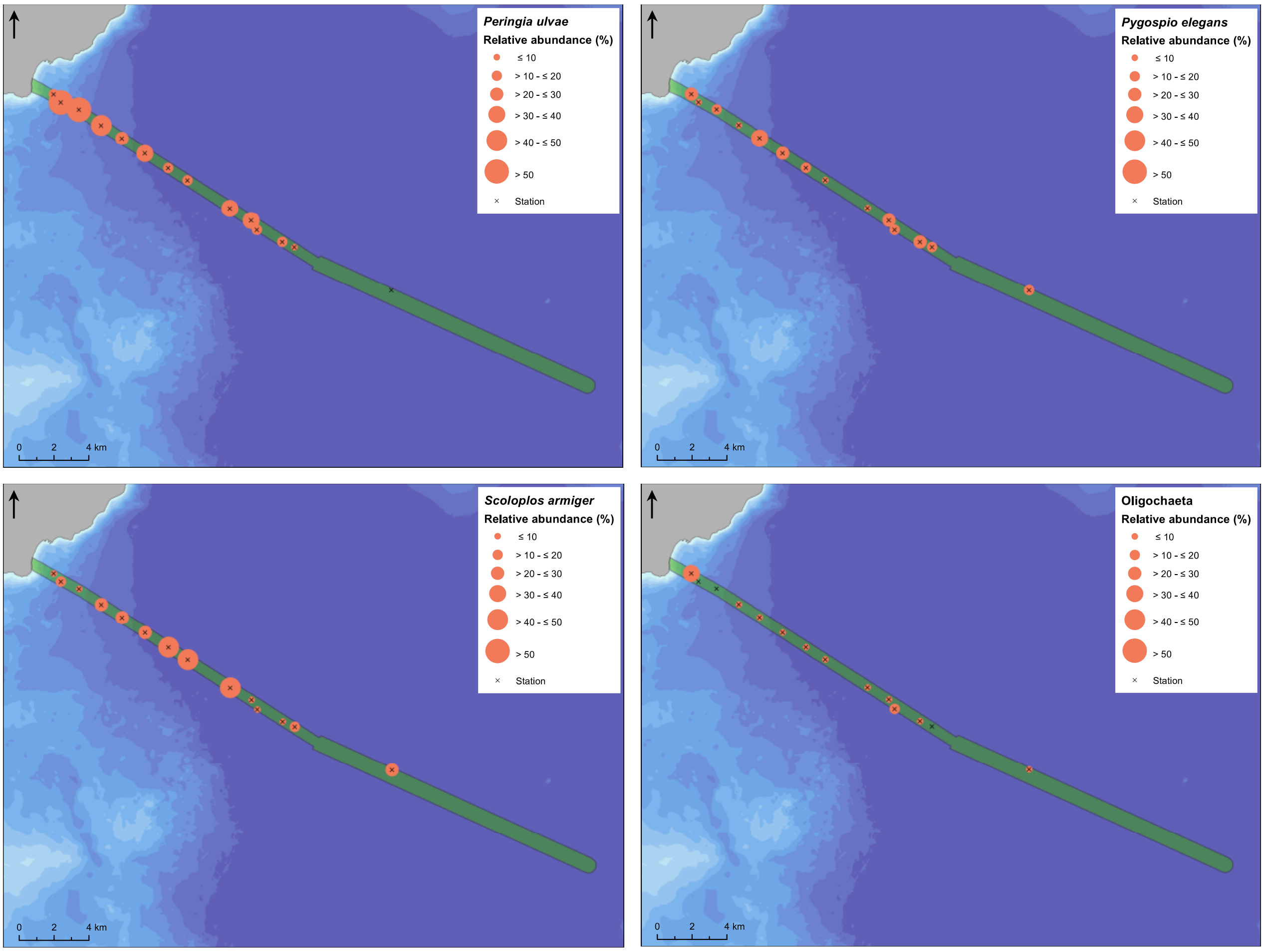


Figure 5-10 Relative abundance of the four most abundant taxa in the cable corridor.

The species number varied between 9 and 21 per station with the lowest value at Station R6 (for station numbers see Figure 4-3 and Figure 4-4), which was a typical station with fine sandy sediment showing the species composition characteristic of these pure sand bottoms. The polychaete *Scoloplos armiger* dominated this station with a relative abundance of 42 %. On the other side of the spectrum, the station with the highest species number (R11 with 21 taxa) also had the highest total abundance (3240 ind./m^2). This station is located closest to the coastline and is located within a region with macrophytes. Hence, it does not only contain infauna species but also epifauna species associated to algae (e.g. the snail *Retusa truncatula* or the bivalve *Cerastobyssum hauniense*).

The *Mytilus* (blue mussel) population at the cable corridor was small with typically only a few specimens per station. Sandy stations had no mussels. High numbers were only observed in regions with mussel clusters lying in patches on sand (station R3) or in regions with dense macrophyte vegetation and hard substrates (station R11). The length-frequency distribution is dominated by small size classes (mainly 2–7 mm) whereas only very few individuals (often only one) were present in larger size classes. The largest measured mussel was 36 mm long. This indicates that the cable corridor is not a typical blue mussel region.

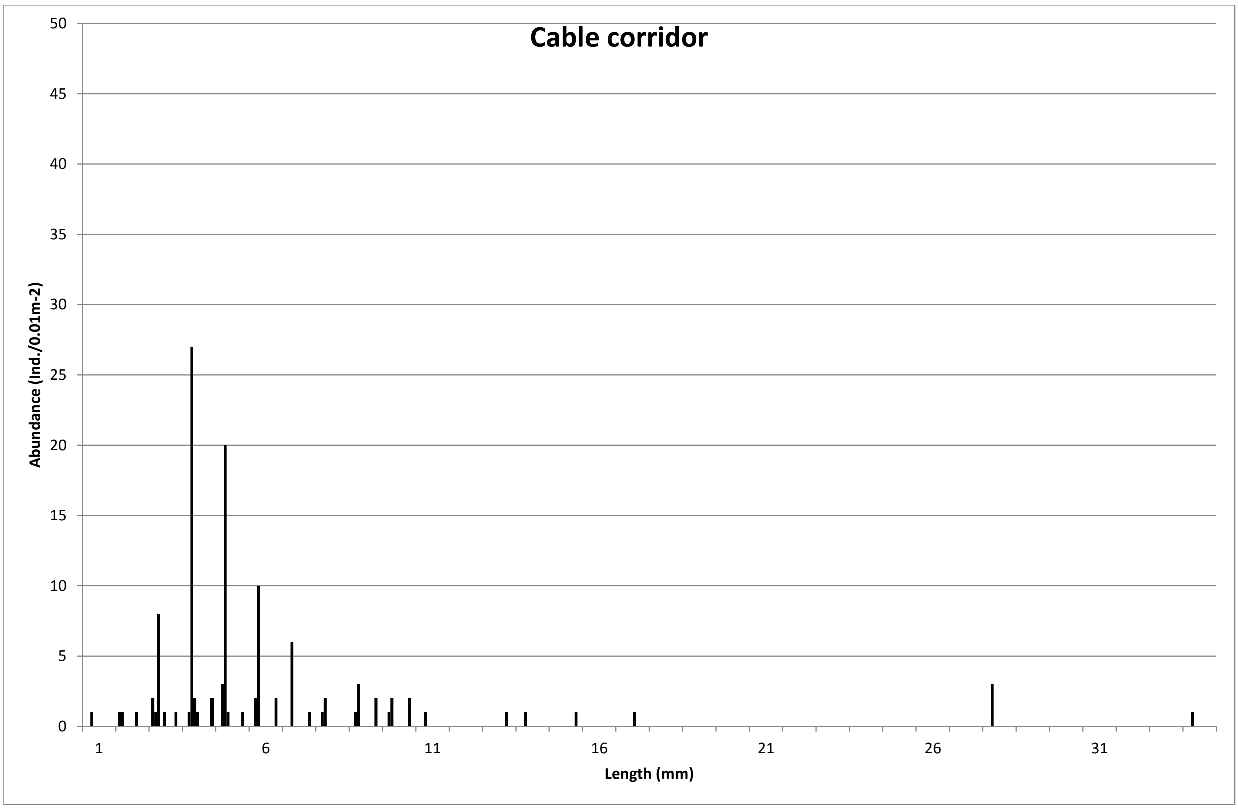


Figure 5-11 Length-Frequency distribution for *Mytilus edulis* at the cable corridor.

5.3 Macrophyte communities

5.3.1 Kriegers Flak

Macrophyte communities did not occur at Kriegers Flak; the macrophyte cover was below 10 % in the whole subarea. With water depths mainly below 20 m the light is not sufficient to maintain dense macrophyte assemblages. Additionally hard substrates, essential for macroalgae settlement, are rare. Boulders with more than 10 % coverage exist only in some smaller regions. Perennial red algae had been detected with single specimens at Station 20 (Table 5-1), but those plants could also be drift material from shallow areas.

Table 5-1 Macrophyte species composition at Kriegers Flak.

Green seaweeds (Chlorophyta)	Brown seaweeds (Phaeophyta)	Red seaweeds (Rhodophyta)	Higher plants (Magnoliophyta)
-	*Saccharina latissima* *(only video)*	*Coccotylus truncatus* *Furcellaria lumbricalis* *Rhodomela confervoides*	-

At two video transects single kelp specimens were visible (Figure 5-12), but density was far below 10 % cover. Although the ability of species identification with video is limited, the brown seaweed *Saccharina latissima is* the only kelp species, which forms stable populations at salinities typical at Kriegers Flak (HELCOM 2013).

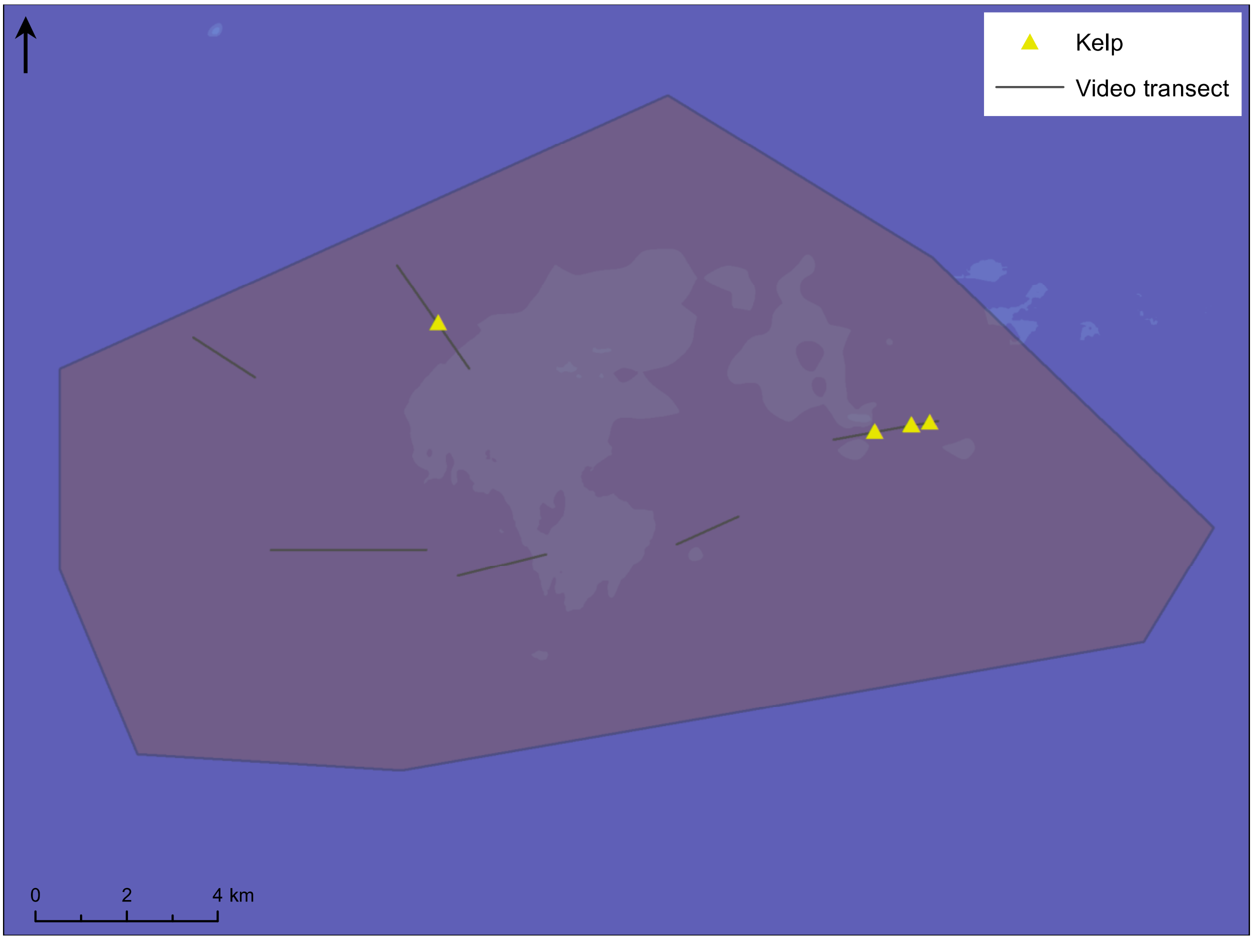


Figure 5-12 Kelp distribution (single specimens) at Kriegers Flak.

5.3.2 Cable corridor

Macrophyte communities did only occur at the nearshore end of the cable corridor from the landfall and down to a water depth of 15 metres (Figure 5-13) since the substrate type (sand) or water depths (below 20 m) in the remaining part of the corridor did not allow to maintain dense macrophyte assemblages.

At the vegetated nearshore part, the sediment was covered by suitable hard substrate for algae on 10-70 % of the area around the eight sampled stations. Macrophyte cover was up to 80 % on the suitable substrate. The suitable substrate consisted of stones, most of them with a diameter of 10-60 cm. At four stations, chalk stones were present but these are not regarded suitable substrate for perennial algae. Because of the comparably low salinity in the area and frequent natural events of chalk resuspension from the sediment, the species richness was not high. The main species were the red algae (Table 5-2) dominated by the robust *Polysiphonia fucoides* and *Furcellaria lumbricalis*. The brown alga *Saccharina latissima* only occurred sporadically in the deeper part of the nearshore area (stations 105 and 108, and in the video).

Table 5-2 Macrophyte species composition at the cable corridor.

Green seaweeds (Chlorophyta)	Brown seaweeds (Phaeophyta)	Red seaweeds (Rhodophyta)	Higher plants (Magnoliophyta)
Chaetomorpha melagonum *Cladophora rupestris*	*Ectocarpus siliculosus* *Saccharina latissima*	*Ahnfeltia plicata* *Ceramium rubrum* *Coccotylus truncatus* *Delesseria sanguinea* *Furcellaria lumbricalis* *Hildenbrandia* spp. *Membranoptera alata* *Phymalithon* spp. *Polysiphonia fucoides*	*Zostera marina*

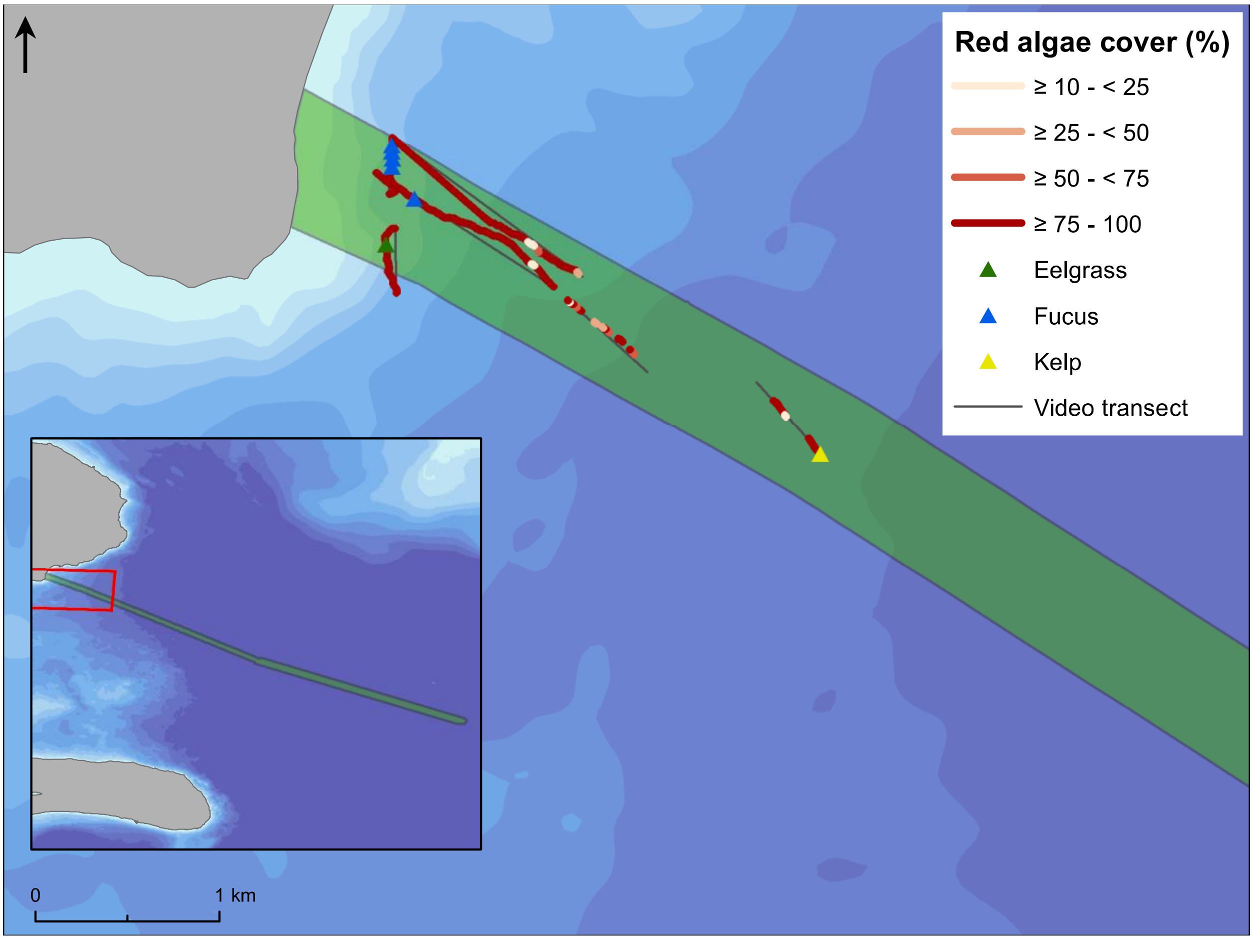


Figure 5-13 Macrophyte distribution at the cable corridor.

5.4 Benthic Habitats

The basis for the delineation of the benthic habitats is the sediment distribution as presented by Rambøll (2013) and GEO (2104). Figure 5-14 to Figure 5-16 show the respective results. All sediments consisting of mainly sandy substrate, including minor gravel or pebble fractions, were classified as sandy habitats. Silty, clayey and mud sediments were classified as muddy habitats. All remaining sediment types had a varying degree of larger grain sizes and boulders (with typically less than 25 % coverage) and where classified as mixed substrate habitats.

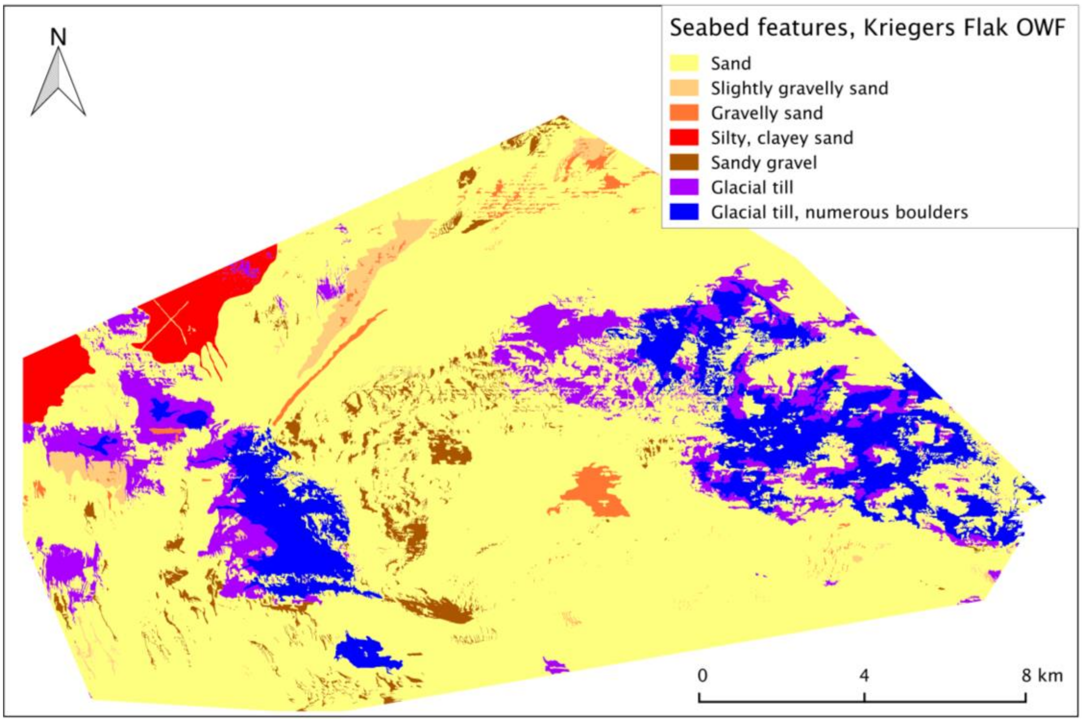


Figure 5-14 Seabed features at Kriegers Flak OWF (Rambøll 2013).

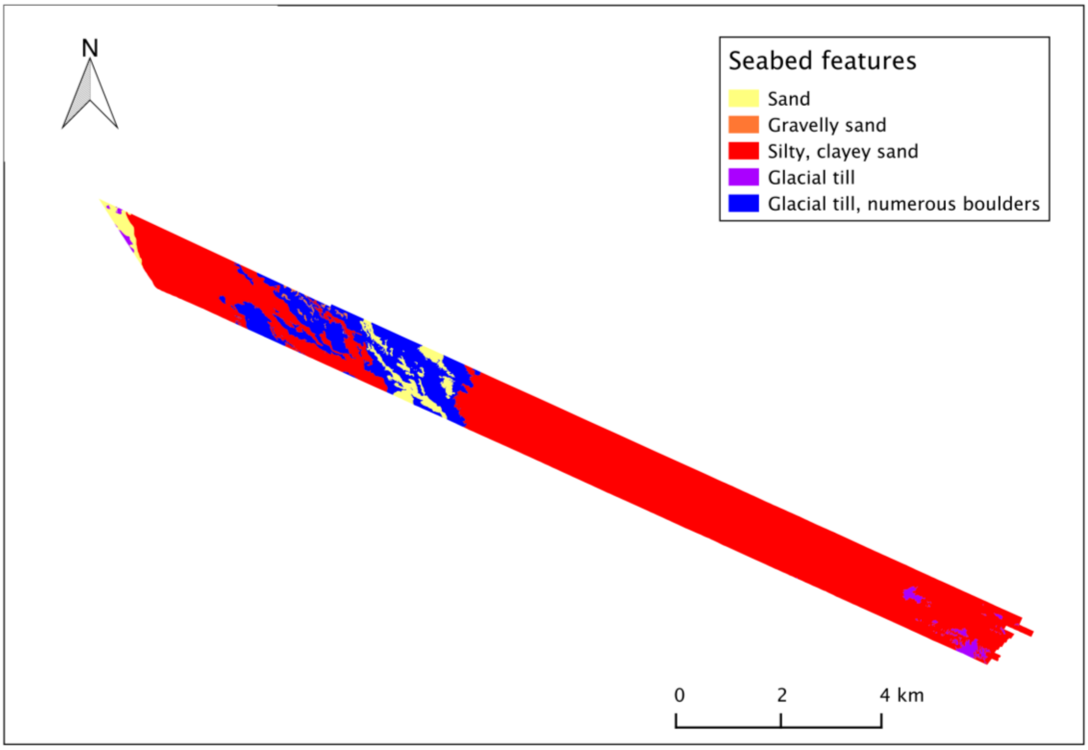


Figure 5-15 Seabed features at the eastern part of the cable corridor (Rambøll 2013).

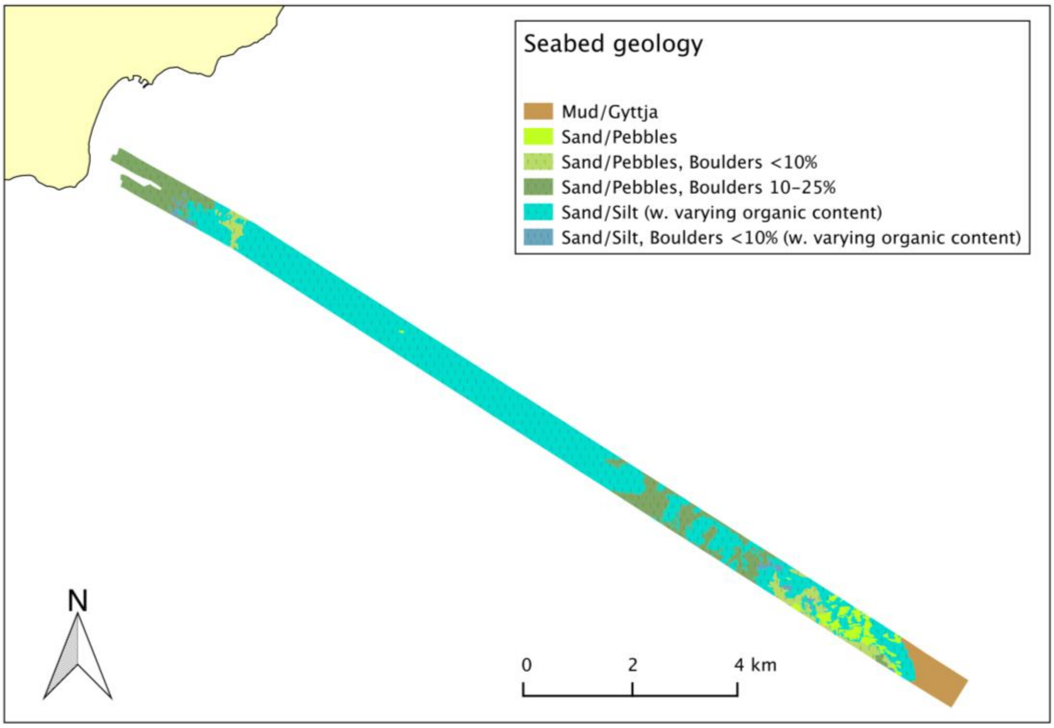


Figure 5-16 Seabed geology at the western part of the cable corridor (GEO 2014).

5.4.1 Kriegers Flak

Benthic habitats at Kriegers Flak (Figure 5-17) were all characterised by infaunal benthic communities. Even in areas where boulders are available (mixed substrate) epibenthos was not able to form a stable community or the epibenthos was only distributed in such a small area (e.g. Station 15) that it was not characterising the habitat in an ecological sense.

The largest part of Kriegers Flak was characterised by sand with infauna. Abundance and biomass were varying strongly, but the infaunal bivalves *Macoma balthica* and *Mya arenaria* were dominant in terms of biomass and represent at least 50 % of the fauna biomass in the sandy bottoms.

The habitat mud with *Macoma balthica* was restricted to the deepest parts of Kriegers Flak at the north-western corner. Beside *Macoma balthica* the polychaetes *Terebellides stroemi* and *Ampharete baltica* together with priapulid worms were characteristic for this biotope. But the bivalve *Macoma balthica* was dominant in terms of relative biomass.

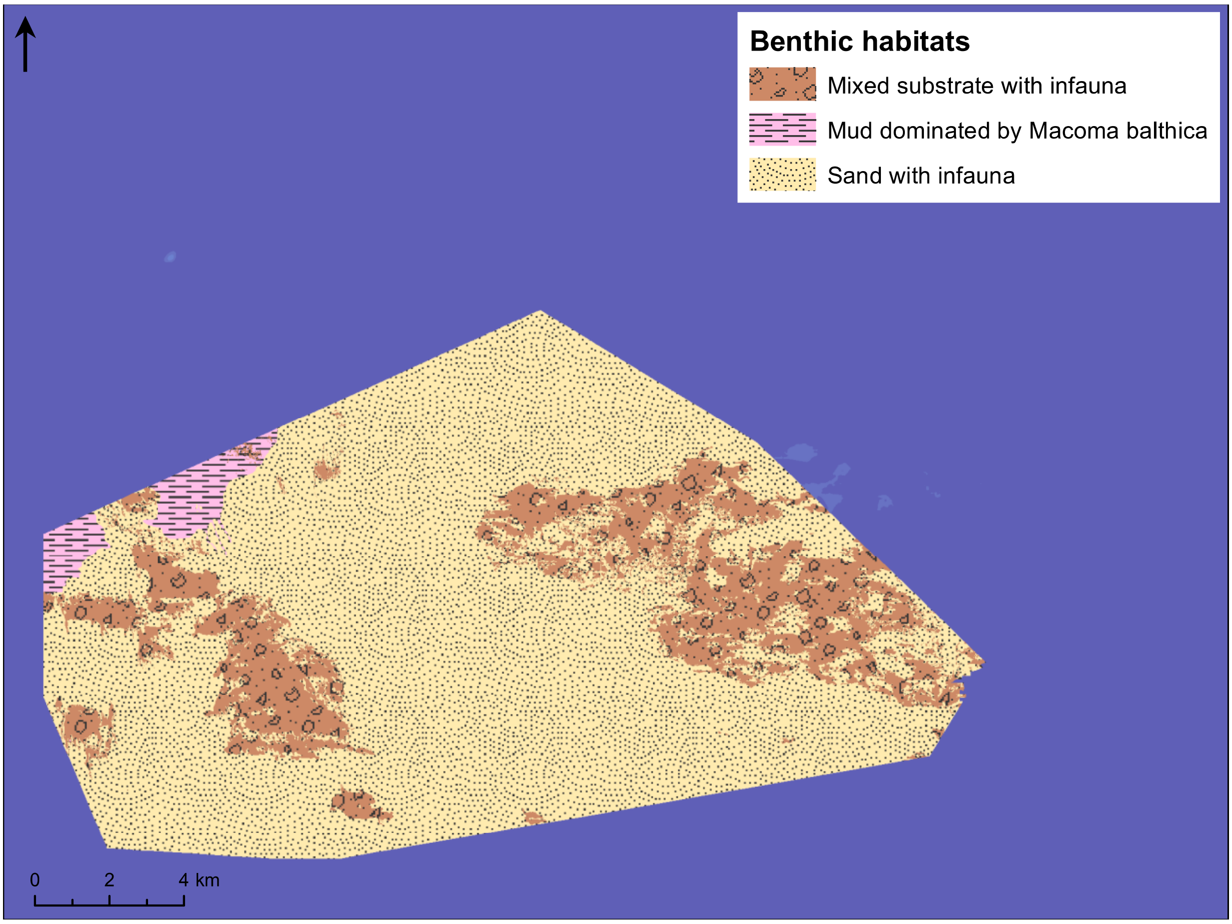


Figure 5-17 **Benthic habitats at Kriegers Flak.**

5.4.2 Cable corridor

Benthic habitats at the cable corridor (Figure 5-19) were (spatially) dominated by infaunal benthic communities. The largest part was thus characterised as "Mud dominated by *Macoma balthica*", occurring at the deepest part of the cable corridor.

Sand with infauna was distributed mainly between the deep muddy area and the shallow habitat with algae. The mud snail *Peringia ulvae* and the polychaetes *Scoloplos armiger* and *Pygospio elegans* were dominant in this habitat. Epifauna like the blue mussel did only sporadically occur, otherwise the sediment was only inhabited by infauna.

In the remaining areas, the mixed substrates were based on a sandy substrate that also contained larger grain sizes besides sand (pebbles to bouders) in varying densities, but always below 25 % cover. However, epibenthos was not able to form a diverse community on the hard substrates and the soft bottoms still dominated. These areas were subsequently assigned to the habitat "Mixed substrate with infauna".

Just off the coastline, dense perennial macrophyte vegetation was found on the available hard substrate. The sediment was sandy or consisted of chalk and included pebbles and up to 25 % boulders (according to the geophysical survey, GEO (2014)). The diver groundtruthing revealed an even higher coverage with smaller stones (typically between 10 and 60 cm in diameter and with a coverage up to 70 %). In the deeper parts of that area, blue mussels became increasingly abundant (Figure 5-18). The area as a whole is heterogen and comprises both algae on hard substrate, soft bottoms with infauna and blue mussels on hard substrate. These biotopes are spatially intertwined and functionally belong to the same ecosystem. The area is thus classified as biotope complex “reef” since it corresponds to the definition and interpretation of the habitat type “reef” of the EU Habitats Directive and includes a stone coverage above 25 %. The area is also comparable to the reef areas in the adjacent Natura 2000 site “Stevns Rev”.

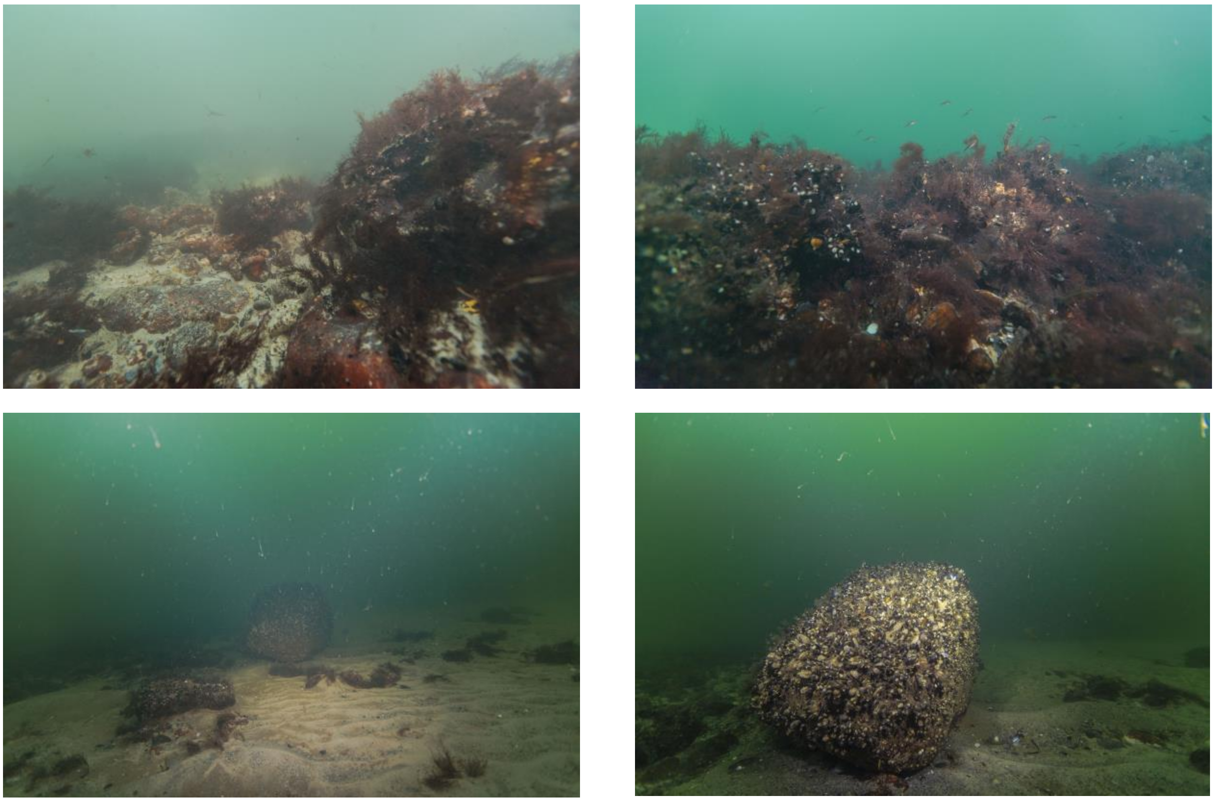
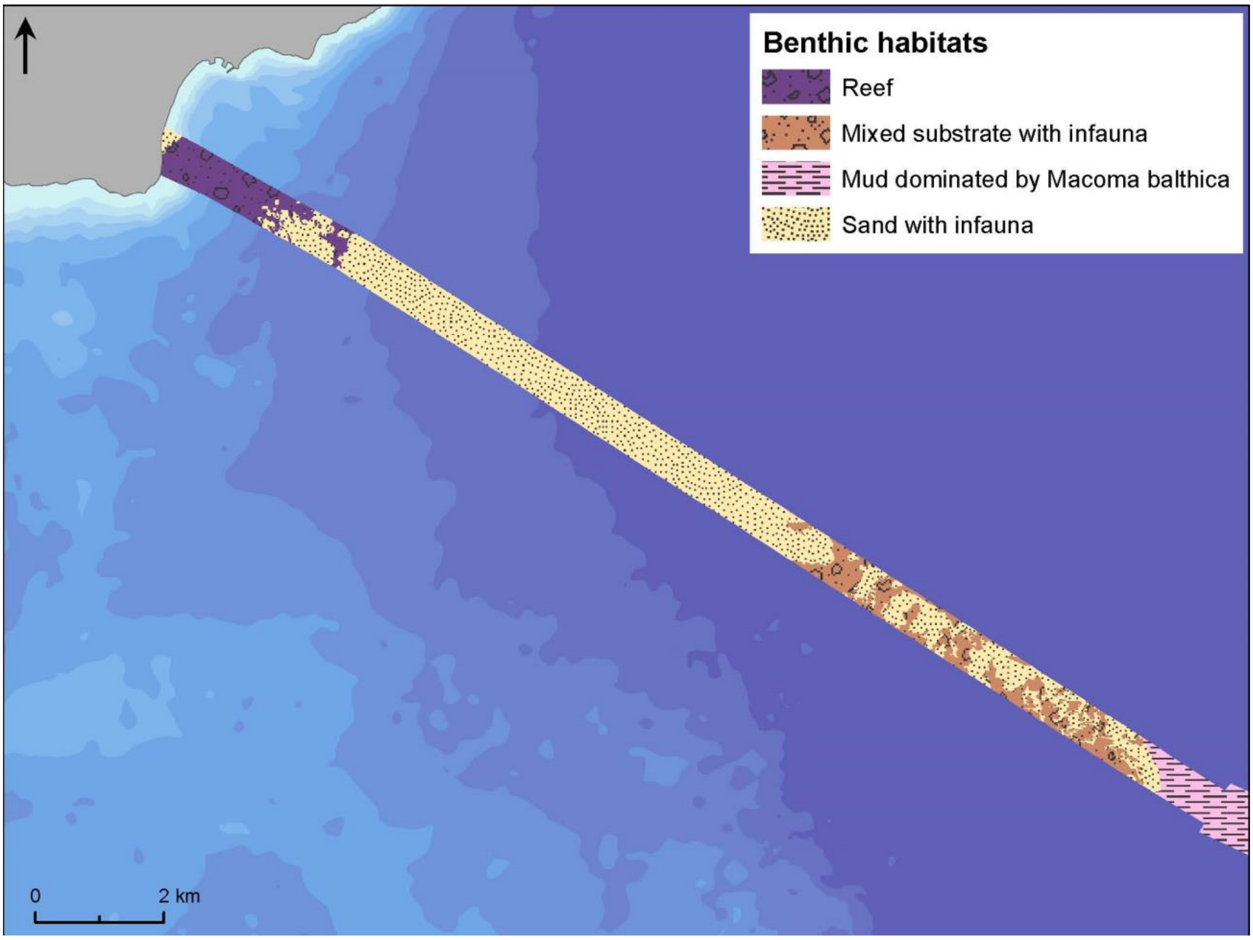


Figure 5-18 **Examples of the biotopes forming the biotope complex “Reef” in the shallow area near the landfall (upper row: Hard substrate dominated by algae; lower row: Sandy sediments and mixed substrate with in- and epifauna).**


Benthic habitats
Reef
Mixed substrate with infauna
Mud dominated by Macoma balthica
Sand with infauna
0
2 km

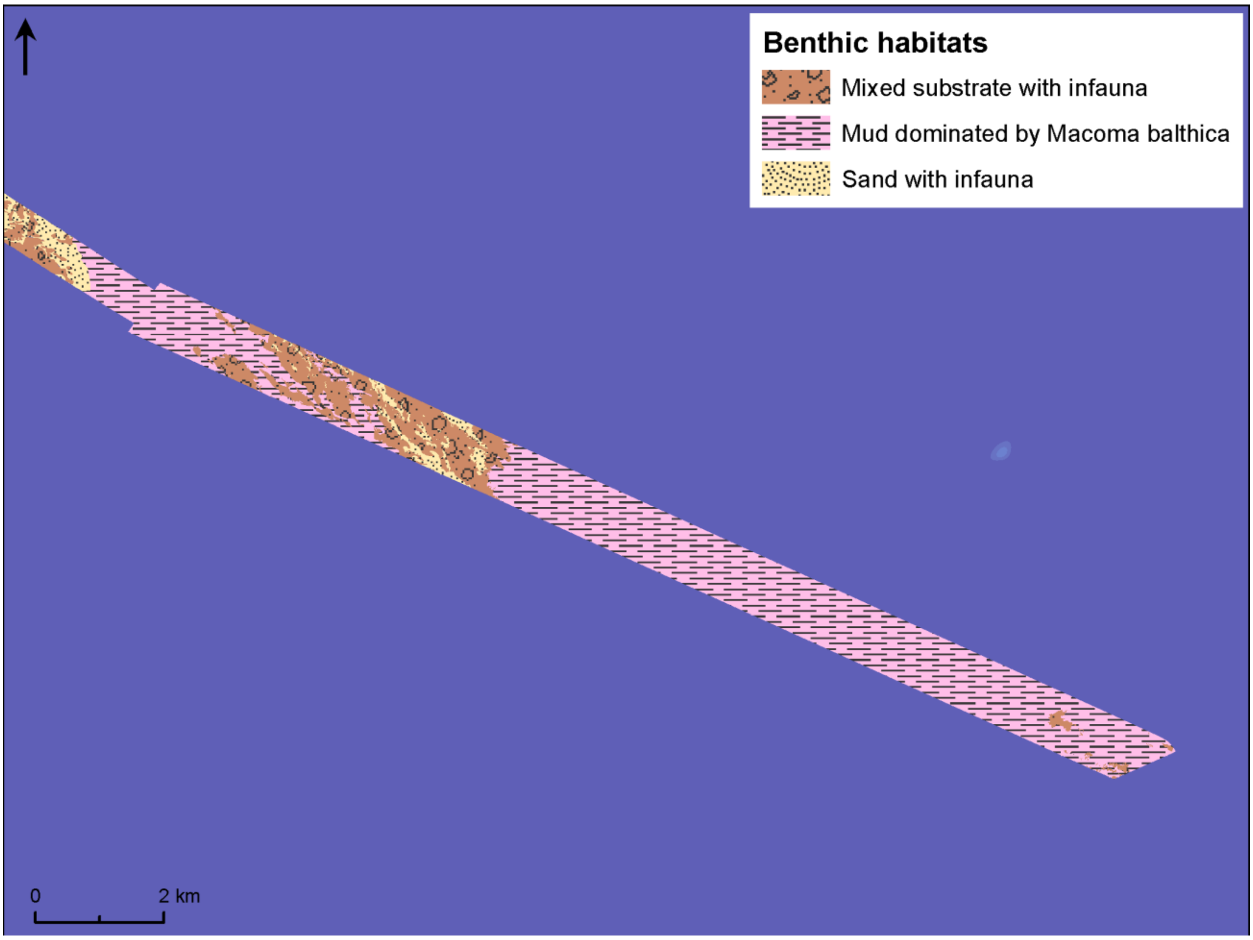


Figure 5-19 Benthic habitats at the cable corridor.

6 Description of project pressures and potential impacts

6.1 Project activities and pressures

All activities during the three phases of the project (construction, operation, decommissioning) can cause pressures that potentially impact certain elements of the marine environment. This report focuses only on the activities and pressures that can affect benthic flora, fauna and habitats. For this purpose, all possible activities and their subsequent pressures on the benthic environment are derived from the technical project description (see section 3) and listed in Table 6-1. While activities during the construction and decommissioning phase have a limited duration, the pressures during the operation phase can be considered as being permanent (lasting over the entire period).

Table 6-1 List of activities and pressures on benthic flora, fauna and habitats during the three project phases, based on the technical project description.

Project phase	Project activity	Resulting pressures
Construction	Turbine installation	Suspended sediments Sedimentation Footprint Nutrients Solid substrate Toxic substances
Construction	Installation of submarine cables	Suspended sediments Sedimentation Footprint Nutrients Toxic substances
Construction	Installation of substations	Suspended sediments Sedimentation Footprint Nutrients Solid substrate Toxic substances
Operation	None, only structure-related sources	Solid substrate
Decommissioning	Removal of turbines	Footprint Solid substrate
Decommissioning	Removal of submarine cables	Suspended sediments Sedimentation Footprint Nutrients Toxic substances
Decommissioning	Removal of substations	Footprint Solid substrate

The following pressures from Table 6-1are not relevant for the benthic environment:

Nutrients: As an indirect effect of sediment spill by e.g. dredging or excavation activities, nutrients buried in the sediments can be released into the water column and increase the nutrient concentration in the water. According to the investigation of nutrient concentrations (i.e. nitrogen and phosphorus) in the sediment (NIRAS 2014), the sediments at Kriegers Flak have a very low content of nutrients. Mean values measured were 0.6 gm^{-3} nitrogen and 0.3 gm^{-3} phosphorus. Compared to typical values in the water column of 0.25 gm^{-3} total nitrogen and 0.015 gm^{-3} total phosphorus (annual means according to HELCOM (2009), corresponding to 18 and 0.5 µmol l^{-1} respectively) and due to the fact that less than 10 % of the nutrients in the sediment are biologically available, these values are negligible and do not have an effect on benthic flora and fauna organisms. Consequently, this pressure is not considered further in this report.

Toxic substances: Toxic substances can either be released from the seafloor sediment during e.g. dredging and excavation activities and thus have an effect on benthic organisms (indirect pressure), or they can be part of the treatment of project structures as paint, grout or other substances and be dissolved into the seawater and thus affect benthic organisms (direct pressure). Based on an investigation done in connection with the Øresund Bridge, the concentrations of toxic substances in the sediment of the Kriegers Flak area are so low, that no effects are expected (WaterConsult 1993). The EIA for sand extraction at Kriegers Flak (Femern 2013: chapter 24) also concluded that all concentrations of harmful substances are below the threshold values given by OSPAR and below the Danish lower action values ("nedre aktionsværdi").

Grout is not considered a problem for the marine environment (see section 3.2.5.3). The use of protective paint or metal spray on the project structures can have a toxic effect depending on the product and amount used. No numbers exist on the amount of paint or spray to be used (compare section 3.2.5.1). Nonetheless, possible effects will be very local and constrained to the surface of the project structure. Thus, toxic substances on the structure are likely to prevent settling of benthic organisms but are not considered to affect the existing benthic communities on the seafloor. Consequently, this pressure is not considered further in this report.

The following sections describe in more detail the remaining four relevant pressures from Table 6-1 and the impacts they can have on the benthic flora, fauna and habitats.

6.1.1 Suspended sediments

During the construction phase, sediment will be spilled due to activities involving dredging and excavation. The spilled sediment is dispersed to the surrounding areas by currents and stays in the water column as suspended sediments until it settles on the seafloor. It may, after sedimentation, be re-suspended again by waves and currents.

The spatial range of the increased concentrations of suspended sediment and the concentration itself depends on the amount and characteristics of the spilled sediment and the hydrographical conditions (i.e. current direction and speed). Small particles have the lowest settling velocity and are therefore transported further away (beyond the direct activity zone) than larger particles which typically settle inside or very close to the zone of activity.

6.1.1.1 Possible impacts of suspended sediments

Benthic flora

The impact of increased concentrations of suspended sediment on **macrophytes** is indirect. An increase in suspended particles in the water reduces the light availability for photosynthesis. Reduced light availability may decrease production and thus the slow down the build-up or even reduce the biomass of the benthic flora.

Natural values of suspended sediment concentrations along the Danish coasts are between 1 and 5 mgl^{-1} in depths between 3–12 m (Femern 2013). In order to harm the macrophytes, concentrations above 5–10 mg/l^{-1} must be maintained at least more than a few days, otherwise all macrophytes are able to sustain their normal activity without losing biomass or viability.

Benthic fauna

The impact of increased concentrations of suspended sediment on **benthic fauna** is direct. In general, suspension feeders such as mussels and other bivalves, barnacles or tunicates are sensitive to high concentrations of suspended sediments because the solids can dilute their food (i.e. phytoplankton), cause mechanical clogging of the filtering apparatus and overload it. Thus high concentrations of suspended sediments can lead to reduced growth rates and even to a reduction of the biomass. Depending on the concentrations, an increased mortality rate can be the result if the duration of the pressure is long compared to the typical turnover of body mass for a specific species and individual. Deposit feeders are less sensitive to increases in suspended sediments.

When the duration of the event with increased concentrations of suspended sediments is less than a few days, an increased mortality is not expected (Essink et al. 1989, Lisbjerg et al. 2002) regardless of the sediment concentration. Events with concentrations below 10 mgl^{-1} will also not affect benthic fauna since this value is a typical natural background concentration that all organisms are exposed to regularly. Values between 10 and 50 mgl^{-1} result in a low degree of disturbance when the duration is less than a month (Purchon 1937). Sensitive suspension feeders show reduced growth rates because of starvation and use more energy cleaning the filtering apparatus needed for feeding (Navarro & Widdows 1997, Velasco & Navarro 2002).

The Blue Mussel *Mytilus edulis* as the most important filter feeder of the Kriegers Flak subarea, is insensitive to increased concentrations of suspended sediments and only begins to show reduced growth rated when exposed to concentrations above 30 mgl-1 for a long time (more than 7 days).

6.1.2 Sedimentation

Spilled sediment in suspension will eventually deposit on the seabed and accumulate there. This sedimentation process depends on the amount and characteristics (grain size) of the sediment spilled and the hydrographical conditions (i.e. current direction and speed).

6.1.2.1 Possible impacts of sedimentation

Benthic flora

For macrophytes, sedimentation may lead to physical stress as sediment on the thallus of the plant reduces the active surface area for photosynthesis and nutrient uptake (Lyngby & Mortensen 1996). A reduction of primary production, growth (Santelices et al. 1984) and, if physical stress is too severe, an increased mortality rate (Airoldi 2003 and references therein) are the consequences. Sedimentation can also affect recruitment of macroalgae, layers of sediment on hard bottom are known to reduce attachment of spores and survival and growth of juvenile plants (Devinny & Volse 1978, Chapman & Fletcher 2002, Umar et al. 1997, Eriksson & Johansson 2005).

In general, sediment layers less than 2 mm thick and staying on plants for less than 10 days are considered as having no effect. These values also occur in nature and the species are adapted to such conditions. Layers of up to 1 cm can affect recruitment if they occur during reproduction phases but they do only cause a low degree of disturbance for the adult algae (plants attached to hard substrate). Flowering plants like eelgrass occurring in shallow waters are also adapted to layers of up to 1 cm if the sedimentation event is shorter than 10 days.

Benthic fauna

Effects of sedimentation on benthic fauna will vary depending on sedimentation rates, depth of deposition, previous life history of the community and structure of the habitat. The possible impacts range from a decrease in the viability of species to lethal events that destroy the benthic communities. The broad range in between these two extremes is the sub-lethal sedimentation that can alter the functional stability of a community through the alteration of food supply and physical structure of the habitat (Lohrer et al. 2004). Adverse effects of even moderate sedimentation may appear when sedimentation takes place over longer periods. Re-structuring of the community may also be a result of sedimentation caused by the retreat of mobile species that do not favour the adverse conditions, or by increased predation of infauna organisms forced to approach the sediment surface if the oxygen supply in the sediment becomes obstructed (e.g. in tubes of polychaetes). Sedimentation of mud on a diverse sand flat community will presumably have a more severe effect than the same sedimentation on a low-diverse mudflat community adapted to a silt/clay habitat (Gibbs & Hewitt 2004). Series of individual sedimentation events in short intervals can prolong the recovery time and induce cumulative effects. On the other hand benthic fauna communities may quickly recover from single sedimentation events under favourable conditions.

Net sedimentation below 3 mm is not considered having adverse effects using a conservative approach (Gibbs & Hewitt 2004), regardless of the sedimentation rate (including instantaneous sedimentation). All benthic fauna organisms are able to either escape from these events or to adjust burrowing depth accordingly. Also feeding is not affected noteworthy (Miller et al. 2002). Beginning with sedimentation thicknesss of a few centimetres effects have been observed on e.g. the bivalves *Macoma balthica* and *Mytilus edulis* (Essink 1999; 10 cm burial), the polychaete *Streblospio benedicti* (Hinchey et al. 2006; > 5 cm burial) or the snail *Peringia ulvae* (Chandrasekara & Frid 1998; 5 cm burial).

6.1.3 Footprint

All solid structural elements of the project placed on the seafloor are footprints and as such typically destroy the benthic flora and fauna beneath. When the footprint is temporary, as is the case for the spud cans of jack-up barges or cable trenches, the benthic community can recover and re-establish after the impact has ceased. In the case of permanent footprint, i.e. for the wind turbine and substation fundaments, the benthic communities are also permanently lost.

6.1.3.1 Possible impacts of footprint

Benthic flora and fauna

The immediate impact is typically the death of the organisms under the footprint area. This must be assumed under the spud cans because they penetrate at least 2 m into the sediment. However, during dredging, excavation or jetting activities, benthic organisms can survive when the displacement is done without direct physical destruction and not includes deep burial. Nonetheless, the benthic habitat area is always initially removed from the footprint area and is thus not available any more.

The recovery time, after a temporary structural footprint has been removed or the seabed is able to naturally fill in and re-establish, depends on the life cycle and reproduction abilities of the organism, the character of the remaining sediment and the time it takes to re-establish natural abiotic conditions in the footprint area. This can range from a few months for short-lived opportunist species (e.g. *Pilayella littoralis* or *Capitella capitata*) to years and decades for slowly growing and long-living species (e.g. *Zostera marina* or *Arctica islandica*). This will be assessed individually when the different impacts are treated in sections 7–9.

Permanent footprint can lead to the loss of habitats in a region when the footprint is large enough and many (spatially) small-scaled habitats are affected. This decreases habitat diversity and is often followed by the reduction of species diversity within the region.

6.1.4 Solid substrate

All kind of solid material from the project structure like stones, rock, gravel, concrete or steel is regarded solid substrate. Part of this substrate is biologically available and benthic organisms can settle and grow on the solid substrate.

6.1.4.1 Possible impacts of solid substrate

Benthic flora and fauna

The solid substrate itself is living space for benthic organisms that live attached to a solid surface, like all macroalgae or benthic fauna like *Mytilus edulis*, *Balanus*, tunicates, bryozoans and others and can therefore be the basis of an artificial reef. The type of the colonization depends on hydrographic parameters like water depth (light availability for flora, food availability for fauna), currents and waves (exposure) and also the salinity. As such, additional solid substrate has a positive effect in terms of species richness and diversity. If the area, where the solid substrate is placed, also naturally is a hard substrate habitat, there is even no change in the benthic habitat. On the other hand, if solid substrate is placed into soft bottom benthic communities which naturally lack hard substrates, the consequence is a shift in the habitat type and a subsequent change of the species inventory for that area. The increasing biomass due to the hard bottom community (both flora and fauna) also increases the input of organic matter into the surrounding soft bottom fauna community (e.g. faeces and mud particles). This can give rise to a shift in the abundance distribution or even species composition, stimulating the occurrence of species adapted to a higher content of organic matter in the sediment. This effect is, however, a local one and restricted to the vicinity of the solid substrate and also depends on the amount of solid substrate and the hydrographical conditions (water depth and currents).

6.2 Worst case scenarios

Based on the pressures described in section 6.1, two principal solutions of the project are assessed using the worst case scenario. This is done using either 3 MW or 10 MW wind turbines only. Thus, the assessment also covers other possible solutions within that range of turbines that will potentially result in impacts between the magnitudes of the impacts from the 3 and 10 MW solutions. This distinction is only relevant for the wind turbines in Kriegers Flak subarea, not for the export cable subarea.

All structural parts of the OWF that have the largest footprint, i.e. the highest consumption of seafloor that is either temporarily or permanently lost, are being regarded as worst case. The area of the footprint is permanently lost seabed that is not inhabitable anymore by the original benthic community and where the benthic habitat thus changes completely. Also scenarios with the highest amount of temporary footprint, e.g. through placing spud cans or from dredging the cable corridor, are being regarded as worst case, since regeneration of the pre-impact habitat takes potentially long time (several years).

All project structures that are installed aided by activities causing the largest amount of suspended sediments and subsequent sedimentation (e.g. excavation, dredging, jetting) are being regard as worst case. These pressures have a spatial extent exceeding the area of activity and can potentially affect benthic habitats far away from the source of activity.

The placement of stones and rock as scour protection is not regarded as having a decisive effect on the choice of a worst case. These hard substrates can even be regarded as having a positive (reef) effect in areas where hard substrate occurs naturally. Stones constitute a 3-dimensional structure and offer many ecological niches, thus supporting a large biodiversity.

The following sections derive the worst case scenario for each of the relevant pressures described in section 6.1. These worst cases are assessed in the sections 7 to 9 for the individual project phases for which they are relevant.

6.2.1 Suspended sediments

With respect to the wind turbines and the substations on Kriegers Flak, a concrete gravity base foundation will cause the largest amount of sediment to be removed and thus be the worst case (see section 3.2.2.3). This foundation requires the removal of the upper sediment layer until a depth of undisturbed sediment. A back-hoe excavator is used for this purpose and causes spill of sediment throughout the whole water column. The sediment spill model described in NIRAS (2014) evaluates this scenario for 3 MW wind turbines and estimated that the spill has the same magnitude when using 10 MW wind turbines since the maximum amount of sediment to be removed is similar per individual fundament. The results of this scenario are consequently used in the assessment of impacts on the benthic environment and taken from NIRAS (2014).

Submarine cables can be installed either by excavation, ploughing or jetting (see section 3.4.2.1). Jetting will result in the largest sediment spill since all the removed sediment potentially is brought into suspension above the seafloor. Also, pre-trenching using an excavator is planned. The worst case in terms of suspended sediment is that the complete excavated/jetted material is spilled. The corresponding spill model results from NIRAS (2014) are used for the assessment.

6.2.2 Sedimentation

As for suspended sediments (see previous section), also the amount of sedimentation is depending on the amount of sediment being removed or displaced from the seafloor. Thus, the worst case scenario for suspended sediments is also the worst case for sedimentation. Consequently, concrete gravity base foundations for wind turbines and substations and jetting plus pre-trenching using excavators for submarine cables are regarded here and the impact assessed on the basis of the corresponding results from NIRAS (2014).

6.2.3 Footprint

6.2.3.1 Wind turbines

Both the 3 MW and the 10 MW wind turbines need to be considered. Table 4-1 shows the total footprint including scour protection for the different wind turbine fundament types outlined in section 3.2. The numbers are based on the assumption that the total power of 600 MW from the OWF is produced by either 200 (+3) individual 3 MW turbines or 60 (+4) individual 10 MW turbines. The largest footprint is thus consumed by driven steel monopiles consuming a total of 304,500 m^2 (0.12 % of the OWF area) of the seafloor using 3 MW turbines and 147,200 m^2 (0.06 % of the OWF area) using 10 MW turbines consumed by a concrete gravity foundation (including scour protection).

Tabelle 6-1 Amount of footprint including scour protection consumed by the wind turbine foundations, based on the numbers from the technical project description (ENDK 2014, see also section 3.2).

Turbine fundament type	Amount of footprint for 3 MW turbines (m^2)	Amount of footprint for 10 MW turbines (m^2)
Driven steel monopile	304,500	128,000
Concrete gravity foundation	223,300	147,200
Jacket foundation	142,100	102,400
Suction bucket foundation	< 223,300	< 147,200

6.2.3.2 Inter-array and export cables

Pre-trenching of cable trenches will result in the temporary loss of benthic habitat. Irrespective of the type of pre-trenching (excavation, ploughing, jetting) it is expected that a cable trench will be 0.5 m wide. In addition to this, it is assumed that if jetting or ploughing is used as the worst case for sedimentation, also the adjacent regions of the cable trench will be lost as habitat since most of the material (average depth of trench: 2 m) will deposit right beside the trench when jetting is used, or will be pushed/shoved to the sides of the trench when ploughing is used, thus burrowing the original seafloor under a thick layer of sediment. Consequently, as a conservative assumption, a habitat loss with a width of 1 m is used as the worst case footprint on all cable corridors.

6.2.3.3 Offshore substations

Two HVAC platforms are used. A gravity based structure (either hybrid or GBS) has the largest footprint because of the caisson used to serve as fundament including a scour protection around the structure (see section 3.3). The worst case is thus two HVAC platforms with each having maximum 1,704 m^2 footprint including scour protection (caisson of 21x24 m and scour protection of max. 1,200 m^2). This results in a total footprint area of 3,408 m^2.

6.2.3.4 Spud cans

Spud cans are used to keep jack-up barges in place during installation of wind turbines and substations. The spud cans of each vessel have a footprint area of 350 m^2 (see section 3.1). As a worst case, the employment of two vessels per wind turbine is assumed: one barge for the installation plus one supporting barge. This means a footprint area of 700 m^2 per wind turbine and per substation being installed.

6.2.4 Solid substrate

Regarding the wind turbines, driven steel monopile foundations generate the largest footprint on the seafloor. It is assumed that there is not much difference in the actual surface area of the different piles or lattices of the wind turbine foundation types that stretch from the seafloor to the surface of the water. Also, their surface area is small compared to the area of the footprint at seafloor level. Therefore, this part of the structure is ignored in the assessment. For the foundation as the remaining part of the structure, the area of footprint is considered to also be the area of solid substrate, resulting in a total area of solid substrate of 304,500 m^2 for 3 MW wind turbines and 147,200 m^2 for 10 MW wind turbines. Thus, 304,500 m^2 is the worst case.

Regarding the substations, gravity based foundations generate the worst case since these will be constructed using larger areas for scour protection. Corresponding to the scenario described in section 6.2.3.3, the caisson of the HVAC substation fundament has a surface area of 21x24x16 m resulting in available solid substrate of 8,064 m^2 per platform plus 1,200 m^2 area of scour protection, a total of 9,264 m^2. As two HVAC platform are planned, the overall total solid substrate area would result in 18,528 m^2.

7 Impact assessment for the construction phase

7.1 Kriegers Flak

7.1.1 Suspended sediments

The sediment spill model (NIRAS 2014) describes the processes of the sediment being suspended in the water column during the construction phase and documents the expected impact of the suspended sediments in terms of their spatial and temporal concentrations in the impacted area using 3 MW turbines on a gravity foundation (see also section 6.2.1). This includes the installation of turbines and inter-array cables. In the bottom layer (below 15 m water depth) the time where the concentration exceeds 10 mgl-1 has a maximum value of 27 hours (out of the total construction period used in the model of 238 days). According to the threshold values derived in section 6.1.1.1, this is not regarded a disturbance. Also, the area where the exceedance time is over 24 hours is 1,944,250 m2 large, which is 0.78 % of the Kriegers Flak area and the affected area is partly outside the actual investigation area (

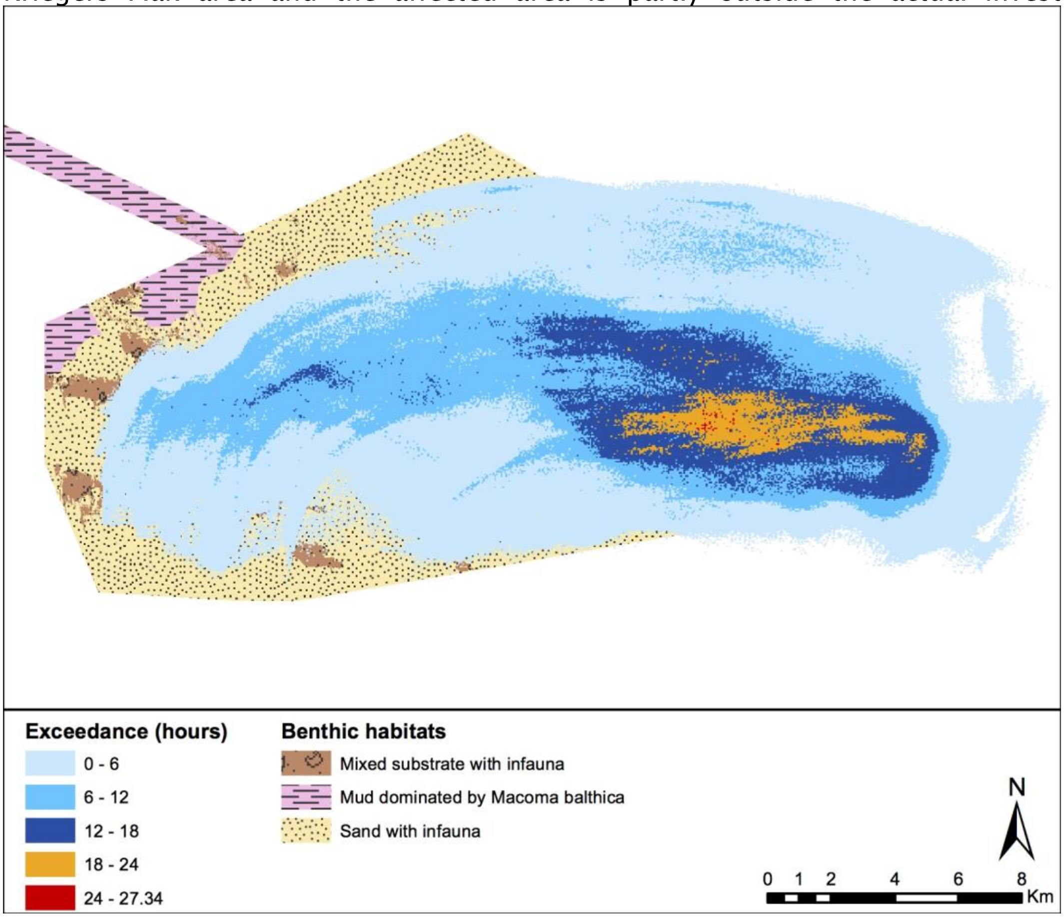


Figure 7-1).

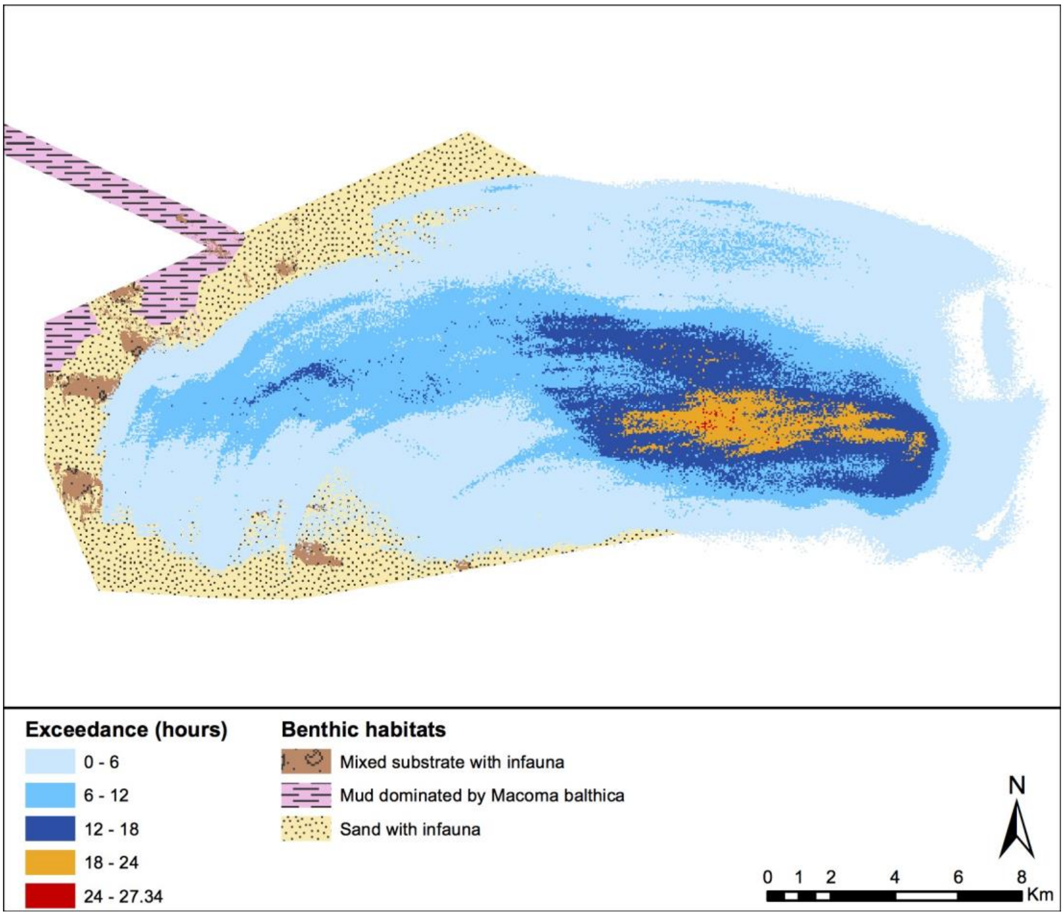


Figure 7-1 **Exceedance time of a suspended sediment concentration of 10 mgl^{-1} in the bottom layer of the water column below 15 m water depth. Maximum value found in the area = 27 hours (NIRAS 2014). This scenario reflects the installation of 3 MW turbines on gravity foundations, the substations and the inter-array cables.**

The events with suspended sediments are thus occurring with a very short duration which all benthic organisms are adapted to. In extreme cases, where the concentration of suspended sediments is very large (over 100 mgl^{-1} but still with a duration of under half an hour), filter-feeding fauna might stop feeding for this period. This does, however, not affect their viability so there will be no impact.

7.1.2 Sedimentation

The sediment spill model (NIRAS 2014) describes the processes of the sedimentation after events causing suspended sediments in the water column during the construction phase of 3 MW turbines on gravity foundations and the inter-array cabling (see section 6.2.2). The model derives the expected impacted area defined by the simulated spatial and temporal distribution of sedimentation and thicknesses. The net sedimentation at the end of the construction phase (i.e. 238 days as used in the spill model) is largely below 50 mm (Figure 7-2). Only an area of 60,000 m^2 show thicknesses of over 50 mm. 22,500 m^2 are inside the "Sand with infauna" habitat and obviously tied to the excavation for the fundament of a substation platform. The remaining 37,500 m² are outside the investigation area east of Kriegers Flak and may indicate a deeper zone which acts as a sediment trap. Most of the sediment seems to be trapped in that area too, since there is a larger area around the 37,500 m² with sedimentation thicknesses above 10 mm.

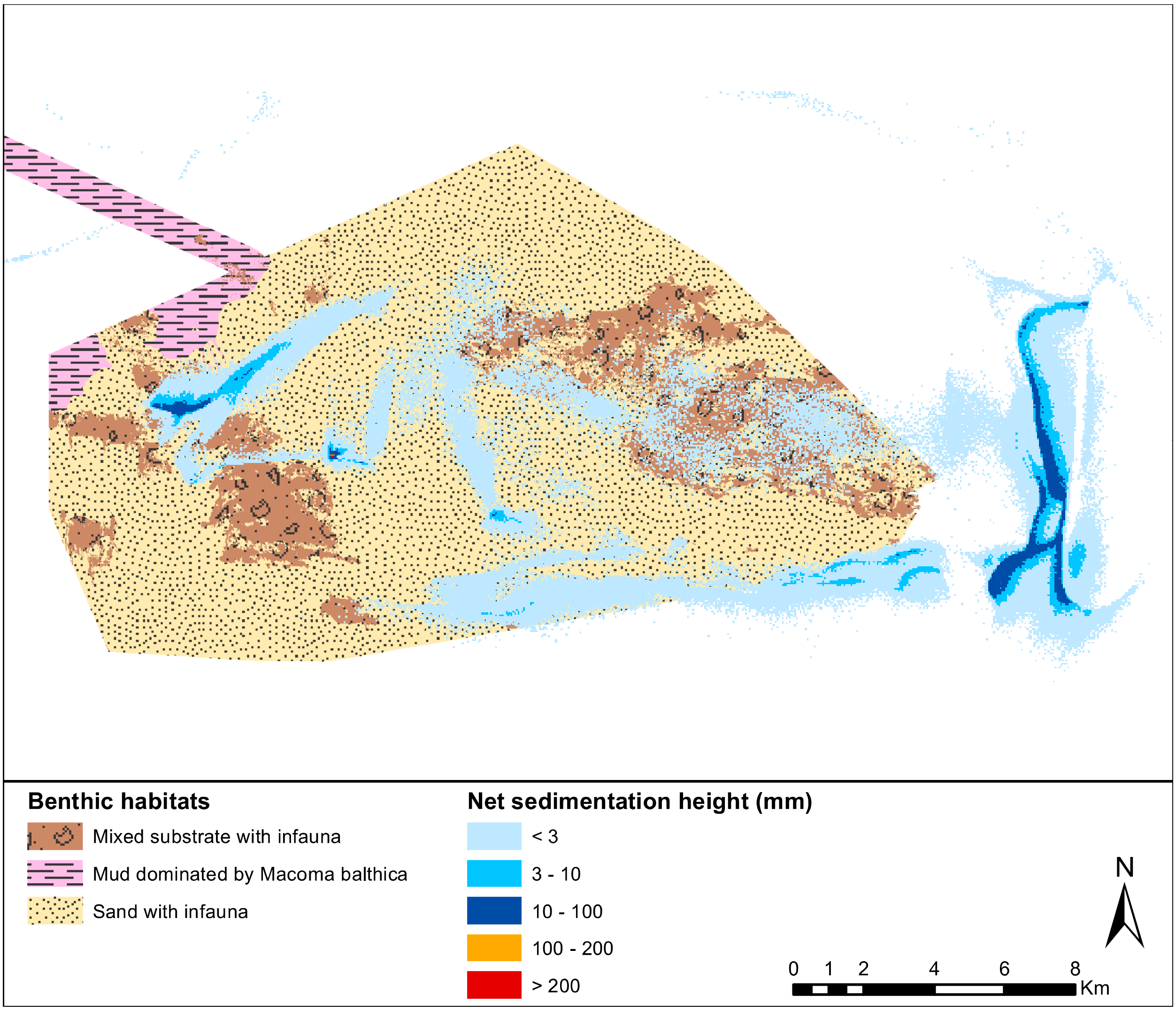


Figure 7-2 **Net sedimentation thickness at the end of the construction phase. Maximum value found in the area = 1840 mm in one single model cell, otherwise maximum of 180 mm (NIRAS 2014). This scenario reflects the installation of 3 MW turbines on gravity foundations, the substations and the inter-array cables.**

Most of the Kriegers Flak area (approx. 99 %) is undisturbed and shows net sedimentation thicknesses below 3 mm. Nonetheless, areas with net sedimentation above 3 mm do not immediately mean a disturbance of the benthic communities. The sediment accumulates during the whole construction phase and besides the sedimentation thickness, the rate of the sedimentation is decisive for the degree of disturbance. The typical maximum sedimentation rate during installation of a single wind turbine is shown in Figure 7-3. The model shows that the maximum sedimentation rate over a period of 130 minutes is 0,18 mm min^{-1}.

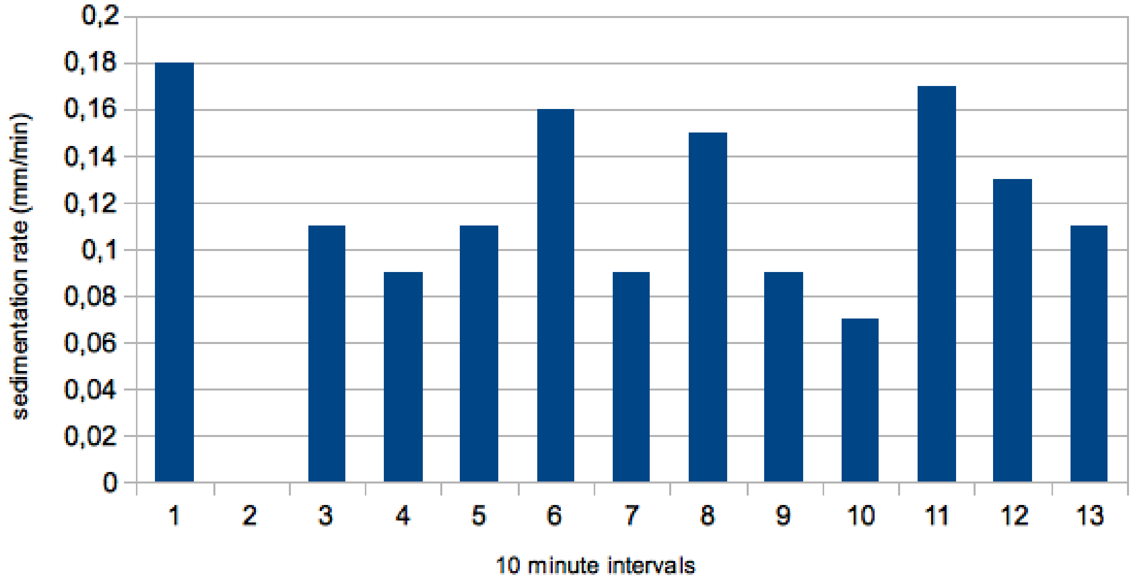


Figure 7-3 **Time series of sedimentation rate during installation of a representative single 3 MW wind turbine (gravity based foundation) on Kriegers Flak OWF. Each bar represents the maximum sedimentation rate (in mm/min) observed in the 50x50 m model cells with sedimentation (NIRAS 2014).**

During these two hours and without resuspension, a sediment layer of maximum 14.6 mm would accumulate (inside the 50 x 50 m model cell), roughly corresponding to an accumulation of 1–2 mm per 10 minutes. The model results, however, show that in the region on Kriegers Flak where the sedimentation rates in Figure 7-3 are taken from, the net sedimentation thicknesses at the end of the construction period is only 0.58 mm. Accordingly, a large portion of resuspension must happen and the sediment is spread across a larger region than just directly near the excavation site.

Still, in approx. 1 % of the Kriegers Flak subarea a noticeable sedimentation takes place. If the sedimentation follows the same pattern as outlined above, effects will be observed there, mainly a reduction in the viability of the species for a short time (less than a month).

Conclusion

99 % of the Kriegers Flak subarea displays less than 3 mm net sedimentation over the construction phase. Therefore, a disturbance of benthic organisms can be excluded in this part of the area. In 1 % of Kriegers Flak, the sedimentation is larger but still has a short duration. Where larger sedimentation rates occur (up to 2 mm per 10 minutes), resuspension takes place and spreads the sediment after the initial sedimentation event, reducing the net sedimentation thickness. Consequently, a low degree of disturbance is judged to affect the benthic habitats.

As a result of the local importance and short duration of the impact, a negligible magnitude of impact is concluded (Table 7-1).

Table 7-1 Assessment of magnitude of impact from sedimentation on Kriegers Flak during the construction phase.

Construction phase – Kriegers Flak – Sedimentation				
Degree of disturbance	**Importance**	**Likelihood of occurrence**	**Persistence**	**Magnitude of impact**
Low	Local	High	Short-term (0–1 year)	Negligible/None
Only approx. 1 % of Kriegers Flak is affected with sedimentation above the threshold value of 3 mm	Disturbance only affects the directly impacted area	Sedimentation is a certain consequence of physically disturbing the seafloor	Duration of pressure is in terms of one day per event	

7.1.3 Footprint

The wind turbines on Kriegers Flak will be placed partly in the "Mixed substrate with infauna" (size: 46,010,000 m^2) and partly in the "Sand with infauna" habitats (size: 197,340,000 m^2) (see section 5.4.1).

The footprint of the wind turbines on Kriegers Flak will amount to 304,500 m^2 for a 3 MW wind turbine solution plus 3,408 m^2 from the substations, a total of 307,908 m^2. For a 10 MW solution, the numbers will be 147,200 m^2 plus 3,408 m^2, a total of 150,608 m^2.

For 3 MW wind turbines, roughly a third of the wind turbines will be placed into the habitat "Mixed substrate with infauna" (see Figure 3-2). Consequently, approx. 101,500 m^2 of "Mixed substrate with infauna" and 203,000 m^2 of "Sand with infauna" will permanently be lost. This is equivalent to 0.2 % and 0.1 % of the respective habitat area on Kriegers Flak. For 10 MW wind turbines, the corresponding numbers are 0.1 % and 0.05 % respectively.

These losses are negligible in comparison to the total area and do not have any effect on the distribution of soft and hard substrates and their inhabiting communities. Also, no effect on biodiversity is expected, since all species are distributed over their complete habitat area without hotspots or other sensitive areas. Inside the "Mixed substrate with infauna", the footprint is even part of additional solid substrate that adds to the natural hard bottoms, thus supporting the local species diversity and abundance (see section 7.1.4).

During installation of wind turbines and substations, jack-up barges are used which fix themselves on the seafloor during installation of the project structures. For this purpose, spud cans are used with a footprint of 700 m^2 per wind turbine/substation (see section 6.2.3.4). For a 3 MW solution, the total temporary footprint of spud cans will thus amount 141,400 m^2 (200 wind turbines and 2 substations) and to 43,400 m^2 for a 10 MW solution (60 wind turbines and 2 substations). With the same distribution between the two affected habitats as above, this will result in values below 0.1 % of the respective habitat areas. Since these footprints are temporary, the impacted areas will re-establish their original habitat in the order of years. Only in places where stones have been pushed into the deeper sediment, no replacement for the lost hard substrate will be present after the disturbance ceases. On the other hand, new hard substrate is generated by the foundations of the wind turbines and substations, compensating manifold for this loss.

Another temporary footprint is resulting from the cable trenches. In total approximately 173.5 km of cable will be installed on Kriegers Flak for a 3 MW solution (NIRAS 2014). With a trench width of 1 m in terms of footprint decisive for benthic organisms (see section 6.2.3.2), this amounts to 173,500 m^2 temporary loss of habitat, distributed between the two affected habitats. This amount is in the same order of magnitude as the maximum temporary footprint from the spud cans (for a 3 MW solution). Potentially, the trenches are not so deep as the holes from the spud cans. Therefore, recovery is quicker and the probability that specimens survive the pre-trenching is much higher. None of the infauna species communities on Kriegers Flak have a very long recovery time, the longest being about 10 years for *Mytilus edulis*. Typical recovery times for the other species vary between two and five years. No significant macrophyte vegetation will be affected. However, different from the spud cans, the cable trenches are a spatially continuous structure, appearing throughout the whole construction area and cutting through the marine landscape. They are thus more likely to produce an effect on the habitats in terms of topography and may also hinder mobile benthic species to move freely from one region of the habitat to another. As a consequence, the degree of disturbance by cable footprint is regarded as being minor.

Conclusion

The wind turbines and substations of neither a 3 MW nor a 10 MW solution have a detectable degree of disturbance effect because the lost areas are very small compared to the existing area of the two affected habitats. The spud cans do cause temporary footprint that is of even smaller size that from the wind turbines and consequently are not able to create a detectable degree of disturbance for the area as a whole. Local loss of hard substrate can occur but is compensated by the introduced solid substrate of the project structures. The temporary footprint of cable trenches is in the order of magnitude as for the spud cans, with quicker recovery but cutting through the habitats completely and having a minor degree of disturbance despite their small overall area.

Consequently, using a conservative estimate, the magnitude of impact is minor (Table 7-2).

Table 7-2 Assessment of magnitude of impact from footprint on Kriegers Flak during the construction phase.

Construction phase – Kriegers Flak – Footprint				
Degree of disturbance	**Importance**	**Likelihood of occurrence**	**Persistence**	**Magnitude of impact**
Low Habitat loss is always less then 1 % of the respective habitat	Local Disturbance only affects the directly impacted area	High Every wind turbine will have a footprint	Permanent (> 5 years) The footprint is permanent, since the project structure is permanent	Minor

7.1.4 Solid substrate

Where the wind turbines are placed, the main natural benthic habitats of Kriegers Flak are partly "Mixed substrate with infauna" and partly "Sand with infauna" (see section 5.4.1). The character as an area that also contains boulders, stones and gravel as hard substrate is evident in the "Mixed substrate with infauna" habitat area. According to the recorded boulders during the geophysical survey, the total area of boulders and boulder clusters in the area is 247,010 m^2 distributed among 4,229 individually recorded objects. The median size of the objects is 1.28 m^2. Nearly all of these objects are located inside the "Mixed substrate with infauna" habitat (Figure 7-4). Besides these boulders, additional hard substrate comes from the smaller stones and from gravel down to a size of some few centimetres. This habitat has an area of 46,010,000 m^2 on Kriegers Flak (18 % of the total area). The video survey revealed that a maximum of 10 % of the habitat area typically is covered with hard substrate (see section 5.3.1), amounting to an area of 4,600,000 m^2.

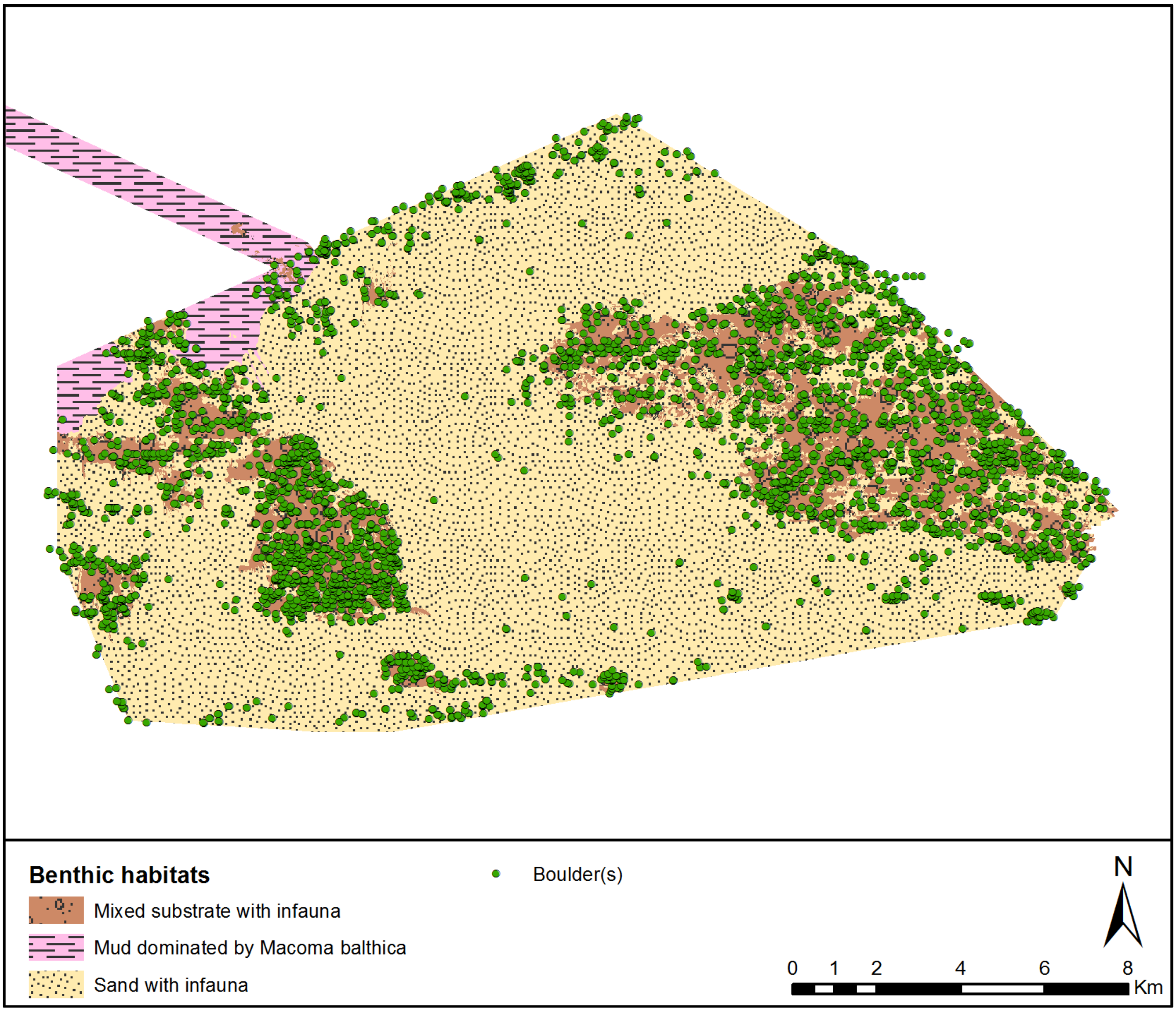


Figure 7-4 Boulder distribution on Kriegers Flak (including boulder clusters).

The amount of additional solid substrate that is being installed in terms of project structures on Kriegers Flak will amount to 304,500 m^2 for a 3 MW wind turbine solution plus 18,528 m^2 from the substations, a total of 323,028 m^2. For a 10 MW solution, the number will be 147,200 m^2 plus 18,528 m^2, a total of 165,728 m^2.

From these numbers and for 3 MW wind turbines, the amount of solid substrate added to Kriegers Flak is 7 % of the calculated hard substrate area on Kriegers Flak. Roughly two third of the turbines are planned to be placed in the soft bottom habitat which is lacking natural hard substrates (Figure 7-5). Compared to the total amount of sandy habitats (197,340,000 m^2), this is equivalent to a change of 0.1 % of sandy habitats into hard substrate habitats. These amounts do not change the character of the area or the principal distribution of soft and hard substrates and thus have no influence on the benthic fauna in the area as a whole. Local effects of increased organic matter are expected where the additional solid substrate is placed, but this effect will be restricted to the same small areas, especially since the bottom currents in the area typically are around 0.2 ms^{-1} and consequently are not able to transport organic matter over long distances.

Macrophyte vegetation is sparse on Kriegers Flak (see section 5.3.1) and the additional solid substrate at the seafloor will not stimulate macrophyte settlement and growth because the light availability is too low. However, the upper parts of the foundations located nearer to the sea surface will have the potential to be colonized by macroalgae and thus add to the species diversity in the area. Also, *Mytilus edulis* will settle on these structures and be in competition with the algae. Nonetheless, compared to the total amount of *Mytilus edulis* on the seafloor, this effect will be of no significance.

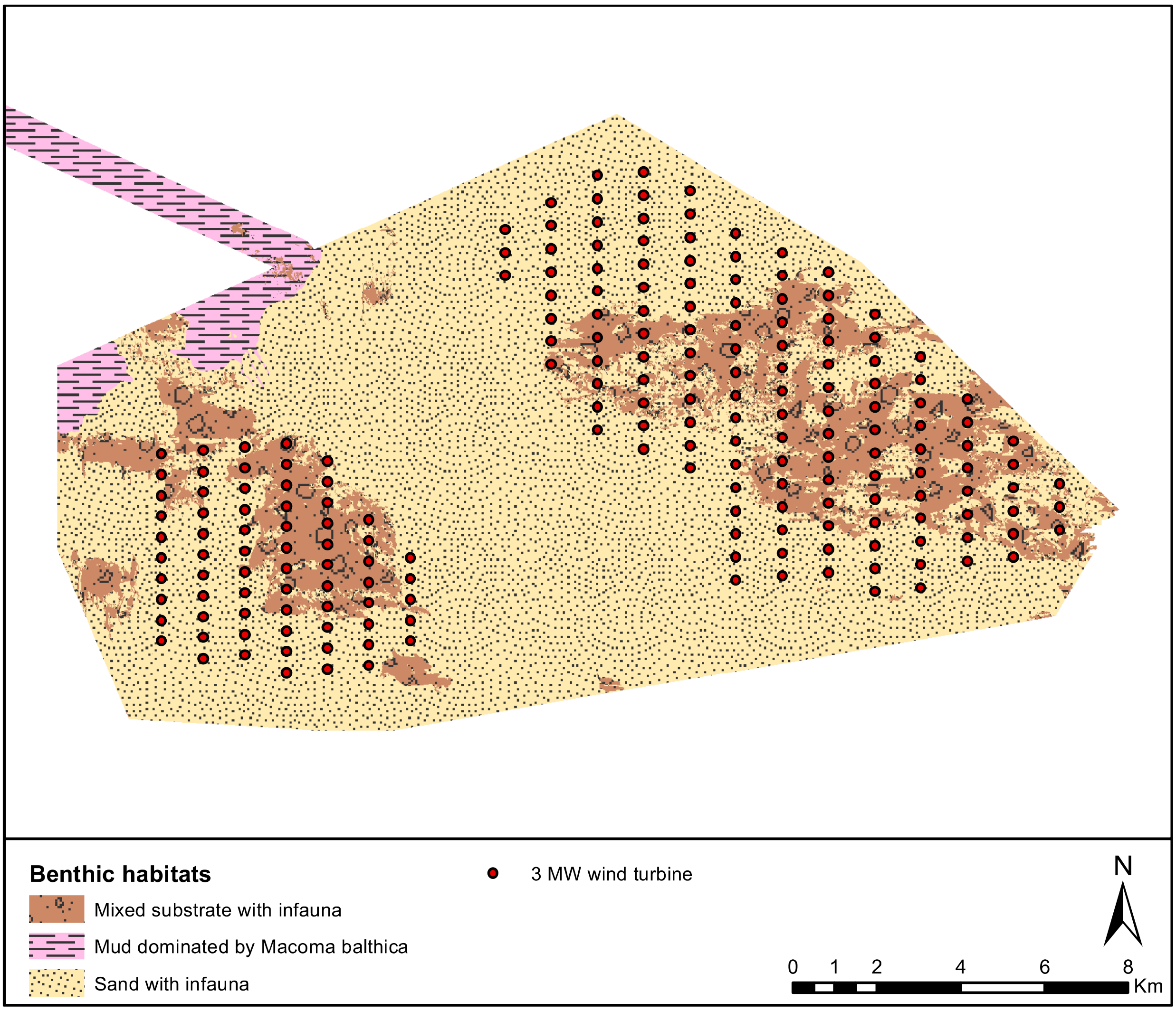


Figure 7-5 Placement example of 3 MW wind turbines on Kriegers Flak used in the impact assessment.

Conclusion

The wind turbines of a 3 MW solution have the largest local effect. Since the solid substrate area of a 10 MW wind turbine solution is even smaller, this solution has a negligible impact. The solid substrate area of the transformer platforms does play no measurable role for both solutions since their area is less than 1 % of the total natural hard substrate of the Kriegers Flak subarea. Thus, the additional solid substrate from the project structure has a non-existing (in the “Mixed substrate with infauna” habitat) to low degree of disturbance (in the “Sand with infauna” habitat) and the disturbance can not be regarded as being negative, since it supports overall species diversity in the Kriegers Flak subarea. The effect is restricted to the immediate area of introduction of the substrate and it will slowly establish throughout the construction phase, since colonization will start during the two-year installation of the wind turbines. Possible changes in oxygen concentrations will also be restricted to the area directly at the solid substrate. A higher oxygen demand is expected at the seafloor where the hard substrate fauna communities are forming and a higher oxygen production is expected where the algae are attached in the upper water column. However, this effect is very local and has no effect for the area as a whole since the amount of solid substrate introduced is only 7 % of the already colonized hard bottoms.

Consequently, using a conservative estimate, the magnitude of impact is minor (Table 7–3).

Table 7–3 Assessment of magnitude of impact from solid substrate on Kriegers Flak during the construction phase.

Construction phase – Kriegers Flak – Solid substrate				
Degree of disturbance	**Importance**	**Likelihood of occurrence**	**Persistence**	**Magnitude of impact**
Low Very small amounts of additional solid substrate compared to the natural amount	Local Changes in communities only directly where the solid substrate occurs	High All footprint will form solid substrate	Permanent Solid substrate is part of the permanent project structure	Minor

7.2 Cable corridor

7.2.1 Suspended sediments

The model results show that concentrations of suspended sediment above 10 mgl^{-1} do occur along the cable corridor (NIRAS 2014) and in a wide area beyond. The maximum concentration is 2083 mgl^{-1}, but concentrations above 50 mgl^{-1} are mainly restricted to the cable corridor itself and the nearshore shallower region north of the corridor (Figure 7-6). The duration of these events is below one day (24 hours) for the affected area during the construction phase used in the model of 27 days (Figure 7-7).

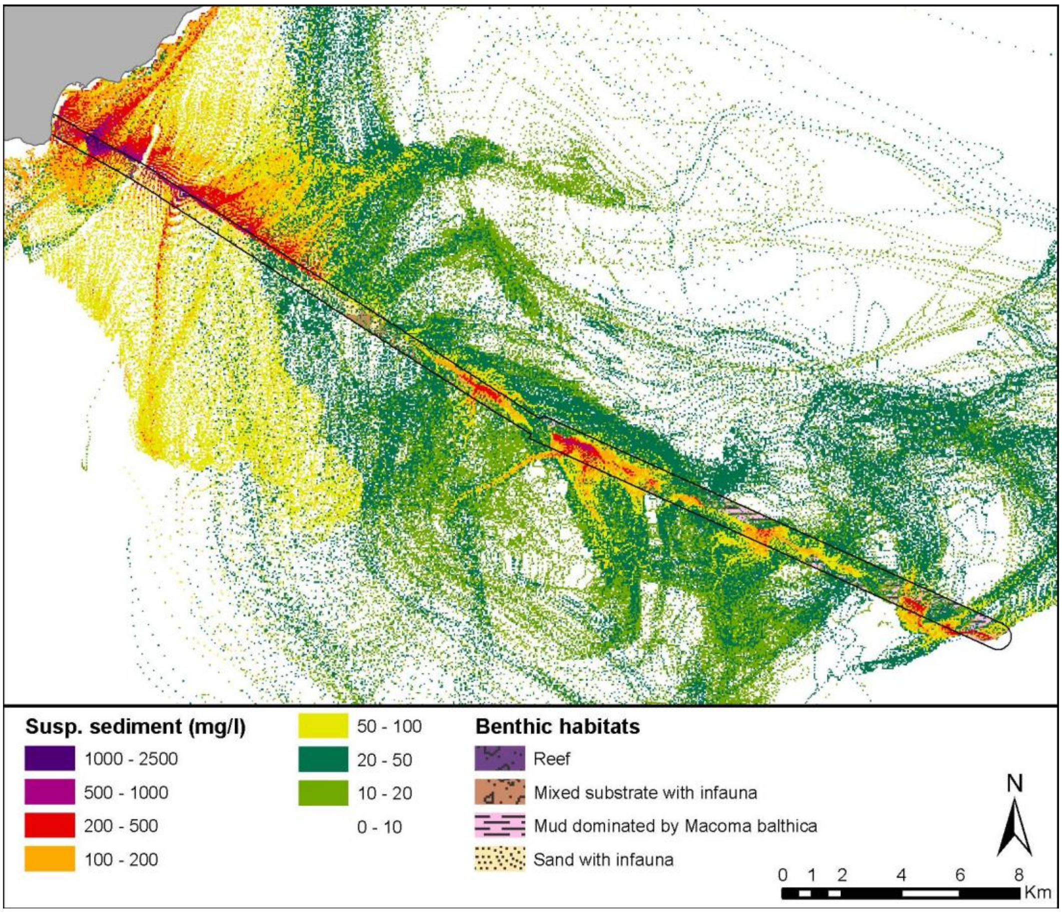


Figure 7-6 **Maximum concentration of suspended sediments along the cable corridor during the modelled construction phase of 27 days.**

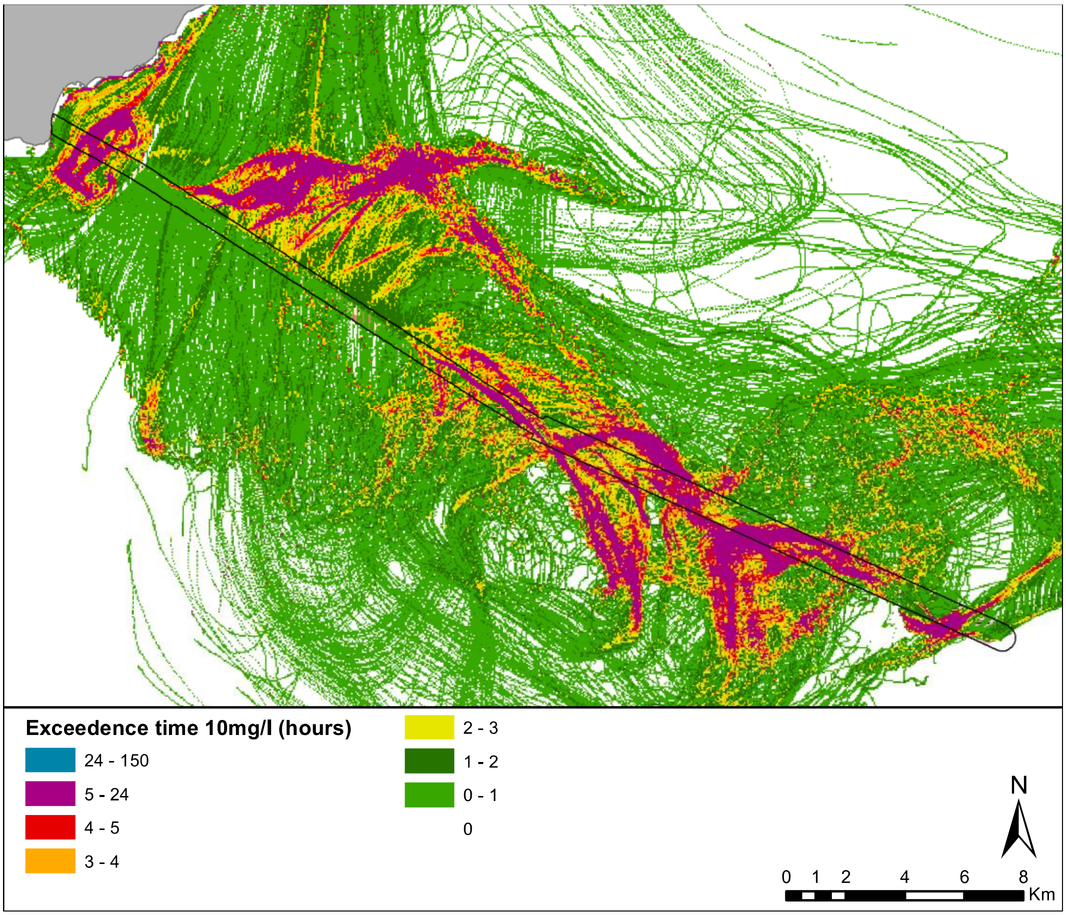


Figure 7-7 **Exceedance time of suspended sediments along the cable corridor during the modelled construction phase of 27 days.**

Accordingly, although high concentrations of suspended sediments occur, no part of the area is affected longer than a day and the typical values will be below 200 mgl^{-1} nearshore and below 100 mgl^{-1} offshore, lasting for less than 2 hours outside the cable corridor and up to a day within the cable corridor. This is regarded a low degree of disturbance since all organisms found in the area are adapted to those short periods of increased turbidity.

Table 7-4 **Assessment of magnitude of impact from suspended sediments along the cable corridor during the construction phase.**

Construction phase – cable corridor – Suspended sediments				
Degree of disturbance	**Importance**	**Likelihood of occurrence**	**Persistence**	**Magnitude of impact**
Low Only short events with high sediment concentrations	Regional The sediment spreads far beyond the actual cable corridor	High Increased turbidity is a certain consequence of physically disturbing the seafloor	Short-term (0–1 year) Maximum exceedance time is below 24 hours, installation of cable takes 27 days	Negligible/None

7.2.2 Sedimentation

The model results on the basis of the 50x50 m grid of the model show that the net sedimentation along the cable corridor is very small (NIRAS 2014). The majority of the area is affected by a net sedimentation below 2 mm which is below the threshold for a detectable disturbance. Within the cable corridor values above the threshold of 3 mm occur in an area of 2.26 km^2 very close to the modelled trench. This area amounts to 8.2 % of the total area of the cable corridor. North of the corridor, single spots near the coastline with a total of 27,500 m^2 are affected by net sedimentation above 3 mm (mostly below 10 mm) (Figure 7-8).

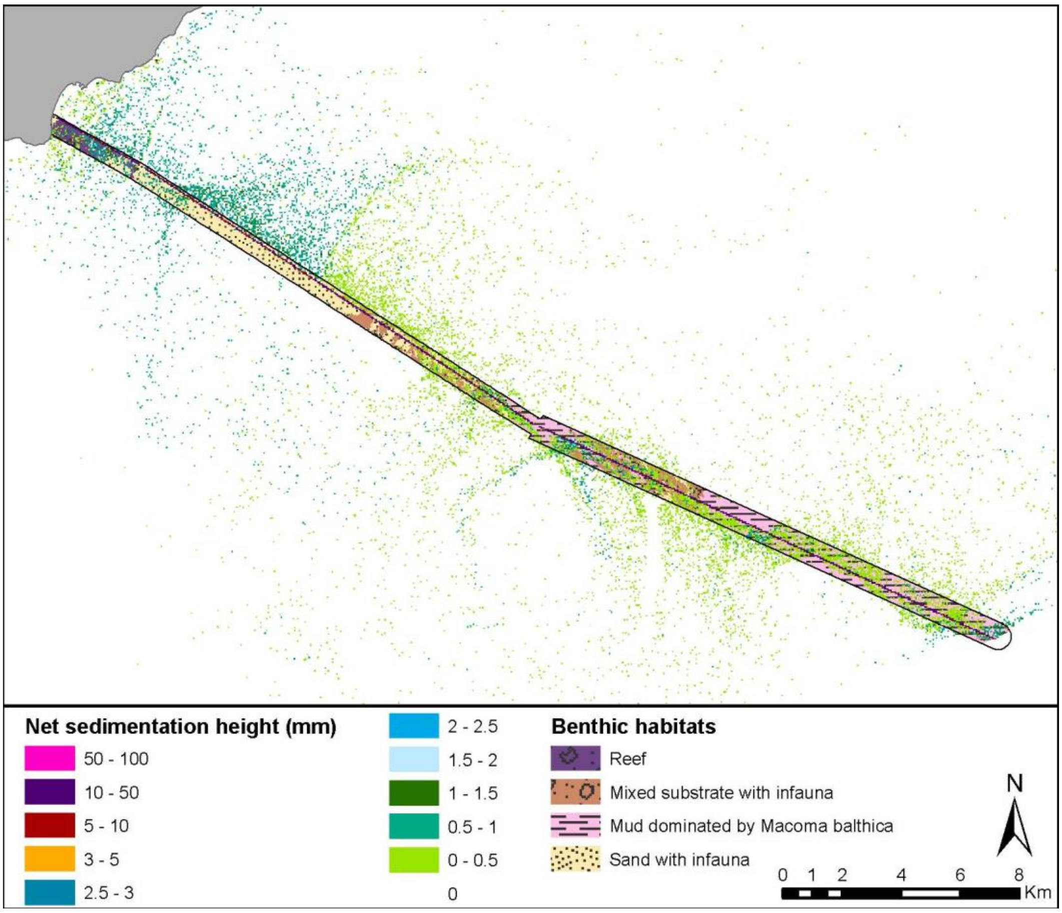


Figure 7-8 **Net sedimentation at the end of the modelled construction phase (27 days) along the cable corridor.**

The majority of the affected cable corridor area is in the "Mud dominated by *Macoma balthica*" habitat and the "Sand with infauna" habitat (see section 5.4.2). Mud areas are typically natural sedimentation areas and the fauna living in this habitat is adapted to continuous sedimentation. The dominating species *Macoma balthica* is able to move through a sediment layer of 320–410 mm (Powilleit et al. 2009) and is one of the most resistant species in the Baltic Sea. Since the maximum net sedimentation thickness is below 40 mm and in most of this habitat below 30 mm, the degree of disturbance on this part of the corridor is only low. The characteristic species of the "Sand with infauna" habitat are *Peringia ulvae* and the polychaetes

Scoloplos armiger and *Pygospio elegans*. All these species can tolerate the expected net sedimentation thicknesses within this habitat of mostly less than 20 mm (maximum 34 mm). Only a low degree of disturbance is expected here, especially since the affected area is small compared to the total habitat area.

In the “Mixed sediment with infauna” habitat, net sedimentation thicknesses are mostly below 30 mm (with a maximum of approx. 40 mm). Since this habitat is characterised by coarser grain sizes, the sediment surface will be covered by finer sand. This is regarded a local change of the habitat character. However, since the affected area is below 10 % of the total habitat area the degree of disturbance is still regarded as being low.

Macrophytes only occur in the nearshore part of the cable corridor within the “Reef” habitat. Where the algae occur, the sediment is not sand, but mixed and generally has a larger grain size, resulting in the spilled sediment to settle very close to the trench. Chalk sediment that is also present in the area, will go into suspension and settle over a much larger area (in very thin layers) and are discussed in section 7.2.1. Most of the affected area has a net sedimentation thickness below 20 mm (maximum 35 mm) which is a minor degree of disturbance for the reef. However, this amount of sediment can cause damage to juvenile and small macrophyte specimens and especially to propagules and shoots. The affected area is 11.6 % of the total habitat area and recovery will probably take a few years. Therefore the degree of disturbance is expected to be medium in this “Reef” habitat. It should also be noted that resuspension of the chalk seabed and introduction of new chalk material from the cliffs is natural in this area. Therefore, the organisms that are present in the reef area are adapted to such events and more sensitive species will typically not inhabit the area or be removed by these resuspension events.

Conclusion

Although the main part of the affected area only has a low degree of disturbance, the nearshore habitat complex “Reef” is expected to be disturbed with a medium degree. Using a worst case consideration, the overall degree of disturbance is taken to be medium also. In connection with an expected recovery time of less than 5 years and the locally restricted effect, the magnitude of the impact is considered minor (Table 7-5).

Table 7-5 Assessment of magnitude of impact from sedimentation along the cable corridor during the construction phase.

Construction phase – cable corridor – Sedimentation				
Degree of disturbance	**Importance**	**Likelihood of occurrence**	**Persistence**	**Magnitude of impact**
Medium Most of the area is affected to a low degree, but the nearshore reef habitat complex is affected to a medium dregree	Local The sedimentation is very close to the trench	High Sedimentation is a certain consequence of physically disturbing the seafloor	Temporary (1-5 years) Typical sedimentation thickness are up to 40 mm and it can take up to a few years for the affected habitat areas to recover	Minor

7.2.3 Footprint

The cable corridor is approx. 37 km long from the northern edge of Kriegers Flak to the shoreline close to Rødvig. With an estimated maximum width of the cable trench of 1.5 m and two parallel cables (see section 3.4.2), a temporary footprint of 111,000 m^2 is expected. Compared to the mapped area of 27,434,726 m^2 this is a fraction of 0.4 %. Since the benthic habitats described along the cable corridor (see section 5.4.2) are extending further than the mapped area, an even smaller part of the benthic habitats in the region of the cable corridor are temporarily lost. None of the infauna communities along the cable corridor have a very long recovery time, the longest being up to 5 years for *Macoma balthica*. Macrophyte vegetation will only be affected along a stretch of 3.1 km directly off the coastline. The main species here are *Polysiphonia fucoides*, *Furcellaria lumbricalis* and encrusting red algae, so recovery will accordingly take 5–10 years since e.g. *Furcellaria lumbricalis* is a slowly-growing species which reached maturity only after 4–6 years. In conclusion, a local effect with a low degree of disturbance is expected having a duration of 5–10 years. Consequently, this results in a negligible magnitude of impact (Table 7-6).

Table 7-6 Assessment of magnitude of impact from footprint along the cable corridor during the construction phase.

Construction phase – cable corridor – Footprint				
Degree of disturbance	**Importance**	**Likelihood of occurrence**	**Persistence**	**Magnitude of impact**
Low Footprint area is only 0.4 % of mapped area	Local Disturbance only affects the directly lost area	High Pre-trenching is required in order to bury the cables	Permanent (> 5 years) The footprint is temporary, since the cable trench will naturally refill, but recovery of the algae communities will take more than 5 (5–10) years	MinorNegligible/None

8 Impact assessment for the operation phase

During the operation phase, only the presence of turbines and their structure together with the scour protection is a factor to be evaluated. The only relevant pressure is solid substrate. The assessment is restricted to the Kriegers Flak subarea since solid substrate on submarine cables (nearshore) is ignored (see section 6.2.4).

Footprint is also not considered here since the footprint area of barges used for maintenance is very small compared to the total habitat area (around 0.1 %; compare section 7.1.3).

8.1 Kriegers Flak

8.1.1 Solid substrate

The solid substrate placed in the Kriegers Flak subarea during the construction phase (see section 7.1.4) will stay in place during the whole operation phase. At the beginning of the operation phase, colonization of the available parts of the solid substrate will not be finished yet since such colonization will take more than two years until a stable flora and fauna community has been established. During the first years of the operation phase, strong succession events can occur between the pioneer species (mostly annual and opportunistic species like annual brown and red algae, but also e.g. *Mytilus edulis*) and the local environmental conditions will determine which kind of hard bottom community finally will establish. Since most of the hard substrate on Kriegers Flak is colonized with *Mytilus edulis* (in terms of abundance and biomass), it is expected that this species also will dominate the introduced solid substrate at the seafloor. In the parts near the sea surface, also algae will grow and increase the local species diversity.

Conclusion

The additional solid substrate from the project structure will develop stable hard substrate communities over time that will stay during the whole operation phase. These communities will have a low degree of disturbance when located in the "Sand with infauna" habitat, and the disturbance will be restricted to the immediate vicinity of the wind turbines. The disturbance can not be regarded as being negative, since it leads to a higher overall species diversity in the Kriegers Flak subarea and does not change the character of the soft bottom areas, especially because the solid substrate placed into the soft bottom habitat only comprises about 0.1 % of the total soft bottom area. In addition, part of the scour protection is likely to sink into the sediment over time and thus not be available as hard substrate any more, reducing the amount of available solid substrate and thus reducing the degree of disturbance.

Consequently, the magnitude of impact is minor (Table 8-1).

Table 8-1 Assessment of magnitude of impact from solid substrate on Kriegers Flak during the operation phase.

Operation phase – Kriegers Flak – Solid substrate				
Degree of disturbance	**Importance**	**Likelihood of occurrence**	**Persistence**	**Magnitude of impact**
Low Only a very small amount of solid substrate is introduced	Local Changes in communities only directly where the solid substrate occurs	High All project structures are considered solid substrate	Permanent The project structure is permanent, consequently also the solid substrate	Minor

9 Impact assessment for the decommissioning

9.1 Kriegers Flak and cable corridor

9.1.1 Suspended sediments

During the decommissioning process, submarine cables will be removed by lifting them up from their buried position. This causes small amounts of increased suspended sediment concentrations around the cable. The magnitude of this effect is much less than during the construction phase because no excavation or pre-trenching is required. No concentrations above 10 mg l^{-1} are expected with a longer exceedance time than one day, based on the concentrations predicted for the more severe construction phase (see section 7.2.1). Hence, no impact is expected during the decommissioning process.

9.1.2 Sedimentation

Sedimentation can occur during the decommissioning of the submarine cables. The sedimentation is restricted to the immediate surrounding of the cable being lifted out of the sediment as it pushes the sediment aside. The disturbance will thus be minimal and most of the displaced fauna organisms will be able to relocate themselves into the sediment again. Locally, algae can be buried within the nearshore macrophyte habitat by turned over stones or by sediment. This is also a negligible effect since the coverage with stones and boulders is lower than 25 % and consequently the major part of the habitat is soft bottom. As a conclusion, no significant disturbance is expected from the sedimentation and the effect is expected to be negligible for the respective subareas as a whole.

9.2 Kriegers Flak

9.2.1 Footprint

The fundaments of wind turbines and substations will remain intact at seabed level. Also the scour protection will be left in place. As during the construction phase, spud cans from jack-up barges will produce holes in the sediment where the upper parts of wind turbines and substations are being removed. As for the construction phase, no detectable degree of disturbance is produced by the spud cans for the Kriegers Flak area as a whole.

The inter-array cables will be removed completely. This involves the reverse process as during the installation of the cables in the construction phase. However, the disturbance is expected to be much less since the cables are just lifted up from their position 1 m under the seafloor and no excavation or pre-trenching is required.

Consequently, no new significant disturbance in terms of footprint will be generated from the decommissioning process that has an impact on the character and distribution of the benthic species and habitats of the area as a whole.

9.2.2 Solid substrate

During decommissioning, most of the solid substrate is planned to be left in situ. This is true for the scour protection and the parts of foundations at seafloor level. Only the upper parts of the fundament (near the water surface) are definitely being removed.

When decommissioning begins after roughly 25 years of operation, stable hard bottom communities will have established on the solid substrate. Removing these reef-like structures will thus also remove the established hard bottom communities. This will lead to partly removing species diversity from the subarea. Especially the upper parts of the foundations near the sea surface will be removed and these are the parts that carry algae vegetation.

The degree of disturbance in the construction and operation phase is considered minor. Since not all solid substrate will be removed, the degree of disturbance during the decommissioning phase is less than during the two preceding phases. Nonetheless, as a conservative assessment using the worst case, the disturbance can not be neglected and is considered minor (see Table 9-1).

Table 9-1 Assessment of magnitude of impact from solid substrate on Kriegers Flak during the decommissioning phase.

Decommissioning phase – Kriegers Flak – Solid substrate				
Degree of disturbance	**Importance**	**Likelihood of occurrence**	**Persistence**	**Magnitude of impact**
Low Only a small change in the total amount of solid substrate will occur	Local Changes in communities only directly where the solid substrate occurs	High Removal of wind turbines is part of the decommissioning process	Permanent The removed solid substrate is permanently lost	Minor

9.3 Cable corridor

9.3.1 Footprint

The export cables will be removed completely. This involves the reverse process as during the installation of the cables in the construction phase. However, the disturbance is expected to be much less since the cables are just lifted up from their position 1 m under the seafloor and no excavation or pre-trenching is required.

Consequently, no new significant disturbance in terms of footprint will be generated from the decommissioning process that has an impact on the character and distribution of the benthic species and habitats of the area as a whole.

10 Impact on WFD and MSFD

The Water Framework Directive (WFD; Directive 2000/60/EC) aims at establishing a good ecological status of all European marine surface waters until 2016. The project is crossing the water body “Fakse Bugt” of the Danish coastal waters with submarine cables. Also, the outer water body “Åbne del, Fakse Bugt” is crossed but in this water body only the chemical status is relevant. Since no chemicals are released in significant amounts (compare section 6.1), there is no impact on that quality component.

Although a medium degree of disturbance has been assessed for the part of the water body “Fakse Bugt” where the cable is going to reach the shoreline and crosses algae habitats, this has no impact on the ecological status on water body level since only a very small fraction of the algae stock is affected (less than 1 %). Further, since no decrease of light availability is expected for more than a day during the excavation of the cable trench, no changes in the viability of the algae and no effect on the depth distribution will occur. Consequently, the project has no consequences for the implementation of the WFD in the project area.

The Marine Strategy Framework Directive (MSFD; Directive 2008/56/EC) aims at establishing a good environmental status of the European marine waters until 2020. The Kriegers Flak project involves the establishment of an OWF and an export cable in the Danish offshore waters which belong to the MSFD assessment unit of the Baltic Sea. Since no spatially far-reaching effects on the benthic environment are expected from the project (all effects are local to the area of the source of the disturbance), the project will have no consequence for the implementation of the MSFD in the Baltic Sea region in terms of the contribution of the benthic organisms to the environmental status.

11 Cumulative impacts

Five projects are to be considered as potentially having cumulative impact on the Kriegers Flak project

11.1 Femern sand extraction area

The sand extraction area is located in the centre of Kriegers Flak between the western and eastern part of the Kriegers Flak OWF. The sand extraction is not yet approved, but planned to take place from June 2016 to November 2018, using a trailing hopper suction dredger with capacity of 6,000–10,000 m^3 and a total extraction of max. 6 mio. m^3. Dredging will be done three times per 24 h, resulting in approx. 750 events, i.e. about 300 per year.

It has been evaluated that a concentration of more than 10 mgl-1 of suspended sediments will occur in less than 10 % of the time (Femern 2013). Sedimentation will only occur in relevant layers larger than 2–2.5 mm inside the extraction area. Thus, the sand extraction has no significant effect on the benthic flora and fauna outside the actual sand extraction area and no relevant cumulative effect is expected.

11.2 Baltic II OWF

The German OWF Baltic II is already approved and the installation of the wind turbines and other structures is on-going with installation being planned to end in 2015, thus before the construction phase of Kriegers Flak OWF starts. Accordingly, since suspended sediments and sedimentation are the only effects expected to spatially reach into the project area of Kriegers Flak, and these are short and temporary disturbances, no overlap of disturbance is expected.

11.3 Swedish OWF at Kriegers Flak

The Swedish OWF at Kriegers Flak is already approved, but currently set on hold. No construction is planned in the near future and it is unknown when the construction will start. However, the potential disturbance can be expected to be in the same order of magnitude as from the German Baltic II OWF or the Kriegers Flak project itself. Consequently, no significant impact is expected to occur in the Danish part of Kriegers Flak.

11.4 German Baltic I OWF

The German Baltic I OWF is approved and already in operation, and there are no far-reaching disturbances on the benthic environment. The OWF is approx. 40 km south-south-west of Kriegers Flak and thus too far away to have an influence on the benthic environment of Kriegers Flak.

11.5 Other projects

Other projects like the North Stream pipeline or the planned Rønne Banke OWF are too far away from the project area (> 100 km) and do consequently have no impact on the project area.

12 Zero alternative

If the Kriegers Flak OWF is not built, the benthic communities will be able to develop naturally. The only impacts could potentially come from the establishment of the Baltic II OWF and the planned sand extraction on the central part of the Kriegers Flak subarea. These projects will lead to short times with increased concentrations of suspended sediments and sedimentation. The levels, however, are not expected to be of a degree that can change the character or distribution of benthic species, communities or habitats and will not alter the current baseline conditions in a significant way.

13 Mitigation measures

No impacts with a degree of impact higher than “minor” do occur. Consequently, no mitigation is mandatory. However, the largest local effect is expected on the algae habitat area being removed due to pre-trenching of the cable trench. Although the disturbance is not significant for the subareas as a whole, a boring of the cable under the seafloor without temporarily removing the habitat at all, would minimize the impact significantly and spare the macrovegetation in the region.

14 Knowledge gaps

No significant knowledge gap has been detected that could invalidate the results of the impact assessment.

15 Væsentlighedsvurdering af påvirkningen af Natura 2000-område nr. 206 “Stevns Rev”.

I medfør af habitatbekendtgørelsen (Habitatbekendtgørelsen 2007) skal der foretages en vurdering af, om projektet i sig selv, eller i forbindelse med andre projekter, kan påvirke Natura 2000-områder væsentligt (væsentlighedsvurdering).

Et Natura 2000-område bliver krydset af havmølleparkens eksportkabelkorridor, men de to ilandføringskabler vil blive anlagt uden for Natura 2000-området:

- 206 Stevns Rev

For dette område præsenteres i de følgende afsnit en væsentlighedsvurdering af påvirkningen af Natura 2000-området.

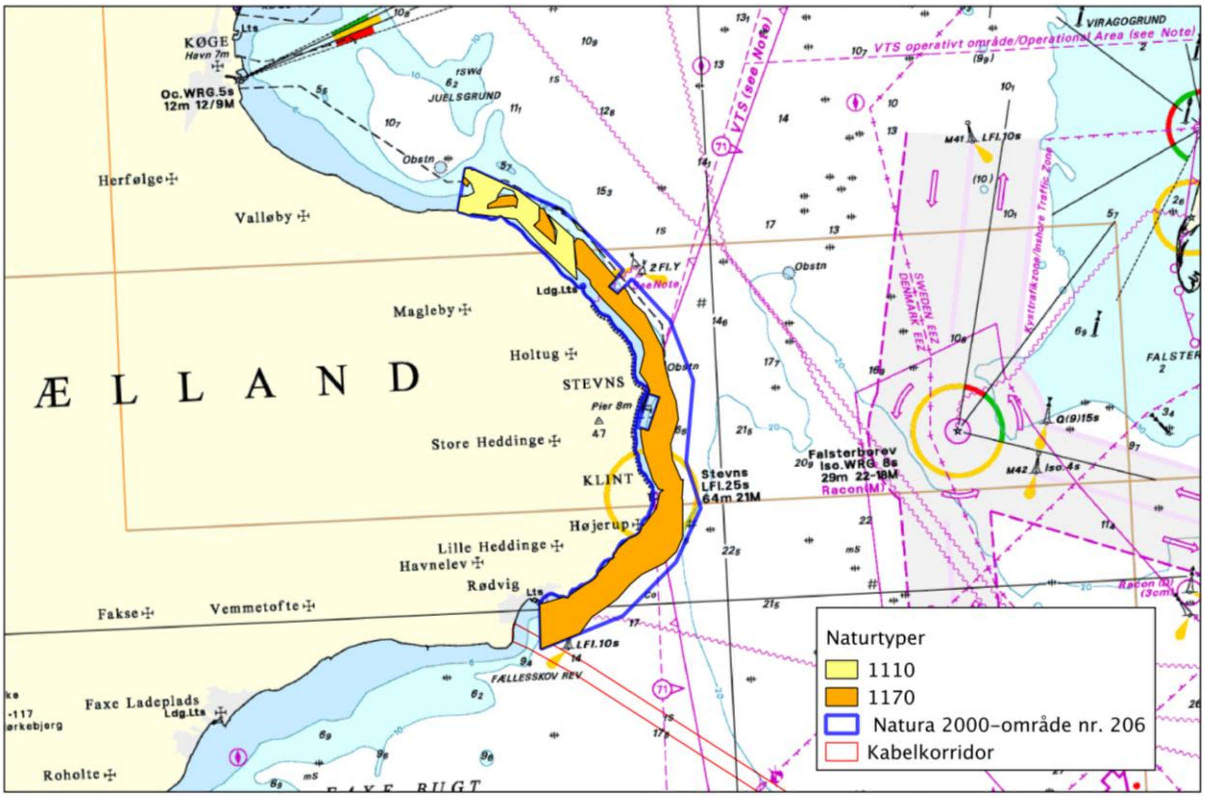
15.1 Indledning

Efter habitatbekendtgørelsens § 7 stk. 1 skal det belyses, om projektets to parallele ilandføringskabler nær Rødvig i sig selv, eller i forbindelse med andre planer og projekter, kan påvirke Natura 2000-område nr. 206 “Stevns Rev” væsentligt (væsentlighedsvurdering). Hvis det vurderes, at projektet kan påvirke et Natura 2000-område væsentligt, skal der ifølge habitatbekendtgørelsens § 7 stk. 2 foretages en nærmere konsekvensvurdering af projektets virkninger på Natura 2000-området under hensyn til områdets bevaringsmålsætning. Der kan ikke meddeles tilladelse m.v. til et projekt, som vurderes at ville skade Natura 2000-området.

Der fokuseres her på ilandføringskablernes potentielle påvirkninger på udpegningsgrundlaget. Der tages udgangspunkt i områdets basisanalyse (Storstrøms Amt 2006) og Natura 2000 plan for 2010–2015 (Naturstyrelsen 2011).

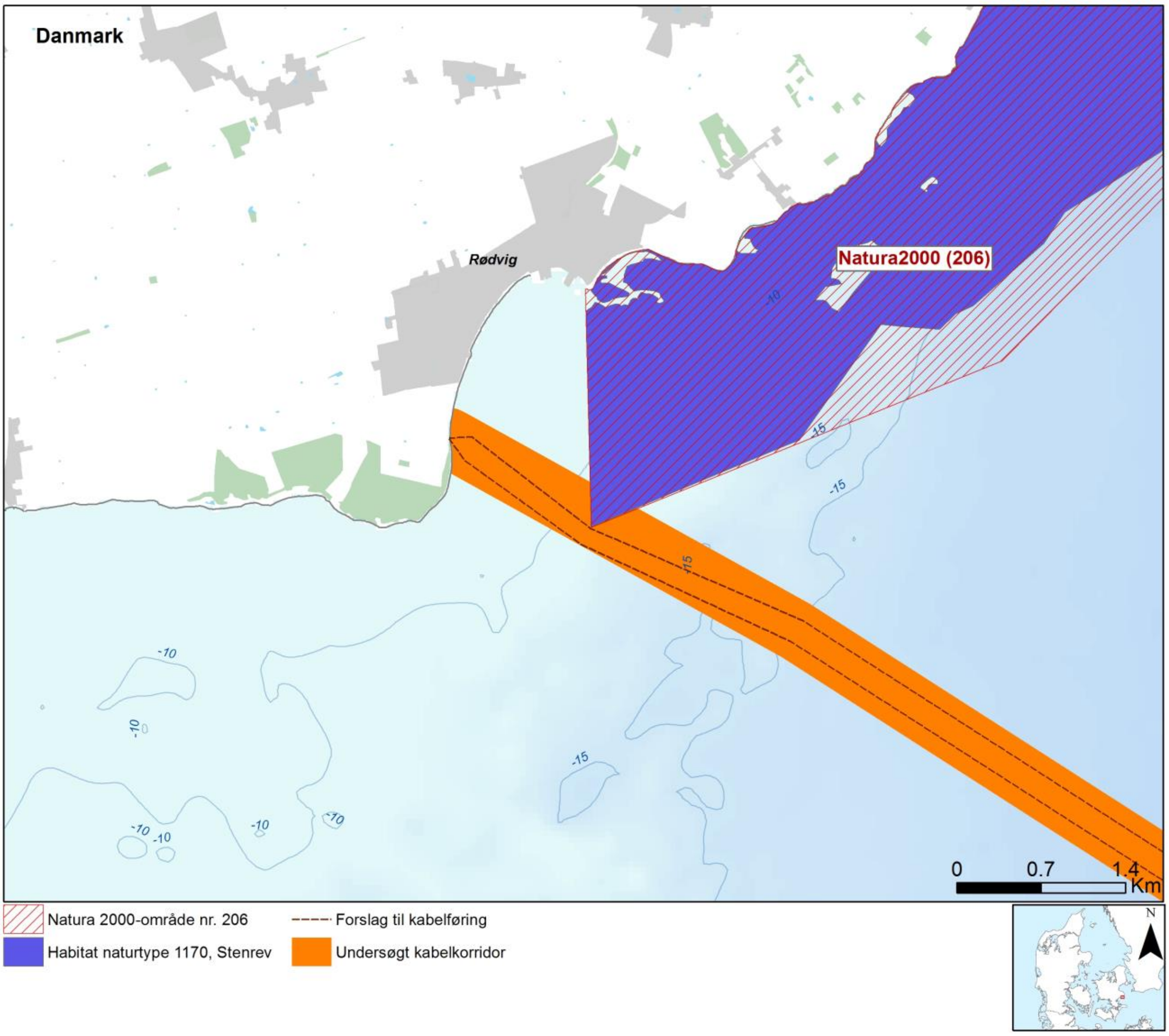
15.2 Udpegningsgrundlag

Områdets udpegningsgrundlag er naturtyperne ”sandbanke” (1110) og ”rev” (1170). Der er ingen arter på udpegningsgrundlaget. Det samlede areal af området er 4.640 ha, og det vurderes i basisanalysen, at sandbanke udgør 2.350 ha og rev udgør 591 ha. Forekomsterne fremgår af Figur 15-1.



Figur 15-1 **Afgrænsning af habitatområde nr. 206 "Stevns Rev" med forekomsten af naturtyperne 1110 (sandbanke) og 1170 (rev). Den undersøgte kabelkorridor passerer Natura 2000 områdets sydspids med et overlap på 0,24 % af habitatområdets samlede areal. Ilandføringskablerne vil blive anlagt uden for habitatområdet.**

Den undersøgte kabelkorridor går igennem den yderste del af sydspidsen af Natura 2000-område nr. 206 og Habitatområde H206 tæt på land, syd for Rødvig. Den endelige linjeføring for ilandføringskablerne er ikke fastlagt, men søkablerne vil blive anlagt inden for et anlægsbælte, som går syd om habitatområdet og ikke berører dette, Figur 15-2. Ud for habitatområdet vil afstanden mellem ilandføringskablerne blive lidt mindre end 200 meter, så der opnås tilstrækkelig afstand til habitatområdet til at sikre, at anlægsarbejdet ikke berører habitatområdet.



Figur 15-2 **Den undersøgte kabelkorridor går gennem et hjørne af Natura 2000-område nr. 206, men kabelføringen vil ikke berøre habitatområdet. Den undersøgte korridor er 500 meter bred og angivet med orange farve på figuren.**

Habitatområdet er marint, og afgrænsningen af området går ved strandkanten bortset fra et lille landområde nord for Mandehoved (øst for Holtug kirke i Figur 15-1). Dette område er registreret som beskyttet overdrev jf. Naturbeskyttelseslovens § 3. Området er meget eksponeret med hensyn til strøm og bølger. Vanddybden falder hurtigt til et par meter, for herefter at falde jævnt ud til ca. 20 meters dybde. Bunden består mest af kridt, stenplader og sten i alle størrelser fra 2–50 cm. Sand forekommer også, men en decideret sandbund forekommer kun enkelte steder i området. Området er præget af rørhinde (*Enteromorpha* spp.) på det lave vand, mens rødalgerne og blåmuslingerne (*Mytilus edulis*) dominerer på det dybe vand. Enkelte steder hvor bundforholdene tillader det, findes tætte bede af ålegræs (*Zostera marina*).

15.3 Tilstand og trusler

Bevaringsprognosen er vurderet ugunstig for både rev og sandbanke. Der er ikke udviklet et system til vurdering af den enkelte naturtypes aktuelle tilstand for marine naturtyper. Trusler mod områdets naturværdier er for høj næringsstofbelastning, miljøfarlige stoffer (bl.a. TBT) og fiskeri med bundslæbende udstyr. Fiskeri, hvorved der sker en fysisk ødelæggelse af naturtyperne, dels fjernelse af bundflora og bundlevende dyr, og dels fjernelse af hårdbund, sten og skaller, er en trussel mod områdets marine naturtyper. Omfanget af det aktuelle fiskeri kendes ikke.

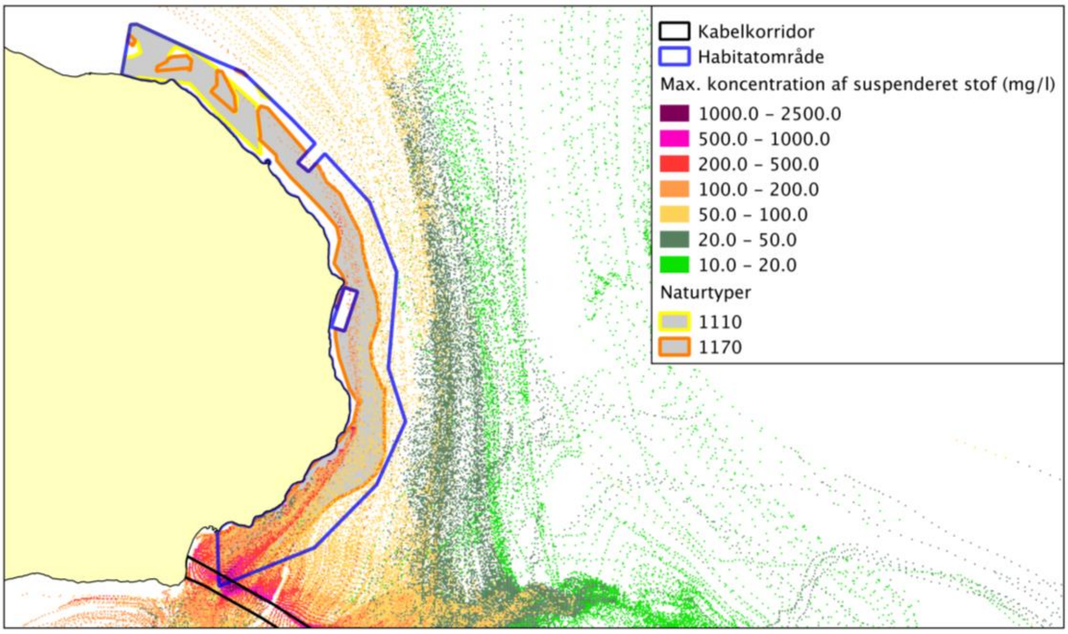
15.4 Bevaringsmålsætning

Den overordnede målsætning for området er, at Stevns Rev skal have en god vandkvalitet og en artsrig undervandsvegetation og være et godt levested for de normalt forekommende arter af bunddyr og fisk. Den generelle retningslinje i naturplanen (Naturstyrelsen 2011) er, at areal og tilstand af udpegede naturtyper ikke må gå tilbage eller forringes. Indsatser for at opnå målsætningen er reduktion af miljøfarlige stoffer og reduktion af næringsstoftilførsel med virkemidler via vandplanlægningen. Desuden nævnes indsats for beskyttelse af utilstrækkeligt beskyttede arealer mod truslen fra fiskeri med bundslæbende redskaber. Her er virkemidlet den gældende lovgivning.

15.5 Påvirkninger på habitatområdet

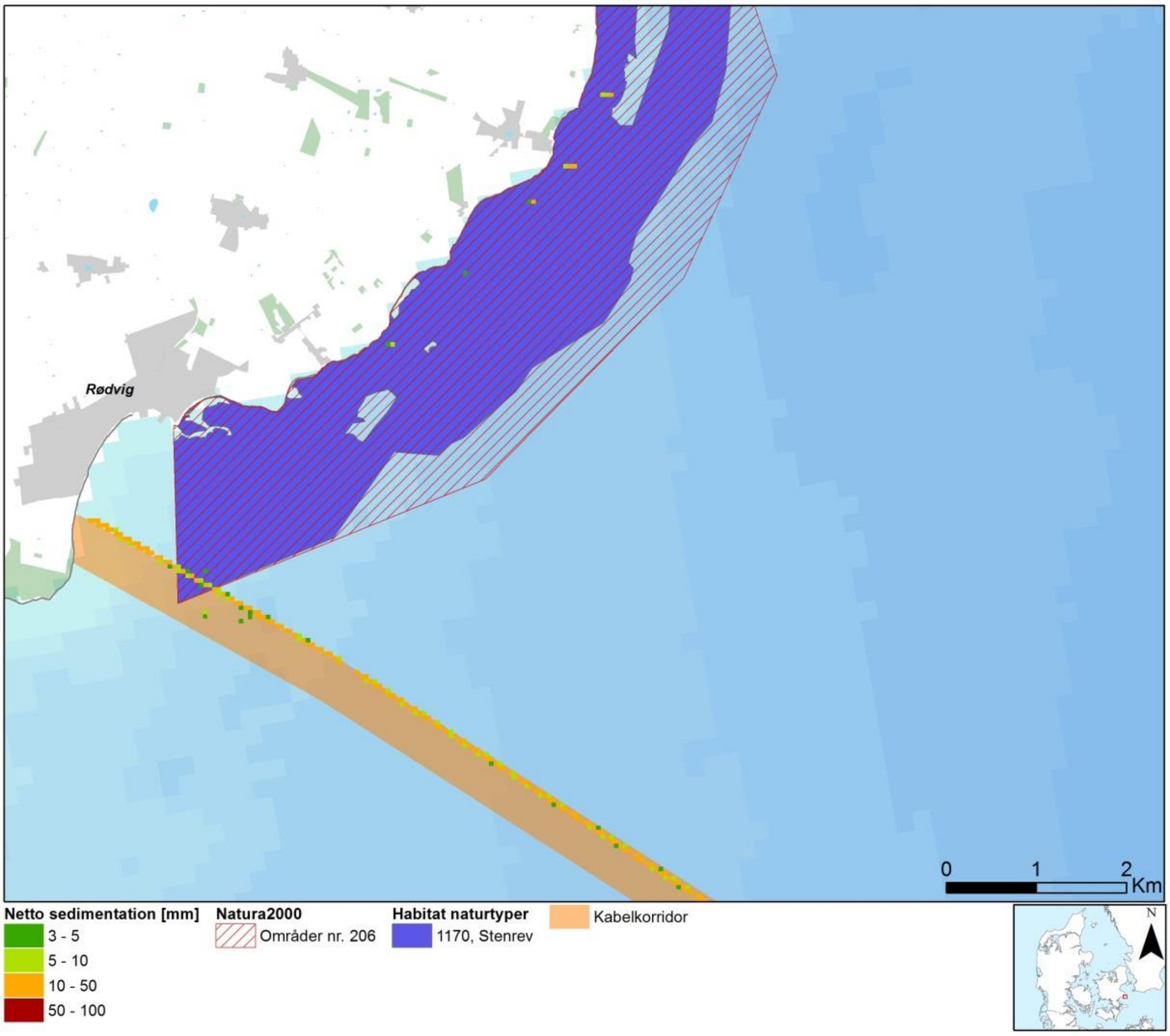
Potentielle påvirkninger af udpegningsgrundlaget i habitatområdet er knyttet til anlægsfasen, hvor selve arbejdet med nedspuling eller nedgravning af kablerne foregår. Påvirkninger kan ske indirekte i form af sedimenttransport ind i habitatområdet (øget koncentration af sediment i vandet) og efterfølgende sedimentation. Anlægsarbejdet vil foregå uden for habitatområdet, så der vil ikke være direkte påvirkninger af området i forbindelse med, at søkablerne spules eller graves ned i havbunden.

Detaljeret modellering af det sedimentspild, der knytter sig til nedspuling/nedgraving af søkablerne, blev foretaget som del af vurderingen af miljøpåvirkningerne. Modelleringen viser at sedimentspildet spreder sig og rækker ind i habitatområdet (Figur 15-3). I ca. 10 til 20 % af habitatområdet øges koncentrationen af suspenderet sediment i vandet. Den maksimale koncentration er i størrelsesordenen 100–200 mg/l i store dele af området og kan lokalt stige til 1000 mg/l habitatområdets sydlige ende. På enkelte lokaliteter kan der også forekomme værdier på over 1000 mg/l. Denne koncentration har dog meget begrænset varighed og er typisk kun tilstede i en til to timer. Kun i den sydlige ende, hvor koncentrationerne kan være over 100 mg/l, er overskridelsen af 10 mg/l på op til 24 timer.



Figur 15-3 Maximal koncentration af suspenderet stof (mg l^{-1}) i habitatområdet under anlægsfasen.

Sedimentationen, der følger, når sedimentet i vandet aflejres på havbunden, er lokalt begrænset. aflejringstykkelser på over 3 mm forekommer kun direkte ved den simulerede kabelrende og meget lokalt enkelte steder i habitatområdet (Figur 15-4). Det vurderes, at sedimentationstykkelser på under 3 mm ikke kan påvirke habitaterne, da en sådan mængde tolereres af alle forekommende arter.



Figur 15-4 Netto sedimentationshøjde (mm) i slutningen af anlægsfasen.

15.6 Vurdering af mulige påvirkninger

I henhold til vejledning til habitatbekendtgørelsen må det antages, at en påvirkning af udpegningsgrundlaget ikke er væsentlig:

- hvis påvirkningen skønnes at indebære negative udsving i bestandsstørrelser, der er mindre end de naturlige udsving, der anses for at være normale for den pågældende art eller naturtype, eller
- hvis den beskyttede naturtype eller art skønnes hurtigt og uden menneskelig indgriben at ville opnå den hidtidige tilstand eller en tilstand, der skønnes at svare til eller være bedre end den hidtidige tilstand.

De kortvarige forringelser eller forstyrrelser den belyste anlægsfase medfører, vurderes ikke at, have efterfølgende konsekvenser for de naturtyper, Natura 2000-området er udpeget for at beskytte.

Ved etablering af ilandføringskablerne ved Rødvig igennem nedspuling eller nedgravning kan det på grundlag af miljøvurderingen ikke afklares, om påvirkningerne vil være mindre end de naturlige udsving i sedimenttransport og sedimentation, da der ikke foreligger data over de naturlige mængder for sedimenttransport i området. Det kan derimod vurderes, at de prognosticerede belastninger ikke kan resultere i en væsentlig påvirkning af naturtyperne.

Alle i forrige afsnit beskrevne belastninger er enten kortvarige (typisk en dag) eller lokale (mindre end 1 % af naturtyperne) og ligger dermed på et meget lavt niveau. Det vurderes, at den naturlige sedimenttransport og sedimentation, især under dårlige vejrfohold i vinterhalvåret eller ved stormvejr, også kan føre til tilsvarende belastninger som etableringen af kablerne. Dette er stærkest udpræget i lavvandsområdet tæt på kystlinjen.

15.7 Konklusion

Natura 2000-området nr. 206 ”Stevns Rev” vil ikke blive væsentlig påvirket af etableringen af ilandføringskablerne til havmølleparken på Kriegers Flak, da sedimentspredningen er lokal og kortvarig. Der er desuden ingen andre projekter eller planer, der kan virke kumulerende i forbindelse med oprettelsen af havmølleparken. Mølleparkens oprettelse, drift og nedtagning udgør dermed ingen trussel mod områdets udpegningsgrundlag, og der er ikke behov for at gennemføre en fuld Natura 2000-konsekvensvurdering.

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17 Appendix

17.1 Relevant parameters of video transects

Table 17-1 Video transects (position, approximate length and depth range) at Kriegers Flak.

Transect	Start		End		Depth range	Approximate length
	Longitude	Latitude	Longitude	Latitude	(m)	(km)
24	12°49.292	55°02.860	12°48.059	55°03.373	29.8-29.1	1.6
25	12°53.705	55°02.827	12°52.335	55°04.097	17.0-23.9	2.7
26	12°53.232	55°00.388	12°55.067	55°00.586	20.5-17.9	1.9
27	13°01.104	55°01.743	13°03.278	55°01.897	18.9-20.0	2.4
34	12°57.753	55°00.616	12°59.064	55°00.900	19.0-20.5	1.4
35	12°49.414	55°00.816	12°52.615	55°00.724	19.2-23.3	3.4
Total						**13.4**

Table 17-2 Video transects (position, approximate length and depth range) at the cable corridor.

Transect	Start		End		Depth range	Approximate length
	Longitude	Latitude	Longitude	Latitude	(m)	(km)
1	12°22.817	55°14.094	12°21.934	55°14.453	12.0 - 5.3	1.1
2	12°22.008	55°14.097	12°22.026	55°14.553	7.9 - 4.1	0.4
3	12°22.026	55°14.553	12°22.968	55°14.121	6.2 - 12.9	1.9
4	12°23.275	55°13.831	12°22.885	55°14.052	15.0 - 1.3	0.6
5	12°23.829	55°13.787	12°24.176	55°13.544	14.8 - 15.8	0.6
6	12°27.325	55°12.350	12°27.792	55°12.141	19.0 - 19.4	0.6
7	12°30.939	55°10.812	12°31.352	55°10.678	20.9 - 22.1	0.5
8	12°32.761	55°10.014	12°33.307	55°09.915	24.5 - 24.8	0.6
9	12°33.882	55°09.678	12°34.297	55°09.442	24.8 - 25.5	0.6
10	12°35.145	55°09.047	12°35.877	55°08.873	25.6 - 26.6	0.8
36	12°41.850	55°06.900	12°39.561	55°07.583	28.1-26.9	2.7
Total						**9.8**

17.2 Basic ecological parameters

Table 17-3 Basic ecological parameters of the benthic community at Kriegers Flak.

	Station:	11	12	13	14	15	16	17	18	19	20	21	22	23	24	103			
	Depth (m):	30.1	28.4	20.7	20.1	25.7	17.4	19.5	18.4	26.1	26.3	19.2	23.2	19.7	19.7	19.7			
Group	**Species/taxa**	**Ind./m²**	**Ind./m²**	**Ind./m²**	**Ind./m²**	**Ind./m²**	**Ind./m²**	**Ind./m²**	**Ind./m²**	**Ind./m²**	**Ind./m²**	**Ind./m²**	**Ind./m²**	**Ind./m²**	**Ind./m²**	**Ind./m²**	**Presence [%]**	**Mean [Ind./m²]**	**Relative abundance [%]**
Bivalvia	*Mytilus edulis*	40.00	590.00	400.00	170.00	66440.00	760.00	14290.00	980.00	570.00	1640.00	40.00	160.00	440.00	0	2740.00	93	5950.67	85
Gastropoda	*Peringia ulvae*	0	50.00	320.00	2590.00	40.00	480.00	460.00	1060.00	530.00	380.00	280.00	560.00	610.00	60.00	30.00	93	496.67	7
Bivalvia	*Macoma balthica*	1090.00	160.00	0	20.00	160.00	0	10.00	20.00	90.00	100.00	50.00	40.00	20.00	30.00	10.00	87	120.00	2
Polychaeta	*Pygospio elegans*	10.00	140.00	40.00	130.00	0	0	100.00	0	110.00	420.00	50.00	30.00	360.00	80.00	60.00	80	102.00	1
Oligochaeta	Oligochaeta	0	10.00	440.00	0	40.00	320.00	210.00	20.00	0	60.00	0	10.00	0	20.00	40.00	67	78.00	1
Polychaeta	*Marenzelleria neglecta*	0	0	0	70.00	40.00	0	40.00	0	150.00	60.00	50.00	250.00	40.00	60.00	30.00	67	52.67	1
Cirripedia	*Amphibalanus improvisus*	0	10.00	0	0	480.00	0	0	0	0	0	0	0	0	0	10.00	20	33.33	0
Polychaeta	*Scoloplos (Scoloplos) armiger*	160.00	140.00	0	0	0	0	10.00	0	10.00	170.00	0	0	0	0	0	33	32.67	0
Polychaeta	*Terebellides stroemii*	210.00	270.00	0	0	0	0	0	0	0	0	0	0	0	0	0	13	32.00	0
Amphipoda	*Bathyporeia pilosa*	0	0	0	0	0	0	10.00	0	0	0	0	0	0	300.00	60.00	20	24.67	0
Polychaeta	Nereididae juv.	10.00	0	0	0	40.00	80.00	40.00	60.00	0	40.00	0	10.00	0	60.00	30.00	60	24.67	0
Amphipoda	*Pontoporeia femorata*	220.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	14.67	0
Bivalvia	*Mya arenaria*	0	0	0	50.00	0	0	0	0	50.00	40.00	30.00	10.00	20.00	0	0	40	13.33	0
Isopoda	*Jaera (Jaera) albifrons*	0	0	0	0	80.00	0	40.00	20.00	30.00	0	0	0	10.00	0	10.00	40	12.67	0
Amphipoda	*Gammarus salinus*	0	0	0	0	40.00	0	60.00	60.00	20.00	0	0	0	0	0	0	27	12.00	0
Polychaeta	*Bylgides sarsi*	0	0	0	0	120.00	0	20.00	0	0	30.00	0	0	0	0	0	20	11.33	0
Polychaeta	*Hediste diversicolor*	0	0	0	0	0	0	30.00	0	30.00	20.00	20.00	20.00	0	20.00	0	40	9.33	0
Priapulidae	*Halicryptus spinulosus*	30.00	30.00	0	0	0	0	0	0	0	0	0	10.00	0	0	0	20	4.67	0
Amphipoda	*Microdeutopus gryllotalpa*	0	0	0	0	0	40.00	0	0	0	0	0	0	0	0	10.00	13	3.33	0
Polychaeta	*Ampharete baltica*	10.00	30.00	0	0	0	0	0	0	0	0	0	0	0	0	0	13	2.67	0
Nematoda	Nematoda	0	0	40.00	0	0	0	0	0	0	0	0	0	0	0	0	7	2.67	0
Cumacea	*Diastylis rathkei*	30.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	2.00	0
Amphipoda	*Gammarus*	0	0	0	0	0	0	0	20.00	0	0	0	0	0	0	0	7	1.33	0
Amphipoda	*Gammarus zaddachi*	0	0	0	0	0	0	0	20.00	0	0	0	0	0	0	0	7	1.33	0
Bivalvia	Cardiidae juv.	0	0	0	0	0	0	0	0	0	0	10.00	0	0	0	0	7	0.67	0
Gastropoda	*Littorina tenebrosa*	0	10.00	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0.67	0
Nemertina	*Nemertea*	0	10.00	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0.67	0
Priapulidae	*Priapulus caudatus*	10.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0.67	0
Gastropoda	*Theodoxus fluviatilis*	0	0	0	0	0	0	10.00	0	0	0	0	0	0	0	0	7	0.67	0
Bryozoa	*Alcyonidium gelatinosum*	0	0	0	0	0	+	0	0	0	0	0	0	0	0	0	7	+	+
Bryozoa	*Callopora lineata*	+	0	+	0	+	0	+	0	0	0	0	0	0	0	+	33	+	+
Bryozoa	*Einhornia crustulenta*	0	0	0	0	+	0	+	0	0	+	0	0	+	0	+	33	+	+
Hydrozoa	Hydrozoa	0	0	0	0	+	0	0	0	0	0	0	0	0	0	0	7	+	+
Overal abundance		**1820.00**	**1450.00**	**1240.00**	**3030.00**	**67480.00**	**1680.00**	**15330.00**	**2260.00**	**1590.00**	**2960.00**	**530.00**	**1100.00**	**1500.00**	**630.00**	**3030.00**		**7042.00**	**100**
Overall species/taxa number	**33**	**12**	**12**	**6**	**6**	**13**	**6**	**16**	**9**	**10**	**12**	**8**	**10**	**8**	**8**	**13**			
Shannon-Wiener (H)		**1.96**	**2.58**	**1.88**	**0.89**	**0.15**	**1.83**	**0.53**	**1.61**	**2.38**	**2.17**	**2.25**	**2.05**	**1.89**	**2.38**	**0.74**			
Pielou-Evenness (J)		**0.51**	**0.66**	**0.73**	**0.35**	**0.04**	**0.71**	**0.13**	**0.47**	**0.66**	**0.57**	**0.75**	**0.62**	**0.57**	**0.79**	**0.19**			

+ Species/taxa is colony forming

Table 17-4 Basic ecological parameters of the benthic community at the cable corridor.

	Station:	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	30			
	Depth (m):	25.3	24.8	23.8	23.7	21.8	19.9	19.3	16.4	14.6	13.6	11.0	17.4	17.4	28.0			
Group	Species/taxa	Ind./m²	Ind./m²	Ind./m²	Ind./m²	Ind./m²	Ind./m²	Ind./m²	Ind./m²	Ind./m²	Ind./m²	Ind./m²	Ind./m²	Ind./m²	Ind./m²	Presence [%]	Mean [Ind./m²]	Relative abundance [%]
Gastropoda	*Peringia ulvae*	70.00	280.00	540.00	170.00	280.00	220.00	240.00	950.00	1450.00	720.00	540.00	620.00	790.00	0	93	490.71	27
Polychaeta	*Scoloplos (Scoloplos) armiger*	100.00	150.00	100.00	40.00	390.00	520.00	810.00	650.00	170.00	150.00	50.00	510.00	590.00	330.00	100	325.71	18
Polychaeta	*Pygospio elegans*	100.00	340.00	320.00	150.00	10.00	120.00	400.00	170.00	340.00	80.00	770.00	530.00	950.00	210.00	100	320.71	18
Oligochaeta	Oligochaeta	0	160.00	480.00	30.00	10.00	40.00	40.00	10.00	0	0	1010.00	10.00	30.00	30.00	79	132.14	7
Bivalvia	Cardiidae juv.	440.00	320.00	30.00	20.00	20.00	0	60.00	30.00	360.00	10.00	40.00	0	40.00	0	79	97.86	5
Bivalvia	*Mytilus edulis*	30.00	110.00	850.00	30.00	20.00	10.00	10.00	0	0	10.00	100.00	0	0	20.00	71	85.00	5
Bivalvia	*Macoma balthica*	30.00	60.00	10.00	0	60.00	120.00	190.00	80.00	30.00	30.00	70.00	90.00	110.00	80.00	93	68.57	4
Bivalvia	*Mya arenaria*	60.00	40.00	0	0	0	20.00	40.00	50.00	260.00	10.00	10.00	20.00	60.00	0	71	40.71	2
Isopoda	*Cyathura carinata*	0	90.00	360.00	0	20.00	0	0	0	0	0	80.00	0	0	0	29	39.29	2
Bivalvia	*Cerastoderma glaucum*	20.00	10.00	0	0	0	180.00	80.00	30.00	30.00	0	0	110.00	80.00	0	57	38.57	2
Polychaeta	Nereididae juv.	0	0	0	0	10.00	0	10.00	230.00	20.00	20.00	170.00	10.00	60.00	0	57	37.86	2
Polychaeta	*Terebellides stroemii*	0	0	0	0.00	0	0	0.00	0	0	0	0.00	0	0	380.00	7	27.14	1
Polychaeta	*Streblospio shrubsolii*	0	0	0	10.00	0	0	10.00	0	0	0	210.00	0	0	0	21	16.43	1
Polychaeta	*Travisia forbesii*	40.00	0	0	0	0	0	0	0	150.00	0	20.00	0	0	0	21	15.00	1
Polychaeta	*Aricidea (Allia) suecica*	30.00	10.00	0	0	20.00	0	30.00	0	0	0	0	10.00	0	40.00	43	10.00	1
Gastropoda	*Retusa truncatula*	0	0	10.00	0	40.00	10.00	0	20.00	0	0	10.00	30.00	10.00	10.00	57	10.00	1
Polychaeta	*Ampharete baltica*	0	0	20.00	10.00	0	0	0	0	0	0	0	0	0	100.00	21	9.29	1
Polychaeta	*Heteromastus filiformis*	0	10.00	0	0	0	0	0	0	0	0	90.00	10.00	0	10.00	29	8.57	0
Priapulidae	*Halicryptus spinulosus*	10.00	0	0	0	20.00	0	20.00	0	0	0	0	0	0	40.00	29	6.43	0
Cirripedia	*Amphibalanus improvisus*	0	0	50.00	10.00	0	0	0	0	0	0	0	0	0	0	14	4.29	0
Polychaeta	*Hediste diversicolor*	0	0	0	0	0	0	50.00	10.00	0	0	0	0	0	0	14	4.29	0
Polychaeta	*Marenzelleria neglecta*	0	0	0	0	0	0	0	0	10.00	20.00	30.00	0	0	0	21	4.29	0
Polychaeta	*Arenicola marina*	0	0	0	0	10.00	0	0	0	0	20.00	10.00	0	0	0	21	2.86	0
Nemertina	*Nemertea*	10.00	0	20.00	0	0	0	0	0	0	0	10.00	0	0	0	21	2.86	0
Cumacea	*Diastylis rathkei*	0	20.00	0	0	0	0	0	0	0	0	0	10.00	0	0	14	2.14	0
Polychaeta	*Eteone longa*	0	0	0	0	0	0	0	0	0	10.00	0	0	0	10.00	14	1.43	0
Polychaeta	*Magelona mirabilis*	0	0	0	0	0	0	20.00	0	0	0	0	0	0	0	7	1.43	0
Amphipoda	*Microdeutopus gryllotalpa*	0	0	20.00	0	0	0	0	0	0	0	0	0	0	0	7	1.43	0
Gastropoda	*Odostomia scalaris*	0	0	10.00	10.00	0	0	0	0	0	0	0	0	0	0	14	1.43	0
Bivalvia	*Parvicardium hauniense*	0	0	10.00	0	0	0	0	0	0	0	10.00	0	0	0	14	1.43	0
Priapulidae	*Priapulus caudatus*	0	0	0	0	0	0	0	0	0	0	0	0	0	20.00	7	1.43	0
Polychaeta	*Spio goniocephala*	0	0	0	20.00	0	0	0	0	0	0	0	0	0	0	7	1.43	0
Polychaeta	*Bylgides sarsi*	0	0	10.00	0	0	0	0	0	0	0	0	0	0	0	7	0.71	0
Hexapoda	*Chironomus aprilinus*	0	0	10.00	0	0	0	0	0	0	0	0	0	0	0	7	0.71	0
Gastropoda	*Littorina saxatilis*	0	0	0	0	0	0	0	0	0	0	10.00	0	0	0	7	0.71	0
Amphipoda	*Pontoporeia femorata*	0	0	0	0	0	0	0	0	0	0	0	0	0	10.00	7	0.71	0
Gastropoda	*Retusa obtusa*	0	0	0	0	0	0	0	10.00	0	0	0	0	0	0	7	0.71	0
Polychaeta	*Spio*	0	0	0	10.00	0	0	0	0	0	0	0	0	0	0	7	0.71	0
Bryozoa	*Callopora lineata*	0	0	+	0	0	0	0	0	0	0	+	0	0	0	14	+	+
Hydrozoa	*Clava multicornis*	0	0	+	0	0	0	0	0	0	0	0	0	0	0	7	+	+
Bryozoa	*Einhornia crustulenta*	0	+	0	0	0	0	0	0	0	0	+	0	0	0	14	+	+
Hydrozoa	*Hydrozoa*	0	0	+	0	0	0	0	0	0	0	0	0	0	+	14	+	+
Overal abundance		**940.00**	**1600.00**	**2850.00**	**510.00**	**910.00**	**1240.00**	**2010.00**	**2240.00**	**2820.00**	**1080.00**	**3240.00**	**1960.00**	**2720.00**	**1290.00**		**1815.00**	**100**
Overall species/taxa number	**42**	**12**	**14**	**20**	**12**	**13**	**9**	**15**	**12**	**10**	**11**	**21**	**12**	**10**	**15**			
Shannon-Wiener (H)		**2.66**	**3.06**	**2.80**	**2.74**	**2.40**	**2.39**	**2.71**	**2.29**	**2.25**	**1.78**	**2.91**	**2.33**	**2.30**	**2.82**			
Pielou-Evenness (J)		**0.70**	**0.76**	**0.62**	**0.68**	**0.63**	**0.72**	**0.65**	**0.62**	**0.65**	**0.50**	**0.62**	**0.63**	**0.66**	**0.69**			

+ Species/taxa is colony forming

17.3 Biomass parameters

Table 17–5 Biomass parameters of the benthic community at Kriegers Flak.

	Station:	11	12	13	14	15	16	17	18	19	20	21	22	23	24	103			
	Depth (m):	30.1	28.4	20.7	20.1	25.7	17.4	19.5	18.4	26.1	26.3	19.2	23.2	19.7	19.7	19.7			
Group	Species/taxa	g/m²	g/m²	g/m²	g/m²	g/m²	g/m²	g/m²	g/m²	g/m²	g/m²	g/m²	g/m²	g/m²	g/m²	g/m²	Presence [%]	Mean [g/m²]	Relative biomass [%]
Bivalvia	*Mytilus edulis*	0.24	97.31	12.76	1.87	6990.61	44.08	942.09	282.29	154.88	324.21	1.73	0.78	29.41	0	118.47	93	600.05	96
Bivalvia	*Macoma balthica*	154.77	13.36	0	10.88	33.84	0	2.04	4.20	5.35	11.07	10.07	3.64	4.56	5.47	5.58	87	17.66	3
Bivalvia	*Mya arenaria*	0	0	0	0.92	0	0	0	0	10.47	2.39	2.21	0.42	11.47	0	0	40	1.86	0
Cirripedia	*Amphibalanus improvisus*	0	0.50	0	0	16.89	0	0	0	0	0	0	0	0	0	0.19	20	1.17	0
Gastropoda	*Peringia ulvae*	0	0.10	0.64	5.35	0.06	0.95	1.29	2.92	1.02	0.62	0.45	1.13	1.87	0.13	0.07	93	1.11	0
Polychaeta	*Marenzelleria neglecta*	0	0	0	0.60	0.12	0	0.09	0	1.12	0.08	0.22	2.18	0.27	0.63	0.42	67	0.38	0
Polychaeta	*Hediste diversicolor*	0	0	0	0	0	0	1.64	0	0.62	0.39	0.76	0.94	0	0.20	0	40	0.30	0
Polychaeta	*Bylgides sarsi*	0	0	0	0	1.74	0	0.33	0	0	0.93	0	0	0	0	0	20	0.20	0
Amphipoda	*Gammarus salinus*	0	0	0	0	1.09	0	0.87	0.63	0.35	0	0	0	0	0	0	27	0.20	0
Polychaeta	Nereididae juv.	0.03	0	0	0	0.24	1.16	0.10	0.58	0	0.07	0	0.01	0	0.13	0.04	60	0.16	0
Polychaeta	*Terebellides stroemii*	1.32	0.83	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0.14	0
Polychaeta	*Scoloplos (Scoloplos) armiger*	0.50	0.53	0	0	0	0	0.02	0	0.16	0.84	0	0	0	0	0	33	0.14	0
Polychaeta	*Pygospio elegans*	0.02	0.03	0.02	0.06	0	0	0.03	0	0.04	0.23	0.01	0.00	0.25	0.03	0.06	80	0.05	0
Amphipoda	*Pontoporeia femorata*	0.72	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0.05	0
Priapulidae	*Halicryptus spinulosus*	0.36	0.19	0	0	0	0	0	0	0	0	0	0.08	0	0	0	20	0.04	0
Amphipoda	*Bathyporeia pilosa*	0	0	0	0	0	0	0.02	0	0	0	0	0	0	0.47	0.12	20	0.04	0
Oligochaeta	Oligochaeta	0	0.01	0.12	0	0.02	0.15	0.14	0.00	0	0.01	0	0.00	0	0.00	0.02	67	0.03	0
Cumacea	*Diastylis rathkei*	0.38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0.03	0
Amphipoda	*Gammarus zaddachi*	0	0	0	0	0	0	0	0.23	0	0	0	0	0	0	0	7	0.02	0
Isopoda	*Jaera (Jaera) albifrons*	0	0	0	0	0.06	0	0.03	0.02	0.03	0	0	0	0.01	0	0.02	40	0.01	0
Priapulidae	*Priapulus caudatus*	0.14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0.01	0
Amphipoda	*Microdeutopus gryllotalpa*	0	0	0	0	0	0.04	0	0	0	0	0	0	0	0	0.01	13	0.00	0
Gastropoda	*Theodoxus fluviatilis*	0	0	0	0	0	0	0.04	0	0	0	0	0	0	0	0	7	0.00	0
Nemertina	*Nemertea*	0	0.03	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0.00	0
Bivalvia	Cardiidae juv.	0	0	0	0	0	0	0	0	0	0	0.02	0	0	0	0	7	0.00	0
Amphipoda	*Gammarus*	0	0	0	0	0	0	0	0.02	0	0	0	0	0	0	0	7	0.00	0
Polychaeta	*Ampharete baltica*	0.00	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0.00	0
Gastropoda	*Littorina tenebrosa*	0	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0.00	0
Nematoda	Nematoda	0	0	0.00	0	0	0	0	0	0	0	0	0	0	0	0	7	0.00	0
Bryozoa	*Alcyonidium gelatinosum*	0	0	0	0	0	+	0	0	0	0	0	0	0	0	0	7	0.00	0
Bryozoa	*Callopora lineata*	+	0	+	0	+	0	+	0	0	0	0	0	0	0	+	33	0.00	0
Bryozoa	*Einhornia crustulenta*	0	0	0	0	+	0	+	0	0	+	0	0	+	0	+	33	0.00	0
Hydrozoa	Hydrozoa	0	0	0	0	+	0	0	0	0	0	0	0	0	0	0	7	0.00	0
Overall wet weight		**158.47**	**112.91**	**13.54**	**19.67**	**7044.67**	**46.37**	**948.72**	**290.89**	**174.04**	**340.85**	**15.49**	**9.18**	**47.84**	**7.05**	**124.99**		**623.65**	**100**
Overall species/	**33**	**12**	**12**	**6**	**6**	**13**	**6**	**16**	**9**	**10**	**12**	**8**	**10**	**8**	**8**	**13**			

+ Species/taxa is colony forming

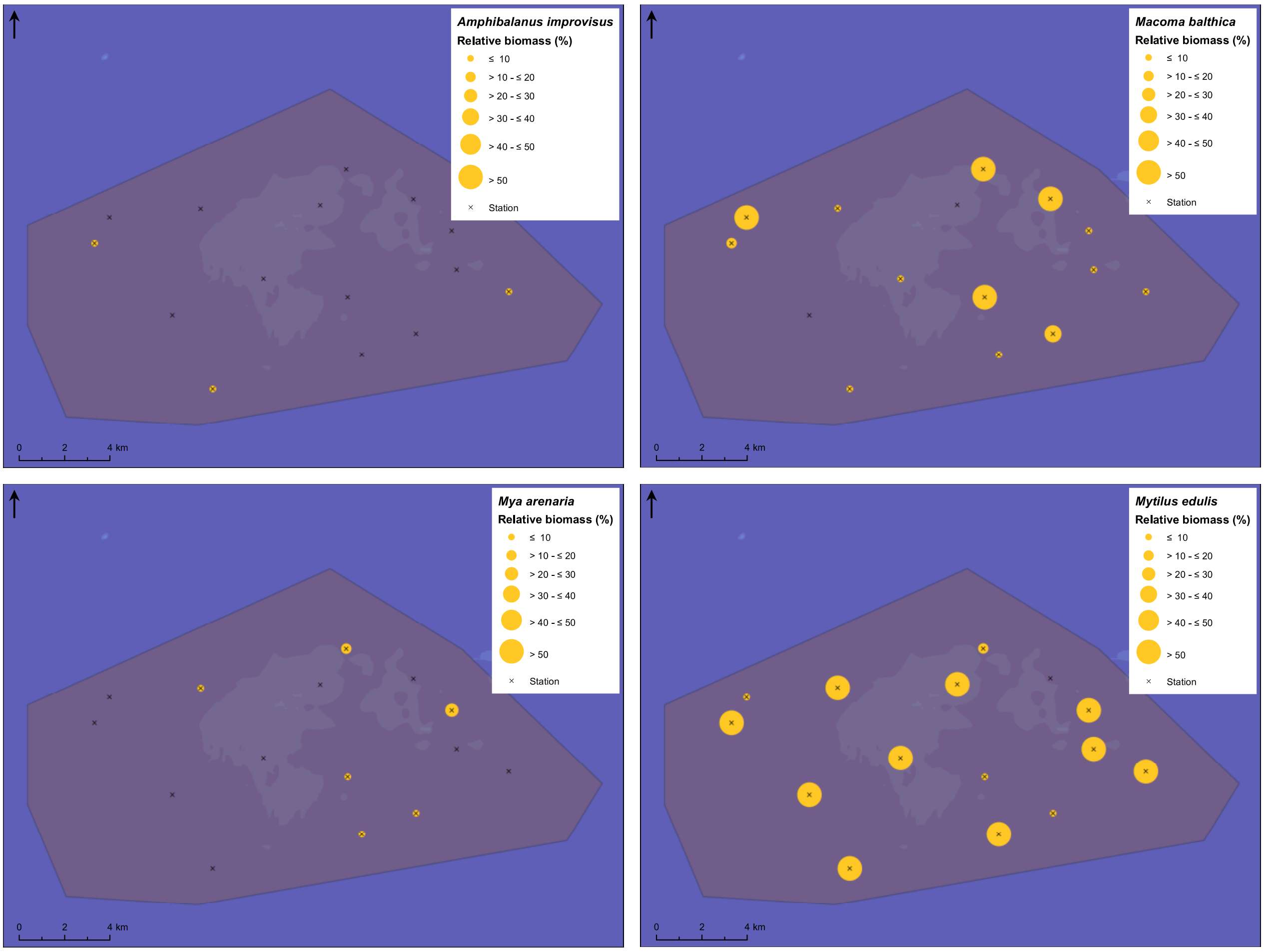

Figure 17-1 **Relative biomass of the four dominant species (in terms of biomass) at Kriegers Flak.**

Table 17-6 Biomass parameters of the benthic community at the cable corridor.

Group	Species/taxa	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	30	Presence	Mean	Relative biomass
	Depth (m):	25.3	24.8	23.8	23.7	21.8	19.9	19.3	16.4	14.6	13.6	11.0	17.4	17.4	28.0			
		g/m²	g/m²	g/m²	g/m²	g/m²	g/m²	g/m²	g/m²	g/m²	g/m²	g/m²	g/m²	g/m²	g/m²	[%]	[g/m²]	[%]
Bivalvia	*Cerastoderma glaucum*	1.08	8.30	0	0	0	78.58	25.90	9.39	15.84	0	0	32.90	39.53	0	57	15.11	31
Bivalvia	*Macoma balthica*	8.85	26.55	2.82	0	9.29	16.83	23.40	11.75	0.03	3.32	18.91	29.76	22.02	25.26	93	14.20	30
Bivalvia	*Mytilus edulis*	0.02	1.09	89.51	0.11	0.02	2.63	0.00	0	0	1.10	6.84	0	0	0.03	71	7.24	15
Bivalvia	*Mya arenaria*	1.33	2.29	0	0	0	24.93	3.54	44.02	6.88	0.29	0.23	0.15	0.73	0	71	6.03	13
Gastropoda	*Peringia ulvae*	0.15	0.39	0.66	0.32	0.79	0.54	0.59	2.83	3.47	2.22	1.34	1.28	2.39	0	93	1.21	3
Polychaeta	*Scoloplos (Scoloplos) armiger*	0.32	0.17	0.22	0.09	1.31	1.50	2.88	2.73	0.93	0.77	0.21	1.93	2.44	1.03	100	1.18	2
Priapulidae	*Halicryptus spinulosus*	1.50	0	0	0	5.76	0	0.33	0	0	0	0	0	0	0.84	29	0.60	1
Polychaeta	*Arenicola marina*	0	0	0	0	4.04	0	0	0	0	3.49	0.19	0	0	0	21	0.55	1
Polychaeta	*Travisia forbesii*	1.02	0	0	0	0	0	0	0	4.88	0	1.05	0	0	0	21	0.50	1
Bivalvia	Cardiidae juv.	1.84	1.30	0.04	0.04	0.05	0	0.46	0.14	2.06	0.07	0.25	0	0.29	0	79	0.47	1
Polychaeta	Nereididae juv.	0	0	0	0	0.06	0	0.02	0.85	0.04	0.02	1.11	0.08	0.16	0	57	0.17	0
Polychaeta	*Pygospio elegans*	0.04	0.07	0.06	0.06	0.01	0.03	0.10	0.07	0.32	0.04	0.25	0.27	0.53	0.07	100	0.14	0
Polychaeta	*Terebellides stroemi*	0	0	0	0	0	0	0	0	0	0	0	0	0	1.45	7	0.10	0
Polychaeta	*Heteromastus filiformis*	0	0.30	0	0	0	0	0	0	0	0	0.78	0.03	0	0.14	29	0.09	0
Isopoda	*Cyathura carinata*	0	0.07	0.80	0	0.12	0	0	0	0	0	0.16	0	0	0	29	0.08	0
Oligochaeta	Oligochaeta	0	0.12	0.23	0.02	0.01	0.02	0.01	0.01	0	0	0.52	0.02	0.02	0.00	79	0.07	0
Gastropoda	*Retusa truncatula*	0	0	0.06	0	0.19	0.09	0	0.12	0	0	0.07	0.18	0.05	0.02	57	0.06	0
Polychaeta	*Marenzelleria neglecta*	0	0	0	0	0	0	0	0	0.04	0.18	0.52	0	0	0	21	0.05	0
Polychaeta	*Hediste diversicolor*	0	0	0	0	0	0	0.58	0.13	0	0	0	0	0	0	14	0.05	0
Cirripedia	*Amphibalanus improvisus*	0	0	0.43	0.01	0	0	0	0	0	0	0	0	0	0	14	0.03	0
Cumacea	*Diastylis rathkei*	0	0.15	0	0	0	0	0	0	0	0	0	0.07	0	0	14	0.02	0
Bivalvia	*Parvicardium hauniense*	0	0	0.05	0	0	0	0	0	0	0	0.12	0	0	0	14	0.01	0
Priapulidae	*Priapulus caudatus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0.13	7	0.01	0
Polychaeta	*Aricidea (Allia) suecica*	0.03	0.00	0	0	0.02	0	0.02	0	0	0	0	0.02	0	0.03	43	0.01	0
Gastropoda	*Retusa obtusa*	0	0	0	0	0	0	0	0.12	0	0	0	0	0	0	7	0.01	0
Polychaeta	*Ampharete baltica*	0	0	0.00	0.01	0	0	0	0	0	0	0	0	0	0.07	21	0.01	0
Polychaeta	*Streblospio shrubsolii*	0	0	0	0.00	0	0	0.00	0	0	0	0.07	0	0	0	21	0.01	0
Polychaeta	*Bylgides sarsi*	0	0	0.06	0	0	0	0	0	0	0	0	0	0	0	7	0.00	0
Amphipoda	*Pontoporeia femorata*	0	0	0	0	0	0	0	0	0	0	0	0	0	0.05	7	0.00	0
Gastropoda	*Odostomia scalaris*	0	0	0.03	0.01	0	0	0	0	0	0	0	0	0	0	14	0.00	0
Polychaeta	*Eteone longa*	0	0	0	0	0	0	0	0	0	0.00	0	0	0	0.03	14	0.00	0
Nemertina	*Nemertea*	0.01	0	0.01	0	0	0	0	0	0	0	0.02	0	0	0	21	0.00	0
Polychaeta	*Spio goniocephala*	0	0	0	0.02	0	0	0	0	0	0	0	0	0	0	7	0.00	0
Amphipoda	*Microdeutopus gryllotalpa*	0	0	0.02	0	0	0	0	0	0	0	0	0	0	0	7	0.00	0
Gastropoda	*Littorina saxatilis*	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0	7	0.00	0
Hexapoda	*Chironomus aprilinus*	0	0	0.01	0	0	0	0	0	0	0	0	0	0	0	7	0.00	0
Polychaeta	*Magelona mirabilis*	0	0	0	0	0	0	0.01	0	0	0	0	0	0	0	7	0.00	0
Polychaeta	*Spio*	0	0	0	0.01	0	0	0	0	0	0	0	0	0	0	7	0.00	0
Bryozoa	*Callopora lineata*	0	0	+	0	0	0	0	0	0	0	+	0	0	0	14	+	+
Hydrozoa	*Clava multicornis*	0	0	+	0	0	0	0	0	0	0	0	0	0	0	7	+	+
Bryozoa	*Einhornia crustulenta*	0	+	0	0	0	0	0	0	0	0	+	0	0	0	14	+	+
Hydrozoa	*Hydrozoa*	0	0	+	0	0	0	0	0	0	0	0	0	0	+	14	+	+
Overall wet weight		**16.17**	**40.81**	**94.99**	**0.69**	**21.67**	**125.13**	**57.85**	**72.14**	**34.49**	**11.51**	**32.63**	**66.68**	**68.14**	**29.15**		**48.00**	**100**
Overall species/taxa number	**42**	**12**	**14**	**20**	**12**	**13**	**9**	**15**	**12**	**10**	**11**	**21**	**12**	**10**	**15**			

+ Species/taxa is colony forming

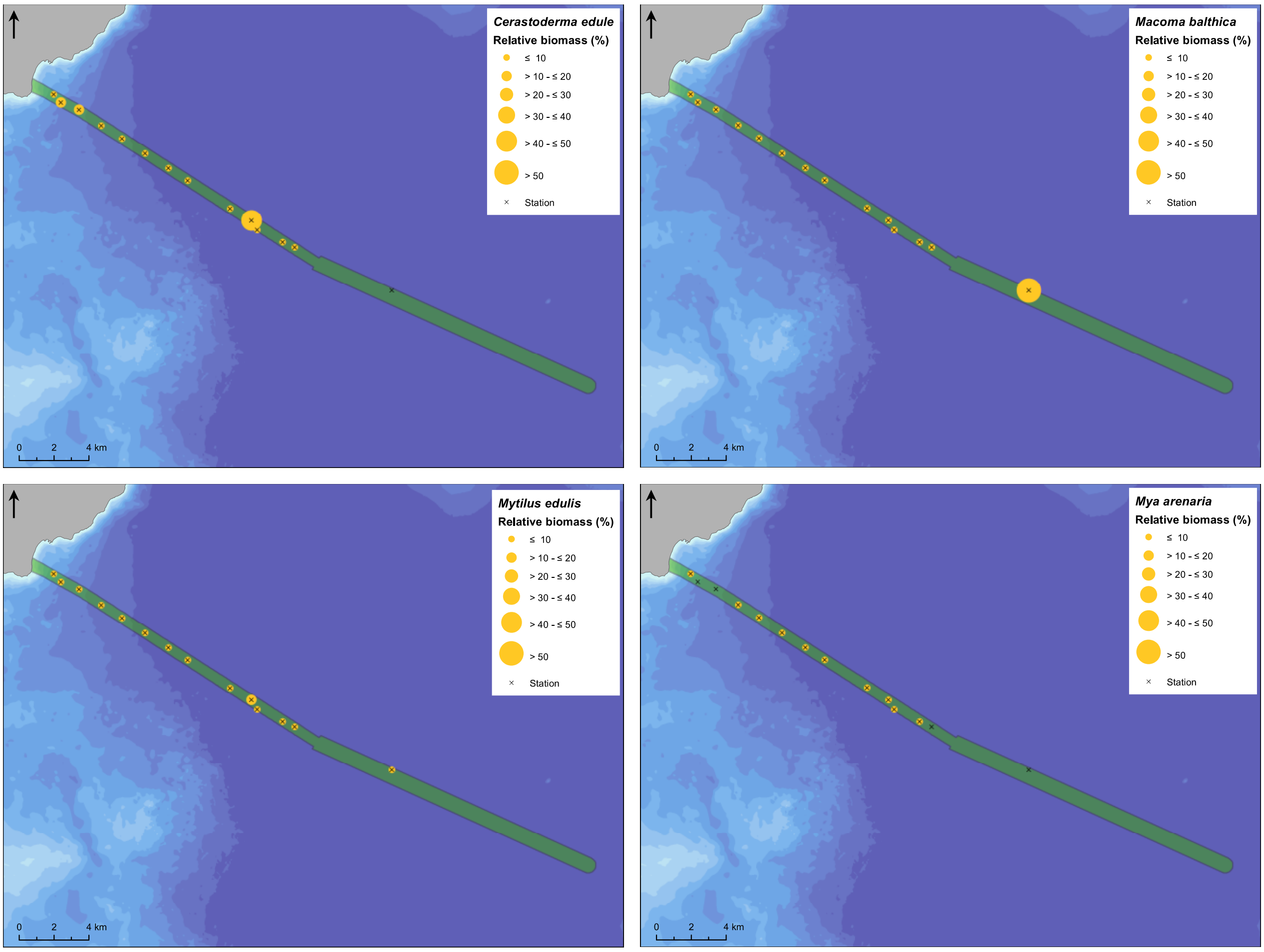

Figure 17-2 Relative biomass of the four dominant species (in terms of biomass) at the cable corridor.