AARHUS UNIVERSITET
DCE - NATIONALT CENTER FOR MILJØ OG ENERGI

NIRAS

# Hesselø Offshore Wind Farm

## Benthic flora and fauna: Hard bottom
## Technical report

Energinet Eltransmission A/S

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# Preface

This report was commissioned by Energinet to the consortium of NIRAS and Aarhus University and constitutes a description of the baseline status as well as a sensitivity analysis for the benthic hard bottom communities relevant in connection with the assessment of environmental impacts of the panned Hesselø Offshore Wind Farm (OWF)

The sensitivity analysis builds upon existing knowledge as well as new data and analyses collected and conducted during this project.

The report is divided into five chapters and begin by introducing the aim of the report (chapter 3) as well as examples of scenarios for Hesselø OWF (first section in chapter 4). In chapter 4 the methods used in the field work are described and chapter 5 describes the results as well as the baseline situation with in the Hesselø OWF area for each species. In chapter 6 the sensitivity analysis is presented.

This report solely concerns benthic communities associated with hard bottom habitats and is hence limited to descriptions of the benthic flora and fauna found in the coastal area of the export cable corridor. The report is complemented by a corresponding study of benthic communities associated with soft bottom habitats in the planned wind farm area as well as the offshore part of the export cable corridor (NIRAS & DCE, 2022). This division is due to the distribution of hard and soft bottom substrates within the plan area of Hesselø OWF.

A consortium of NIRAS Group A/S (NIRAS) and Aarhus University, Danish Centre for Environment and Energy (DCE) have undertaken this work which was divided so that DCE have been the main authors and responsible for chapter 4 (except section 4.1) and chapter 5 and NIRAS have been main author and responsible for the other chapters. All contributors have however consensus with regard to the main conclusion in the sensitivity assessment.

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# Contents

# 1 List of key terms

A list of terms related to sensitivity analysis is provided here.

*Table 1.1 Terminology related to sensitivity analysis including Danish and English terms as well as explanations.*

| English | Danish | Explanation |
|---|---|---|
| Activity | Aktivitet | Human-mediated activity that may lead to pressure(s). |
| Benthic | Bentisk | Associated with the bottom (of the sea) |
| Biogenic | Biogen | Formed by living organisms (e.g. reef composed of mussels) |
| Geogenic | Geogen | Formed by rocks |
| Effect | Effekt | The effect of a pressure on the receptor. |
| Pressure | Belastning | Mechanisms – physical, chemical or biological – through which an activity affects the receptors. |
| ROV | ROV | Remote Operated Vehicle |
| Sensitivity | Følsomhed | The tolerance of a species or habitat to change caused by an external factor and the time taken for its subsequent recovery. |
| Receptor | Receptor | A species, population, community or habitat that is subject to external changes. |
| Recoverability | Genopretningsevne | The ability of a receptor to recover from changes. |
| Resistance | Tolerance | Resistance characteristics indicate whether a receptor can absorb disturbance or stress without changing character. |
| Sensitivity score | Sensitivitetsscore | Resistance and recoverability of a receptor is scored according to one of four categories, which in turn is used to score the overall sensitivity into one of four categories. |

## 2 Summary


This technical report presents information on the benthic flora and fauna associated with hard bottom habitats in the the planned export cable corridor for Hesselø Offshore Wind Farm (Hesselø OWF), focusing on the Natura 2000 Site 'Gilleleje Flak and Tragten'. Data acquired during project survey work are used together with other available information to characterise the hard bottom habitats and associated communities. No hard bottom habitats were identified within the planned offshore wind farm array area.

Stony reef areas represented by both seabed types 3 and 4 were present and these, together with an area of potential biogenic-geogenic reef, were identified as receptors for the purpose of a sensitivity analysis. Biogenic-geogenic reef was not confirmed because only a small (25m$^2$) of *Modiolus modiolus* amongst rocky habitat was found but it cannot be ruled out that this habitat may cover a more extensive area. The sensitivity analysis provides a categorisation of sensitivity, from Not Sensitive to High, for each receptor in relation to pressures which are expected to result from the activities planned for the construction, operation and decommissioning of the wind farm.

The key pressures are habitat change and abrasion/disturbance to which all identified receptors have high sensitivity. Biogenic-geogenic reef is also considered to have high sensitivity to smothering and penetration pressures. Invasive non-indigenous species (INIS) is also identified as a pressure to which all receptors have high sensitivity.

The sensitivity ratings will be used to support the strategic environmental assessment of the plan for Hesselø OWF and the future environmental assessments of a specific project for Hesselø OWF, at which point pressures will be elaborated with reference to other factors such as their spatial and temporal extent to determine an overall impact significance and identify potential mitigation required.

# 3 Introduction and aim

With the Energy Agreement in June 2018 and the following 'Climate agreement for energy and industry, etc. 2020' in June 2020, the Danish parliament decided to tender for a new offshore wind farm of 800 – 1200 MW with grid connection in 2027. The offshore wind farm will be located in the central Kattegat approx. 30 km north of Gilbjerg Hoved on the north coast of Zealand. The wind farm is named Hesselø Offshore Wind Farm (Hesselø OWF) after the small uninhabited island of Hesselø, which is located southwest of the area. The Hesselø OWF will have an installed capacity of minimum 800 MW and maximum 1,200 MW.

The planned area for Hesselø OWF is shown in Figure 3.1.

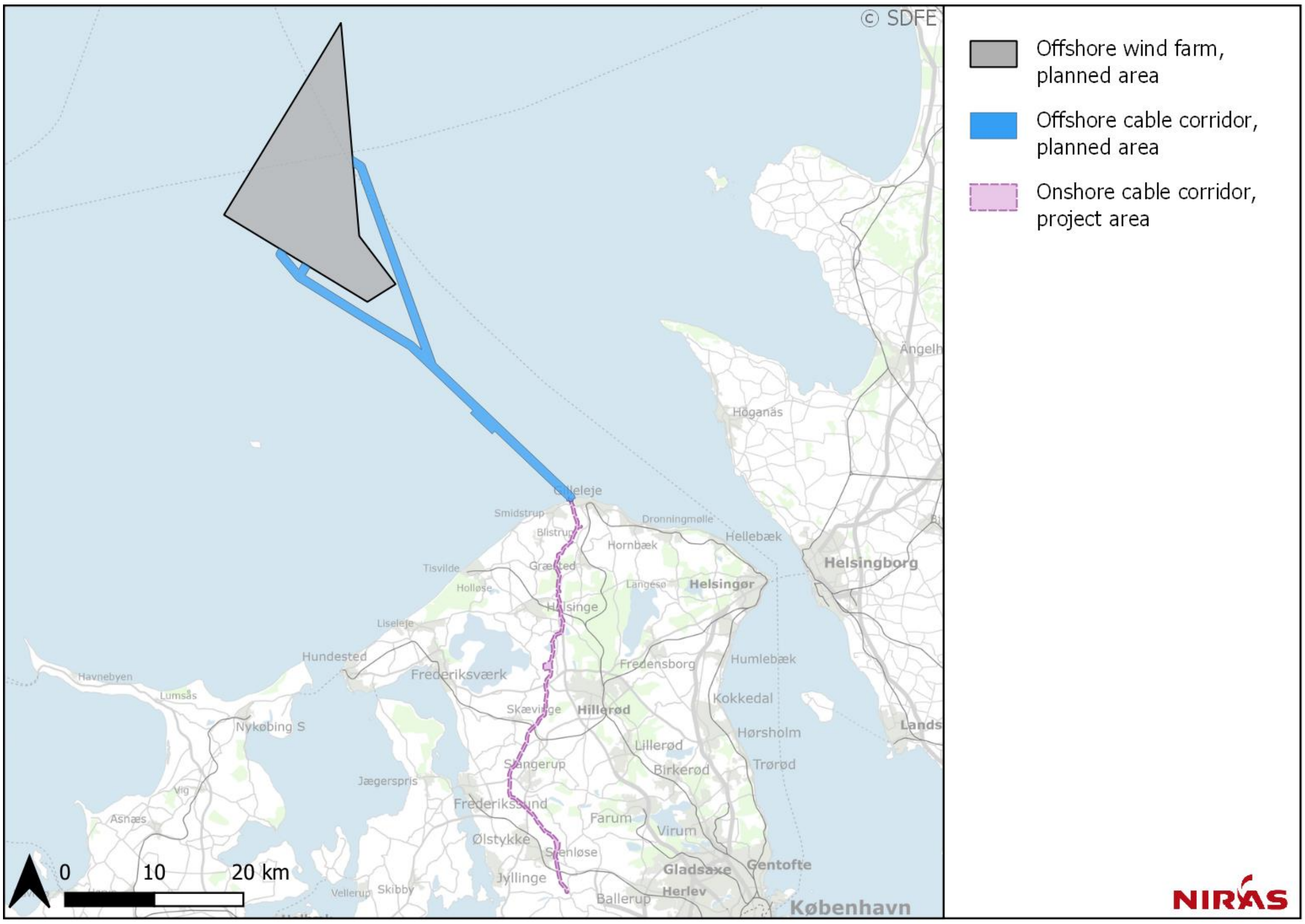



*Figure 3.1: Plan area for Hesselø Offshore Wind Farm. An example of a project area for the onshore cable corridor is illustrated on the figure.*

In order to ensure that Hesselø OWF will be supplying electricity by 2027, the Minister of Climate, Energy and Utilities has instructed Energinet to initiate the preliminary studies for the project – both offshore and onshore. This includes strategic environmental assessment (SEA) of the plan for the overall project, completion of relevant environmental surveys etc., investigation of a grid connection from the coast to the connection point at Hovegaard High Voltage (HV) station and preparation of an environmental impact report (EIA) for the onshore facilities.

The location of Hesselø OWF is based on a detailed screening of multiple areas for offshore wind farms in Danish waters carried out for the Danish Energy Agency and reported in spring 2020 (COWI, 2020).

The plan for Hesselø OWF is described in a memorandum from the Danish Energy Agency (Energistyrelsen, 2021a) and in the scoping report for the environmental assessment of the plan (Energistyrelsen, 2021b), which was issued in connection with the first public consultation (February 12th to March 19th 2021).

### 3.1 Aim

This technical report presents baseline and sensitivity information on benthic flora and fauna associated with hard bottom substrate (stone reef) in relation to the planned Hesselø Offshore Wind Farm export cable corridor (soft bottom habitat is the subject of a separate report (NIRAS & DCE, 2022) and limited areas of soft sediment between stone reef are outside the scope of the study). The focus of the survey is on hard bottom (reef habitat) present in the inshore part of the export cable corridor, within and adjacent to the Natura 2000 Site 'Gilleleje Flak and Tragten' and the hard bottom investigations were therefore undertaken in this area (Figure 3.2). An area of hard bottom was also mapped by geophysical survey in the export cable corridor immediately to the south of the wind farm area (Rambøll, 2021).

The first part of the report presents the plan for Hesselø OWF including a description of project scenarios followed by a method description. Next, existing (baseline) conditions are outlined, including data and results from benthic ecological surveys as well as data and information from other sources concerning benthic flora and fauna. Finally, a sensitivity analysis of benthic flora and fauna communities associated with hard bottom habitats is presented.

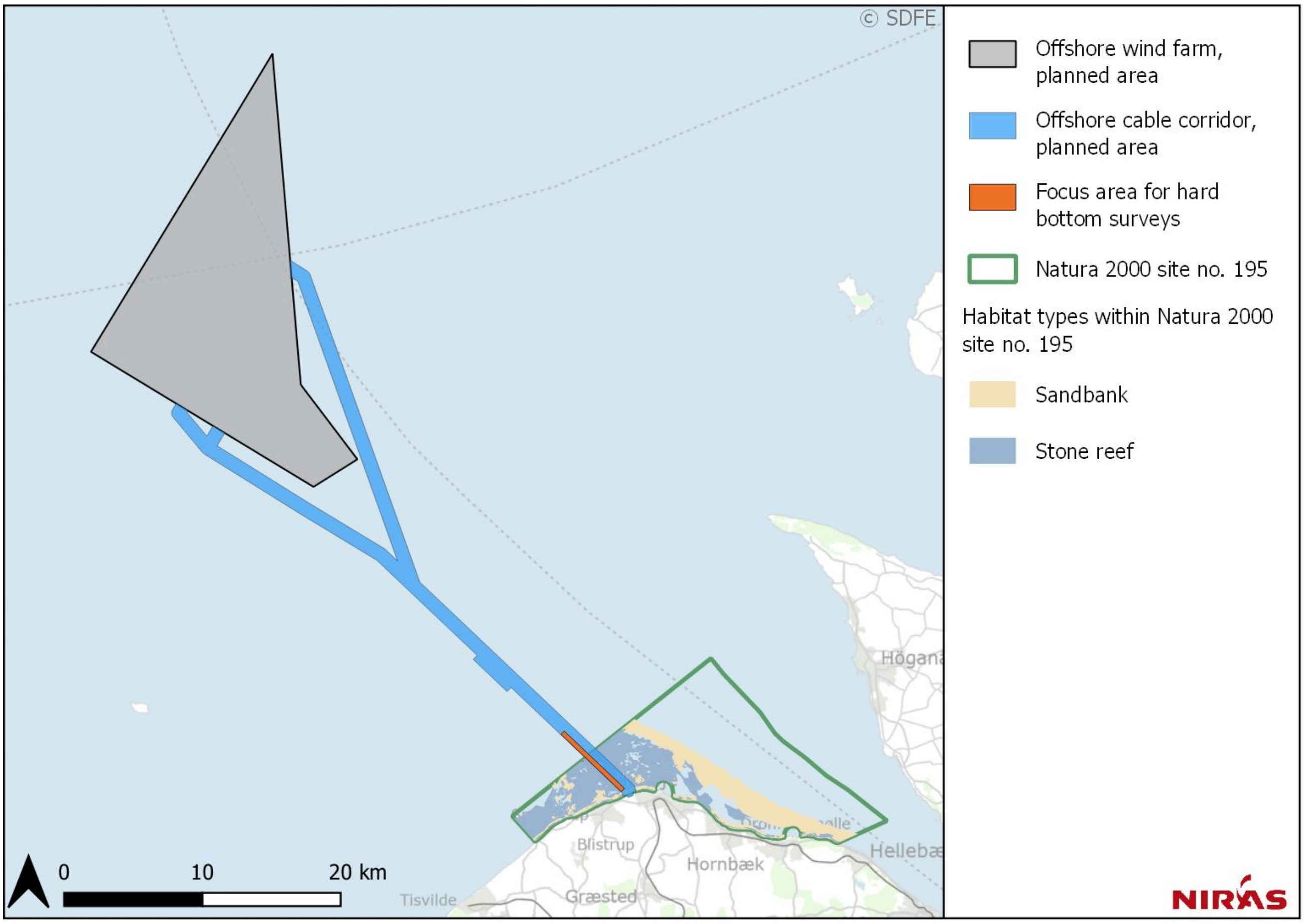



*Figure 3.2 Plan area for Hesselø Offshore Wind Farm and area of focus for hard bottom survey investigations. The map also shows the delimitation of Natura 2000 site no. 195 as well as habitat types within the site.*

## 4 Methods and surveys

### 4.1 Scenarios for Hesselø Offshore Wind Farm

In the order to Energinet, the Minister of Climate, Energy and Utilities has instructed Energinet to initiate a series of preliminary studies for the offshore part of the project. The results of the studies will be provided to the tenderers for the offshore wind farm and will form important input for the future environmental impact assessment of the specific project. To ensure that the studies have the right focus and are relevant for an offshore wind farm of 800 – 1,200MW, a set of key technical parameters has been considered and a number of scenarios have been developed. The key technical parameters and scenarios listed in Table 3.1 are used in relation to the sensitivity assessment in this report.

Wind turbines with a capacity in the range of 8-20 MW is the base for the assessment. The minimum turbine capacity of 8 MW corresponds to the installation of up to 150 turbines, and the maximum turbine capacity of 20 MW corresponds to the installation of up to 60 turbines. A grid of inter-array cables (66kV) installed in the seabed will connect the individual turbines to the offshore transformer platform, which will connect the wind farm to the onshore grid via 2-3 export cables also installed in the seabed.

*Table 4.1: Technical parameters for the scenarios for Hesselø OWF included in this report.*

| Technical parameters | | | |
|---|---|---|---|
| Offshore wind turbines | | | |
| | 8 MW turbine | 15 MW turbine | 20 MW turbine |
| No. of WTGs | 100 - 150 | 54 - 80 | 40 - 60 |
| Rotor diameter, meter | 170 | 260 | 280 |
| Hub height, meter | 105 | 150 | 170 |
| Tip height, meter | 190 | 280 | 310 |
| Nacelle (length, width, height), meter | 20x8x8 | 29x13x13 | 32x15x15 |
| Fundaments | | | |
| Monopile diameter, meter | 10 | 13 | 15 |
| Pile driving; hammer size, blow strength and blow rate | IHC S-4000, 6000kJ, 7000 blows.<br>Rate: 4 seconds for 'soft start-procedure' thereafter 2 seconds. | | |
| Scour protection | 15 – 20 meter in diameter | | |
| Offshore transformer platform* | | | |
| Dimensions (length/width), meter | 40/25 | | |
| Inter array cables | | | |
| | 66 kV | 66 kV | 66 kV |
| Export cables | | | |
| No. of cables | 2-3 | | |
| Voltage level | 220 kV – 345 kV (AC) | | |
| Investigated cable corridor (offshore), meter | 1.000 | | |
| Distance between cables in Natura 2000 sites/other areas, meter | 50/150-200 | | |
| Depth of cable trench, centimeter | 60-100 | | |
| Length of directional drilling (at landfall), meter | Up to 1,000 | | |

* One platform is expected to be established, but two possible locations are included in the preliminary investigations and in the strategic environmental assessment.

The parts of the project located on land are described in the technical project description that forms the basis for the environmental impact assessment of the project on land.

The layout of the offshore wind farm and turbines is not decided at present, as this will be determined by the future Concessionaire. The current assessments have therefore been made at an overall level, taking into account the different variations regarding total installed capacity, sizes of turbines and the consequent difference in the number of turbines and layouts of Hesselø OWF. For each of the turbine sizes (8MW, 15MW and 20MW) specific layouts have been developed to support the visualizations and other parts of the assessment. An environmental impact assessment will be prepared for the specific offshore project by the Concessionaire.

## 4.2 General

The overarching objective of the survey was to characterise the near-shore cable corridor survey area in order to support the subsequent work evaluating the sensitivity of the flora and fauna communities present to wind farm development. This was pursued using 1) visual observations of seabed features at larger spatial scale (conducted with a ROV) and 2) sampling of the hard bottom flora and fauna according to the technical guidelines developed for the national Danish monitoring programme (NOVANA) and use of state-of-the-art community analysis.

The Danish Environmental Protection Agency (EPA) uses the same seabed sediment classification system for Natura 2000 habitats as for managing sand and gravel extraction (Table 4.2). A full description is found in Appendix 2.

*Table 4.2: Seabed sediment classes used for classification.*

| Class | Description of substrate class |
|---|---|
| 1a | Sand, silty soft bottom |
| 1b | Sand solid soft bottom |
| 1c | Clay bottom |
| 2a | Sand, gravel and pebbles – few larger stones |
| 2b | Sand, gravel pebbles – seabed cover of larger stones 1-10% |
| 3 | Sand, gravel pebbles – seabed cover of larger stones 10-25% |
| 4 | Stony areas and stone reefs – seabed cover of larger stones 25-100% |

According to EPA's definition of reef sites within protected Natura 2000 sites, there must be a core area with at least 25% hard bottom (seabed type 4), given that adjacent areas with 10-25% hard substrate (seabed type 3) are included in the overall protection of a given reef structure.

This investigation was conducted focusing on mapped reef structures within the Natura 2000 site 'Gilleleje Flak and Tragten', through which the proposed export cable route is located. In addition, the adjacent hard bottom area following the definition above was included in the investigation. Energinet provided the mapped background data on seabed types and high-resolution bathymetric data (Rambøll, 2021). The depth range in the investigated area was 6-19 m and the overall length of the area of interest extended approx. 6.2 km from the shore.

## 4.3 ROV investigation

Six areas for transect investigation were identified based on an analysis of multibeam and sidescan sonar data focusing on seabed types 3 and 4 (Table 4.3 and Figure 4.1). A special map combining seabed roughness and mapped substrate types was used actively by the ROV team as guiding background for selecting and conducting the six transect investigations in the field. Roughness was calculated by subtracting a low-resolution bathymetry (1 m) from a high-resolution bathymetry (25 cm) (Dahl, et al., 2012; Göke & Dahl, 2014).

*Table 4.3: Estimated minimum length of the six transects.*

| ID | Length (m) | x start | y start | x end | y end |
|---|---|---|---|---|---|
| ROV1 | 245 | 12° 15.577' E | 56° 7.820' N | 12° 15.758' E | 56° 7.735' N |
| ROV2 | 628 | 12° 14.330' E | 56° 8.524' N | 12° 14.749' E | 56° 8.279' N |
| ROV3 | 64 | 12° 14.082' E | 56° 8.668' N | 12° 14.124' E | 56° 8.643' N |
| ROV4 | 555 | 12° 13.514' E | 56° 8.998' N | 12° 13.885' E | 56° 8.783' N |
| ROV5 | 292 | 12° 12.816' E | 56° 9.404' N | 12° 13.011' E | 56° 9.291' N |
| ROV6 | 668 | 12° 12.034' E | 56° 9.859' N | 12° 12.482' E | 56° 9.600' N |

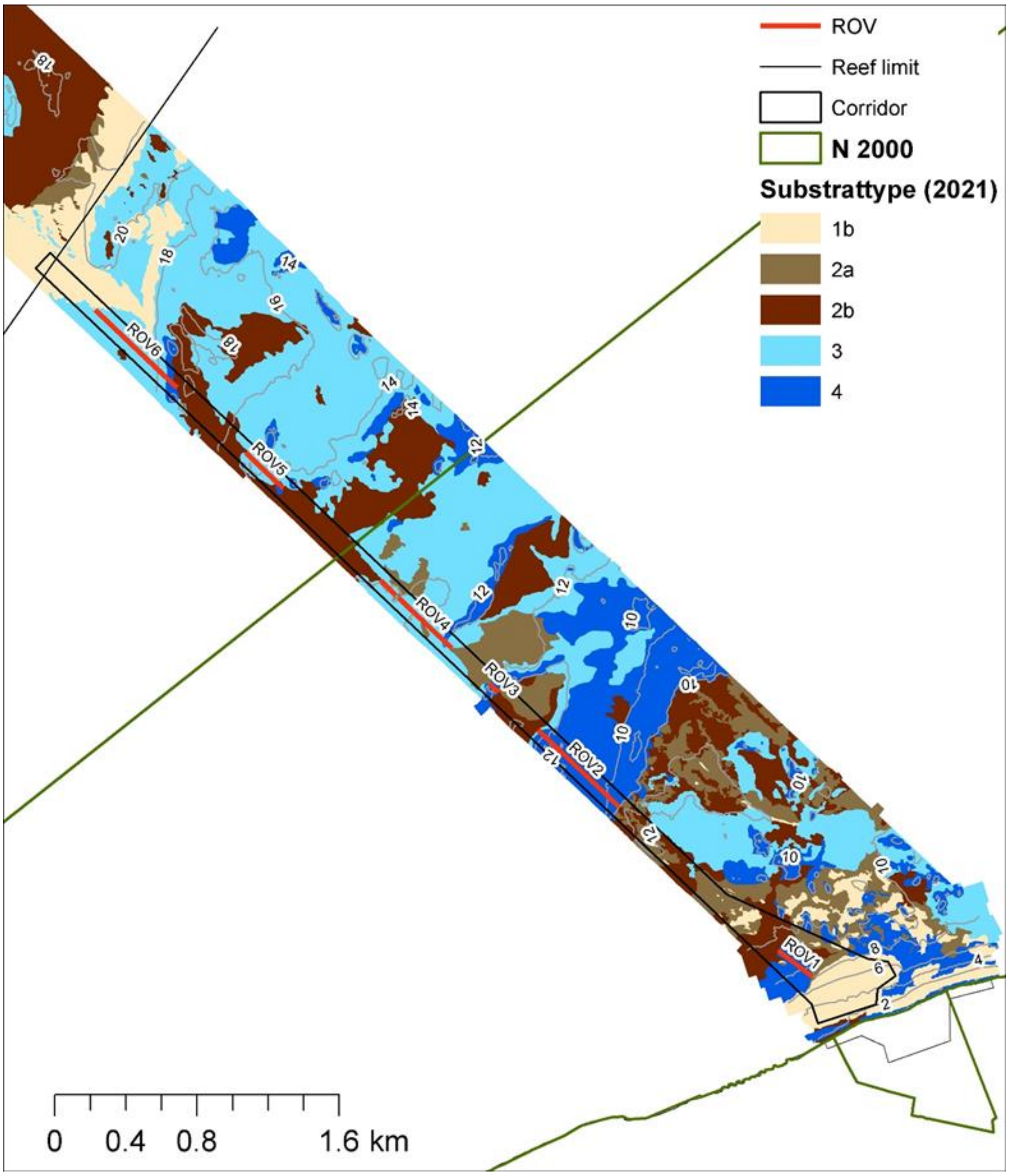



*Figure 4.1: Seabed sediment map for the 1 km wide survey (Rambøll, 2021) showing the narrow nearshore cable corridor (black line) off Gilbjerg Hoved and six transects (red lines) covering seabed types 3 and 4. Minor differences might occur compared to the previous seabed mapping by GEUS that was used to designate reef structures within the protected Natura 2000 site. The seabed sediment type 4 includes 25-100% hard substrate, type 3 includes10-25% hard substrate, type 2 a and b are sand with some stones and type 1 is sand.*

The ROV investigation was conducted on 9 June 2021 under calm weather conditions and very favourable underwater visibility. The ROV survey was carried out using the R/V Niisa, a smaller vessel appropriate for the nearshore area. It was not a prerequisite for the investigation to follow exactly the predefined ROV transect lines as the purpose was not to look for specific sections but to get an idea of the six selected reef structures from S-E to N-E. However, we did try to follow the predefined line as far as possible.

On 7 June 2021, a similar investigation was conducted as part of an AU training programme for the newly bought ROV using transects (1-6) to practice survey methods. The video recordings from that day are included in the evaluation of seabed composition and biological information in the six investigated areas.

This investigation focused on describing the overall seabed within the mapped reef areas (type 4 and type 3) in terms of sediment composition (cover of sand and different sizes of stones up to large-sized boulders) and large-scale biological information in terms of the overall cover of macroalgae vegetation and cover of larger hard bottom fauna organisms.

The ROV used for the investigation (RSV-8 ROV) was operated from R/V Niisa, in most cases following the ROV without anchoring. The ROV is equipped with a USBL for underwater localisation during operation, and the software allows the pilot to navigate the ROV within areas defined on pre-installed geo-referenced GIS maps as shown in Figure 4.2.

All ROV investigations resulted in video recordings of the seabed along an approx. 2 m wide line and a simultaneous recording of the present location of the ROV in the GIS map in a secondary window in the software (Figure 4.2).

All recordings were carefully reviewed back in the office. Based on this review, a relevant description of each transect was made in accordance with the defined objective of the ROV investigation.

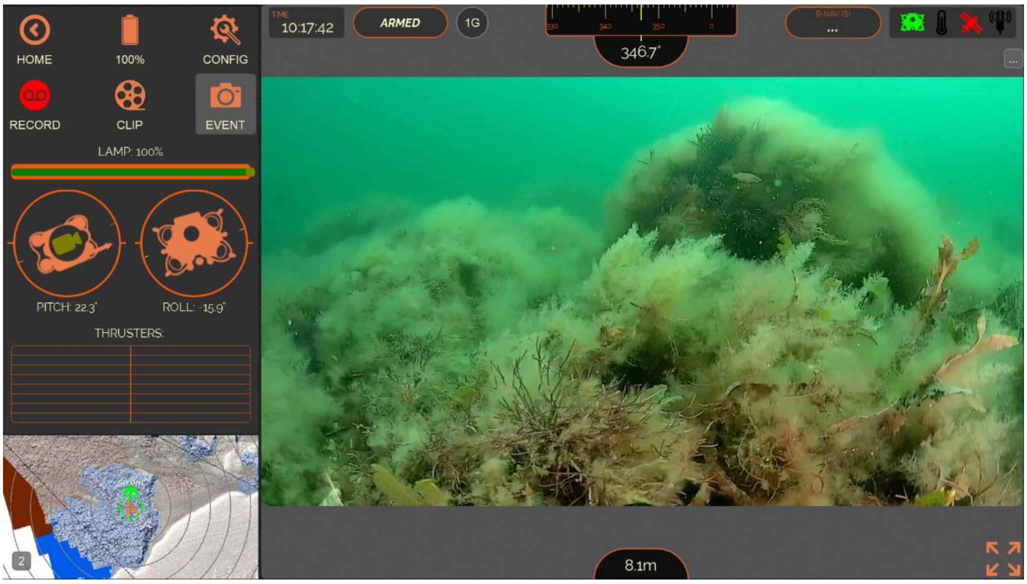



*Figure 4.2: Software window with boulder reef in the video window and the geo-referenced map in the secondary window showing the present location of the ROV. ROV transect 1 at 8.1 m water depth.*

## 4.4 Dive investigation

The sampling encompassed 21 stations placed from 6 to 19 m water depth with three stations (replicates) for each 2 m depth interval. The stations were located on seabed type 4 (>25% hard bottom), if possible; otherwise on seabed type 3 (10-25%). Figure 4.3 shows the sampling location within the Natura 2000 area and Figure 4.4 shows the stations in the adjacent area just outside the protected area. The sampling positions are given in Table 4.4.

Unfortunately, one station at the 16-17 m depth interval was not sampled by mistake. The dive was registered as taken although it was aborted due to hazardous diving conditions. Given the large dataset collected by divers and the successful ROV investigation, this missing sample will not compromise the overall results.

*Table 4.4: Dive stations with position and depth measured by divers.*

| Station name | Position | | Depth (m) | Depth interval (m) |
|---|---|---|---|---|
| h1 | 12° 15.724' E | 56° 7.718' N | 6.2 | 5.9-6.5 m |
| h2 | 12° 15.710' E | 56° 7.713' N | 5.9 | 5.9-6.5 m |
| h3 | 12° 15.735' E | 56° 7.746' N | 6.5 | 5.9-6.5 m |
| h4 | 12° 15.609' E | 56° 7.749 N | 7.7 | 7.5-7-7 m |
| h5 | 12° 15.650' E | 56° 7.754' N | 7.7 | 7.5-7-7 m |
| h6 | 12° 15.737' E | 56° 7.763' N | 7.5 | 7.5-7-7 m |
| h7 | 12° 14.763' E | 56° 8.300' N | 9.4 | 9.4-9.8 m |
| h8 | 12° 14.701' E | 56° 8.354' N | 9.8 | 9.4-9.8 m |
| h9 | 12° 14.677' E | 56° 8.305' N | 9.5 | 9.4-9.8 m |
| h10 | 12° 14.079' E | 56° 8.642' N | 12.2 | 11.9-12.2 m |
| h11 | 12° 14.350' E | 56° 8.527' N | 12.2 | 11.9-12.2 m |
| h12 | 12° 13.863' E | 56° 8.819' N | 11.9 | 11.9-12.2 m |
| h13 | 12° 12.017' E | 56° 8.729' N | 12.7 | 12.7-14.3 m |
| h14 | 12° 12.862' E | 56° 9.363' N | 13.7 | 12.7-14.3 m |
| h15 | 12° 12.816' E | 56° 9.375' N | 14.3 | 12.7-14.3 m |
| h17 | 12° 12.464' E | 56° 9.602' N | 17.5 | 16.1-17.5 m |
| h18 | 12° 12.414' E | 56° 9.627' N | 16.1 | 16.1-17.5 m |
| a4 | 12° 12.283' E | 56° 9.678' N | 18.6 | 18.6-18.9 m |
| h19 | 12° 12.194' E | 56° 9.786' N | 18.9 | 18.6-18.9 m |
| h21 | 12° 12.208' E | 56° 9.786' N | 18.9 | 18.6-18.9 m |

The dive investigation included an on-site description of the seabed sediment composition at the station and a description of the total vegetation cover and species-specific cover of macroalgae and hard bottom fauna organisms identified by the diver. The area covered by one dive was at least 25 $m^2$. The investigation followed the technical guideline TA-M14 for reef monitoring (Dahl & Lundsteen, 2018), which describes the reef monitoring conducted as part of the Danish national monitoring programme (NOVANA).

Some organism groups are not identified to species level, but are kept in larger group. Examples are crust-forming algae that are separated into calcified red crusts, red crusts and brown crusts and then the species *Litothamnion glaciale*. In addition, samples were taken for verification of the diver observations and identification of species not observed on site. The samples were stored in 5-10 l buckets to which 70% alcohol was added for conservation. The investigation was made by skilled divers, Karsten Dahl and Peter A.P Stæhr, both conducting the NOVANA Reef monitoring.

High-resolution underwater pictures were taken using a Nikon D810 camera in a Subal underwater housing. Pictures were only taken at stations where the water visibility and weather conditions allowed it.

The dive investigation took place during a three-day period from 14-16 June 2021. The investigation used R/V Seamaster as dive platform. The water visibility was poor in deeper water areas during the first two days due to windy conditions in the period leading up to the investigation. Increasing wind and a relatively strong current perpendicular to the wind direction stopped the diving operation before time in the afternoon on the second day. On the third day, diving conditions had improved considerably.

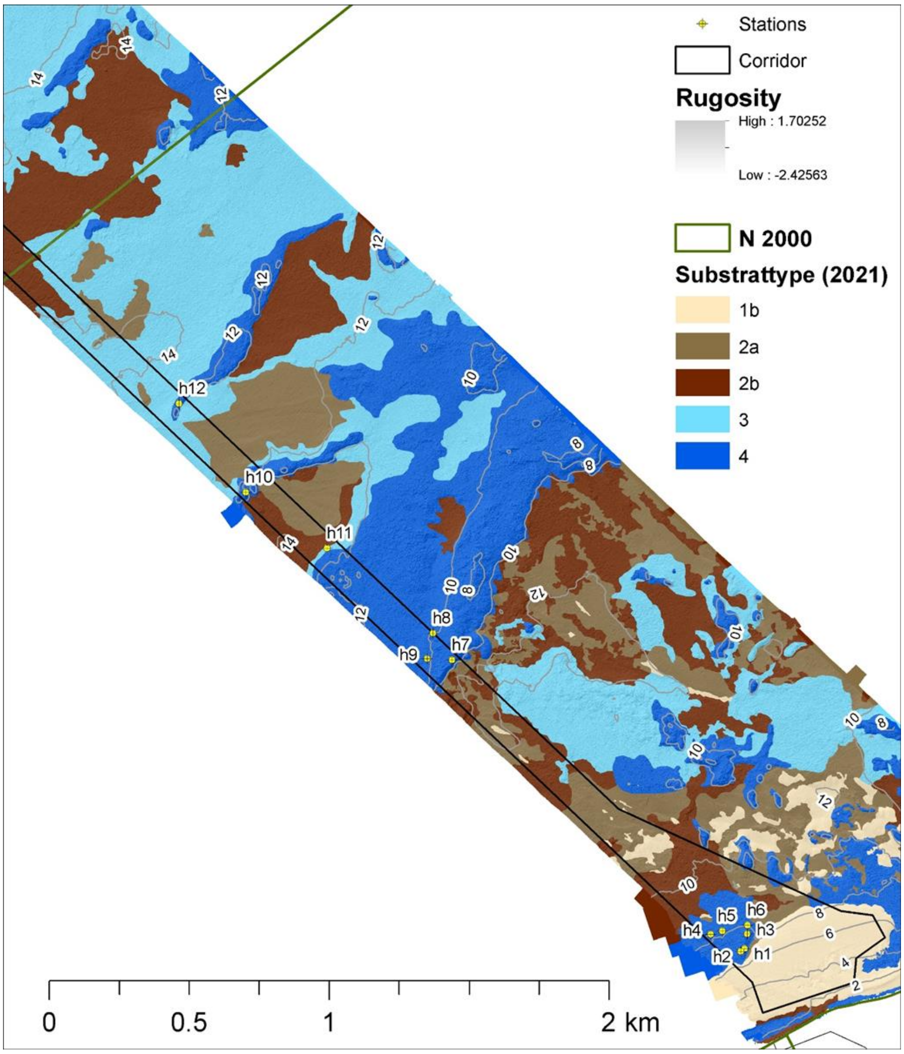



*Figure 4.3: Seabed sediment map with dive stations in hard bottom areas within the Natura 2000 site "Gilleleje Flak and Tragten". The map shows the original 1 km wide survey area and the narrow final survey area (termed "corridor").*

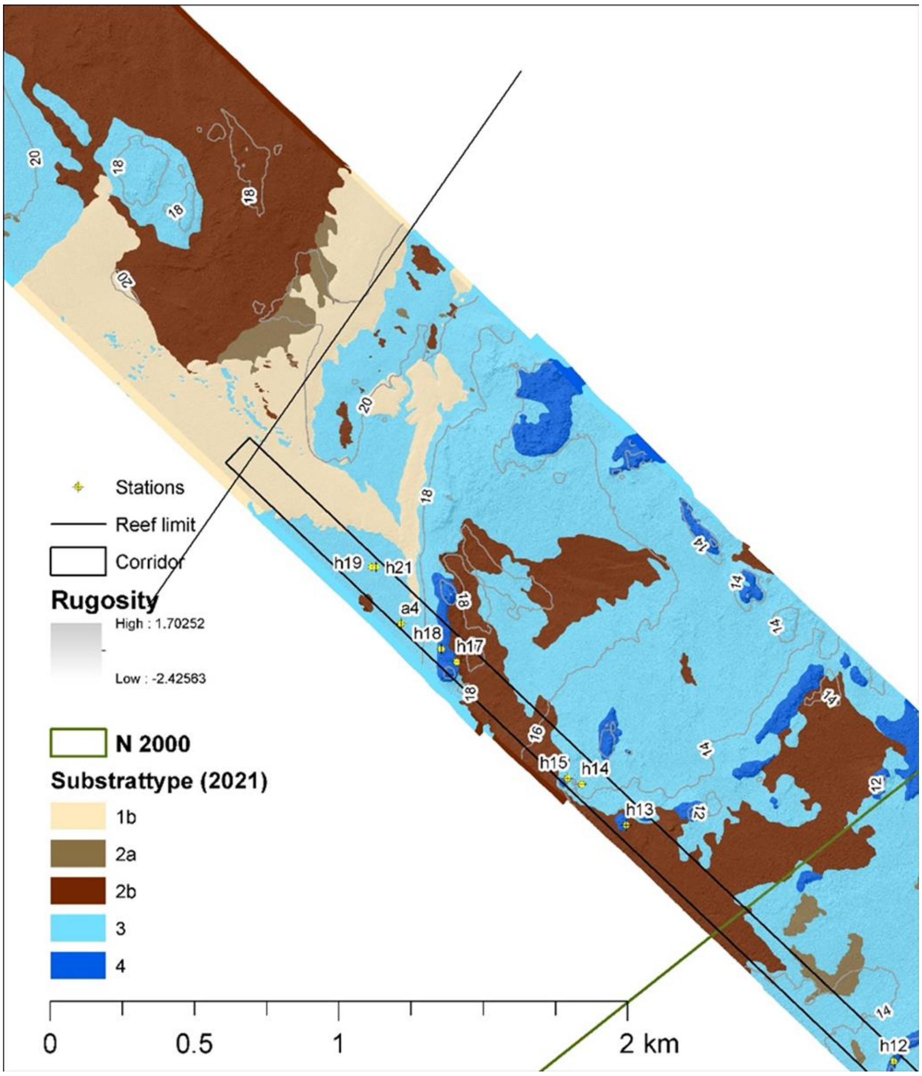



*Figure 4.4. Seabed sediment map with dive stations in hard bottom areas just outside the Natura 2000 site "Gilleleje Flak and Tragten" indicated by the green line. The map shows the seabed sediment in the original 1 km wide survey area and the narrow final survey area (termed "corridor").*

### 4.5 Laboratory procedures for species identification

The collected samples were investigated in the laboratory using a Leica stereomicroscope (100x) and a Leitz microscope (400x). The divers' species identifications were checked and corrected, if needed; for example, *Coccotylus truncates* was changed to *Phyllophora brodeie*. Small species not identified by the divers were added to the overall species list and assigned a cover of 0.1%.

### 4.6 Additional data

Salinity data with long time series from three stations relatively close to Gilbjerg Hoved were extracted from the national database and presented with mean values and standard deviation. The data were all gathered as part of the national NOVANA programme.

### 4.7 Statistical analysis

Multivariate analyses were performed using PRIMER software and the Permanova add-on routine in the PRIMER package. The analysis was done using non-transformed data on species cover in percentage. The similarity between communities in each sample is expressed by the Bray-Curtis similarity (Clarke, Gorley, & Somerfield, 2014). The description of key species composition in each investigated depth interval was done by calculating the average cover per interval.

# 5 Results and baseline

This presents results of the survey investigations which provide baseline information on hard bottom habitats and communities within and adjacent to the Natura 2000 site.

## 5.1 ROV investigation

### Transect 1

The planned transect was 245 m long and mapped as seabed type 4. The depth ranged from 6 m nearshore to 9 m.

Sampling the transect from SE, we noticed a sharp border between a coarse sandy seabed and hard bottom at 6 m depth. The hard bottom area had a very high cover (almost 100%) of stones and boulders, the majority ranging from 20-40 cm and a few larger ones. Further north, the water depth increased to app. 7-7.5 m and patches of coarse sand appeared between the stones, still ranging from 20-40 cm. In general, stones and boulders dominated in most cases with an overall coverage of 75%. From 8 to 9 m water depth, the hard bottom cover decreased from 70% to 20%. Larger boulders >60 cm were observed. At 9 m depth, the seabed changed to sand with scattered smaller stones in accordance with the acoustic mapping.

The vegetation completely covered stones and boulders and consisted of a top layer of annual filamentous algae. The lower level of the vegetation layers was only partly visible. In this layer, *Furcellaria lumbricalis* seemed common and was, to some extent, *Fucus serratus* (Figure 5.1).

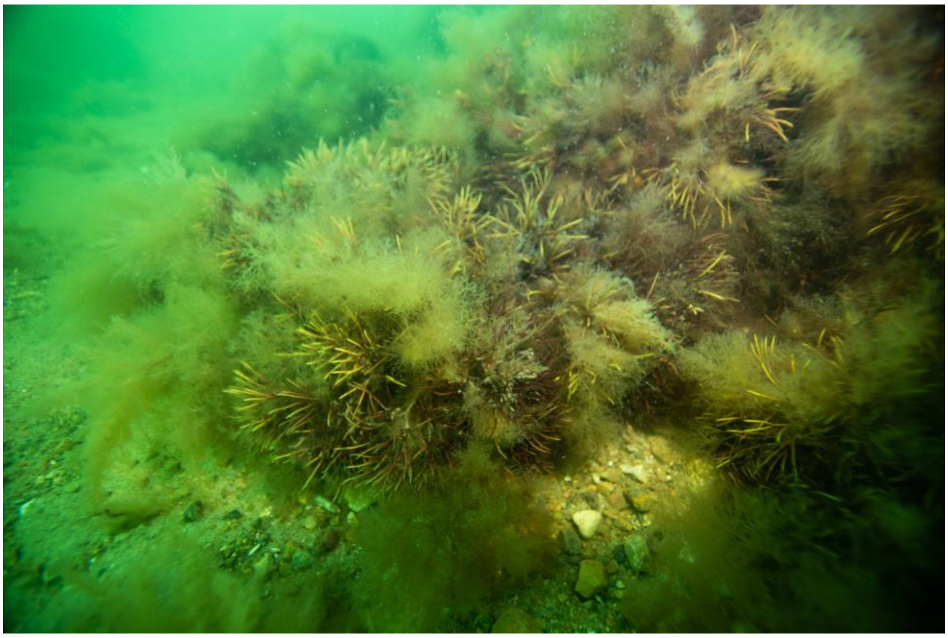


*Figure 5.1: Boulder at 6.5 m depth. Furcellaria lumbricalis was the main algae on the hard surface. Filamentous algae grew epiphytically on the Furcellaria, forming a top vegetation layer. Photo: Peter Stæhr.*

### Transect 2

The planned transect was almost 630 m long and mapped mainly as seabed type 4 ending with a narrow stretch of seabed type 3 in NW. The depth mapped as reef varied from app. 7.5 to 12.5 m.

The investigation was initiated a short distance before the reef structure from the southern end on a sandy seabed with scattered stones at app. 11 m depth. The reef rose from the surrounding seabed to app. 7.5 m with a high cover of stones and boulders (>75% cover of hard stable substrate). From the top of this particular reef structure, the depth gradually increased to 12 m, often with stable hard substrate ranging from 30 to 100% cover, in most cases the cover exceeded 80%.

The vegetation cover was dense (100%) where the substrate was hard, making it difficult to judge the size of the boulders; however, most seemed to be within the range 10 to 40 cm with occasional boulders as large as 1 m. From 12 m depth, the cover of hard substrate decreased to 15-20%. No stones/boulders were observed at 13 m where sandy seabed completely took over.

The vegetation seemed to be dominated by a layer of annual filamentous algae on top of *Furcellaria lumbricalis* and leaf-forming red algae species and, to some extent, also *Fucus serratus* and *Halidrys siliculosus* (Figure 5.2)

*Figure 5.2: Boulder field at 9.4 m depth (Dive station H7). The vegetation cover was dense and dominated by red algae, but the brown algal species Halidrys silicuoses and Fucus serratus were also present. The sponge Halichondria panica can be seen as a yellow spot partly hidden by vegetation in the lower right-hand side of the picture. Photo: Peter Stæhr.*

### Transect 3

This boulder field was comparatively small relative to the cable corridor (transect line calculated to 64 m), ranging from 12 to 13 m water depth. The coverage of hard substrate was very high; thus, stones within the size range 20-60 cm and a few larger ones covered more than 90% of the area (Figure 5.3). Only minor patches of sand-dominated areas were observed during two parallel ROV transects. At the NW end of the transects, a short transition zone was observed with fewer boulders before the appearance of sandy seabed dominated by stones.

The stable hard substrate was still completely covered by algal vegetation.

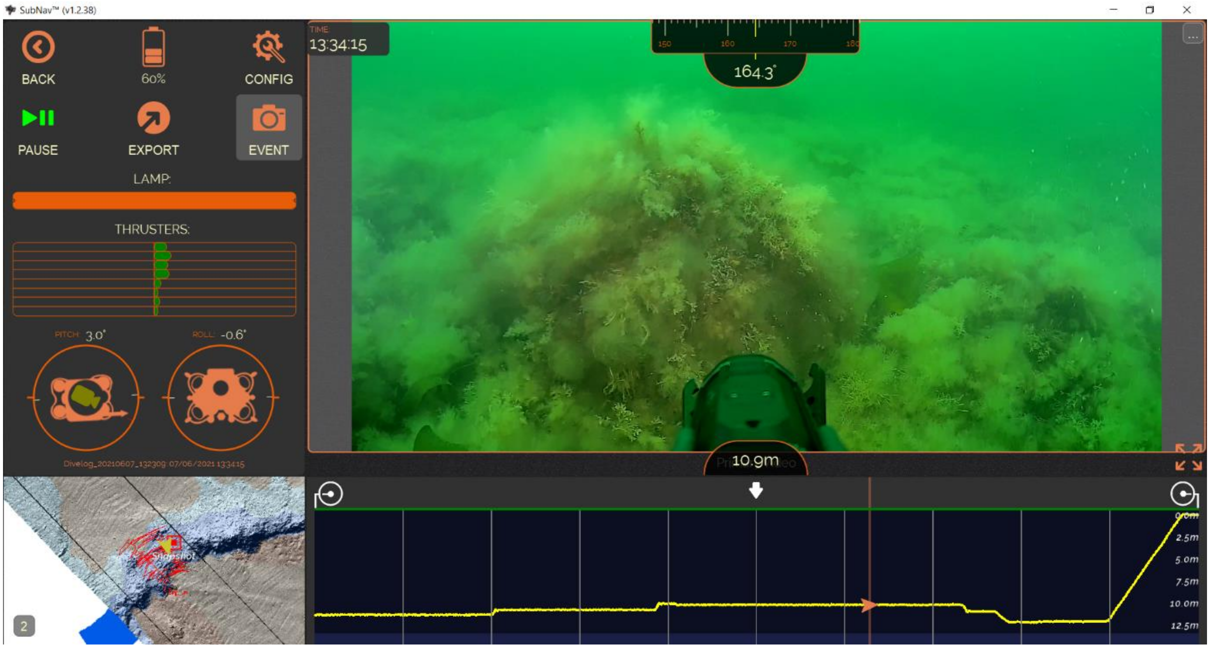



*Figure 5.3: Dense boulder field completely covered by algae vegetation at app. 11.3 m depth.*

### Transect 4

This transect was 555 m long and the majority was mapped as seabed type 3. The depth ranged from app. 12 to 14 m. Coming from SE, the seabed presented scattered stones (<5% cover) just outside the planned transect line. On the majority of investigated reef structure, the cover of hard stable substrate was judged to range between 10 and 15%. The minor part of the seabed mapped as type 4 had a considerably higher cover of stones and boulders (>95%). Other minor patches with dense stone and boulder fields (range 25-80% hard substrate cover) were also located within the seabed mapped as type 3. In addition, dense areas with minor stones (pebbles and minor cobbles with size 5-10 cm were observed. Those minor stones were hardly visible when using a sidescan sonar for seabed classification. The vegetation cover on those small stones was dense and consisted of both filamentous annual and perennial algae species, indicating a stable or partly stable substrate.

Some filamentous algal vegetation was observed on top of the perennial vegetation. The perennials were dominated by red algal species. The large brown algae *Laminaria digitata* was common. The other large brown algae *Saccharina latissima* was also observed.

### Transect 5

The length of the transect was app. 300 m and it covered two minor areas in the southern part mapped as seabed type 4 and a larger stretch mapped as seabed type 3. The depth varied from 13 to 14 m. This transect was located outside the Natura 2000 site.

Using the ROV, we found several areas with a very dense cover of hard substrate with larger stones (type 4 areas) (Figure 5.4) within the mapped type 3 area. In general, the vegetation cover on the major part of the investigated seabed indicated a cover of hard stable substrate close to or exceeding 25%. Some of those stones were likely smaller than 10-15 cm and hard to identify using sidescan sonar. However, the minor stones still hosted perennial algae species. We also recorded transect stretches of with only scattered stones on a sandy seabed (Figure 5.5).

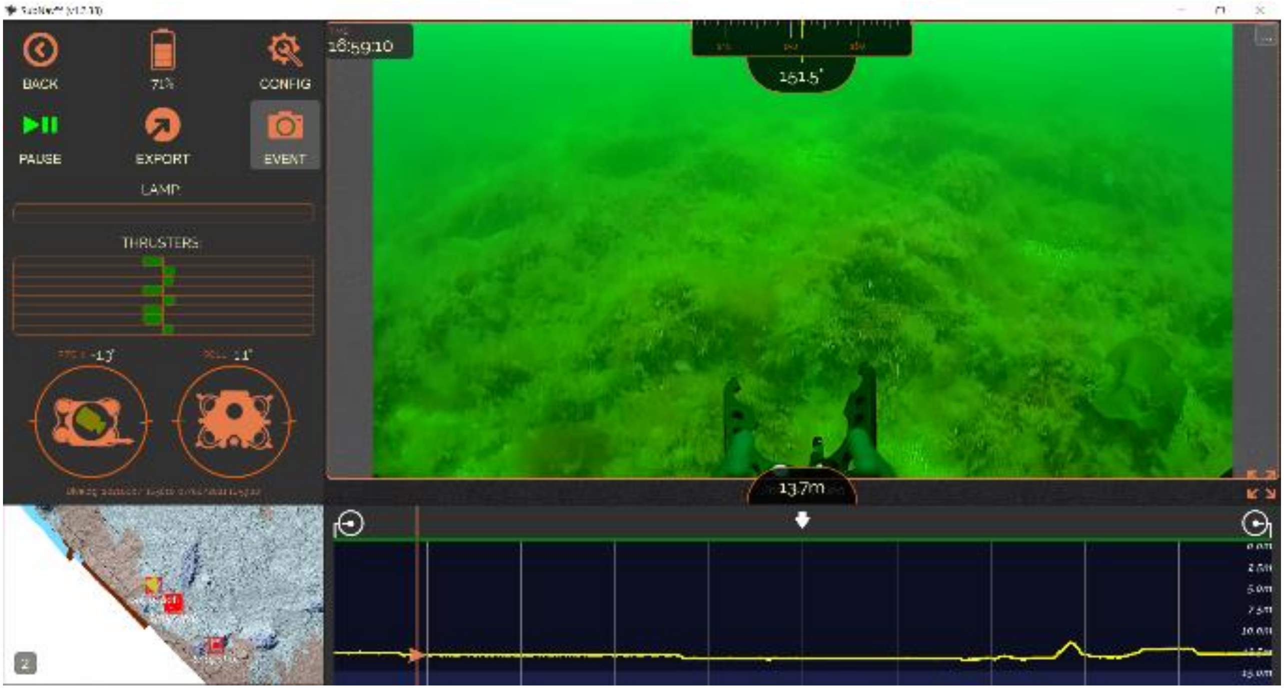



*Figure 5.4: Boulder field within a seabed classified as type 3.*

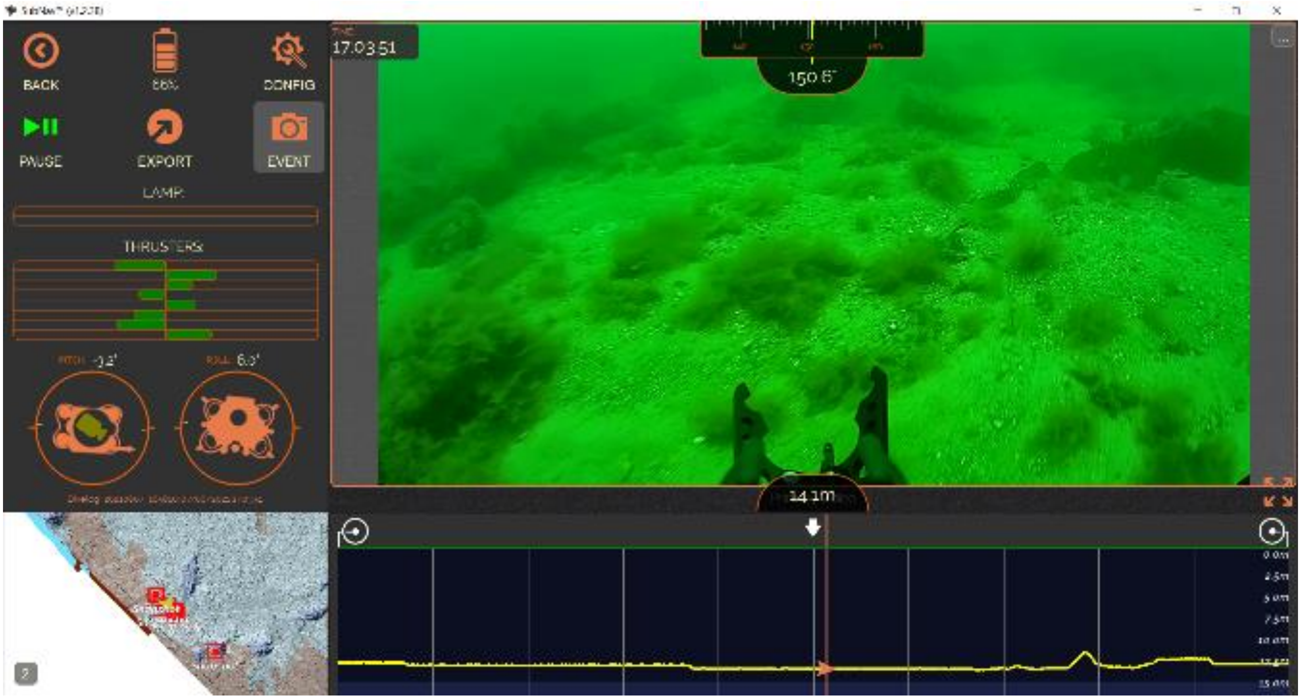



*Figure 5.5: Seabed type 3 with scattered stones and boulders and a rough sandy seabed.*

Algal vegetation completely covered the hard substrate, consisting of filamentous algae as a top layer and leaf forming red algae as the bottom layer or to some extend the brown algae species *Laminaria digitata* and more seldom *Saccharina latissima* (Figure 5.6)

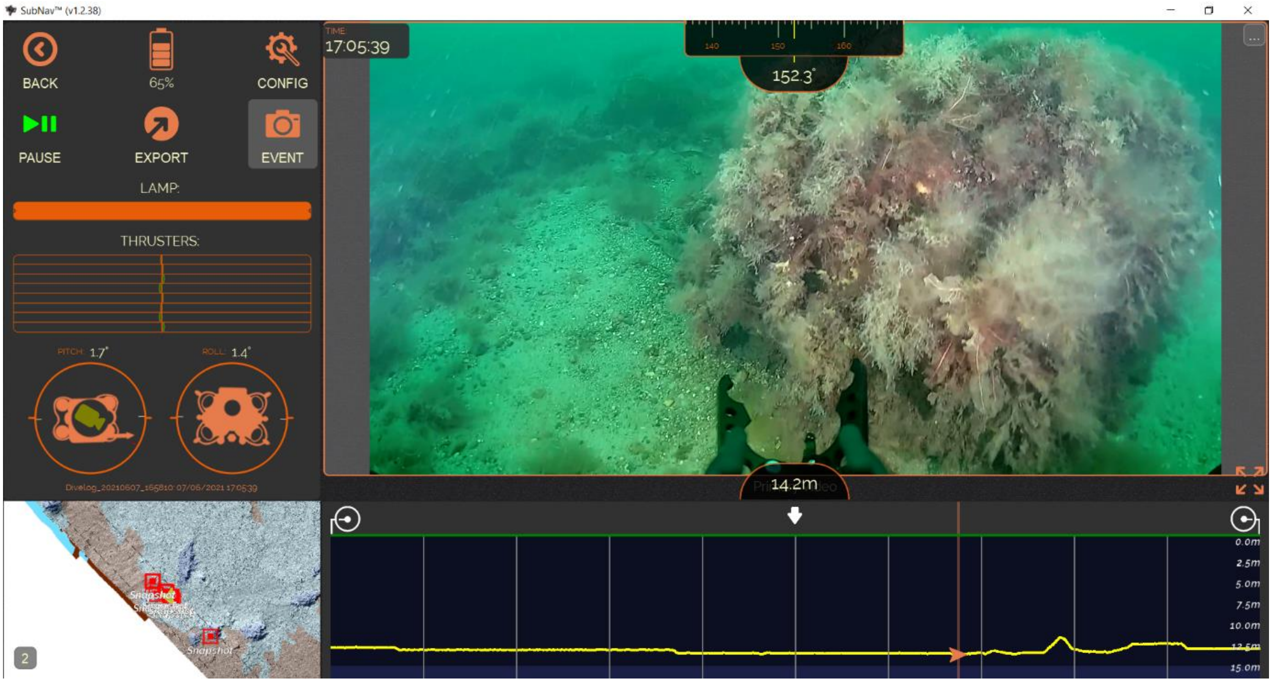



*Figure 5.6: A large boulder >60 cm at app. 15 m depth completely covered by filamentous algae species as top layer and leaf-forming red algae species such as Deleseria sanguinea as bottom layer.*

### Transect 6

This transect was the most diverse varying from almost 20 m water depth in the outer part to 16 m in the most shallow part. The seabed was mostly mapped as type 3 within the cable corridor, but the SE part had a higher cover of hard substrate. The length of the planned transect was 668 m.

Coming from SE at 18 m depth, the seabed was mapped as type 2 (sandy seabed and scattered stones) but rather resembled a dense gravel bed with scattered stones (Figure 5.7). The high cover of the brown algae *Saccharina latissima* might be caused by complete or partial drifting from shallower parts of the reef area. Perennial species continued to the dominant cover on the gravel (Figure 5.7)

A reef structure of larger stones rose two meter above the surrounding seabed consisting of more than 40% hard bottom. The hard substrate was covered by a relatively dense vegetation layer (>75% cover) (Figure 5.8). The structure seemed a bit larger than that mapped by sidescan sonar. *Laminaria digitata* occurred together with annual and perennial red algae vegetation. The water depth in the shallow part was 16 m.

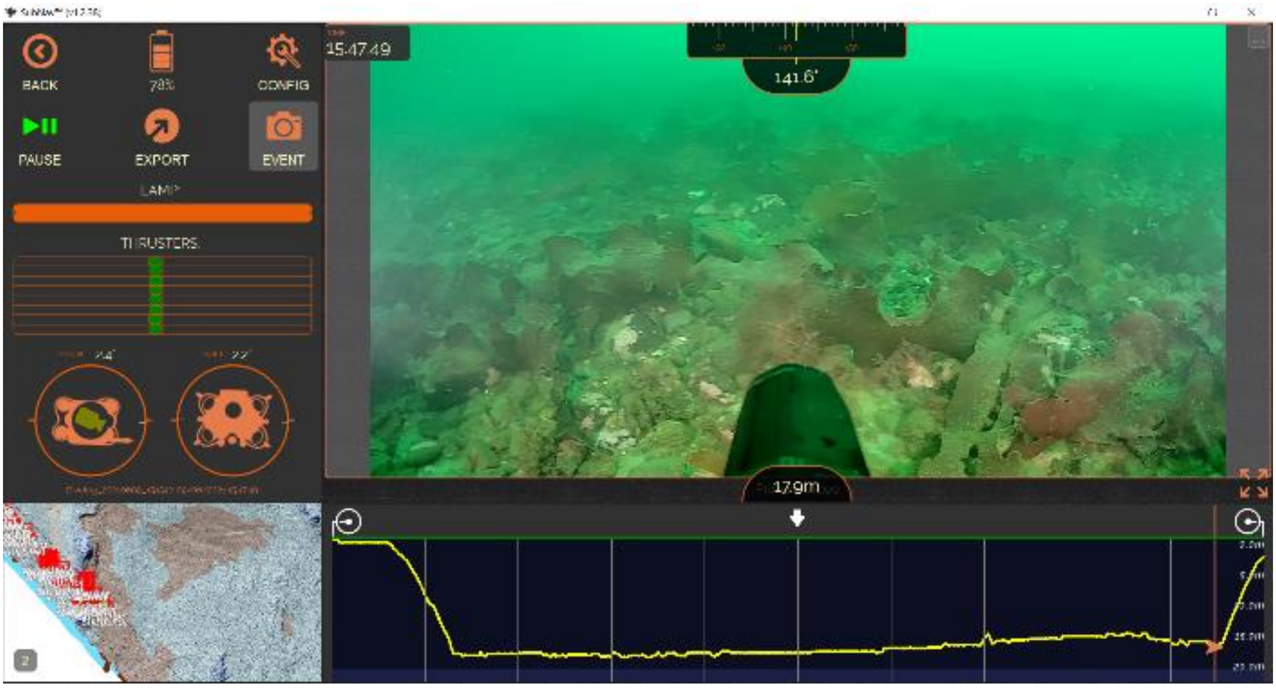



*Figure 5.7: Seabed mapped as type 2 but consisting of a gravel bed with scattered stones. The high cover of Saccharina latissimi could be a result of algal drifting from shallower parts of the reef area. The large red algae species Dilsea carnosa can be discerned in the lower right-hand side of the picture and the occurrence of other leaf-forming perennial algal species indicated stable conditions, even for minor stones.*

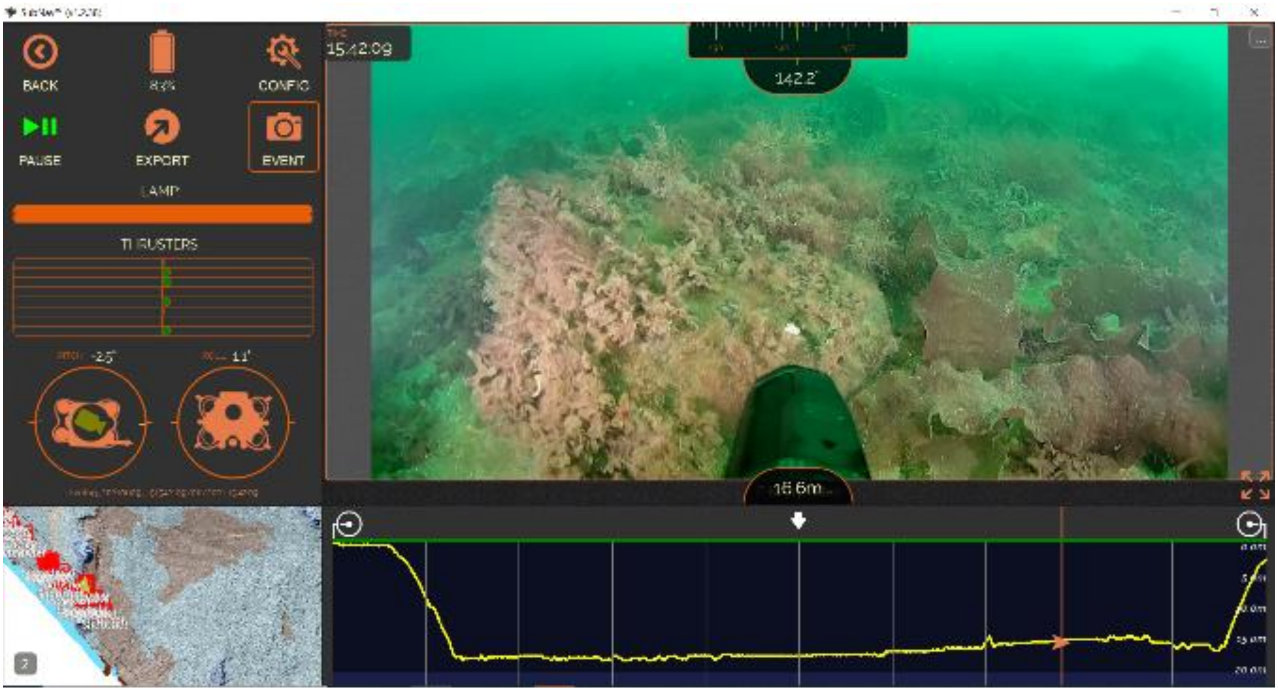



*Figure 5.8: Boulder at app. 17 m water depth covered by dense perennial red algal vegetation and Saccharina latissimi.*

Further north the depth increased and the brown algae *Saccharina latissima* became highly dominant around 17 m depth. This species often settles on minor stones as well. Without diving, it would be difficult to distinguish between firmly settled or drifting *S. latissima* anchored to small-sized stones. The large red algae *Dilsia carnosa* was also observed at 17m depth.

The red algae *Delesseria sanguinea* was obserseved down to 18 m depth and newly settled *Laminaria* species appeared at 18.7m depth. Between 20 and 18 m, epifauna species like *Asterias rubens*, *Martasterias glaciale* (Figure 5.9 left), the soft coral *Alcyonium digitatum* (Figure 5.9 right) and hydrozoans (Figure 5.9 left) were the most dominant species. One individual of the red-listed mussel *Modiolus modiolus* was also observed as were a number of *Pagurus bernhardus*.

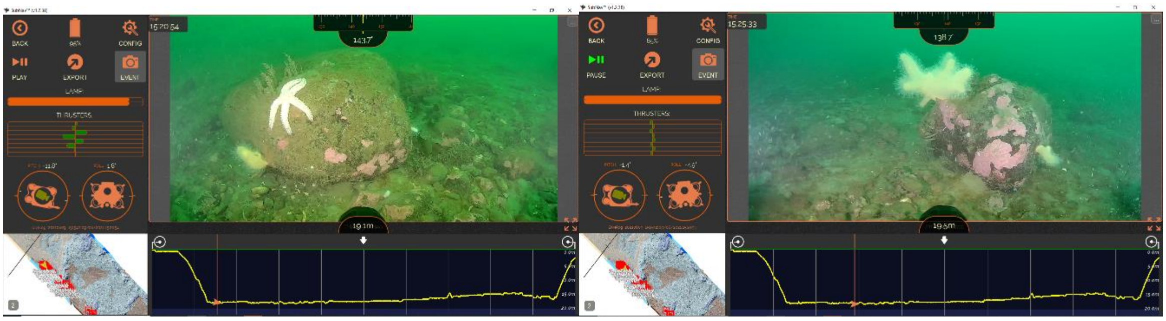


*Figure 5.9. Martasterias glaciale and hydrozoans at the top of the left picture and the soft coral Alcyonium digitatum and red crust-forming algae on both pictures.*

A large part of the seabed mapped as type 3 between 17 and 20 m consisted of dense gravel beds with scattered larger stones in the investigated transect. In between the gravel beds, some more muddy sand areas were observed, still with scattered stones present.

## 5.2 Diver investigations

### 5.2.1 Seabed sediment composition

Information from each dive station on depth, seabed sediment composition, overall vegetation cover and presence of drifting algae is given in Table 5.1. The table also includes the divers' estimates of the minimum size of stable hard substrate that hosts the same perennial vegetation and fauna as larger-sized hard substrate. Size combined with sediment composition determined the estimate of the percentage of hard stable substrate.

The divers' estimates of the percentage of hard stable substrate were relatively high for most of the investigated stations within the Natura 2000 site, ranging from 85 to 35%, but with the majority above 50%. Between 6 and 10 m depth, the fraction of boulders larger than 60 cm were estimated to make up >25% of the seabed. Also, the size class 30-60cm was very dominant. In deeper waters outside the Natura 2000 site, the fraction of stable hard bottom estimated by the diver was lower and the size generally decreased compared to the seabed inside the Natura 2000 site. Two stations, H14 and H15, were mapped as type 3 seabed, but the diver found the fraction of stable hard substrate to be higher than 25%, separating type 3 from type 4 seabed. The reason for this might be the problems of detecting minor stones using acoustic mapping equipment, but it may also be a question of scaling when evaluating the acoustic image in case of patchy distributions of hard substrate.

*Table 5.1: Sampling depth at the 20 investigated stations, their distribution in depth intervals and estimates of seabed sediment composition (in percentage) of selected size classes, including biogenic elements such as reef-forming mussels. The table also includes information on minimum size of stable hard substrate and total cover of hard stable substrate. Finally, the total vegetation cover is given for hard stable substrate as well as the cover of drifting vegetation for the whole seabed.*

| | Inside the Natura 2000 site | | | | | | | | | | | | Outside the Natura 2000 site | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Station | H-1 | H-2 | H-3 | H-4 | H-5 | H-6 | H-9 | H-8 | H-7 | H-10 | H-12 | H-11 | H-13 | H-15 | H-14 | H-17 | H-18 | MIS | H-21 | H-19 | A-4 |
| Mapped seabed type | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 3-4 | 4 | 3 | 3 | 4 | 4 | | 3 | 3 | 3 |
| Depth | 6.2 | 5.9 | 6.5 | 7.7 | 7.7 | 7.5 | 9.5 | 9.8 | 9.4 | 12.2 | 11.9 | 12.2 | 12.7 | 14.3 | 13.7 | 17.5 | 16.1 | | 18.9 | 18.9 | 18.6 |
| Depth interval | 5.9-6.5 m | | | 7.5-7-7 m | | | 9.4-9.8 m | | | 11.9-12.2 m | | | 12.7-14.3 m | | | 16.1-17.5 m | | | 18.6-18.9 m | | |
| Seabed sediment composition (%) | | | | | | | | | | | | | | | | | | | | | |
| Sand | 0 | 5 | 0 | 5 | 2 | 20 | 0 | 0 | 0 | 50 | 5 | 10 | 39 | 10 | 15 | 0 | 20 | | 20 | 20 | 30 |
| Coarse sand | 24 | 0 | 10 | 30 | 40 | 30 | 0 | 5 | 0 | 0 | 10 | 20 | | 0 | 0 | 0 | 0 | | 0 | 0 | |
| Stone 2-5 cm | 1 | 5 | 25 | 10 | 5 | 0 | 25 | 30 | 10 | 20 | 5 | 10 | 25 | 45 | 50 | 10 | 40 | | 71 | 76 | 53 |
| Stone 5-10 cm | 20 | 10 | 10 | 5 | 1 | 0 | 20 | 5 | 20 | 10 | 2 | 0 | 5 | 10 | 5 | 65 | 10 | | 5 | 1 | 5 |
| Stone 10-30 cm | 5 | 10 | 20 | 2 | 1 | 5 | 5 | 5 | 20 | 5 | 5 | 5 | 30 | 5 | 10 | 20 | 20 | | 1 | 2 | 5 |
| Stone 30-60 cm | 20 | 25 | 10 | 23 | 20 | 20 | 25 | 30 | 25 | 5 | 68 | 50 | 0 | 15 | 20 | 5 | 5 | | 2 | 0 | 2 |
| Stone >60 cm | 30 | 45 | 25 | 25 | 31 | 25 | 25 | 25 | 25 | 10 | 5 | 5 | 0 | 15 | 0 | 0.1 | 5 | | 1 | 1 | 0.1 |
| *Modiolus modiolus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | | 0 | | 0 | 0 | 5 |
| Smallest stone size for stable hardbottom (cm) | 7 | 8 | 10 | 10 | 10 | 30 | 10 | 10 | 10 | 5 | 10 | 15 | 8 | 5 | 5 | 7 | 8 | | 5 | 5 | 3 |
| Hardbottom cover (%) | 65 | 85 | 55 | 50 | 52 | 45 | 55 | 60 | 60 | 30 | 78 | 55 | 33 | 45 | 35 | 55 | 33 | | 9 | 4 | 20 |
| Total erect algal cover (%) | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 99 | 100 | 100 | 100 | 100 | 100 | 95 | 95 | 20 | 80 | | 2 | 2 | 15 |
| Drifting algae cover (%) | | | | | | | | 20 | | | | | 5 | | | | 60 | | | | 5 |

### 5.2.2 Community structures and species composition

A complete list of identified species and their cover at each sampling station is given in Appendix 1.

Concerning vegetation, the light reaching the seabed is a very important factor structuring the community, and light declines with depth. Therefore, it is not surprising that a highly significant (p=0.0001) overall effect of depth intervals on community structure was found when analysing the data using the Permanova add-on routine in Primer software (Table 5.2).

*Table 5.2: Permanova test for differences between depth intervals using untransformed community data. (Type III SS type, Fixed effects sum to zero for mixed terms and unrestricted permutation of raw data).*

| Source | Df | SS | MS | Pseudo-F | P(perm) | perms |
|---|---|---|---|---|---|---|
| De | 6 | 31728 | 5288 | 4.5158 | 0.0001 | 9907 |
| Res | 13 | 15223 | 1171 | | | |
| Total | 19 | 46951 | | | | |

A higher similarity among stations within depth intervals compared to other depth intervals with one exception was found, and in most cases the similarity decreased with increasing depth differences (Table 5.3). The MDS plot in Figure 5.10 visualizes the decreasing similarity in community structure with increasing differences in depth with a relatively low level of stress.

*Table 5.3: Similarity of samples within and between depth intervals expressed by the Bray-Curtis similarity.*

| | 5.9-6.5 m | 7.5-7.7 m | 9.4-9.8 m | 11.9-12.2 m | 12.7-14.3 m | 16.1-17.5 m | 18.6-18.9 m |
|---|---|---|---|---|---|---|---|
| 5.9-6.5 m | 56.6 | 51.9 | 49.5 | 38,.3 | 20.8 | 13.3 | 8.5 |
| 7.5-7.7 m | | 65.3 | 55.1 | 54.5 | 30.8 | 10.1 | 9.8 |
| 9.4-9.8 m | | | 65.8 | 57.8 | 44.9 | 18.7 | 12.8 |
| 11.9-12.2m | | | | 62.8 | 46.6 | 13.3 | 11.5 |
| 12.7-14.3m | | | | | 50.8 | 23.6 | 11.4 |
| 16.1-17.5m | | | | | | 33.2 | 41.5 |
| 18.6-18.9m | | | | | | | 47.2 |

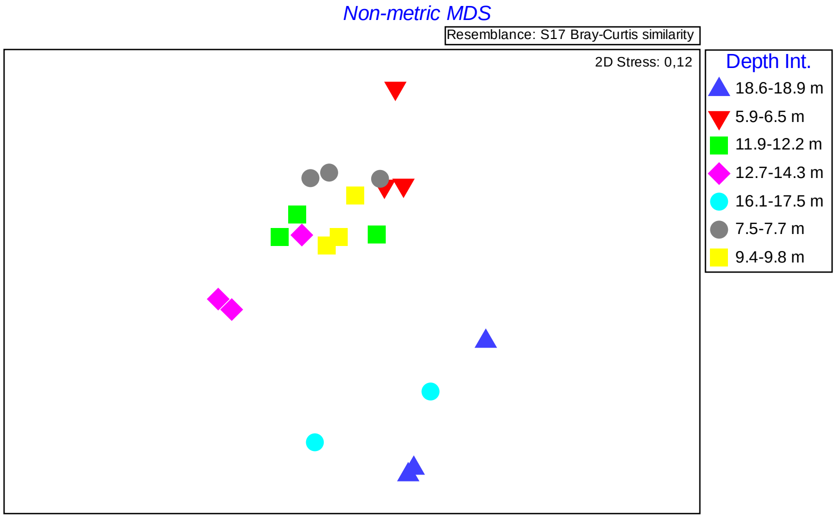



*Figure 5.10: MDS plot of species data described by cover collected from stations distributed into depth intervals. Data are untransformed.*

Table 5.4 presents the results for a pairwise test between depth intervals. A Monte Carlo test was performed instead of a normal permutation test due to the very low number of samples in each group. Despite the low number of replicates, there was a significant (P<5%) distinction between depth groups, apart from between the closest and the two closest depth groups.

*Table 5.4: Pairwise test for differences between depth intervals using a Monte Carlo test (Type III SS type, Fixed effects sum to zero for mixed terms and unrestricted permutation of raw data). *=P(MC) <5%. ns= not significant*

| | 7.5-7.7 m | 9.4-9.8 m | 11.9-12.2 m | 12.7-14.3 m | 16.1-17.5 m | 18.6-18.9 m |
|---|---|---|---|---|---|---|
| 5.9-6.5 m | ns | ns | * | * | * | * |
| 7.5-7.7 m | | ns | ns | * | * | * |
| 9.4-9.8 m | | | ns | ns | * | * |
| 11.9-12.2 m | | | | ns | * | * |
| 12.7-14.3 m | | | | | ns | * |
| 16.1-17.5 m | | | | | | ns |

Looking at the average cumulative cover of species from different taxonomic classes in each depth interval (Figure 5.11), the communities were highly dominated by red algae species (Rhodophyta). Bryozoans were also a dominant to around the pygnocline at 12 m water depth. Brown algae (Phaeophyta) increased in importance in the two deepest investigated depth intervals.

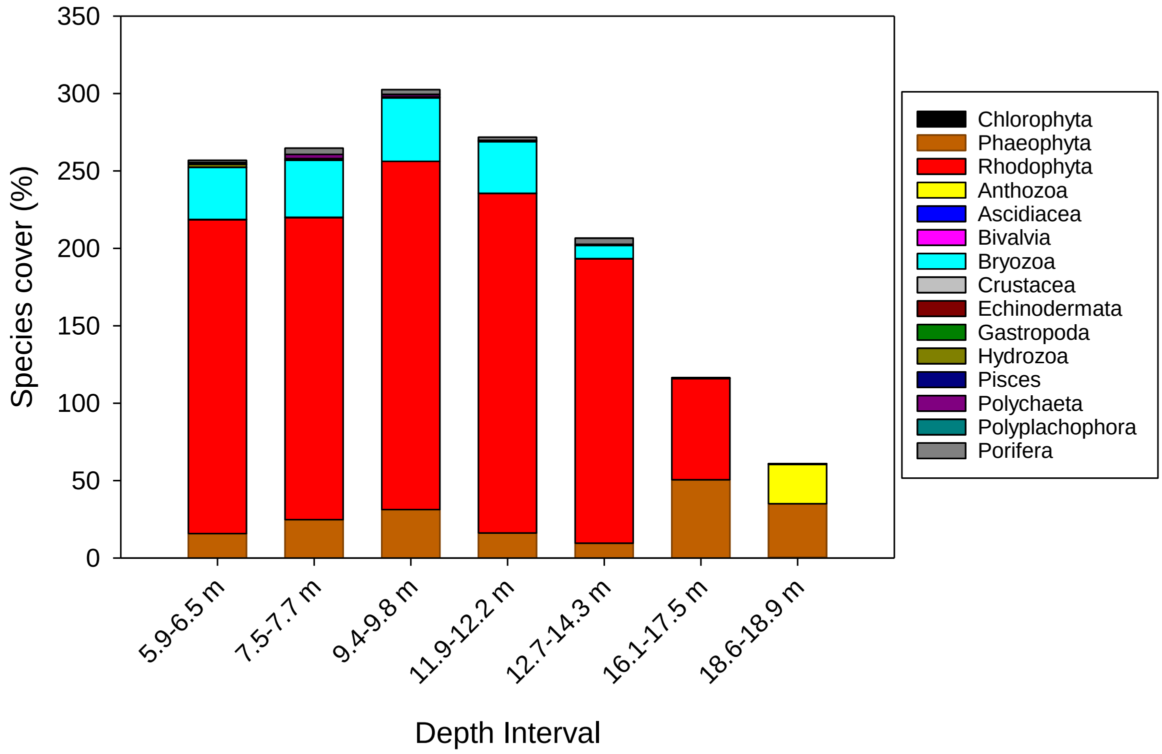



*Figure 5.11: Cumulative cover of species according to different taxonomic groups averaged for the sample stations within the 7 depth intervals.*

In descriptions of algae vegetation in relation to habitats, there is often a differentiation between crust-forming species and erect algal species. The crust-forming species always occur directly on the surface of stones. The crust-forming species may have a high cover, but a low biomass and are as a group adapted to low light levels. Generally, the erect species have a higher biomass/percent cover compared to the crust-forming species, and they add to the spatial complexity of the reef habitat for fish, fauna and other algae.

Crust-forming red and brown algae vegetation increases in relative importance with increasing depth compared to the erect algae form (Figure 5.12) Thus, in our investigation, the red algae *Furcellaria lumbricalis* had a high cover on stable hard substrate from 6 to 12 m water depth, but was absent at 16 m depth. The filamentous *Ceramium virgatum*, typically forming the top layer of the vegetation, was dominant in the two most shallow intervals. The larger leaf-forming red algae *Coccotylus brodiei*, which typically competes for space directly on the hard substrate with *Furcellaria*, had a high coverage on the stations sampled in the tree most shallow depth intervals. The other leaf-forming and larger red algae species *Phyllophora pseudoceranoides*, looking rather similar to *Coccotylus brodiei*, was common from 7 to 17 m depth and had its highest cover in the interval around 12 m depth. The leaf-forming red algae *Phycodrys rubens* was the most dominant erect algae at 17-18 m depth. The red algae *Cystoclonium purpureum* was present in all the investigated depth intervals apart from the deepest. The highest cover of *Cystoclonium* was found in between, in the depth interval from 9 to 14 m. The large brown algae *Fucus serratus* covered 8% of the hard substrate at 6 m, decreasing to 2% in the 9.2-9.5 m interval. Other large brown algae species like *Laminaria digitata* and *Saccharina latissima* were more scattered but occurred in the 7.6-17.5 m depth interval. They were an important part of the remaining vegetation in "Other brown algae".

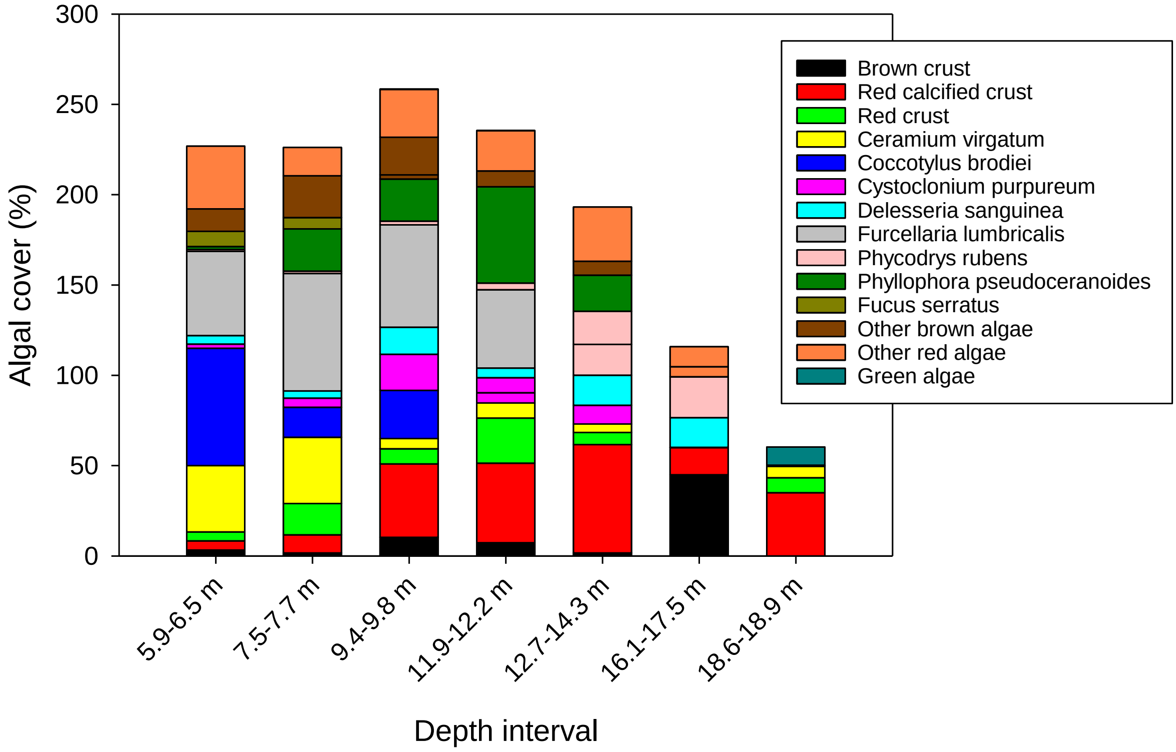



*Figure 5.12: Average cumulative cover of the eight most dominant erect algae species, three groups of crusts and the remaining species of red, green and brown algae within the 7 depth intervals.*

In terms of cover, from 6 to 14 m depth, the fauna was completely dominated by the bryozoan *Electra pilosa*, which grows epiphytically on the algae (Figure 5.13). The sponge *Halichondria panica* was also found and is a species that lives entangled in the vegetation or alternatively fixed directly on to the surface of boulders. The cover of fauna organism below 16 m was very low, but some larger species like "dead man's finger" (*Alcyonium digitatum*) were observed.

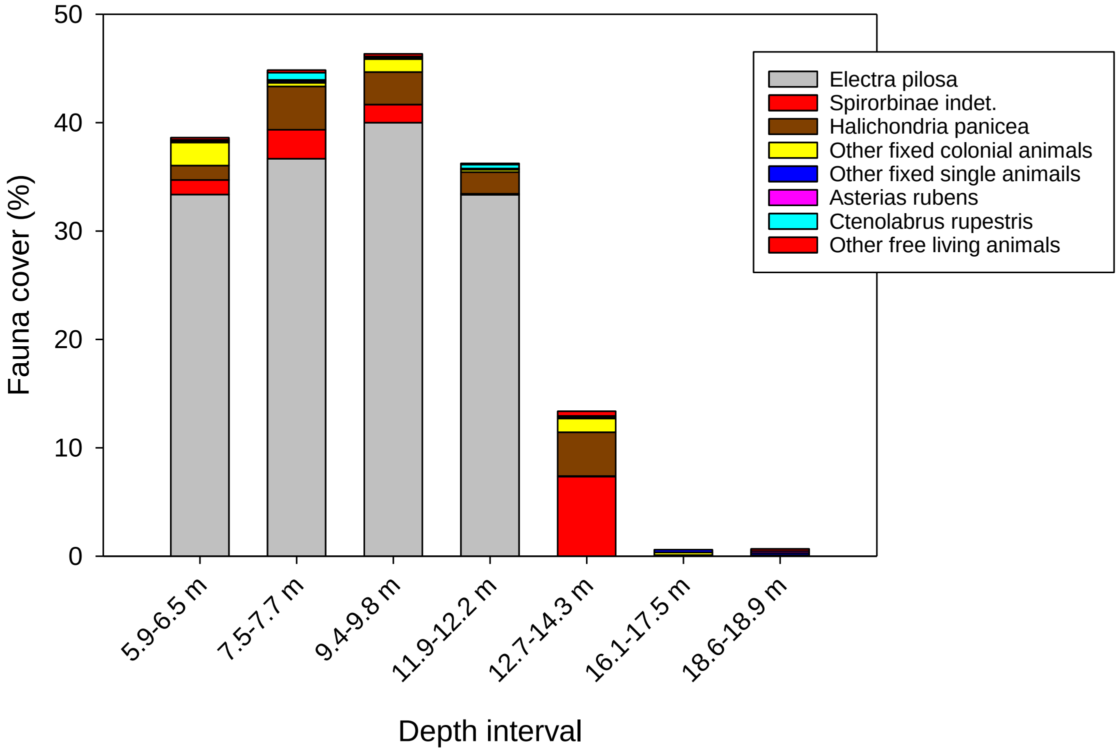



*Figure 5.13: Average cumulative cover of the five most dominant fauna species and remaining species within the 7 depth intervals. The remaining species are grouped into "other free living", "fixed single animals" or "colonial animals".*

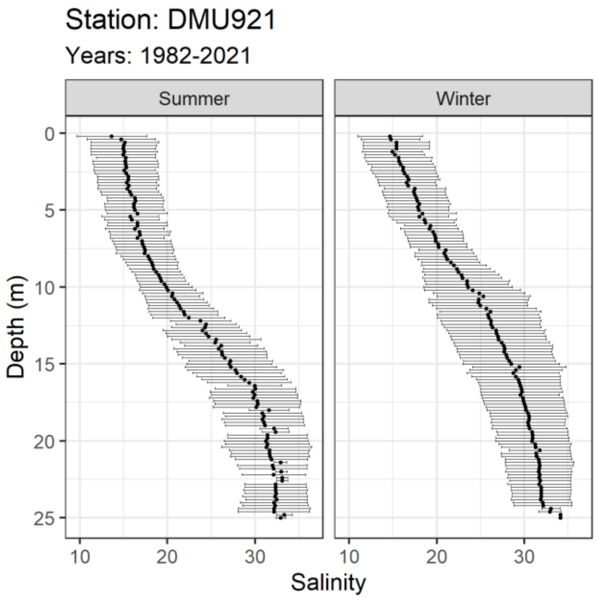
## 5.3 Red-listed species

We observed horse mussel, *Modiolus modiolus*, at one dive station (A-4) at 18.6 m depth where it covered 5% of the seabed. One individual *Modiolus* was also found when investigating the deepest ROV transect 6.

*Modiolus modiolus* is categorised as vulnerable on the HELCOM red list (HELCOM, 2013) and *Modiolus* beds are described as near threatened by both the EU 28 and the EU 28+ countries because of recent and future threats (Saunders & Gubbay, 2015).

The finding of *Modiolus* concurs as with other findings in the Danish reef-monitoring program. The mussels are buried 2/3 in the seabed where they are anchored to minor stones in mixed seabed sediments of sand, gravel and larger stones. Based on the Baltic Sea distribution pattern, Dinesen & Morton (2014) argued that *Modiolus* requires a long-term salinity of app. 26; however, it can cope with less for shorter periods by closing the shell.

Salinity data are available from three NOVANA monitoring stations near Gilbjerg Hoved, station 1939 outside Gilleleje and two offshore NE and NW of Gilbjerg (Figure 5.14). The salinity distribution at these stations indicates that *Modiolus modiolus* may appear from approximately 18 m depth. The salinity distribution is almost similar for all three stations.



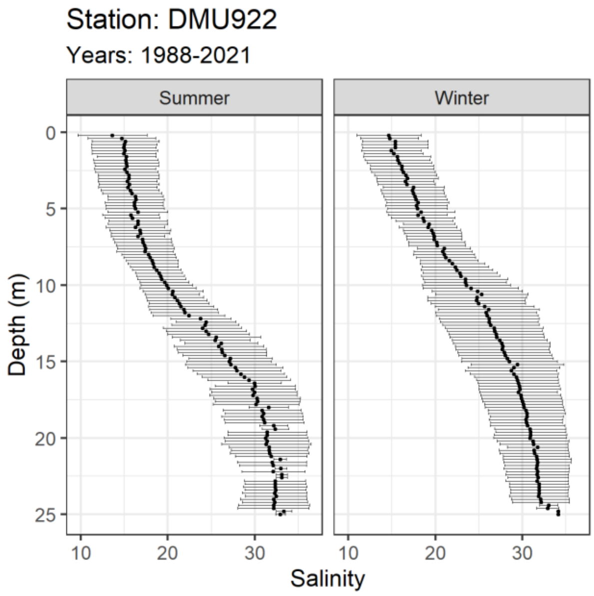
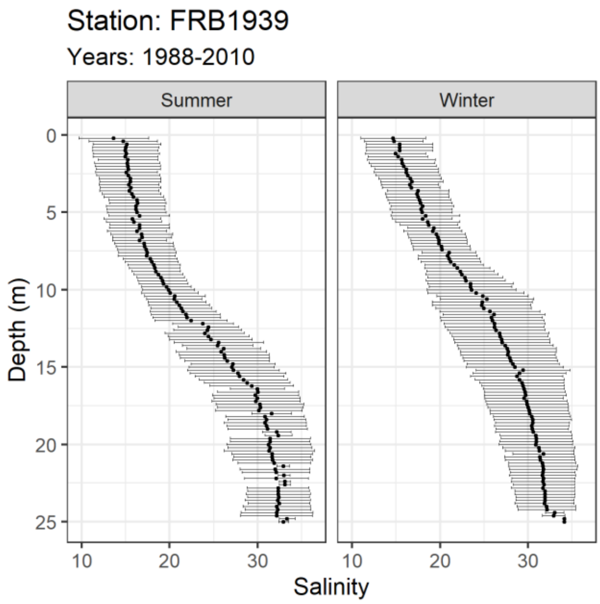




*Figure 5.14: Distribution of salinity (mean and standard deviation) with increasing depth in the summer half year (April-September) and the winter half year (October-March). Data from three NOVANA monitoring stations near Gilbjerg Hoved.*




The Danish EPA has a definition of biogenic and combined biogenic and geogenic reefs formed by *Modiolus modiolus* (Box 1).

*Box 1: The Danish Environmental Protection Agency's definition of reef structures with Modiolus modiolus ( (Dahl & Petersen, 2018).*

| |
|---|
| *Biogenic reef:*<br>A bed of horse mussels (*Modiolus modiolus*) is defined as a biogenic reef of *Modiolus modiolus* when it cover at least 100m$^2$, achieves a cover of 20% mussels and shells, of which 10% are live mussels and consist of mussels where the majority are longer than 4cm. |
| *Combined biogenic and geogenic reef:*<br>An area is defined as a combined reef (of mussels and stones) when it covers a minimum area of 500m$^2$ and achieves a coverage of stones, live *Modiolus modiolus* and shells of at least 25% of the seabed. Living *Modiolus* should make up at least 5% of the seabed. The outer boundary of the reef is found where the total coverage of stones and mussels falls below 10% of the seabed. The majority of mussels on the reef should be longer than 4cm. |

The findings at dive station A-4 fulfill the criteria for a combined biogenic and geogenic reef structure regarding the coverage of *Modiolus* and hard substrate. However, the area investigated by divers at A-4 was limited to approximately 25 $m^2$. For this reason, it is not possible to conclude whether the observed *Modiolus modiolus* population was part of a combined biogenic-geogenic reef structure, i.e. covered a minimum 500 $m^2$ of the area, or whether it was just a scattered distribution of this particular mussel species. The absence of this habitat at adjacent stations (H-18 and H-21) provides some indication that any distribution of biogenic-geogenic reef is limited to the area around transect A-4 but it is not possible to state with certainty whether the 500 $m^2$ area threshold is exceeded.

## 5.4 Recovery of hard bottom communities

There are no scientific investigations available regarding recovery rates of benthic hard bottom communities in Danish waters from physical disturbance of the seabed.

However, some results of colonization rate of hard bottom communities exist in connection to the reef restoration projects at Læsø Trindel in the northern Kattegat. In this case boulders from a query were deployed at a Nature 2000 reef site found not to be in an unfavorable conservation state due to extraction of boulders. Stable hard substrate with perennial algae vegetation was still present but too scattered.

A surveillance program followed the colonization of the new boulders took since the deployment in 2009 and up to today at one station at 7.5 m water depth. In addition, a very comprehensive biodiversity study was conducted 3.5 year after the deployment covering the new reefs whole depth distribution.

A long succession period was found were dominance of opportunistic algae species and sessile fauna species like *Balanus balanus* and *Metridium senile* gradually was substituted by perennial species (Stenberg, et al., 2015). However, the development of a full multilayered canopy vegetation of common red algae species took around 10-12 years (Dahl pers. com.). In addition, establishment of kelp vegetation in terms of algal cover took time (≥ 7 years) (Figure 5.15).

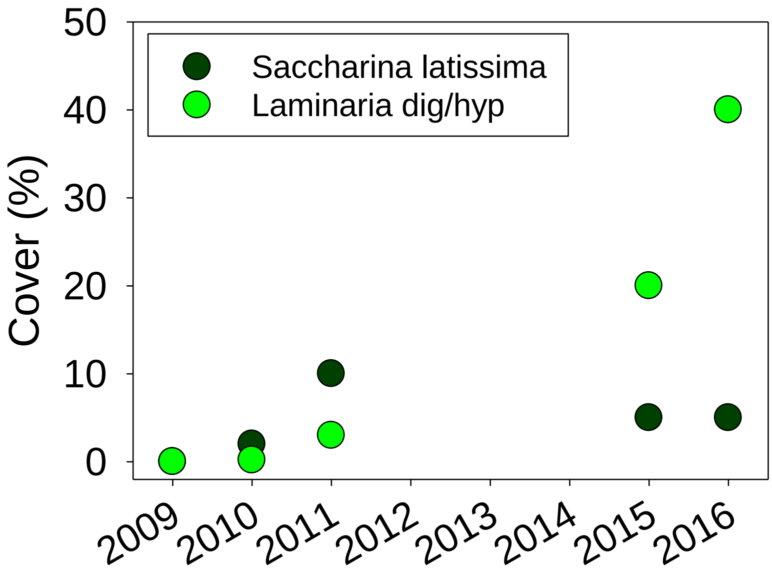



*Figure 5.15: Cover of the kelp species Saccharina Latissima and a joint group of Laminaria hyperboria and Laminaria digitata. The two Laminaria species are very difficult to differentiate in Kattegat*

## 5.5 Overall conclusions

- Reef structures mapped with acoustics were confirmed by ROV and dive investigations.

- In general, the coverage of hard stable substrate was high in areas mapped as seabed type 4.

- Some areas mapped as seabed type 3 had a high cover of hard stable substrate, even exceeding the 25% threshold separating seabed type 3 from 4.

- The sediment composition within the Natura 2000 site had a high proportion of larger boulders (>60 cm) but was also mixed with smaller stones.

- Erect algal vegetation, dominated by red algae, completely or almost completely covered the hard stable substrate from 6 to 14 m depth.

- *Fucus serratus*, *Laminaria digitata* and *Saccharina latissima* were the most dominant brown algae species in terms of cover.

- Fauna, in terms of cover, was heavily dominated by the bryozoan *Electra pilosa* from 6 to 14 m depth. *Electra* grew epiphytically on the algae. The sponge *Halichondria panica* also occurred entangled in the vegetation or alternatively fixed directly to the surface of boulders.

- Below 16 m, the cover of faunal organism was very low, but some larger species, for instance dead man's finger (*Alcyonium digitatum*), were observed.

- Combined biogenic-geogenic reef structures formed by the red-listed species *Modiolus modiolus* may be present in deeper waters, likely below 18 m depth. Further investigations of the spatial distribution of such reef structures are required to allow firm conclusions since it is unclear whether the feature covers more than the minimum 500 $m^2$ area necessary for to qualify as biogenic-geogenic reef. For the purposes of the sensitivity analysis in the subsequent section it is assumed that biogenic-geogenic reef may be present, i.e. on a precautionary basis that the minimum area threshold is exceeded.

- Based on experiences from a reef restoration project, colonization of opportunistic flora and fauna species is expected almost immediately. However, a full recovery of a climax hard bottom flora and fauna community dominated by perennial species in full sizes from physical damaged or on deployed new hard substrate is expected to take at least 10 years.

# 6 Sensitivity analysis

In ecology and environmental science, sensitivity analysis is applied in order to assess how sensitive a species, population, community or habitat is to environmental change caused by external, human-mediated activities. The sensitivity analysis in this technical report is based on the Marine Evidence-based Sensitivity Assessment (MarESA) methodology (Tyler-Walters, Tillin, d'Avack, Perry, & Stamp, 2018).

The sensitivity score classification system used in the MarESA method, as well as similar approaches, have recently been applied in technical reports or environmental impact assessments in relation to establishment of offshore wind farms in the North Sea (Moray Offshore Windfarm (West) Limited, 2018; Ørsted, 2019), as well as the Fehmarnbelt tunnel in the Baltic Sea connecting Denmark and Germany (FEMA, 2013a; FEMA, 2013b).

The MarESA approach was developed to provide a robust method to evaluate the sensitivity of marine and coastal habitats and invertebrate communities to various human activities using the EUNIS and UK Marine Habitat Classification (Connor, et al., 2004) systems as the basis for classification. However, although developed specifically for benthic habitats it should be noted that MarESA, and the related Marine Life Information Network (MarLIN), apply to the Mediterranean and Atlantic, and not directly to the Baltic. For example, MarESA provides sensitivity information for a range of communities associated with the EUNIS habitat 'A3.2 Atlantic and Mediterranean moderate energy infralittoral rock', but not the equivalent Baltic habitat 'A3.5 Baltic moderately exposed infralittoral rock'.

The direct application of the MarESA methodology is further compounded by the fact that national protocols in Denmark on which survey methods and analyses for this investigation are based (see chapter 4) do not apply the EUNIS classification system. Notwithstanding these limitations, the definitions and key terminology in MarESA provide a clear framework for the analysis, allowing for consistency with other topics, and much of the information available via MarESA can, with appropriate caution, be used to support a sensitivity analysis of benthic habitats and communities in the Kattegat.

In the following, the sensitivity analysis of hard bottom flora and fauna is performed in relation to the planned establishment of Hesselø Offshore Wind Farm, and specifically the proposed export cable installation through the identified area of stony reef as described in chapter 5.

## 6.1 Method description

The sensitivity of a receptor (species, population, community or habitat) is defined as a product of:

- intolerance to changes (i.e. damage or impact) due to an external pressure (resistance) *and*
- time taken for subsequent recovery (recoverability)

Expanding on these terms, where resistance to a particular pressure is high a receptor can absorb or tolerate disturbance or stress without changing character; conversely, receptors with low resistance are more readily affected by the same external pressure. Recoverability, or resilience, describes the ability to return to a previous state once the pressure is removed.

Pressures are mechanisms through which an activity has an effect on receptors and can be physical, chemical or biological in character. Different activities (e.g. cable trenching and anchoring by construction vessels) can cause the same pressure (e.g. seabed penetration) and different pressures (e.g. abrasion/disturbance and contaminants) may have the same effect (e.g. mortality of individuals) (Figure 6.1). The MarESA method includes a classification of potential pressures which has been reviewed to identify those which are relevant to the activities associated with the proposed development. The standard pressure descriptions within the MarESA methods have also been adapted so that they relate directly to the activities relevant for the planned Hesselø OWF including the export cables

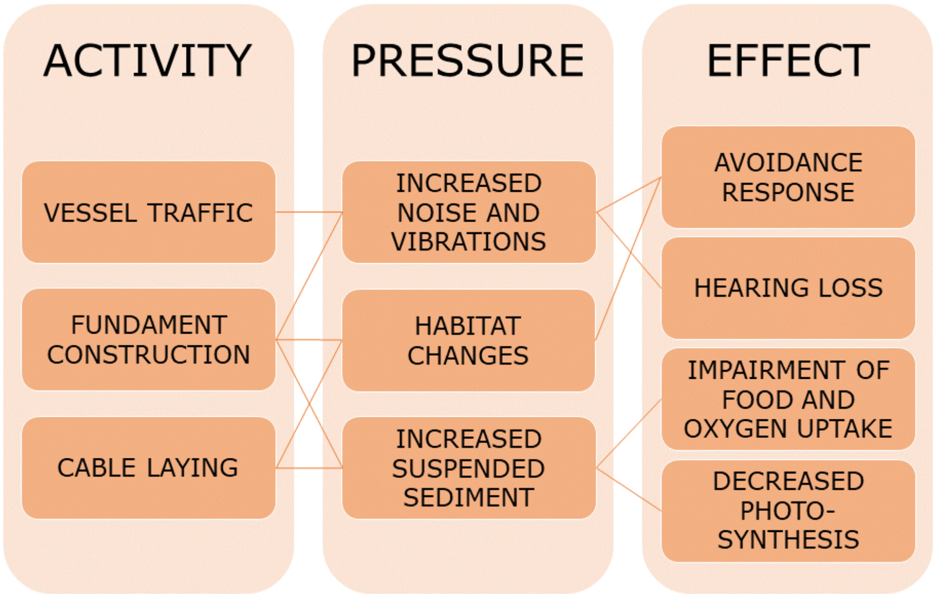



*Figure 6.1: Overview of the relationships between activity, pressure and effect including examples relating to establishment of offshore wind farms.*

The resistance of a receptor is scored using a scale of none, low, medium and high resistance, which are defined either quantitatively or qualitatively (Tyler-Walters, Tillin, d'Avack, Perry, & Stamp, 2018) (Table 6.1). A receptor with high resistance to a pressure will experience no significant change, although it may still experience effects on feeding, respiration and reproduction rates.

*Table 6.1 Scale for scoring resistance to a pressure (Tyler-Walters, Tillin, d'Avack, Perry, & Stamp, 2018).*

| Resistance | Qualitative description | Quantitative description |
|---|---|---|
| None | Severe change | Significant decline of 75% of the extent, density or abundance of the receptor |
| Low | Significant change | Significant decline of 25-75% of the extent, density or abundance of the receptor |
| Medium | Some change | Significant decline of <25% of the extent, density or abundance of the receptor |
| High | No change | No significant decline |

The recoverability of a receptor is scored using a scale of very low, low, medium and high recoverability (Tyler-Walters, Tillin, d'Avack, Perry, & Stamp, 2018) (Table 6.2). Recoverability assumes that the pressure is relieved or stopped, and that the receptor experiences the conditions that existed prior to the pressure.

*Table 6.2 Scale for scoring recoverability after a pressure has been relieved (Tyler-Walters, Tillin, d'Avack, Perry, & Stamp, 2018).*

| Recoverability | Description |
|---|---|
| Very low | Negligible or prolonged recovery possible; at least 25 years to recover structure and function |
| Low | Full recovery within 10-25 years |
| Medium | Full recovery within 2-10 years |
| High | Full recovery within 2 years |

The combination of a receptor's resistance and recoverability scores gives the overall sensitivity score of the receptor, which can be categorised as not sensitive, low, medium or high sensitivity (Tyler-Walters, Tillin, d'Avack, Perry, & Stamp, 2018) (Table 6.3).

*Table 6.3 The combination of resistance and recoverability scores to categorise sensitivity (Tyler-Walters, Tillin, d'Avack, Perry, & Stamp, 2018).*

| | | Resistance | | | |
|---|---|---|---|---|---|
| | | None | Low | Medium | High |
| Recoverability | Very low | High | High | Medium | Low |
| | Low | High | High | Medium | Low |
| | Medium | Medium | Medium | Medium | Low |
| | High | Medium | Low | Low | Not sensitive |

In cases where a sensitivity analysis is not possible, the following terms can be used:

- Not relevant. Recorded where the evidence suggests unlikely or no direct interaction between pressure and receptor.
- No evidence. Recorded where there is not enough evidence to assess the sensitivity.

At this stage of the assessment process (sensitivity determination) it is important to note the following:

- The duration (length of time) of an impact is not a factor in determining receptor sensitivity. For example, if a pressure (e.g. 'habitat change') is permanent receptor recoverability following theoretical reinstatement of the original conditions is evaluated.
- Sensitivity is a key element of the impact assessment process, but not in itself necessarily an indicator of impact importance (significance). The future environmental assessment of a specific project for Hesselø OWF will consider other factors including the duration and magnitude of pressures.

## 6.2 Analysis

The sensitivity analysis of hard bottom flora and fauna provided here is composed of the following parts:

- A summarised baseline description of hard bottom habitats and communities as **receptors** occurring in the planned corridor for the export cables from Hesselø Offshore Wind Farm (such habitat not being present in the proposed wind farm array area where only soft bottom habitats occur).
- A list and description of possible **activities** during construction, operation and decommission of Hesselø OWF and the expected associated **pressures** and **effects** relevant for these identified receptors. As Hesselø OWF is not a defined project, the description of pressures is based on professional experience and general knowledge about the establishment and operation of offshore wind farms.
- Scoring of **resistance** and **recoverability** of the identified receptors to relevant pressures based on knowledge from existing literature and professional experience.
- Scoring of **sensitivity** of the receptors to relevant pressures caused by possible activities during construction, operation and decommissioning of Hesselø OWF.

### 6.2.1 Receptors

The following description is based on the detailed characterisation of hard bottom habitats and associated benthic communities in chapter 5, primarily informed by field work undertaken for this project.

Hard bottom habitat in the form of stone reef was restricted to a section of the export cable corridor, approximately 6 km in length, within and immediately adjacent to the Natura 2000 site 'Gilleleje Flak and Tragten' (see Figure 3.2 in Section 3.1 ). Water depths in this area ranged between 6 and 19 m. Based on geophysical survey investigations and the diver and ROV surveys seabed type 4 (stony areas and stone reefs – seabed cover of larger stones 25-100%) was present together with seabed type 3 (sand, gravel pebbles – seabed cover of larger stones 10-25%) which is also considered to be reef habitat.

Seabed types 3 and 4 are both noted to be highly important habitats, present here as Habitats Directive Annex I habitat (reef).

The area also has patches of finer sediment in between the stony reef areas. These areas are outside of the scope of the hard bottom study but sensitivity of these are considered within the soft bottom benthic technical report (NIRAS & DCE, 2022).

The composition of flora and fauna communities of reef habitat recorded during diver investigations was influenced by depth which is likely related primarily to the amount of light reaching the seabed. Erect algal vegetation, dominated by red algae, completely or almost completely covered the hard stable substrate from 6 to 14 m depth. *Fucus serratus*, *Laminaria digitata* and *Saccharina latissima* were the most dominant brown algae species in terms of cover.

Fauna, in terms of cover, was heavily dominated by the bryozoan *Electra pilosa* from 6 to 14 m, growing epiphytically on the algae with the sponge *Halichondria panica* also occurring entangled in the vegetation or fixed directly to the surface of boulders.

Below 16 m the cover of faunal organism was very low but some larger species, for instance dead man's finger (*Alcyonium digitatum*), were observed.

The red list species *Modiolus modiolus* was present and the survey identified the possibility (although unconfirmed) that combined biogenic-geogenic reef structures may be present in deeper waters, likely below 18 m depth. Further investigation of the spatial distribution of such reef structures are required since the total extent of this feature was unclear.

The following receptors are identified based on the above information:

1. Stony Reef (Seabed Type 3 and 4)
2. *M. modiolus* Biogenic-geogenic reef (this feature is assumed to be present on a precautionary basis)

For the purpose of sensitivity analysis, it is helpful to describe discrete biotopes (a habitat and associated communities) wherever possible. As noted above, the MarESA method cannot be applied directly to Baltic habitats because reference biotopes are only available for the Mediterranean and Atlantic. Therefore, in order to support the sensitivity analysis several analogous EUNIS biotopes have been identified along with a number of representative species occurring in the project area for which peer reviewed sensitivity scores are available. These are as detailed in Table 6.4.

*Table 6.4 Representative biotope and species references used to inform the sensitivity analysis*

| Reference Biotope/Species (with MarLin source) | Notes |
|---|---|
| Biotopes | |
| A3.343 (*Polyides rotunda* and/or *Furcellaria lumbricalis* on reduced salinity infralittoral rock) (Perry, Tillin, & Garrad, 2016) | This biotope is considered to be an informative analogue for those areas where red algae such as *Furcellaria lumbricalis* had a high cover on stable hard substrate. It must be noted, however, that the erect form of this |

| | |
|---|---|
| | species was recorded whereas the representative biotope includes the crust-forming variant. |
| A3.211 (*Laminaria digitata* on moderately exposed sublittoral fringe rock) (Jasper & Hill, [Laminaria digitata] on moderately exposed sublittoral fringe rock, 2018) | This biotope is not directly analogous, but sensitivity information is considered to be informative. |
| A5.623 (*Modiolus modiolus* beds with fine hydroids and large solitary ascidians on very sheltered circalittoral mixed substrata) (Tillin & Tyler-Walters, 2018) | There is no direct analogue in MarESA for either the biogenic or biogenic-geogenic reef forms potentially present in the survey. This biotope is referred to because of similarities in seabed sediments, stability and the low energy of the environment. |
| Species | |
| *Fucus serratus** (Jackson, 2008) | One of the dominant brown algal species present |
| *Electra pilosa** (Tyler-Walters, 2005) | This bryozoan was a dominant component of the fauna between 6 and 14 m depth |
| *Saccharina latissima** (Jasper, 2015) | This large brown algal kelp species was an important part of the 'other brown algae community' between 7.6 and 17.5 m water depth. |
| *Alcyonium digitatum** (Budd, 2008) | Prominent member of the low diversity and coverage faunal community in deeper water (below 16 m). |

* For the species references (*Fucus serratus*, *Electra pilosa*, *Saccharina latissimi* and *Alcyonium digitatum*) only MarLIN data were available. MarLIN is now superseded but remains available as a reference source. Pressures referred to in MarLIN do not directly align with MarESA and expert judgement was used to apply sensitivity and recoverability scores for each of the identified pressures.

### 6.2.2 Activities, pressures and effects

This section describes possible activities during construction, operation and decommissioning of Hesselø Offshore Wind Farm that may cause pressures relevant for hard bottom benthic receptors as well as the potential effects of these pressures. An overview of possible activities from establishment of Hesselø OWF is provided in Table 6.5. The identified pressures potentially apply to all receptors since it is assumed that activities could occur at any location within the survey corridor where hard bottom habitats are present. Benchmarks are described for each pressure, and these indicate the minimum scale of environmental effect against which sensitivity is assessed. Benchmarks are taken directly from Tyler-Walters *et al.* (2018), or adapted from this source for the purpose of this analysis.

*Table 6.5 Overview of activities during construction, operation and decommissioning of Hesselø OWF and the related possible pressures for hard bottom benthic receptors.*

| Receptor | Activity | Pressure | Effect |
|---|---|---|---|
| CONSTRUCTION | | | |
| Seabed Types 3 & 4; Biogenic - geogenic reef | Rock dump (with habitat change), application of mattress or other cable protection | Habitat change | 1) Change in sediment type by one class (i.e. mud to sandy mud; sand; coarse sediment; mixed sediment; rock and boulders);<br>2) Substantial change in character, e.g. loss of large boulders from rock and boulder area; or,<br>3) Change from rock substrata to artificial substrata.<br>(Definition applied for the purpose of this sensitivity analysis.) |
| | Rock dump (without habitat change), cable plough skids, anchors/chains, surface lay of cable (if not subsequently protected). Disturbance of seabed by vessel (DP) thrusters | Abrasion/disturbance | Damage to surface features (e.g. species and physical habitat structures) (Definition applied for the purpose of this sensitivity analysis.) |
| | Trenching, jetting and ploughing, HDD punch out (drilling muds). (NB no vessel anchoring in hard bottom areas) | Penetration | Damage to sub-surface features (e.g. species and physical structures within the habitat) (Definition applied for the purpose of this sensitivity analysis.) |
| | Trenching, jetting and ploughing, directional drill punch out (drilling muds), seabed clearance. | Suspended solids | An elevation above background levels which persists for more than one day (24 hours) following completion of short term works (less than one month in duration), or elevation above background levels from works lasting more than one month. (Definition applied for the purpose of this sensitivity analysis.) |
| | Trenching, jetting and ploughing, directional drill punch out (drilling muds), seabed clearance. | Smothering | 'Light' deposition of up to 5 cm of fine material added to the habitat in a single, discrete event.<br>'Heavy' deposition of more than 5 cm of fine material added to the habitat in a single discrete event. |
| | Vessel use (especially DP), rock dump, trenching | Underwater noise | Underwater noise which elicits a behavioural response (Definition applied for the purpose of this sensitivity analysis.) |
| | Vessel use (spills), trenching and ploughing (mobilisation of buried contaminants through seabed disturbance) | Contaminants | Any spill causing harmful effects to local benthic receptors. (Definition applied for the purpose of this sensitivity analysis.) |
| OPERATION | | | |
| Seabed Types 3 & 4; Biogenic - geogenic reef | Presence of rock berm | Hydrological changes | A change in peak mean spring bed flow velocity of between 0.1m/s to 0.2m/s for more than 1 year |
| | Cable operation (power transmission) | EMF | Local electric field of 1V/m.<br>Local magnetic field of 10µT |
| | Vessel transits, local port use | INIS | The introduction of one or more invasive non-indigenous species (INIS) |
| | Exposure of cable to repair (rock armour removal) | Abrasion/disturbance | Damage to surface features (e.g. species and physical habitat structures) |
| | Exposure of cable to repair (buried cable) | Penetration | Damage to sub-surface features (e.g. species and physical structures within the habitat) |
| DECOMMISSIONING | | | |

| Receptor | Activity | Pressure | Effect |
|---|---|---|---|
| Seabed Types 3 & 4; Biogenic - geogenic reef | Removal cable protection | Habitat Change | 1) Change in sediment type by one Folk class (mud to sandy mud; sand; coarse sediment; mixed sediment; rock and boulders);<br>2) Substantial change in character, e.g. loss of large boulders from rock and boulder area; or,<br>3) Change from rock substrata to artificial substrata. |
| | Removal, or moving, of cable protection | Abrasion/disturbance | Damage to surface features (e.g. species and physical habitat structures) |
| | Cable removal | Penetration | Damage to sub-surface features (e.g. species and physical structures within the habitat) |
| | Cable removal | Suspended solids | An elevation above background levels which persists for more than one day (24 hours) following completion of short-term works (less than one month in duration), or elevation above background levels from works lasting more than one month. (Definition applied for the purpose of this sensitivity analysis.) |
| | Cable removal | Smothering | 'Light' deposition of up to 5 cm of fine material added to the habitat in a single, discrete event.<br>'Heavy' deposition of more than 5 cm of fine material added to the habitat in a single discrete event. |
| | Vessel use (especially DP) | Underwater noise | Underwater noise which elicits a behavioural response. (Definition applied for the purpose of this sensitivity analysis.) |
| | Vessel use (spills), cable removal (mobilisation of buried contaminants through seabed disturbance) | Contaminants | Any spill causing harmful effects to local benthic receptors. (Definition applied for the purpose of this sensitivity analysis.) |

The following sections describe each pressure further. For benthic ecological receptors the effects (consequences) of the pressures are in many cases self-evident, e.g. a contaminant spill being harmful (toxic) to benthic receptors, but potential effects are also considered in more detail below. Pressures are associated with each phase of the project unless otherwise stated.

#### *6.2.2.1 Habitat change*

Habitat change is the permanent change of one marine habitat type to another marine habitat type, through a change in the substratum. It is typically used to describe the change from soft bottom to hard bottom substrata, but applies to any change of one Folk class (e.g. coarse sediment to rock). It is the most appropriate pressure to consider in relation to the change in character of stony reef when covered by rock protection, especially where the original conditions show less than 100% rock cover, or rock particle size range is very different (e.g. loss of boulders). Where the physical character of the original reef is not substantially changed then the relevant pressure will be abrasion/disturbance.

In relation to the planned Hesselø OWF, and specifically hard bottom habitats within the export cable corridor, habitat change is used mainly to refer to the addition of cable protection over stony reef habitat. In addition to loss of boulders an example of habitat change in this situation would be covering of existing reef structures which have diverse stone sizes with a uniformly graded material.

Although occurring throughout the operational phase this pressure is considered in relation to the construction phase as the effect, which includes loss of existing habitat, commences at this point and continues through subsequent phases. It is also included for the decommissioning phase to cover the possibility that cable protection could be removed, leaving behind a different (e.g. coarse or fine sediment) seabed, in order to expose and remove the cables.

As previously noted, when considering recoverability for this pressure it is assumed that the pressure is removed. It is recognised that habitat change in the context of the project will be either very long term or effectively permanent. Recoverability then becomes effectively ‘Zero’; however, this will be considered within the later assessment work.

#### *6.2.2.2 Abrasion/disturbance*

Abrasion is described as a physical disturbance at the surface of the substratum in sedimentary or rocky habitats. The effects are relevant to epiflora and epifauna living on the surface of the substratum which can be killed or injured. The pressure also applies where rock is dumped onto existing rocky reef habitat when the physical character of the reef is not substantially altered. (Note that the appropriate pressure where the character of the reef is altered would be 'habitat change').

#### *6.2.2.3 Penetration*

Penetration is defined as physical disturbance of sediments where there is limited or no loss of substratum from the system. This pressure is associated with activities such as taking of sediment/geological cores, cone penetration tests, cable burial (ploughing or jetting) and propeller wash from vessels in finer sediment areas (propellor wash over hard substrate habitats is considered here as abrasion/disturbance). The principal effects are killing or injury to organisms, including both infauna and epiflora/fauna.

#### *6.2.2.4 Suspended solids*

The pressure termed ‘suspended solids’ describes changes in water clarity (or turbidity) due to changes in sediment and organic particulate matter. It is related to activities which disturb sediment and/or organic particulate matter and mobilise these into the water column. It may be caused by dredging, sediment disposal or dumping, cable burial, or secondary effects of construction works, e.g. rock berms leading to localised scour. Particle size, hydrological energy (current speed & direction) and tidal excursion magnitude are all influencing factors on the spatial extent and temporal duration. Salinity, turbulence, pH and temperature may influence in flocculation of suspended organic matter.

Increases in suspended solids may have a range of effects, for example reducing light penetration at depth which would limit photosynthesis, or affecting the ability of filter feeding organisms to feed effectively.

This pressure is principally associated with the construction and decommissioning phases. Any cable exposure for repair during the operational phase would have relatively limited potential to mobilise sediments to a sufficient degree to result in significant suspended sediment elevation.

#### *6.2.2.5 Smothering*

Siltation (or sedimentation) is the settling out of silt/sediments suspended in the water column. Activities associated with this pressure type include dredging, disposal of sediments at sea, cable laying and various construction activities. It can result in short-lived sediment concentration gradients and the accumulation of sediments on the sea floor. The pressure only applies where the sediment type of the existing and deposited sediment has similar physical characteristics, or where smothering of a different seabed sediment type (e.g. rock) is temporary. If the seabed conditions are changed as a result, then the relevant pressure is 'habitat change'.

For “light” smothering most benthic biota may be able to adapt, i.e. vertically migrate through the deposited sediment.

With “heavy” smothering most species of marine biota are unable to adapt, e.g. sessile organisms are unable to make their way to the surface; however, a similar biota could, with time, re-establish provided that conditions are not significantly changed. Note that if the smothering becomes more permanent, i.e. the deposited sediments do not disperse over time, the pressure is ‘habitat change’.

This pressure is principally associated with the construction and decommissioning phases. Any cable exposure for repair during the operational phase would have relatively limited potential to mobilise sediments to a sufficient degree to result in significant smothering effects.

#### *6.2.2.6 Hydrological changes*

‘Hydrological changes’ describes changes in water movement associated with tidal streams (the rise and fall of the tide), prevailing winds and ocean currents. The pressure is therefore associated with activities that have the potential to modify hydrological energy flows, e.g. structures on the seabed. The pressure extremes are a shift from a high to a low energy environment (or vice versa). The biota associated with these extremes will be markedly different as will the substratum, sediment supply/transport and associated seabed/ground elevation changes. The pressure is considered in relation to the operational phase, by which time any structures, such as berms, would be in place.

#### *6.2.2.7 Electromagnetic fields (EMF)*

Localized electric and magnetic fields are associated with operational power cables. Such cables may generate electric and magnetic fields that could alter the behaviour or development of sensitive species. Limited information is available on the potential effects associated with this pressure for benthic organisms.

#### *6.2.2.8 Underwater noise*

Underwater noise is associated with a range of activities such as rock dumping, dredging, trenching, construction activities and vessel use. Behavioural effects on benthic invertebrates are possible if noise levels are sufficiently high.

#### *6.2.2.9 Contaminants*

The pressure which is termed contaminants describes the introduction of pollutants through accidental or deliberate release from vessels or equipment, or mobilisation of contaminants present in seabed sediments that would not otherwise be released.

#### *6.2.2.10 Invasive non-indigenous species (INIS)*

The pressure termed INIS is defined as the direct or indirect introduction of invasive non-indigenous species, e.g. Chinese mitten crabs, slipper limpets, Pacific oyster and their subsequent spreading and out-competing of native species. Ballast water, hull fouling, stepping stone effects (e.g. rock protection in otherwise fine sediment areas) may facilitate the spread of such species.

### 6.2.3 Resistance, recoverability and sensitivity

As explained in Section 6.1 (Table 6.3), sensitivity is determined by the resistance and recoverability attributes of each receptor. Established scores for analogous EUNIS biotopes and representative species are listed for each pressure in Table 6.6 and Table 6.7 respectively, followed by scoring for the identified receptors in Table 6.8.

The classifications for analogous EUNIS biotopes (Table 6.6) and representative species (Table 6.7) are taken directly from the MarLIN system (references as cited in Section 0, Table 6.4) where two pressures (EMF and underwater noise) are not assessed. Expert judgement based on available evidence was used to arrive at a sensitivity rating. On this basis A3.43 and A3.211 were judged to be ‘Not Sensitive’ to underwater noise and EMF. Available evidence such as Gill, et al. (2005) and Thomsen, et al. (2015) for underwater noise suggest that the invertebrate fauna present are not sensitive to these pressures relevant to any magnitude likely to occur.

*Table 6.6 Resistance, recoverability and resultant sensitivity ratings for analogous EUNIS biotopes.*

| Pressure | A3.43 (*Polyides rotunda* and/or *Furcellaria lumbricalis* on reduced salinity infralittoral rock) | | | A3.211 (*Laminaria digitata* on moderately exposed sublittoral fringe rock) | | | A5.623 (*Modiolus modiolus* beds with fine hydroids … on very sheltered circalittoral mixed substrata) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Resistance | Recoverability | Sensitivity | Resistance | Recoverability | Sensitivity | Resistance | Recoverability | Sensitivity |
| Habitat change | None | Very Low | High | None | Very Low | High | None | Very Low | High |
| Abrasion/disturbance | Medium | Medium | Medium | Low | High | Low | Low | Low | High |
| Penetration | n/a | n/a | n/a | n/a | n/a | n/a | Low | Low | High |
| Suspended solids | High | High | Not sensitive | Medium | High | Low | High | High | Not sensitive |
| Smothering | Medium | High | Low | High | High | Not Sensitive | Low | Low | High |
| Hydrological changes | High | High | Not Sensitive | High | High | Not Sensitive | High | High | Not Sensitive |
| EMF | No evidence | | | No evidence | | | No evidence | | |
| Underwater noise | Not assessed | | Not Sensitive | Not assessed | | Not Sensitive | No evidence | | |
| Contaminants | No evidence | | | No evidence | | | No evidence | | |
| INIS | Medium | Very Low | Medium | Low | Very Low | High | No evidence | | |

Table 6.7 Resistance, recoverability and resultant sensitivity ratings for representative species.

| Pressure | *Fucus serratus* | | | *Electra pilosa* | | | *Saccharina latissima* | | | *Alcyonium digitatum* | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Resistance | Recoverability | Sensitivity | Resistance | Recoverability | Sensitivity | Resistance | Recoverability | Sensitivity | Resistance | Recoverability | Sensitivity |
| Habitat change | Low | High | Low | Low | High | Low | Low | High | Low | Low | High | Low |
| Abrasion/disturbance | Medium | High | Low | High | High | Low | Medium | High | Low | Medium | High | Low |
| Penetration | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Suspended solids | High | High | Not sensitive | High | High | Not sensitive | High | High | Not sensitive | High | High | Not sensitive |
| Smothering | Low | High | Medium | Low | High | Medium | Low | High | Medium | Low | High | Medium |
| Hydrological changes | Medium | High | Low | Medium | High | Low | High | High | Low | Medium | High | Low |
| EMF | Not assessed | | Not Sensitive | Not assessed | | Not Sensitive | Not assessed | | Not Sensitive | Not assessed | | Not Sensitive |
| Underwater noise | Not assessed | | Not Sensitive | Not assessed | | Not Sensitive | Not assessed | | Not Sensitive | Not assessed | | Not Sensitive |
| Contaminants | Low | High | Low | Medium | High | Low | No evidence | | | Low | High | Low |
| INIS | No evidence | | | No evidence | | | No evidence | | | No evidence | | |

*Table 6.8 Resistance, recoverability and resultant sensitivity ratings for identified hard bottom benthic receptors.*

| Pressure | Seabed Type 3 | | | Seabed Type 4 | | | Biogenic-geogenic reef* | | |
|---|---|---|---|---|---|---|---|---|---|
| | Resistance | Recoverability | Sensitivity | Resistance | Recoverability | Sensitivity | Resistance | Recoverability | Sensitivity |
| Habitat change | None | Very Low | High | None | Very Low | High | None | Very Low | High |
| Abrasion/disturbance | Low | Low | High | Low | Low | High | Low | Low | High |
| Penetration | n/a | n/a | n/a | n/a | n/a | n/a | Low | Low | High |
| Suspended solids | High | High | Not Sensitive | High | High | Not Sensitive | High | High | Not sensitive |
| Smothering | Low | High | Medium | Low | High | Medium | Low | Low | High |
| Hydrological changes | Medium | High | Low | Medium | High | Low | High | High | Not Sensitive |
| EMF | High | High | Not Sensitive | High | High | Not Sensitive | Limited evidence (assessed as Low Sensitivity) | | |
| Underwater noise | Limited evidence (assessed as Low Sensitivity) | | | Limited evidence (assessed as Low Sensitivity) | | | Limited evidence (assessed as Low Sensitivity) | | |
| Contaminants | Low | High | Low | Low | High | Low | Limited evidence (assessed as Medium Sensitivity) | | |
| INIS | Limited evidence (assessed as High Sensitivity) | | | Limited evidence (assessed as High Sensitivity) | | | Limited evidence (assessed as High Sensitivity) | | |

* as stated in Section 5.5, *Modiolus modiolus* recorded within stony reef during site survey work did not meet the minimum area (500 $m^2$) criteria to qualify as biogenic-geogenic reef but it could not be ruled out that the feature might occupy a larger area than could be surveyed. The inclusion of biogenic-geogenic reef here as a receptor is therefore precautionary.

Sensitivity to habitat change is high for all three receptors. This is based on the high sensitivity of all analogous biotopes (Table 6.6). It is important to note that recovery following habitat change is expected. Where suitable stony habitat exists this will ultimately be colonised, although as noted in Section 5.4 this is expected to take considerable time, ten years or more before full colonization and a climax community is reached. This knowledge was important when determining recoverability scores since the representative species (Table 6.7) have relatively high recoverability.

It is important to note that seabed types 3 and 4 are not differentiated by their sensitivity ratings. This is because the focus of the assessment is on the hard substrate materials (stones) and not the sediment areas in between. Both seabed types, as well as biogenic-geogenic reef, are also considered highly sensitive to abrasion/disturbance (as well as habitat change) with a moderate sensitivity to smothering because of the sensitivity of some of the associated flora and fauna.

Whilst all receptors have limited sensitivity to suspended solids they have greater sensitivity to smothering and this is recognised as a high risk for biogenic-geogenic reef habitat (noting that this feature is only potentially present) because of the known sensitivity of the analogous A5.623 biotope.

Sensitivity to other pressures is largely low, or absent, but the medium sensitivity of biogenic-geogenic reef to contaminants is highlighted together with the high sensitivity of all receptors to INIS. This latter rating is a precautionary one because of the limited reference information available but the importance of invasive species, especially in nearshore areas such as this, is recognised.

Although sensitivity is a key element of the impact assessment process, it is not in itself necessarily an indicator of impact importance (significance). The future environmental assessment of a specific project for Hesselø OWF will consider other factors including the duration and magnitude of pressures and the importance (value) of receptors.

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# Appendix 1

## Species cover of hard bottom flora and fauna distributed over sampling stations and depth intervals

Appendix 1 - Species cover of hard bottom flora and fauna distributed over sampling stations and depth intervals.

| Dybde range (m) | 5.9-6.5 | | | 7.5-7.7 | | | 9.4-9.8 | | |
|---|---|---|---|---|---|---|---|---|---|
| **Stations navn** | H2 | H1 | H3 | H6 | H4 | H5 | H7 | H9 | H8 |
| **Dybde(m)** | 5.9 | 6.2 | 6.5 | 7.5 | 7.7 | 7.7 | 9.4 | 9.5 | 9.8 |
| | | | | | | | | | |
| **Anthozoa** | | | | | | | | | |
| Acontiaria indet. | 0,1 | | | 0,1 | | 0,1 | | | |
| Alcyonium digitatum | | | | | | | | | |
| Cylista undata | | | | 0,1 | | | | | |
| Metridium senile | 0,1 | | | | 0,1 | | | 0,1 | |
| **Ascidiacea** | | | | | | | | | |
| Ascidiacea indet. | | | | | | | | | |
| Botrylloides leachii | | | | | | 0,1 | | | |
| Ciona intestinalis | | | | | | | | | |
| **Bivalvia** | | | | | | | | | |
| Hiatella arctica | | | | | | | | | |
| Modiolus modiolus | | | | | | | | | |
| Mytilus edulis | | | | | 0,1 | | | | |
| **Bryozoa** | | | | | | | | | |
| Alcyonidium gelatinosum | | | | | | | 0,1 | | 0,1 |
| Alcyonidium hirsutum | 0,1 | | | 0,1 | | 0,1 | | | 0,1 |
| Alcyonidium sp. | | | | | | 0,1 | | | |
| Amphiblestrum auritum | 0,1 | 0,1 | | | | | 1 | | 0,1 |
| Bryozoa indet. | 0,1 | | | | 0,1 | | | | 0,1 |
| Callopora lineata | | | 0,1 | | | | | | |
| Celleporella hyalina | | | | | | | | | |
| Cribrilina punctata | 0,1 | | | | | | 0,1 | | |
| Crisia sp. | | | | | | | 0,1 | 0,1 | |
| Electra pilosa | 50 | 50 | 0,1 | 40 | 40 | 30 | 30 | 50 | 40 |
| Escharella immersa | | | | | | | 1 | | |
| Flustrellidra hispida | | | | | | | | | |
| Membranipora membranacea | | | | | | | | | |
| Walkeria uva | | 0,1 | | | | | | | 0,1 |
| **Chlorophyta** | | | | | | | | | |
| Chaetomorpha melagonium | | | | | | | | 0,2 | |
| **Crustacea** | | | | | | | | | |
| Balanus balanus | | | | | | | | | |
| Balanus sp. | | | | | | | | | |
| Cancer pagurus | | | | | | | | | |
| Carcinus maenas | 0,1 | | 0,1 | 0,1 | | | | | |
| Palaemon adspersus | | | | | 0,1 | | | | |
| **Echinodermata** | | | | | | | | | |
| Asterias rubens | 0,1 | 0,1 | 0,1 | 0,1 | 0,1 | 0,1 | | 0,1 | 0,1 |
| Marthasterias glacialis | | | | | | | 0,1 | | |
| **Gastropoda** | | | | | | | | | |
| Pagurus bernhardus | | | | | | | | | |

| Dybde range (m) | 5.9-6.5 | | | 7.5-7.7 | | | 9.4-9.8 | | |
|---|---|---|---|---|---|---|---|---|---|
| **Stations navn** | H2 | H1 | H3 | H6 | H4 | H5 | H7 | H9 | H8 |
| **Dybde(m)** | 5.9 | 6.2 | 6.5 | 7.5 | 7.7 | 7.7 | 9.4 | 9.5 | 9.8 |
| | | | | | | | | | |
| **Hydrozoa** | | | | | | | | | |
| Clytia hemisphaerica | | 0,1 | 0,1 | | 0,1 | | 0,1 | | |
| Dynamena pumila | 0,1 | 0,1 | 0,1 | 0,1 | | 0,1 | 0,1 | | 0,1 |
| Hydrozoa indet. | | 5 | | | | | | | |
| Obelia dichotoma | 0,1 | | | | | | | | |
| Obelia geniculata | | | | 0,1 | | | 0,1 | | 0,1 |
| Obelia longissima | | | | | 0,1 | | | | |
| Obelia sp. | | 0,1 | | | | | | | |
| Sertularella rugosa | | | | | | | 0,1 | | |
| **Phaeophyta** | | | | | | | | | |
| Brown crust | 5 | 5 | | 5 | | | 1 | 20 | 10 |
| Chaetopteris plumosa | | | | | | | | 0,2 | |
| Ectocarpus siliculosus | | | | | | 0,1 | | | |
| Elachista fucicola | | | | | | | 1 | 0,1 | |
| Fucus serratus | 5 | 5 | 15 | 15 | 1 | 3 | 1 | 5 | 1 |
| Halidrys siliquosa | | | 1 | | | | 25 | 10 | 10 |
| Halosiphon tomentosus | | | 1 | | | | | | |
| Laminaria digitata | | | | | 0,1 | | 5 | 1 | 0,1 |
| Laminaria sp. | | | | 0,1 | | | | | |
| Saccharina latissima | | 0,1 | | | | | | | 0,1 |
| Sphacelaria cirrosa | 5 | 5 | 0,1 | 20 | 20 | 10 | | 0,1 | |
| Sphacelaria sp. | | 0,1 | | | | | 1 | 0,1 | 2 |
| Sphaceloderma caespitula | | | | | | | | | |
| **Pisces** | | | | | | | | | |
| Agonus cataphractus | | | | | | | | | |
| Ctenolabrus rupestris | | 0,1 | 0,1 | 1 | | 1 | 0,1 | 0,1 | 0,1 |
| Entelurus aequoreus | | | | | 0,1 | | | | |
| Labrus mixtus | | | | | | | | 0,1 | 0,1 |
| Limanda limanda | | | | | | | | 0,1 | |
| Pholis gunellus | | | | | 0,1 | | | | |
| Platichthys flesus | | | | | | | | | |
| Pomatoschistus minutus | | 0,1 | 0,1 | 0,1 | | | 0,1 | | |
| Scophthalmus maximus | | | | | | | | | |
| Symphodus melops | 0,1 | 0,1 | | 0,1 | | | 0,1 | 0,1 | |
| **Polychaeta** | | | | | | | | | |
| Spirorbinae indet. | 1 | 1 | 2 | 5 | 1 | 2 | 1 | 2 | 2 |
| **Polyplachophora** | | | | | | | | | |
| Polyplacophora indet. | | | | 0,1 | | | | 0,1 | |
| **Porifera** | | | | | | | | | |
| Halichondria (Halichondria) panicea | 1 | 2 | 1 | 5 | 2 | 5 | 2 | 2 | 5 |
| Porifera indet. | | | | | | | 0,1 | | |

| Dybde range (m) | 5.9-6.5 | | | 7.5-7.7 | | | 9.4-9.8 | | |
|---|---|---|---|---|---|---|---|---|---|
| **Stations navn** | H2 | H1 | H3 | H6 | H4 | H5 | H7 | H9 | H8 |
| **Dybde(m)** | 5.9 | 6.2 | 6.5 | 7.5 | 7.7 | 7.7 | 9.4 | 9.5 | 9.8 |
| | | | | | | | | | |
| **Rhodophyta** | | | | | | | | | |
| Ahnfeltia plicata | | | | 0,1 | | | 0,1 | 0,1 | |
| Bonnemaisonia hamifera | | 0,1 | 5 | | | | | 0,1 | 40 |
| Callithamnion corymbosum | 5 | | | | | | | | |
| Ceramium sp. | 0,1 | | 60 | 0,1 | | 0,1 | | 0,1 | 10 |
| Ceramium virgatum | 5 | 5 | 100 | 50 | 20 | 40 | 9 | 8 | |
| Chondrus crispus | | 1 | 5 | 5 | 2 | 1 | 1 | | 2 |
| Coccotylus brodiei | 75 | 70 | 50 | | 50 | | 50 | 20 | 10 |
| Coccotylus truncatus | | | | | | | | | |
| Corallina officinalis | | | | | | | | | |
| Cystoclonium purpureum | 1 | 5 | 1 | 0,1 | 10 | 5 | 30 | 20 | 10 |
| Delesseria sanguinea | 2 | 2 | 10 | 5 | 5 | 2 | 15 | 20 | 10 |
| Dilsea carnosa | | | | | | | | | |
| Furcellaria lumbricalis | 50 | 50 | 40 | 70 | 75 | 50 | 50 | 60 | 60 |
| Leptosiphonia fibrillosa | 0,1 | 0,1 | 0,1 | | 1 | | | 0,1 | 0,1 |
| Lithothamnion glaciale | | | | | | | 10 | | 2 |
| Melobesia membranacea | | | | | 0,1 | 0,1 | | 1 | 0,1 |
| Membranoptera alata | | | 0,1 | 1 | | | 1 | | |
| Odonthalia dentata | | | | | | | | | |
| Palmaria palmata | | | | | | | | | |
| Phycodrys rubens | 1 | | 2 | 2 | | 2 | 2 | 2 | 2 |
| Phyllophora pseudoceranoides | | 5 | | 30 | | 40 | | 30 | 40 |
| Plumaria plumosa | | | 0,1 | | | | 0,1 | 0,1 | 0,1 |
| Polyides rotunda | 5 | | | | | | | | |
| Polysiphonia elongata | | | | 10 | | | | | |
| Polysiphonia stricta | | | | 0,1 | | 0,1 | | 0,1 | |
| Pterothamnion plumula | | | | | | | | | |
| Red calcified crust | 5 | 10 | | 10 | 10 | 10 | 30 | 50 | 30 |
| Red crust | 10 | 5 | | 30 | 20 | 2 | 5 | 10 | 10 |
| Rhodomela confervoides | | | 1 | 1 | 0,1 | 0,1 | 2 | 0,1 | |
| Scagelothamnion pusillum | | | | | | | | | |
| Spermothamnion repens | 10 | 5 | 0,1 | 5 | 15 | | 1 | 4 | 10 |
| Vertebrata byssoides | 0,1 | 1 | 5 | 1 | 1 | 0,1 | 0,1 | 0,1 | 0,1 |
| Vertebrata fucoides | 0,1 | 0,1 | 0,1 | 0,1 | 3 | | | 1 | 5 |

| Dybde range (m) | 11.9-12.2 | | | 12.7-14.3 | | | 16.1-17.5 | | 18.6-18.9 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Stations navn** | H12 | H10 | H11 | H13 | H14 | H15 | H18 | H17 | A4 | H19 | H21 |
| **Dybde(m)** | 11.9 | 12.2 | 12.2 | 12.7 | 13.7 | 14.3 | 16.1 | 17.5 | 18.6 | 18.9 | 18.9 |
| | | | | | | | | | | | |
| **Anthozoa** | | | | | | | | | | | |
| Acontiaria indet. | | | | | | | | | | | |
| Alcyonium digitatum | | | | | | | | | | 0,1 | 0,1 |
| Cylista undata | | | | | | | | | | | |
| Metridium senile | | | | | | | | | | | |
| **Ascidiacea** | | | | | | | | | | | |
| Ascidiacea indet. | | | | | | 0,1 | | | | | |
| Botrylloides leachii | | | | | | | | | | | |
| Ciona intestinalis | | | | | | | 0,1 | 0,1 | | | |
| **Bivalvia** | | | | | | | | | | | |
| Hiatella arctica | 0,1 | | | 0,1 | 0,1 | | | | | | |
| Modiolus modiolus | | | | | | | | | 0,1 | 0,1 | |
| Mytilus edulis | | | | | | | | | | | |
| **Bryozoa** | | | | | | | | | | | |
| Alcyonidium gelatinosum | 0,1 | | | | | 0,1 | | | | | |
| Alcyonidium hirsutum | 0,1 | | | | | | | | | | |
| Alcyonidium sp. | | | | | 0,1 | | | | | | |
| Amphiblestrum auritum | | | | | | | | | | | |
| Bryozoa indet. | | | | | 2 | | | | | | |
| Callopora lineata | | | | | | | | | | | |
| Celleporella hyalina | | | | | | | | 0,1 | | | |
| Cribrilina punctata | | | 0,1 | | | 0,1 | | 0,1 | | 0,1 | |
| Crisia sp. | | | | | | | 0,1 | | | | 0,1 |
| Electra pilosa | 40 | 30 | 30 | 20 | 1 | 1 | 0,1 | | | | |
| Escharella immersa | | | | | | | | | | | |
| Flustrellidra hispida | | 0,1 | | | 0,1 | 0,1 | | | | | |
| Membranipora membranacea | | | | 1 | 0,1 | 0,1 | 0,1 | | | | |
| Walkeria uva | | | | | | | | 0,1 | | | |
| **Chlorophyta** | | | | | | | | | | | |
| Chaetomorpha melagonium | | | | 0,1 | | | | | | | |
| **Crustacea** | | | | | | | | | | | |
| Balanus balanus | | | | | 0,1 | | | | 0,1 | 0,1 | |
| Balanus sp. | | 0,1 | | | | 0,1 | 0,1 | 0,1 | | | |
| Cancer pagurus | | 0,1 | | | | | | | | | |
| Carcinus maenas | | | 0,1 | | | | | | | | |
| Palaemon adspersus | | | | | | | | | | | |
| **Echinodermata** | | | | | | | | | | | |
| Asterias rubens | | 0,1 | 0,1 | 0,1 | 0,1 | | | | | | |
| Marthasterias glacialis | | | | | | | | | | 0,1 | 0,1 |
| **Gastropoda** | | | | | | | | | | | |
| Pagurus bernhardus | | | | | | | | | | 0,1 | |

| Dybde range (m) | 11.9-12.2 | | | 12.7-14.3 | | | 16.1-17.5 | | 18.6-18.9 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Stations navn** | H12 | H10 | H11 | H13 | H14 | H15 | H18 | H17 | A4 | H19 | H21 |
| **Dybde(m)** | 11.9 | 12.2 | 12.2 | 12.7 | 13.7 | 14.3 | 16.1 | 17.5 | 18.6 | 18.9 | 18.9 |
| | | | | | | | | | | | |
| **Hydrozoa** | | | | | | | | | | | |
| Clytia hemisphaerica | | | | 0,1 | | | | | | | |
| Dynamena pumila | 0,1 | | | | | | | | | | |
| Hydrozoa indet. | | 0,1 | | | | | | | | | |
| Obelia dichotoma | | | | | | | | | | | |
| Obelia geniculata | | | | | | | | | | | |
| Obelia longissima | | | | | | | | | | | |
| Obelia sp. | 0,1 | | | | | | | | | 0,1 | |
| Sertularella rugosa | | | | | | | | | | | |
| **Phaeophyta** | | | | | | | | | | | |
| Brown crust | 2 | 20 | | 2 | 2 | 1 | 70 | 20 | 5 | 50 | 50 |
| Chaetopteris plumosa | 0,2 | | | | | | | | 0,2 | | |
| Ectocarpus siliculosus | | | | 0,1 | | 0,1 | | | | | |
| Elachista fucicola | | | | | | | | | | | |
| Fucus serratus | | | | | | | | | | | |
| Halidrys siliquosa | | | | 1 | | | | | | | |
| Halosiphon tomentosus | | | | | | | 0,1 | | | | |
| Laminaria digitata | 5 | 2 | 0,1 | 5 | 10 | 5 | 1 | | | | |
| Laminaria sp. | | 0,1 | | | | | | | | | |
| Saccharina latissima | | | | | | | 5 | 5 | | | |
| Sphacelaria cirrosa | 7 | 0,1 | 5 | | 1 | | | | | | |
| Sphacelaria sp. | | 7 | | 1 | | 0,1 | | | | | |
| Sphaceloderma caespitula | | | | 0,1 | | | | | | | |
| **Pisces** | | | | | | | | | | | |
| Agonus cataphractus | | | | | | | | | | | 0,1 |
| Ctenolabrus rupestris | 1 | 0,1 | | 0,1 | | | | | | | |
| Entelurus aequoreus | | | | | | | | | | | |
| Labrus mixtus | | | | | | | | | | | |
| Limanda limanda | | | | | | | | | | | |
| Pholis gunellus | | | | | | | | | | | |
| Platichthys flesus | | | | | 1 | | | | | | |
| Pomatoschistus minutus | | | | | | | | | | | |
| Scophthalmus maximus | | | | 0,1 | | | | | | | |
| Symphodus melops | | | | | | | | | | | |
| **Polychaeta** | | | | | | | | | | | |
| Spirorbinae indet. | 0,1 | 0,1 | 0,1 | 0,1 | 0,1 | | 0,1 | | | 0,1 | 0,1 |
| **Polyplachophora** | | | | | | | | | | | |
| Polyplacophora indet. | | | | | 0,1 | | | 0,1 | 0,1 | 0,1 | 0,1 |
| **Porifera** | | | | | | | | | | | |
| Halichondria (Halichondria) panicea | 2 | 2 | 2 | 2,1 | 5 | 5 | | | 0,1 | | |
| Porifera indet. | | | | | | | | | | 0,1 | |

| Dybde range (m) | 11.9-12.2 | | | 12.7-14.3 | | | 16.1-17.5 | | 18.6-18.9 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Stations navn** | H12 | H10 | H11 | H13 | H14 | H15 | H18 | H17 | A4 | H19 | H21 |
| **Dybde(m)** | 11.9 | 12.2 | 12.2 | 12.7 | 13.7 | 14.3 | 16.1 | 17.5 | 18.6 | 18.9 | 18.9 |
| | | | | | | | | | | | |
| **Rhodophyta** | | | | | | | | | | | |
| Ahnfeltia plicata | | | | | | | | | | | |
| Bonnemaisonia hamifera | 0,1 | 9 | 5 | 1 | | | | | | 0,1 | 0,1 |
| Callithamnion corymbosum | 30 | 10 | | 0,1 | | 0,1 | 0,1 | 0,1 | 0,1 | 0,1 | 0,1 |
| Ceramium sp. | | 0,1 | 0,1 | 0,1 | | | | | | | |
| Ceramium virgatum | | 20 | 5 | 4 | 10 | 0,1 | | | 0,1 | 0,1 | |
| Chondrus crispus | 0,1 | 2 | 1 | 30 | 1 | 0,1 | | | | | |
| Coccotylus brodiei | 2 | 15 | | | 0,1 | | | | 0,1 | 0,1 | |
| Coccotylus truncatus | | | | | | 10 | | | | | |
| Corallina officinalis | | | 0,1 | 0,1 | | | | | | | |
| Cystoclonium purpureum | 10 | | 15 | 20 | 10 | 1 | 0,1 | | | | |
| Delesseria sanguinea | 10 | 5 | 1 | 10 | 20 | 20 | 30 | 3 | 1 | 0,1 | 0,1 |
| Dilsea carnosa | | | | | | | 0,1 | | 0,1 | | |
| Furcellaria lumbricalis | 30 | 50 | 50 | 50 | 1 | | | | | | |
| Leptosiphonia fibrillosa | 0,1 | 1 | 0,1 | 3 | 3 | 0,1 | | 0,1 | | | |
| Lithothamnion glaciale | | 0,1 | | | 0,1 | | | | | | |
| Melobesia membranacea | | | | | 0,1 | | | | | | |
| Membranoptera alata | 0,1 | 0,1 | | | 0,1 | 10 | | | | | |
| Odonthalia dentata | | | | | | | | 1 | | | 0,1 |
| Palmaria palmata | | | | 1 | 1 | 0,1 | | | 1 | | |
| Phycodrys rubens | 10 | 0,1 | 1 | 5 | 30 | 20 | 45 | 0,1 | | 0,1 | |
| Phyllophora pseudoceranoides | 50 | 60 | 50 | 10 | 10 | 40 | 0,1 | | | | |
| Plumaria plumosa | 0,1 | 0,1 | | 0,1 | 0,1 | 0,1 | 0,1 | | | | |
| Polyides rotunda | | 1 | | | | | | | | | |
| Polysiphonia elongata | | | 0,1 | | | 0,1 | | 0,1 | | | |
| Polysiphonia stricta | 0,1 | | 0,1 | | | | 0,1 | | | | |
| Pterothamnion plumula | | | | | | | 0,1 | 0,1 | 0,1 | 0,1 | 0,1 |
| Red calcified crust | 70 | 2 | 60 | 40 | 80 | 60 | 10 | 20 | 15 | 5 | 5 |
| Red crust | 10 | 50 | 15 | 10 | 5 | 5 | 0,1 | | 15 | 2 | 2 |
| Rhodomela confervoides | 0,1 | | | | | 0,1 | | | | | |
| Scagelothamnion pusillum | | | | | 0,1 | | 0,1 | | 0,1 | 0,1 | 0,1 |
| Spermothamnion repens | 3 | 1 | 0,1 | 1 | 1 | 1 | 0,1 | 10 | 26 | 0,1 | 1,5 |
| Vertebrata byssoides | 0,1 | 1 | | 0,1 | 25 | 0,1 | 10 | 0,1 | 0,1 | | |
| Vertebrata fucoides | 0,1 | 1 | | 0,1 | | | | | 0,1 | | |

# Appendix 2

## Substrate type classification

# Appendix 2 – Substrate type classification

The substrate type map is divided into the following substrate types, cf. the Danish Råstofbekendtgørelsen (BEK no. 1680 of 17/12/2018, Phase IB):

**Substrate type 1 - Sand, silt and mud**: Areas consisting of fine-grained soft bottom or solid sand bottom (possibly with dynamic bottom shapes (sand ripples etc.)) with varying amounts of shells and gravel. Sand is defined as grain sizes in the range of 0.06-2.0 mm.
Typically, substrate type 1 is subdivided into substrate type 1a (silty, soft bottom), 1b (solid sandy bottom) and 1c (clay bottom), which is not stated in the "Råstofbekendtgørelsen". It is a standard substrate type subdivision used in a wide range of marine raw material investigations, Natura 2000 projects etc. The subdivision is approved by MST (MST = Danish Environmental Protection Agency).

**Substrate type 2 - Sand, gravel and pebbles**: Areas consisting of a mixture of coarse sand and gravel with a grain size of approx. 2-20 mm and pebbles with sizes of approx. 2-10 cm. The substrate type also contains some larger stones from approx. 10 cm and larger, covering from 1-10% of the seabed.
Substrate type 2 can be subdivided into substrate types 2a and 2b, respectively. According to the "Råstofbekendtgørelse", these two types constitute the same substrate type, but on the basis of their different characteristics a division can be made. Substrate type 2a consists mainly of coarse sand, gravel and pebbles. This type of substrate typically consists of only a few larger stones over 10 cm. Substrate type 2b consists of 1-10% larger stones typically on a coarse sandy bottom.

**Substrate type 3 - Sand, gravel and pebbles, and larger stones**: Areas consisting of mixed substrates with sand, gravel and pebbles with a varying amount of larger stones from approx. 10 cm covering 10-25% of the seabed. The substrate type differs from substrate type 2 by containing a greater number of stones from ca. 10 cm and upwards. The stones are usually scattered, and only in one layer.

**Substrate Type 4 - stony areas and stone reefs with 25-100% of larger stones**: Areas dominated by stones from approx. 10 cm and up - from dense irrigation to actual stone reefs with or without cavities. There may also be varying amounts of sand, gravel and pebbles, as well as biogenic reefs or limestone reefs in this substrate type. The stones can be in one layer, or form actual stone reefs, which rise above the surrounding bottom with several layers (cavity forming).

Table 1. Substrate classes.

| Class | Description of substrate class |
|---|---|
| 1a | Sand, silty, soft bottom |
| 1b | Sand, solid sandy bottom |
| 1c | Clay bottom |
| 2a | Sand, gravel and pebbles – few larger stones |
| 2b | Sand, gravel and pebbles – seabed cover of larger stones 1% to 10% |
| 3 | Sand, gravel and pebbles – seabed cover of larger stones 10% to 25% |
| 4 | Stony areas and stone reefs - seabed cover of larger stones 25% to 100% |