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Anholt Offshore Wind Farm

Mapping of Substrates and Benthic Community Types

September 2009

RAMBØLL

Energinet.dk

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Background Memo
Mapping of Substrates and Benthic Community Types

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Abbreviations

DPO	Dynamically Positioned Operation – an operation where a ships' thrusters and propulsion systems maintains a stable position without the need for anchoring.
GEUS	Geological Survey of Denmark and Greenland.
ROV	Remotely Operated Vehicle - a tethered underwater robot controlled from the surface through a control unit.

1. Summary

1.1 Summary - UK

The present report is a memo on the possible effects on the benthic communities during and after the construction of an offshore wind farm in Kattegat between Grenå and the island of Anholt. The assessment is divided into a part that focuses on the effects on the benthic communities in vicinity to the wind mills and a part that focuses on the effects of the installation of the connective subsea power cable to land.

From the geological surveys, that includes sonar and acoustic measurements, benthic substrate type maps were constructed. Four different substrate types could be identified; substrate type 1 with sand as dominating substrate; substrate type 2, with sand, gravel and pebbles; substrate type 3 with sand, gravel, pebbles and scattered larger stones and substrate type 4, which is dominated by larger stones forming stone reefs.

Point dives, transect dives and ROV (Remotely Operated Vehicle) dives were performed to verify the geological classifications mentioned above and to relate the substrate types to fauna and flora communities.

In areas with substrate type 1, the fauna and especially different species of mussels were dominating. In areas with substrate type 2, more species was recorded than under substrate type 1. Again, mussels were dominating but starfish and common whelks were also plentiful. In areas with substrate type 3, macro algae were present due to the higher number of larger stones. Mussels, starfish, dead man´s finger and sea urchins were plentiful. In areas with substrate type 4, macro algae and larger mussels were dominating.

The dominating substrate type in the area was type 1 and type 2. Benthic type 3 was also regularly registered while type 4 was only observed in a few limited areas in the wind farm construction site, but at several locations along the cable corridors. Solid limestone formations were recorded close to the shore of the cable corridors and were assigned in the category substrate type 4. Stone reefs with cave forming properties has not been registered in the project area.

It is assessed that the planned construction work at the wind farm area will only have a minor and localized effect on the benthic communities registered. Sediment re-suspension is considered a localized stressor on a temporal scale, as construction time per windmill is estimated to last around three days. Furthermore, the benthic communities present are capable of migrating vertical if minor sediment spills will occur or is adapted to sediment resuspension in relation to strong currents or wind-events.

The fauna and flora communities associated with stone reefs and solid lime-stone structures will only be affected localized by the construction work. However, in the areas where limestone structures have to be broken down to allow the cable to enter land, a localized permanent and irreversible damage will occur on the substrate. It is assessed that the effect on fauna and flora is only temporal.

Scour protection around windmills will add hard substrate to the area and will on a longer scale, most likely have a positive effect on benthic communities.

1.2 Summery – DK

Nærværende rapport er en beskrivelse af de mulige effekter på det bentiske miljø i forbindelse med - og efter konstruktionen, af en planlagt Havvindmøllepark imellem Anholt og Djursland. Notatet er opdelt i en del der omhandler de mulige effekter på det bentiske miljø i havvindmølleparkens projektområde og en del der fokuserer på de mulige effekter af nedlægningen af søkabel fra en offshore transformatorstation til Djurslands kyst.

Via de geologiske undersøgelser, der inkluderede sonar og akustiske opmålinger, blev der udarbejdet et kort over mangfoldigheden i de bentiske bundtyper. Fire forskellige bundtyper kunne identificeres i området og i kabel tracéet; substrattype 1 inkluderer sand som dominerende substrat; substrattype 2 der inkluderer sand med varierende mængder grus og rald; substrattype 3 med sand, grus, rald og med få spredte større sten; substrat type 4 hvor større sten dominerer og hvor egentlige stenrev forefindes.

Punkt-dyk, transekt-dyk og ROV-dyk blev gennemført for at verificere de fire substrattyper nævnt ovenfor, samt at relatere substrattyperne til fauna og flora samfund.

I områder med substratype 1, var fauna og specielt større muslinger dominerende. I områder med substrat type 2 blev flere arter registreret men større muslinger dominerede stadigvæk, sammen med bl.a. almindelig søstjerne. I områder med substrattype 3 var makroalger rigt repræsenteret pga. det forøgede antal større sten. Blandt dyr, var muslinger, dødningehånd koral og søpindsvin dominerende. Under substrattype 4 var makroalger altdominerende sammen med større muslinger.

Dominerende substrattyper i havvindmølleparkens projektområde samt i kabel tracéerne, var type 1 og type 2. Substrattype 3 var ligeledes rigt repræsenteret mens substrattype 4 kun blev observeret i få afgrænsede områder. Der blev ikke registreret huledannende stenrev i projektområdet. Kalkstensformationer blev registreret tæt på land ved ilandføringen af søkablet nord for Grenå. Disse blev inkluderet under substrattype 4.

Det vurderes at det planlagte konstruktionsarbejde i havvindmølleparkens projektområde udelukkende har en mindre og lokal effekt på de registrerede bentiske samfund. Sediment resuspension vurderes at være en lokal stressfaktor på en kort tidslig skala, idet konstruktionsfasen af vindmøllefundamenterne skønnes at vare maksimalt tre dage per mølle. Yderligere forventes det at påvirkede faunasamfund kan migrere vertikalt i tilfælde af sedimentspild i området eller være tilpasset til resuspension i relation til kraftige strøm- eller vindhændelser.

Fauna og flora samfund associeret med stenrev og de registrerede kalkstensformationer vil udelukkende blive kortvarigt påvirkede at konstruktionsarbejdet. Dog vil selve kalkstenen, hvor ilandføringen af søkablet forventes, blive irreversibelt påvirket i et smalt bånd. Det skal dog nævnes i den forbindelse, at påvirkningen på fauna og florasamfund udelukkende skønnes at være af kortvarig karakter.

Bølgebeskyttelsen rundt om vindmøllernes fundamenter vil tilføje hårdt substrat til området og skønnes på længere sigt at have en positiv effekt på de bentiske samfund i områder.

2. Introduction

2.1 Background

In 1998, the Ministry of Environment and Energy empowered the Danish energy companies to build offshore wind farms of a total capacity of 750 MW, as part of fulfilling the national action plan for energy, Energy 21. One aim of the action plan, which was elaborated in the wake of Denmark's commitment to the Kyoto agreement, was to increase energy production from wind power to at total of 5.500 MW in the year 2030. Hereof 4.000 MW has to be produced in offshore wind farms.

In the period 2002-2003, the first two wind farms were established at Horns Rev west of Esbjerg and Rødsand south of Lolland, consisting of 80 and 72 wind turbines, respectively, producing a total of 325,6 MW. In 2004 it was furthermore decided to construct two new wind farms in proximity of the two existing parks at Horns rev and Rødsand. The two new parks, Horns rev 2 and Rødsand 2, are expected to produce 215 MW each and are planned to be fully operational by the end 2010.

The 400 MW Anholt Offshore Wind Farm constitutes the next step of the fulfilment of the aim of the action plan. The wind farm will be constructed in 2012, and the expected production will cover the yearly electricity consumption of approximately 400.000 households. Energinet.dk on behalf of the Ministry of Climate and Energy is responsible for the construction of the electrical connection to the shore and for development of the wind farm site, including the organization of the impact assessment which will result in the identification of the best suitable site for constructing the wind farm. Rambøll with DHI and other sub consultants are undertaking the site development including a full-scale Environmental Impact Assessment for the wind farm.

The present report is a part of a number of technical reports forming the base for the Environmental Impact Assessment for Anholt Offshore Wind Farm.

The Environmental Impact Assessment of the Anholt Offshore Wind Farm is based on the following technical reports:

- Technical Description
- Geotechnical Investigations
- Geophysical Investigations
- Metocean data for design and operational conditions
- Hydrography including sediment spill, water quality, geomorphology and coastal morphology
- Benthic Fauna
- Birds
- Marine mammals
- Fish
- Substrates and benthic communities
- Benthic habitat
- Maritime archaeology

- Visualization
- Commercial fishery
- Tourism and Recreational Activities
- Risk to ship traffic

2.2 Content of specific memo

This technical background report describes the results of the baseline investigations and the impact assessment on marine substrates and benthic community types in the project area for the Anholt Offshore Wind Farm.

The memo is divided into two parts, a baseline description and an impact assessment.

The baseline study was conducted as a combination of a geophysical survey and a visual verification survey in the project area and the two potential cable corridors.

The final output from the geophysical mapping is a substrate type map. The final output of the visual verification survey is a marine benthic community type map and underwater video sequences.

The different benthic substrate types are exemplified with side scan sonar pictures and associated marine benthic community types are exemplified with pictures from the underwater video sequences.

Throughout impact assessment part, the potential impact on the different benthic community types in the project area and along the two possible cable corridors from the planned off-shore wind farm is assessed.

The impact assessment is divided into two phases; possible impacts during the construction phase and possible impacts during the operation phase.

In the different phases, a worst case scenario will be used as model for the possible impact on the different marine benthic community types.

Furthermore this memo discusses the decommissioning phase, possible cumulative effects and mitigation measures.

3. Offshore wind farm

3.1 Project description

This chapter describes the technical aspects of the Anholt Offshore Wind Farm. For a full project description reference is made to / 23/. The following description is based on expected conditions for the technical project. However, the detailed design will not be finely decided before a developer of the Anholt Offshore Wind Farm has been awarded.

3.1.1 Site location

The designated investigation area for the Anholt Offshore Wind Farm is located in Kattegat between the headland Djursland of Jutland and the island Anholt – see Figure 3.1. The investigation area is 144 km^2, but the planned wind turbines must not cover an area of more than 88 km^2. The distance from Djursland and Anholt to the project area is 15 and 20 km, respectively. The area is characterised by fairly uniform seabed conditions and water depths between 15 and 20 meters.

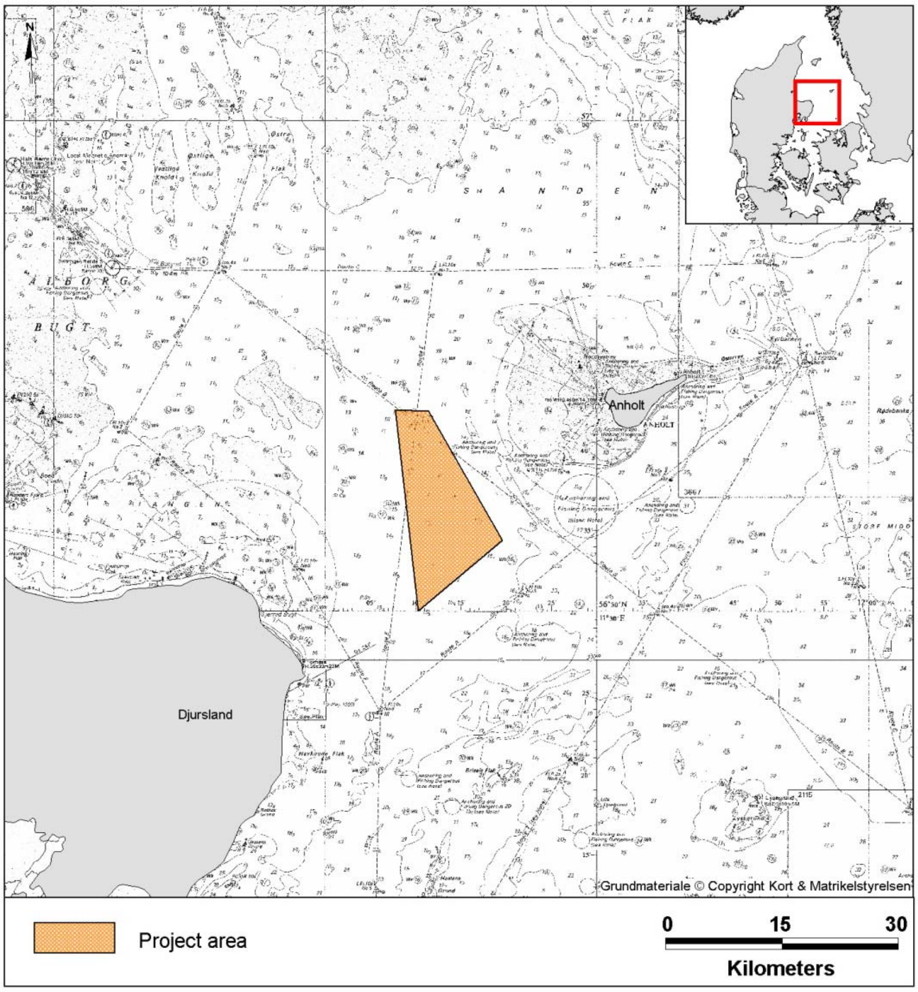

Figure 3.1 Location of the Anholt Offshore Wind Farm project area.

3.1.2 Offshore components

3.1.2.1 Foundations

The wind turbines will be supported on foundations fixed to the seabed. The foundations will be one of two types; either driven steel monopiles or concrete gravity based structures. Both concepts have successfully been used for operating offshore wind farms in Denmark 0/ 28/ 29/.

The monopile solution comprises driving a hollow steel pile into the seabed. A steel transition piece is attached to the pile head using grout to make the connection with the wind turbine tower.

The gravity based solution comprises a concrete base that stands on the seabed and thus relies on its mass including ballast to withstand the loads generated by the offshore environment and the wind turbine.

3.1.2.2 Wind turbines

The maximum rated capacity of the wind farm is by the authorities limited to 400 MW / 30/. The farm will feature from 80 to 174 turbines depending on the rated energy of the selected turbine (2.3 to 5.0 MW).

Preliminary dimensions of the turbines are not expected to exceed a maximum tip height of 160 m above mean sea level for the largest turbine size (5.0 MW) and a minimum air gap of approximately 23 m above mean sea level. An operational sound level is expected in the order of 110 dB(A), but will depend on the selected type of turbine.

The wind turbines will exhibit distinguishing markings visible for vessels and aircrafts in accordance with recommendations by the Danish Maritime Safety Administration and the Danish Civil Aviation Administration. Safety zones will be applied for the wind farm area or parts hereof.

3.1.3 Installation

The foundations and the wind turbine components will either be stored at an adjacent port and transported to the site by support barge or the installation vessel itself, or transported directly from the manufacturer to the wind farm site by barge or by the installation vessel.

The installation will be performed by jack-up barges or floating crane barges depending on the foundation design. In addition, a number of support barges, tugs, safety vessels and personnel transfer vessels will be required.

Construction activity is expected for 24 hours per day until construction is complete. Following installation and grid connection, the wind turbines are commissioned and are available to generate electricity.

A safety zone of 500 m will be established to protect the project plant and personnel, and the safety of third parties during the construction and commissioning phases of the wind farm. The extent of the safety zone at any one time will dependent on the location of the construction activity and can in periods include the entire construction area.

3.1.3.1 **Wind turbines**

The installation of the wind turbines will typically require one or more jack-up barges. These vessels stand on the seabed and create a stable lifting platform by lifting themselves out of the water. The area of seabed taken by a vessels feet is approximately 350 m^2 (in total), with leg penetrations of up to 2 to 15 m (depending on seabed properties). These holes will be left to fill in naturally.

3.1.3.2 **Foundations**

The monopile concept is not expected to require any seabed preparation.

The installation of the driven monopiles will take place from either a jack-up platform or an anchored vessel. In addition, a small drilling spread may be adopted if driving difficulties are experienced. After transportation to the site, the pile is transferred from the barge to the jack-up barge and lifted into vertical position. The pile is driven until target penetration is achieved followed by installation of the transition piece.

For the gravity based foundations, the seabed needs most often to be prepared prior to installation, i.e. the top layer of material is removed and replaced by a stone bed. The material excavated during the seabed preparation works will be loaded onto split-hopper barges for disposal. Some discharge to the water phase is likely to occur in the material excavation process. A conservative estimate is 5% material spill, i.e. up to 200 m^3 for each base, over a period of 3 days per excavation.

The installation of the concrete gravity base will likely take place using a floating crane barge, with attendant tugs and support craft. The bases will either be towed to the site or transported directly to the site on a flat-top barge. The bases will then be lowered from the barge onto the prepared stone bed. After the structure is placed on the seabed, the base is filled with a suitable ballast material, usually sand. A steel 'skirt' may be installed around the base to penetrate into the seabed to constrain the seabed underneath the base.

3.1.4 Protection systems

3.1.4.1 **Corrosion**

Corrosion protection on the steel structure will be achieved by a combination of a protective paint coating and installation of sacrificial anodes on the subsea structure. The anodes are standard products for offshore structures and are welded onto the steel structures.

3.1.4.2 **Scour**

If the seabed is erodible and the water flow sufficiently high, scour holes will form around the structure. The protection system normally adopted against scour consists of rock placement in a ring around the in-situ structure. The rocks are deployed from the host vessel either directly onto the seabed from a barge, via a bucket grab or via a telescopic tube.

For the monopile solution the total diameter of the scour protection is estimated to be 5 times the pile diameter. The total volume of cover stones will be around 850-1,000 m^3 per foundation. For the gravity based solution the quantities are assessed to be 800–1100 m^3 per foundation.

3.2 Baseline study

3.2.1 Methods

To verify the distribution and patterns of the different marine benthic community types in the project area, a series of different methods was applied.

The first field survey was a geophysical survey where side scan sonar and seismic equipment was used and will be further described in section 4.2.1 and in / 1/.

The results of the geophysical survey, which includes a side scan mosaic and a first generation substrate type map (see Figure 3.3), were used to point out specific areas for visual documentation.

The visual documentation was carried out as a number of dives with underwater video (by diving or Remotely Operated Vehicle (ROV)) in the different marine benthic substrate types in the project area and along the two possible cable corridors. This will be further described in section 4.2.2 and in appendix 1.

Initially 6 different substrate types were identified in the first generation substrate type map, but the following visual verification made it clear that the project area is relatively homogenous. Especially, the number of stones was much less than first interpreted. The overall impression of the project area is that it is a relatively flat sandy bottom (16-19 meters of depth) with few larger stones uniformly distributed in the area and with localized areas with gravel and pebbles.

3.2.2 Field survey

3.2.2.1 Geophysical survey

The geophysical survey was conducted by GEUS in April 2009. The project area was surveyed with side scan sonar covering 100 % of the bottom (see Figure 3.2, large map can be seen in appendix 2).

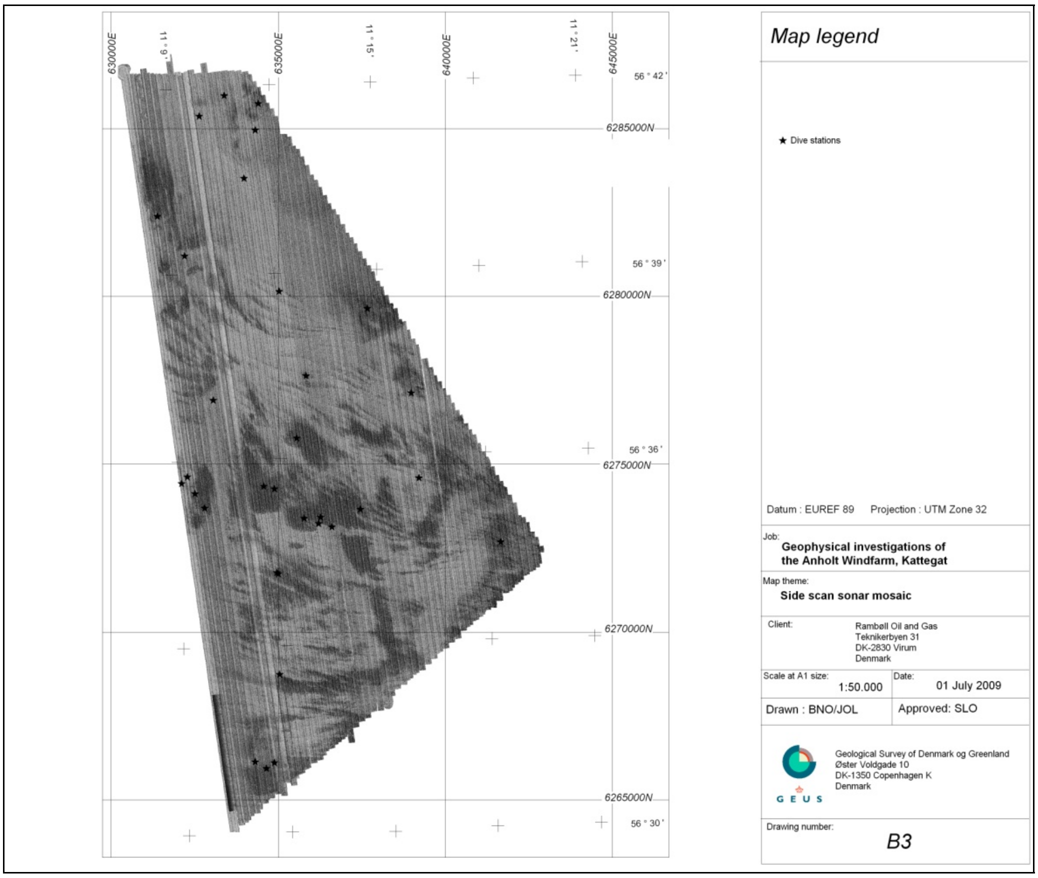

Figure 3.2 Side scan mosaic from the project area

The side scan sonar shows an image of the bottom surface. To get a better understanding of the bottom structure, two different types of seismic equipment was used, a chirp, which penetrates the uppermost layers (few meters), and a boomer, which penetrates deeper into the bottom (several meters). For further details regarding the geophysical survey with descriptions of the different equipment used during the geophysical survey and how the survey was conducted, please see / 1/.

The first output of the geophysical survey is a side scan mosaic of the entire project area. This mosaic gives a first idea of the substrate types found in the project area and what their distribution is – see Figure 3.2.

The side scan mosaic is used to produce a first generation substrate map which can be seen in Figure 3.3.

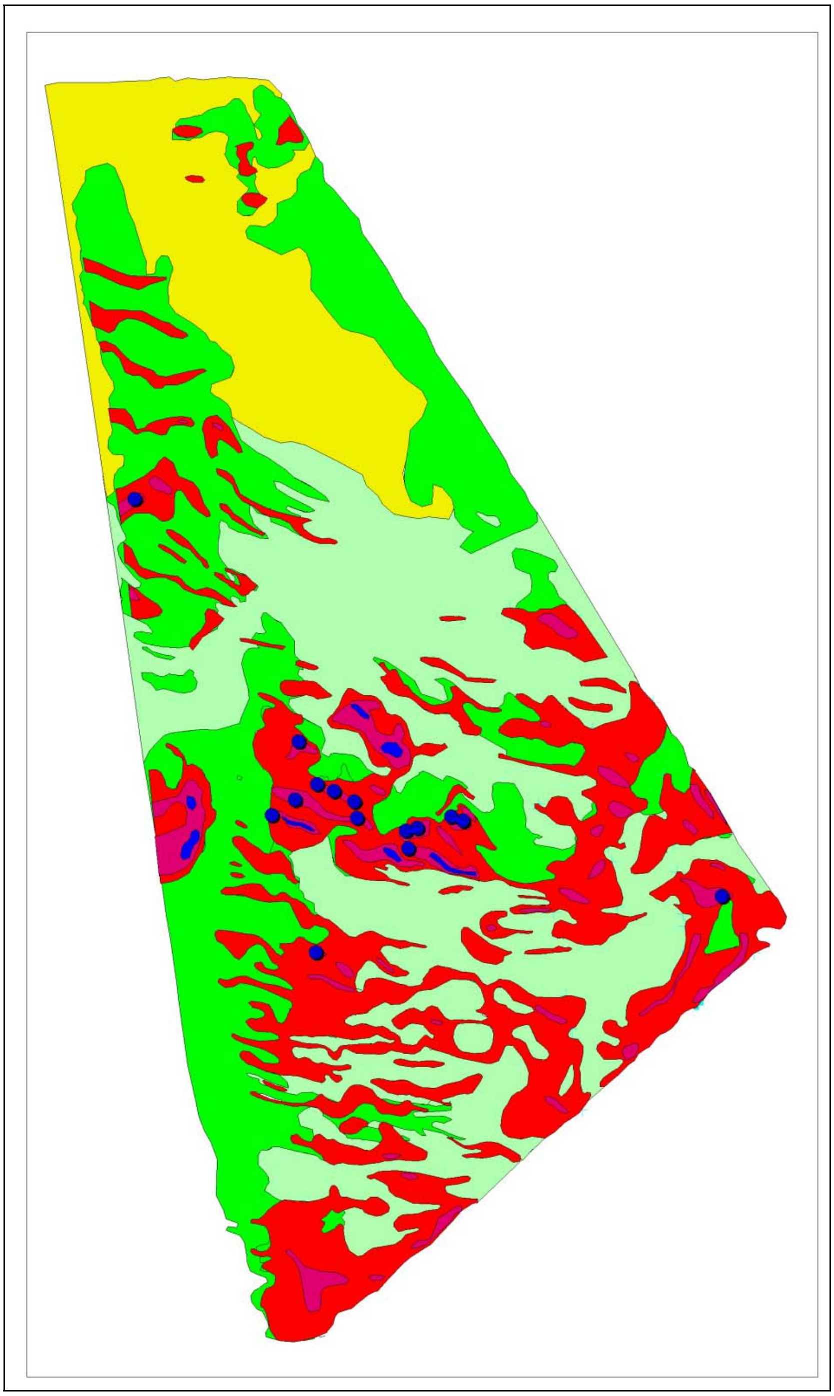

Figure 3.3: First generation benthic substrate map showing the distribution and patterns of 6 different benthic substrate types in the project area (yellow: areas comprising of sand or soft bottom. Light green: areas dominated by sand with scattered gravel or pebble. Dark green: areas dominated by gravel and pebble. Red: areas with 0-20 % coverage of larger stones, remaining substrates are sand, gravel and pebble. Purple: areas with 20-50 % coverage of larger stones, remaining substrates are sand, gravel and pebble. Blue: areas with 50-100 % coverage of larger stones.

3.2.2.2 Visual verification survey with verification of substrates and registration of marine benthic community types

The visual verification in the project area was carried out in May 2009 using a combination of different methods described in section 3.2.2.3 - 3.2.2.5.

Verification points were assigned from the first generation substrate map – see Figure 3.3.

3.2.2.3 Paravane diving

To verify borders between two or more different substrate types and biology associated with the substrate, verification was carried out by diving along five predefined transectlines – see Figure 3.4.

The verifications carried out by paravane diving was carried out as follows; the diver is dragged after a diving boat with a speed of app. 2-4 km/h. The diver and the surface crew on board, use two-way communication to log the divers observations on a laptop, which combines the observation and the specific position of the diver.

In this verification task the, following parameters was registered:

- Water depth
- Overall type of bottom substrate
- Coverage of gravel and pebbles in %
- Coverage of stones larger than app. 10 cm. in %
- Coverage of sand in %
- Coverage of mussels in %
- Coverage of sea stars in %
- Coverage of other dominating animals such as sea urchins, etc in %
- Coverage of macro algae in % and comments on different species

During each dive, the diver continuously reports the different parameters to the surface personnel.

3.2.2.4 Spot diving

Spot dives were conducted to verify the bottom substrate as input to the second generation substrate map, and to describe the overall flora and fauna associated with the different substrate types (sand bottom. bottom with gravel and pebbles etc.).

In the project area, 10 spot dives were performed – see Figure 3.4. The divers descriptions were recorded in a log book along with general observations such as diving depth, visibility in the water, temperature etc. Furthermore, video sequences were recorded by hand-held video camera, for visual documentation purposes.

3.2.2.5 ROV diving

As for the spot diving, there are two purposes for the ROV use. First to verify the bottom substrate as input to the second generation substrate map and second to describe the overall flora and fauna associated with the different substrate types. There were conducted a total of 21 ROV dives in the project area – see Figure 3.4.

The ROV was equipped with a digital video camera. The recorded video sequences were commented by a skilled biologist to be used as visual documentation by geologists and biologists.

The different substrate types and overall biological conditions were recorded in a log book along with general observations such as water depth, visibility in the water etc.

Compared to that of the spot dives, the resolution in the ROV dives are smaller, which means that the number of species detected when using the ROV is less than when a target is spot dived. ROV dives are less time consuming compared to spot dives, but a combination of the two is optimal; it is possible to obtain the biological high resolution with the spot dives, but the number of dives per day is limited, whereas there is no limits to the number of ROV dives that can be performed per day.

From appendix 1 (DVD with video sequences from the project area and log book from all the visual verifications) it will be possible to view underwater sequences from the project area and from the two possible cable corridors. The video sequences verify the substrate types with associated flora and fauna, and give a good understanding of the marine environment in the project area.

In connection with each video sequence, a log book was generated. In the log book, positions of the visual verifications were noted along with water depth, wave height and the type of visual verification (dive or ROV). Furthermore, the substrate and the dominating flora and fauna were described.

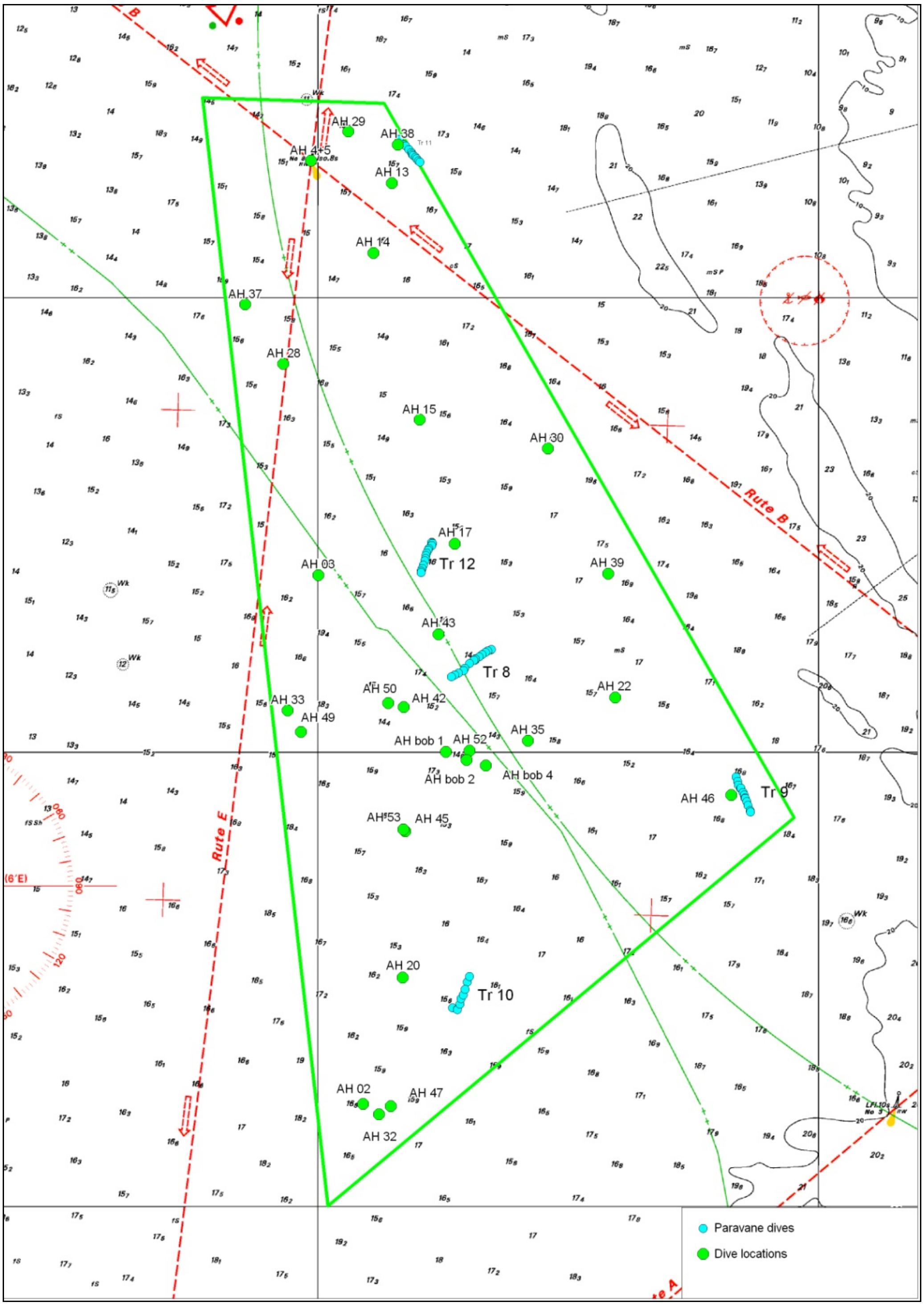

Figure 3.4: Map showing the project area (green frame) and the visual verification points (green dots).

3.2.3 **Benthic substrate types in the project area**

To verify the geophysical "image" of the bottom and to map the different benthic community types, 31 visual verifications was conducted in the project area – see Figure 3.4.

There were initially identified 6 different substrate types in the first generation substrate type map, but the following visual verification made it clear that the project area is relatively homogenous regarding substrate types. The 6 substrate types could therefore be reduced to 4 dominating substrate types.

The 4 benthic substrate types in the project area are defined as follows - see also **Error! Reference source not found.**, large map can be seen in appendix 2:

- **Type 1: Sand:** areas comprising primarily of sandy substrates with variable amounts of ribbons etc.

- **Type 2: Sand, gravel and pebbles:** areas comprising primarily of sand with variable amounts of gravel and pebbles, and with a few scattered stones

- **Type 3: Sand, gravel, pebbles and scattered stones covering app. 1-25 %:** areas comprising of mixed substrates with sand, gravel and pebbles with variable amounts of larger stones

- **Type 4: Stones covering app. 25–100 %:** areas dominated by larger stones (stone reefs) with variable amounts sand, gravel and pebbles

The two substrate types 1 and 4 are obviously easy to identify and differentiate.

The two substrate types 2 and 3 were more difficult to divide, but it is possible to identify the larger stones on the side scan mosaic, and therefore also possible to make a differentiation between the two types by identifying stones in various amounts.

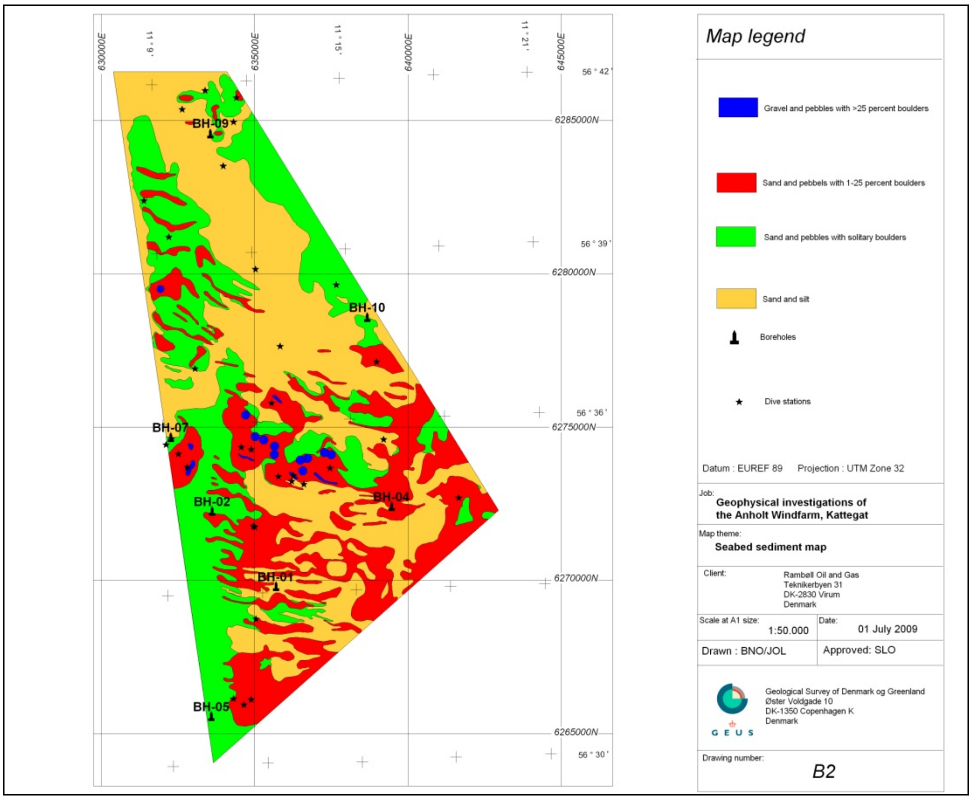

Figure 3.5: Second generation benthic substrate map, showing the area and distribution patterns of the 4 final substrate types defined in the project area. Large version of this map can be seen in app. 2.

In the following section, the different substrate types in the project area will be exemplified with side scan images of the 4 categories.

3.2.3.1 **Substrate type 1: Sand**

Sand is in geological terms defined by a grain size from 0.06 – 2.0 millimetres. In regard to this memo, there have not been collected samples for grain size analysis as it has been evaluated irrelevant in the verification process of side scan data.

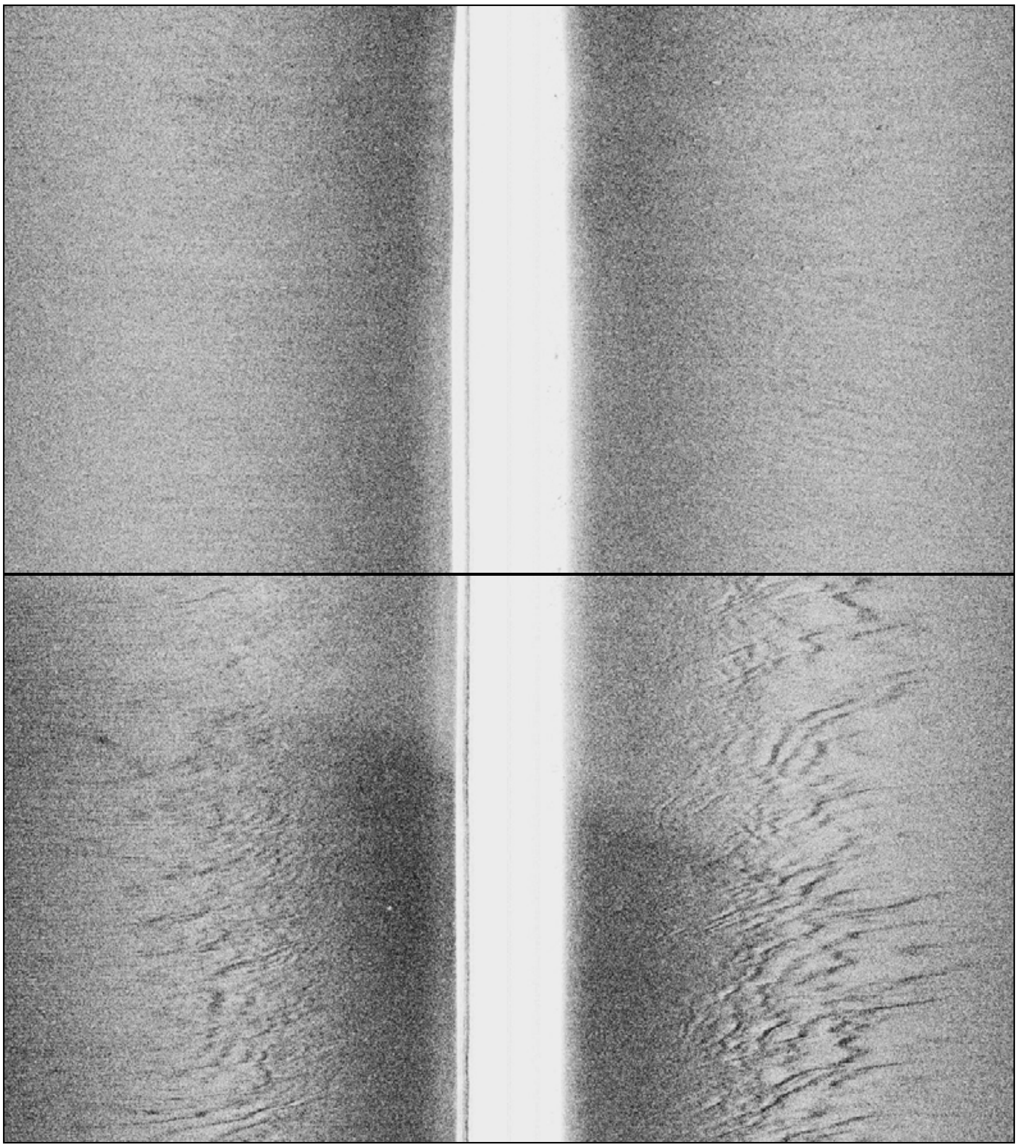

Figure 3.6: Two examples of side scan images from a bottom comprising of substrate type 1: sand. The images are from the positions AH13 and AH15.

3.2.3.2 **Substrate type 2: Sand, gravel and pebbles**

This substrate type comprises a mix of sand, gravel with a grain size from app. 2 - 20 millimetres and pebbles with a grain size of app. 2 - 10 centimetres.

This category can contain a few scattered larger stones from 10 centimetres to larger than 1 meter.

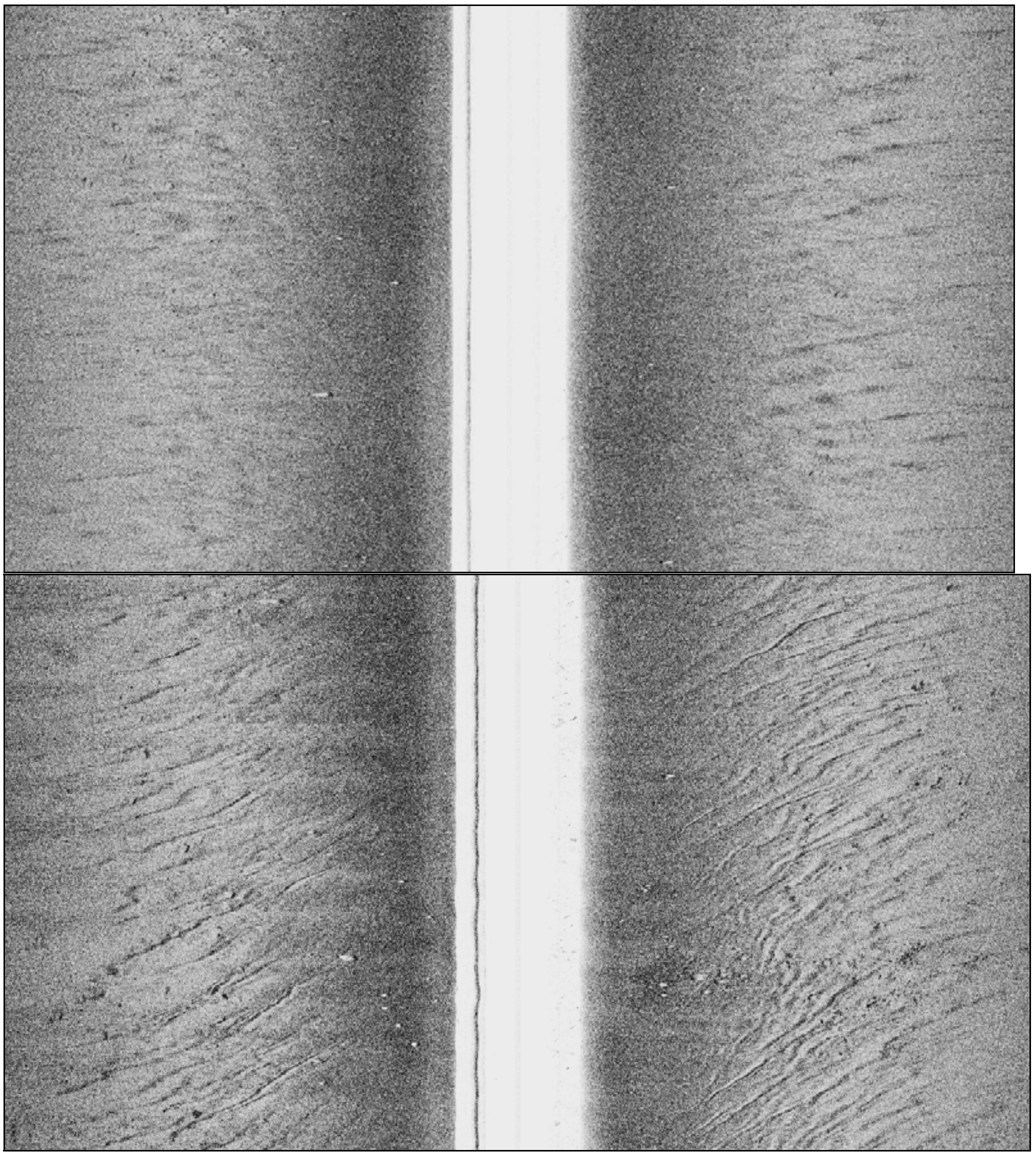

Figure 3.7: Two examples of side scan images from a bottom comprising of substrate type 2: sand, gravel and pebbles. The images are from the positions AH38 and AH33

3.2.3.3 **Substrate type 3: Sand, gravel, pebbles and scattered stones covering app. 1-25 %**

This substrate type resembles the previous, but contains a variable amount of larger stones from 10 centimetres to over 1 meter. Typically the stones are lying solitary but can be found in smaller clusters. In areas with app. 25 % coverage of larger stones, the overall expression can be stone reef like, but stones are placed in a single layer and scattered.

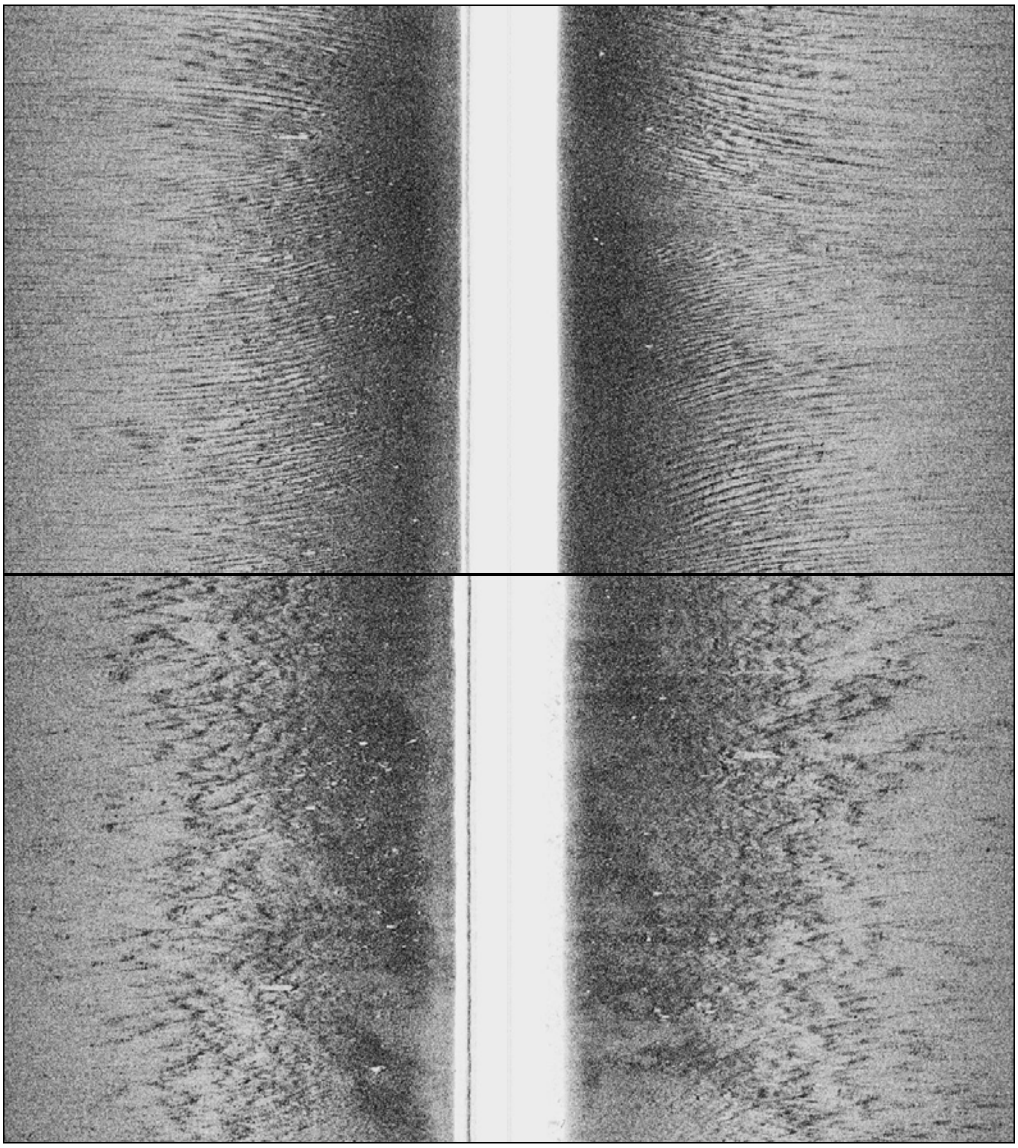

Figure 3.8: Two examples of side scan images from a bottom comprising of substrate type 3: sand, gravel, pebbles and scattered stones covering app. 1-25 %. The images are from the positions AH53 and AH48.

3.2.3.4 **Substrate type 4: Stones covering app. 25–100 %**

This substrate type contains areas dominated by larger stones (stone reefs) and with variable amounts sand, gravel and pebbles. As the former type, the larger stones can be scattered and placed in a single layer. In addition, this category also contains stone reefs that rise above surrounding bottom. This substrate type is limited to one small area within the project area.

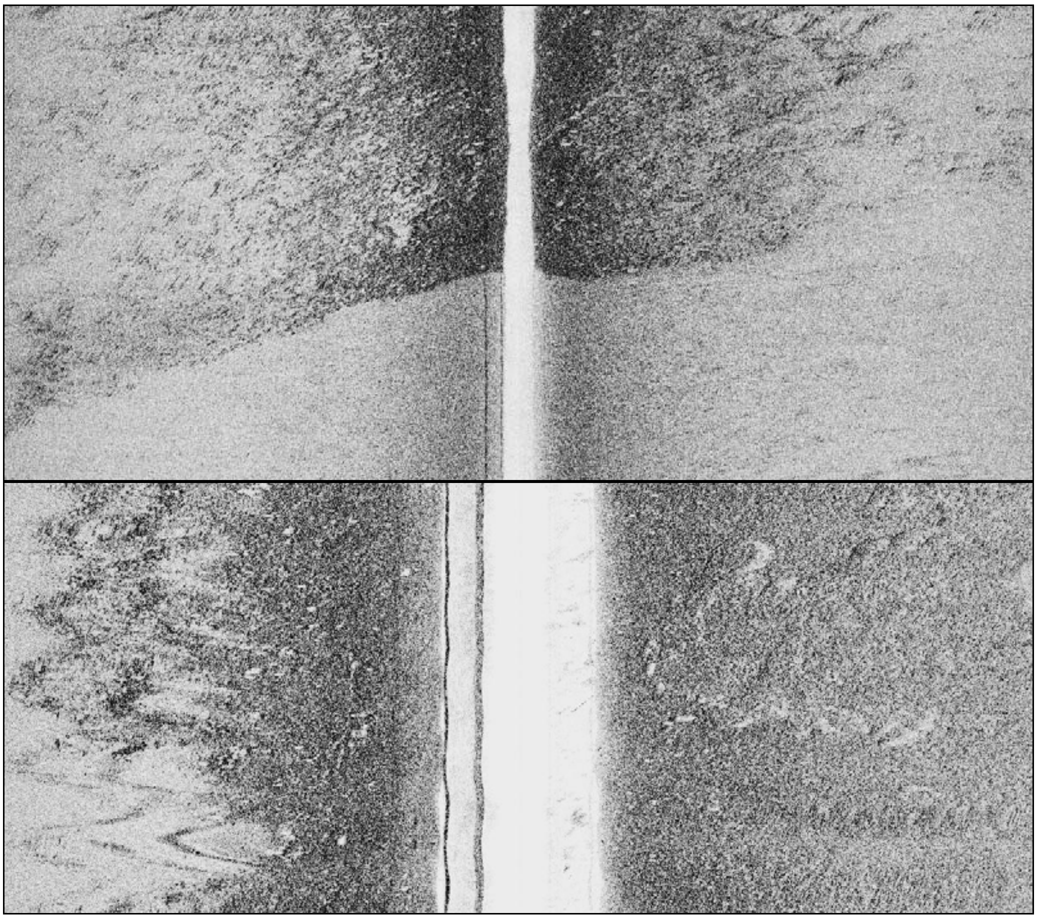

Figure 3.9: Two examples of side scan images from a bottom comprising of substrate type 4: stones covering app. 25-100 %.The images are from the positions KN06 and KS10.

3.2.4 Marine benthic community types in the project area

The second goal of the visual verifications was to identify and map the different flora and fauna communities associated with the substrate types in the project area.

The four different benthic substrate types in the project area have been verified with 31 visual verification points – see Figure 3.4.

The biological benthic communities associated with substrate type 1 and 4 were easy to identify as it was dominated by fauna and was the one with the smallest number of species and also the smallest number of individuals per species.

Substrate type 4 is dominated by flora and fauna with a higher number of species and also a higher number of individuals per species.

The biological communities associated with the two substrate types 2 and 3, were harder to differentiate, but type 2 is mainly dominated by fauna, with a large number of species and also a large number of individuals per species.

The substrate type 3 has the largest number of fauna species and the highest number of individuals per species identified than in any of the other substrate types. Furthermore, it has a variety of macro algae species associated, though not as many species and as high coverage as substrate type “Stone reef”.

In association with the four substrate types, there are different marine benthic flora and fauna communities. Part of the verification is to get an overview of these different (marine benthic community types) and map them on a marine benthic community map – see Figure 3.10.

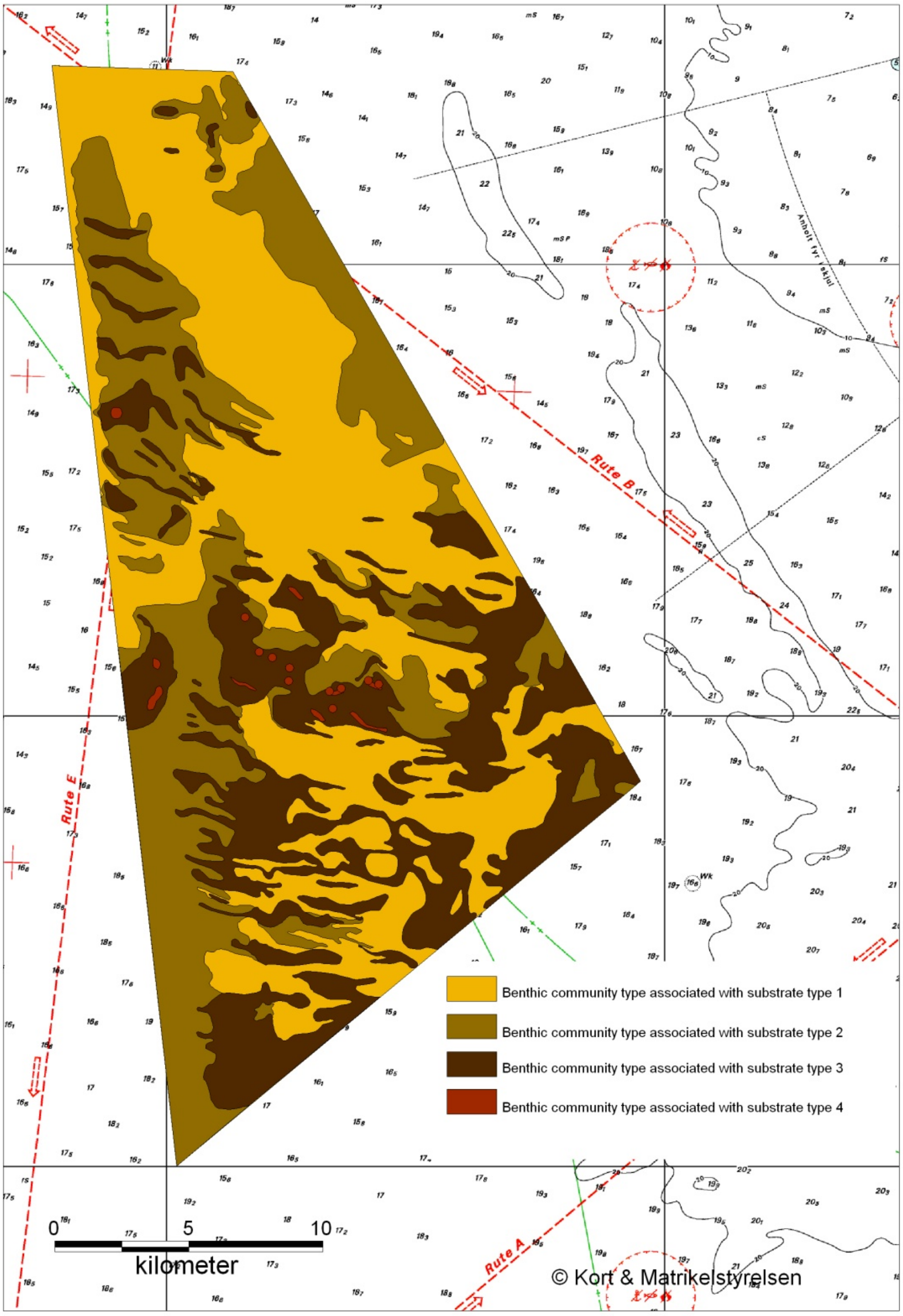

Figure 3.10: Benthic community map showing the 4 different benthic community types in the project area.

In the following section, a description of the four marine benthic community types will be presented and exemplified with pictures.

3.2.4.1 **Benthic community type associated with substrate type 1**

This benthic community is dominated by fauna with a rather limited number of species.

The dominating species are large mussels (Northern horsemussel *(Modiolus modiolus)* and Ocean quahog *(Arctica islandica)* and with scattered observations of Spiny starfish *(Marthasterias glacialis)* and Common sea star *(Asterias rubens)*

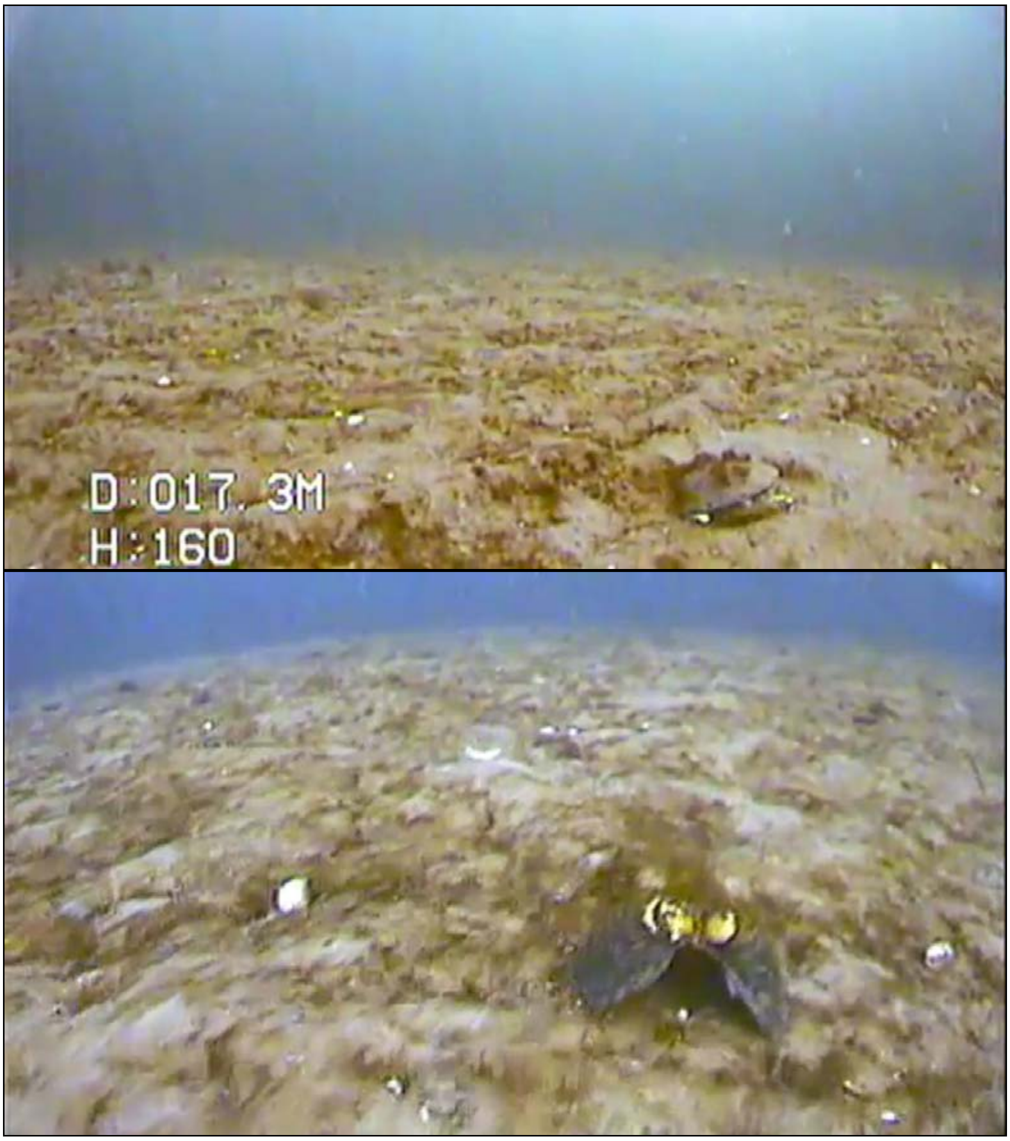

Figure 3.11: Two examples of ROV images showing a type 1 substrate with a single Ocean quahog (*Arctica islandica*) (AH15 and AH13)

3.2.4.2 Benthic community type associated with substrate type 2

This benthic community is dominated by fauna with a slightly larger number of species compared to substrate type 1.

The dominating species are again large mussels (Northern horsemussel *(Modiolus modiolus)* and Ocean quahog *(Arctica islandica)*, but with a larger number of other species scattered in the substrate category.

Species like Tealia anemone *(Tealia sp.)*, European edible sea urchin *(Echinus esculentus),* Green sea urchin *(Strongylocentrotus droebachiensis*), Pelican's foot *(Aporrhais pespelecani),* Spiny starfish *(Marthasterias glacialis),* Common sea star *(Asterias rubens),* Common whelk *(Buccinum undatum),* Dirty sea squirt *(Ascidiella aspersa),* Common sun star *(Crossaster papposus),* Plumose Anemone *(Metridium senile)* and Dead man's fingers *(Alcyonium digitatum)* can be found in this substrate category.

In association with the scattered stones, but especially on top of Northern horsemussel *(Modiolus modiolus)*, a small coverage of different macro algae was observed e.g. species like *Polysiphonia fibrillosa, Coccothylus truncatus* and Sea beech *(Phycodrys rubens).*

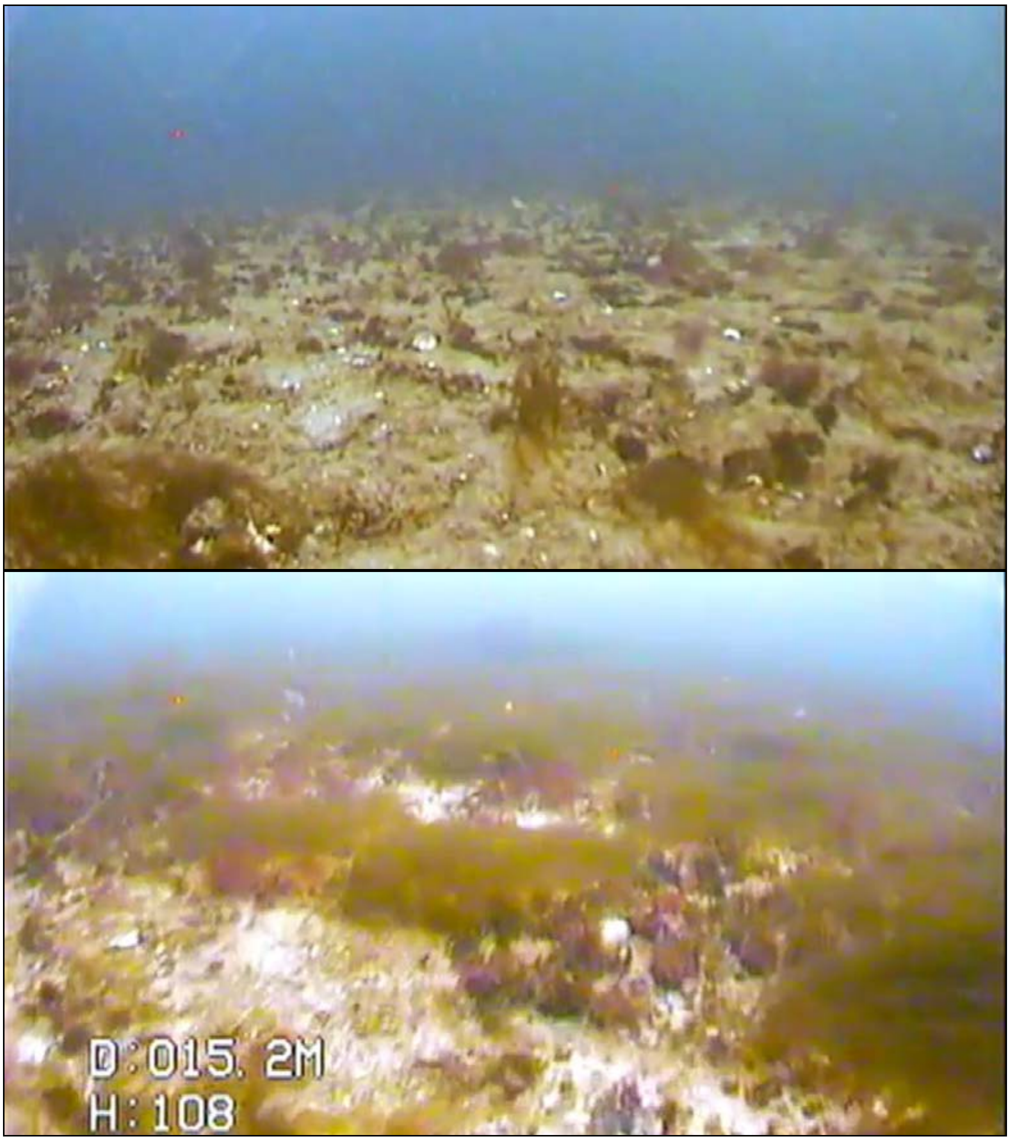

Figure 3.12: Two examples of ROV images showing a type 2 substrate with scattered Northern horsemussel (*Modiolus modiolus*) (AH38 and AH35)

3.2.4.3 **Benthic community type associated with substrate type 3**

This benthic community is dominated by fauna with a larger number of species and with a larger input of macro algae, especially in association with larger mussels, compared to substrate type 2.

The dominating species are Northern horsemussel *(Modiolus modiolus),* Sea cucumber *(Psolus phantapus),* Dead man's fingers *(Alcyonium digitatum),* European edible sea urchin *(Echinus esculentus)* and Green sea urchin *(Strongylocentrotus droebachiensis)*. Furthermore a large number of other species like Brittle stars (Ophiuroidea sp.), Pelican's foot *(Aporrhais pespelecani),* Spiny starfish *(Marthasterias glacialis),* Common sea star *(Asterias rubens),* Common sun star *(Crossaster papposus),* Tealia anemone *(Tealia sp.),* Keel worms *(Pomatoceros triqueter),* Common Heart Urchin *(Echinocardium cordatum),* Edible crab *(Cancer pagurus),* Dirty sea squirt *(Ascidiella aspersa)* and Sponge *(Porifera sp.)* was registered here.

In association with the stones, but especially on top of Northern horsemussel *(Modiolus modiolus)*, a small coverage of different macro algae can be observed e.g. species like *Polysiphonia fibrillosa, Coccothylus truncatus,* Sea beech *(Phycodrys rubens),* Dock-Leaved Delesseria *(Delesseria sanguinea)*, Soft Sour Weed *(Desmarestia viridis)* and Red Rags *(Dilsea carnosa).*

Figure 3.13: Two examples of ROV images showing a type 3 substrate with scattered Northern horsemussel (*Modiolus modiolus*) and Dead man's fingers (*Alcyonium digitatum*)(AH48 and AH53)

3.2.4.4 Benthic community type associated with substrate type 4

The benthic community is partly dominated by fauna with less species than in substrate type 3, and partly dominated by macro algae in association with larger mussels and stones.

The dominating species are Northern horsemussel *(Modiolus modiolus*), Sea cucumber *(Psolus phantapus)* and Dead man's fingers *(Alcyonium digitatum).* Furthermore a number of other species like Spiny starfish *(Marthasterias glacialis),* Common sea star *(Asterias rubens),* Dirty sea squirt *(Ascidiella aspersa),* Keel worms *(Pomatoceros triqueter),* Edible crab *(Cancer pagurus),* and Common hermit crab *(Eupagurus bernhardus)* was observed.

In association with the observed stones and on top of Northern horsemussel *(Modiolus modiolus)*, a small to moderate coverage of different macro algae can be observed e.g. species like *Polysiphonia fibrillosa, Coccotylus truncatus,* Sea beech *(Phycodrys rubens),* Dock-Leaved Delesseria *(Delesseria sanguinea),* Soft Sour Weed *(Desmarestia viridis),* Red Rags *(Dilsea carnosa)* and Dulse *(Palmaria palmata)*.

Figure 3.14: Two examples of ROV images showing a type 4 substrate with varied flora and fauna associated with stone reefs (AHbob2)

3.3 Impacts assessment

3.3.1 Methodology

The methodology used to assess the possible environmental impact on the marine benthic community types in relation to the construction of the planned Anholt Offshore Wind Farm in Kattegat, includes:

- Definition of the project area and the possible impact area
- Description of the different project activities and the associated sources of impacts that may affect the benthic marine community types
- Description of environmental parameters that could be affected by impact parameters form different project activities during construction and operation
- Description of criteria for categorising the environmental impacts
- Description of methods used for assessing specific impacts

The methodology and the criteria for the impact assessment are described in more details in / 4/.

To evaluate the possible impact in the project area from the planned 400 MW offshore wind farm, a worst case scenario will be used as a model. For possible impact on the benthic communities the worst case scenario is assessed to be the 174 pieces of 2.3 MW turbines placed on gravitation foundations – see also the method section under the baseline study and the detailed technical description in / 23/.

GBS structures rely on their mass including ballast to withstand the loads generated by the offshore environment and the wind turbine. The seabed needs most often to be prepared prior to installation, i.e. the top layer of material is removed and replaced by a stone bed. After the structure is placed on the seabed, the base is filled with a suitable ballast material, typically sand, which is likely to be obtained from an offshore source.

Table 3-1 indicates that the sediment works are much more comprehensive for the gravitation foundation than for the mono pile foundation. This is due to the amounts of foundation material to be laid out and the volumes of sediments to be removed from the sea floor.

The extension/propagation of the potentially sediment plumes are strongly dependent on the local current conditions at the time of construction. Sediment plumes generated from the gravitation foundation are assessed to be of larger dimensions than sediment plumes generated from the mono pile foundations / 24/.

Thus, if it is decided to use gravitation foundations and 2.3 MW turbines, it is assessed that a larger area of the sea bottom will be directly affected, mainly because a few meters of the top sediment has to be removed (in average app 2 meters, however large variations are foreseen, as soft ground are expected in various parts of the area, which means that potentially up to 4-8 meters has to be removed) but also because there will be some amount of sediment spill from the excavation / 14/.

Furthermore the scour protection will occupy space and change the substrate type from the original, to small "artificial stone reefs" with a size of app. 1500 m² per reef and a height above the seafloor of app. 1-2 metres.

Table 3-1 Example of the magnitude and duration of important work elements related to the construction of one foundation for each of the two types of foundations mentioned for Horns Rev 2 Offshore Wind Farm / 24/.

	Gravitation	***Mono-pile***
Material removed (m^3) Total	*106,000*	*16,000*
Foundation material (concrete) (m^3) Total	*102,000*	*15,000*
Sediment spill (m^3) Total	*4,000*	*1,000*
Duration per turbine of - Preparation - Installation - Scour protection	 *7 days* *6 hours* *4 days*	 *2 days* *4 hours* *2 days*
Stones and rocks used per turbine (m^3)	*500*	*100*

3.3.2 Sources of potential impacts in the project area

In the following section, the different sources of potential impacts on the marine benthic community types in the project area (144 km^2) will be described.

Table 3-2 shows the project activities and the sources of impacts during construction and operation of the Anholt Offshore Wind Farm, which may result in impacts on the marine benthic community types.

Table 3-2 Project activities during construction and operation of the planned off-shore wind park, sources of impacts and potential impacts on the marine benthic community types.

Project activity	**Source of potential impacts**	**Potential environmental impacts**
Construction		**Environmental parameter affected / target of impact**
Physical activity Seabed intervention works Gravitation foundations	Physical disturbance during construction Spread of sediment and sedimentation Substrate occupation – scour protection	Benthic communities including flora and fauna
Operation		
Wind park (seabed)	Occupation of area on seabed	Flora and fauna

3.3.3 Impacts during construction

In the project area, 4 different substrate types with associate flora and fauna were identified. Three of them; 1: Sand", 2: Sand, gravel and pebbles and 3: Sand, gravel, pebbles and scattered stones covering app. 1-25 %, are all dominated by sandy substrates and with an epi-fauna that comprise species adapted to some kind of sediment re-suspension, during winter storms etc and therefore not vulnerable to the amounts of sediment spill that can occur during the construction phase, if gravitation foundation is chosen / 3/ 7/ 11/ 18/.

The amount of sediment spilled during foundation construction is assessed to be limited / 14/. Modelling of a worst case scenario shows a sediment spill of app. 3 % which is a concentration of less than 5 mg/l and a total sedimentation rate of app. 0,25 m/m^2 within the project area.

In regard to the benthic community types associated with the three substrate types dominated by sand, only little impact is foreseen based on the low levels of re-suspended sediment in the water column.

During construction of Øresundsbroen the maximum sediment spill was not allowed to exceed 5 %. Monitoring results showed an overall sediment spill of 4 %. Results from Øresundsbroen, showed that even large sediment spills (thousands of m^3) over a long period of time, had no significant effect on the benthic communities / 11/ 12/.

However, there will be a minor effect on the benthic communities in the area directly occupied by the gravitation foundation, including scour protection / 2/ 8/ 9/ 11/ 12/. This area is minute (0,16 - 0,226 km^2) compared to the total project area off 88 km^2

and means that the directly affected area is app 0,002 – 0,0025 % of the total area / 19/ 21/.

The last identified substrate type; 4: Stones covering app. 25–100 % has the potentially most vulnerable benthic community type, macro algae and fauna associated to hard substrates.

This benthic community type was only identified in one very limited area within the project area (see **Error! Reference source not found.**), and in a water depth were sediment re-suspension normally occurs during annual winter storms.

Furthermore, the experience from projects were sediment spill occurs close to a stone reef, is that the associated benthic community, shows no sign of a negative impact / 3/.

In regard to the sediment spill that will occur during the construction phase, it is worth considering that parts of the construction area and neighbouring areas are already subject to fishery with bottom trawl. This type of fishery is proved to re-suspend large amounts of sediment with concentrations of suspended material up to 100-550 mg/l in a distance up to 50 meters of the trawl / 13/. The amount of sediment spill during construction of each gravitation foundation will be in the order of up to 5 mg/l in a limited area, and will only last for app. 3 days per foundation.

The benthic communities associated with hard substrates are assessed to benefit from the construction of 174 turbines with scour protection comprising of stones in variable sizes. Furthermore, the large amount of small artificial stone reefs can serve as substrate for macro algae. In Horns Rev I, there were introduced scour protections onto seabed's that almost exclusively consisted of sandy sediments. This increased habitat heterogeneity and changed the benthic communities witch gave an increase in biomass of op to 150 times. Furthermore the species diversity increased / 19/ 21/ 25/ 27/.

In Table 3-3, an evaluation of the overall impact, on the marine benthic community types in the project area during construction phase, is presented.

Table 3-3 Overall impact on the marine benthic community types in the construction phase of the project.

Impact	Intensity of effect	Scale/geographical extent of effect	Duration of effect	Overall significance of impact
Physical disturbance during construction phase	Minor	Local	Short-term	No
Sediment spreading and sedimentation	Minor	Local	Short-term	No/Minor
Occupation of seabed and changes in bathymetry	Minor	Local	Long-term	Minor

3.3.4 Impacts during operation

During operation there will be no direct impacts on the different marine benthic community types in the project area.

However, it has been documented from the different monitoring programmes conducted at Horns Rev I and Nysted Offshore Wind Farm that the introduction of hard substrate results in an increased number of flora and fauna species associated with the artificial stone reefs (scour protections) around each off-shore wind turbine. Especially because the scour protection will have cave forming elements, which, as it was observed at Horns Rev I, can be inhabited by a number of crayfish species such as large crabs and lobsters / 25/ 27/.

In Table 3-4, an evaluation of the overall impact, on the marine benthic community types in the project area during operation phase, is presented.

Table 3-4 Overall impact on the marine benthic community types in the operation phase of the project.

Impact	Intensity of effect	Scale/geographical extent of effect	Duration of effect	Overall significance of impact
Physical disturbance during operation phase	No	Local	Short-term	No
Sediment spreading and sedimentation	No	Local	Short-term	No
Occupation of seabed and changes in bathymetry	Minor	Local	Long-term	Minor

3.4 Mitigation measures

The overall impact on the identified marine benthic community types in the project area is very limited, which means that no special mitigation measures are evaluated to be necessary.

3.5 Cumulative effects

It is assessed that there are no cumulative effects on the marine benthic community types from the construction or operation of Anholt Offshore Wind Farm and other 3. part projects.

3.6 Decommissioning

Potential impacts on benthic communities and substrate types in the area envisaged during decommissioning are similar to some of the impacts expected during construction, depending on the activities of foundation removal.

The objectives of the decommissioning process are to minimize both the short and long term effects on the environment whilst making the sea safe for others to navigate. These obligations are stipulated in the United Nations Convention of the Law of the Sea (UNCLOS).

There are no specific international regulations or guidelines on the decommissioning of offshore installations. Decommissioning will have to consider individual circumstances, such as comparative decommissioning options, removal or partial removal in a way that causes no significant adverse effects on the environment, the likely deterioration of the material involved, possibilities for re-use or recycling as well as its present and future effect on the marine environment.

Based on current available technology, today's practice for decommissioning would imply to remove the wind turbines completely and to remove all other structures and substructures to the natural seabed level. Infield and export cables would be removed, left safely in-situ, buried to below the natural seabed level or protected by rock placement depending on the hydrodynamic conditions. Scour protection would be left in-situ.

The wind turbines, structures and cables would be dismantled using similar craft and methods as deployed during the construction phase. However the operations would be carried out in reverse order. The recovered materials would be transported to shore for later material reuse, recycle or disposal.

The decommissioning programme will be developed during the operations phase, as regulatory controls and industry practices most likely will have changed in 25 years' time, when the wind farm will be decommissioned. Regardless of decommissioning method, decommissioning will comply with all applicable legal requirements regarding decommissioning at that time.

3.7 Technical deficiencies or lack of knowledge

The project area has been covered 100 % by side scan sonar, and so has the two possible cable corridors.

All unidentified objects have been visually verified.

The 4 different substrate types have been verified with a sufficient number of spot dives, ROV dives and paravane dives.

The conclusion is that this report is elaborated without any technical deficiencies or lack of knowledge.

4. Transformer platform and offshore cable

4.1 Project description

An offshore transformer platform will be established to bundle the electricity produced at the wind farm and to convert the voltage from 33 kilovolts to a transmission voltage of 220 kilovolts to fit the national power grid.

4.1.1 Transformer platform

Energinet.dk will build and own the transformer platform together with the high voltage cable which runs from the transformer platform to the shore and further on to the existing substation Trige, where it is connected to the existing transmission network via 220/440 kV transformer.

The transformer platform will be placed on a location with a sea depth of 12-14 metres. The length of the export cable from the transformer station to the shore of Djursland will be approximately 25 km. On the platform the equipment is placed inside a building. In the building there will be a cable deck, two decks for technical equipment and facilities for emergency residence.

The platform will have a design basis of up to 60 by 60 metres. The top of the platform will be up to 25 metres above sea level. The foundation for the platform will be a floating caisson, concrete gravitation base or a steel jacket.

4.1.2 Subsea Cabling

The wind turbines will be connected by 33 kV submarine cables, so-called inter-array cables. The inter-array cables will connect the wind turbines in groups to the transformer platform. There will be up to 20 cable connections from the platform to the wind turbines. From the transformer platform a 220 kV export cable is laid to the shore at Saltbæk north of Grenå. The cables will be PEX insulated or similar with armouring.

Installation of cables will be carried out by a specialist cable vessel that will manoeuvre either by use of a four or eight point moving system or by fully or assisted Dynamically Positioned (DP) operation.

All subsea cables will be buried in order to provide protection from fishing activity, dragging of anchors etc. A burial depth of minimum one meter is expected but the final depth will be decided based on the specific soil conditions and the equipment selected.

The cables will be buried either using an underwater cable plough that executes a simultaneous lay and burial technique that mobilises very little sediment or by the use of a Remotely Operated Vehicle (ROV) that utilises high-pressure water jets to fluidise a narrow trench into which the cable is located. The jetted sediments will settle back into the trench.

4.1.3 Onshore components

At sea the submarine cable is laid from a vessel with a large turn table. Close to the coast, where the depth is inadequate for the vessel, floaters are mounted onto the cable and the cable end is pulled onto the shore. The submarine cable is connected to the land cable close to the coast line via a cable joint. Afterwards the cables and the cable joint are buried into the soil and the surface is re-established.

On shore, the land cable connection runs from the coast to compensation substation 2-3 km from the coast and further on to the substation Trige near Århus. At the substation Trige, a new 220/400 kV transformer, compensation coils and associated switchgear will be installed. The onshore works are not part of the scope of the Environmental Statement for the Anholt Offshore Wind Farm. The onshore works will be assessed in a separate study and are therefore not further discussed in this document.

4.2 Baseline study

4.2.1 Methods

To verify the distribution and patterns of the different marine benthic community types in the two cable corridors, a series of different methods was used. For further details see section 3.2.1.

4.2.2 Field survey

4.2.2.1 Geophysical survey

The geophysical survey was conducted by GEUS in April 2009. The project area and the two cable corridors were surveyed with side scan sonar covering 100 % of the bottom (see

Figure 4-1, large map can be seen in appendix 2).

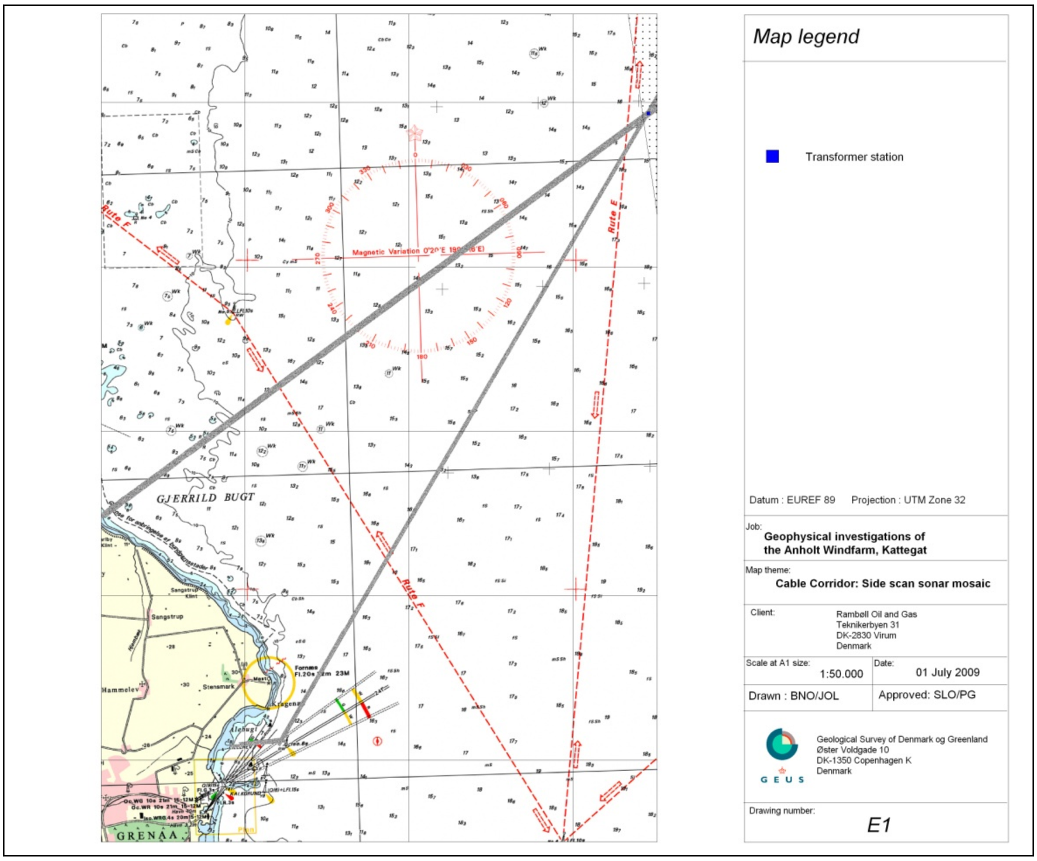

Figure 4-1: Side scan mosaic from the two cable corridors

The side scan sonar shows an image of the bottom surface which can be interpreted. To get a better understanding of the bottom structure, two different types of seismic equipment was used; a chirp, which penetrates the uppermost layers (few meters), and a boomer, which penetrates deeper into the bottom (several meters). For further details regarding the geophysical survey with descriptions of the different equipment used during the geophysical survey and how the survey was conducted see / 1/.

The first output of the geophysical survey is a side scan mosaic of the entire project area. This mosaic gives a first idea of what kind of substrate types that are found in the project area and what their distribution is.

The side scan mosaic (see

Figure 4-1) was used directly to point out small specific spots for visual verification.

4.2.2.2 Visual verification survey with verification of substrates and registration of marine benthic community types

The visual verification along the two possible cable corridors was carried out in May 2009, with a combination of different methods which is described in section 3.2.2.4 and 3.2.2.5.

All verification spots (see

Figure 4-2) were pointed out on the base of the side scan mosaic (see

Figure 4-1).

4.2.2.3 Spot diving

See section 3.2.2.4.

4.2.2.4 ROV diving

See section 3.2.2.5.

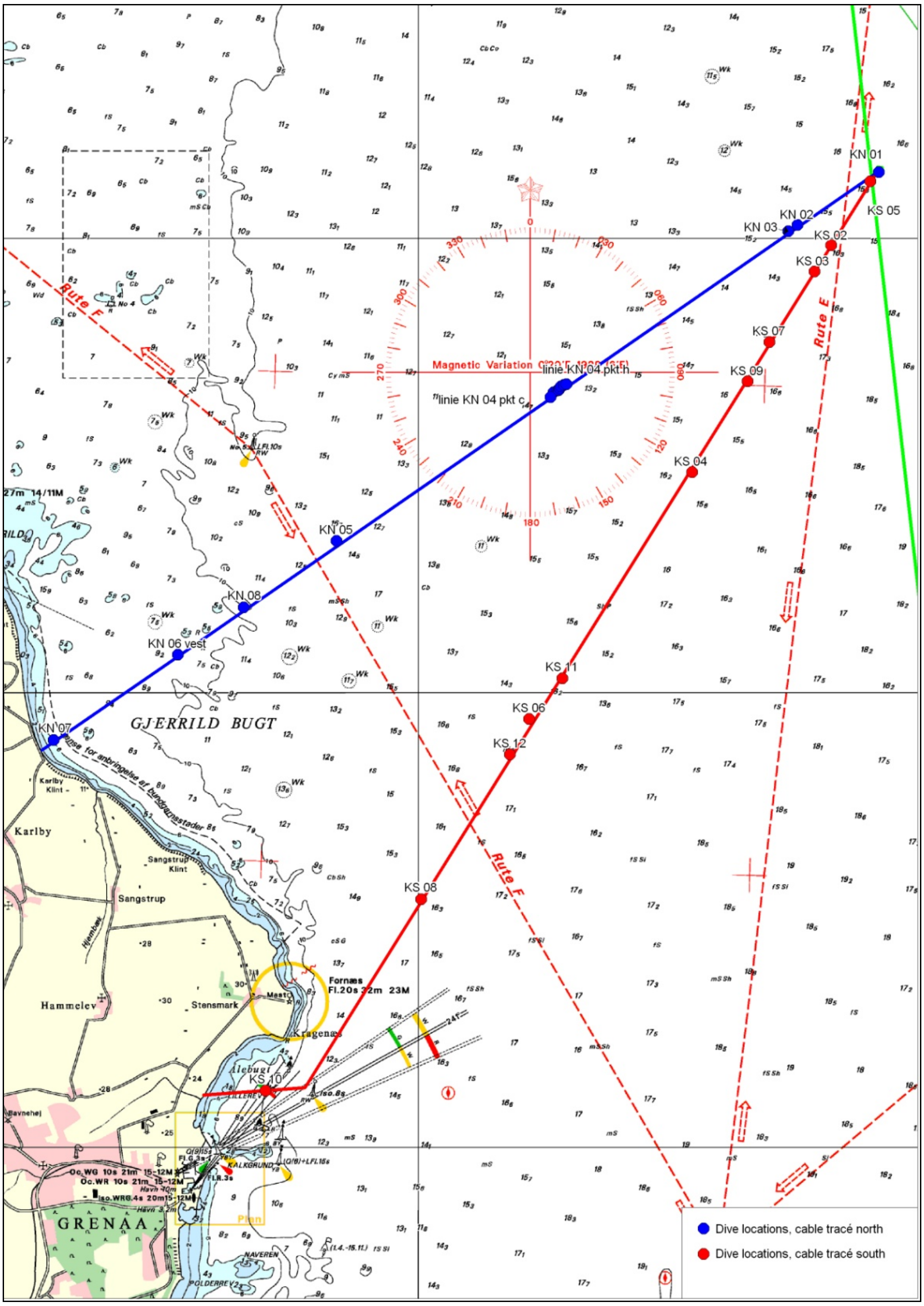

Figure 4-2: Map showing the two possible cable corridors (northern cable corridor is the blue line and southern cable corridor is the red line). Visual verification points along the northern cable corridor are blue spots and visual verification points along the southern cable corridor are red spots.

4.2.3 Benthic substrate types in the two cable corridors

The northern cable corridor is app. 21 km long. The corridor was geophysical surveyed with side scan sonar covering 100 % of the bottom. To verify the geophysical “image” of the bottom and map the different benthic community types, 11 visual verifications were conducted along the corridor (see

Figure 4-2).

The southern cable corridor is app. 24 km long. The corridor was geophysical surveyed with side scan sonar covering 100 % of the bottom. To verify the geophysical "image" of the bottom and map the different benthic community types, 15 visual verifications was conducted along the corridor (see

Figure 4-2).

From the experiences from the project area and the results of the visual verifications, it was made clear that the two cable corridors, as well as the project area, are relatively homogenous regarding substrate types. It was therefore decided to continue with the same 4 dominating substrate types in the two cable corridors as in the project area.

The dominating bottom substrate of the two cable corridors, is sand with scattered larger stones with areas where gravel and pebbles dominates. In the innermost part of the corridors (a few hundreds meters from the shore) the bottom is dominated by stones in the northern corridor and by lime stone in the southern corridor. The depth in the two cable corridors varies between app. 6-20 meters.

The 4 benthic substrate types in the two cable corridors are defined as follows (see also Figure 4-3, large map can bee seen in appendix 2):

- Type 1: Sand: areas comprising primarily of sandy substrates with variable amounts of ribbons etc.

- Type 2: Sand, gravel and pebbles: areas comprising primarily of sand with variable amounts of gravel and pebbles, and with a few scattered stones

- Type 3: Sand, gravel, pebbles and scattered stones covering app. 1-25 %: areas comprising of mixed substrates with sand, gravel and pebbles as dominating, but with variable amounts of larger stones

- Type 4: Stones covering app. 25–100 %: areas dominated by larger stones (stone reefs) but with variable amounts sand, gravel and pebbles. In this category, limestone is included as the innermost part of the southern cable corridor was solid limestone.

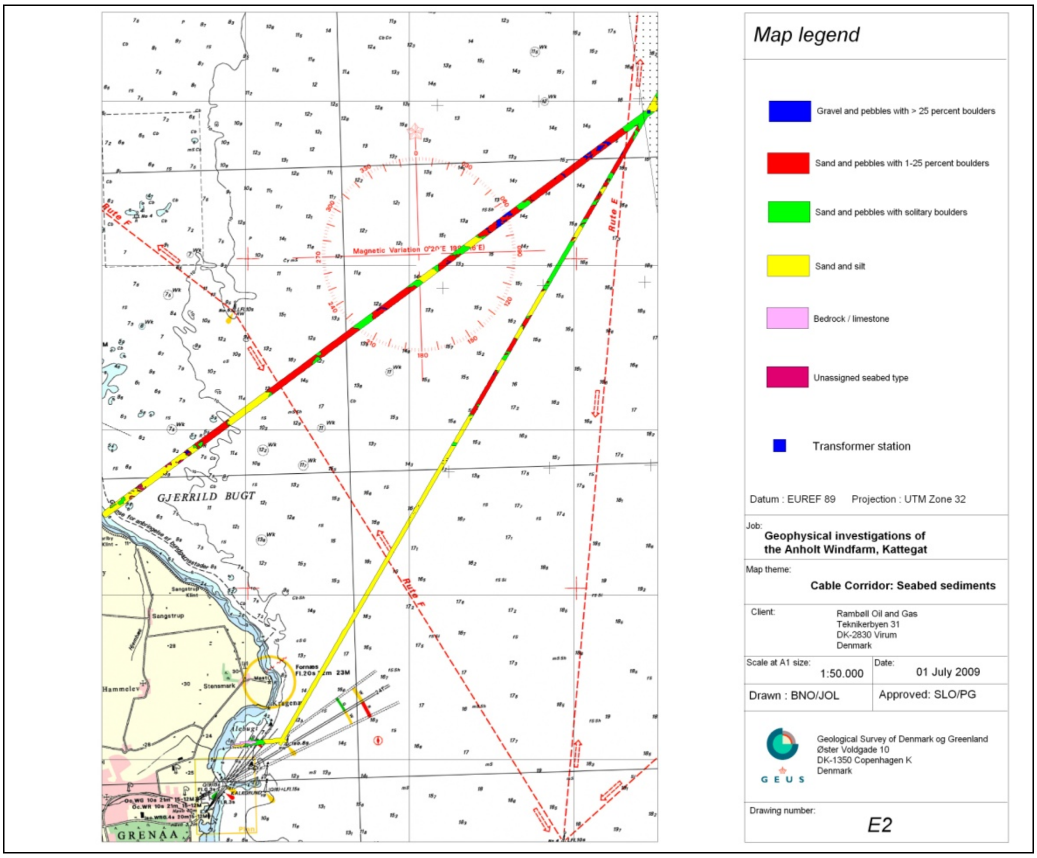

Figure 4-3: Final benthic substrate map, showing the area and distribution patterns of the 4 final substrate types defined in the two cable corridors

The two substrate types: 1 and 4 were the easiest to identify and differentiate.

The two substrate types 2 and 3 were more difficult to differentiate, but from side scan images, larger stones could easily be identified.

In the following section, the different substrate types along the two cable corridors will be exemplified with side scan images of the 4 categories.

4.2.3.1 Substrate type 1: Sand

For further descriptions see section 3.2.3.1.

4.2.3.2 Substrate type 2: Sand, gravel and pebbles

For further descriptions see section 3.2.3.2.

4.2.3.3 Substrate type 3: Sand, gravel, pebbles and scattered stones covering app. 1-25 %

For further descriptions see section 3.2.3.3.

4.2.3.4 Substrate type 4: Stones covering app. 25–100 %

For further descriptions see section 3.2.3.4.

In this category solid limestone is included. It has the same “image” as a stone reef, and the same marine benthic community as stone reefs.

4.2.4 Marine benthic community types in the two cable corridors

The second goal of the visual verifications was to identify and map the different flora and fauna communities associated with the substrate types in the project area.

The four different benthic substrate types in the project area have been verified with 27 visual verification points.

The flora and fauna of the benthic communities associated with substrate type 1 and 4 were the easiest to identify.

Substrate type 1 was dominated by fauna and was the one with the smallest number of species and also the smallest number of individuals per species.

Substrate type 4 was dominated by flora with a variety of different macro algae and with a relatively high coverage of these algae.

The biological communities associated with substrate types 2 and 3 were harder to differentiate, but type 2 is mainly dominated by fauna, with a large number of species and also a large number of individuals per species.

Substrate type 3 has the largest number of fauna species and number of individuals per species identified in any of the substrate types. On top of that it has a variety of macro algae species, though not as many species and as high coverage as substrate type “Stone reef” (lime stone).

In association with the 4 substrate types there are different marine benthic flora and fauna communities. Part of the verification is to get an overview of these different communities (marine benthic community types) and map them on a marine benthic community map – see

Figure 4-4.

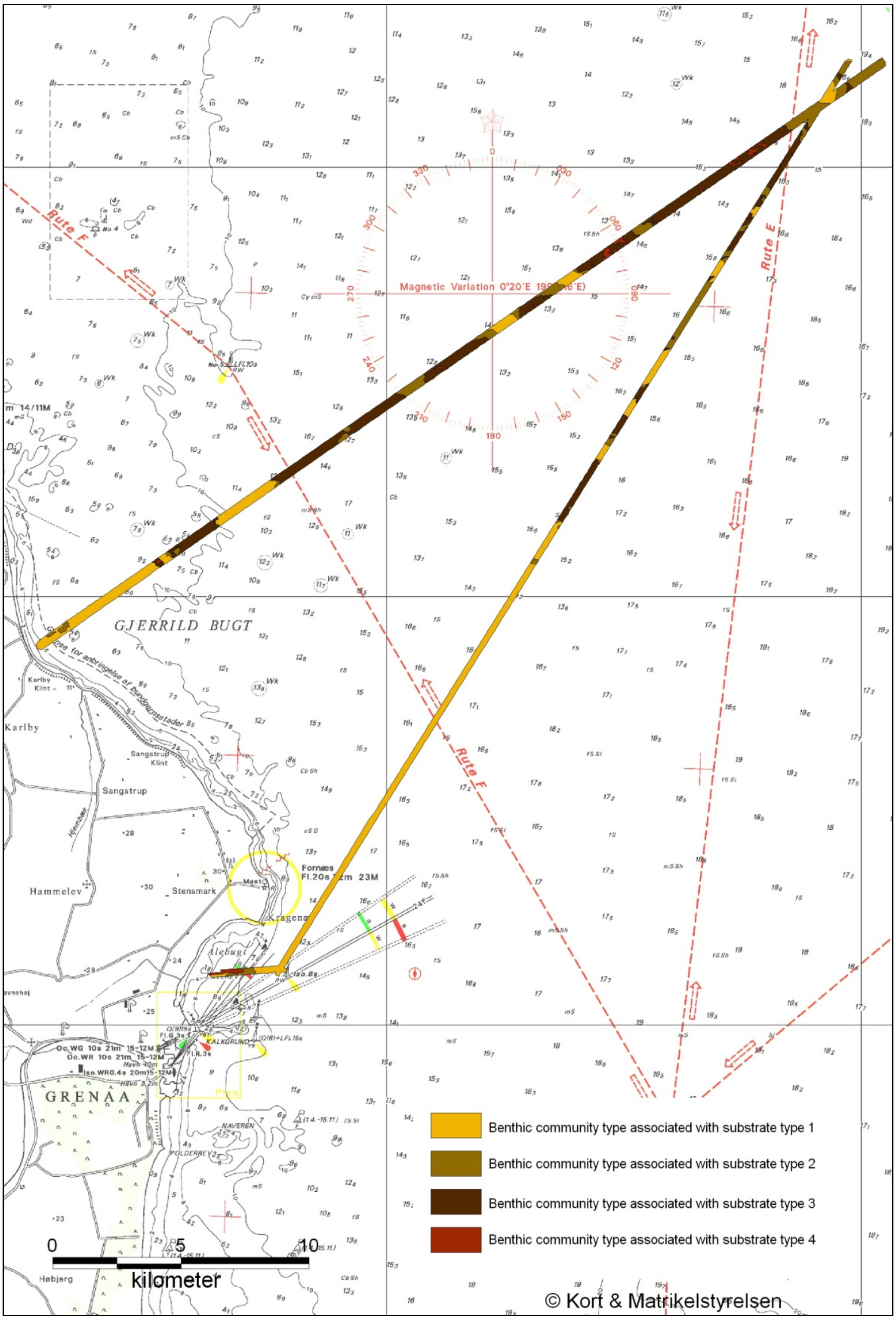

Figure 4-4: Benthic community map showing the 4 different benthic community types in the surveyed cable corridors.

4.2.4.1 Benthic community type associated with substrate type 1

This benthic community is dominated by fauna with a limited number of species.

The dominating species are large mussels (Northern horsemussel *(Modiolus modiolus*) and Ocean quahog *(Arctica islandica*) and with scattered observations of Spiny starfish *(Marthasterias glacialis)* and Common sea star *(Asterias rubens).*

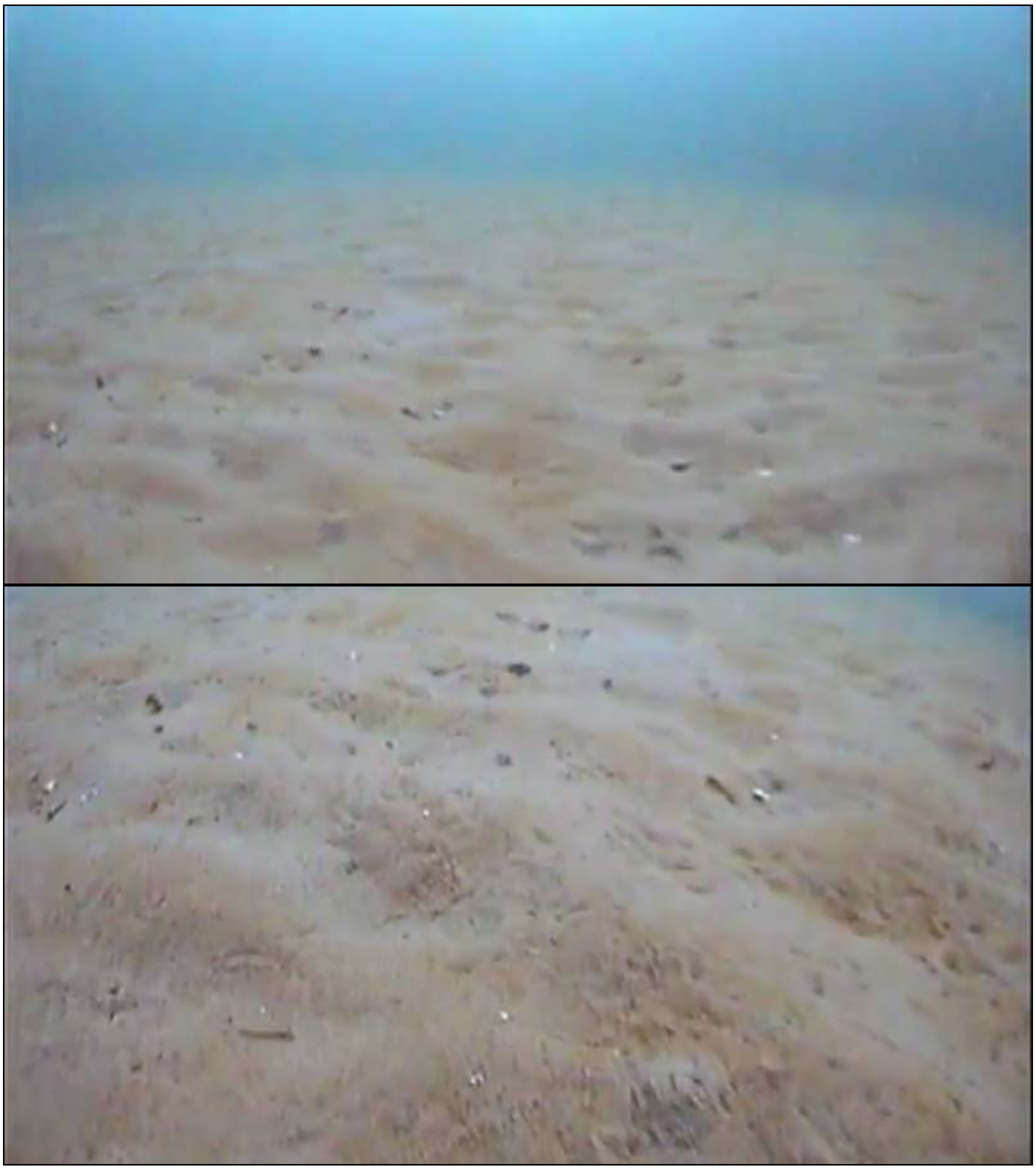

Figure 4-5: Two examples of images showing a type 1 substrate with siphons from Ocean quahog (*Arctica islandica*), (KN08).

4.2.4.2 **Benthic community type associated with substrate type 2**

This benthic community is dominated by fauna, and with a slightly larger number of species compared to substrate type 1.

The dominating species are large mussels Northern horsemussel (*Modiolus modiolus*) and Ocean quahog (*Arctica islandica*) with a larger number of other associated species scattered in the substrate category.

Species like Tealia anemone (*Tealia sp*.), European edible sea urchin (*Echinus esculentus*), Green sea urchin (*Strongylocentrotus droebachiensis*), Pelican's foot (*Aporrhais pespelecani*), Spiny starfish (*Marthasterias glacialis*), Common sea star (*Asterias rubens*), Common whelk (*Buccinum undatum*), Dirty sea squirt (*Ascidiella aspersa*), Common sun star (*Crossaster papposus*), Plumose Anemone (*Metridium senile*) and Dead man's fingers (*Alcyonium digitatum*) can be found in this substrate category. In association with the scattered stones, but especially on top of Northern horsemussel (*Modiolus modiolus*), a small coverage of different macro algae can be observed e.g. species like *Polysiphonia fibrillosa, Coccothylus truncatus* and Sea beech *(Phycodrys rubens)*

Figure 4-6: Two examples of images showing a type 2 substrate with scattered European edible sea urchin (*Echinus esculentus*), Green sea urchin (*Strongylocentrotus droebachiensis*), and Dead man's fingers (*Alcyonium digitatum*) (KS05)

4.2.4.3 **Benthic community type associated with substrate type 3**

This benthic community is dominated by a high number of fauna species and with a larger input of macro algae (especially in association with larger mussels).

The dominating species are Northern horsemussel *(Modiolus modiolus)*, Sea cucumber *(Psolus phantapus)*, Dead man's fingers *(Alcyonium digitatum)*, European edible sea urchin *(Echinus esculentus)* and Green sea urchin *(Strongylocentrotus droebachiensis)*. Furthermore a large number of other species like Brittle stars *(Ophiuroidea sp.)*, Pelican's foot *(Aporrhais pespelecani)*, Spiny starfish *(Marthasterias glacialis)*, Common sea star *(Asterias rubens)*, Common sun star *(Crossaster papposus)*, Tealia anemone *(Tealia sp.)*, Keel worms *(Pomatoceros triqueter)*, Common Heart Urchin *(Echinocardium cordatum)*, Edible crab *(Cancer pagurus)*, Dirty sea squirt *(Ascidiella aspersa)* and Sponge *(Porifera sp.)* can be found here.

In association with the stones, but especially on top of Northern horsemussel (*Modiolus modiolus*), a small cover of different macro algae can be observed with species like *Polysiphonia fibrillosa*, *Coccothylus truncatus*, Sea beech *(Phycodrys rubens)*, Dock-Leaved Delesseria *(Delesseria sanguinea)*, Soft Sour Weed *(Desmarestia viridis)*, Red Rags *(Dilsea carnosa)* and Dulse *(Palmaria palmata)*.

Figure 4-7: Two examples of images showing a type 3 substrate with larger stones with European edible sea urchin (*Echinus esculentus*), Green sea urchin (*Strongylocentrotus droebachiensis*) and different algae (KN03).

4.2.4.4 Benthic community type associated with substrate type 4

The benthic community is partly dominated by fauna, with less species than in substrate type 3, but primarily dominated by macro algae in association with larger stones or the solid limestone bottom.

In association with stones and limestone, a high coverage of different macro algae can be observed. The macro algae community was dominated by perennial species such Oarweed (*Laminaria digitata*), Sea Belt *(Laminaria saccharina),* Sea oak *(Halidrys siliquosa),* Dock-Leaved Delesseria *(Delesseria sanguinea),* Sea beech *(Phycodrys rubens), Coccothylus truncatus,* plus a number of other (annual) species like *Polysiphonia fibrillosa,* Red Rags *(Dilsea carnosa),* Landladys wig *(Ahnfeltia plicata),* Banded weeds *(Ceramium rubrum)* and Brushy Red Weed *(Cystoclonium purpureum).*

The dominating fauna species were Northern horsemussel *(Modiolus modiolus*), Dead man's fingers *(Alcyonium digitatum),* European edible sea urchin (*Echinus esculentus)* and Green sea urchin *(Strongylocentrotus droebachiensis)*. Furthermore a number of other species e.g. Spiny starfish *(Marthasterias glacialis),* Common sea star *(Asterias rubens),* Common whelk *(Buccinum undatum)*, Common hermit crab *(Eupagurus bernhardus)*, Tealia anemone *(Tealia sp.),* Keel worms *(Pomatoceros triqueter),* Barnacle *(Cirripedia sp.)* and Sponge *(Porifera sp.)*

Figure 4-8: Two examples of images showing a type 4 substrate with a broad variety of algae (KN06 and KS10)

In the following the results of the geophysical and visual verification surveys in the two cable corridors will be discussed.

4.3 Impacts assessment

The methodology used to assess the possible environmental impacts associated with the planned high voltage cable running from the transformer platform to the shore, either at Gjerrild Strand (the northern cable corridor) or at Saltbæk, north of Grenå (Grenå Nord) (the southern cable corridor), in regard to the marine benthic community types, will include:

- Definition of the project area and the possible impact area
- Description of the different project activities and the associated sources of impacts that may affect the benthic marine community types
- Description of environmental parameters that could be affected by impact parameters from different project activities during construction and operation
- Description of criteria for categorising the environmental impacts
- Description of methods used for assessing specific impacts

The methodology and the criteria for the impact assessment are more detailed described in / 4/.

To evaluate the possible impacts from the high voltage cable running from the transformer platform to the shore, a worst case scenario will be used as a model. This means a scenario where the cable is trenched or dredged all the way instead of placed directly on the seabed.

The impacts from this scenario will include some amount of sediment spreading and direct disturbance of the bottom, during construction.

Table 4-1 shows the project activities and the sources of impacts during construction, operation and decommissioning of the planned cable corridors from the transformer platform to the shore of Djursland, which may result in impacts on the marine benthic community types.

Table 4-1 Project activities during construction and operation of the planned cable corridors, sources of impacts and potential impacts on the marine benthic community types

Project activity	Source of potential impacts	Potential environmental impacts
Construction		**Environmental parameter affected / target of impact**
Physical activity Seabed intervention works	Physical disturbance during construction Sediment spreading and sedimentation	Benthic communities including flora and fauna
Operation		
Transformer platform	Occupation of area on seabed	Flora and fauna

4.3.1 Impacts during construction

In the two cable corridors, 4 different substrate types with associate flora and fauna were identified. The three of them; 1: Sand, 2: Sand, gravel and pebbles and 3: Sand, gravel, pebbles and scattered stones covering app. 1-25 % are all dominated by sandy substrates and with an epi-fauna that comprises of species adapted to some kind of re-suspension of the sediment, during winter storms etc / 3/ 7/ 11/ 18/.

The amount of sediment suspended during construction is limited / 14/ 26/.

In regard to the benthic community types associated with the three substrate types dominated by sand, little impact from re-suspension and sedimentation of finer sediments will occur. It was observed at Horns Rev I that the species associated with sandy substrates are well adapted to re-suspension of sediment and can even withstand burying / 9/ 10/ 13/ 27/.

The last identified substrate type; 4: Stones covering app. 25–100 % and limestone has the potentially most vulnerable benthic community type, macro algae and fauna associated to hard substrates.

This benthic community type was identified in two geographical limited areas in the northern cable corridor close to the shore at a depth of app. 6-9 meters and shallower. In the southern cable corridor, the substrate in the innermost part, closest to the shore, comprises of limestone at depth at app. 8 meters and shallower.

Dredging through this area is likely, and minor impact on the marine benthic communities closest to the operations in the cable corridor must be anticipated.

In a number of investigations, in regard to excavation of raw materials in inner Danish waters and in the North Sea, it has been observed that the benthic communities in association with stone reefs within a distance of less than 100 meters to the excavation, comprises of the same species and same abundance as benthic communities outside the safety zone from the excavation / 3/ 16/.

Furthermore, the amount of sediment spilled during excavation of raw materials is of a much larger magnitude than when a cable is trenched into the seabed.

The overall impact will therefore be limited and reversible / 5/ 6/ 2/ 16/.

If the northern cable corridor is chosen, there will be some disturbance of the benthic community, but it will not be irreversible. After a year or two, the macro algae etc. will be restored.

If the southern cable corridor is chosen, a limited area of the limestone formations will be affected in a way that is not reversible. However, the benthic communities will not be irreversible affected. The benthic community is assessed to be disturbed during the construction phase only, and a complete restoration of the communities is foreseen after only a year or two following the conclusion of the cable corridor.

Table 4-2 presents an evaluation of the overall impact, on the marine benthic community types in the two cable corridors during construction phase.

Table 4-2 Overall impact on the marine benthic community types in the two cable corridors during construction phase.

Impact	Intensity of effect	Scale/geographical extent of effect	Duration of effect	Overall significance of impact
Physical disturbance during construction phase	Minor	Local	Short-term / long-term	No/Minor
Spread of sediment and sedimentation	Minor	Local	Short-term	No/Minor
Occupation of seabed	Minor	Local	Short-term	Minor

4.3.2 Impacts during operation

It is assessed, that the disturbed parts following the construction phase will be recolonized within a year or two.

This means that during operation there will be no impacts on the different marine benthic community types in the cable corridor chosen / 5/ 6/.

Table 4-3 presents an assessment of the overall impact, on the marine benthic community types in the cable corridors during operation phase.

Table 4-3 Overall impact on the marine benthic community types in the cable corridor during operation phase.

Impact	Intensity of effect	Scale/geographical extent of effect	Duration of effect	Overall significance of impact
Physical disturbance during operation phase	No	Local	Short-term	No
Sediment spreading and sedimentation	No	Local	Short-term	No
Occupation of seabed	No	Local	Long-term	No

4.4 Mitigation measures

The overall impact on the identified marine benthic community types in the two cable corridors is very limited, which means that no special mitigation measures are evaluated to be necessary.

4.5 Cumulative effects

It is assessed that there are no cumulative effects from the construction or operation of Anholt Offshore Wind Farm, and other 3.part projects, on the marine benthic community types identified in the cable corridors.

4.6 Decommissioning

For further details see section 3.6.

4.7 Technical deficiencies or lack of knowledge

For further details see section 3.7.

5. Conclusion

In the Anholt Offshore Wind Farm project area, the dominating substrate types are sandy substrates with a variable amount of gravel, pebble and scattered stones. Only in one smaller location was a small solitary stone reef observed.

The benthic communities associated with the three different substrate types: **Type 1: Sand:** areas comprising primarily of sandy substrates with variable amounts of ribbons etc**.**, **Type 2: Sand, gravel and pebble:** areas comprising primarily of sand with variable amounts of gravel and pebble, and with a few scattered stones, **Type 3: Sand, gravel, pebble and scattered stones covering app. 1-25 %:** areas comprising of mixed substrates with sand, gravel and pebble as dominating, but with variable amounts of larger stones, are mainly dominated by species such as Northern horsemussel *(Modiolus modiolus),* Sea cucumber *(Psolus phantapus),* Dead man's fingers *(Alcyonium digitatum),* European edible sea urchin *(Echinus esculentus)* and Green sea urchin *(Strongylocentrotus droebachiensis)* along with a number of other species which were observed in a variable amount in the sandy substrate types.

Substrate **Type 4: Stones covering app. 25–100 %:** areas dominated by larger stones (stone reefs) but with variable amounts sand, gravel and pebble, were inhabited by two different benthic communities: Species associated with the hard substratum and species associated with the sandy substrates.

The hard substrates was partly dominated by macro algae with perennial species like Oarweed (*Laminaria digitata*), Sea Belt *(Laminaria saccharina),* Sea oak *(Halidrys siliquosa),* Dock-Leaved Delesseria *(Delesseria sanguinea),* Sea beech *(Phycodrys rubens), Coccothylus truncatus,* plus a number of other species, like *Polysiphonia fibrillosa,* Red Rags *(Dilsea carnosa),* Landladys wig *(Ahnfeltia plicata),* Banded weeds *(Ceramium rubrum)* and Brushy Red Weed *(Cystoclonium purpureum)*, and partly dominated by fauna species like Dead man's fingers *(Alcyonium digitatum),* European edible sea urchin (*Echinus esculentus)* and Green sea urchin *(Strongylocentrotus droebachiensis),* Tealia anemone *(Tealia sp.),* Keel worms *(Pomatoceros triqueter),* Barnacle *(Cirripedia sp.)* and Sponge *(Porifera sp.).*

The sandy substrates also included in substrate type 4 were dominated by fauna species like Northern horsemussel *(Modiolus modiolus*) and Sea cucumber *(Psolus phantapus)* plus a number of other species.

The loss of sandy substrates caused by the wind mill foundations and scour protections will be insignificant (app 0,0025 % of the total project area of 88 km²). As shown in studies conducted in relation to other large offshore wind farms such as Horns Rev I and Nysted, the loss of benthic fauna caused by the construction is insignificant both regarding number of species and biomass.

The introduction of hard substrates (scour protections) has instead proven to have a positive effect on the benthic environment, with an increased number of species and biomass as a consequence.

The impact from the construction of the high voltage cable, planned from the substation to shore, is limited to an insignificant sediment spill close to the cable corridor during the short construction phase.

Table 5-1 Summary of the different project activities in the project area and the cable corridor, and there potential impact on the different marine benthic community types

Impacts	**Overall significance of impact**	**Quality of available data**
Impacts on the benthic community types		
Physical disturbance during construction phase	Minor impact	3
Physical disturbance during operation phase	No impact	3
Sediment spreading and sedimentation during construction phase	Minor impact	3
Sediment spreading and sedimentation during operation phase	No impact	3
Occupation of seabed during construction phase	Minor impact	3
Occupation of seabed during operation phase	Minor impact	3

Table 5-2 Principles for the evaluation of potential impact. The significance rating of the assessed impact and the quality of data/documentation (from the memo describing “Method for Impact Assessment (May 2009)”.

<table>
<tr><td colspan="2">Significance rating of data and knowledge for assessment
In order to evaluate the quality and significance of data and documentation for the impact assessment a significance rating of data and documentation should be evaluated within the specific technical subject topics using the following categories:

• 1 – Limited (scattered data, some knowledge)
• 2 – Sufficient (scattered data, field studies, documented)
• 3 – Good (time series, field studies, well documented)

In this memo, an impact arising from a planned activity will, depending on its magnitude and the environmental sensitivity, be given a significance rating as follows:</td></tr>
<tr><td>: No impact</td><td>No impact: There will be no impact on structure or function in the affected area;</td></tr>
<tr><td>: Minor impact</td><td>Minor impact: The structure or functions in the area will be partially affected, but there will be no impacts outside the affected area;</td></tr>
<tr><td>: Moderate Impact</td><td>Moderate Impact: The structure or function in the area will change, but there will be no significant impacts outside the affected area;</td></tr>
<tr><td>: Significant impact</td><td>Significant impact: The structure or function in the area will change, and the impact will have effects outside the area as well;</td></tr>
<tr><td colspan="2">Generally, projects can also result in positive impacts. Positive impacts are suggested to be shown with a “+” in the comprehensive tables for the predicted impacts.</td></tr>
</table>

6. References

/ 1 GEUS 2009, Anholt off shore windfarm, Marine geophysical investigations

/ 2 Orbicon 2009, konsekvensvurdering af råstofindvinding, Lille Lysegrund

/ 3 Orbicon 2008, VVM undersøgelse i relation til råstofindvinding på Jyske Rev

/ 4 Energinet.dk 2009, Anholt Offshore Wind Farm, Method for impact assessment, Rambøll

/ 5 Orbicon 2006, Konsekvensvurdering ifm. etablering af et søkabel fra Romsø til Fyn, igennem Natura 2000 område

/ 6 Orbicon 2008, Konsekvensvurdering ifm. etablering af et søkabel fra forsøgsmølleparken ved Hirsholmene til Frederikshavn, igennem natura 2000 område

/ 7 Lisberg, D., Petersen, J.K. Og Dahl, K. 2002. Biologiske effekter af råstofindvinding på epifauna. Danmarks Miljøundersogelser. Faglig rapport fra DMU nr. 371

/ 8 Lewis, L.J., Davenport, J. and Kelly, T.C., 2003. A study of the impact of a pipeline construction on estuarine benthic invertebrate communities – Part 2. Recolonization by benthic invertebrates after 1 year and response of estuarine birds. Estuarine, Coastal and Shelf Science, Vol. 57, pp. 201-208

/ 9 Lewis, L.J., Davenport, J. and Kelly, T.C., 2002. A study of the impact of a pipeline construction on estuarine benthic invertebrate communities – Part 2. Estuarine, Coastal and Shelf Science, Vol. 55.

/ 10 Sjøfartsverket (2007). Erfarenheter rån dumpningar till havs, Sveriges Hamnar, Rambøll uppdragsnummer: 61470723559.

/ 11 Øresundskonsortiet, 2000. Environmental Impact of the Construction of the Øresund Fixed Link, May 2000.

/ 12 Øresundskonsortiet, 1998. The Øresund Link – Assessment of the Impact on the Marine Environment of the Øresund Link, updated March 1998.

/ 13 Churchill, J.H., 1989. The effect of commercial trawling on sediment re-suspension and transport over the middle Atlantic Bight continental shelf. Continental Shelf Science, Vol9, pp. 841-865.

/ 14 Energinet.dk 2009, Anholt Offshore Wind Farm, Hydrography, sediment spill, water quality, geomorphology and coastal morphology. DHI.

/ 15 Orbicon 2009, Konsekvensvurdering af oprensning af sejlrenden til Ålborg Havn i relation til Natura 2000 område

/ 16 Orbicon 2008, Konsekvensvurdering af råstofindvinding på Marthe Flak

/ 17 Rambøll 2009, VVM redegørelse ifm fase 3 udvidelsen af Århus Havn (in press)

/ 18 Hiscock, k., 1999. Identifying marine sensitive areae – the importance of understanding life-cycles (in aquatic Life Cycle strategies – Survival in a variable environment, Plymouth: Marine Biological Association of the United Kingdom.

/ 19 ELSAM 2000, VVM redegørelse, Horns Rev I

/ 20 DONG Energy 2006, VVM redegørelse, Horns Rev II

/ 21 Energi E2 2000, VVM redegørelse Nysted I

/ 22 Orbicon 2001-2003, konsekvensvurdering ifm etablering af havvindmølleparken på Middelgrund

/ 23 Energinet.dk 2009, Anholt Offshore Wind Farm, Technical Description, Rambøll.

/ 24 Engell-Sørensen, K. & Skyt, P.H., 2001. Evaluation of the effect of noise from off-shore pile-driving to marine fish. Bio/consult. Report commissioned by SEAS Distribution A.m.b.A: 1-23.

/ 25 Review report 2005, The Danish Offshore Wind Farm Demonstration Project: Horns Rev and Nysted Offshore Wind Farms, Environmental impact assessment and monitoring

/ 26 E.On, Rødsand 2, Waves and Sediment Transport - Spill Assessment, DHI, 2007

/ 27 Benthic Communities at Horns Rev Before, During and After Construction of Horns Rev Offshore Wind Farm, Final Report 2005, Bio/consult

/ 28 E.On, Rødsand 2 Havmøllepark, Vurdering af Virkninger på Miljøet, VVM-redegørelse, Juni 2007.

/ 29 Dong Energy, Horns Rev 2, Vurdering af Virkninger på Miljøet, VVM-redegørelse, oktober 2006.

/ 30 Energistyrelsen, Betingelser for offentligt udbud om Anholt Havmøllepark 30. april 2009.

Appendices

Appendix 1: DVD with visual verifications

Appendix 2: Maps

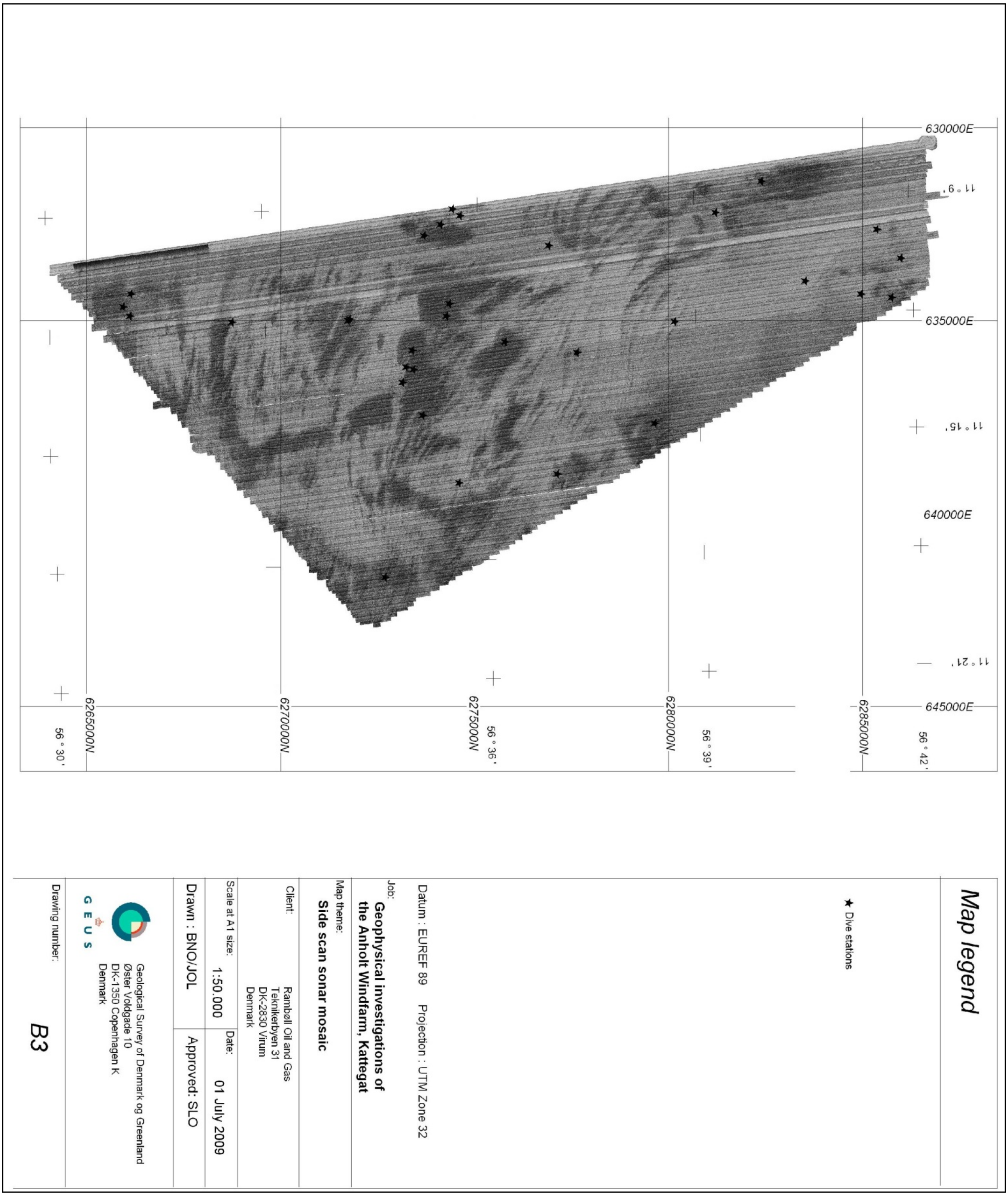

Figure 6-1 Side scan mosaic from the project area

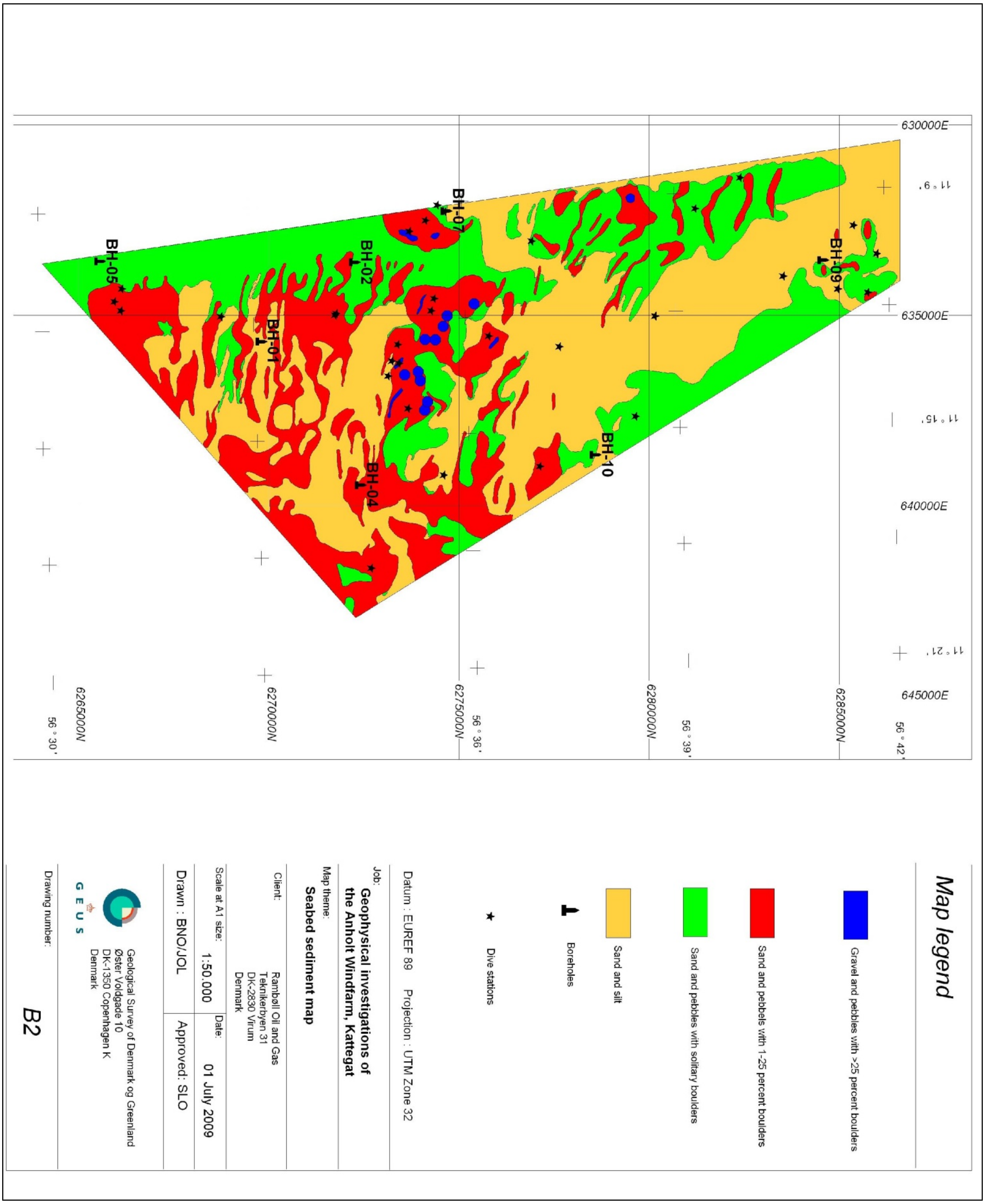

Figure 6-2: Second generation benthic substrate map, showing the area and distribution patterns of the 4 final substrate types defined in the project area.

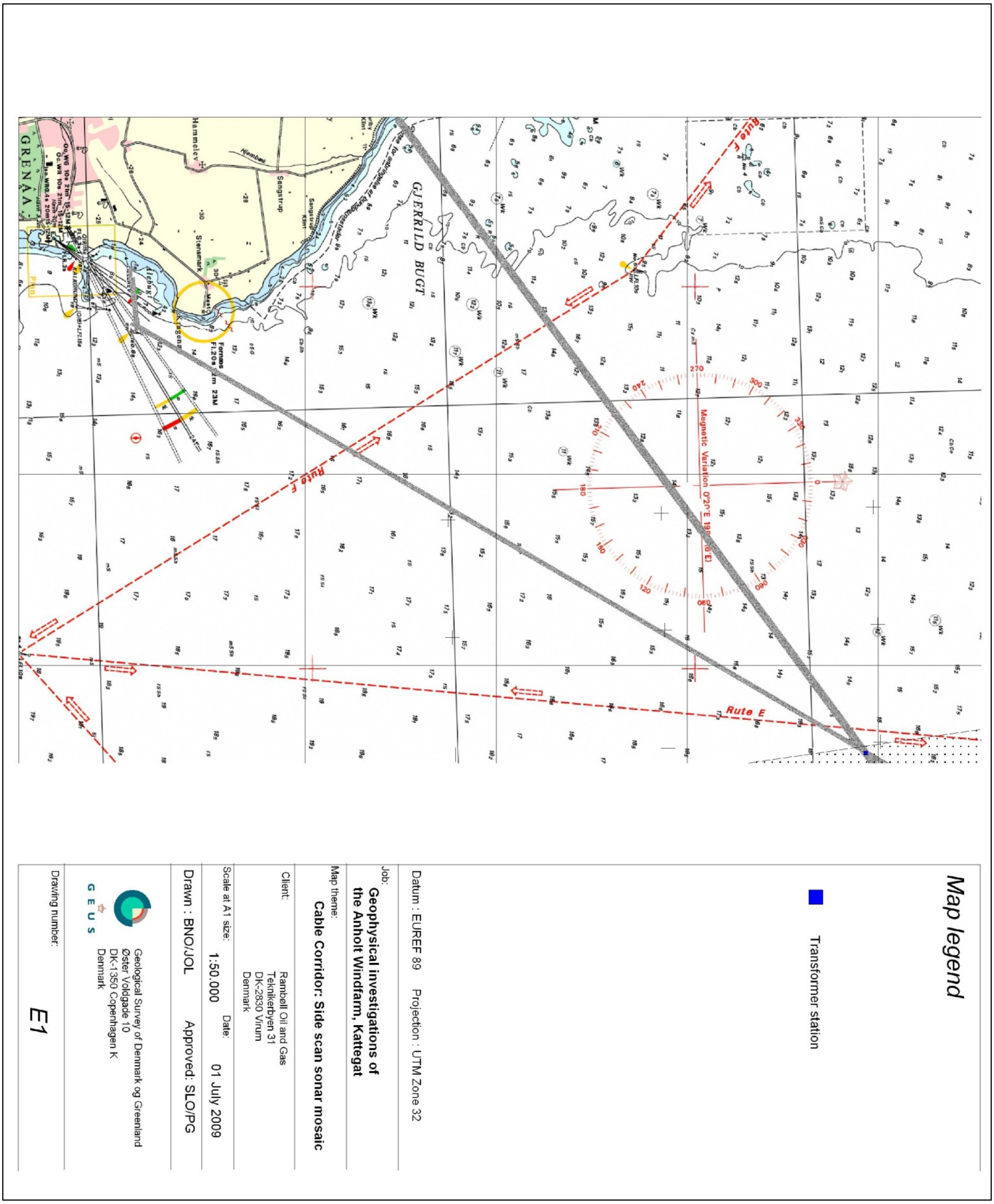

Figure 6-3: Side scan mosaic from the two cable corridors

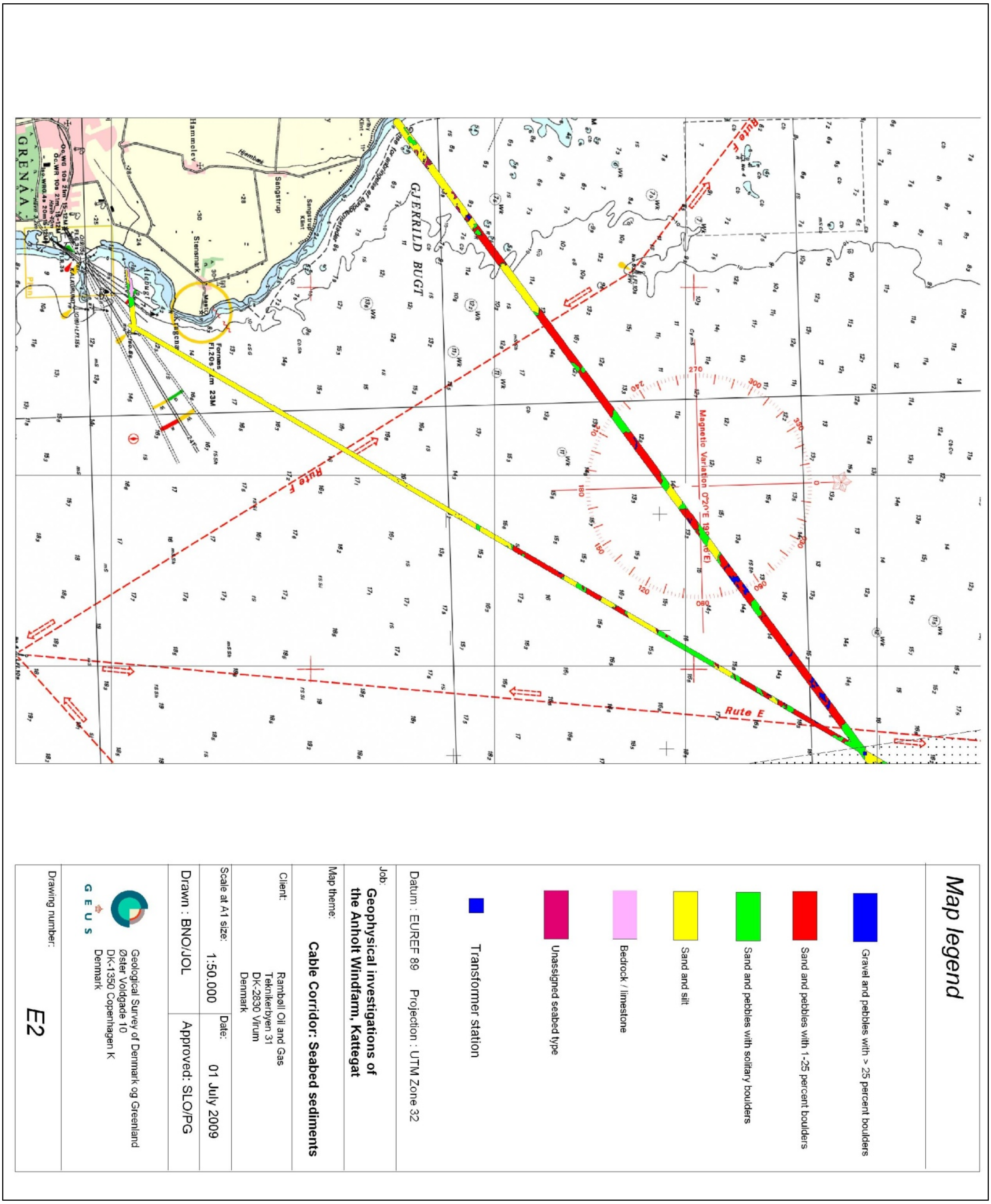

Figure 6-4: Final benthic substrate map, showing the area and distribution patterns of the 4 final substrate types defined in the two cable corridors

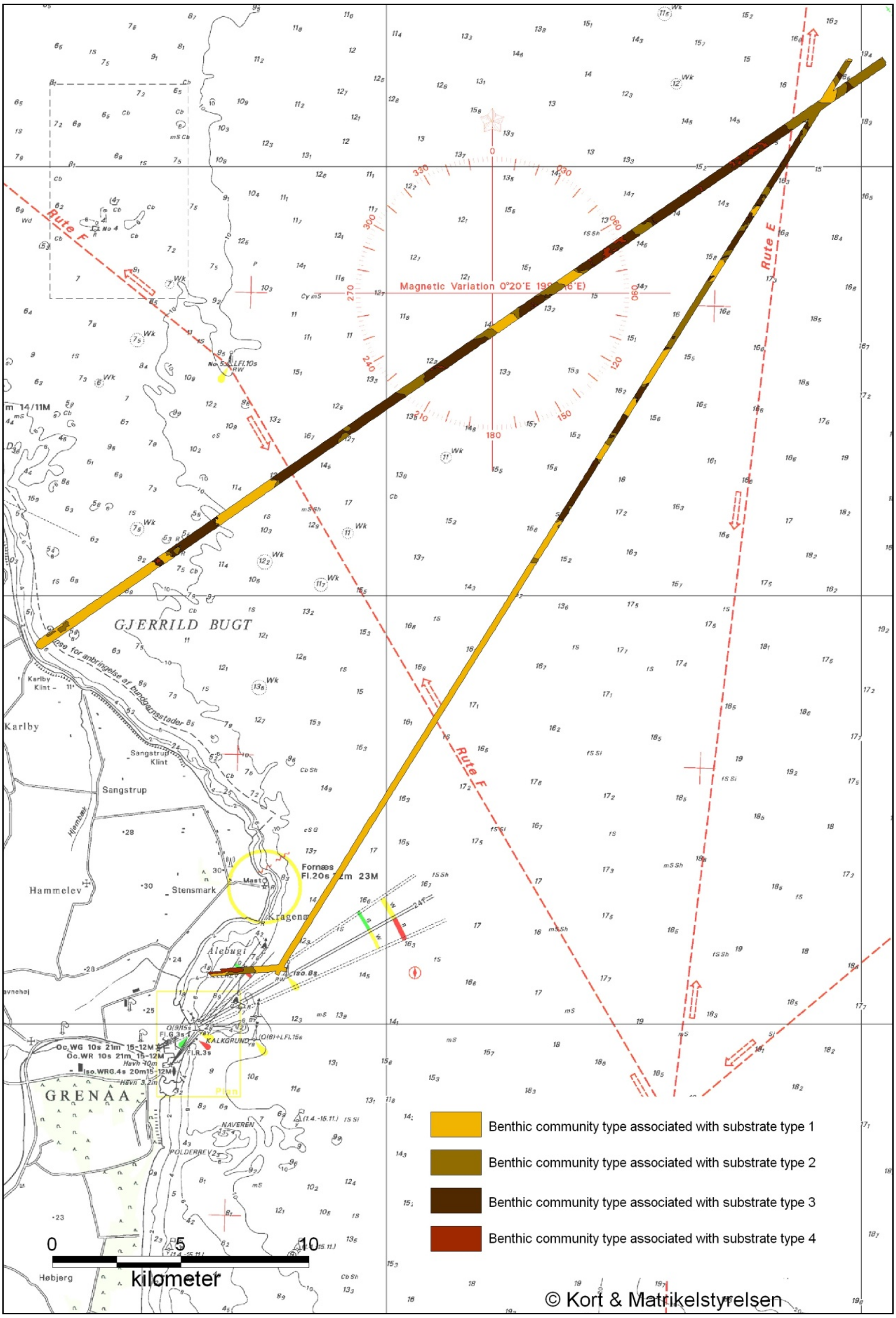

Figure 6-5: Benthic community map showing the 4 different benthic community types in the surveyed cable corridors.