



Nysted Offshore Wind Farm at Rødsand

Annual Status Report for the Environmental Monitoring
Program

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SEAS Wind Energy Centre

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Summary

2 Introduction

With the former Danish government's plan of action for energy, Energi 21, from 1996, it was decided to establish 5,500 MW of wind power in Denmark before 2030. Of this total, 4,000 MW was supposed to be established offshore in large wind farms.

In 1997 a plan of action was made and in this five areas were pointed out as usable for offshore wind farms. These are the area south of Læsø, Horns Rev (in the North Sea), Omø Stålgrunde (in the Great Belt south of Omø), Rødsand (in the Femeer Belt south of Lolland) and Gedser (in the Femeer Belt south of Falster). In Figure 1.1 the five areas are marked.

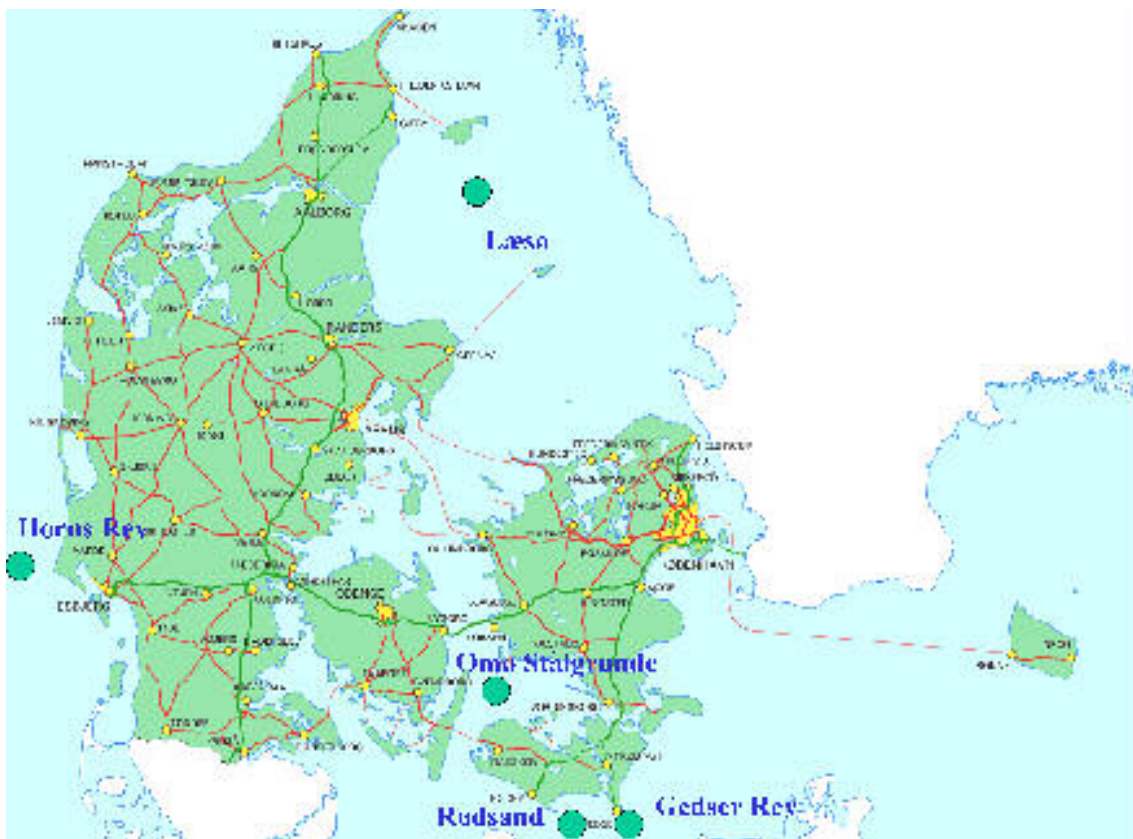


Figure 1.1. Map of the marine areas appointed for the construction of offshore wind farms in Denmark.

The five wind farm areas are going to form the basis for the 4000 MW established offshore. As a follow-up to Energiplan 21 in 1998 the Danish Environment and Energy Minister ordered the power producing companies to establish 750 MW¹ of offshore wind power as demonstrations projects in Denmark.

¹ ***The Government that came into office late 2001 reversed that obligation only to include the two first wind farms at Horns Rev and Rødsand (equalling 318 MW).***

The five proposed wind farms have been given the status of 'demonstration projects'. The objective of the demonstration projects is to shed light on the technical, financial and environmental circumstances with regard to the future electric power production in the Danish offshore environment.

The Danish Energy Agency has given an approval to make a pre-assessment for the five areas. In that approval it is stated that environmental monitoring programmes should shed light on the different environmental impacts of both the specific offshore wind farm and offshore wind farms in general. In each of the proposed wind farm areas, a series of studies on the environmental conditions and the possible impact of an offshore wind farm are undertaken.

The studies belong to two different categories, namely, studies which are important for the extension of the offshore wind farm at the specific sites, and studies which are important for the establishment of 4000 MW offshore wind farms in Denmark.

In 1999 the Danish Energy Agency approved the installation of in principle on 15th June 1999, so the SEAS could carry out preliminary surveys and planning of the wind farm.

In the summer of 2000 the Environmental Impact Assessment was submitted to the authorities.

An environmental monitoring program was initiated following the Environmental Impact Assessment. The monitoring program is divided into three steps. A baseline program carried out prior to the construction phase, a monitoring program for the construction phase and a monitoring program for the operation phase.

On the 27 July 2001 the application to build an offshore demonstration wind farm was approved by the authorities on a set of specified conditions.

The environmental studies carried out in 2001 in relation to the Nysted Offshore Wind Farm are part of the baseline program which will provide enough data and knowledge to describe the environmental conditions in the area of the wind farm and surrounding the wind farm, prior to constructing the wind farm.

This present report describes and concludes on the environmental studies carried out in 2001 in relation to Nysted Offshore Wind Farm at Rødsand. The report is divided into different parts. The first part contains a description of the wind farm and the construction of the wind farm. The second part is divided into different parts, each with a description of one of the environmental studies carried out in 2001 in connection to the offshore wind farm. The third part describes the program for the environmental studies in year 2002.

3 Description of the Rødsand area

The planned offshore wind farm "Nysted Offshore Wind Farm at Rødsand" is placed in the south-eastern part of Denmark, east of the island Lolland.

Two barrier-island, western Rødsand and eastern Rødsand, separate Rødsand Lagune from Femer Bælt and from the planned wind farm. The distance from the barrier-islands to the nearest row of wind turbines will be about 2 kilometres.

The Nysted Offshore Wind Farm at Rødsand is to be placed 10-14 kilometres south of Nysted on Lolland and 11-17 kilometres west of the town Gedser on the south tip of Falster.

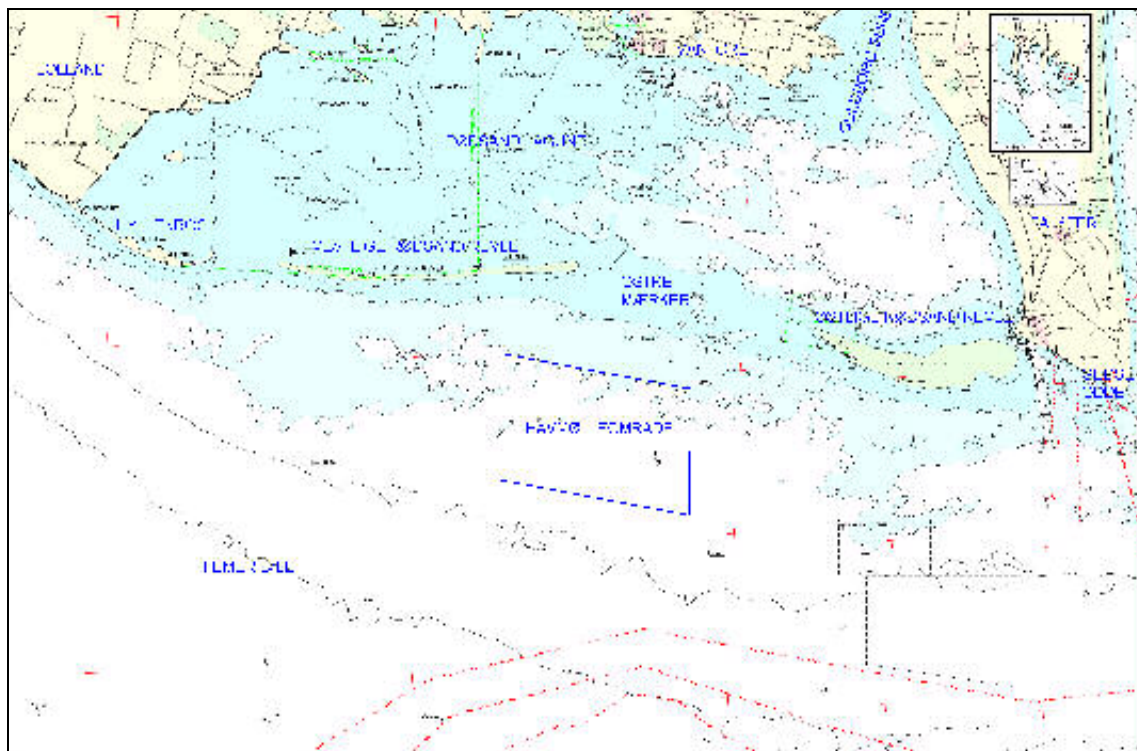


Figure Map of the area south of the island Lolland showing the position of Nysted Offshore Wind Farm at Rødsand (Havmølleområdet).

The wind farm will cover an area of approximately 24km² and a 200m wide exclusion zone will be established around the wind farm, resulting in an overall area of approximately 28km².

The wind farm is located on a gently sloping seabed consisting of glacier deposits covered by thin layers of sand. The water depth in the wind farm is between 6 metres and 9.5 metres.

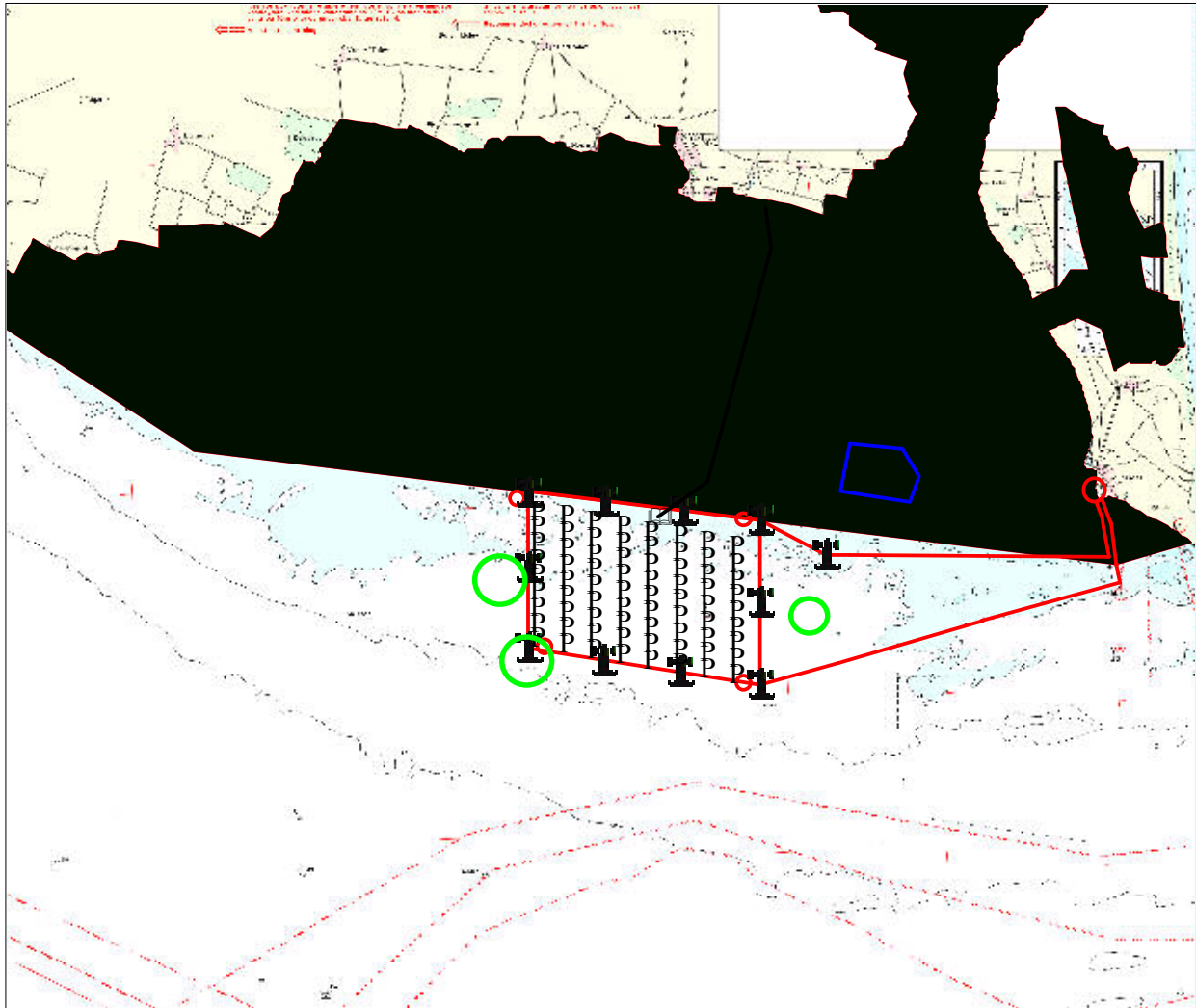


Figure Nysted Offshore Wind Farm: the wind turbines, the meteorology mast (green circles), the construction site, including the transport corridor from Gedser harbour (red lines) and the buoys marking the construction site.

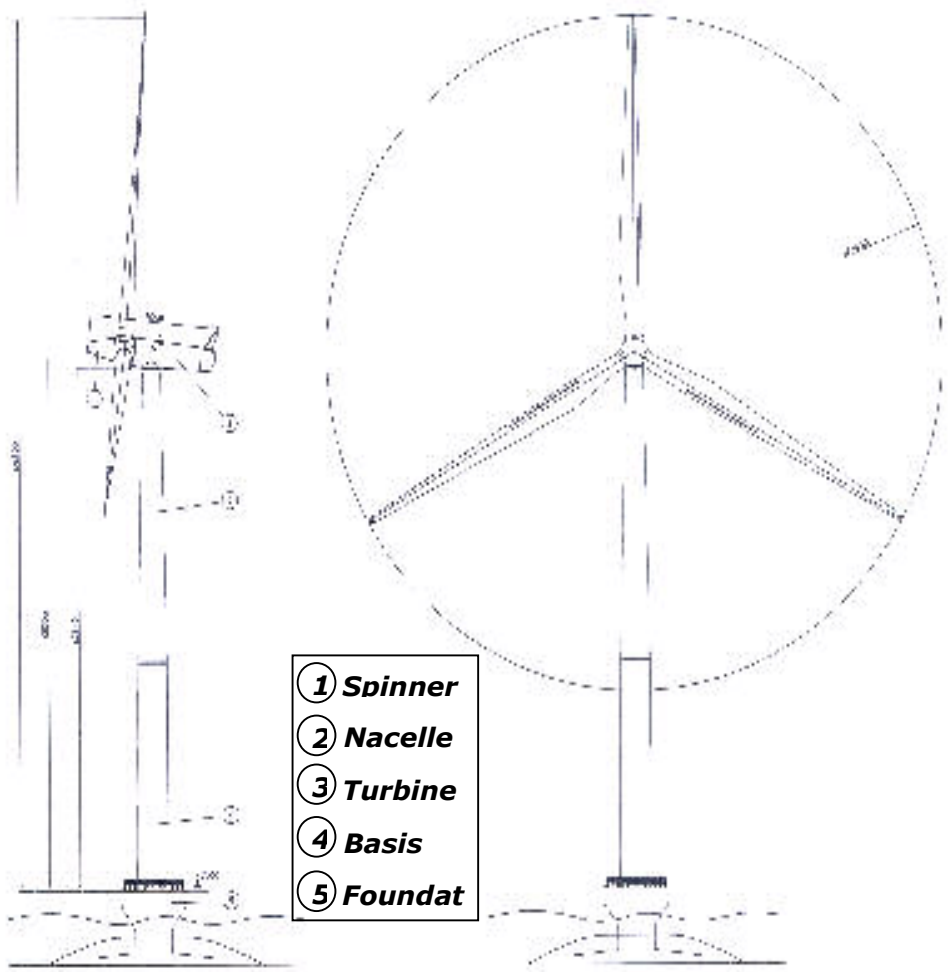
The wind farm will consist of 72 wind turbines each of 2.2MW, with a hub height of 68.8m and a rotor diameter of 82.4m. The total height of the turbines is 110m. The colour of the turbines will be light grey (RAL 7035).

| Hoveddata for møllerne | |
|------------------------------|------------------|
| Elektrisk effekt: | 1,5 - 2,5 MW |
| Rotor diamenter | 66 - 80 m |
| Navhøjde | 55-75 m.o.h. |
| Fundamentoverkant | 3,5 - 5 m.o.h. |
| Højde til øverste vingespids | maks. 110 m.o.h. |

| | |
|---------------------------------------|------------------------------------|
| Farve (alle udefra synlige mølledele) | lys grå RAL 7035 eller tilsvarende |
|---------------------------------------|------------------------------------|

Tabel 5. Error! Unknown switch argument. Hoveddata for møllerne.

The turbines are placed in 8 north-south orientated rows separated by a distance of 850m. Each row holds 9 turbines separated by a distance of 480m.



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Figure Showing the wind turbine type to be installed in Nysted Offshore Wind Farm.

The turbine foundations will be concrete caisson foundations. The foundations are placed on a (bærelag) consisting of a 30cm thick (skærvepude). The expected erosion around the bottom plate of the foundations will be prevented by a scour protection, consisting of stones of various diameters.

The foundations will take up an area of about 45.000m², corresponding to 0.2% of the total area of the wind farm. The foundations will cause an increase of the overall surface area of up to 56.000m².

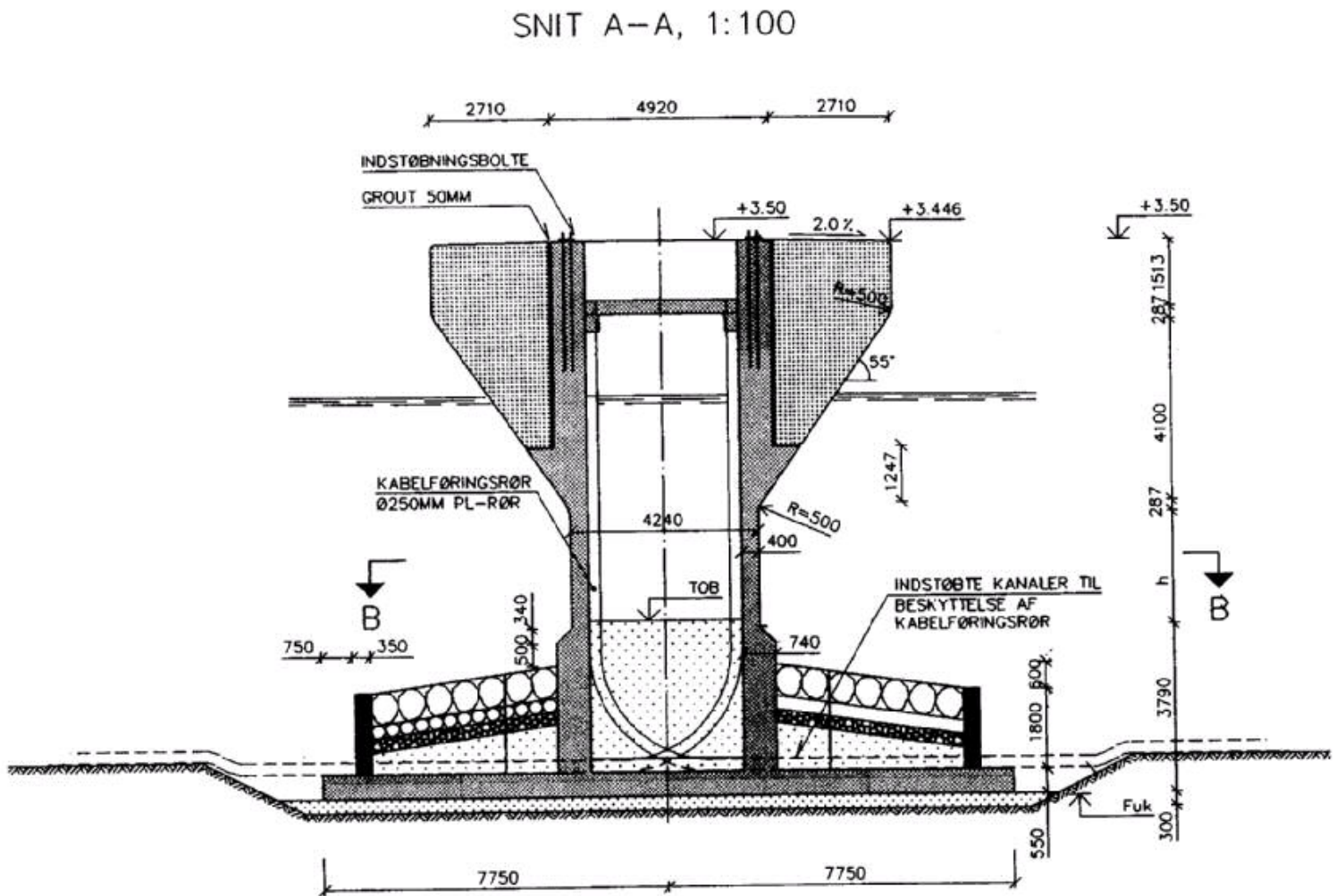


Figure Showing the type of foundation used for installing the wind turbines at Nysted Offshore Wind Farm.

3.1 Cable connection

The turbines will be interconnected with a 33kV sea-cable, buried into minimum 1m depth in the seabottom. The sea-cable continues from the most northerly turbine, in the fourth row from east, to a 33/132kV transformer platform 200m north of the most northerly turbine. The total length of the 33kV sea-cable is about 48 kilometres, including in- and output on the wind turbines.

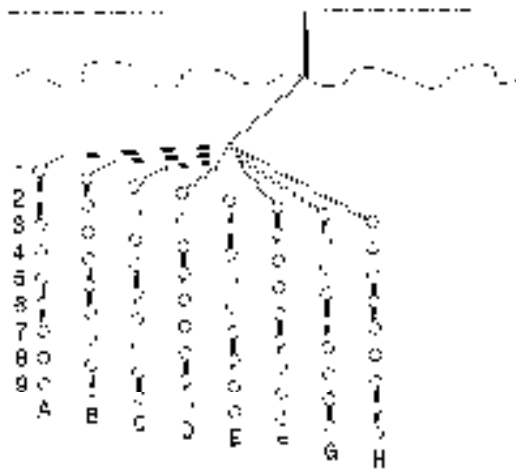


Figure Showing the cable connection between the wind turbines in the wind farm.

From the transformer platform to Vantore Strandhuse east of Nysted, a 132kV cable will be sluiced/buried at a depth of 1 metre. The total length of the 132kV-cable connection to land is about 10 kilometres.

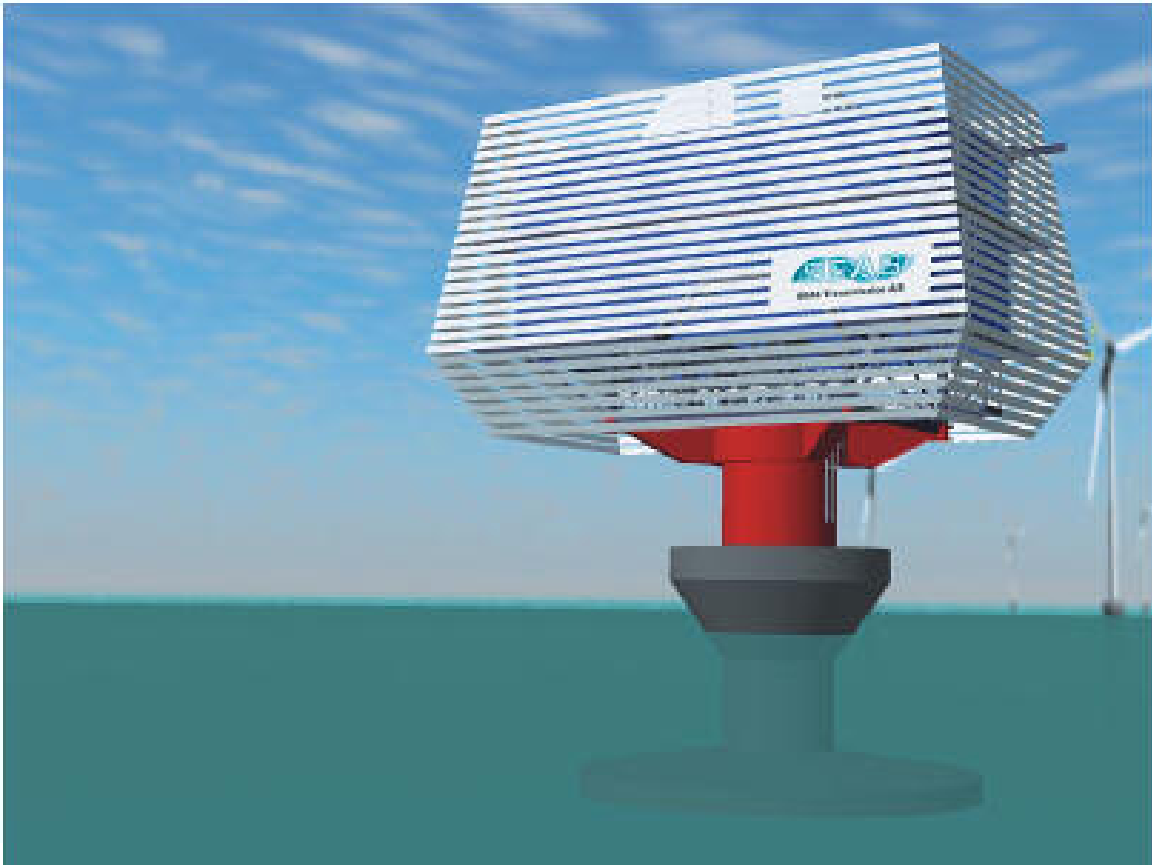
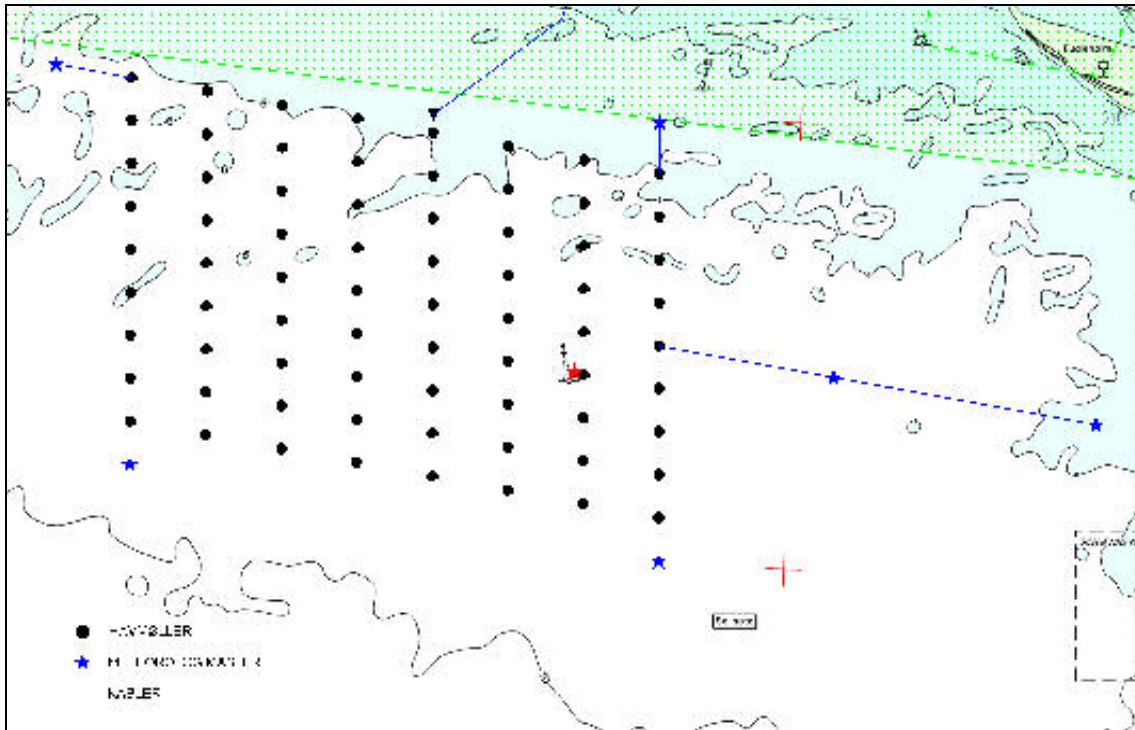


Figure A model of the transformer platform at Nysted Offshore Wind Farm at Rødsand.

The cables in the Nysted Offshore Wind Farm at Rødsand will be Alternating Current (AC) cables.

Besides from the turbines the park consists of four meteorology masts. One of the masts will be placed ca. 250m west of the south-westerly wind turbine in the park. The other three masts will be placed on a line running in the middle of the park from west to east, so that one mast is placed ca. 850 m west of the park, the two others, respectively 2km and 5km east of the park. The met-masts will be placed on a foundation with a diameter of 1,5m (monopile). The measuring mast will have a height of about 70m above sea-level.



The water depth in the offshore wind farm area is between 6m and 9.5m.

Due to the shallow water depth in the area and the mixing of the water masses caused by wind and currents, the water column will in most cases be completely mixed in and around the wind farm area. On the other hand, stratification typically occurs in the Femer Belt.

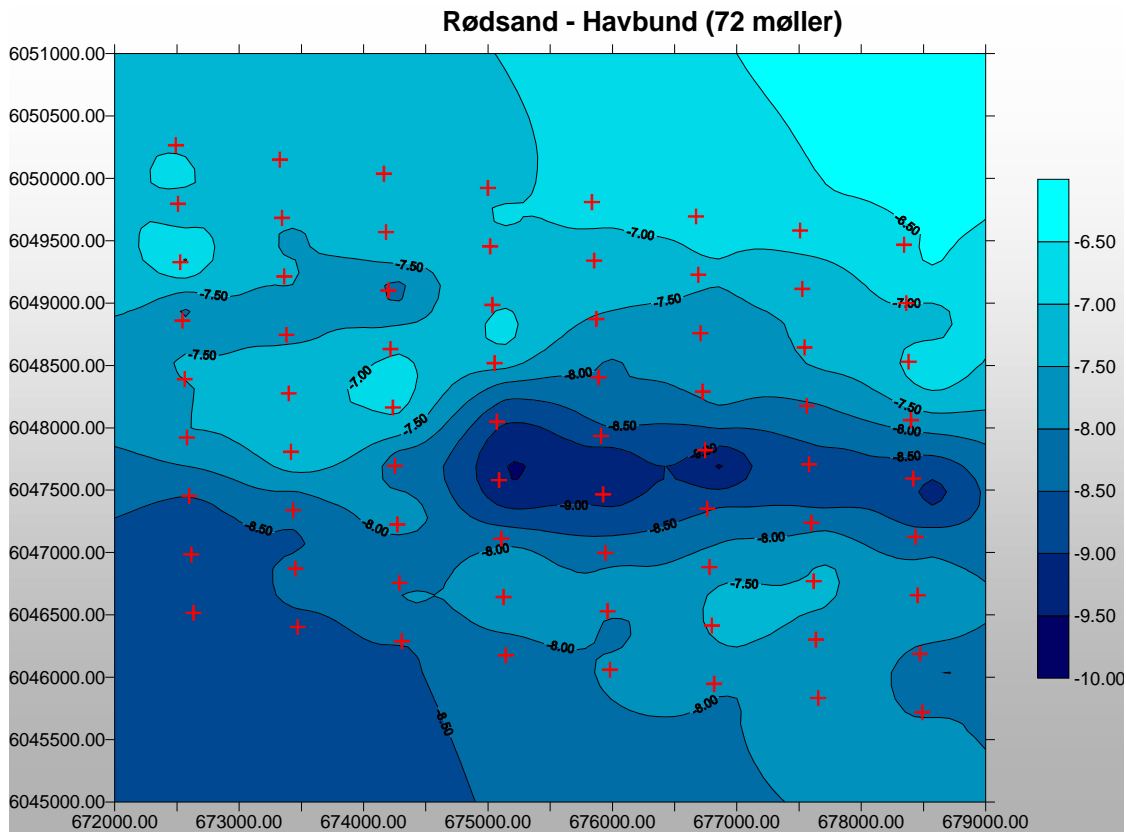
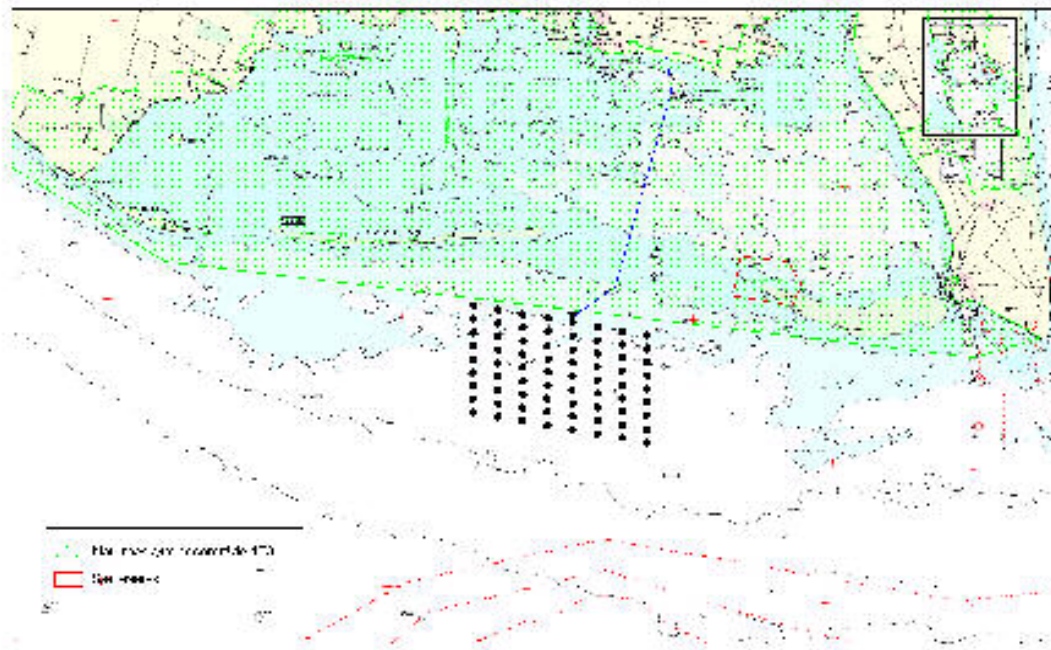


Figure Water depths in the Rødsand offshore wind farm area.

Geologically the cable trace area is generally characterised by the presence of moraine clay deposits with a variable cover of post-glacial sediments in the form of sand and/or mud.

4 Environmental criteria

The offshore wind farm area is located outside an area protected under the EC-Habitat Directive, the EC Bird Directive and the Ramsar Convention. The 132 kV cable trace to land will pass through the protected area.



Map showing the designated areas north of the planned offshore wind farm at Rødsand.

5 Environmental Management

In connection with the Danish Energy Agency's approval of the project it was a requirement to implement an environmental management system for the wind farm project. The environmental management system for the wind farm project comprises two separate systems:
 Environmental management of the wind farm

Monitoring of the environment

5.1 Environmental management of the wind farm

5.2 Monitoring of the environment

6 Construction phase

The construction site consists of three sub-areas:

The construction site in Gedser Harbour

The transport corridor to the construction area

The construction area of the offshore wind farm. This area consists of the wind farm area and a 500 metre wide security zone to the wind turbines and the transformer station.

6.1 Environmental management during construction period

The plan for the environmental management during the construction period is build up around the plans for environmental management from the different contractors. The environmental management will consist of inspection of the environmental management carried out by the different contractors.

Furthermore, the environmental management will include the environmental preparedness, which is ready if an environmentally damaging situation arises on the construction site. Another part of the environmental management is superintends and gathering of documentation from the different constructors who must register information about their activities on the construction site.

7 Environmental Monitoring Program 2001

8 Benthic vegetation and fauna

In 1999 marine biological surveys were carried out in the wind farm area. The marine biological surveys were updated in May and August 2001 and included a survey along the planned cable connection between the wind farm and the coast of Lolland via the lagoon of Rødsand.

8.1 Objective

To describe the spatial and temporal changes of the benthic communities in the proposed wind farm since 1999.

8.2 Design and methods

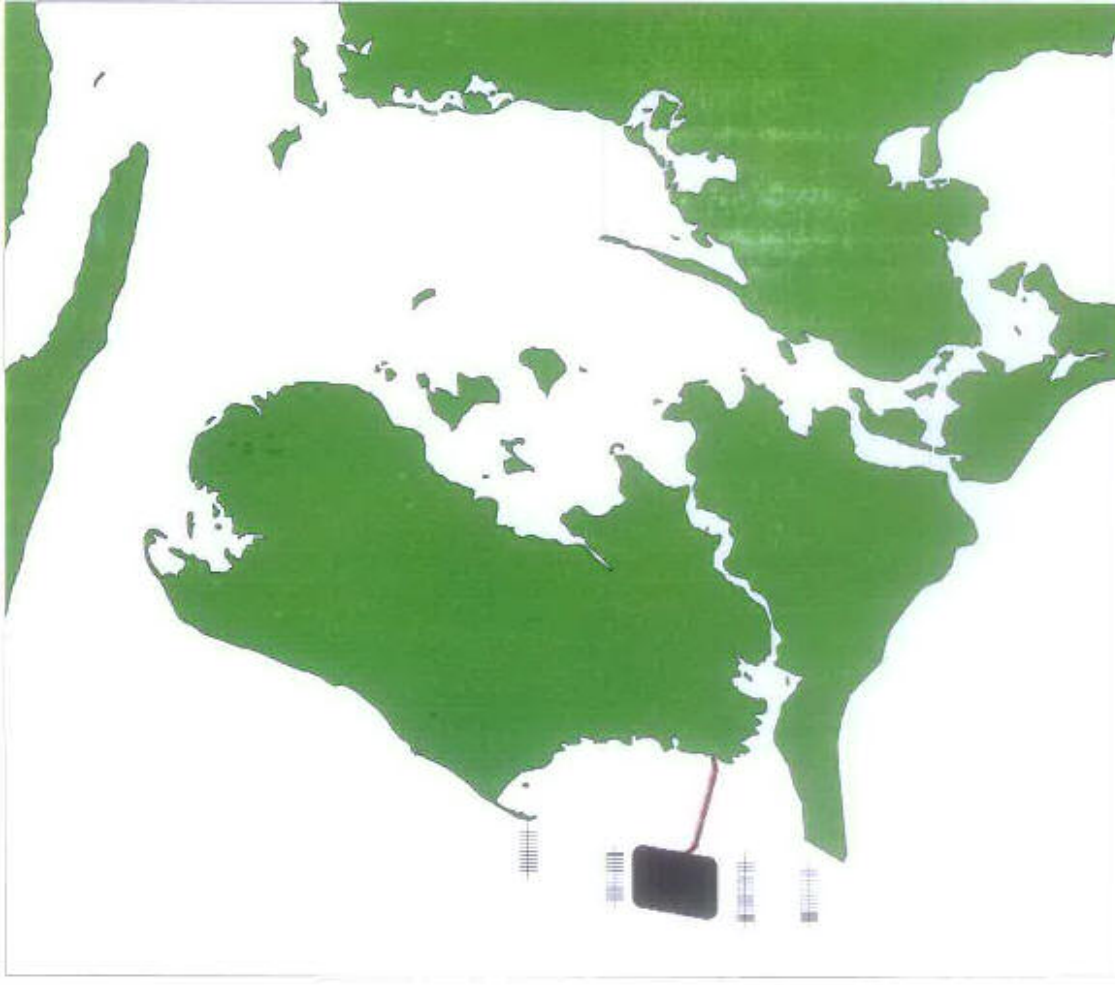
The survey in the wind farm area was conducted using the same methods in 2001 as in 1999. Photosampling in May and surveys of bottom fauna in August were undertaken at the same stations in 1999 and 2001.

The surveys of the benthic communities were based on underwater photo and video (so-called photosampling) and collection of quantitative samples of the benthic communities.

The photosampling was done by lowering a photo-sampler to the seabed and recording. The bottom and recording conditions are followed continuously on the monitor. At each station the position was registred using DGPS and the water depth was recorded from the echo sounder.

Samples of the bottom fauna and surface sediment were collected at 88 stations in the wind farm and along the reference transect. One sampled of the bottom fauna was collected at each station using a van Veen grab sampler (0.1 m²). A sub-sample of the top 5-cm of the sediment (if possible) was obtained from each sample before the sieving.

Quantitative samples of common mussels (*Mytilus edulis*) were collected on the seabed and on the foundations of the monitoring mast at the wind farm.



Map of the study area, showing the planned wind farm, the reference transects and the cable connection between the wind farm and the coast of Lolland.

Marine biological condition in the wind farm at Rødsand in 2001.

8.3 Results

8.3.1 Sediment

The surface sediment consists mostly of pure sand with scattered stones. The composition characterised by the median grain size of the sediment and the content of silt/clay, dry matter and loss on ignition differ significantly in the wind farm and along the transects.

The median grain size of the sediment has remained unaltered since 1999 but the frequency of stations with a higher content of silt/clay has increased in the wind farm.

8.3.2 Bottom fauna

The bottom fauna in the wind farm and along the transects has a high similarity and belong to the typical shallow water (Macoma-) community. The community is characterised by a low diversity but a high abundance and biomass dominated by a few species of polychaetes, bivalves and gastropods.

The number of species and the species composition have changed little between 1999 and 2001, but the average abundance of the bottom fauna has declined by 30% in the wind farm and 10% along transects since 1999. The average biomass has declined by 10% in the wind farm and 50% along transects since 1999. The decline in benthic abundance and biomass since 1999 is regarded as natural fluctuations in abundance of short living species of polychaetes and gastropods and die away of older year-classes of infauna bivalves.

8.3.3 Common mussels

The overall pattern in distribution and coverage of mussels was similar in 1999 and 2001 but changes in coverage were recorded at stations with identical positions in the wind farm and along transects.

The average biomass of common mussels has declined about 30% since 1999. The size and the condition of the mussels were higher in 2001 than in 1999. The decline in biomass of mussels since 1999 was the result of a lower density of mussels in 2001.

8.3.4 Benthic vegetation

In contrast to 1999, eelgrass (*Zostera marina*) was recorded at one station in 2001.

Attached annuals filamentous brown algae were observed in the southern part of the wind farm and along transects 2 and 3 in May 1999 and 2001. The spatial distribution of macroalgae and common mussels is largely similar, probably because mussels and stones are suitable substrates for attachment of algae.

Because of the limited and short-term occurrence no sampling of macro algae was carried out in 1999 and 2001.

8.3.5 Common mussels on foundation of monitoring mast

A dense layer of common mussels covered the foundation from surface to bottom. The density and biomass of mussels have increased since 1999. The total biomass of mussels varied between 15-20 kg wet weight/m² in 2001.

The foundation of the mast was established in 1996 and the oldest mussels may be five years old. However, the median and the maximum size of the mussels have not increased since 1999.

Mussels on the foundation have a better condition than mussels on the seabed. The density of mussels is higher on the foundation compared with the seabed. However, a more intense competition for food on the foundation is counteracted by a better water movement and availability of food.

Conclusion

Report

DHI Water & Environment, 2002. Marine Biological Conditions in the Wind Farm at Rødsand in 2001.

Marine biological surveys along the cable connection in the lagoon of Rødsand in 2001

Objective

To describe the benthic communities along the planned cable connection in the lagoon of Rødsand.

8.3.6 Sediment

The composition of the sediment along the cable connection is highly variable and ranges of silt/clay to coarse sand. The sediment consists of mud and muddy sand in deeper water in the interior and middle section of the alignment. The lagoon of Rødsand is separated from Femer Belt by shallow sand barriers. The sediment on the barriers and south of these consists of sand with a low content of organic matter.

8.3.7 Bottom fauna

The bottom fauna in the lagoon of Rødsand is a *Macoma*-community characterised by a low diversity and a high abundance. The fauna is dominated by a few species of gastropods, polychaetes and bivalves. The mud snail *Hydrobia* sp. and the tube building polychaete *Pygospio elegans* account for almost 75% of the total abundance of the bottom fauna.

The bottom fauna is most diverse and abundant in the inner and middle section of the alignment and less diverse and abundant in the outermost section. Exposure and a low content of organic matter in the sediment are limiting factors for the bottom fauna in the outermost section of the alignment.

8.4 Benthic vegetation

Eelgrass (*Zostera marina*) is mainly distributed in shallow water in the innermost section of the cable alignment. The shoot density and the biomass of rhizomes show a linear decline with increasing water depth.

Low transparency of the water due to re-suspension of fine sediment and accumulation of detached macro algae on the seabed are limiting factors for development of eelgrass in the area.

Attached macro algae are mainly confined to stony bottom in the middle section of the alignment. The biomass varies between 400-600 g DW/m². Red algae are abundant and *Furcellaria lumbricalis* is a dominant species. Brown and green algae are of inferior importance at the time of sampling, but annual filamentous brown algae may be more numerous during spring and early summer.

Conclusion

Report

DHI Water & Environment, 2002. Marine Biological Surveys Along the Cable Connection in the Lagoon of Rødsand in 2001.

9 Fish and fishery

9.1 Fish and commercial fishery in the wind farm area

Two baseline fish studies were carried out in the year of 2001. In spring, the program for "Baseline study of fish" was undertaken with two identical sampling sessions in May and June, respectively. In autumn, the sampling program "Baseline study of fry" was executed with three identical sampling sessions in respectively September, October and November.

A baseline study including adult fish, fry (juveniles and small fish species) and commercial fishery has been carried out in 2001. The

Objective

The objective of the baseline study is to provide enough data to enable the verification of the possible changes in the fish population in the wind farm area during its operational phase, with a given degree of certainty.

The possible effect-parameters included in the study are:

- Density and biomass of selected fish species
- Length distribution of selected fish species
- Behavioural patterns of selected fish species
- Density and biomass of fish fry
- Fishery pattern
- Migration of selected fish species across

Design and methods

All sampling concerning the baseline study of fish and the baseline study of fry was conducted at the same 12 permanent stations in the area of the wind farm and 12 permanent stations in the adjacent reference area.

Gill and fyke nets were used, and were set in the afternoon and retrieved the next morning in the same order to ensure that active sampling time was approximately the same for each sample.

Results

Conclusions

Report

Bio/consult, 2002. Baseline study. Fish, fry and commercial fishery. Nysted Offshore Wind Farm at Rødsand

9.2 Fish along the cable trace

Objective

The objective of the study is to develop and evaluate a method to investigate the possible effects of electromagnetic fields created by underwater cables on the fish fauna, particularly migratory species.

9.2.1 Bottom conditions at the pound net sites

A homogeneous sandy bottom with sand ripples dominated the seabed along the four pound net sites. At most stations detached filamentous algae were found, but significant amounts occurred

only at a few stations at the two deepest and southernmost sites (pound nets 2 and 4). In general, only insignificant and scattered occurrences of attached living macro algae and common mussels were present.

Report

DHI Water & Environment, 2002. Marine Biological Surveys Along the Cable Connection in the Lagoon of Rødsand in 2001.

Design and methods

In a study area located near the outer part of Rødsand lagoon catches were made from the end of September to the end of November. With the objective of performing a time series analysis catches were gathered in co-operation with local fisherman two to three times a week from 4 pound nets, 2 east and 2 west of the planned cable trace.

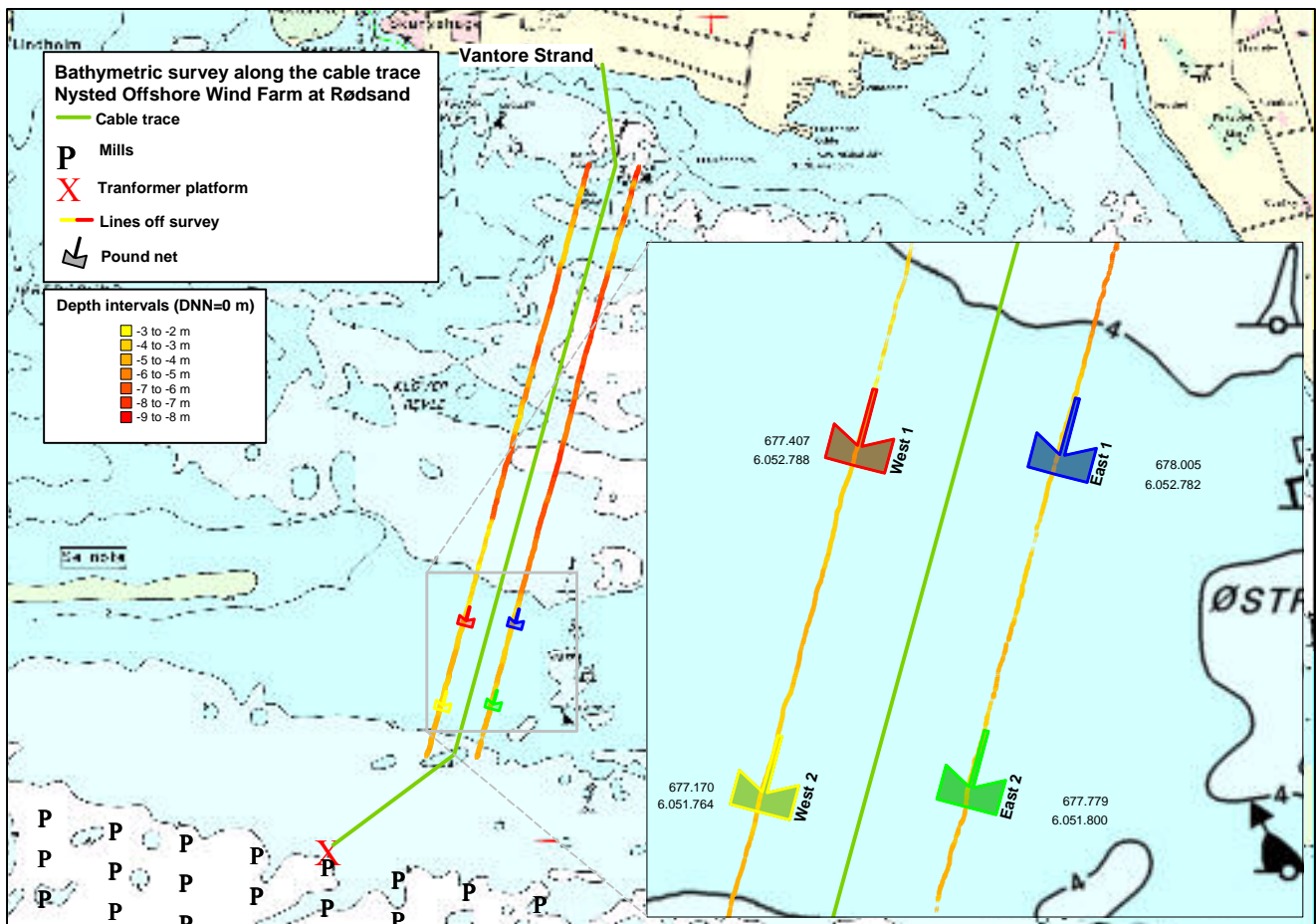


Figure Map of the planned cable trace, the selected study area, depth conditions at the bathymetric survey lines and geographical placement of four pound nets.

Similarity comparisons of CPUE (Catch Per Unit Effort) for fish abundance and weight as well as mean length and condition factors for a number of chosen indicator species were undertaken with the use of statistical time series analysis between samples from the 4 pound nets.

Besides silver eel and Atlantic cod, which possess a typical migratory behaviour, statistical time series analysis was also performed on catch data for Baltic herring, flounder, turbot, short-spined sea scorpion and lumpsucker to establish the possibility of finding indicator species with different behavioural patterns.

9.3 Results

A total number of 8716 individuals with a total weight of 988 kg representing 34 fish species were caught in the four pound nets east and west of the planned cable trace. A considerable number of common eel (678 individuals) and Atlantic cod (2108 individuals) were registered as well as a large number of Baltic herring (2815 individuals) and short-spined sea scorpion (1171 individuals). Six new fish species were registered in comparison with earlier investigations in the area.

Results of the time series analysis for CPUE-number on catches gathered at the 4 pound nets showed the common eel was the only species with correlations between all the pound nets. CPUE-number correlations for Baltic herring, Atlantic cod and short-spined sea scorpion were significant in at least four of six comparable combinations. Significant correlations of CPUE-number values for the remaining species were only achieved in some cross combinations.

Good CPUE-weight correlations were observed in the majority of fish species, with the exception of hornfish, lumpsucker, turbot and flounder.

Mean length and condition factors correlations were generally poor with few significant results. Thus, these parameters had only limited use in similarity comparisons between the four pound nets.

The species composition in the supplemental area near Hyllekrog largely reflected the fish fauna along the cable trace at Nysted Offshore Wind Farm.

9.4 Conclusion

In this investigation the common eel, which has a characteristic directional migration, appeared to fulfil the behavioural and statistical criteria to be a good indicator species of the possible effects associated with sea cables from offshore wind farms.

Baltic herring could also be used as a reference species because electro-magnetic fields from do not affect them buried cables due to their pelagic and constantly moving lifestyle. Biases in cod and short-spined sea scorpion results originated from a sampling regime with unequal times between samples as well as their comparatively stationary behaviour and/or migration parallel to the cable trace.

By adjusting the sampling procedure to reduce the mentioned biases it should be possible to improve the monitoring program by including other species and ultimately improve the foundation for interpretation of possible effects of sea cables in connection with offshore wind farms.

The statistical foundation for time series comparisons can be improved considerably by avoiding interpolation between sampling periods, thus equal time between sampling is strongly suggested.

Furthermore, a modification of the pound nets to include a fyke net can give information on the directional movement for the individual species and thus strengthen interpretation of results considerably. In light of this, it would also be beneficial to use a TDC-sonde to compare fish behavioural patterns with oceanographic parameters.

Report

Bio/consult, 2002. Baseline study. Fish at the cable trace. Nysted Offshore Wind Farm at Rødsand.

10 Birds

Program for 2001

Objective

Design and methods

Results

Conclusions

11 Marine mammals

11.1 Seals

Program for 2001

Objective

Design and methods

Results

Conclusions

11.2 Harbour porpoises

In order to study possible effects from the erection and operation of the windfarm on the harbour porpoises, stationary acoustic data-loggers, PODs (porpoise click detectors) have been used in the area at Nysted Offshore Wind Farm.

The study included deployment of PODs in three planned offshore windfarms: Horns Reef, Mecklenburg Bay and Nysted Offshore Wind Farm at Rødsand. The following description will primarily focus on the study and the results from the investigation at Rødsand.

Objective

To evaluate the performance of the PODs and optimise the settings to most efficiently collect data on harbour porpoise echolocation.

The specific aims of the study were:

to test the reliability of recorded T-POD-data in controlled conditions with and without captive animals

to test the directionality and inter-differences between T-PODs using artificial and recorded harbour porpoise echolocation signals

to compare visual observations with T-POD data to document whether echolocation activity reflects the density of animals

to develop statistical methods for analysing POD data
to develop robust monitoring design for detecting effects of offshore windfarms on harbour porpoises
to document the present knowledge of POD research during an international workshop

Design and methods

In the Rødsand area a total of four PODs have been deployed, two in the windfarm area and two in the reference area at Gedser Reef, 18 km east of the windfarm area.

Sporadic test deployments were made from February to May 2001 while more permanent deployments took place since May 2001.

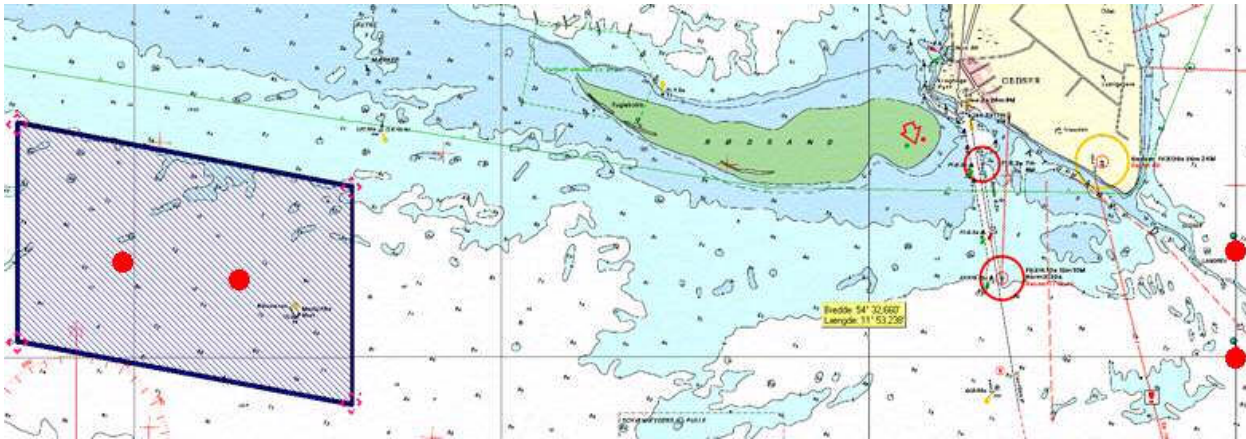


Figure . Map of the Rødsand area. The wind farm area is indicated by a blue square and the location of the POD deployments are indicated with red dots.

Four different indicators extracted from the POD signals were considered:

- Daily click frequency
- Daily click intensity
- Event duration
- Waiting time

Results

The proposed indicators provide information extracted from the POD data, which can be readily interpreted.

Considering the different POD deployments the information encapsulated in the indicators is partially equivalent. Low click activity at stations is reflected in low click frequency, low click intensity, low event duration and long waiting time.

Conclusion

It is concluded that results from PODs do indicate the porpoise density and that PODs can be used as a tool to detect changes in density of animals over time.

The study suggests that the POD data be analysed using all the proposed indicators to investigate if the indicators provide a consistent pattern.

12 Conclusion

References