Elsam Engineering

Infauna Monitoring
Horns Rev Offshore Wind Farm

Annual Status Report 2003

Bio/consult as

Infauna Monitoring
Horns Rev Offshore Wind Farm

Annual Status Report 2003

Published:	13 May 2004		
Prepared:	Michael Bech Simon B. Leonhard John Pedersen	Editing:	Gitte Spanggard
Checked:	Bjarne Moeslund	Artwork:	Kirsten Nygaard
Approved:	Simon B. Leonhard	Cover photos:	Jens Christensen
		English text consultants:	Word Design ApS.

TABLE OF CONTENTS **PAGE**

Summary

ELSAM and ELTRA have established an offshore wind farm with an output of 160 MW in the waters of Horns Rev 14–20 km off Blåvands Huk, which is the most westerly point of Denmark. The first phase of construction of the wind farm started in spring 2002.

The monitoring programme of the benthic fauna was carried out in September 2003 after the wind farm had become operational. Baseline surveys for the present monitoring programme were conducted in the wind farm area on three occasions prior to the construction of the offshore wind farm: spring 1999, spring 2001 and September 2001. In designated reference areas, surveys were conducted in spring 1999 and September 2001. The reference areas in 1999 and September 2001 were placed at two different geographical locations because the survey in September 2001 was planned to be a part of a fish-monitoring programme. Assessment of possible impacts of the establishment of the wind farm was mainly done by comparing results from September 2003 with the results from the baseline study conducted in September 2001.

The survey in September 2003 included collection of bottom fauna at 6 turbine sites, a total of 18 stations in the wind farm, and at 6 stations in a designated reference area outside the wind farm area. The stations in the wind farm were situated respectively 5, 25 and 100 metres in a leeward direction from the scour protection of the wind turbine towers at each turbine site.

The bottom samples were collected by SCUBA divers. Additional samples were collected for sediment analysis.

In the laboratory samples for identification of species composition, abundance and biomass were carefully sieved through a 1.0 mm test sieve. A total of 42 species were identified from the surveys in the Horn Rev area in September 2003, whereas 47 species were recorded in the survey from September 2001.

The molluscs were the most abundant group in 2003 and they constituted 65.2% of the total number of individuals and 42.8% of the total biomass in the wind farm area. In 2001, the molluscs represented 82% of the total biomass in the area.

The commercial important bivalve *Spisula solida*, which is a common species in the North Sea, constituted 33.7% of the total biomass in the wind farm area in 2003, but 77.4% of the total biomass in the survey from September 2001. The bivalve *Thracia phaseolina* was the fourth most abundant species in the wind farm area in 2003, where it constituted 2.9% of the total abundance.

The bristle worms were the second most abundant group, as they constituted 22% of the total number of individuals and 2.3% of the total biomass. In the survey from September 2001, the bristle worms constituted 44% of the total individuals in the wind farm area.

The third most abundant species in the wind farm area was the crustacean *Jassa marmorata*, not previously recorded in Denmark. *J. marmorata* is a typical fouling organism found in hard substrate habitats. Larger crustaceans, including the hermit crab *Pagurus bernhardus*, were the most important species with respect to biomass in the wind farm area in 2003.

With respect to biomass, the echinoderms were the fourth most important group with 6% of the total biomass, representing only 1% of the total number of individuals in the wind farm area.

Epifouling organisms were not recorded in the reference area, but apart from this and the recording of some larger species of the razor clam *Ensis ensis* in the reference area, almost identical abundance/biomass relations was found for the dominant species in the two areas surveyed at Horns Rev.

The fauna in the Horns Rev area can be characterised as a *Goniadella-Spisula* community named after characteristic species in the community.

In 2001, results revealed that the following species could be used as indicator organisms of environmental changes in the wind farm area due to relative uniformity in dominance relations: *Pisione remota*, *Goodallia triangularis*, *Goniadella bobretzkii*, *Ophelia borealis*, *Orbinia sertulata* and *Nephtys longosetosa*. The character species *Spisula solida*, although dominant in biomass, showed a more aggregated distribution in 2001.

In September 2003, the surveyed areas were characterised by the presence of character species such as the bristle worm *Goniadella bobretzkii* and the mussels *Spisula solida* and *Goodallia triangularis*, because they were the most important species in respect of abundance or biomass. Other character and appointed indicator species such as *Ophelia borealis* and *Nephtys longosetosa* were less common or absent compared with previous surveys.

The main difference between the survey in 2001 and in 2003 was the decline of the *Pisione remota* population and an increase in the population of *Goodallia triangularis*. Presence of new species to the infauna community at Horns Rev, the bristle worms *Euzonus flabelligerus* and *Polygordius appendiculatus*, typically associated with coarse sand, might be a result of changes in sediment characteristics towards coarser sediments.

The particle size of the sediment in the wind farm area increased from a range of 228–426 µm in September 2001 to a range of 404–699 µm in September 2003. It is unlikely that storm events, hydrodynamic changes or heavy shipping traffic during the construction phase could have caused the changes. Parallel with the increase in particle size in the wind farm area, a comparable increase in particle size was found for the reference area. It is important to note that Horns Rev is a highly dynamic environment with migrating bedforms, and therefore an area with constant resuspension and reworking of the sediment.

The multidimensional scaling tests of the fauna in the wind farm area in September 2001 and in September 2003 revealed that they were significantly different. No differences in community structure between the wind farm area and reference area were found in 2003, indicating that natural variation rather than effects of the establishment of the wind farm caused changes in community structure between 2001 and 2003.

Reductions in current regimes are modelled to less than 15% within 5 m from the edge of the scour protection of turbine foundations, and literature shows that hydrodynamic changes have been found to have only small impact on the infauna community very close to deployed hard substrate habitats. No significant impact on the infauna in the wind farm area was detectable concerning distance-related effects.

Though general reductions in the population size of some of the character species in the surveyed areas might be related to changes in the sediment structure, the infauna community at Horns Rev showed no obvious sign of stress response as a consequence of possible impact from construction and operating activities.

New species typically associated with hard substrate habitats were introduced in the infauna survey in 2003. The small crustaceans *J. marmorata* found in numbers in infauna samples probably cannot build tubes and establish themselves on the sandy bottom. Drifting organisms caught by the current at the foundations or the occurrence of small stones colonised by fouling organisms presumably caused the presence of *J. marmorata* and other fouling species found on the seabed. *J. marmorata* and other epifouling organisms were found locally dominating the community at the turbine foundations in abundances more than 300,000 individuals/m^2.

Recommendations for future monitoring programmes for benthos will emphasise sampling at the same stations in the month of September to provide further data sets on sediment, species abundance and biomass relationships.

Sammenfatning (in Danish)

ELSAM og ELTRA har etableret en havbaseret vindmøllepark med en samlet effekt på 160 MW ved Horns Rev beliggende 14-20 km ud for Blåvands Huk, Danmarks vestligste punkt. Første fase af etableringen af vindmølleparken blev påbegyndt i foråret 2002.

Overvågningsprogrammet for bundfaunaen blev gennemført i september 2003 efter vindmølleparken var sat i produktion. Basisbeskrivelser af faunaen som grundlag for nærværende overvågningsprogram blev gennemført forud for anlæggelsen af havmølleparken ved 3 undersøgelser i henholdsvis foråret 1999 samt forår og september 2001. I udvalgte referenceområder blev der foretaget undersøgelser i henholdsvis foråret 1999 og september 2001. Referenceområderne i 1999 og september 2001 var placeret i to geografisk forskellige områder som følge af, at undersøgelserne i september 2001 var planlagt til at være en del af overvågningsprogrammet for fisk. Fastlæggelsen af mulige påvirkninger som følge af etableringen af havmølleparken blev grundlæggende baseret på sammenligninger af resultater fra september 2003 og resultater fra basisbeskrivelsen af faunaen udført i september 2001.

Undersøgelsen i september 2003 inkluderede indsamling af bundprøver ved 6 vindmøllelokaliteter, i alt 18 stationer, i selve mølleparken og på 6 stationer i et udvalgt referenceområde udenfor mølleparken. Stationerne i mølleparken blev placeret langs et transekt i læretningen af hver vindmøllelokalitet, henholdsvis 5, 25 og 100 meter fra vindmøllens scour-beskyttelse.

Prøverne blev indsamlet af SCUBA-dykkere. Der blev indsamlet supplerende prøver fra samtlige stationer til bestemmelse af sedimentkarakteristika.

I laboratoriet blev prøverne til bestemmelse af artssammensætning, individtæthed og biomasse omhyggeligt sigtet gennem en 1,0 mm certificeret sigte. I alt blev der identificeret 42 arter fra Horns Rev i september 2003, hvor der blev fundet 47 arter ved den tilsvarende undersøgelse i september 2001.

Molluskerne var den mest talrige gruppe i 2003, og de udgjorde 65,2% af det totale individantal og 42,8% af den totale biomasse i mølleområdet. I undersøgelsen fra september 2001 udgjorde molluskerne 82% af den totale biomasse i området.

Den kommercielt vigtige trugmusling *Spisula solida*, som er en almindelig art i Nordsøen, udgjorde i mølleområdet 37,7% af den samlede biomasse i 2003, men 77,4% af biomassen i 2001. Papirmuslingen *Thracia phaseolina* var den fjerde hyppigste art i mølleområdet i 2003, hvor den udgjorde 2,9 % af det totale individantal.

Børsteormene var den næst hyppigste gruppe i 2003, da de udgjorde 22% af det totale individantal, men kun 2,3% af den totale biomasse i mølleområdet. I september 2001 udgjorde børsteormene 44% af individantallet i mølleområdet.

Den tredje mest talrige organisme i mølleområdet var krebsdyret *Jassa marmorata*, som ikke tidligere er registreret fra Danmark. *J. marmorata* er en typisk begroningsorganisme knyttet til hårdbundshabitater. Større krebsdyr som eremitkrebsen *Pagurus bernhardus* var den mest betydende art i relation til biomasse inden for mølleområdet i 2003.

Med hensyn til biomasse udgjorde pighuderne den fjerde største gruppe med 6% af biomassen, men kun 1% af det totale individantal.

Arter typisk for begroningssamfund blev ikke registreret i referenceområdet; men bortset herfra, og fra registreringen af nogle store individer af sværdskedemuslingen *Ensis ensis* i referenceområdet, var individtæthed- og biomasserelationerne for de dominerende arter næsten identiske for de to undersøgte områder ved Horns Rev.

Faunasammensætningen i Horns Rev området kan karakteriseres som et *Goniadella-Spisula* samfund opkaldt efter karakterarterne i samfundet.

Undersøgelsen i 2001 viste, at følgende arter på grund af en relativt ensartethed i dominansforhold kunne anvendes som indikatororganismer for miljømæssige ændringer i mølleområdet: *Pisione remota* og *Goniadella bobretzkii*, *Goodallia triangularis*, *Ophelia borealis*, *Orbinia sertulata* og *Nephtys lonogsetosa*. Skønt karakterarten *Spisula solida* dominerede biomassen, udviste denne art en mere klumpet fordeling i 2001.

I september 2003 kunne undersøgelsesområderne ligeledes karakteriseres ved tilstedeværelsen af karakterarter som børsteormen *Goniadella bobretzkii*, muslingerne *Spisula solida* og *Goodallia triangularis* på grund af dominans i enten individtæthed eller biomasse. Andre karakter- og indikatorarter, som *Ophelia borealis* og *Nephtys longosetosa,* var mindre talrige eller manglende i forhold til tidligere undersøgelser.

Den væsentligste forskel mellem undersøgelserne i 2001 og 2003 var faldet i bestanden af *Pisione remota* samt en stigning i bestanden af *Goodallia triangularis*. Tilstedeværelsen af nye arter for infauna-samfundet på Horns Rev som børsteormene *Euzonus flabelligerus* og *Polygordius appendiculatus*, der begge typisk findes i grovkornet sand, kan skyldes at sedimentforholdene er ændret i retning af et mere grovkornet sediment.

Partikelstørrelsen af sedimentet i mølleområdet steg fra 228 - 426 µm i september 2001 til 404 – 699 µm i september 2003. Det er usandsynligt, at stormhændelser, ændringer i hydrodynamiske forhold eller stærk skibstrafik under anlægsarbejdet kan have forårsaget ændringerne. Parallelt til stigningen i partikelstørrelsen inden for mølleområdet er der sket en tilsvarende stigning i referenceområdet. Det er væsentligt her at nævne, at Horns Rev området er meget dynamisk med hensyn til bundforhold, hvor der konstant sker ændringer i bundstrukturen som følge af resuspension og omlejringer af sedimentet.

En statistisk multidimensional analyse viste, at faunaen i mølleområdet i september 2001 var signifikant forskellig fra faunaen i samme område i september 2003. Der var ingen forskelle i samfundsstukturen mellem faunaen i mølleområdet og faunaen i referenceområdet i 2003, hvilket indikerer at ændringerne i samfundsstrukturen mellem 2001 og 2003 skyldes naturlig variation mere end effekter af etableringen af havmølleparken.

Modelberegninger viser en reduktionen i strømforholdene mindre end 15% inden for de nærmeste 5 m fra kanten af scour-beskyttelsen, og resultater fra andre undersøgelser viser, at ændringer i hydrodynamiske forhold som følge af udlæggelsen af hårdbundssubstrat kun har en begrænset effekt på infauna-samfundet i umiddelbar nærhed heraf. Der blev ikke konstateret nogen sammenhæng eller effekt på infauna-samfundet i mølleområdet som funktion af afstanden til møllefundamenterne.

Skønt generelle reduktioner i bestandsstørrelser for nogle af karakterarterne i de undersøgte områder muligvis kan relateres til ændringer i sedimentstrukturen, viste infauna-samfundet ved Horns Rev ingen tydelige tegn på en stressreaktion som følge af mulige påvirkninger fra anlægsarbejdet og aktiviteter i tilknytning til driftsfasen.

Nye arter, som typisk er tilknyttet hårbundssubstrater, blev introduceret i infaunaundersøgelserne i 2003. Det lille krebsdyr *J. marmorata*, som blev fundet ret talrig i prøverne fra møllefundamenterne, kan formentlig ikke bygge beboelsesrør og fastholde en bestand på den rene sandbund. Formentlig skyldes tilstedeværelsen af *J. marmorata* og andre begroningsarter, at disse er fanget og ført med strømmen fra møllefundamenterne til havbunden, eller at små sten på havbunden er koloniseret med begroningsorganismer. *J. marmorata* og andre begroningsorganismer blev fundet lokalt med tætheder større end 300.000 individer/m^2 på selve møllefundamenterne.

Anbefalinger for et fremtidigt overvågningsprogram for bundfauna omfatter prøvetagning på samme stationer i september for at tilvejebringe yderligere datasæt til analyse for sammenhænge mellem sediment og artssammensætning og biomasseforhold.

1. Introduction

ELSAM and ELTRA have established an offshore wind farm with an output of 160 MW in the waters of Horns Rev 14–20 km off Blåvands Huk, which is the most westerly point of Denmark.

The first phase of construction of the wind farm started in spring 2002. Before the construction activities took place, a baseline description of the benthos was conducted as a part of an environmental monitoring programme for the establishment of the Horns Rev Offshore Wind Farm.

The baseline surveys for the present monitoring programme were conducted in the wind farm area on three occasions: spring 1999, spring 2001 and September 2001 (ELSAM, 2000a, 2000b and 2001). In designated reference areas, surveys were conducted in spring 1999 and September 2001. The reference areas in 1999 and September 2001 were placed at two different geographical locations because the survey in September 2001 was planned to be a part of a fish monitoring programme. A comparison between the baseline study in spring 2001 and the baseline study in autumn 2001 clearly revealed that the biomass of most species increased considerably from spring to September. Despite the increase in biomass, the overall distribution of the species and their relative abundance did not change. In order to use the baseline data to investigate a possible impact after the construction of the wind farm, it was essential to arrange the monitoring programme either in spring or in September 2003, because the baseline studies were conducted in these periods. The monitoring programme was conducted in September 2003 after the wind farm had become operational, parallel with the survey on hard bottom substrates.

The impacts of the wind farm on the benthic fauna (infauna) in the area were mainly expected to be due to the alteration of the local currents. As the changes in the currents are only minor, impacts on the water chemistry and on the benthic fauna resulting from hydrodynamic causes were expected to be limited or non-existent. The main objective of the present monitoring programme was to investigate these possible changes in the benthic fauna and to compare the distribution, abundance and biomass of the indicator organisms with the results from the previous baseline surveys.

This report describes the results of the monitoring programme conducted in September 2003. To detect possible impacts of the establishment of the wind farm, the results from September 2003 was mainly compared with the results from the baseline study conducted in September 2001.

2. Methods

2.1. Field activities

All bottom samples collected around the Horns Rev Wind Farm were collected by SCUBA divers. The coordinates of the infauna localities are given in the following table (WGS 84), table 1. Actual GPS positions and actual depths at sampling dates are presented in appendix 1.

Location	"WGS84_MIN_Y"	WGS84_MIN_X"	Depth (app. M)
Turbine 26	55°28.596'	07°49.139'	8.0
Turbine 51	55°30.106'	07°50.366'	10.0
Turbine 55	55°28.910'	07°50.660'	10.4
Turbine 58	55°28.013'	07°50.881'	8.2
Turbine 73	55°29.518'	07°51.576'	9.3
Turbine 95	55°28.930'	07°52.786'	9.1
Reference 1	55°30.07'	07°46.64'	10.1
Reference 7	55°29.48'	07°47.32'	9.7
Reference 35	55°27.73'	07°53.08'	7.6
Reference 36	55°30.13'	07°53.03'	6.2
Reference 37	55°29.53'	07°53.17'	6.3
Reference 40	55°27.74'	07°53.61'	8.7

Table 1. Positions for sampling locations for infauna survey 2003.

Weather and wind conditions, as well as hydrographical data such as current direction, approximate current speed, wave height and transparency, were recorded at each sampling site. The Secchi depth was measured by lowering a white Secchi disc (diameter = 30 cm) several times until the disc became invisible. The estimated Secchi depth was adjusted for wave height according to Danish Standard DS 293.

Adjusted Secchi depth = estimated Secchi depth X (1+ 0.4 x wave height).

Depth at each sampling site was measured with an echo-sounder. Data on hydrographics and weather conditions is presented in appendix 2.

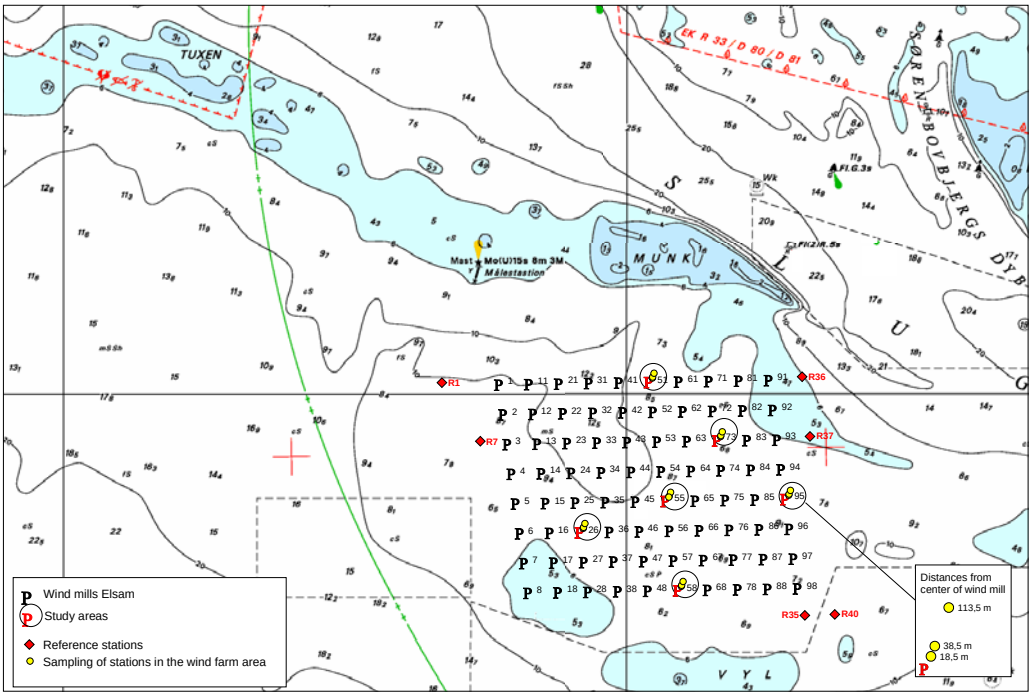


Figure 1. Map of locations sampled in September 2003.

The coordinates of turbine positions are given in appendix 1.

In September 2003, samples were collected at three stations along a transect at each of six individual turbines and at six reference stations, see figure 1. The transects were placed in the lee of the prevailing current as the impact was expected to be due to the effect of possible changes in currents by the wind turbine foundations. Samples were recovered using a core sampler of 0.0123 m^2 seabed surface area. The three stations were located at distances of 5, 25 and 100 m from the edge of the scour protection.

At each of the 24 stations, a diver collected two replicates of samples for detailed macrofaunal analysis.

The present monitoring programme was mainly compared with the baseline study from September 2001. The reference stations in 2003 were not equal to the reference stations in 2001. In 2003, the reference area was selected at stations identical to stations sampled in 1999 because results from 2001 had shown that the designated reference area in 2001 was not comparable with the wind farm area in respect of infaunal community structure.

In September 2001, samples were recovered from 9 stations at 3 wind turbine locations (55, 58 and 95), see figure 2.

Samples for identification of species composition, abundance and biomass were carefully sieved through a 1.0 mm test sieve, and the material retained was preserved in 96% ethanol, which is equivalent to approx. 80% when taking the water content of the sample into consideration.

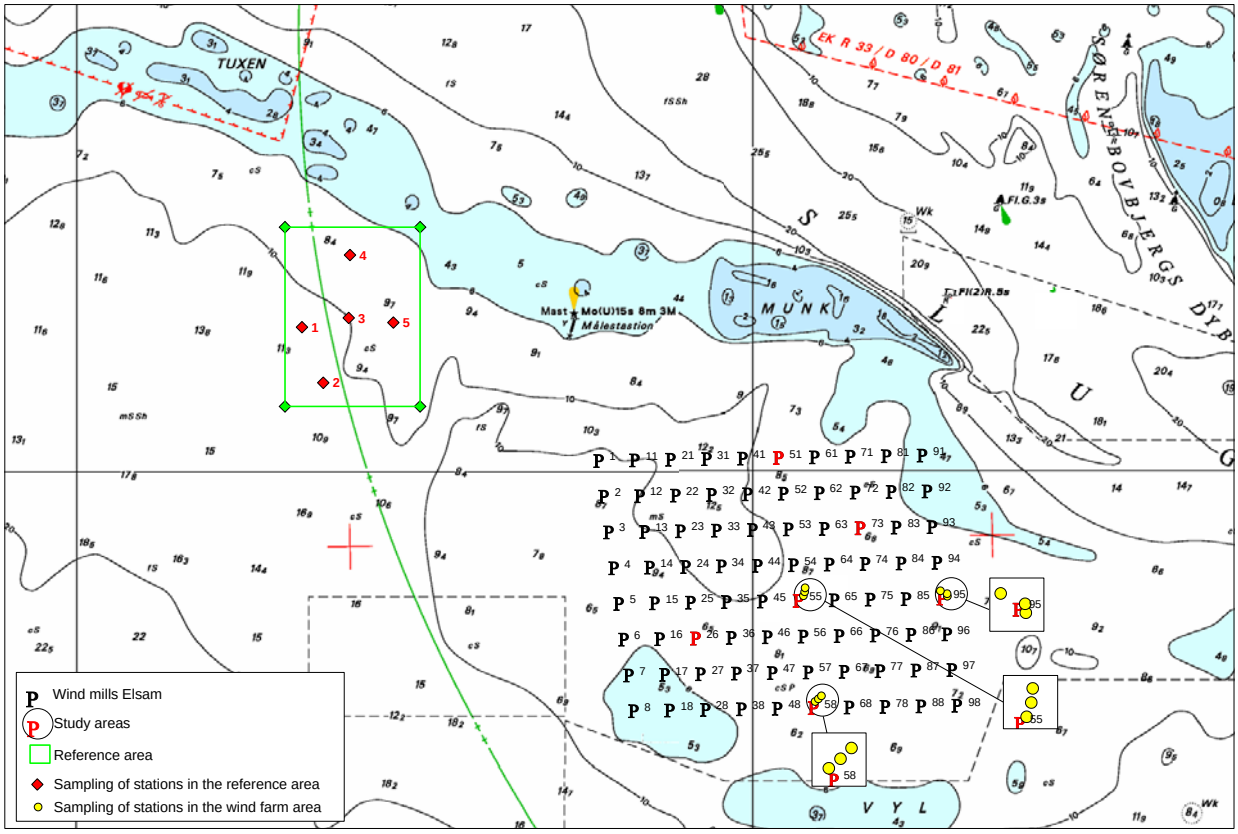


Figure 2. Map of locations sampled in September 2001. The designated reference area was not comparable with the wind farm area in respect of infaunal community structure.

At all stations, both at the wind farm site and in the reference area, an additional core sample was recovered at each station for analysis of sediment characteristics.

Video recordings were made at each sampling station as documentation of the bottom conditions.

2.2. Laboratory activities

2.2.1. Sediment characterisation

Sediment was characterised by analyses for grain size distribution, dry matter content and the amount of organic material, measured by combustion loss. Dry matter content was measured as a percentage of the wet weight. The combustion loss was measured as a percentage of the dry weight. Data are presented in appendices 3 and 4. The samples were treated according to DS 405.11 and DS 204. The sediment was washed in distilled water to remove any remaining salts, and dried at 105°C until constant weight was obtained. The sediment was pre-treated with hydrogen peroxide to remove organic material.

Grain size distribution was determined using a combination of sieve analysis and sedigraph technique. Sieve analysis was used for the sand fraction, i.e. all the material retained by a 63µ sieve according to a modified standard DS 405.9 using a total of 15 sieves.

A sedigraph 5100 was used for analysis of the silt/clay fraction, i.e. all the material passing through a 63µ sieve. The sediment was pre-treated with a 0.005 molar solution of sodium pyro phosphate and treated with an ultrasound vibrator for 5 minutes.

Cumulative percentage curves of the sieve and the sedigraph analysis data were prepared and their characteristics described by means of median particle diameter and measured as the point at which the 50% abscissa intersects the cumulative percentage curve. Results of grain size are presented in appendix 4.

On the basis of sediment statistics, a sorting index was calculated. Sediments with a sorting index less than 0.5 are characterised as well-sorted. A sorting index of 0.5–1 characterises sediments as medium-sorted, and finally, a sorting index of >1 characterises sediments as poorly sorted (modified after Folk & Ward [GEUS, 2002]).

2.2.2. Benthos

In the laboratory samples for identification of species, composition, abundance and biomass were carefully sieved through a 0.5 mm test sieve. The fauna samples were sorted under a microscope and the animals identified to the lowest possible taxon. The number of individuals and the ethanol wet weight of each taxon were determined. Abundance (ind m^{-2}) and biomass (g wet weight [ww] m^{-2}) were calculated for the total fauna.

The shell length of the mussels, i.e. the longest distance between anterior end and posterior end, and the disc diameter of the brittle stars were measured by means of electronic slide gauge.

2.3. Statistical analyses

Differences between the wind farm area and reference areas, and between survey campaigns were analysed on the basis of the combined data of sediment characteristics and species composition in terms of abundance and biomass.

Due to the nature of the sampling layout, where the reference area was moved between 2001 and 2003 to stations identical with stations surveyed in 1999, the samples were segmented into the following subsets:

1. Wind farm area: 2 campaigns (September 2001, September 2003)
2. Reference area: 2 campaigns (spring 1999, September 2003)

2.3.1. Sediment characteristics

For each subset, differences in sediment characters were analysed using a series of ANOVA. Each variable was checked for normality and homogeneity of variance. In addition, the correlations between characters were quantified using Pearson's correlation coefficient, also called *linear* or *product-moment* correlation.

For further explanation, see http://www.statsoft.com/textbook/stbasic.html#Correlations.

2.3.2. Species composition

Within each subset, differences in the species compositions between the wind farm area and the reference area, and between survey campaigns were quantified using the Bray-Curtis dissimilarity index based on root-root transformed data. Root-root transformation reduces the importance of dominating species, which gives a better reflection of the species composition based on presence/absence compared with non-transformed data.

The Bray-Curtis index is calculated as follows:

$$BC = \frac{\sum_k \left| x_{ik} - x_{jk} \right|}{\sum_k x_{ik} + \sum_k x_{jk}}$$

Where i and j are sub-samples, and k is the number of species in the sub-samples, similarity is expressed as 1 – BC. At maximum similarity, BC = 0 and at maximum dissimilarity, BC = 1.

The BC values were used for a data presentation in 2-dimensional plots using a non-metric Multidimensional Scaling (MDS) ordination. For further description of the MDS technique, see http://www.statsoft.com/textbook/stmulsca.html.

A formal test for differences between areas and campaigns was made for each subset using a non-parametric permutation procedure applied to the similarity matrix underlying the ordination. To evaluate the relative importance of the different species, the average contribution to the overall similarity within groups and the average contribution to the overall dissimilarity between groups were calculated for each species. The results are presented listing the most important species first.

To link sediment characteristics to species composition, two different approaches were used. Firstly, a dissimilarity matrix was calculated between samples based on all sediment characters using the Euclidean distance as dissimilarity measure. This matrix was tested for agreement with the dissimilarity matrix based on species composition using the weighted Spearman rank correlation, see http://www.statsoft.com/textbook/stnonpar.html#correlations.

Secondly, the same test for agreement was performed on combinations of sediment characters at steadily increasing levels of complexity to find the combination with the highest rank correlation.

No environmental criteria or identification of indicators for the impact on benthic infauna communities have been established. As a consequence of this, no power analysis was made prior to the design of the monitoring programme. The monitoring programme established for the benthic infauna is thus minimised and only major changes in the community structure can be detected.

Photo 1. The common starfish Asterias rubens *on seabed with migrating bedforms.*

3. Results

3.1. Sediment

In September 2003, the sediments in the wind farm area could generally be characterised as ***medium-fine*** sand with a median particle size of 515 µm measured as an average of the 18 stations at the 6 turbine sites. The median particle size in the same area in 2001 was 345 µm, see table 2. The particle size was found to be in the range from 228 µm to 426 µm in 2001, whereas the range in September 2003 was from 404 µm to 699 µm. The coarser sand was found at the turbine sites M26 and M58 in the western and southern part of the wind farm area. In the northern part of the wind farm area, the sea bottom apparently consists of slightly finer sediment. A statistical analysis revealed a significant ($P<0.01$) negative correlation between the depth and the median particle size in the wind farm area.

Campaign	Spring 1999	September 2001	September 2003
Average median grain size µm	370	345	515

Table 2. Average median grain size in the wind farm area found in survey campaigns from 1999 to 2003.

In the reference area, analysis has also shown a significant ($P<0.05$) negative correlation between depth and particle size. The particle size of the reference areas in 2001 and in 2003 was not compared, because new stations were selected in 2003, but a significant ($P<0.01$) positive correlation between depth and particle size was found for the designated reference area in 2001. Between 1999 and 2003 a significant ($P<0.01$) difference in median particle size was shown for the reference area. At the 6 reference stations, the average median particle size was 347 µm and 498 µm in 1999 and 2003, respectively.

No correlation was found between the particle size of sediment and the distance of sampling station to turbine foundation.

Both in the wind farm area and in the reference area, the values for sediment characteristics indicated sediments to be homogeneous and medium sorted. The general characteristic of the sediments was pure sand with an ignition loss of less than 1% (appendices 3 and 4).

3.2. Fauna

This section presents the results of the macrofaunal analysis of samples taken in the Horn Rev area within the wind farm site and in a reference area in September 2003. The faunal composition in 2003 was compared with the results from the survey in September 2001 to identify possible effects of the new environment. The development in faunal composition in the reference area between 1999 and 2003 was partly based on the result from the survey in this area in spring 1999.

The macrofauna was defined here as those animals that live in or on the seabed and are retained when sediments are washed on a 1 mm mesh. Where soft sediments occur, the animals are principally infaunal, either burrowing through the sediment or constructing tubes within it. As the sediment provides support and protection, as well as the food source for many species, members of the infauna are particularly vulnerable to external influences, which alter their chemical, physical or biological nature.

As infauna animals are largely sedentary in habit, they are unable to avoid unfavourable conditions. As each species has its own response and degree of sensitivity to changes in various environmental factors, the species composition and relative abundance to the community in a particular location provide a reflection of the environment there, both current and historical.

Previous studies in the Horns Rev area have revealed that the main characteristics of the faunal composition in the area can be described as an *Ophelia borealis* community, or more commonly accepted as the *Goniadella-Spisula* community, named after one or more of the characteristic and important species in the area (ELSAM, 2001). The studies also have shown that the area is very heterogeneous with regards to the faunal composition and that the number of species, density of individuals and biomass of the benthic fauna can vary greatly within the area as also shown for the survey in 2003, see figures 3 and 4.

Photo 2. Fringes of tubes of the bristle worm Lanice conchilega *and shells of the razor shell* Ensis ensis.

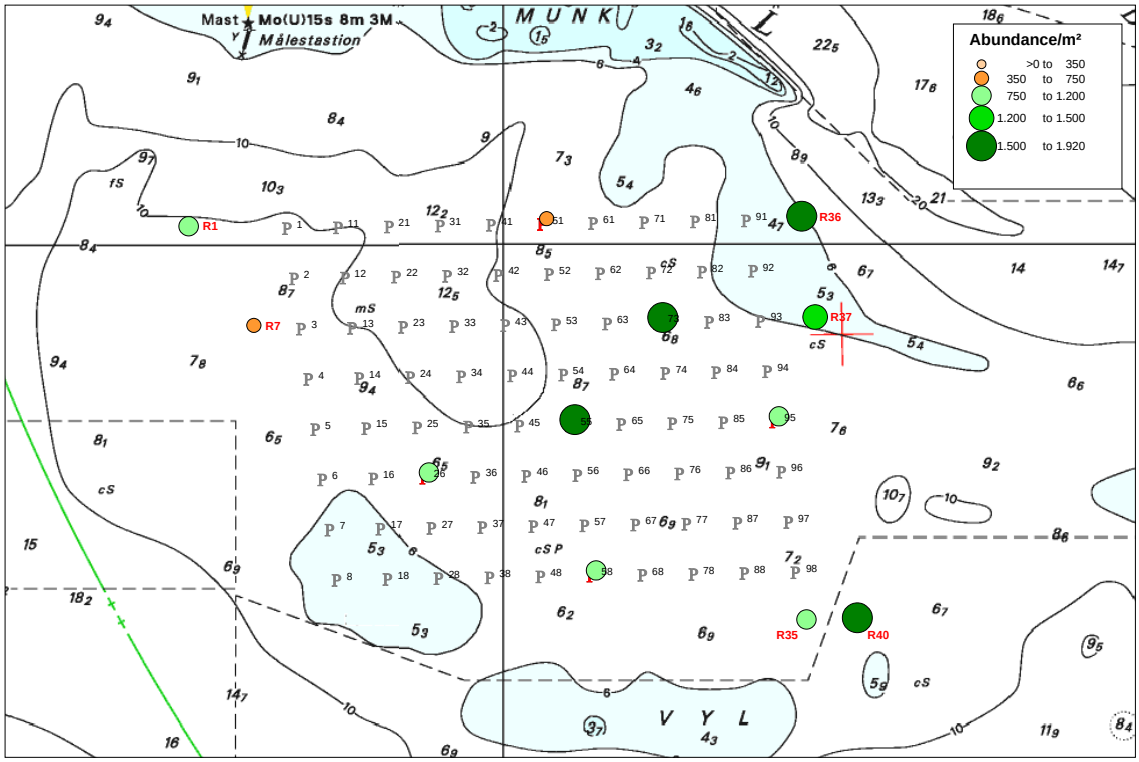


Figure 3. Distribution pattern of total abundance in September 2003, shown as average abundance for the three stations at each turbine site.

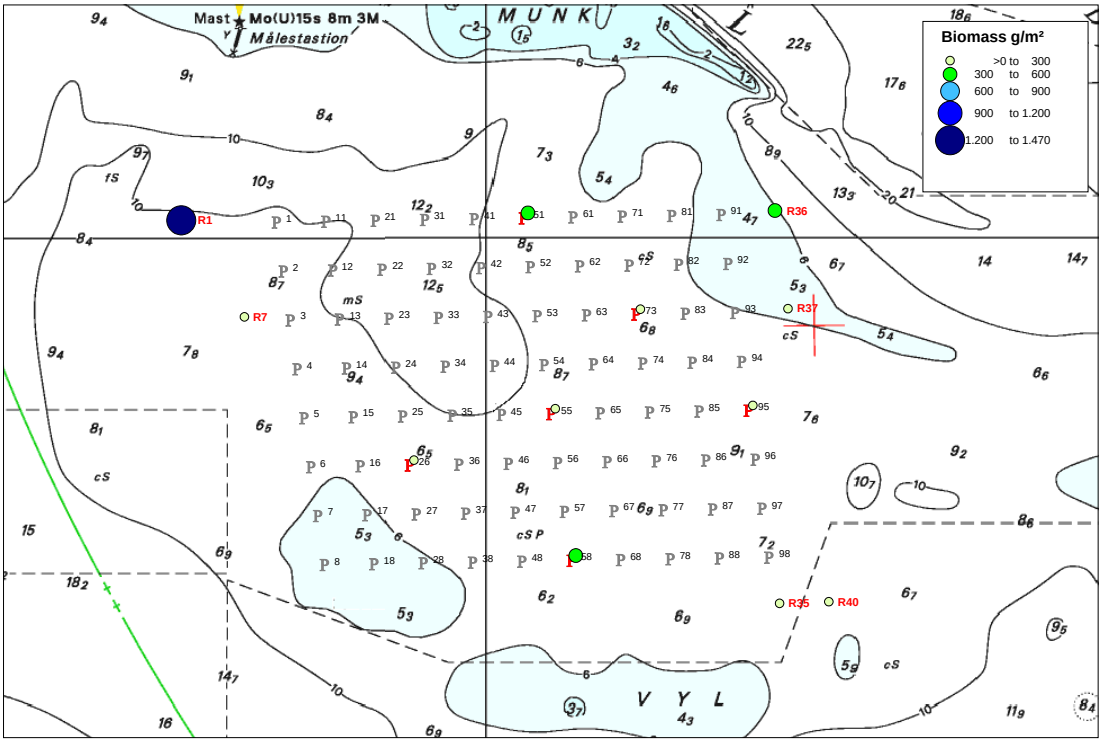


Figure 4. Distribution pattern of total biomass in September 2003, shown as average biomass for the three stations at each turbine site.

A total of 42 species were identified from the surveys in the Horn Rev area in September 2003, whereas 47 species were recorded in the survey in September 2001 (Elsam, 2001).

The phyletic composition in 2003 showed that a total of 21% of the species (9 crustaceans of 42 species) were crustaceans representing 6.5% of the total abundance and 36% of the biomass. A full list of species enumerated from the survey in September 2003 is given in appendix 5.

The most abundant species found in 2003 are listed in table 3 and the most dominant species in terms of biomass are listed in table 4.

Abundance, number/m²		Sampling area			
		Wind Farm area		Reference area	
		2003		2003	
		Campaign		Campaign	
		Autumn		Autumn	
Species	Group	Mean abundance	Relative abundance%	Mean abundance	Relative abundance%
Goodallia triangularis	Bivalve	664.0	58.3	630.1	53.8
Goniadella bobretzkii	Bristle worm	146.8	12.9	149.1	12.7
Thracia phaseolina	Bivalve	36.1	3.2	33.9	2.9
Ensis ensis	Bivalve	.	.	61.0	5.2
Spio filicornis	Bristle worm	20.3	1.8	40.7	3.5
Branchiostoma lanceolatum	Chordata	27.1	2.4	27.1	2.3
Spisula solida	Bivalve	20.3	1.8	27.1	2.3
Jassa marmorata	Crustacean	40.7	3.6	.	.
Pisione remota	Bristle worm	22.6	2.0	13.6	1.2
Travisia forbesii	Bristle worm	9.0	0.8	20.3	1.7
Nephtys sp,	Bristle worm	15.8	1.4	13.6	1.2
Pontocrates arenarius	Crustacean	6.8	0.6	20.3	1.7
Ophelia borealis	Bristle worm	11.3	1.0	13.6	1.2
Orbinia sertulata	Bristle worm	9.0	0.8	13.6	1.2
Total		**1,029.8**	**90.5**	**1,063.7**	**90.8**

Table 3. Mean abundance of the most abundant species found in the wind farm and reference area in September 2003.

Biomass, wet weight g/m²		Sampling area			
		Wind Farm area		Reference area	
		2003		2003	
		Campaign		Campaign	
		Autumn		Autumn	
Species	Group	Mean biomass	Relative biomass%	Mean biomass	Relative biomass%
Ensis ensis	Bivalve	.	.	240,718	67,1
Spisula solida	Bivalve	62,580	33,7	77,699	21,7
Pagurus bernhardus	Crustacean	66,644	35,9	13,311	3,7
Actiniaria indet,	Anthozoan	22,482	12,1	.	.
Thracia phaseolina	Bivalve	7,203	3,9	9,458	2,6
Asterias rubens	Echinoderm	10,974	5,9	.	.
Polinices polianus	Gastropod	7,881	4,2	2,376	0,7
Ophelia borealis	Bristle worm	0,299	0,2	6,654	1,9
Goodallia triangularis	Bivalve	1,504	0,8	1,794	0,5
Ophiura ophiura	Echinoderm	.	.	3,169	0,9
Orbinia sertulata	Bristle worm	1,834	1,0	0,614	0,2
Crangon crangon	Crustacean	.	.	1,165	0,3
Travisia forbesii	Bristle worm	0,725	0,4	0,259	0,1
Branchiostoma lanceolatum	Chordata	0,712	0,4	0,078	0,0
Goniadella bobretzkii	Bristle worm	0,555	0,3	0,068	0,0
Total		**183,392**	**98,9**	**357,362**	**99,6**

Table 4. Biomass of the most dominant species found in the wind farm and reference area in September 2003.

The most common species in the Horns Rev area are fairly uniformly distributed in both the wind farm area and in the reference area, see table 2. The cumulative percentage abundance of the most common species as an indicator of community domination by few taxa was high in both areas.

In the survey from September 2001, crustaceans representing 38% of the species (18 crustaceans of 47 species) and 14.7% of the total abundance was also found to dominate the phyletic composition.

The most dominant species found in all of the infauna surveys from 1999 to 2003 are shown in tables 5 and 6, representing between 62% and 82.5% of the total abundance and between 28.5% and 82.8% of the total biomass registered in the individual surveys.

Abundance, number/m²		Sampling area							
		Wind Farm area				Reference area			
		2001		2003		1999		2003	
		Campaign		Campaign		Campaign		Campaign	
		Autumn		Autumn		Spring		Autumn	
Species	Group	Mean	Relative %	Mean	Relative %	Mean	Relative %	Mean	Relative %
Goodallia triangularis	Bivalve	203.3	10.9	664.0	58.3	237.1	9.2	630.1	53.8
Pisione remota	Bristle worm	411.0	22.0	22.6	2.0	691.1	26.7	13.6	1.2
Goniadella bobretzkii	Bristle worm	189.7	10.1	146.8	12.9	338.8	13.1	149.1	12.7
Hydractinia echinata	Hydrozoan	225.8	12.1	2.3	0.2	13.6	0.5	6.8	0.6
Ophelia borealis	Bristle worm	72.3	3.9	11.3	1.0	149.1	5.8	13.6	1.2
Spio filicornis	Bristle worm	90.3	4.8	20.3	1.8	27.1	1.0	40.7	3.5
Spisula solida	Bivalve	36.1	1.9	20.3	1.8	33.9	1.3	27.1	2.3
Nemertini indet.	Nemertinean	27.1	1.4	4.5	0.4	40.7	1.6	13.6	1.2
Pontocrates arenarius	Crustacean	4.5	0.2	6.8	0.6	47.4	1.8	20.3	1.7
Branchiostoma lanceolatum	Chordata	9.0	0.5	27.1	2.4	6.8	0.3	27.1	2.3
Polinices polianus	Gastropod	9.0	0.5	11.3	1.0	6.8	0.3	6.8	0.6
Pagurus bernhardus	Crustacean	4.5	0.2	2.3	0.2	13.6	0.5	6.8	0.6
Total		**1,282.7**	**68.6**	**939.5**	**82.5**	**1,605.7**	**62.0**	**955.3**	**81.5**

Table 5. The most dominant species found in the wind farm and reference area in all infauna surveys from 1999 to 2003.

Biomass, wet weight g/m²		Sampling area							
		Wind Farm area				Reference area			
		2001		2003		1999		2003	
		Campaign		Campaign		Campaign		Campaign	
		Autumn		Autumn		Spring		Autumn	
Species	Group	Mean	Relative %	Mean	Relative %	Mean	Relative %	Mean	Relative %
Spisula solida	Bivalve	231.883	77.4	62.580	33.7	15.413	7.3	77.699	21.7
Pagurus bernhardus	Crustacean	4.503	1.5	66.644	35.9	76.295	36.1	13.311	3.7
Ophelia borealis	Bristle worm	7.405	2.5	0.299	0.2	27.560	13.0	6.654	1.9
Polinices polianus	Gastropod	3.210	1.1	7.881	4.2	0.035	0.0	2.376	0.7
Goodallia triangularis	Bivalve	0.542	0.2	1.504	0.8	0.904	0.4	1.794	0.5
Hydractinia echinata	Hydrozoan	0.000	0.0	0.064	0.0	1.331	0.6	0.001	0.0
Branchiostoma lanceolatum	Chordata	0.080	0.0	0.712	0.4	0.348	0.2	0.078	0.0
Goniadella bobretzkii	Bivalve	0.184	0.1	0.555	0.3	0.245	0.1	0.068	0.0
Spio filicornis	Bristle worm	0.208	0.1	0.068	0.0	0.234	0.1	0.051	0.0
Pisione remota	Bristle worm	0.035	0.0	0.078	0.0	0.174	0.1	0.003	0.0
Pontocrates arenarius	Crustacean	0.004	0.0	0.035	0.0	0.079	0.0	0.030	0.0
Nemertini indet.	Nemertinean	0.038	0.0	0.002	0.0	0.078	0.0	0.019	0.0
Total		**248.093**	**82.8**	**140.422**	**75.7**	**122.696**	**58.1**	**102.085**	**28.5**

Table 6. The most dominant species in terms of biomass found in the wind farm and reference area in all infauna surveys from 1999 to 2003.

New species not previously registered for the infaunal community in the wind farm area at Horns Rev are shown in table 7.

New species		Wind Farm area			
		2003		2003	
		Abundance, number/m²		Biomass, wet weight g/m²	
Species	Group	Mean	Relative %	Mean	Relative %
Jassa marmorata	Crustacean	40,7	3,6	0,016	0,0
Caprella linearis	Crustacean	9,0	0,8	0,017	0,0
Asterias rubens *	Echinoderm	6,8	0,6	10,974	5,9
Arenicola marina	Bristle worm	4,5	0,4	0,218	0,1
Echinocyamus pusillus	Echinoderm	4,5	0,4	0,259	0,1
Crepidula fornicata	Gastropod	2,3	0,2	0,069	0,0
Liocarcinus pusillus	Crustacean	2,3	0,2	0,177	0,1
Tubularia indivisa	Hydrozoan	2,3	0,2	0,022	0,0
Total		**72,3**	**6,3**	**11,752**	**6,3**

*Table 7. New species for the infaunal community in the wind farm area. Species marked with * have previously been observed in the area.*

Molluscs (Bivalvia & Gastropoda)

The molluscs were the most abundant group in 2003 because they constituted 65.2% of the average number of individuals and 42.8% of the average biomass per m^2. In 2001, the molluscs represented 82% of the total biomass in the area. The molluscs group includes both bivalves and gastropods, but the gastropods only constituted 0.5% of the total number of individuals and 1.1% of the total biomass.

In terms of abundance, the small bivalve *Goodalia triangularis* was the most numerous species representing 57% of the total individuals found, but only less than 1% of the total biomass. The abundance distribution pattern for *G. triangularis* is shown in figure 5. In 2001, this species was also one of the most abundant species in the area.

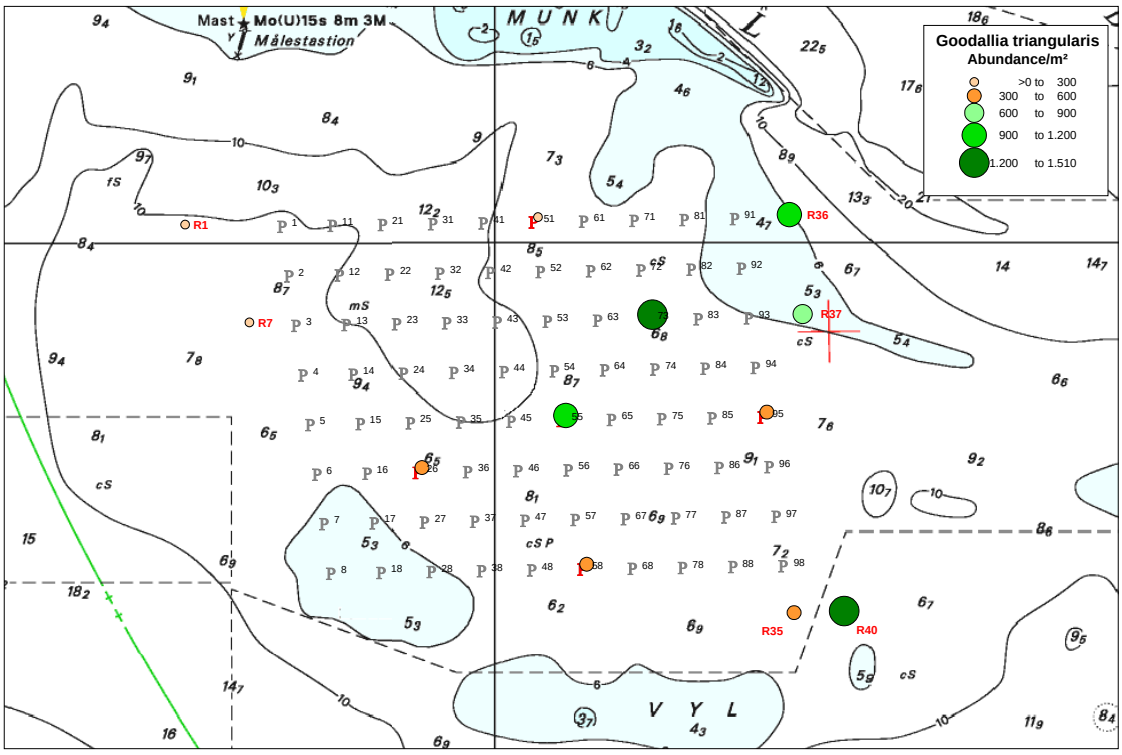


Figure 7. Abundance of the bivalve Goodallia triangularis *shown as average for the three stations at each turbine site.*

The commercially important bivalve *Spisula solida*, which is a common species in the North Sea, constituted 33.7% of the biomass in the wind farm area in 2003, but 77.4% of the biomass in the survey from September 2001.

In the wind farm area, *S. solida* was found on an average of 20.3 individuals or 62.6 g per m^2 in 2003 and 27.1 individuals or 77.7 g per m^2 in the reference area. In 2001, *S. solida* was found on an average of 36 individuals or 231.9 g per m^2. The average shell length of *S. solida* decreased from 27.0 mm in 2001 to 12.6 mm in 2003, whereas the maximal shell length found was approximately equal at 37.4–40.0 mm in 2001 and 2003, respectively.

The bivalve *Thracia phaseolina* was the fourth most abundant species in the wind farm area, where it constituted 2.9% of the abundance. It was the fifth most abundant species at the reference stations, where it constituted 3.2% of the number of individuals per m^2.

The distribution pattern of the mussels *Spisula solida* and *Thracia phasseolina* is shown in figures 6 and 7.

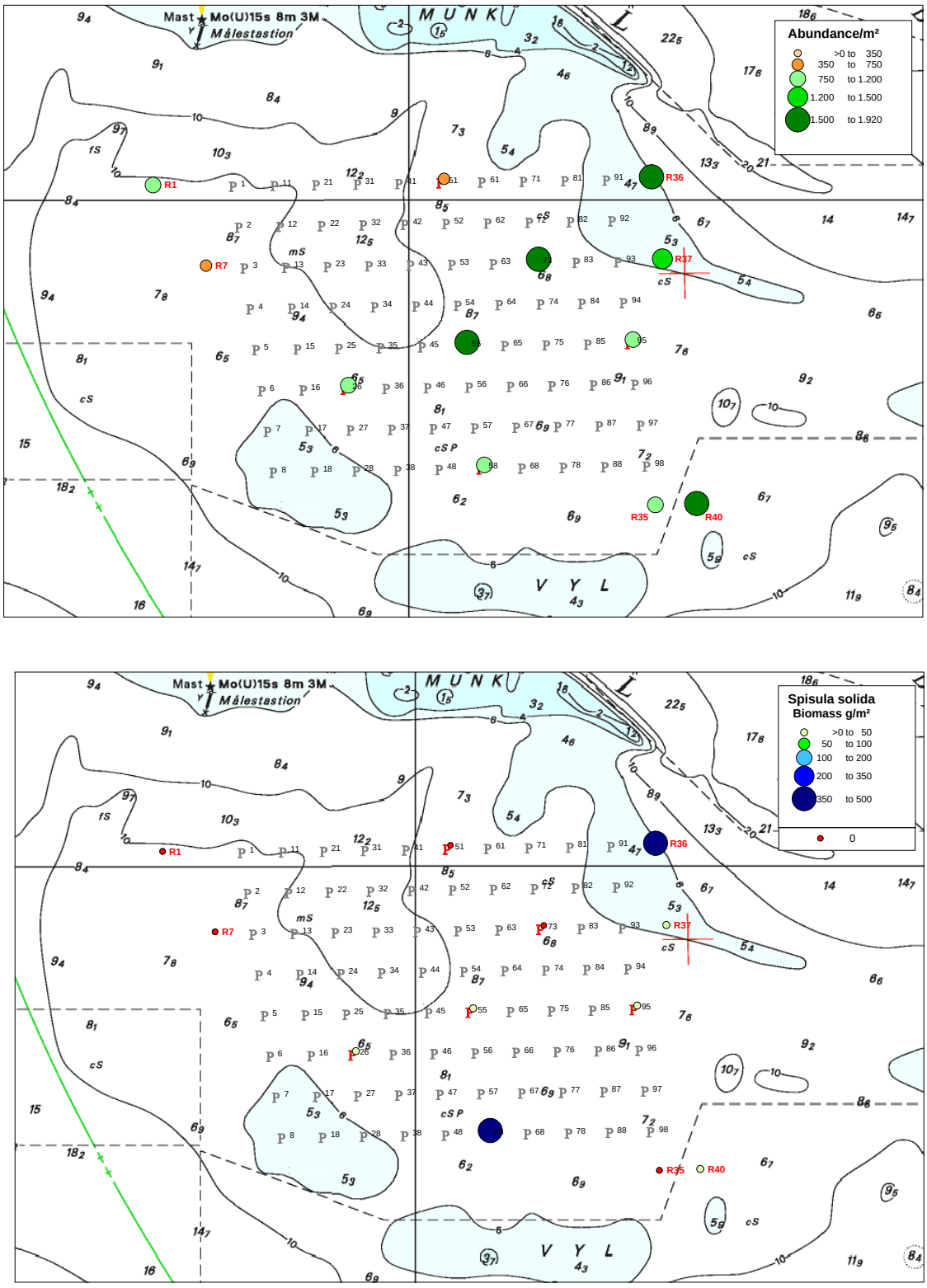


Figure 6. Abundance and biomass distribution of the mussel Spisula solida, *shown as average for the three stations at each turbine site.*

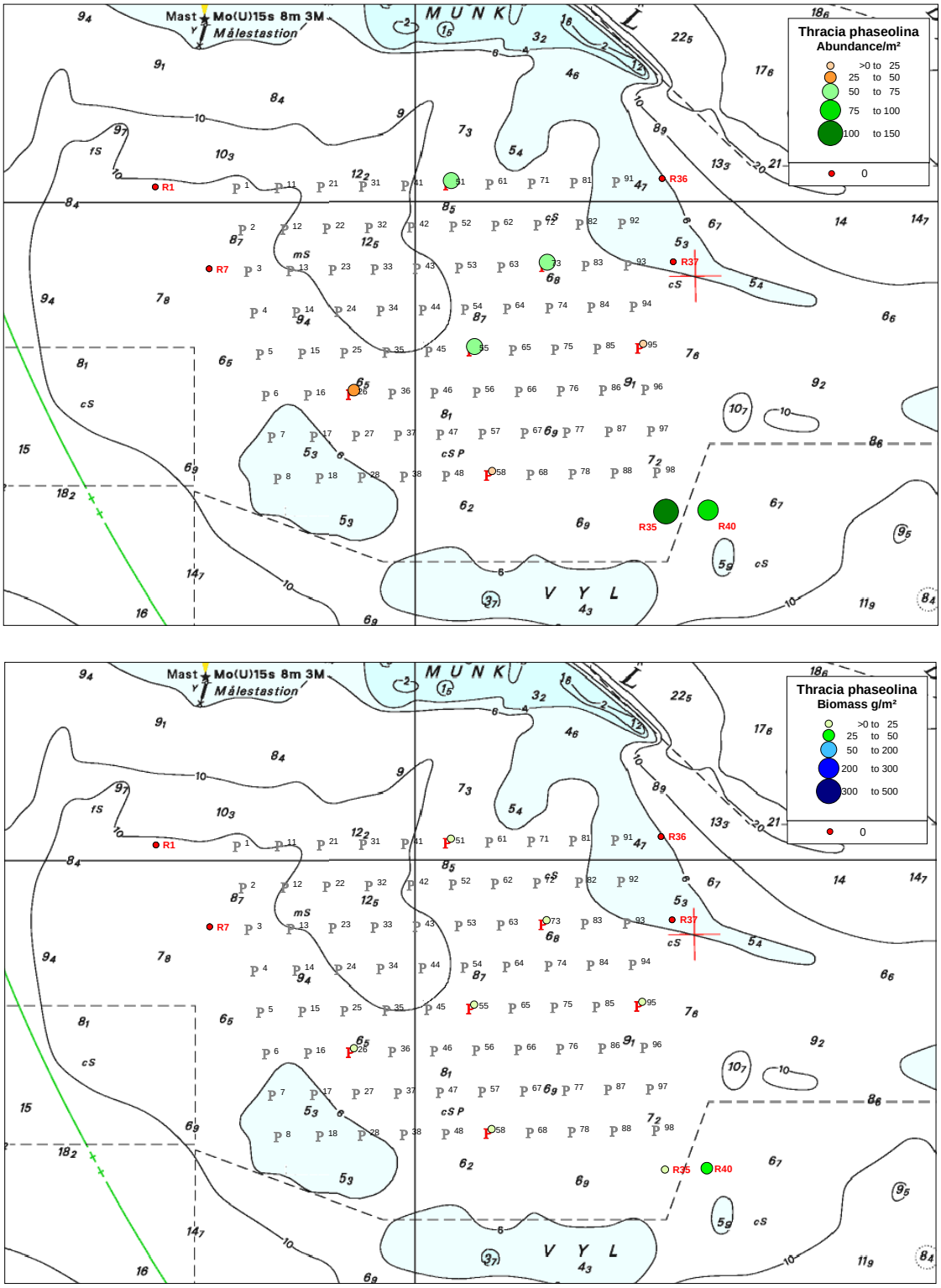


Figure 7. Abundance and biomass of the mussel Thracia phaseolina, *shown as average for the three stations at each turbine site.*

In 2003, two subsamples from reference station number 1 contained nine adult specimens of the common razor shell *Ensis ensis*, representing a weight of 35.5 g. Compared with the biomass of the other organisms, *E. ensis* constituted 67% of the total biomass at the reference stations. *E. ensis* was not found at any other stations in the wind farm area during the survey and was not previously found in samples from the Horns Rev area, although shells of this

species were observed in numbers. Despite the high biomass of *E. ensis*, this single finding at reference station number 1 of nine specimens should not be interpreted as an important attribute to the species composition.

Apart from the presence of *E. ensis* at the reference stations, similar species were among the most abundant and with the highest biomass in the wind farm area and at the reference stations, see tables 3 and 4.

A single specimen of the slipper limpet *Crepidula fornicata* not previously recorded from the infaunal community, see table 7, was found at a distance 100 m from one wind turbine. The slipper limpet was commonly found in the survey on the scour protections (Elsam Engineering, 2004).

Bristle worms (Polychaeta)
The bristle worms were the second most abundant group as they constituted 22% of the number of individuals per m^2 and 2.3% of the biomass per m^2. In the survey from September 2001, the bristle worms constituted 44% of the individuals per m^2 in the wind farm.

The small bristle worm *Goniadella bobretzkii*, see figure 8, was the most abundant of all bristle worms and one of the dominant species in both the wind farm area and in the reference area, representing 13% of the individuals, but less than 0.5% of the total biomass. Another small bristle worm, *Pisione remota*, which dominated in 2001 with a relative abundance of 22%, was much less numerous in 2003, only representing 2% of the total number of individuals.

In the survey from 2001, these two species constituted 33% of the average abundance.

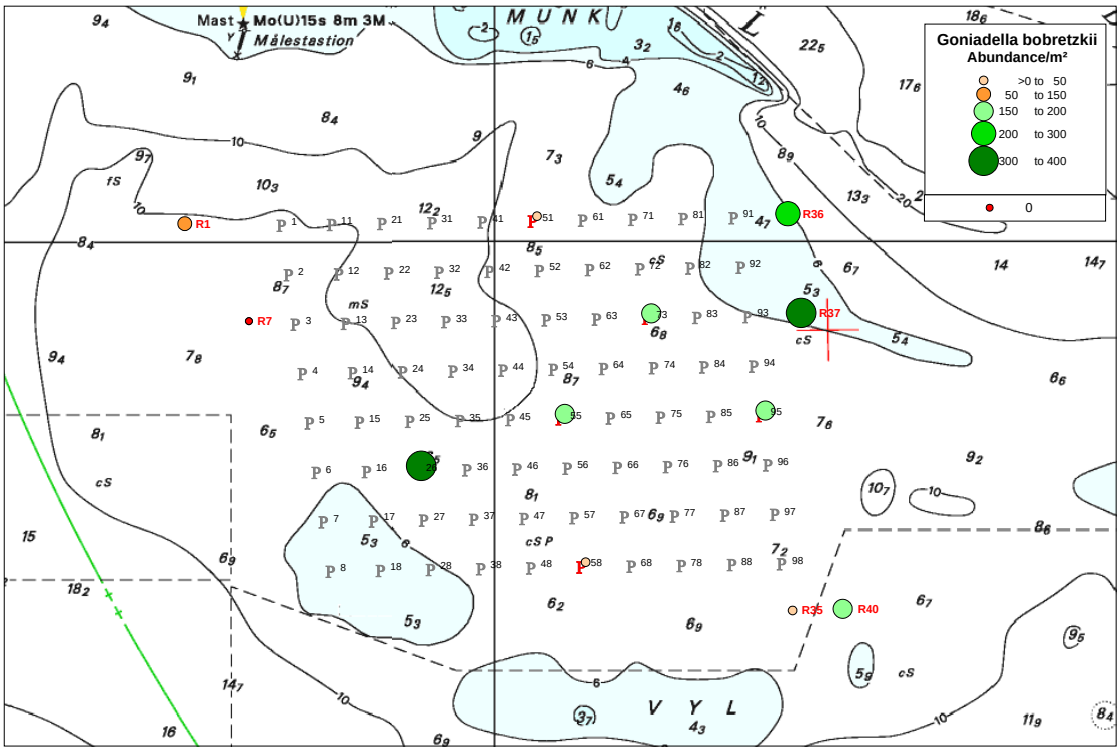


Figure 8. Abundance of the bristle worm Goniadella bobretzkii, *shown as average for the three stations at each turbine site.*

The bristle worm *Ophelia borealis*, a character species for the community, decreased in abundance from 2001 to 2003 in both the wind farm area and the reference area. In 2003, it constituted less than 1% of the abundance, whereas it constituted 3.9% in 2001. An average of 11.3 individuals or 0.3 g per m^2 was recorded in 2003. In 2001, an average abundance of 72.3 individuals or 7.4 g per m^2 was recorded. The abundance pattern of *Ophelia borealis* is shown in figure 9.

The familiar lugworm *Arenicola marina*, see table 7, a widely distributed infaunal species on all coasts in North-West Europe, has not previously been recorded in the Horns Rev area.

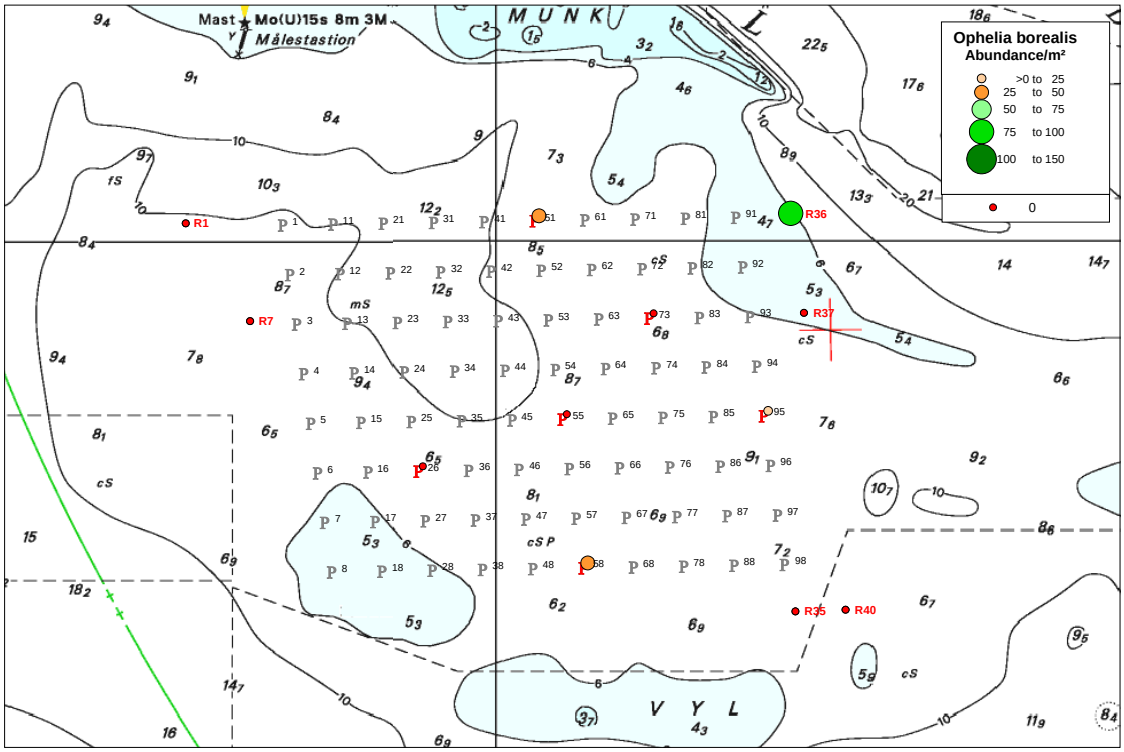


Figure 9. Abundance of the bristle worm Ophelia borealis*, shown as average for the three stations at each turbine site.*

Crustaceans (Crustacea)

The third most abundant species in the wind farm area was the crustacean *Jassa marmorata*. This species was not found at the reference stations at all. *J. marmorata* is an important fouling organism, which builds tubes among solid structures. High abundances of *J. marmorata* were found at the scour of the turbines and at the turbine itself (Elsam Engineering, 2004). In the infauna survey, *J. marmorata* was found in samples 5, 25 and 100 metres from the solid structure of the scour. It was found at five of the six turbine sites, at two of which it was most abundant close to the scour protection. *J. marmorata* has not previously been recorded in Denmark.

The skeleton shrimp *Caprella linearis* is also a typical fouling organism not previously found in the infauna surveys at Horns Rev, see table 7.

Larger crustaceans such as the hermit crab *Pagurus bernhardus* were the most important species with respect to biomass in the wind farm area in 2003. *P. bernhardus* has adapted to live

in gastropod shells, and growing crabs move to progressively larger shells. The biomass of this species was based on one large specimen with a total weight of 29.5 g caught at turbine site 51. A single specimen was also found in the reference area. Despite the high biomass, the presence of this single specimen was considered a coincidence without significant importance to the overall interpretation of the faunal distribution.

The swimming crab *Liocarcinus pusillus* has not previously been recorded from samples in the infauna surveys, although other species of swimming crabs have been observed in the wind farm area.

Other species
With respect to biomass, the echinoderms were the fourth most important group with 6% of the biomass per m^2, representing only 1% of the number of individuals. The small sea urchin *Echinocyamus pusillus*, one of the character species of coarse sand habitats in the North Sea area, and the common starfish *Asterias rubens* have not previously been recorded in the infauna samples from the wind farm area. *Asterias rubens* was previously commonly observed in the survey area.

The hydrozoan *Tubularia indivisa* is a typical species from exposed hard substrata and was found as one of the dominant species at the scour protections (Elsam Engineering, 2004). In the infauna survey, it was found in low abundance on small stones or shells 100 m from one of the turbine foundations.

3.2.1. Results of the survey in September 2001
The ten most abundant taxa recorded in the wind farm area in September 2001 are listed in tables 8 and 9, along with their cumulative percentage of dominance. The number of species recorded at the individual stations in the wind farm area in September was fairly uniform and varied between 9 and 15. The abundance and the biomass varied from 772 to 4,797 individuals/m^2 and from 2 to 436 g wet weight/m^2, respectively. There was apparently no general tendency or difference in the distribution of the benthos in the area.

Number of individuals/m²		2001				Total	
		Wind farm area		Reference		Average	Dominance%
		Average	Dominance%	Average	Dominance%		
Pisione remota	Bristle worm	411.02	22.0%	853.66	44.1%	632.34	33.2%
Goodallia triangularis	Bivalve	203.25	10.9%	89.43	4.6%	146.34	7.7%
Goniadella bobretzkii	Bristle worm	189.70	10.1%	56.91	2.9%	123.31	6.5%
Spio filicornis	Bristle worm	90.33	4.8%	56.91	2.9%	73.62	3.9%
Ophelia borealis	Bristle worm	72.27	3.9%	56.91	2.9%	64.59	3.4%
Thracia phaseolina	Bivalve	45.17	2.4%	56.91	2.9%	51.04	2.7%
Spisula solida	Bivalve	36.13	1.9%	48.78	2.5%	42.46	2.2%
Cyclopoida indet.	Crustacean	36.13	1.9%	.	.	36.13	.9%
Arctica islandica	Bivalve	31.62	1.7%	.	.	31.62	.8%

Table 8. Abundance of benthos at the stations at Horns Rev, September 2001.

Biomass mg (wet weight)/m^2		2001				Total	
		Wind farm area		Reference		Average	Dominance%
		Average	Dominance%	Average	Dominance%		
Spisula solida	Bivalve	231.883	77.4%	130.703	91.6%	181.293	82.0%
Balanus sp.	Crustacean	37.229	12.4%	.	.	37.229	8.4%
Thracia phaseolina	Bivalve	10.004	3.3%	1.048	.7%	5.526	2.5%
Ophelia borealis	Bristle worm	7.405	2.5%	3.093	2.2%	5.249	2.4%
Pagurus bernhardus	Crustacean	4.503	1.5%	.	.	4.503	1.0%
Polinices polianus	Gastropod	3.210	1.1%	.497	.3%	1.853	.8%
Gastrosaccus spinifer	Crustacean	2.363	.8%	.214	.1%	1.288	.6%
Nephtys longosetosa	Bristle worm	.940	.3%	.	.	.940	.2%
Branchiostoma lanceolatum	Chordata	.080	.0%	.901	.6%	.491	.2%

Table 9. Biomass (wet weight) at the stations at Horns Rev, September 2001.

3.3. Statistics

The use of multivariate techniques condenses large data matrices such as the list of species into a much more manageable form, and compares data from each station and each survey with all other data in the process. This means that subtle trends in the data as a whole may be elucidated by multivariate analyses.

Possible impact of the establishment of the wind farm on the infauna is measured as differences in community structure between the reference area and the wind farm area. A statistical multidimensional scaling (MDS) analysis using both abundance and biomass of each species from the two replicates at the 18 stations in the wind farm and at the six stations in the reference area in September 2003 showed no significant difference. The similarity between the wind farm and the reference area in 2003 strongly indicated that the establishment of the wind farm had no impact on abundance or biomass of the infaunal community at Horns Rev.

In term of abundance, using a SIMPER and ANOSIM statistical analysis, a significant difference in community structure was found in the wind farm area between September 2001 and September 2003, see table 10. A significant difference was also found if the same analysis was performed using biomass instead of abundance to express community structure. Significant differences were also found in community structure between the wind farm area in September 2001 and the reference area in September 2003, and in community structure in the reference area between 1999 and 2003.

ANOSIM analysis	1999	2001	2003
	Reference	Wind farm	Reference
2003, Reference	P<0.1%	P<0.1%	
2003, Wind farm		P<0.1%	P=15.5%

Table 10. Level of significance in analysis of differences in community structure between different surveys and sample sites.

The SIMPER test is an analysis of the species contributions to dissimilarity. The following tables 11–13 list the highest contributions to the difference between the community structure in September 2001 and 2003.

Species	Abundance 2001 ind./m^2	Abundance 2003 ind./m^2	Contribution to dissimilarity (%)
Pisione remota	411.02	22.58	10.96
Goodallia triangularis	203.25	663.96	6.90
Goniadella bobretzkii	189.70	146.79	6.66
Nematoda indet,	121.95	4.52	6.31
Ophelia borealis	72.27	11.29	5.60
Thracia phaseolina	45.17	36.13	5.32
Spio filicornis	90.33	20.33	5.10
Spisula solida	36.13	20.33	4.54
Mytilus edulis	49.68	6.78	3.39
Branchiostoma lanceolatum	9.03	27.10	3.32
Nemertini indet,	27.10	4.52	2.61
Arctica islandica	31.62	0.00	2.00
Polinices polianus	9.03	11.29	1.98

Table 11. The species contributing to the highest dissimilarity in community structure between the wind farm area in September 2001 and in 2003.

Species	Abundance 2001 ind./m^2	Abundance Reference area 2003 ind./m^2	Contribution to dissimilarity (%)
Pisione remota	411.02	13.55	10.48
Goodallia triangularis	203.25	630.08	7.64
Goniadella bobretzkii	189.70	149.05	7.28
Nematoda indet,	121.95	0.00	6.01
Spio filicornis	90.33	40.65	5.38
Ophelia borealis	72.27	13.55	5.34
Thracia phaseolina	45.17	33.88	5.32
Spisula solida	36.13	27.10	4.41
Mytilus edulis	49.68	13.55	3.35

Table 12. The species contributing to the highest dissimilarity in community structure between the wind farm area in September 2001 and the reference area in 2003.

Species	Abundance 2003 ind./m^2	Abundance Reference area 2003 ind./m^2	Contribution to dissimilarity (%)
Goodallia triangularis	663.96	630.08	11.52
Goniadella bobretzkii	146.79	149.05	9.85
Thracia phaseolina	36.13	33.88	6.32
Spio filicornis	20.33	40.65	6.13
Spisula solida	20.33	27.10	4.84
Branchiostoma lanceolatum	27.10	27.10	4.83
Pisione remota	22.58	13.55	4.08
Nephtys sp,	15.81	13.55	3.88
Pontocrates arenarius	6.78	20.33	3.81
Travisia forbesii	9.03	20.33	3.38
Ensis ensis	0.00	60.98	3.08

Table 13. The species contributing to the highest dissimilarity in community structure between the wind farm area in September 2003 and the reference area in 2003.

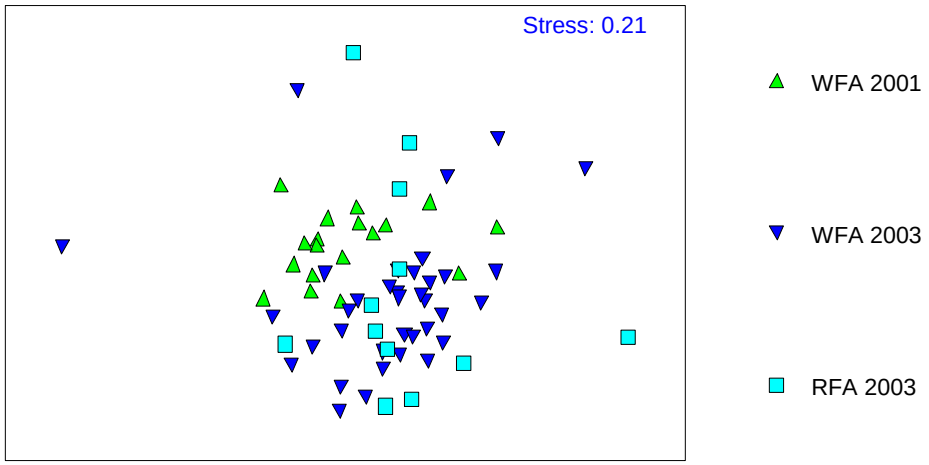


Figure 11. A multidimensional scaling (MDS) plot of the abundance of each species in the wind farm area (WFA) in September 2001,September 2003 and in the reference area (RFA) in September 2003.

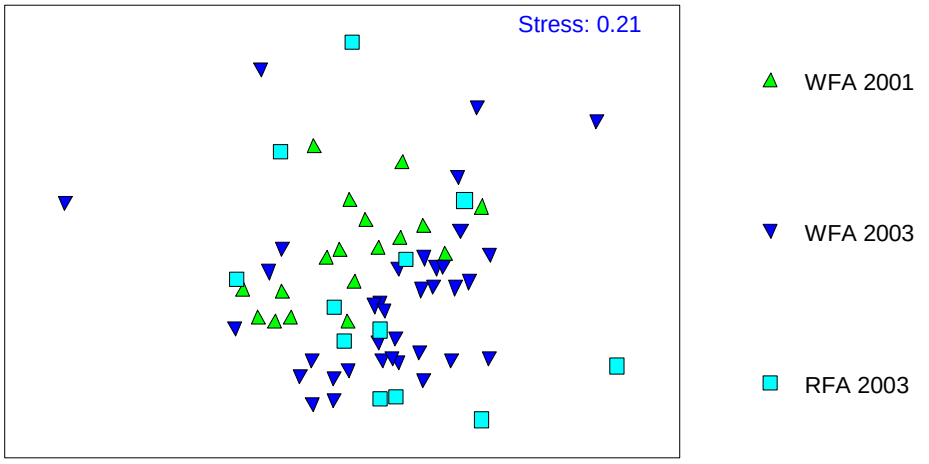


Figure 12. A multidimensional scaling (MDS) plot of the biomass of each species in the wind farm area (WFA) in September 2001, September 2003 and in the reference area (RFA) in September 2003.

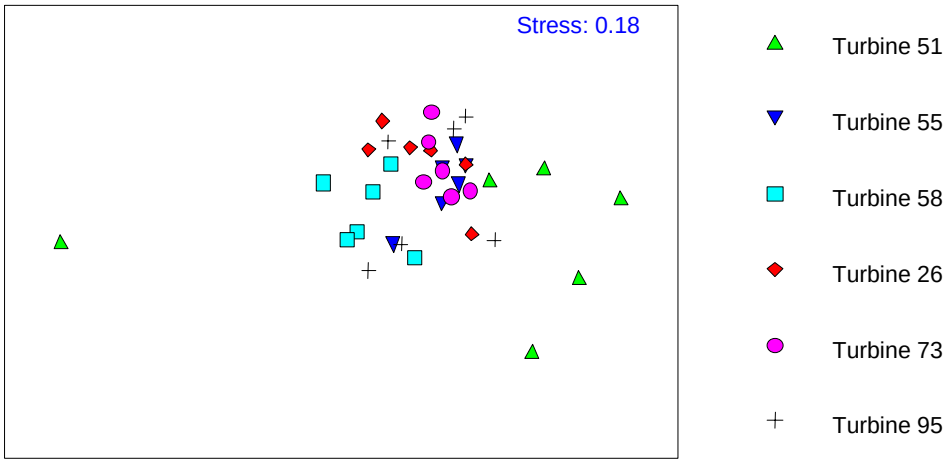


Figure 13. A multidimensional scaling (MDS) plot of the abundance of each species at turbine sites in September 2003.

At each turbine site, three stations were selected along a transect 5, 25 and 100 metres from the edge of the scour protection. A statistical analysis of the effect of distance showed no significant differences between the benthos communities related to the distance from the wind turbine foundations. A similar community structure was present 5, 25 and 100 metres from the foundation.

In September 2003, the community structure at each of the individual six turbines was investigated using multidimensional scaling. The MDS test revealed that the samples from turbine 51 varied from the other samples, see figure 13, mainly because *Pisione remota* and *Spisula solida* were absent from the three stations at turbine site 51, see appendix 6.4. The individual distances between each station on the MDS plot represent the relative difference between the stations. In figure 13, the samples from turbines 55, 58, 26, 73 and 95 are grouped, whereas the six samples from turbine 51 are placed outside.

3.3.1. Sediment

The sediment characteristics were clearly different in the wind farm area in September 2001 and 2003 and in the reference area in 2003, see figure 14. A statistical analysis of the contribution to the dissimilarity of each parameter showed that the amount of dry matter, organic content and grain size had a clear influence on the dissimilarities between the sediment in the wind farm area in September 2001 and 2003 and in the reference area in 2003.

In September 2003, a significant ($P<0.01$) negative correlation between depth and particle size was found, whereas no such relation was shown for the other survey campaigns.

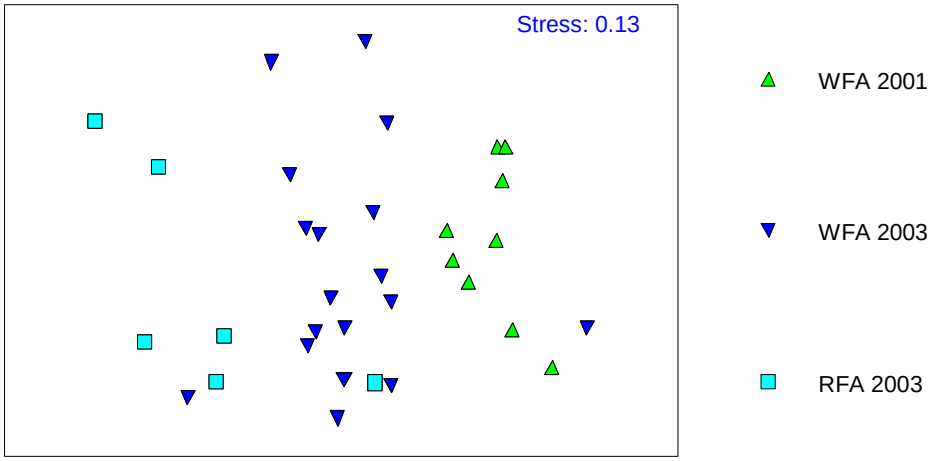


Figure 14. A multidimensional scaling (MDS) plot of the sediment characteristics in the wind farm area (WFA) in September 2001 and 2003 and in the reference area (RFA) in 2003.

4. Discussion

The particle size of the sediment in the wind farm area increased from a range of 228–426 µm in September 2001 to a range of 404–699 µm in September 2003. Storm events, heavy shipping traffic or hydrodynamic changes due to the establishment of wind turbine might have caused this change. The extraordinary storm event in December 1999 apparently caused no changes in the sediment structure between 1999 and 2001, and no correlation between particle size and distance to turbine foundations was found. This means it is unlikely that other storm events or hydrodynamic changes could have caused the changes. Parallel with the increase in particle size in the wind farm area, a comparable increase in particle size was found for the reference area, which makes it unlikely that heavy shipping traffic during the construction phase was responsible for the recorded changes in sediment structure. It is important to note that Horns Rev is a highly dynamic environment with migrating bedforms, and therefore an area with constant resuspension and reworking of the sediment. No final conclusions can thus be drawn from only two years of sediment samples, although significant differences in sediment structure were found between the wind farm area and the reference area.

An extensive amount of literature exists on benthos surveys covering the North Sea in general (Kröncke & Bergfeld, 2001). The data sets from the DANA cruises 1932–1955 (Ursin, 1960; Kirkegaard, 1969; Petersen 1977) and the results of Birkett's (Birkett, 1953) survey are valuable historical baselines of the community structure of North Sea benthos, but rather few data are available from more regional shallow sandbank areas such as Horns Rev. Other studies on sublittoral sandbanks in the North Sea have shown that the fauna on the sandbanks is both variable and heterogeneous, and that the fauna of these areas is difficult to compare with other sandbanks and adjoining deeper areas (Vanosmael et al. 1982; Salzwedel et al. 1985; Degraer et al. 1999). The benthos community at Horns Rev has a great similarity with the benthos communities described in other shallow coastal waters of the North Sea, where the sediment consists of medium–coarse sand. The community in such areas can be described as the *Ophelia borealis* community (Dewarumez et al. 1992) or, more commonly accepted, as the *Goniadella-Spisula* community (Kingston & Rachor 1982; Salzwedel at al. 1985).

In 2001, results revealed that the following species could be used as indicator organisms of environmental changes in the wind farm area due to relative uniformity in dominance relations: *Pisione remota, Goodallia triangularis, Goniadella bobretzkii, Ophelia borealis, Orbinia sertulata* and *Nephtys longosetosa.* Although dominant in biomass, the character species *Spisula solida* showed a more aggregated distribution in 2001.

In September 2003, the surveyed area could also be characterised by the presence of character species like the bristle worm *Goniadella bobretzkii* and the mussels *Spisula solida* and *Goodallia triangularis,* because they were the most important species in respect of abundance or biomass. Other character and appointed indicator species like *Ophelia borealis* and *Nephtys longosetosa* were less common or absent compared with previous surveys, whereas *Orbinia sertulata* was more abundant compared with September 2001. The bristle worm *Spio filicornis,* found to be one of the dominants in 2003, showed relative consistency in abundance and dominance between surveys in spring and autumn 2001, which means that this species might be used as an indicator species for environmental changes at Horns Rev.

The main difference between the survey in 2001 and in 2003 was the decline of the *Pisione remota* population from an average abundance of 411 individuals per m^2 in 2001 to an aver-

age abundance of 22 individuals per m^2 in 2003. In the same period, the population of *Goodallia triangularis* increased from an average of 203 individuals per m^2 in September 2001 to an average of 663 individuals per m^2 in 2003.

The multidimensional scaling tests of the fauna in the wind farm area in September 2001 and September 2003 revealed that they were significantly different. If this difference was a result of the construction and establishment of the wind farm, the difference would have been restricted to the area inside the wind farm, resulting in a difference between the wind farm area and the reference area in 2003. No such differences were found, which indicates that natural variation rather than effects of the establishment of the wind farm caused the changes in community structure between 2001 and 2003. In 2001, significant differences and high variations in average abundance and biomass were found between surveys conducted a short time after each other in June 2001 and September 2003, respectively. The differences in abundance and biomass between the two surveys were due to natural variations, reproduction and growth of the benthic species. Although differences in biomass and abundance were found, "fingerprints" in respect of community structure were identical between the two surveys in 2001 and between the reference area and the wind farm area in 2003.

The commercially important bivalve *Spisula solida*, which is a common species in the North Sea, was also found to be less abundant in 2003 compared with 2001. A reduction in average size of the mussels was also found from 2001 to 2003, and *S. solida* constituted 33.7% of the biomass in the wind farm area in 2003 compared with 77.4% in September 2001. It is important to note that this reduction in population size and structure was registered in both the wind farm area and in the reference area. If the decline was linked to the activities and changes in the wind farm area, the abundance of *S. solida* at the wind farm area should be significantly different from the reference area. *S. solida* was found on an average of 20.3 individuals or 62.6 g per m^2 in the wind farm in 2003, and 27.1 individuals or 77.7 g per m^2 in the reference area.

The foundation and the turbine itself are modelled to result in minor reduction, less than 15% in current speed within 5 m from the edge of the scour protection of turbine foundations (Elsam, 2000a). Changes in hydrodynamic regimes due to deployment of "artificial reefs" in the North Sea were found to have only small impact on the infauna community very close to the reef (Leewis & Hallie, 2000). Statistical analysis of the correlation between the various sediment parameters and the abundance of the fauna in the wind farm area at Horns Rev was not significant, and no significant impact on the fauna was detectable concerning distance-related effects.

Stress-induced changes in infaunal communities result in rather complex sequential shifts in species abundance and biomass interactions (Boesch & Rosenberg, 1981; Pearson, 1981). In general, few species that are high in abundance and low in biomass dominate in high-impacted areas, whereas more species in relatively lower abundance and biomass ratios characterise unstressed natural habitats. Differences in species abundance and biomass relations were not found between the wind farm area and the reference area at Horns Rev.

Although general reductions in population size of some of the character species in the surveyed areas might be related to the changes in sediment structure, more data sets on sediment characteristics and species abundance relations are required for more detailed analysis and conclusions. The infaunal community at Horns Rev shows no obvious sign of stress response,

but longer time series analysis must be established to monitor possible impact as a result of the construction and operating activities.

Species not previously recorded in the infauna surveys were introduced in 2003. The occurrence of the infauna bristle worms *Euzonus flabelligerus* and *Polygordius appendiculatus* typically associated with coarse sand might be a result of changes in sediment characteristics towards coarser sediments.

The crustaceans *Jassa marmorata* and *Caprella linearis* typically associated with hard substrate habitats were found locally dominating the epifouling communities at the wind turbine foundations and turbine towers in 2003, in concentrations of over 300,000 individuals per m^2 (Elsam Engineering, 2004). Patches of small stones or shell assemblages at the seabed between the wind turbine sites are easily colonised by these epifaunal species drifting from the turbine foundations. It is most likely that *J. marmorata* cannot build tubes and establish itself on the sandy bottom. The presence of *J. marmorata* and other epifouling species found on the seabed was presumably caused by drifting organisms caught by the current at the foundations, or the occurrence of small stones or shells colonised by epifouling species. Currents may also have transported small stones from the scour protection colonised by epifouling organisms to the station sampled, which would also explain the occurrence of the epizoan *Tubularia indivisa* found in a sample 100 m from the turbine foundation.

5. Conclusion

The wind farm area and the reference area are characterised by bottom conditions that are relatively uniform with sediments consisting of pure medium-fine sand with no organic matter. The particle size increased from a range of 228 µm to 426 µm in 2001 to a range of 404 µm to 699 µm in September 2003, indicating shifts in current regimes at Horns Rev.

Changes in community structure of infaunal benthos and sediment characteristics before and after the wind farm was established were found both inside and outside the wind farm area, indicating that the changes were the results of natural variation rather than impacts due to the establishment of the wind farm.

Statistical analysis using both abundance and biomass of each species at the 18 stations in the wind farm and at the six stations in the reference area showed no significant difference. These results indicate that the level of variance was higher than a possible effect from the establishment of the wind farm and that a community structure “fingerprint” of infauna was identical in the two surveyed areas.

There was no significant difference in benthos community structure related to the distance from the wind turbine foundations.

The main difference between the survey in 2001 and in 2003 was the decline of the *Pisione remota* and *Spisula solida* populations and the increase of the *Goodallia triangularis* population.

New species were introduced in 2003. The occurrence of some of these might be a result of changes in sediment characteristics. Others may be a result of the introduction of hard bottom habitants in the wind farm area.

Recommendations for future monitoring programmes for benthos will emphasise sampling at the same stations in the month of September to provide further data sets on sediment, species abundance and biomass relationships.

6. References

Birkett, L., 1953. Changes in the compositions of the bottom fauna of the Dogger Bank area. Nature 171: 265

Boesch, D.F. & R. Rosenberg, 1981. Response to Stress in Marine Benthic Communities. In Barret, G.W. & R. Rosenberg. (Eds.) Stress Effects on Natural Ecosystems. Chichester: 179–200.

Degraer, S., M. Vincx, P. Meire & H. Offringa, 1999. The macrozoobenthos of an important wintering area of the common scoter (Melanitta nigra). J. Mar. Biol. Ass. U.K. 79: 243–251.

Dewarumez, J.M., D. Devoult, L.E.S. Anorve & S. Frontier, 1992. Is the 'muddy heterogeneous sediment assemblage' an ecotone between the pebbles community and the Abra alba community in the Southern Bight of the North Sea? Netherlands Journal of Sea Research.30: 229–238.

ELSAM, 2000a. Havmøller Horns rev. Vurderinger af Virkninger på Miljøet VVM-redegørelse: 1–187.(In English. Horns Rev Offshore Wind Farm. Environmental Impact Assessment. Summary of EIA Report: 1–15).

ELSAM, 2000b. Horns Rev Offshore Wind Power Farm. Environmental Impact Assessment of Sea Bottom and Marine Biology: 1–53.

ELSAM, 2001. Horns Rev Offshore Wind Farm. Introducing hard bottom substrate sea bottom and marine biology. Status report 2001.

Elsam Engineering, 2004. Hard bottom substrate monitoring. Horns Rev Offshore Wind Farm. Annual Report 2003.

GEUS, 2002. Personal communication.

Kingston, P. & E. Rachor, 1982. North Sea level bottom communities. ICES CM 1982/L:41: 1–15.

Kirkegaard, J.B., 1969. A quantitative Investigation of the Central North Sea. Polychaeta. Spolia 29. 1–284.

Kröncke, I. & C. Bergfeld, 2001. Berichte aus dem Zentrum für Meeres- und Klimaforschung Reihe Z, nr. 12. Synthesis and New Conception of North Sea Research (SYCON). Working Group 10. Review of the Current Knowledge on North Sea Benthos: 1–138.

Leewis, R. & F. Hallie, 2000. An artificial reef experiment off the Dutch Coast. In Jensen, A.C., K.J. Collins and A.P.M. Lockwood (Eds.). Dordrecht. Artificial Reefs in European Seas: 289–305.

Pearson, T.H., 1981. Stress and Catastrophe in Marine Benthic Ecosystems. In Barret, G.W. & R. Rosenberg. (Eds.) Stress Effets on Natural Ecosystems. Chichester: 2001–214.

Petersen, G.H., 1977. The Density, Biomass and Origin of the Bivalves of the Central North Sea. Meddr. Danm. Fisk.- og Havunders. N.S Vol. 7: 221–273.

Salzwedel, H., E. Rachor & D. Gerdes, 1985. Benthic macrofauna communities in the German Bight. Veröff. Inst. Meeresforsch. Bremerh. 20: 199–267.

Ursin, E., 1960. A Quantitative investigation of the Echinoderm Fauna of the central North Sea. Meddr. Danm. Fisk.- og Havunders. N.S Vol. 2 nr. 24: 1–204.

Vanosmael, C., K.A. Willems, D. Claeys, M. Vincx & C. Heip, 1982. Macrobenthos of a sublittoral sandbank in the southern Bight of the North Sea. J. Mar. Biol. Ass. U.K. 62: 521–534.

Appendices

Appendix 1. List of positions

Sampling was performed at the following locations presented. Positions and actual depth are registered at the position by the sampling vessel.

Location	"WGS84_MIN_Y"	WGS84_MIN_X"	Depth (app. m)
Turbine 26_005	07°49.145'	55°28.605'	7.8
Turbine 26_025	07°49.152'	55°28.615'	7.8
Turbine 26_100	07°49.176'	55°28.653'	7.8
Turbine 51_005	07°50.372'	55°30.115'	8.9
Turbine 51_025	07°50.378'	55°30.126'	8.9
Turbine 51_100	07°50.403'	55°30.164'	8.9
Turbine 55_005	07°50.666'	55°28.919'	11.1
Turbine 55_025	07°50.673'	55°28.930'	11.1
Turbine 55_100	07°50.697'	55°28.968'	11.1
Turbine 58_005	07°50.887'	55°28.022'	7.8
Turbine 58_025	07°50.893'	55°28.033'	7.8
Turbine 58_100	07°50.918'	55°28.071'	7.8
Turbine 73_005	07°51.582'	55°29.527'	8.5
Turbine 73_025	07°51.589'	55°29.538'	8.5
Turbine 73_100	07°51.613'	55°29.576'	8.5
Turbine 95_005	07°52.792'	55°28.939'	8.7
Turbine 95_025	07°52.799'	55°28.949'	8.8
Turbine 95_100	07°52.823'	55°28.987'	8.8
Reference_1	07°46.640'	55°30.070'	10.3
Reference_7	07°47.320'	55°29.480'	8.8
Reference_35	07°53.080'	55°27.730'	7.6
Reference_36	07°53.030'	55°30.130'	6.6
Reference_37	07°53.170'	55°29.530'	6.6
Reference_40	07°53.610'	55°27.740'	8.3

Appendix 2. Meteorological and hydrographical data

Location	Date	Current		Wind		Secchi depth m	Wave height	Adjusted Secchi depth m
		Direction	m/sec	Direction	m/sec			
Turbine 26_005	040903	NNE	<1	SW	<5	6	<1.0	8.4
Turbine 26_025	040903	NNE	<1	SW	<5	6	<1.0	8.4
Turbine 26_100	040903	NNE	<1	SW	<5	6	<1.0	8.4
Turbine 51_005	040903	NNE	<1	SW	<5	6	<1.0	8.4
Turbine 51_025	040903	NNE	<1	SW	<5	6	<1.0	8.4
Turbine 51_100	040903	NNE	<1	SW	<5	6	<1.0	8.4
Turbine 55_005	040903	SSW	<1	SW	<5	6	<1.0	8.4
Turbine 55_025	040903	SSW	<1	SW	<5	6	<1.0	8.4
Turbine 55_100	040903	SSW	<1	SW	<5	6	<1.0	8.4
Turbine 58_005	040903	SSW	<1	SW	<5	6	<1.0	8.4
Turbine 58_025	040903	SSW	<1	SW	<5	6	<1.0	8.4
Turbine 58_100	040903	SSW	<1	SW	<5	6	<1.0	8.4
Turbine 73_005	050903	SSW	<1	SSE	<5	6	<1.0	8.4
Turbine 73_025	050903	SSW	<1	SSE	<5	6	<1.0	8.4
Turbine 73_100	050903	SSW	<1	SSE	<5	6	<1.0	8.4
Turbine 95_005	050903	NNE	<1	SSE	<5	6	<1.0	8.4
Turbine 95_025	050903	NNE	<1	SSE	<5	6	<1.0	8.4
Turbine 95_100	050903	NNE	<1	SSE	<5	6	<1.0	8.4
Reference 1	040903	NNE	<1	SW	<5	6	<1.0	8.4
Reference 7	040903	NNE	<1	SW	<5	6	<1.0	8.4
Reference 35	050903	SSW	<1	SSE	<5	6	<1.0	8.4
Reference 36	050903	SSW	<1	SSE	<5	6	<1.0	8.4
Reference 37	050903	SSW	<1	SSE	<5	6	<1.0	8.4
Reference 40	050903	SSW	<1	SSE	<5	6	<1.0	8.4

Appendix 3. Sediment characteristics. Content of dry matter and organic matter.

Horns Reef Sediment charcteristics September 2003

Station	Water content		Loss of combustion	
			DS 204	
StatID	Water content%	Dry matter %	Loss of combustion Organics %	Rest %
Turbine 26_005	13.1	86.9	0.22	99.78
Turbine 26_025	12.3	87.7	0.23	99.77
Turbine 26_100	13.6	86.4	0.23	99.77
Turbine 51_005	15.1	84.9	0.22	99.78
Turbine 51_025	15.3	84.7	0.19	99.81
Turbine 51_100	14.1	85.9	0.27	99.73
Turbine 55_005	17.0	83.0	0.27	99.73
Turbine 55_025	15.2	84.8	0.35	99.65
Turbine 55_100	14.0	86.0	0.26	99.74
Turbine 58_005	13.7	86.3	0.31	99.69
Turbine 58_025	14.3	85.7	0.24	99.76
Turbine 58_100	14.3	85.7	0.25	99.75
Turbine 73_005	9.2	90.8	0.27	99.73
Turbine 73_025	13.4	86.6	0.23	99.77
Turbine 73_100	15.9	84.1	0.14	99.86
Turbine 95_005	15.7	84.3	0.32	99.68
Turbine 95_025	14.0	86.0	0.17	99.83
Turbine 95_100	12.8	87.2	0.19	99.81
Reference 01	18.6	81.4	0.09	99.91
Reference 07	17.8	82.2	0.15	99.85
Reference 35	15.1	84.9	0.10	99.90
Reference 36	17.3	82.7	0.20	99.80
Reference 37	15.8	84.2	0.16	99.84
Reference 40	12.8	87.2	0.13	99.87
Mean	**14.6**	**85.4**	**0.2**	**99.8**

Appendix 4. Grain size of sediments in September 2003

		Median grain size
Station	**Depth**	**50% percentile**
Turbine 26_005	7.8	0.628
Turbine 26_025	7.8	0.600
Turbine 26_100	7.8	0.541
Turbine 51_005	8.9	0.441
Turbine 51_025	8.9	0.418
Turbine 51_100	8.9	0.404
Turbine 55_005	11.1	0.427
Turbine 55_025	11.1	0.429
Turbine 55_100	11.1	0.446
Turbine 58_005	7.8	0.617
Turbine 58_025	7.8	0.567
Turbine 58_100	7.8	0.597
Turbine 73_005	8.5	0.480
Turbine 73_025	8.5	0.465
Turbine 73_100	8.5	0.699
Turbine 95_005	8.7	0.471
Turbine 95_025	8.8	0.534
Turbine 95_100	8.8	0.504
Reference 1	10.3	0.418
Reference 7	8.8	0.345
Reference 35	7.6	0.509
Reference 36	6.6	0.574
Reference 37	6.6	0.571
Reference 40	8.3	0.570
Average reference.area	8.0	0.498
Average wind farm	8.8	0.515

Appendix 5. Benthos. Complete list of species

Complete list of species. Horns Rev. September 2003

Group	Taxon		Common Danish name	Common English name
HYDROZOA				
	Tubularia indivisa			
	Hydractinia echinata	Fleming		
	Campanulariidae indet.			
ANTHOZOA				
	Actiniaria indet.			
NEMERTINI				
	Nemertini indet.			
NEMATODA				
	Nematoda indet.			
POLYCHAETA				
	Pisione remota	(Southern)		
	Nephtys caeca	(Fabricius)		
	Nephtys sp.			
	Goniadella bobretzkii	(Annenkova)		
	Orbinia sertulata	(Savigny)		
	Spio filicornis	(O.F. Muller)		
	Euzonus flabelligerus	(Ziegelmeier)		
	Travisia forbesii	Johnston		
	Ophelia borealis	Quatrefages		
	Polygordius appendiculatus	Fraipont		
	Arenicola marina	(L.)	Sandorm	Blow lug
	Lanice conchilega	(Pallas)		
HYDRACARINA				
	Halacaridae indet.			
COPEPODA				
	Harpacticoida indet.			
DECAPODA				
	Crangon crangon	L.	Hestereje	
	Liocarcinus pusillus	(Leach)	Svømmekrabbe	Harbour crab
	Pagurus bernhardus	L.	Erimitkrebs	Hermit crab
AMPHIPODA				
	Haustorius arenarius	Slabber		
	Pontocrates arenarius	Bate		
	Jassa marmorata	Holmes		
	Caprella linearis	L.		
GASTROPODA				
	Crepidula fornicata	(L.)	Tøffelsnegl	Slipper limpet
	Polinices polianus	(delle Chiaje)		
BIVALVIA				
	Bivalvia indet.			
	Mytilus edulis	L.	Blåmusling	Common mussel
	Goodallia triangularis	(Montagu		
	Spisula elliptica	(Brown)		
	Spisula solida	(L.)	Tykskalet trugmusling	Thick trough shell
	Angulus tenuis	(Da Costa)	Alm. tallerkenmusling	Thin Tellin
	Thracia phaseolina	(Lamarck)	Papirmusling	
	Ensis ensis	(L.)	Sværdskedemusling	Razor shell
BRYOZOA				
	Bryozoa indet.			
ECHINODERMATA				
	Asterias rubens	L.	Alm. søstjerne	Common starfish
	Ophiura ophiura			
	Echinocyamus pusillus	O.F. Müller		
CORDATA				
	Branchiostoma lanceolatum	(Pallas)	Lancetfisk	Amphioxus

Appendix 6. Benthos. Abundance

Appendix 6.1. Total mean abundance

Abundans, number/m²		Total		
		no./m²	Kol Sum %	N
HYDROZOA	Tubularia indivisa	2	.1%	48
	Hydractinia echinata	3	.3%	48
	Campanulariidae indet,	3	.3%	48
ANTHOZOA	Actiniaria indet,	2	.1%	48
NEMERTINI	Nemertini indet,	7	.6%	48
NEMATODA	Nematoda indet,	3	.3%	48
POLYCHAETA	Pisione remota	20	1.8%	48
	Nephtys caeca	7	.6%	48
	Nephtys sp,	15	1.3%	48
	Goniadella bobretzkii	147	12.9%	48
	Orbinia sertulata	10	.9%	48
	Spio filicornis	25	2.2%	48
	Euzonus flabelligerus	2	.1%	48
	Travisia forbesii	12	1.0%	48
	Ophelia borealis	12	1.0%	48
	Polygordius appendiculatus	12	1.0%	48
	Arenicola marina	3	.3%	48
	Lanice conchilega	2	.1%	48
HYDROCARINA	Halacaridae indet,	2	.1%	48
CRUSTACEA	Harpacticoida indet,	8	.7%	48
	Crangon crangon	2	.1%	48
	Liocarcinus pusillus	2	.1%	48
	Pagurus bernhardus	3	.3%	48
	Haustorius arenarius	2	.1%	48
	Pontocrates arenarius	10	.9%	48
	Jassa marmorata	30	2.7%	48
	Caprella linearis	7	.6%	48
GASTROPODA	Crepidula fornicata	2	.1%	48
	Polinices polianus	10	.9%	48
BIVALVIA	Bivalvia indet,	3	.3%	48
	Mytilus edulis	8	.7%	48
	Goodallia triangularis	655	57.2%	48
	Spisula elliptica	0	.0%	48
	Spisula solida	22	1.9%	48
	Angulus tenuis	2	.1%	48
	Thracia phaseolina	36	3.1%	48
	Ensis ensis	15	1.3%	48
BRYOZOA	Bryozoa indet,	2	.1%	48
ECHINODERMATA	Asterias rubens	5	.4%	48
	Ophiura ophiura	2	.1%	48
	Echinocyamus pusillus	3	.3%	48
CHORDATA	Branchiostoma lanceolatum	27	2.4%	48

Appendix 6.2. Mean abundance. Wind farm area – reference area

Abundance - 3 years: Year

		Sampling area							
		Wind Farm area				Reference area			
		2001		2003		1999		2003	
		Campaign		Campaign		Campaign		Campaign	
		Autumn		Autumn		Spring		Autumn	
Abundance, number/m²		Mean	Relative %	Mean	Relative %	Mean	Relative %	Mean	Relative %
HYDROZOA	Hydractinia echinata	225.84	12.1%	2.26	.2%	13.55	.5%	6.78	.6%
	Campanulariidae indet,	.	.	4.52	.4%	.	.	.	.
	Tubularia indivisa	.	.	2.26	.2%	.	.	.	.
ANTHOZOA	Actiniaria indet,	.	.	2.26	.2%	.	.	.	.
GOPLER	Beroe cucumis	.	.	.	.	13.55	.5%	.	.
NEMERTINI	Nemertini indet,	27.10	1.4%	4.52	.4%	40.65	1.6%	13.55	1.2%
NEMATODA	Nematoda indet,	121.95	6.5%	4.52	.4%	40.65	1.6%	.	.
POLYCHAETA	Protodorvillea kefersteini	.	.	.	.	440.38	17.0%	.	.
	Pisione remota	411.02	22.0%	22.58	2.0%	691.06	26.7%	13.55	1.2%
	Goniadella bobretzkii	189.70	10.1%	146.79	12.9%	338.75	13.1%	149.05	12.7%
	Travisia forbesii	.	.	9.03	.8%	155.83	6.0%	20.33	1.7%
	Ophelia borealis	72.27	3.9%	11.29	1.0%	149.05	5.8%	13.55	1.2%
	Spio filicornis	90.33	4.8%	20.33	1.8%	27.10	1.0%	40.65	3.5%
	Orbinia sertulata	.	.	9.03	.8%	101.63	3.9%	13.55	1.2%
	Scolelepis bonnieri	36.13	1.9%	.	.	6.78	.3%	.	.
	Nephtys hombergii	.	.	.	.	20.33	.8%	.	.
	Nephtys longosetosa	4.52	.2%	.	.	33.88	1.3%	.	.
	Nephtys sp,	.	.	15.81	1.4%	6.78	.3%	13.55	1.2%
	Polygordius appendiculatus	.	.	13.55	1.2%	.	.	6.78	.6%
	Eulalia viridis	9.03	.5%	.	.	.	.	.	.
	Nephtys caeca	.	.	4.52	.4%	.	.	13.55	1.2%
	Pholoe sp.	.	.	.	.	6.78	.3%	.	.
	Magelona mirabilis	.	.	.	.	6.78	.3%	.	.
	Euzonus flabelligerus	.	.	.	.	.	.	6.78	.6%
	Lanice conchilega	.	.	.	.	.	.	6.78	.6%
	Polychaeta indet.	4.52	.2%	.	.	.	.	.	.
	Scoloplos armiger	4.52	.2%	.	.	.	.	.	.
	Arenicola marina	.	.	4.52	.4%	.	.	.	.
	Glycera sp.	.	.	.	.	.	.	.	.
	Aonides paucibranchiata	.	.	.	.	.	.	.	.
	Polygordius sp.	.	.	.	.	.	.	.	.
HYDROCARINA	Halacaridae indet,	.	.	2.26	.2%	.	.	.	.
CRUSTACEA	Balanus sp.	135.50	7.2%	.	.	.	.	.	.
	Metopidae indet.	.	.	.	.	40.65	1.6%	.	.
	Jassa marmorata	.	.	40.65	3.6%	.	.	.	.
	Cyclopoida indet.	36.13	1.9%	.	.	.	.	.	.
	Pontocrates arenarius	4.52	.2%	6.78	.6%	47.43	1.8%	20.33	1.7%
	Haustorius arenarius	4.52	.2%	2.26	.2%	47.43	1.8%	.	.
	Westwoodilla caecula	18.07	1.0%	.	.	.	.	.	.
	Gastrosaccus spinifer	13.55	.7%	.	.	.	.	.	.
	Crangon crangon	.	.	.	.	13.55	.5%	6.78	.6%
	Harpacticoida indet,	4.52	.2%	11.29	1.0%	13.55	.5%	.	.
	Mysidacea indet.	9.03	.5%	.	.	.	.	.	.
	Eurysteus nitida	4.52	.2%	.	.	13.55	.5%	.	.
	Pontocrates sp.	9.03	.5%	.	.	.	.	.	.
	Atylus swammerdami	9.03	.5%	.	.	.	.	.	.
	Caprella linearis	.	.	9.03	.8%	.	.	.	.
	Carcinus maenas	.	.	.	.	6.78	.3%	.	.
	Pagurus bernhardus	4.52	.2%	2.26	.2%	13.55	.5%	6.78	.6%
	Oedicerotidae indet.	.	.	.	.	6.78	.3%	.	.
	Diastylis sp.	4.52	.2%	.	.	.	.	.	.
	Pseudocuma longicornis	4.52	.2%	.	.	.	.	.	.
	Bathyporeia guilliamsoniana	4.52	.2%	.	.	.	.	.	.
	Metopa sp.	4.52	.2%	.	.	.	.	.	.
	Stenothoe sp.	4.52	.2%	.	.	.	.	.	.
	Liocarcinus pusillus	.	.	2.26	.2%	.	.	.	.
	Bathyporeia sp.	.	.	.	.	.	.	.	.
GASTROPODA	Polinices polianus	9.03	.5%	11.29	1.0%	6.78	.3%	6.78	.6%
	Crepidula fornicata	.	.	2.26	.2%	.	.	.	.
BIVALVIA	Goodallia triangularis	203.25	10.9%	663.96	58.3%	237.13	9.2%	630.08	53.8%
	Ensis ensis	.	.	.	.	.	.	60.98	5.2%
	Thracia phaseolina	45.17	2.4%	36.13	3.2%	.	.	33.88	2.9%
	Arctica islandica	31.62	1.7%	.	.	.	.	.	.
	Spisula solida	36.13	1.9%	20.33	1.8%	33.88	1.3%	27.10	2.3%
	Mytilus edulis	49.68	2.7%	6.78	.6%	.	.	13.55	1.2%
	Bivalvia indet,	4.52	.2%	.	.	.	.	13.55	1.2%
	Fabulina fabula	.	.	.	.	6.78	.3%	.	.
	Angulus tenuis	.	.	2.26	.2%	.	.	.	.
	Spisula elliptica	.	.	.00	.0%	.	.	.	.
BRYOZOA	Electra pilosa	4.52	.2%	.	.	.	.	.	.
	Bryozoa indet,	.	.	2.26	.2%	.	.	.	.
ECHINODERMATA	Ophiura ophiura	.	.	.	.	.	.	6.78	.6%
	Asterias rubens	.	.	6.78	.6%	.	.	.	.
	Echinocyamus pusillus	.	.	4.52	.4%	.	.	.	.
	Echinocardium cordatum	.	.	.	.	.	.	.	.
CHAETOGHNATHA	Sagitta sp.	4.52	.2%	.	.	.	.	.	.
CHORDATA	Branchiostoma lanceolatum	9.03	.5%	27.10	2.4%	6.78	.3%	27.10	2.3%

Appendix 6.3. Mean abundance. Total distance.

		Sampling area							
		Wind Farm area						Reference area	
		Campaign						Campaign	
		Autumn 2003						Autumn 2003	
		Distance (m)						Distance (m)	
		5		25		100		Reference	
Abundance, number/m²		no./m²	Kol Sum %	no./m²	Kol Sum %	no./m²	Kol Sum %	no./m²	Kol Sum %
HYDROZOA	Tubularia indivisa	.	.	.	.	7	.8%	.	.
	Hydractinia echinata	.	.	7	.7%	.	.	7	.6%
	Campanulariidae indet,	.	.	.	.	14	1.5%	.	.
ANTHOZOA	Actiniaria indet,	.	.	7	.7%	.	.	.	.
NEMERTINI	Nemertini indet,	.	.	.	.	14	1.5%	14	1.2%
NEMATODA	Nematoda indet,	7	.4%	.	.	7	.8%	.	.
POLYCHAETA	Pisione remota	41	2.6%	14	1.4%	14	1.5%	14	1.2%
	Nephtys caeca	.	.	.	.	14	1.5%	14	1.2%
	Nephtys sp,	7	.4%	14	1.4%	27	3.1%	14	1.2%
	Goniadella bobretzkii	156	10.0%	115	11.8%	169	19.2%	149	12.7%
	Orbinia sertulata	7	.4%	14	1.4%	7	.8%	14	1.2%
	Spio filicornis	20	1.3%	20	2.1%	20	2.3%	41	3.5%
	Euzonus flabelligerus	.	.	.	.	.	.	7	.6%
	Travisia forbesii	.	.	14	1.4%	14	1.5%	20	1.7%
	Ophelia borealis	20	1.3%	7	.7%	7	.8%	14	1.2%
	Polygordius appendiculatus	14	.9%	20	2.1%	7	.8%	7	.6%
	Arenicola marina	.	.	.	.	14	1.5%	.	.
	Lanice conchilega	.	.	.	.	.	.	7	.6%
HYDROCARINA	Halacaridae indet,	.	.	.	.	7	.8%	.	.
CRUSTACEA	Harpacticoida indet,	7	.4%	14	1.4%	14	1.5%	.	.
	Crangon crangon	.	.	.	.	.	.	7	.6%
	Liocarcinus pusillus	.	.	.	.	7	.8%	.	.
	Pagurus bernhardus	.	.	.	.	7	.8%	7	.6%
	Haustorius arenarius	7	.4%	.	.	.	.	.	.
	Pontocrates arenarius	.	.	14	1.4%	7	.8%	20	1.7%
	Jassa marmorata	54	3.5%	20	2.1%	47	5.4%	.	.
	Caprella linearis	7	.4%	.	.	20	2.3%	.	.
GASTROPODA	Crepidula fornicata	.	.	.	.	7	.8%	.	.
	Polinices polianus	14	.9%	7	.7%	14	1.5%	7	.6%
BIVALVIA	Bivalvia indet,	.	.	.	.	.	.	14	1.2%
	Mytilus edulis	7	.4%	.	.	14	1.5%	14	1.2%
	Goodallia triangularis	1104	70.9%	569	58.3%	318	36.2%	630	53.8%
	Spisula elliptica	.	.	0	.0%	.	.	.	.
	Spisula solida	7	.4%	27	2.8%	27	3.1%	27	2.3%
	Angulus tenuis	.	.	7	.7%	.	.	.	.
	Thracia phaseolina	20	1.3%	54	5.6%	34	3.8%	34	2.9%
	Ensis ensis	.	.	.	.	.	.	61	5.2%
BRYOZOA	Bryozoa indet,	7	.4%	.	.	.	.	.	.
ECHINODERMATA	Asterias rubens	20	1.3%	.	.	.	.	.	.
	Ophiura ophiura	.	.	.	.	.	.	7	.6%
	Echinocyamus pusillus	14	.9%	.	.	.	.	.	.
CHORDATA	Branchiostoma lanceolatum	20	1.3%	34	3.5%	27	3.1%	27	2.3%

Appendix 6.4. Mean abundance.

		Wind Farm area					
		Autumn 2003					
		Mill51					
		Distance (m)					
		5		25		100	
Abundance, number/m²		no./m²	Kol Sum %	no./m²	Kol Sum %	no./m²	Kol Sum %
HYDROZOA	Tubularia indivisa	.	.	.	.	40.7	5.6%
	Hydractinia echinata	.	.	40.7	16.7%	.	.
	Campanulariidae indet,	.	.	.	.	81.3	11.1%
ANTHOZOA	Actiniaria indet,	.	.	40.7	16.7%	.	.
NEMATODA	Nematoda indet,	40.7	20.0%	.	.	.	.
POLYCHAETA	Nephtys caeca	.	.	.	.	40.7	5.6%
	Nephtys sp,	.	.	.	.	40.7	5.6%
	Goniadella bobretzkii	40.7	20.0%	.	.	81.3	11.1%
	Spio filicornis	.	.	.	.	81.3	11.1%
	Ophelia borealis	.	.	40.7	16.7%	40.7	5.6%
CRUSTACEA	Harpacticoida indet,	.	.	.	.	40.7	5.6%
	Pagurus bernhardus	.	.	.	.	40.7	5.6%
	Caprella linearis	.	.	.	.	122.0	16.7%
GASTROPODA	Crepidula fornicata	.	.	.	.	40.7	5.6%
BIVALVIA	Goodallia triangularis	40.7	20.0%	.	.	.	.
	Angulus tenuis	.	.	40.7	16.7%	.	.
	Thracia phaseolina	40.7	20.0%	81.3	33.3%	40.7	5.6%
ECHINODERMATA	Asterias rubens	40.7	20.0%	.	.	.	.
CHORDATA	Branchiostoma lanceolatum	.	.	.	.	40.7	5.6%
Total		203.3	100.0%	243.9	100.0%	731.7	100.0%

		Wind Farm area					
		Autumn 2003					
		Mill55					
		Distance (m)					
		5		25		100	
Abundance, number/m²		no./m²	Kol Sum %	no./m²	Kol Sum %	no./m²	Kol Sum %
NEMERTINI	Nemertini indet,	.	.	.	.	40.7	5.3%
POLYCHAETA	Nephtys sp,	.	.	40.7	2.9%	.	.
	Goniadella bobretzkii	284.6	11.9%	243.9	17.6%	40.7	5.3%
	Spio filicornis	81.3	3.4%	40.7	2.9%	40.7	5.3%
	Polygordius appendiculatus	.	.	40.7	2.9%	.	.
CRUSTACEA	Harpacticoida indet,	.	.	.	.	40.7	5.3%
	Jassa marmorata	.	.	40.7	2.9%	.	.
GASTROPODA	Polinices polianus	40.7	1.7%	.	.	.	.
BIVALVIA	Goodallia triangularis	1910.6	79.7%	813.0	58.8%	528.5	68.4%
	Spisula solida	.	.	40.7	2.9%	40.7	5.3%
	Thracia phaseolina	40.7	1.7%	122.0	8.8%	.	.
CHORDATA	Branchiostoma lanceolatum	40.7	1.7%	.	.	40.7	5.3%
Total		2398.4	100.0%	1382.1	100.0%	772.4	100.0%

		Wind Farm area					
		Autumn 2003					
		Mill58					
		Distance (m)					
		5		25		100	
Abundance, number/m²		no./m²	Kol Sum %	no./m²	Kol Sum %	no./m²	Kol Sum %
NEMATODA	Nematoda indet,	.	.	.	.	40.7	4.5%
POLYCHAETA	Pisione remota	162.6	10.3%	81.3	10.0%	81.3	9.1%
	Nephtys sp,	40.7	2.6%	.	.	40.7	4.5%
	Goniadella bobretzkii	40.7	2.6%	.	.	.	.
	Orbinia sertulata	40.7	2.6%	40.7	5.0%	.	.
	Spio filicornis	40.7	2.6%	.	.	.	.
	Travisia forbesii	.	.	40.7	5.0%	81.3	9.1%
	Ophelia borealis	81.3	5.1%	.	.	.	.
	Polygordius appendiculatus	.	.	40.7	5.0%	.	.
HYDROCARINA	Halacaridae indet,	.	.	.	.	40.7	4.5%
CRUSTACEA	Haustorius arenarius	40.7	2.6%	.	.	.	.
	Pontocrates arenarius	.	.	40.7	5.0%	.	.
	Jassa marmorata	.	.	.	.	203.3	22.7%
BIVALVIA	Mytilus edulis	.	.	.	.	81.3	9.1%
	Goodallia triangularis	1097.6	69.2%	406.5	50.0%	203.3	22.7%
	Spisula elliptica	.	.	.0	.0%	.	.
	Spisula solida	40.7	2.6%	81.3	10.0%	81.3	9.1%
	Thracia phaseolina	.	.	40.7	5.0%	.	.
CHORDATA	Branchiostoma lanceolatum	.	.	40.7	5.0%	40.7	4.5%
Total		1585.4	100.0%	813.0	100.0%	894.3	100.0%

		Wind Farm area					
		Autumn 2003					
		Mill26					
		Distance (m)					
		5		25		100	
Abundance, number/m²		no./m²	Kol Sum %	no./m²	Kol Sum %	no./m²	Kol Sum %
POLYCHAETA	Pisione remota	40.7	3.0%	.	.	.	.
	Nephtys sp,	.	.	.	.	40.7	3.3%
	Goniadella bobretzkii	243.9	18.2%	243.9	25.0%	447.2	36.7%
	Orbinia sertulata	.	.	.	.	40.7	3.3%
	Travisia forbesii	.	.	40.7	4.2%	.	.
	Polygordius appendiculatus	40.7	3.0%	.	.	40.7	3.3%
	Arenicola marina	.	.	.	.	81.3	6.7%
CRUSTACEA	Harpacticoida indet,	.	.	40.7	4.2%	.	.
	Jassa marmorata	162.6	12.1%	40.7	4.2%	81.3	6.7%
GASTROPODA	Polinices polianus	40.7	3.0%	.	.	40.7	3.3%
BIVALVIA	Goodallia triangularis	650.4	48.5%	447.2	45.8%	365.9	30.0%
	Spisula solida	.	.	.	.	40.7	3.3%
	Thracia phaseolina	40.7	3.0%	40.7	4.2%	.	.
ECHINODERMATA	Asterias rubens	40.7	3.0%	.	.	.	.
	Echinocyamus pusillus	40.7	3.0%	.	.	.	.
CHORDATA	Branchiostoma lanceolatum	40.7	3.0%	122.0	12.5%	40.7	3.3%
Total		1341.5	100.0%	975.6	100.0%	1219.5	100.0%

		Wind Farm area					
		Autumn 2003					
		Mill73					
		Distance (m)					
		5		25		100	
Abundance, number/m²		no./m²	Kol Sum %	no./m²	Kol Sum %	no./m²	Kol Sum %
POLYCHAETA	Nephtys caeca	.	.	.	.	40.7	3.2%
	Goniadella bobretzkii	81.3	3.2%	162.6	9.5%	243.9	19.4%
	Orbinia sertulata	.	.	40.7	2.4%	.	.
	Spio filicornis	.	.	81.3	4.8%	.	.
	Polygordius appendiculatus	40.7	1.6%	.	.	.	.
CRUSTACEA	Harpacticoida indet,	40.7	1.6%	40.7	2.4%	.	.
	Liocarcinus pusillus	.	.	.	.	40.7	3.2%
	Pontocrates arenarius	.	.	40.7	2.4%	40.7	3.2%
	Jassa marmorata	.	.	40.7	2.4%	.	.
GASTROPODA	Polinices polianus	.	.	40.7	2.4%	40.7	3.2%
BIVALVIA	Goodallia triangularis	2276.4	90.3%	1219.5	71.4%	731.7	58.1%
	Thracia phaseolina	.	.	40.7	2.4%	122.0	9.7%
ECHINODERMATA	Echinocyamus pusillus	40.7	1.6%	.	.	.	.
CHORDATA	Branchiostoma lanceolatum	40.7	1.6%	.	.	.	.
Total		2520.3	100.0%	1707.3	100.0%	1260.2	100.0%

		Wind Farm area					
		Autumn 2003					
		Mill95					
		Distance (m)					
		5		25		100	
Abundance, number/m²		no./m²	Kol Sum %	no./m²	Kol Sum %	no./m²	Kol Sum %
NEMERTINI	Nemertini indet,	.	.	.	.	40.7	10.0%
POLYCHAETA	Pisione remota	40.7	3.1%	.	.	.	.
	Nephtys sp,	.	.	40.7	5.6%	40.7	10.0%
	Goniadella bobretzkii	243.9	18.7%	40.7	5.6%	203.3	50.0%
	Ophelia borealis	40.7	3.1%	.	.	.	.
	Polygordius appendiculatus	.	.	40.7	5.6%	.	.
CRUSTACEA	Jassa marmorata	162.6	12.5%	.	.	.	.
	Caprella linearis	40.7	3.1%	.	.	.	.
BIVALVIA	Mytilus edulis	40.7	3.1%	.	.	.	.
	Goodallia triangularis	650.4	50.0%	528.5	72.2%	81.3	20.0%
	Spisula solida	.	.	40.7	5.6%	.	.
	Thracia phaseolina	.	.	.	.	40.7	10.0%
BRYOZOA	Bryozoa indet,	40.7	3.1%	.	.	.	.
ECHINODERMATA	Asterias rubens	40.7	3.1%	.	.	.	.
CHORDATA	Branchiostoma lanceolatum	.	.	40.7	5.6%	.	.
Total		1300.8	100.0%	731.7	100.0%	406.5	100.0%

		Reference area											
		Autumn 2003											
		Ref01		Ref07		Ref35		Ref36		Ref37		Ref40	
Abundance, number/m²		no./m²	Kol Sum %	no./m²	Kol Sum %	no./m²	Kol Sum %	no./m²	Kol Sum %	no./m²	Kol Sum %	no./m²	Kol Sum %
HYDROZOA	Hydractinia echinata	.	.	40.7	9.1%	.	.	.	.	.	.	.	.
NEMERTINI	Nemertini indet,	.	.	.	.	.	.	40.7	2.2%	40.7	3.2%	.	.
POLYCHAETA	Pisione remota	.	.	.	.	40.7	5.3%	.	.	40.7	3.2%	.	.
	Nephtys caeca	.	.	40.7	9.1%	.	.	40.7	2.2%	.	.	.	.
	Nephtys sp,	40.7	5.0%	40.7	9.1%	.	.	.	.	.	.	.	.
	Goniadella bobretzkii	81.3	10.0%	.	.	40.7	5.3%	243.9	13.3%	365.9	29.0%	162.6	8.5%
	Orbinia sertulata	.	.	.	.	40.7	5.3%	.	.	.	.	40.7	2.1%
	Spio filicornis	.	.	162.6	36.4%	40.7	5.3%	.	.	.	.	40.7	2.1%
	Euzonus flabelligerus	.	.	40.7	9.1%	.	.	.	.	.	.	.	.
	Travisia forbesii	.	.	.	.	.	.	81.3	4.4%	.	.	40.7	2.1%
	Ophelia borealis	.	.	.	.	.	.	81.3	4.4%	.	.	.	.
	Polygordius appendiculatus	.	.	.	.	.	.	40.7	2.2%	.	.	.	.
	Lanice conchilega	40.7	5.0%	.	.	.	.	.	.	.	.	.	.
CRUSTACEA	Crangon crangon	40.7	5.0%	.	.	.	.	.	.	.	.	.	.
	Pagurus bernhardus	.	.	40.7	9.1%	.	.	.	.	.	.	.	.
	Pontocrates arenarius	40.7	5.0%	.	.	40.7	5.3%	40.7	2.2%	.	.	.	.
GASTROPODA	Polinices polianus	40.7	5.0%	.	.	.	.	.	.	.	.	.	.
BIVALVIA	Bivalvia indet,	40.7	5.0%	40.7	9.1%	.	.	.	.	.	.	.	.
	Mytilus edulis	.	.	.	.	.	.	81.3	4.4%	.	.	.	.
	Goodallia triangularis	122.0	15.0%	40.7	9.1%	447.2	57.9%	935.0	51.1%	731.7	58.1%	1504.1	78.7%
	Spisula solida	.	.	.	.	.	.	40.7	2.2%	81.3	6.5%	40.7	2.1%
	Thracia phaseolina	.	.	.	.	122.0	15.8%	.	.	.	.	81.3	4.3%
	Ensis ensis	365.9	45.0%	.	.	.	.	.	.	.	.	.	.
ECHINODERMATA	Ophiura ophiura	.	.	.	.	.	.	40.7	2.2%	.	.	.	.
CHORDATA	Branchiostoma lanceolatum	.	.	.	.	.	.	162.6	8.9%	.	.	.	.
Total		813.0	100.0%	447.2	100.0%	772.4	100.0%	1829.3	100.0%	1260.2	100.0%	1910.6	100.0%

Appendix 7. Benthos. Biomass

Appendix 7.1. Total mean biomass

Biomass, wet weight g/m²		Total		
		g/m²	Kol Sum %	N
HYDROZOA	Tubularia indivisa	.016	.0%	48
	Hydractinia echinata	.048	.0%	48
	Campanulariidae indet,	.019	.0%	48
ANTHOZOA	Actiniaria indet,	16.862	7.4%	48
NEMERTINI	Nemertini indet,	.007	.0%	48
NEMATODA	Nematoda indet,	.003	.0%	48
POLYCHAETA	Pisione remota	.059	.0%	48
	Nephtys caeca	.239	.1%	48
	Nephtys sp,	.207	.1%	48
	Goniadella bobretzkii	.433	.2%	48
	Orbinia sertulata	1.529	.7%	48
	Spio filicornis	.064	.0%	48
	Euzonus flabelligerus	.013	.0%	48
	Travisia forbesii	.609	.3%	48
	Ophelia borealis	1.888	.8%	48
	Polygordius appendiculatus	.006	.0%	48
	Arenicola marina	.164	.1%	48
	Lanice conchilega	.097	.0%	48
HYDROCARINA	Halacaridae indet,	.000	.0%	48
CRUSTACEA	Harpacticoida indet,	.009	.0%	48
	Crangon crangon	.291	.1%	48
	Liocarcinus pusillus	.133	.1%	48
	Pagurus bernhardus	53.311	23.3%	48
	Haustorius arenarius	.362	.2%	48
	Pontocrates arenarius	.034	.0%	48
	Jassa marmorata	.012	.0%	48
	Caprella linearis	.013	.0%	48
GASTROPODA	Crepidula fornicata	.051	.0%	48
	Polinices polianus	6.504	2.8%	48
BIVALVIA	Bivalvia indet,	.110	.0%	48
	Mytilus edulis	.005	.0%	48
	Goodallia triangularis	1.576	.7%	48
	Spisula elliptica	.022	.0%	48
	Spisula solida	66.359	29.0%	48
	Angulus tenuis	.007	.0%	48
	Thracia phaseolina	7.767	3.4%	48
	Ensis ensis	60.180	26.3%	48
BRYOZOA	Bryozoa indet,	.013	.0%	48
ECHINODERMATA	Asterias rubens	8.230	3.6%	48
	Ophiura ophiura	.792	.3%	48
	Echinocyamus pusillus	.194	.1%	48
CHORDATA	Branchiostoma lanceolatum	.554	.2%	48

Appendix 7.2. Mean biomass. Wind farm area – reference area

Biomass - 3 years: Year

		Sampling area							
		Wind Farm area				Reference area			
		2001		2003		1999		2003	
		Campaign		Campaign		Campaign		Campaign	
		Autumn		Autumn		Spring		Autumn	
Biomass, wet weight g/m²		Mean	Relative %	Mean	Relative %	Mean	Relative %	Mean	Relative %
HYDROZOA	Hydractinia echinata	.000	.0%	.064	.0%	1.331	.6%	.001	.0%
	Campanulariidae indet,	.	.	.026	.0%	.	.	.	.
	Tubularia indivisa	.	.	.022	.0%	.	.	.	.
ANTHOZOA	Actiniaria indet,	.	.	22.482	12.1%	.	.	.	.
GOPLER	Beroe cucumis	.	.	.	.	.265	.1%	.	.
NEMERTINI	Nemertini indet,	.038	.0%	.002	.0%	.078	.0%	.019	.0%
NEMATODA	Nematoda indet,	.007	.0%	.003	.0%	.003	.0%	.	.
POLYCHAETA	Ophelia borealis	7.405	2.5%	.299	.2%	27.560	13.0%	6.654	1.9%
	Nephtys longosetosa	.940	.3%	.	.	10.184	4.8%	.	.
	Orbinia sertulata	.	.	1.834	1.0%	9.194	4.4%	.614	.2%
	Travisia forbesii	.	.	.725	.4%	8.249	3.9%	.259	.1%
	Scoloplos armiger	.449	.1%	.	.	.	.	.	.
	Nephtys hombergii	.	.	.	.	.428	.2%	.	.
	Lanice conchilega	.	.	.	.	.	.	.387	.1%
	Protodorvillea kefersteini	.	.	.	.	.322	.2%	.	.
	Polychaeta indet.	.298	.1%	.	.	.	.	.	.
	Scolelepis bonnieri	.068	.0%	.	.	.476	.2%	.	.
	Goniadella bobretzkii	.184	.1%	.555	.3%	.245	.1%	.068	.0%
	Arenicola marina	.	.	.218	.1%	.	.	.	.
	Nephtys caeca	.	.	.266	.1%	.	.	.158	.0%
	Nephtys sp,	.	.	.204	.1%	.046	.0%	.215	.1%
	Spio filicornis	.208	.1%	.068	.0%	.234	.1%	.051	.0%
	Magelona mirabilis	.	.	.	.	.137	.1%	.	.
	Pisione remota	.035	.0%	.078	.0%	.174	.1%	.003	.0%
	Euzonus flabelligerus	.	.	.	.	.	.	.050	.0%
	Polygordius appendiculatus	.	.	.007	.0%	.	.	.005	.0%
	Pholoe sp.	.	.	.	.	.001	.0%	.	.
	Eulalia viridis	.001	.0%	.	.	.	.	.	.
	Glycera sp.	.	.	.	.	.	.	.	.
	Aonides paucibranchiata	.	.	.	.	.	.	.	.
	Polygordius sp.	.	.	.	.	.	.	.	.
HYDROCARINA	Halacaridae indet,	.	.	.000	.0%	.	.	.	.
CRUSTACEA	Pagurus bernhardus	4.503	1.5%	66.644	35.9%	76.295	36.1%	13.311	3.7%
	Balanus sp.	37.229	12.4%	.	.	.	.	.	.
	Carcinus maenas	.	.	.	.	28.392	13.4%	.	.
	Crangon crangon	.	.	.	.	24.765	11.7%	1.165	.3%
	Gastrosaccus spinifer	2.363	.8%	.	.	.	.	.	.
	Haustorius arenarius	.003	.0%	.482	.3%	5.044	2.4%	.	.
	Liocarcinus pusillus	.	.	.177	.1%	.	.	.	.
	Mysidacea indet.	.089	.0%	.	.	.	.	.	.
	Pontocrates arenarius	.004	.0%	.035	.0%	.079	.0%	.030	.0%
	Caprella linearis	.	.	.017	.0%	.	.	.	.
	Jassa marmorata	.	.	.016	.0%	.	.	.	.
	Atylus swammerdami	.007	.0%	.	.	.	.	.	.
	Harpacticoida indet,	.000	.0%	.012	.0%	.001	.0%	.	.
	Eurysteus nitida	.000	.0%	.	.	.007	.0%	.	.
	Bathyporeia guilliamsoniana	.003	.0%	.	.	.	.	.	.
	Metopa sp.	.003	.0%	.	.	.	.	.	.
	Oedicerotidae indet.	.	.	.	.	.003	.0%	.	.
	Westwoodilla caecula	.002	.0%	.	.	.	.	.	.
	Metopidae indet.	.	.	.	.	.001	.0%	.	.
	Cyclopoida indet.	.001	.0%	.	.	.	.	.	.
	Diastylis sp.	.000	.0%	.	.	.	.	.	.
	Pseudocuma longicornis	.000	.0%	.	.	.	.	.	.
	Stenothoe sp.	.000	.0%	.	.	.	.	.	.
	Pontocrates sp.	.000	.0%	.	.	.	.	.	.
	Bathyporeia sp.	.	.	.	.	.	.	.	.
GASTROPODA	Polinices polianus	3.210	1.1%	7.881	4.2%	.035	.0%	2.376	.7%
	Crepidula fornicata	.	.	.069	.0%	.	.	.	.
BIVALVIA	Ensis ensis	.	.	.	.	.	.	240.718	67.1%
	Spisula solida	231.883	77.4%	62.580	33.7%	15.413	7.3%	77.699	21.7%
	Thracia phaseolina	10.004	3.3%	7.203	3.9%	.	.	9.458	2.6%
	Goodallia triangularis	.542	.2%	1.504	.8%	.904	.4%	1.794	.5%
	Fabulina fabula	.	.	.	.	1.022	.5%	.	.
	Bivalvia indet,	.001	.0%	.	.	.	.	.438	.1%
	Arctica islandica	.055	.0%	.	.	.	.	.	.
	Spisula elliptica	.	.	.030	.0%	.	.	.	.
	Angulus tenuis	.	.	.009	.0%	.	.	.	.
	Mytilus edulis	.015	.0%	.003	.0%	.	.	.008	.0%
BRYOZOA	Electra pilosa	.049	.0%	.	.	.	.	.	.
	Bryozoa indet,	.	.	.018	.0%	.	.	.	.
ECHINODERMATA	Asterias rubens	.	.	10.974	5.9%	.	.	.	.
	Ophiura ophiura	.	.	.	.	.	.	3.169	.9%
	Echinocyamus pusillus	.	.	.259	.1%	.	.	.	.
	Echinocardium cordatum	.	.	.	.	.	.	.	.
CHAETOGHNATHA	Sagitta sp.	.000	.0%	.	.	.	.	.	.
CHORDATA	Branchiostoma lanceolatum	.080	.0%	.712	.4%	.348	.2%	.078	.0%

Appendix 7.3. Mean biomass. Total distance.

		Sampling area							
		Wind Farm area						Reference area	
		Campaign						Campaign	
		Autumn 2003						Autumn 2003	
		Distance (m)						Distance (m)	
		5		25		100		Reference	
Biomass, wet weight g/m²		g/m²	Kol Sum %	g/m²	Kol Sum %	g/m²	Kol Sum %	g/m²	Kol Sum %
HYDROZOA	Tubularia indivisa	.	.	.	.	.065	.0%	.	.
	Hydractinia echinata	.	.	.192	.1%	.	.	.001	.0%
	Campanulariidae indet,	.	.	.	.	.077	.0%	.	.
ANTHOZOA	Actiniaria indet,	.	.	67.446	38.0%	.	.	.	.
NEMERTINI	Nemertini indet,	.	.	.	.	.007	.0%	.019	.0%
NEMATODA	Nematoda indet,	.009	.0%	.	.	.001	.0%	.	.
POLYCHAETA	Pisione remota	.049	.0%	.183	.1%	.001	.0%	.003	.0%
	Nephtys caeca	.	.	.	.	.799	.3%	.158	.0%
	Nephtys sp,	.124	.1%	.163	.1%	.327	.1%	.215	.1%
	Goniadella bobretzkii	1.109	.7%	.071	.0%	.485	.2%	.068	.0%
	Orbinia sertulata	4.148	2.8%	1.235	.7%	.118	.1%	.614	.2%
	Spio filicornis	.125	.1%	.026	.0%	.054	.0%	.051	.0%
	Euzonus flabelligerus	.	.	.	.	.	.	.050	.0%
	Travisia forbesii	.	.	.687	.4%	1.488	.7%	.259	.1%
	Ophelia borealis	.856	.6%	.012	.0%	.028	.0%	6.654	1.9%
	Polygordius appendiculatus	.006	.0%	.013	.0%	.001	.0%	.005	.0%
	Arenicola marina	.	.	.	.	.655	.3%	.	.
	Lanice conchilega	.	.	.	.	.	.	.387	.1%
HYDROCARINA	Halacaridae indet,	.	.	.	.	.000	.0%	.	.
CRUSTACEA	Harpacticoida indet,	.001	.0%	.003	.0%	.032	.0%	.	.
	Crangon crangon	.	.	.	.	.	.	1.165	.3%
	Liocarcinus pusillus	.	.	.	.	.532	.2%	.	.
	Pagurus bernhardus	.	.	.	.	199.932	87.4%	13.311	3.7%
	Haustorius arenarius	1.447	1.0%	.	.	.	.	.	.
	Pontocrates arenarius	.	.	.012	.0%	.095	.0%	.030	.0%
	Jassa marmorata	.033	.0%	.006	.0%	.009	.0%	.	.
	Caprella linearis	.013	.0%	.	.	.037	.0%	.	.
GASTROPODA	Crepidula fornicata	.	.	.	.	.206	.1%	.	.
	Polinices polianus	5.920	3.9%	.871	.5%	16.851	7.4%	2.376	.7%
BIVALVIA	Bivalvia indet,	.	.	.	.	.	.	.438	.1%
	Mytilus edulis	.003	.0%	.	.	.007	.0%	.008	.0%
	Goodallia triangularis	2.429	1.6%	1.293	.7%	.789	.3%	1.794	.5%
	Spisula elliptica	.	.	.089	.1%	.	.	.	.
	Spisula solida	90.459	60.1%	96.724	54.6%	.557	.2%	77.699	21.7%
	Angulus tenuis	.	.	.028	.0%	.	.	.	.
	Thracia phaseolina	9.994	6.6%	6.150	3.5%	5.467	2.4%	9.458	2.6%
	Ensis ensis	.	.	.	.	.	.	240.718	67.1%
BRYOZOA	Bryozoa indet,	.053	.0%	.	.	.	.	.	.
ECHINODERMATA	Asterias rubens	32.921	21.9%	.	.	.	.	.	.
	Ophiura ophiura	.	.	.	.	.	.	3.169	.9%
	Echinocyamus pusillus	.778	.5%	.	.	.	.	.	.
CHORDATA	Branchiostoma lanceolatum	.052	.0%	2.074	1.2%	.010	.0%	.078	.0%

Appendix 7.4. Mean biomass.

		Wind Farm area					
		Autumn 2003					
		Mill51					
		Distance (m)					
		5		25		100	
Biomass, wet weight g/m²		g/m²	Kol Sum %	g/m²	Kol Sum %	g/m²	Kol Sum %
HYDROZOA	Tubularia indivisa	.	.	.	.	.390	.0%
	Hydractinia echinata	.	.	1.154	.3%	.	.
	Campanulariidae indet,	.	.	.	.	.459	.0%
ANTHOZOA	Actiniaria indet,	.	.	404.679	99.4%	.	.
NEMATODA	Nematoda indet,	.057	.1%	.	.	.	.
POLYCHAETA	Nephtys caeca	.	.	.	.	2.606	.2%
	Nephtys sp,	.	.	.	.	.902	.1%
	Goniadella bobretzkii	.484	.6%	.	.	.020	.0%
	Spio filicornis	.	.	.	.	.240	.0%
	Ophelia borealis	.	.	.073	.0%	.171	.0%
CRUSTACEA	Harpacticoida indet,	.	.	.	.	.126	.0%
	Pagurus bernhardus	.	.	.	.	1199.593	98.8%
	Caprella linearis	.	.	.	.	.224	.0%
GASTROPODA	Crepidula fornicata	.	.	.	.	1.236	.1%
BIVALVIA	Goodallia triangularis	.228	.3%	.	.	.	.
	Angulus tenuis	.	.	.171	.0%	.	.
	Thracia phaseolina	15.398	19.6%	1.033	.3%	8.793	.7%
ECHINODERMATA	Asterias rubens	62.264	79.4%	.	.	.	.
CHORDATA	Branchiostoma lanceolatum	.	.	.	.	.004	.0%
Total		78.431	100.0%	407.110	100.0%	1214.764	100.0%

		Wind Farm area					
		Autumn 2003					
		Mill55					
		Distance (m)					
		5		25		100	
Biomass, wet weight g/m²		g/m²	Kol Sum %	g/m²	Kol Sum %	g/m²	Kol Sum %
NEMERTINI	Nemertini indet,	.	.	.	.	.024	.9%
POLYCHAETA	Nephtys sp,	.	.	.211	1.0%	.	.
	Goniadella bobretzkii	2.663	15.8%	.089	.4%	.073	2.6%
	Spio filicornis	.679	4.0%	.016	.1%	.081	2.9%
	Polygordius appendiculatus	.	.	.020	.1%	.	.
CRUSTACEA	Harpacticoida indet,	.	.	.	.	.065	2.3%
	Jassa marmorata	.	.	.004	.0%	.	.
GASTROPODA	Polinices polianus	5.996	35.6%	.	.	.	.
BIVALVIA	Goodallia triangularis	3.337	19.8%	1.744	8.5%	1.081	38.4%
	Spisula solida	.	.	.419	2.0%	1.451	51.5%
	Thracia phaseolina	3.939	23.4%	18.065	87.8%	.	.
CHORDATA	Branchiostoma lanceolatum	.252	1.5%	.	.	.041	1.4%
Total		16.866	100.0%	20.569	100.0%	2.817	100.0%

		Wind Farm area					
		Autumn 2003					
		Mill58					
		Distance (m)					
		5		25		100	
Biomass, wet weight g/m²		g/m²	Kol Sum %	g/m²	Kol Sum %	g/m²	Kol Sum %
NEMATODA	Nematoda indet,	.	.	.	.	.004	.0%
POLYCHAETA	Pisione remota	.276	.0%	1.098	.2%	.004	.0%
	Nephtys sp,	.744	.1%	.	.	.593	5.5%
	Goniadella bobretzkii	3.146	.5%	.	.	.	.
	Orbinia sertulata	24.890	4.2%	2.663	.4%	.	.
	Spio filicornis	.069	.0%	.	.	.	.
	Travisia forbesii	.	.	3.715	.6%	8.931	83.2%
	Ophelia borealis	5.045	.9%	.	.	.	.
	Polygordius appendiculatus	.	.	.012	.0%	.	.
HYDROCARINA	Halacaridae indet,	.	.	.	.	.000	.0%
CRUSTACEA	Haustorius arenarius	8.683	1.5%	.	.	.	.
	Pontocrates arenarius	.	.	.016	.0%	.	.
	Jassa marmorata	.	.	.	.	.024	.2%
BIVALVIA	Mytilus edulis	.	.	.	.	.045	.4%
	Goodallia triangularis	3.146	.5%	1.089	.2%	.602	5.6%
	Spisula elliptica	.	.	.537	.1%	.	.
	Spisula solida	542.752	92.2%	579.638	96.2%	.524	4.9%
	Thracia phaseolina	.	.	13.614	2.3%	.	.
CHORDATA	Branchiostoma lanceolatum	.	.	.004	.0%	.012	.1%
Total		588.752	100.0%	602.386	100.0%	10.740	100.0%

		Wind Farm area					
		Autumn 2003					
		Mill26					
		Distance (m)					
		5		25		100	
Biomass, wet weight g/m²		g/m²	Kol Sum %	g/m²	Kol Sum %	g/m²	Kol Sum %
POLYCHAETA	Pisione remota	.004	.0%	.	.	.	.
	Nephtys sp,	.	.	.	.	.171	2.3%
	Goniadella bobretzkii	.171	.1%	.264	1.6%	.150	2.0%
	Orbinia sertulata	.	.	.	.	.707	9.5%
	Travisia forbesii	.	.	.407	2.5%	.	.
	Polygordius appendiculatus	.020	.0%	.	.	.004	.1%
	Arenicola marina	.	.	.	.	3.931	52.6%
CRUSTACEA	Harpacticoida indet,	.	.	.004	.0%	.	.
	Jassa marmorata	.073	.0%	.004	.0%	.033	.4%
GASTROPODA	Polinices polianus	29.524	14.6%	.	.	.053	.7%
BIVALVIA	Goodallia triangularis	1.833	.9%	1.167	7.1%	1.053	14.1%
	Spisula solida	.	.	.	.	1.366	18.3%
	Thracia phaseolina	40.626	20.1%	3.776	23.0%	.	.
ECHINODERMATA	Asterias rubens	125.581	62.2%	.	.	.	.
	Echinocyamus pusillus	4.081	2.0%	.	.	.	.
CHORDATA	Branchiostoma lanceolatum	.053	.0%	10.821	65.8%	.004	.1%
Total		201.967	100.0%	16.443	100.0%	7.472	100.0%

		Wind Farm area					
		Autumn 2003					
		Mill73					
		Distance (m)					
		5		25		100	
Biomass, wet weight g/m²		g/m²	Kol Sum %	g/m²	Kol Sum %	g/m²	Kol Sum %
POLYCHAETA	Nephtys caeca	.	.	.	.	2.187	1.8%
	Goniadella bobretzkii	.053	1.0%	.045	.3%	2.362	2.0%
	Orbinia sertulata	.	.	4.748	35.5%	.	.
	Spio filicornis	.	.	.142	1.1%	.	.
	Polygordius appendiculatus	.016	.3%	.	.	.	.
CRUSTACEA	Harpacticoida indet,	.004	.1%	.012	.1%	.	.
	Liocarcinus pusillus	.	.	.	.	3.191	2.7%
	Pontocrates arenarius	.	.	.053	.4%	.569	.5%
	Jassa marmorata	.	.	.028	.2%	.	.
GASTROPODA	Polinices polianus	.	.	5.224	39.1%	101.053	84.8%
BIVALVIA	Goodallia triangularis	4.512	87.1%	2.699	20.2%	1.768	1.5%
	Thracia phaseolina	.	.	.411	3.1%	7.967	6.7%
ECHINODERMATA	Echinocyamus pusillus	.585	11.3%	.	.	.	.
CHORDATA	Branchiostoma lanceolatum	.008	.2%	.	.	.	.
Total		5.179	100.0%	13.362	100.0%	119.098	100.0%

		Wind Farm area					
		Autumn 2003					
		Mill95					
		Distance (m)					
		5		25		100	
Biomass, wet weight g/m²		g/m²	Kol Sum %	g/m²	Kol Sum %	g/m²	Kol Sum %
NEMERTINI	Nemertini indet,	.	.	.	.	.020	.1%
POLYCHAETA	Pisione remota	.016	.1%	.	.	.	.
	Nephtys sp,	.	.	.764	20.1%	.293	1.7%
	Goniadella bobretzkii	.138	1.2%	.028	.7%	.305	1.8%
	Ophelia borealis	.089	.7%	.	.	.	.
	Polygordius appendiculatus	.	.	.045	1.2%	.	.
CRUSTACEA	Jassa marmorata	.126	1.1%	.	.	.	.
	Caprella linearis	.077	.6%	.	.	.	.
BIVALVIA	Mytilus edulis	.016	.1%	.	.	.	.
	Goodallia triangularis	1.516	12.7%	1.057	27.8%	.232	1.4%
	Spisula solida	.	.	.285	7.5%	.	.
	Thracia phaseolina	.	.	.	.	16.041	95.0%
BRYOZOA	Bryozoa indet,	.317	2.6%	.	.	.	.
ECHINODERMATA	Asterias rubens	9.683	80.8%	.	.	.	.
CHORDATA	Branchiostoma lanceolatum	.	.	1.618	42.6%	.	.
Total		11.980	100.0%	3.797	100.0%	16.890	100.0%

		Reference area											
		Autumn 2003											
		Ref01		Ref07		Ref35		Ref36		Ref37		Ref40	
Biomass, wet weight g/m²		g/m²	Kol Sum %	g/m²	Kol Sum %	g/m²	Kol Sum %	g/m²	Kol Sum %	g/m²	Kol Sum %	g/m²	Kol Sum %
HYDROZOA	Hydractinia echinata	.	.	.008	.0%	.	.	.	.	.	.	.	.
NEMERTINI	Nemertini indet,	.	.	.	.	.	.	.037	.0%	.077	2.1%	.	.
POLYCHAETA	Pisione remota	.	.	.	.	.004	.0%	.	.	.016	.4%	.	.
	Nephtys caeca	.	.	.447	.5%	.	.	.500	.1%	.	.	.	.
	Nephtys sp,	.427	.0%	.866	1.0%	.	.	.	.	.	.	.	.
	Goniadella bobretzkii	.077	.0%	.	.	.024	.1%	.085	.0%	.171	4.6%	.049	.1%
	Orbinia sertulata	.	.	.	.	.370	1.9%	.	.	.	.	3.317	7.0%
	Spio filicornis	.	.	.240	.3%	.012	.1%	.	.	.	.	.057	.1%
	Euzonus flabelligerus	.	.	.301	.4%	.	.	.	.	.	.	.	.
	Travisia forbesii	.	.	.	.	.	.	1.443	.3%	.	.	.110	.2%
	Ophelia borealis	.	.	.	.	.	.	39.927	7.6%	.	.	.	.
	Polygordius appendiculatus	.	.	.	.	.	.	.033	.0%	.	.	.	.
	Lanice conchilega	2.321	.2%	.	.	.	.	.	.	.	.	.	.
CRUSTACEA	Crangon crangon	6.988	.5%	.	.	.	.	.	.	.	.	.	.
	Pagurus bernhardus	.	.	79.866	94.6%	.	.	.	.	.	.	.	.
	Pontocrates arenarius	.008	.0%	.	.	.126	.6%	.045	.0%	.	.	.	.
GASTROPODA	Polinices polianus	14.256	1.0%	.	.	.	.	.	.	.	.	.	.
BIVALVIA	Bivalvia indet,	.065	.0%	2.565	3.0%	.	.	.	.	.	.	.	.
	Mytilus edulis	.	.	.	.	.	.	.049	.0%	.	.	.	.
	Goodallia triangularis	.329	.0%	.093	.1%	1.484	7.7%	2.764	.5%	1.894	50.8%	4.199	8.8%
	Spisula solida	.	.	.	.	.	.	464.280	87.8%	1.569	42.1%	.341	.7%
	Thracia phaseolina	.	.	.	.	17.370	89.6%	.	.	.	.	39.378	83.0%
	Ensis ensis	1444.309	98.3%	.	.	.	.	.	.	.	.	.	.
ECHINODERMATA	Ophiura ophiura	.	.	.	.	.	.	19.012	3.6%	.	.	.	.
CHORDATA	Branchiostoma lanceolatum	.	.	.	.	.	.	.467	.1%	.	.	.	.
Total		1468.780	100.0%	84.386	100.0%	19.390	100.0%	528.642	100.0%	3.728	100.0%	47.451	100.0%

Appendix 8. Mussels

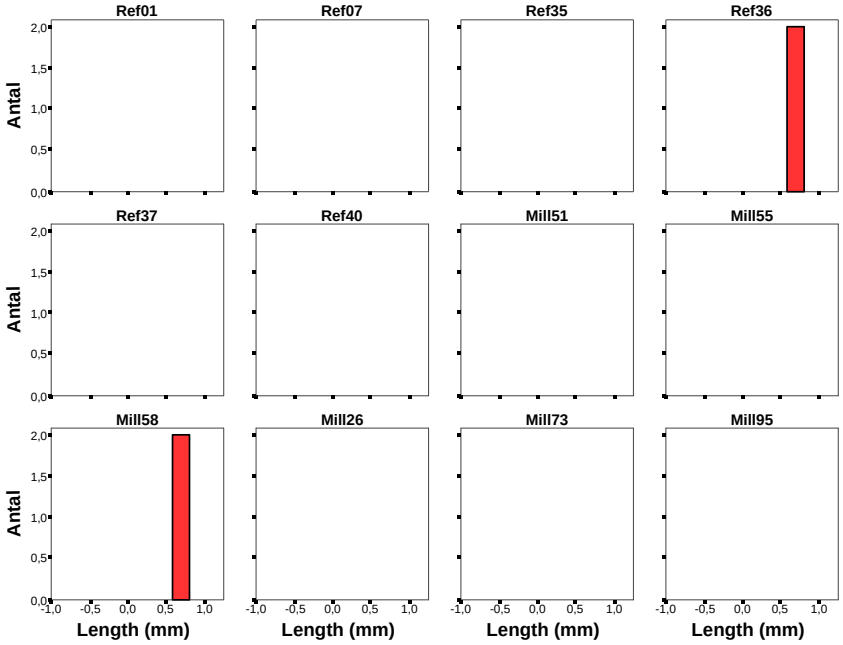
Horns Rev, 2003
Mussels
Length in mm[a]

			Mean	Std.v.	N	Min	Max
Mytilus edulis	Station	Ref36	0.71	.0	N=2	0.71	0.71
		Turbine 58	0.79	.0	N=2	0.79	0.79
		Turbine 95	1.26	.	N=1	1.26	1.26
	Species total		0.852	0.23	N=5	0.71	1.26
Goodallia triangularis	Station	Ref01	1.87	.0	N=3	1.87	1.87
		Ref07	1.95	.	N=1	1.95	1.95
		Ref35	2.33	.0	N=11	2.33	2.33
		Ref36	1.83	0.04	N=23	1.8	1.88
		Ref37	2.09	0.40	N=18	1.52	3.12
		Ref40	1.95	26,00	N=37	1.6	2.92
		Turbine 51	2.46	.	N=1	2.46	2.46
		Turbine 55	1.80	0.22	N=80	1.57	2.18
		Turbine 58	2.14	14,00	N=42	1.82	2.24
		Turbine 26	1.96	0.09	N=36	1.9	2.16
		Turbine 73	1.76	,10	N=104	1.52	1.82
		Turbine 95	1.83	0.26	N=31	1.45	2.52
	Species total		1.89	0.24	N=387	1.45	3.12
Spisula solida	Station	Ref36	40.44	.	N=1	40.44	40.44
		Ref37	5.22	0.47	N=2	4.89	5.55
		Ref40	3.32	.	N=1	3.32	3.32
		Turbine 55	4.99	1.30	N=2	4.07	5.91
		Turbine 58	18.10	19.77	N=5	2.83	40.38
		Turbine 26	5.9	.	N=1	5.9	5.9
		Turbine 95	3.78	.	N=1	3.78	3.78
	Species total		12.64	15.61	N=13	2.83	40.44
Angulus tenuis	Station	Turbine 51	3.53	.	N=1	3.53	3.53
	ART total		3.53	.	N=1	3.53	3.53
Thracia phaseolina	Station	Ref35	10.46	3.55	N=3	7.31	14.31
		Ref40	16.42	2.86	N=2	14.39	18.44
		Turbine 51	10.09	6.27	N=4	4.24	15.57
		Turbine 55	9.96	2.49	N=4	7.02	12.86
		Turbine 58	14.32	.	N=1	14.32	14.32
		Turbine 26	14.54	8.86	N=2	8.27	20.8
		Turbine 73	7.04	4.38	N=4	3.99	13,43
		Turbine 95	14.98	.	N=1	14.98	14.98
	Species total		11.00	4.94	N=21	3.99	20.8
Ensis ensis	Station	Ref01	77.16	16.21	N=9	57.43	109.9
	Species total		77.16	16.21	N=9	57.43	109.9

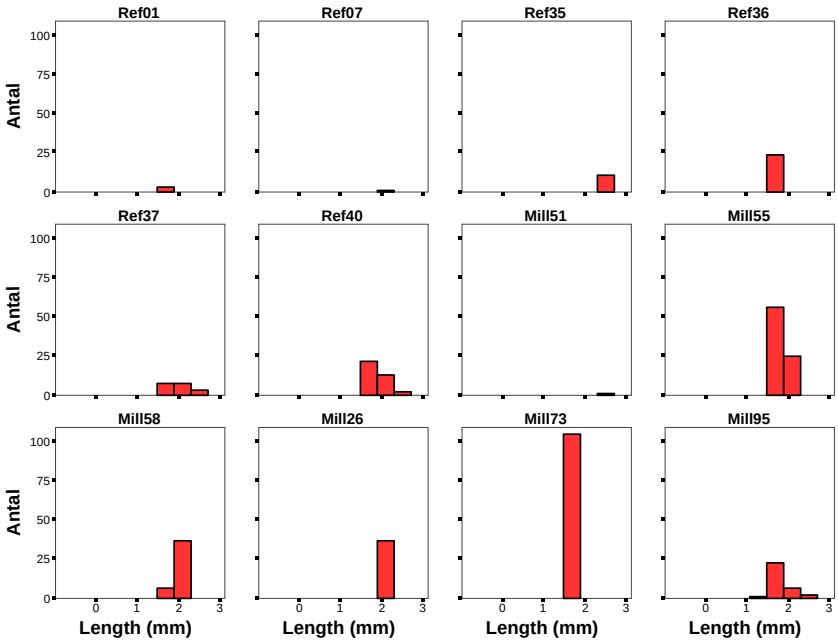
a. dato = 20030905,00

Appendix 8.1. Mussels. Length frequencies

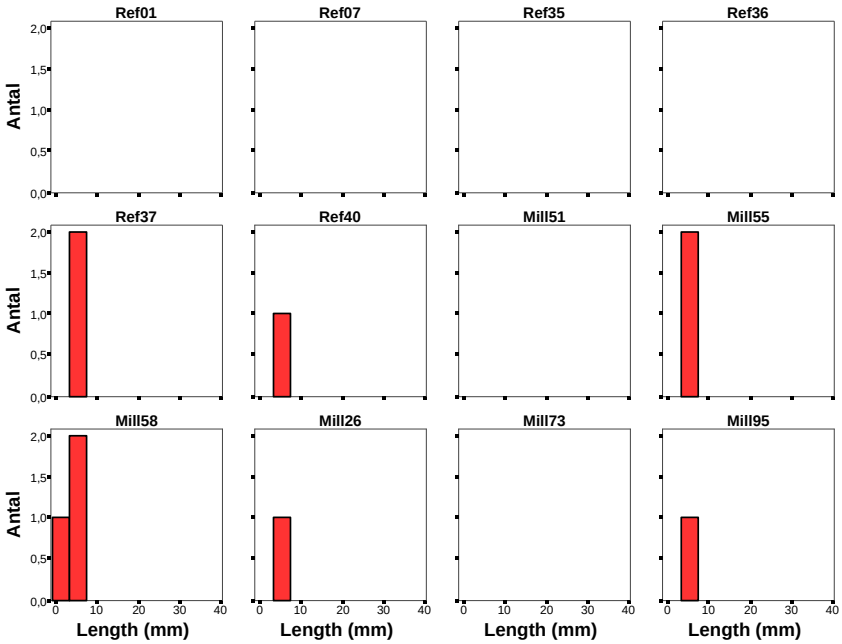
Mytilus edulis



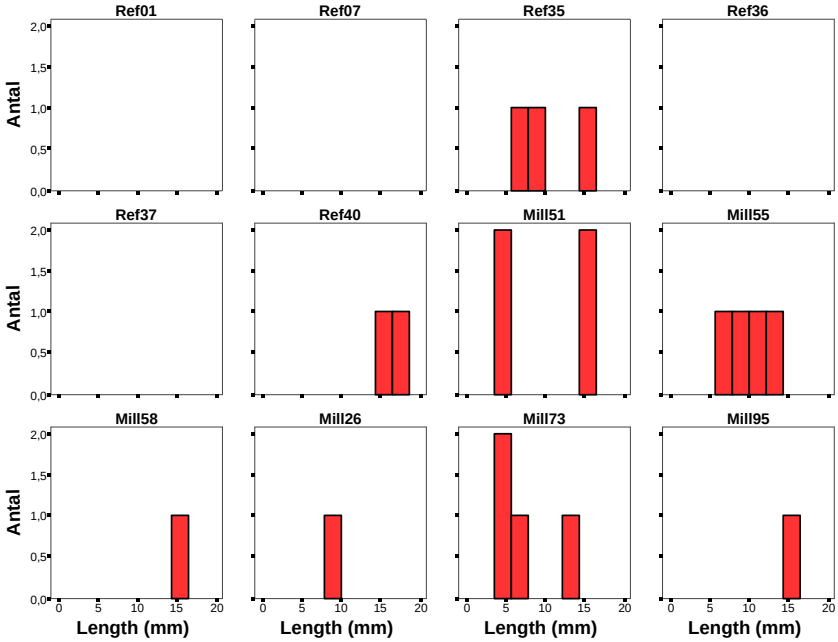
Goodallia triangularis



Spisula solida



Thracia phaseolina



Ensis ensis