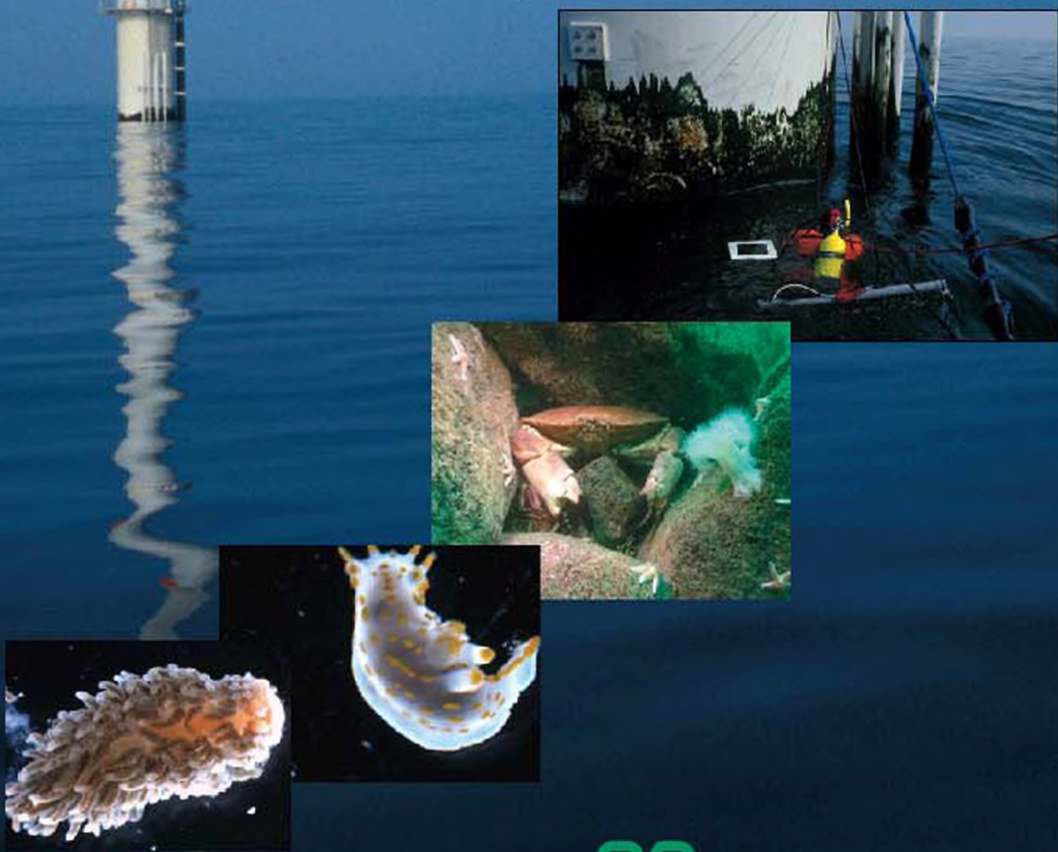
Elsam Engineering

Hard Bottom Substrate Monitoring
Horns Rev Offshore Wind Farm

Annual Status Report 2004



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Hard Bottom Substrate Monitoring Horns Rev Offshore Wind Farm

Annual Status Report 2004

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TABLE OF CONTENTS **PAGE**

Summary

As part of the monitoring programme concerning the ecological impact from the introduction of hard substrate related to the Horns Rev Wind Farm, the second survey on the fouling communities since the erection of the wind farm in 2002 was performed in March and September 2004. The survey is a continuation of the survey performed in 2003.

Horns Rev is situated 14-20 km off Blåvands Huk, Denmark's most western point. Horns Rev was formed by a huge accumulation of Holocene marine sand deposits up to 20 m in depth. The water depth in the wind farm area varies from 6-14 m. The first of a total of 80 wind turbine foundations was in place in March 2003 and the last of the foundations was in place in August 2003.

Methodology
The wind turbine (WTG) foundations are constructed using the "mono-pile" concept. At the seabed, a "gravel mattress" or scour protection is arranged around the foundation to minimise erosion. The diameter of the mono-pile foundation of the turbines is 4 m. The scour protection with a diameter of approximately 27 m in total consists of a protective stone mattress of stones up to 55 cm in diameter and a subjacent layer of smaller stones 3-20 cm in diameter. Surveys were performed at six turbine sites concerning the horizontal distribution of epifouling assemblages on scour protections whereas the vertical distribution of epifouling assemblages was only performed at tree mono-piles. Epifouling communities exposed to different current regimes were studied both on the mono-piles as well as on the scour protection.

Sampling was performed by SCUBA diving. Quantitative samples were collected from stone blocks and mono-piles while semi-quantitative (not precisely counted records) observations on flora- and fauna fouling communities were made according to a modified Braun-Blanquet scale along transects on both the scour protections and the mono-piles. Fish species were observed and in addition standard gill nets were used for specific test fishing. For documentation, under water video recordings were made.

In March, samples were taken on populations of the "giant" midge *Telmatogeton japonicus* inhabiting the splash/wash zone at the mono-piles. Recent observations on *Telmatogeton japonicus*, recorded for the first time in Denmark at Horns Rev in 2003, have revealed that this species is common and widely distributed on strongly exposed coasts in Denmark. It is especially common on large boulders in breakwaters and seawalls.

Results flora
A total of 11 taxa of seaweeds were registered on the mono-piles and scour protections showing a distinct variation in spatial and temporal distribution. The vegetation was more frequently found on the mono-piles compared to the scour protections. Only a few species were found on stones at the scour protections and almost exclusively at turbine sites in the shallowest areas. Typical vertical zonations were found on the mono-piles with the species of *Ulva (Enteromorpha)* being the most frequent. Considerable changes in the vegetation community especially in the splash zone and at the upper part of the mono-piles between 2003 and 2004 were observed which might be a result of natural succession. The vegetation cover of filamentous algae was more or less replaced by species of *Ulva* in 2004 but also marked higher coverage of *Ulva* on the scour protections.

Results fauna
A total of 70 taxa of invertebrates were registered and of these 12 very mobile species were exclusively observed during the transect surveys. Great variations were found between surveys in 2003 and 2004 and in spatial and temporal distribution between species and communities. In general, community structure between sites and sample locations were statistically different. Differences in abundances of the dominant species of amphipods *Jassa marmorata* and *Caprella linearis* were the main factors to the vertical and spatial differences. The cosmopolitan *Jassa marmorata* was most frequently found on the mono-piles in abundances as high as 1,230,537 ind./m^2.

Distinct vertical zonations and changes were observed between 2003 and 2004 in the faunal assemblages on the mono-piles. In the splash zone, the almost monoculture population of the "giant" midge *Telmatogeton japonicus* increased markedly since 2003. Dense aggregations of either spat or larger individuals of *Mytilus edulis* were found in the sublittoral just beneath the sea surface at the mono-piles. Changes in population structure between 2003 and 2004 clearly demonstrated growth of the common mussels. Clear discrepancies in the distribution and abundance between the common mussel *Mytilus edulis*, the barnacle *Balanus crenatus* and the predator *Asterias rubens* indicated that the starfish was the main keystone predator controlling the vertical and horizontal distribution of its prey species. Larger starfish eat mainly larger mussels whereas smaller starfish eat both smaller mussels and barnacles. In 2004, for example, smaller starfish were more abundant while barnacles were less abundant compared to 2003.

In the lower zone at the mono-piles, the bristle worm *Pomatoceros triqueter*, a primary coloniser, was more abundant than in the upper zones. This species was also found to be less frequent in 2004 compared to 2003. The apparent stagnation in population size of *Pomatoceros triqueter* might be the result of competition for space from other species. Equally, another primary coloniser, the hydrozoan *Tubularia indivisa*, was less abundant in 2004 compared to 2003, which could be a result of lack of space or predation from sea slugs, *Facelina bostoniensis* among others new to the Horns Rev fauna in 2004.

Impact from predation, recruitment and competition for space will contribute to a continuously repeating succession process until a relatively stabile community is reached.

Compared to 2003, a considerably higher abundance of juvenile edible crabs were found on the mono-piles and larger individuals were often observed in caves and crevices among stones in the scour protection in 2004. Growth in individuals of *Cancer pagurus* was demonstrated from September 2003 to March 2004 while registration of both juveniles of other crabs and egg masses of bristle worms and sea slugs indicated that the turbine foundations were used as hatchery and nursery grounds.

A very high variation and a general significant difference was found between faunal assemblages at different sampling sites on the scour protection, but some similarity between different zones mainly reflecting different types of substrate was demonstrated.

New species
14 epifaunal species were newly recorded hard bottom fauna at Horns Rev in 2004. Of these, special attention should be given to the bristle worm *Sabellaria*, presumably *S. spinulosa*, and the white weed *Sertularia cupressina*, which in the Wadden Sea area are regarded as threatened or red listed species. In Europe, *Sertularia cupressina* is harvested for decoration pur-

poses. *Sertularia cupressina* and more of the species found on the hard substrate at Horn Rev are typical for sand scoured habitats categorised as "slightly scoured circalittoral rock".

Fish community
As in 2003, a marked succession in the number of fish species was observed from the survey in March to the survey in September. This might be a result of seasonal migrations of fish species to the turbine site for foraging. Bip (pouting) was observed presumably partly feeding on crustaceans on the scour protection together with schools of cod. Individuals of species like the rock gunnel and the dragonet were commonly found inhabiting caves and crevices between the stones. Compared to 2003, only a few more fish species were observed in 2004 for a total of 17 different species. Apparently the lumpsucker and the broad-nosed pipefish have established themselves at the turbine sites but also pelagic and semipelagic fish like the European sprat, the Atlantic mackerel and the small sandell seem to be more frequently observed than previously.

Comparisons with fish fauna on shipwrecks in other parts of the North Sea showed that there was great similarity in the species observed including benthic species. Also, there was no indication that noise or vibrations from the turbine generators had any impact on the fish community at Horns Rev.

By comparing the average biomass of the infauna on the sand bottom between the turbines (Bech et al. 2004), it was estimated that the availability of food for fish in the area has increased by a factor of approximately 60 after the introduction of the hard substratum at Horns Rev. Therefore, an increase of fish production related to the presence of the hard substratum is considered possible. Precautions must be drawn to the estimation of the comparable factor for biomass due to the high variability in the presence of larger soft bottom species.

Regulatory factors
A number of benthic invertebrates and fish species have been "newly" recorded in the Horns Rev area while changes in community structures have also been detected. There are no indications that natural succession in communities, predation, recruitment and the presence of hard bottom substrates were regulatory factors for the observed changes.

Perspective
Compared to the fauna community in the wind farm prior to the erection of the wind turbines and the establishment of the scour protections, the fauna communities on the introduced hard substrates are completely different. Larger hard structures did not exist in the area and the fauna inside the wind farm areas consisted mainly of typical infauna species characteristic for sandbanks in the North Sea. At the turbine sites, new habitats were introduced changing the substrates form pure sand to foundations of steel, gravel and stones and a typical epifaunal community has replaced the native infaunal community. The newly established epifaunal community will continuously undergo changes due to ecological succession enabling a climax community to be formed. A climax community is not expected within 5-6 years after hard substrate deployment and occasionally disruption of community succession due to effects from storm events and hard winters may even prolong this process until a stable community is attained. More species found on wrecks in other parts of the North Sea are likely to be found at Horns Rev in the future.

Sammenfatning (in Danish)

Som et led i moniteringsprogrammet i forbindelse med etableringen af Horns Rev vindmølle park er der i marts og september 2004 foretaget anden undersøgelsesrunde af begroningssamfundet, siden mølleparken blev etableret i 2002. Undersøgelserne er foretaget med henblik på at vurdere den økologiske påvirkning som følge af introduktionen af hårbunds substrat i området og er en opfølgning på de undersøgelser, der blev udført i 2003.

Horns Rev er beliggende ca. 14-20 km ud for Blåvands Huk Danmarks vestligste punkt. Horns Rev er dannet af enorme sandophobninger af Holocænt marint sand som er indtil 20 m i tykkelse. Vanddybden i området varierer fra ca. 6 til 14 m. Den første af de i alt 80 vindmøllefundamenter blev rejst i marts 2002 og det sidste fundament var på plads i august 2002.

Metode
Konstruktionen af møllefundamenterne er baseret på monopæl konceptet. For at sikre monopæl-fundamentet mod erosion er der på havbunden udlagt en beskyttelseskappe af sten. Monopælen er 4 m i diameter. Erosionsbeskyttelsen, som består af et øvre lag af store dæksten op til 55 cm i diameter og et underlag af mindre sten på omkring 3-20 cm i diameter, har en total diameter på ca. 27 m. Undersøgelser af den horisontale fordeling af begroningssamfundet blev udført på erosionsbeskyttelsen ved 6 vindmøllelokaliteter mens den vertikale fordeling af begroningssamfundet kun blev udført på tre monopæle. Begroningssamfundet blev undersøgt i relation til eventuelle forskelle i strømforhold på både erosionsbeskyttelsen og på monopælene. .

Indsamlingen af prøver blev foretaget af dykkere. Der blev indsamlet kvantitative prøver fra både monopæle og erosionsbeskyttelsen og langs transekter omfattende både monopæle og erosionsbeskyttelsen blev der foretaget semi-kvantitative undersøgelser af begroningssamfundet efter en modificeret Braun-Blanquet skala. Forekomsten af fiskearter blev registreret og tillige blev der udført et testfiskeri med standard undersøgelsesgarn. Til dokumentation blev der optaget undervandsvideo.

I marts blev der foretaget specifikke undersøgelse af bestanden af den "store" dansemyg *Telmatogeton japonicus,* der findes i sprøjte/bølgezonen på monopælene. *Telmatogeton japonicus* der første gang blev registreret i Danmark på Horns Rev i 2003, har senere vist sig at være udbredt og almindelig i Danmark på stærkt eksponerede kyststrækninger med sten, høfdeanlæg og moleanlæg.

Resultater flora
Der blev på monopælene og erosionsbeskyttelsen i alt registreret 11 forskellige taxa af makroalger. Samfundet af makroalger udviste en tydelig tidsmæssig og rummelig variation i udbredelse. Vegetationen blev i sammenligning med erosionsbeskyttelsen hyppigst registreret på monopælene. Der blev kun fundet få arter på stenene på erosionsbeskyttelsen, og det var karakteristisk at disse næsten udelukkende var beliggende på møllepositioner med de mindste vanddybder. Der blev registreret en tydelig vertikal zonering af algerne på monopælene, hvor arter af slægten Ulva (*Enteromorpha)* var de hyppigst forekommende. Betydelig variation i vegetationssamfundet mellem 2003 og 2004 blev observeret, hvilket kan være resultatet af en naturlig succession. Forekomsten af trådformede alger var mere eller mindre erstattet af arter af *Ulva* i 2004 og også dækningen af *Ulva* på erosionsbeskyttelsen var markant større i 2004.

Resultater fauna
Der blev registreret i alt 70 forskellige taxa af invertebrater, hvoraf 12 fortrinsvis meget mobile arter, kun blev observeret ved transektundersøgelserne. Der blev fundet en stor variation mellem undersøgelserne i 2003 og 2004 samt mellem arter og samfund med hensyn til både den rummelige og tidsmæssige fordeling. Generelt blev der fundet statistiske forskelle i samfundene mellem de enkelte møllepositioner og indsamlingslokaliteter. Den væsentligste faktor til variationen skyldtes forskelle i individtæthederne af de dominerende arter tanglopperne *Jassa marmorata* og *Caprella linearis*. *Jassa marmorata*, der er en kosmopolitisk art, blev hyppigst fundet på selve monopælene med tætheder så høje som 1.230.537 individer/m^2.

Der blev registreret en tydelig zonering samt forskel mellem 2003 og 2004 i den vertikale fordeling af faunasamfundene på monopælene. I sprøjtezonen eller bølgeskvulpzonen er populationen af den store dansemyg *Telmatogeton japonicus* øget betydeligt siden 2003. Tætte bestande af enten yngel eller større individer af blåmuslingen *Mytilus edulis* blev registreret sublittoralt på monopælene lige under havoverfladen. Tydelig adskillelse i fordelingen og tætheden mellem blåmuslingen *Mytilus edulis*, delvis ruren *Balanus crenatus* og rovdyret *Asterias rubens* indikerer, at søstjernen var "nøgle" rovdyret, der kontrollerede både den vertikale og horisontale fordeling af byttedyrene. Større søstjerner spiser fortrinsvis større muslinger og mindre søstjerner spiser især mindre muslinger og rurer. For eksempel var små søstjerner mere talrige og rurer mindre talrige i 2004 end i 2003.

Den primære kolonisator børsteormen *Pomatoceros triqueter* var mindre talrig i 2004 sammenlignet med forekomsten i 2003, og denne art var generelt mere talrig i den nedre zone af monopælene end i den øvre zone. Den tilsyneladende stilstand i bestandsudviklingen af *Pomatoceros triqueter* kan være et resultat af konkurrencen om plads fra andre arter. Ligeledes var tætheden af en anden primær kolonisator polypdyret *Tubularia indivisa* mindre i 2004 i forhold til 2003, hvilket igen kan være et resultat af manglende plads eller predationstryk fra nøgensnegle bl.a. *Facelina bostoniensis*, som i 2004 er registreret som ny art for Horns Rev fauna.

Påvirkninger fra rovdyr, rekruttering og konkurrence om plads vil bidrage til en kontinuerlig successionsproces indtil en højere grad af stabilitet i samfundsstrukturen er opnået.

Sammenlignet med 2003 blev der konstateret en betydelig større tæthed af yngel af taskekrabben *Cancer pagurus* på monopælene og større krabber blev ofte observeret i hulrum og sprækker mellem stenene på erosionsbeskyttelsen i 2004. Fra september 2003 til marts 2004 blev der konstateret en tilvækst af de enkelte individer af *Cancer pagurus* og registreringen af både yngel af andre krabber og ægmasser af havbørsteorme og nøgensnegle viser at møllefundamenterne anvendes som yngel- og opvækstområde for flere arter.

På erosionsbeskyttelsen blev der konstateret en meget stor variation og en generel statistisk forskel i faunasamfundene mellem de forskellige prøvetagningsstationer. Der er påvist en vis lighed mellem forskellige zoner som generelt afspejler de forskellige substratforhold.

Nye arter
14 arter er i 2004 registret som nye for hårdbundsfaunaen på Horns Rev. Af disse skal to arter specielt bemærkes. Det gælder børsteormen *Sabellaria* formentlig *S. spinulosa* og hav cypressen *Sertularia cupressina,* der begge i vadehavsområdet bliver betragtet som truede eller rødlistede. *Sertularia cupressina* er i Europa genstand for indsamling og anvendes til dekorationsformål. *Sertularia cupressina* og flere andre arter, der er registreret på hårdbundssubstratet

på Horns Rev, er karakteristiske for habitater med sandskuring kategoriseret efter MarLin habitatklassifikationen som "slightly scoured circalittoral rock".

Fiskesamfund
Som i 2003 blev der fundet en markant udvikling i antallet af fiskearter mellem undersøgelserne i marts og september. Dette skyldes muligvis en sæsonbetonet migration af visse fiskearter til og fra møllefundamenterne. Skægtorsk og stimer af almindelig torsk blev ofte observeret omkring møllefundamenterne og langs kanten af erosionsbeskyttelsen, hvor de tilsyneladende søgte føde blandt dyrene på hårdbundssubstratet.

Tangspræl og fløjfisk blev ofte observeret i hulrum og sprækker mellem stenene. Der blev i alt registreret 17 forskellige arter i 2004, og sammenlignet med 2003 blev der kun registreret enkelte ”nye” arter. Tilsyneladende er stenbideren og den almindelige tangnål etableret på møllefundamenterne, men også pelagiske og semipelagiske arter som brisling, almindelig makrel og kysttobis synes at være blevet observeret hyppigere end tidligere.

Der var stor lighed mellem den artssammensætning, inklusive bundlevende arter, der er blevet fundet på skibsvrag i andre områder af Nordsøen og den artssammensætning, der er blevet observeret på Horns Rev. Der var derfor ingen indikation af at støj og vibrationer fra turbine generatorerne skulle kunne have nogen effekt på fiske samfundet på Horns Rev.

En estimering af den tilgængelige fødemængde i området viste en indtil ca. 60 ganges forøgelse i biomassen i forhold til den normale infauna i mølleområdet. Det er derfor vurderet at tilstedeværelsen af hårdbundssubstratet kan være en medvirkende faktor til en forøgelse af fiskeproduktionen i området. På grund af den store variation i tilstedeværelsen af større infauna arter skal estimatet for sammenligningsfaktoren for biomasse tages med forhold.

Regulerende faktorer
Skønt flere arter af invertebrater og fisk er blevet registret som ”nye” for Horns Rev området, og der er registreret ændringer i begroningssamfundets samfundsstruktur, er der ingen indikation på, at de konstaterede ændringer skyldes andre regulerende faktorer end den blotte tilstedeværelse af hårdbundsubstrat, naturlige samfundssuccessioner, påvirkning fra rovdyr samt rekruttering.

Perspektivering
Faunaen på det udlagte hårdbundssubtrat er helt forskellig fra den fauna, der fandtes i vindmølle området forud for opstillingen af møllerne og etableringen af erosionsbeskyttelsen. Større faste strukturer fandtes ikke i området, og faunaen inden for vindmølle området bestod hovedsageligt af typiske infauna arter, som karakteristisk findes på sandbanker i Nordsøen. På møllepositionerne er nye habitater introduceret, hvorved substratet er ændret fra rent sand til fundamenter af stål, grus og sten, og et typisk epifauna samfund har erstattet det oprindelige infauna samfund. Det nyligt etablerede epifauna samfund vil løbende ændres som følge af den økologiske succession mod et klimaks samfund. Et klimaks samfund vil ikke være forventeligt inden for de nærmeste 5-6 år efter etableringen af hårdbundssubstratet. Afbrydelser i successionsforløbet som følge af effekter af storme og kolde vintre vil medvirke til at denne proces mod et stabilt samfund oven i købet kan forlænges. I fremtiden vil flere af de arter, der er fundet på skibsvrag i andre dele af Nordsøen, forventes at kunne findes på Horns Rev.

1. Introduction

Elsam and Eltra have built the offshore demonstration wind farm at Horns Rev in the North Sea. Elsam is the owner and is responsible for the operation of the wind farm. Eltra is responsible for the connection of the wind farm to the national onshore grid.

In the summer months of 2002, Elsam constructed the world's largest offshore wind farm at the Danish west coast. The wind farm is located 14-20 km into the North Sea, west of Blåvands Huk. The first wind turbine foundation was in place in March 2002 and the last mono-pile was in place in August 2002 for a total of 80. The construction work was completed with the last connecting cables sluiced down in September 2002. All the wind turbines were in production in December 2002.

The expected impact from the wind farm will primarily be an alternation of habitats due to the introduction of hard bottom substrates as wind mono-piles and scour protections. A continuous development in the epifouling communities will be expected together with an introduction of new or alien species in the area.

The indigenous benthic community in the area of Horn Rev can be characterised by infauna species belonging to the *Goniadella-Spisula* community (Bech et al. 2004). This community is typical of sandbanks in the North Sea area, although communities in such areas are very variable and site specific. Character species used as indicators for environmental changes in the Horns Rev area are the bristle worms *Goniadella bobretzkii*, *Ophelia borealis*, *Psione remota* and *Orbinia sertulata* and the mussels *Goodallia triangularis* and *Spisula solida*.

In connection with the implementation of the monitoring programme concerning the ecological impact of the introduction of hard substrate related to the Horns Rev Wind Farm, surveys on hard bottom substrates were initialised in March 2003 with monitoring conducted in September 2003 and March and September 2004.

This report describes the results from surveys on hard substrates in 2004.

Photo 1. Bib (pouting) Trisopterus luscus.

Photo 2. Atlantic cod Gadus morhua.

2. Methodology

Survey and sampling operations took place during two separate surveys in March and September 2004.

2.1. The research area

Horns Rev is an extension of Blåvands Huk, which is Denmark's most western point. The reef consists primarily of gravel and sand. The water depth over the reef varies between 2 and 9 metres. In geomorphological terms, Horns Rev is a terminal moraine. Its formation is probably due to glacio-fluvial sediment that was deposited in front of the ice shelf during the Saale glaciation, being pushed up at some point when the ice advanced. The constituents of the reef are therefore not the typical mixed sediment of a moraine but rather well-sorted sediments in the form of gravel, grit and sand. Huge accumulations of Holocene marine sand deposits, up to 20 m in depth, formed the Horns Rev area that is known today with continuous accumulations (Larsen, 2003).

Horns Rev is considered to be a stable landform that has not changed position since it was formed (Danish Hydraulic Institute, 1999). Blåvands Huk forms the northern extremity of the European Wadden Sea area, which covers the area within the Wadden Sea islands from Den Helder in Holland to Blåvands Huk.

The wind farm area is located approximately 14-20 km off Blåvands Huk and the water depths in the wind farm area are 6-14 m. Surveys were performed at six turbine sites at the Horns Rev Wind Farm, Figure 1. The sites were selected according to differences in depth regimes and turbine site locations. Faunal colonisation patterns might be different between turbine foundations in the centre, along the border of the wind farm area and at the turbine foundations at different depth regimes.

The native sediment in the area generally can be characterised as medium-fine sand with a median particle size of 345 µm in 2001 (Leonhard, 2002).

Photo 3. Goldsinny-wrasse Ctenolabrus rupestris.

Photo 4. Goldsinny-wrasse Ctenolabrus rupestris *and the edible crab* Cancer pagurus.

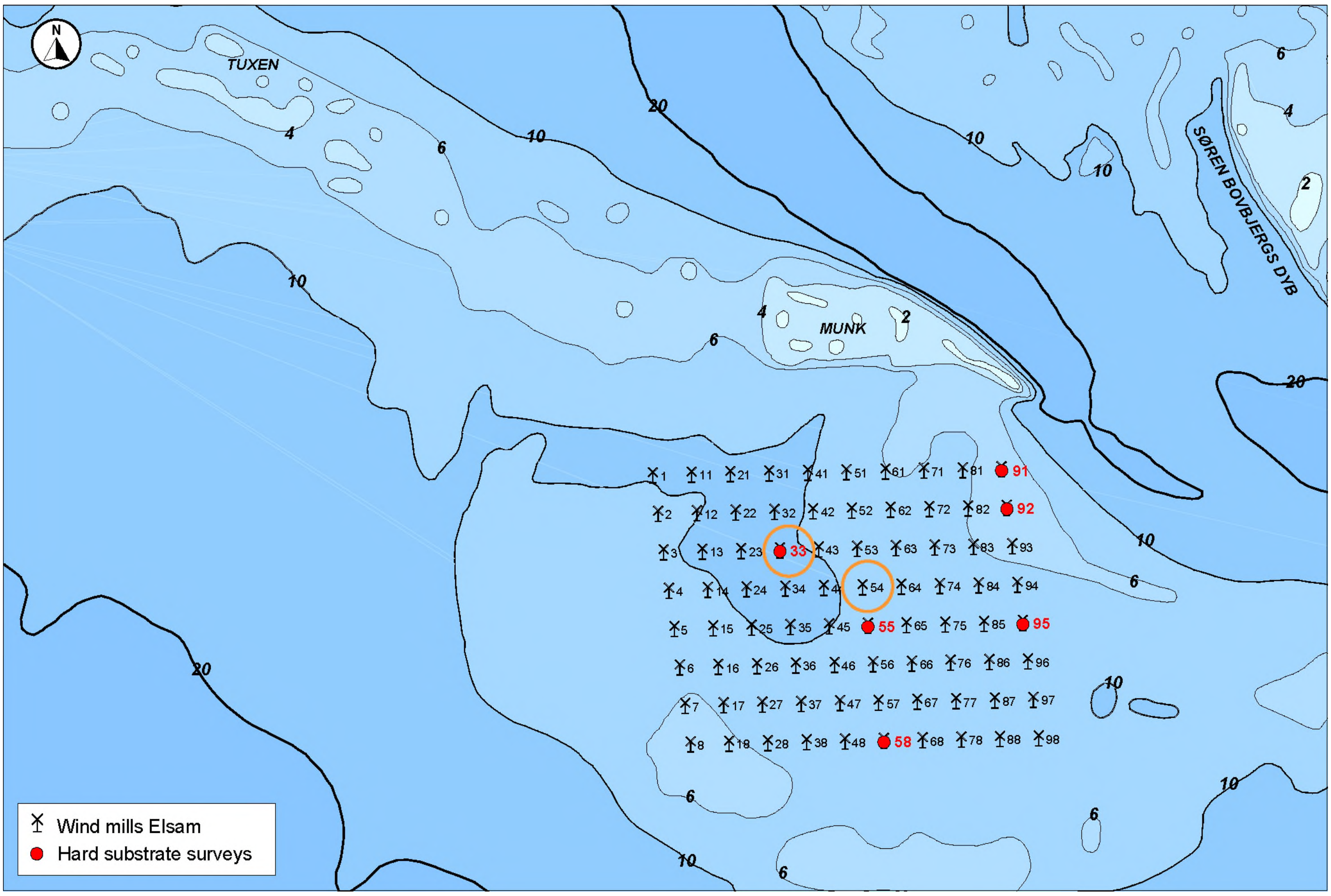


Figure 1. Map of locations sampled in March 2004 and September 2004. The test fishing was performed at the encircled turbine sites.

The co-ordinates of the six turbine positions are given in Table 1 (WGS 84). Actual GPS positions and actual depths at sampling dates are presented in Appendix 1.

Location	"WGS84_MIN_Y"	WGS84_MIN_X"	Depth (app. m)	Mono-pile in place	Programme
Turbine 33	55°29.609'	07°49.526'	11.0	15-Jul-02	*
Turbine 55	55°29.022'	07°50.736'	10.0	30-Jul-02	**
Turbine 58	55°28.124'	07°50.956'	8.0	02-Aug-02	**
Turbine 91	55°30.237'	07°52.569'	6.0	19-Aug-02	*
Turbine 92	55°29.938'	07°52.642'	6.0	19-Aug-02	*
Turbine 95	55°29.041'	07°52.862'	9.0	22-Aug-02	**

*Table 1. Turbine positions for hard substrate surveys on scour protections *. Additional sampling of mono-piles marked with **.*

The wind turbine (WTG) foundations are constructed using the "mono-pile" concept. At the seabed, a "gravel mattress" or scour protection is arranged around the foundation to minimise erosion due to the strong current at the site. The diameter of the mono-pile foundation of the turbines is 4 m.

The scour protection, Figure 2, has a diameter of approximately 27 m in total varying between sites. The scour protection is approximately 1.3 m in height above the original seabed and generally consists of a protective stone mattress, 0.8 m in thickness, of large stones up to 55 cm in diameter at distances of 0–10 m from the towers with a subjacent layer, 0.5 m in thickness, of smaller stones 3-20 cm in diameter. At the edge of the area with large protective stones, an area up to 4 m in width consisting of the smaller stones was generally observed at the turbine sites. In the areas outside the scour protection, the seabed consists of sand.

In the NNE direction at turbine sites 55 and 58, the area with large stones was up to 12-14 metres from the mono-piles.

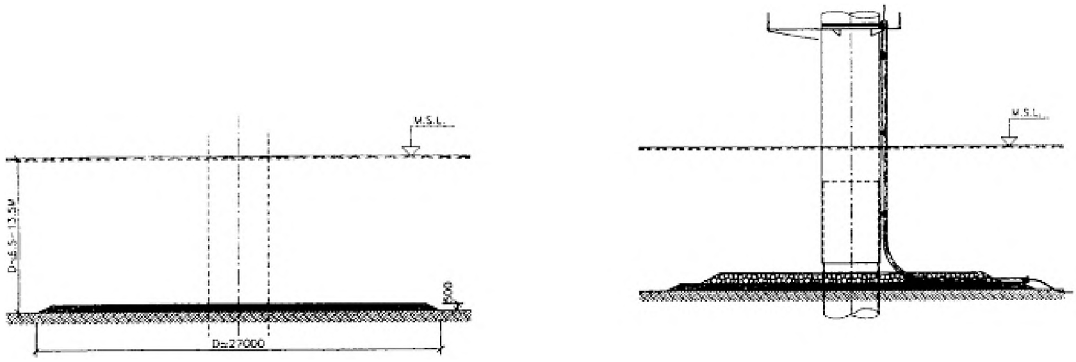


Figure 2. Wind turbine foundation and scour protection.

2.2. Field activities

At each sampling site, weather and wind conditions as well as hydrographical data such as current direction, approximate current speed, wave height and transparency depth were recorded. 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 the turbine sites was measured with an echo-sounder with the depth being from the water surface to the top of the scour protection close to the mono-pile. Data are presented in Appendix 2.

At different stations at the individual foundations, Figure 1, samples were collected by SCUBA divers along a line (transect) in the direction of the main current (NNE 20°) to cover a number of zones exposed to different current situations. Three stations at distances 0.5 m, 2 m and 5 m (NNE0.5, NNE2, and NNE5, respectively) from the mono-piles were selected along the transects. As a reference, one station (SSW5) was sampled additionally at a distance 5 m upstream (SSW 200°) from the mono-pile.

At each station, samples of fouling organisms were thoroughly scraped off the stone blocks within a frame of 0.04 m² using a special scraping tool and a special underwater air-lift device. Three replicates of faunal samples were collected in bags with a mesh size of 1 mm. A total of 72 samples from scour protections were collected at each survey.

At each foundation along each transect upstream (SSW) and downstream (NNE), a visual determination was performed of the fouling communities and species that could be identified were identified on site by the divers in addition to the quantitative sampling. A semi-quantitative assessment was carried out on the frequency of each group of organism as well as an evaluation of the coverage of species and substrate. The species-specific degree of coverage is the term used to describe the degree of coverage by a single species on a specific substrate based on a suitable adaptation of the Braun-Blanquet scale (Leewis and Hallie, 2000), Table 2. Fish species observed were registered and numbered according to Table 2 and under water video recordings were made for documentation.

Sessile species		**Mobile species**	**Fish species**	
Code	**Degree of coverage %**	**Number of individuals/m²**	**Code**	**Number of individuals**
R	< 0.05	0.5	O	Observed
+	0.05–0.50	2	R	Common
1	0.50–5	5	∞	Numerous
2	5–25	5–50		
3	25–50	50–500		
4	50–75			
5	75–100			

Table 2. Braun-Blanquet scores for hard substrate fouling organisms. Code for observations of mobile benthic species and fish species.

The total degree of coverage for floral and faunal communities on the scour protection and the mono-piles is termed the substrate-specific degree of coverage. Certain groups of organisms were collected for species identification in the laboratory. Some green algae in the genus *Ulva,* especially the species in the "*Enteromorpha*" group, are very difficult to identify during field surveys and identification of *U. intestinalis* and *U. linza* were done in the laboratory. Some species of sea anemones were identified using video recordings. The identification of *Facelina bostoniensis* was only made from divers' descriptions and still photos and must be regarded with caution.

Sampling also included the mono-pile at three locations (marked with ** in Table 1). The sampling covered the vertical variation at depth intervals of 0, 2, 4, 6 and 8 metres measured from the top of the scour protection. The sampling was performed to cover the direction of the principal current on both the currentward (SSW) and leeward sides (NNE) of the towers.

In addition to the visual studies and the photographic documentation, the studies on the mono-piles included the collection of quantitative samples by divers to determine the composition of species, abundance, and biomass. Two 0.04 m² frame samples were taken within each depth interval on each side of the mono-pile. Larger algae and shellfish as well as other fouling organisms were scraped off using the same technique used at the scour protection. A total of 54 and 60 samples from the towers were collected at the March and September surveys, respectively. The difference in the number of samples between the two surveys was caused by minor differences in water depth at the time of sampling.

In March, additional samples concerning the abundance of specific epifauna communities in the splash zone were made at a selected number of mono-piles. At turbine sites 33, 55, 91, 92 and 95, 0.04 m² frame samples were taken at different directions (SSW-NNE) in the splash zone at the mono-pile.

2.3. Test fishing

For the validation of the fish species observed, in addition to the standard monitoring programme, two fish tests using standard gill nets were performed at turbine site 54 in March and at turbine site 33 in September. In September, turbine site 33 was selected due to the fact that the divers observed more species than at any other sites investigated. In March, pelagic gill nets were set from the 25th to the 26th during the night from 18:00 to 09:00 while sinking gill nets were set on the 26th during the day from 09:00 to 17:00. In September, the gill nets were set from the 2nd to the 3rd during the night from 20:00 to 10:00 and during the day on the 3rd from 10:00 to 17:00.

The standard biological survey gill net used was 42 m long and 1.5 m high. The net is composed of 14 different mesh sizes from 6.25 mm to 60 mm in 14 sections. The net was placed with the southern end close to the mono-pile in the direction of the main current towards 20° NNE. The net was placed in the pelagic approximately 1.5-2.5 m above the seabed covering both the scour protection and the seabed outside the scour protection, Figure 3.

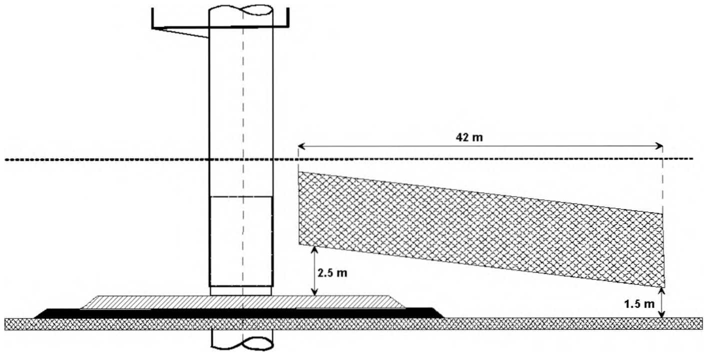


Figure 3. Schematic illustration of the placement of the gill net at the test fishing site.

2.4. Laboratory activities

In the laboratory, samples for identification of species composition, abundance and biomass were carefully sieved through the 1.0 mm test sieve. All remaining organisms in the collection net bag were carefully removed with use of a pincer.

The fauna samples were sorted under a microscope and the animals were identified to the lowest possible taxon. Due to the large number of individuals in the samples, standard sub sampling was practised for both numbering and measurement of biomass. 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.

2.5. Statistical analyses

Differences between the faunal communities at the individual wind turbine sites, variation in fauna communities at mono-piles according to depth and variation in fauna communities between turbine sites were analysed on the basis of the combined data of species composition in terms of abundance and biomass.

2.5.1. Species composition

Within each subset, differences in the species composition between the sampling sites 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:

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

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

The BC values are used for presenting data in 2-dimensional plots using a non-metric Multi-dimensional Scaling (MDS) ordination. For further description of the MDS technique, see http://www.statsoft.com/textbook/stmulsca.html. In MDS plots, usually a *stress* factor (0-0.5) is displayed as the distortion between the similarity rankings and the corresponding distance rankings in the ordination plot. Low stress 0.1-0.2 corresponds to a good agreement between the calculated similarity rankings and the ordination shown.

The software package PRIMER was used for statistical analysis (Clarke & Warwick, 1994). A formal test for differences between sites 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.

Photo 5. The sea slug Facelina bostoniensis *with egg masses and tubes of* Jassa marmorata *and* Tubularia indivisa.

Photo 6. The sea slug Polycera quadrilineata *and tubes of* Jassa marmorata *and* Tubularia indivisa.

3. Results

In 2004, the hard bottom community on the artificial substrates at Horns Rev represents 11 different species of macroalgae and 70 species of macroinvertebrates, Appendix 3. Also, a total of 17 different species of fish have been observed on the scour protections or in schools on the edge of the scour protections. Besides these observations, schools of juvenile Atlantic mackerel *Scomber scombrus* were noticed between some turbine sites swimming in the upper water column.

3.1. Fish observed

Fish were observed by divers at each of the turbines investigated, Appendix 4. In March 2004, eight species were recorded and each of these was only observed in few numbers. The rock gunnel *Pholis gunnellus* was the most numerous and it was observed at all turbines. Also, the hooknose *Agonus cataphractus* and the shorthorn sculpin *Myoxocephalus scorpius* were frequently recorded.

In September, a total of 16 fish species were observed often in numbers and in schools around the wind turbines and at the edge of the scour protections. The observed abundance and the distribution of the fish species inside the wind farm area are shown in Table 4. Two species, goldsinny-wrasse and rock gunnel, were found often in numbers at each of the examined turbine sites. Common but less numerous and scattered among the turbine sites was bib (pouting), shorthorn sculpin, hooknose and dragonet.

Rare species in the Horns Rev area in 2004 were European sprat, pollock (saithe), broad-nosed pipefish, ballan wrasse, lumpsucker and viviparous blenny. A small shoal of European sprat was observed at turbine site 58, whereas only single individuals of the other rare species were observed around or on the scour protections.

A number of juvenile dragonets were observed on the seabed just outside the scour protection at turbine site 92.

Common name	Scientific name	Number of sites observed	Max. Abundance
European sprat	*Sprattus sprattus*	1	O
Atlantic cod	*Gadus morhua*	2	R
Bib (Pouting)	*Trisopterus luscus*	3	R
Pollock (Saithe)	*Pollachius virens*	1	O
Broad-nosed pipefish	*Syngnathus typhle*	1	O
Shorthorn sculpin	*Myoxocephalus scorpius*	4	R
Hooknose	*Agonus cataphractus*	4	O
Longspined bullhead	*Taurulus bubaris*	2	O
Ballan wrasse	*Labrus bergylta*	1	O
Goldsinny-wrasse	*Ctenolabrus rupestris*	6	∞
Lumpsucker	*Cyclopteus lumpus*	1	O
Viviparous blenny	*Zoarces viviparous*	1	O
Small sandeel	*Ammodytes tobianus*	2	O
Rock gunnel	*Pholis gunnellus*	6	R
Dragonet	*Callionymus lyra*	3	R
Sand goby	*Pomatoschistus minutus*	6	∞
Painted goby	*Pomatoschistus pictus*	2	R

Table 4.Observed abundance of fish at turbine sites at Horns Rev offshore wind farm 2004. O: Observed, R: common, ∞: numerous.

In 2004, the presence of goldsinny-wrasse, Atlantic cod, bib (pouting), small sandeel and shorthorn sculpin was verified during the test fishing performed in the wind farm area, Table 5. Goldsinny-wrasse was most numerously caught in daytime whereas most species were caught at night. In September, the test fishing was much more successful in terms of the number of fish caught than the test fishing in March.

Fishing	Common name	Scientific name	Number		Length cm
			March	September	
Night	Atlantic cod	*Gadus morhua*		5	28-38
	Bib (Pouting)	*Trisopterus luscus*		1	23
	Goldsinny-wrasse	*Ctenolabrus rupestris*		2	9-10
	Shorthorn sculpin	*Myoxocephalus scorpius*		2	18-20
	Small sandeel	*Ammodytes tobianus*	1		13
Day	Atlantic cod	*Gadus morhua*		4	30-36
	Goldsinny-wrasse	*Ctenolabrus rupestris*		26	8-14
	Shorthorn sculpin	*Myoxocephalus scorpius*	1		23

Table 5. Fish species caught in gill nets during the test fishing.

3.2. Additional field observations

Additional collections of samples were made within the splash zones of the mono-piles in March. The samples were collected with the objective to estimate the abundance of the giant midge *Telmatogeton japonicus*, which was recorded for the first time in Denmark at Horns Rev in 2003. In 2004, the abundance of *Telmatogeton japonicus* was found as high as 4,300 ind./m² at selected mono-piles, Table 6. Even single adult midges were found in March.

Mono-pile: Splash zone										
Sample no.	Turbine no.	Area of samples								
		0,04 m²	*Telmatogeton japonicus*					*Balanus balanus*	*Jassa marmorata*	*Caprella linearis*
			Larvae	Puppae	Number of imagines			Number	Number	Number
			Abundance	Abundance	Total	Male	Female			
11	Turbine 33	Not specified	1,300	200	2	2		2	0	0
12	Turbine 33	SSW	2,025	250				0	0	0
13	Turbine 55	Top S	1,975	325				0	0	0
14	Turbine 55	Above surface	2,000	25				0	6	0
1	Turbine 91	SSE	2,575	125				3	0	0
2	Turbine 91	Not specified	2,900	400				2	0	0
3	Turbine 91	Not specified	225	125				0	1	0
4	Turbine 92	Not specified	2,250	275				0	0	0
5	Turbine 92	Not specified	3,625	200				0	0	0
6	Turbine 92	Not specified	875	50				0	0	0
8	Turbine 92	Not specified	1,275	25	1	1		0	0	0
9	Turbine 95	SSW	4,025	275				0	0	0
10	Turbine 95	NNE	2,600	250				1	0	0
7	Turbine 95	20 NNE	2,225	250				0	0	1
15	Turbine 95	SSW	3,300	275				0	0	0

Table 6. The abundance of Telmatogeton japonicus *at a selected number of turbine sites in March 2004. The direction of the samples taken on the mono-pile was specified only for some samples.*

3.3. Vegetation

A total of 11 taxa of seaweeds were registered from the mono-piles and scour protections at Horns Rev wind farm, Appendix 3.1.

In the splash zone on the mono-piles, a green/brown coating of microscopic green algae and diatoms was generally very distinct.

Just beneath the surface down to approximately 2 metres, the seaweeds *Petalonia fascia*, *Petalonia zosterifolia* and the filamentous brown algae *Ectocarpus* were found at most turbines, Appendix 5.2.

Relatively sparse vegetation on the mono-piles was found down to 4-6 m below the surface. The vegetation was generally more abundant in the upper 4 m. Only species of the most abundant green algae *Ulva* (*Enteromorpa*) and the brown algae *Pilayella littoralis* were generally found in the lower part of the mono-piles down to 4-6 metres. But *Petalonia fascia* was occasionally found in low numbers down to 6 metres in depth. The green algae genus *Ulva* was represented by the species *U.* (*Enteromorpha*) *intestinalis*, *U.* (*Enteromorpha*) *linza* and *U. lactuca.*

Between the two surveys, small variations in the species composition and coverage of the vegetation on the turbines below the water line were also found. The algae *Pilayella littoralis* was only registered in March and *Hildenbrandia rubra* was only registered in September. Compared to March, the relative coverage of green algae *Ulva lactuca* and *Ulva (Enteromorpha) spp*. was higher in September.

On the scour protection, the vegetation was generally sparse especially in March. Compared to March, a pronounced higher coverage, especially of the green algae *Ulva (Enteromorpha)*, was found in September, Figure 4.

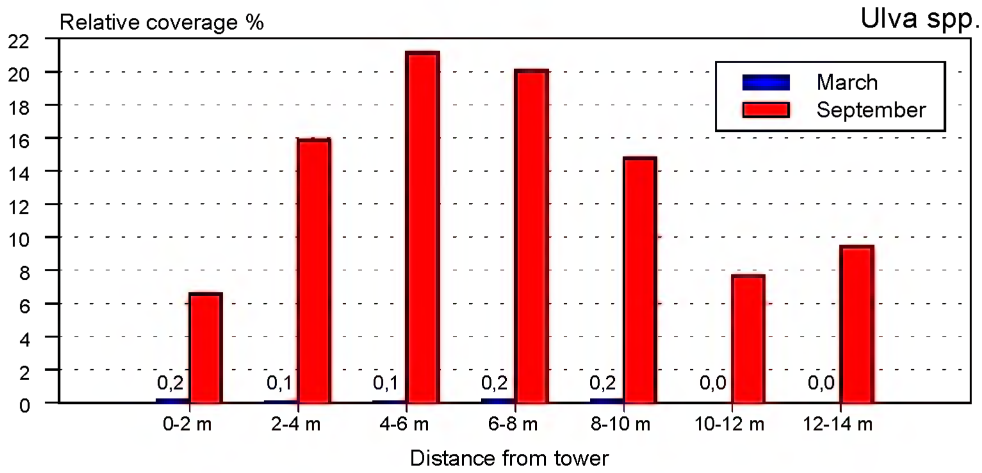


Figure 4. Relative coverage of the Ulva (Enteromorpha) sp. on the scour protections in 2004.

Distinct differences in the species composition and vegetation cover were found mainly related to different depth regimes between the different turbine sites. No vegetation was registered at turbine site 55, Table 7. In March and September, a very scarce vegetation of the brown filamentous algae *Ectocarpus* and *Pilayella littoralis* was found at turbine sites 33 and 58. In September, a relatively high coverage of *Ulva (Enteromorpha*), up to 37%, was found on the scour protection at turbine site 58. An even higher coverage of *Ulva (Enteromorpha*) was found at turbine sites 91 and 92. The red algae *Callithamnion corymbosum* was observed in low numbers on the scour protection at turbine sites 58 and 92. The highest coverage of *Callithamnion corymbosum* was found at turbine site 91. The encrusting red algae *Hildenbrandia rubra* was found scattered on the stones at turbine sites 92 and 95 in March.

Turbine site	33		55		58		91		92		95	
Actual depth m	9.6-10.8		8.3-8.8		6.3-7.3		5.6-5.7		4.5-5.0		7.0-7.8	
Sample time	S	A	S	A	S	A	S	A	S	A	S	A
Red algae						x	x	x	x	x	x	
Brown Algae	x	x				x			x			
Green algae						x	x	x	x	x		x
No vegetation			x	x	x							

Table 7. Groups of vegetation registered at the turbine sites in March (S) and September (A), respectively.

The green laver *Ulva lactua* was only found on the scour protection at turbine site 91. In September, a single specimen of the red algae *Phyllophora pseudoceranoides* was observed outside the transect line at turbine site 91.

3.4. Fauna

Out of 70 invertebrate species registered and observed, 12 species/taxons were not sampled or identified in the quantitative samples. These species were only observed by divers during the transect surveys, Appendix 3.3. It was mainly very mobile species such as crabs, larger species of the common whelk, species of hydrozoans and bristle worms. These species were occasionally observed or difficult to identify in the field. Sea anemones, such as the plumose anemone *Metridium senile*, were often more easily identifiable in the field than in the laboratory and that's why it was registered in the field survey only. Other species of sea anemones, registered as unidentified species during the field surveys and in the analyses of samples, were identified based on the video recordings. *Sargartia (troglodytes/elegans)* and *Sargartiogeton laceratus* were very abundant on both the mono-piles and scour protections at all turbine sites but the sea anemones were slightly more abundant on the scour protections. The thick trough shell *Spisula solida* was observed in the outer periphery of the scour protection in March.

A total of 36 species were found during the transect surveys. Some species were almost exclusively observed on the mono-piles; whereas others, mostly species of crabs and infauna species, were found on the scour protection, Table 8.

	Scour protections	Turbine towers
Species	*Balanus crenatus*	*Aeolidia pappilosa*
	Lanice conchilega	*Balanus balanus*
	Liocarcinus depurator	*Nemertini Indet.*
	Pagurus bernhardus	*Nudibranchia indet.*
	Polyplacophora indet.	*Onchidoris muricata*
		Ostrea edulis
		Telmatogeton japonicus

Table 8. Species exclusively found on scour protections and mono-piles during field surveys.

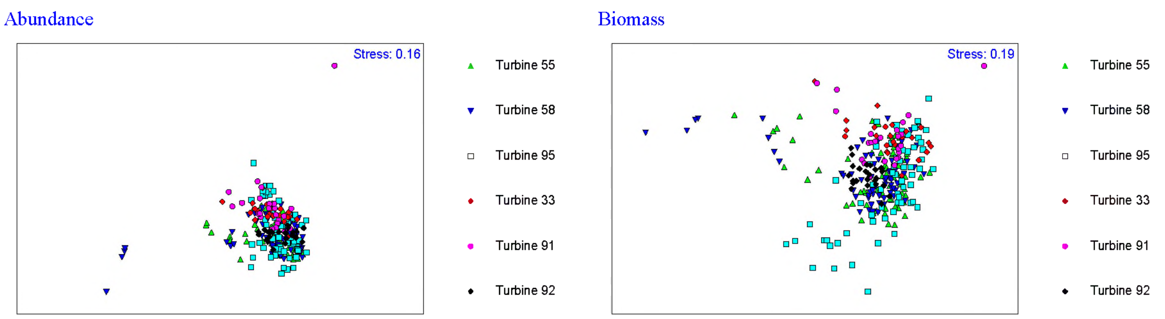


Figure 5. MDS showing abundance and biomass distribution in 2004 at turbine sites. At turbine sites 33, 91 and 92, only investigations on scour protections have been conducted.

Based on the quantitative samples, the statistical ANOVA analysis generally showed that faunal assemblages with respect to both abundance and biomass distribution between different turbine sites were significantly different. This difference was not very distinct in the MDS plots, Figure 5[1]. The graphic presentation (MDS) of the similarities showed some similarity

[1] A graphic presentation of the similarities as a Multi-Dimensional Scaling plot or MDS-plot is a complex mathematical method to construct a map of the samples in a certain number of dimensions. The purpose of the

between turbine sites where samples from each turbine site were forming groups more or less differentiated from samples matching different sites. The slight difference between sites in the MDS plots was mainly the result of rather small variations in the species representation at each site. The statistical differences between sites were mainly the result of significant differences in abundance and biomass between sites. Only two foundation sites (turbine sites 55 and 33) were slightly comparable (P< 0.05) with respect to fauna characteristics. Although some generalisations can be made, the fauna at all other turbine sites was different (P<0.001) with respect to species composition and abundance relations between individual species.

Hard bottom substrate dominants		Abundance ind./m²				Biomass g/m²			
		March 2004		September 2004		March 2004		September 2004	
Species	Group	Mean	Relative %	Mean	Relative %	Mean	Relative %	Mean	Relative %
Jassa marmorata	Crustacean	95,563	94.0	228,081	91.0	234.424	11.914	272.507	17.237
Caprella linearis	Crustacean	4,743	4.7	19,119	7.6	18.326	0.931	42.245	2.672
Mytilus edulis	Bivalve	865	0.9	2,206	0.9	1,624.208	82.547	1,134.795	71.780
Balanus crenatus	Crustacean	74	0.1	23	0.0	1.079	0.055	0.670	0.042
Asterias rubens	Echinoderm	41	0.0	122	0.0	32.657	1.660	36.657	2.319
Cancer pagurus	Crustacean	7	0.0	350	0.1	0.968	0.049	4.221	0.267
Pomatoceros triqueter	Bristle worm	34	0.0	23	0.0	1.266	0.064	1.103	0.070
Total		**101,326**	**99.6**	**249,924**	**99.7**	**1,912.927**	**97.2**	**1,492.198**	**94.4**

Table 9. Distribution pattern found for some typical hard bottom substrate dominants at the two survey campaigns at Horns Rev.

Two species of amphipods *Jassa marmorata* and *Caprella linearis* constituted the most important species with respect to abundance at all turbine sites. *Jassa marmorata* was the most numerous species with only 7 dominant species contributing to more than 99% of the total individuals found on the hard bottom substrate at Horns Rev, Table 9. Furthermore, these 7 species contributed to more than 94% of the total biomass registered.

Abundance ind./m²		March 2004				September 2004			
		Towers		Foundations		Towers		Foundations	
Species	Group	Mean	Relative %	Mean	Relative %	Mean	Relative %	Mean	Relative %
Jassa marmorata	Crustacean	168,413	92.7	34,854	96.7	350,029	89.3	97,911	97.5
Caprella linearis	Crustacean	9,573	4.9	718	1.9	34,527	7.5	1,590	1.5
Mytilus edulis	Bivalve	1,664	1.7	199	0.6	4,017	1.1	150	0.2
Balanus crenatus	Crustacean	155	0.1	6	0.0	30	0.0	14	0.0
Asterias rubens	Echinoderm	13	0.0	65	0.2	71	0.0	159	0.2
Cancer pagurus	Crustacean	14	0.0	0	0.0	456	0.1	205	0.2
Pomatoceros triqueter	Bristle worm	59	0.0	14	0.0	24	0.0	20	0.0
Total		179,891	99.4	35,856	99.4	389,154	98.1	100,049	99.5

Biomass g/m²		March 2004				September 2004			
		Towers		Foundations		Towers		Foundations	
Species	Group	Mean	Relative %	Mean	Relative %	Mean	Relative %	Mean	Relative %
Jassa marmorata	Crustacean	374.105	9.2	118.023	56.7	377.889	14.2	160.064	60.7
Caprella linearis	Crustacean	35.567	0.9	3.958	1.9	75.294	2.9	4.507	1.7
Mytilus edulis	Bivalve	3,572.984	87.6	0.227	0.1	2,143.190	75.3	0.312	0.1
Balanus crenatus	Crustacean	22.375	0.5	0.114	0.1	0.343	0.0	0.922	0.3
Asterias rubens	Echinoderm	21.942	0.5	41.586	20.0	31.149	1.1	38.091	14.4
Cancer pagurus	Crustacean	2.125	0.1	0.003	0.0	5.647	0.2	2.326	0.9
Pomatoceros triqueter	Bristle worm	24.592	0.6	0.272	0.1	1.425	0.1	0.658	0.2
Total		4,053.690	99.4	164.183	78.8	2,634.937	93.9	206.881	78.4

Table 10. Abundance and biomass distribution pattern found for typical hard bottom dominants on two types of substrates at Horns Rev in March and September 2004.

Differences in the abundance of *Jassa marmorata* and *Caprella linearis* were also the main reason for the differences between the turbine sites, which partly reflected the statistical differences between sampling at mono-piles and sampling at scour protections, Figure 6. A significantly higher abundance of these two species were found at the mono-piles, particularly compared to the abundance at the scour protections, Table 10, which contributed to the over-

map is to place the samples on the map in accordance with the calculated distances in similarity. If sample A is more like sample B than C then A should be closer to B than to sample C.

all statistical significance (P<0.001) between the fauna composition at the mono-piles and the scour protections, Figure 6.

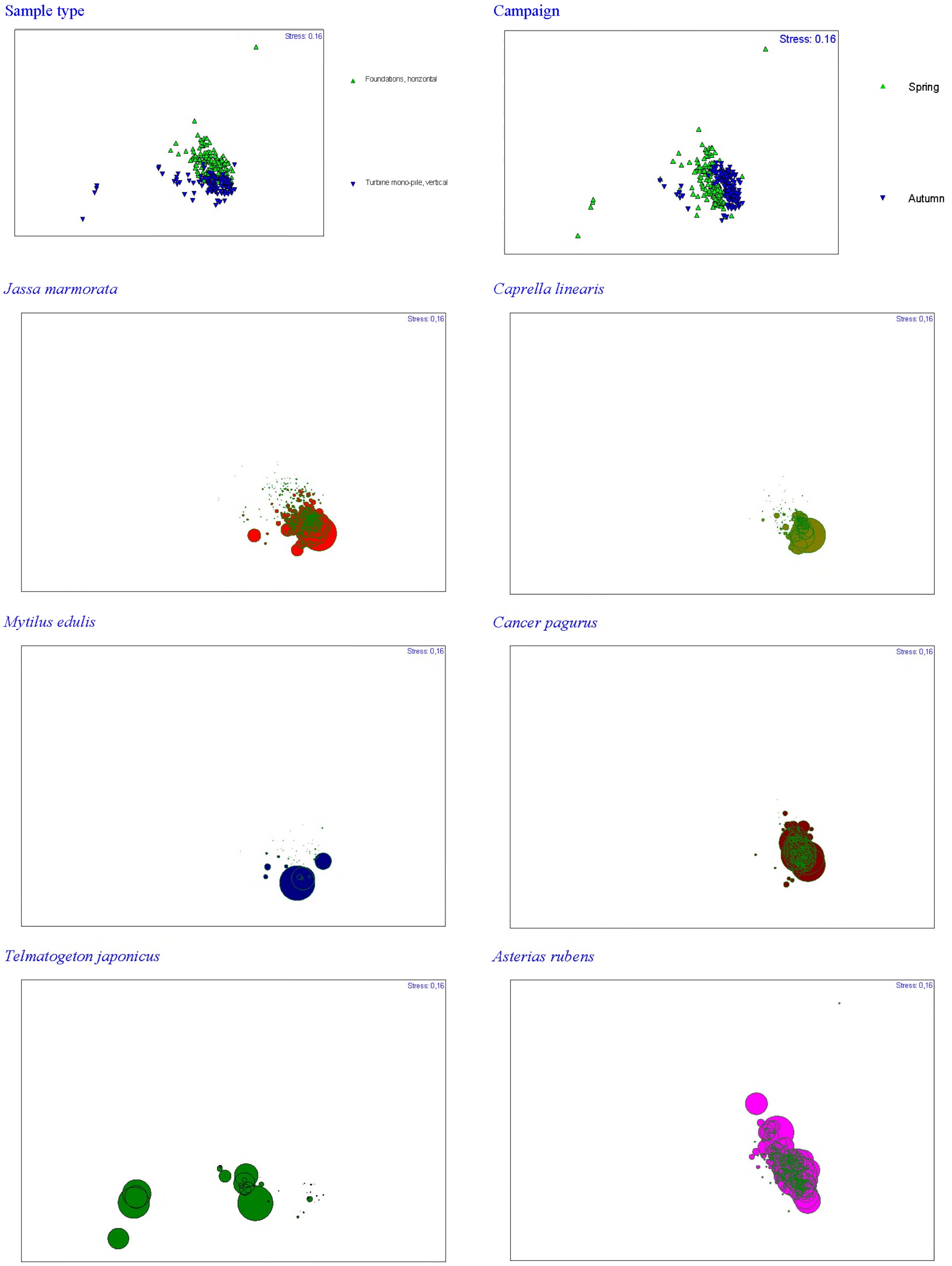


Figure 6. MDS plots of relative abundance concerning differences between sample types and sample campaigns of six of the most important species contributing to the differences between sites. The figure shows almost separate groups of samples for sample types and campaigns. Very high abundances at the mono-piles were found compared to the abundance at the scour protections.

The main results displayed in Figure 6 were the results of differences in distribution patterns of the most commonly found species. A considerably higher abundance of the common mussel *Mytilus edulis*, higher abundance of the bristle worm *Pomatoceros triqueter* and juveniles of the edible crab *Cancer pagurus* at the mono-piles contributed to the differences between the two types of substrate. The common starfish was more common and abundant on the scour protections compared to the mono-piles. Observations and results from the samples also showed that the distribution and abundance of the edible crab was considerably higher in September compared to the results from March. A typical distribution of the giant midge *Telmatopogon japonicus* contributed to the difference between some sites. This midge, found almost exclusively in the splash zone, was represented in high abundances at turbine sites 55 and 58. Very high numbers of the giant midge, up to 4,000 ind./m^2, were found during spring at turbine site 58.

Jassa marmorata, the common starfish *Asterias rubens* and the common mussel were more abundant in September, whereas the barnacles were more abundant in March, Table 10. In contrast to this, the biomass for the common mussel showed the opposite result while the biomass of *Jassa marmorata* in March was almost equal to the biomass recorded for September, although with a higher abundance.

The average individual weight displayed some differences in reproduction and growth of two of the dominant species, Figure 7. At the mono-piles, most juveniles of *Jassa marmorata* were found in September, indicating reproduction in summer. Reproduction success was only displayed in the average numbers, Table 10, and not in the average weight for the common mussel *Mytilus edulis*, but evident growth was shown at the mono-piles in the depth zones from 0-3. Outside these two depth zones, only small mussels were registered with average individual weights of 1-3 mg.

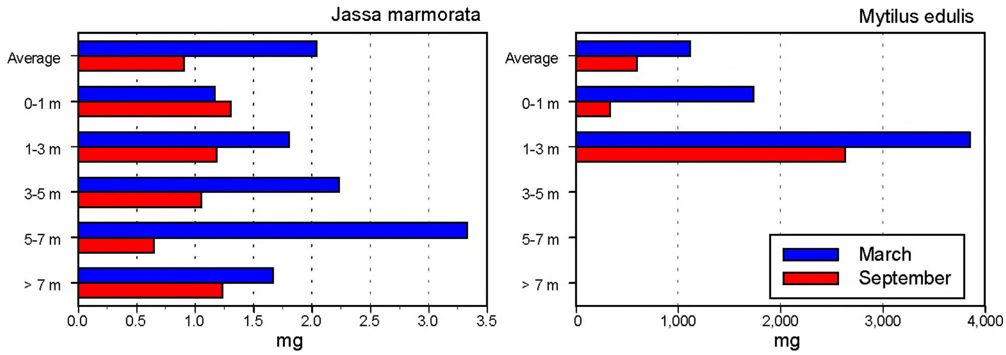


Figure 7. Average individual weights of Jassa marmorata *and* Mytilus edulis *in different depth zones at the mono-piles in March and September 2004.*

A general statistical difference (P<0.001) between the sampling in March and September was shown for abundance, but no significant difference was found for biomass relations.

A very high biomass was found at the mono-piles in spring for *Mytilus edulis* at turbine site 95, Figure 8, compared to the biomass at the scour protections, whereas the biomasses of *Asterias rubens* and *Jassa marmorata* were more evenly distributed. Although the biomass of *Cancer pagurus* shows a rather even distribution, especially high biomasses were found in spring at mono-pile 95.

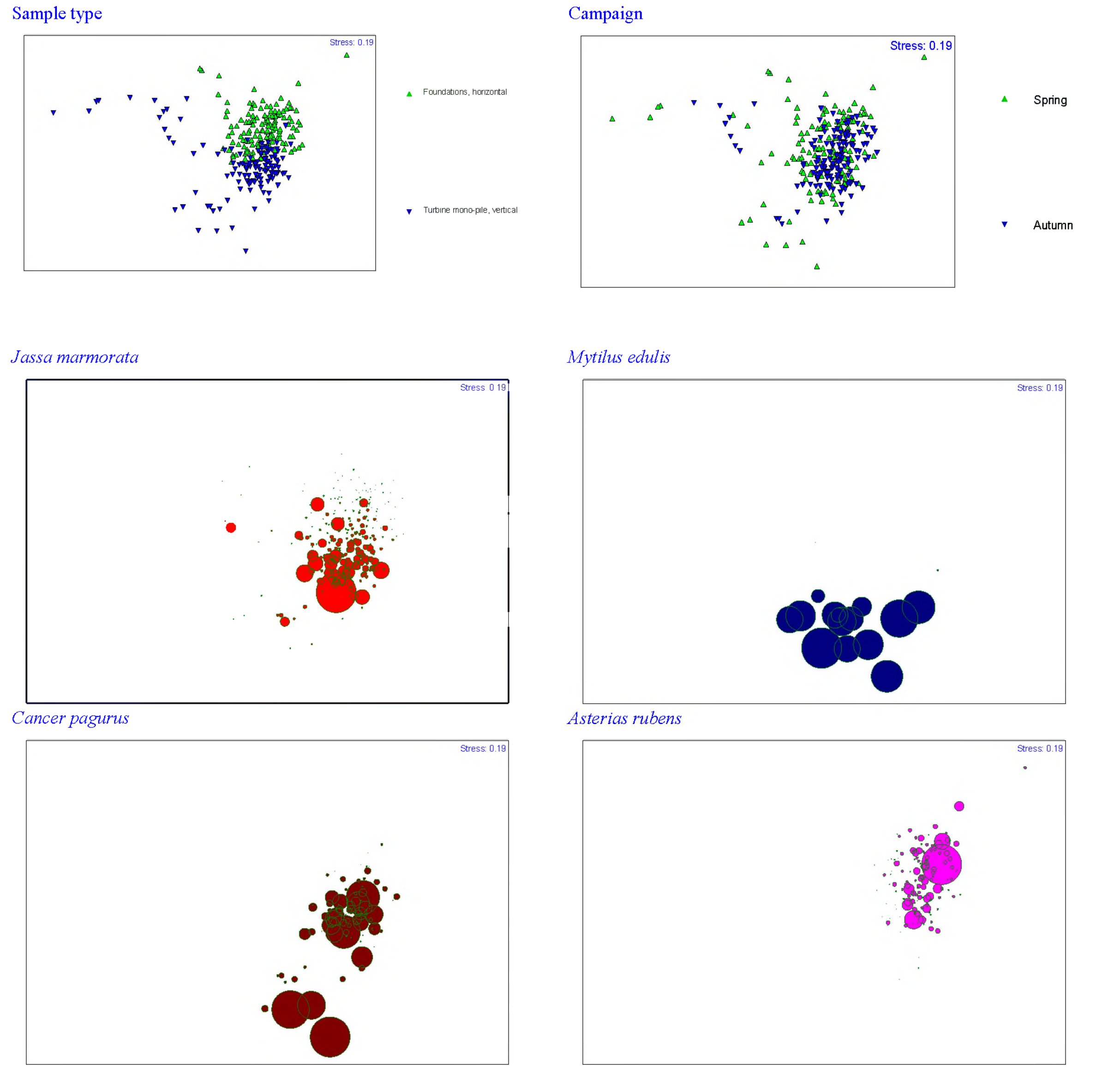


Figure 8. MDS plots of relative biomass concerning differences between sample types and sample campaigns of four of the most important species. The figure shows almost separate groups of samples for sample types.

3.4.1. Mono-piles

A statistical difference (P<0.001) was found between the fauna communities at the mono-piles at different turbine sites. It was mainly differences in the abundance of the amphipods *Caprella linearis* and *Jassa marmorata* that contributed to the dissimilarity between the mono-pile sites. But a noticeable difference in the abundance of the common mussel *Mytilus edulis*, the giant midge *Telmatogeton japonicus* and the edible crab *Cancer pagurus* was also found. At mono-pile 95, a pronounced average abundance of *Mytilus edulis* was found compared to the two other turbine sites, Table 11. The mean abundance of *Jassa marmorata* was lower at turbine site 95 in both March and September, whereas the abundance of *Caprella linearis* was markedly higher in March at mono-pile 95 compared to the abundance at the mono-piles 55 and 58. In Figures 9 and 10, the MDS plots for differences in distribution between mono-piles of the most important species are shown for March and September.

Abundance ind./m^2													
Tower sites		Turbine 55				Turbine 58				Turbine 95			
	Group	March		September		March		September		March		September	
Species		Mean	Relative %	Mean	Relative %	Mean	Relative %	Mean	Relative %	Mean	Relative %	Mean	Relative %
Jassa marmorata	Crustacean	175,396	97.2	405,486	90.5	187,629	77.3	441,400	91.9	142,214	84.4	270,484	82.5
Caprella linearis	Crustacean	3,660	1.9	36,298	7.3	5,945	2.8	40,875	6.6	19,113	11.1	39,854	14.0
Mytilus edulis	Bivalve	381	0.2	292	0.1	281	0.1	1,076	0.3	4,329	4.0	13,033	3.3
Balanus crenatus	Crustacean	190	0.1	42	0.0	68	0.0	19	0.0	209	0.1	40	0.0
Cancer pagurus	Crustacean	1	0.0	390	0.1	4	0.0	989	0.2	38	0.1	186	0.1
Asterias rubens	Echinoderm	13	0.0	55	0.0	13	0.0	144	0.0	14	0.0	45	0.0
Pomatoceros triqueter	Bristle worm	36	0.0	23	0.0	70	0.0	30	0.0	71	0.0	29	0.0
Total		**179,678**	**99.5**	**442,585**	**98.1**	**194,009**	**80.3**	**484,533**	**99.0**	**165,986**	**99.8**	**323,670**	**99.8**

Biomass g/m^2													
Tower sites		Turbine 55				Turbine 58				Turbine 95			
	Group	March		September		March		September		March		September	
Species		Mean	Relative %	Mean	Relative %	Mean	Relative %	Mean	Relative %	Mean	Relative %	Mean	Relative %
Jassa marmorata	Crustacean	378.029	67.1	394.279	53.0	414.772	65.1	508.282	58.8	329.515	38.3	295.403	31.7
Caprella linearis	Crustacean	21.001	4.0	87.538	11.8	25.138	4.4	98.166	10.2	60.562	6.8	67.827	12.1
Mytilus edulis	Bivalve	7.158	2.3	1.265	0.1	2.279	0.3	5.108	0.7	10,709.515	39.7	7,708.858	33.9
Balanus crenatus	Crustacean	3.958	0.6	0.472	0.1	0.731	0.1	0.484	0.1	2.024	0.4	0.186	0.0
Cancer pagurus	Crustacean	0.029	0.0	3.903	0.4	0.032	0.0	11.875	1.3	6.313	0.0	0.186	0.0
Asterias rubens	Echinoderm	26.010	5.3	4.611	0.9	25.367	5.9	51.556	5.8	14.450	3.4	55.048	11.4
Pomatoceros triqueter	Bristle worm	1.662	0.3	1.739	0.4	2.307	0.5	1.248	0.1	3.409	0.7	1.797	0.4
Total		**437.848**	**79.6**	**493.806**	**66.7**	**470.625**	**76.3**	**676.717**	**77.0**	**11,125.788**	**89.4**	**8,129.305**	**89.7**

Table 11. Abundance and biomass of dominant species found at mono-piles at Horns Rev in March and September 2004.

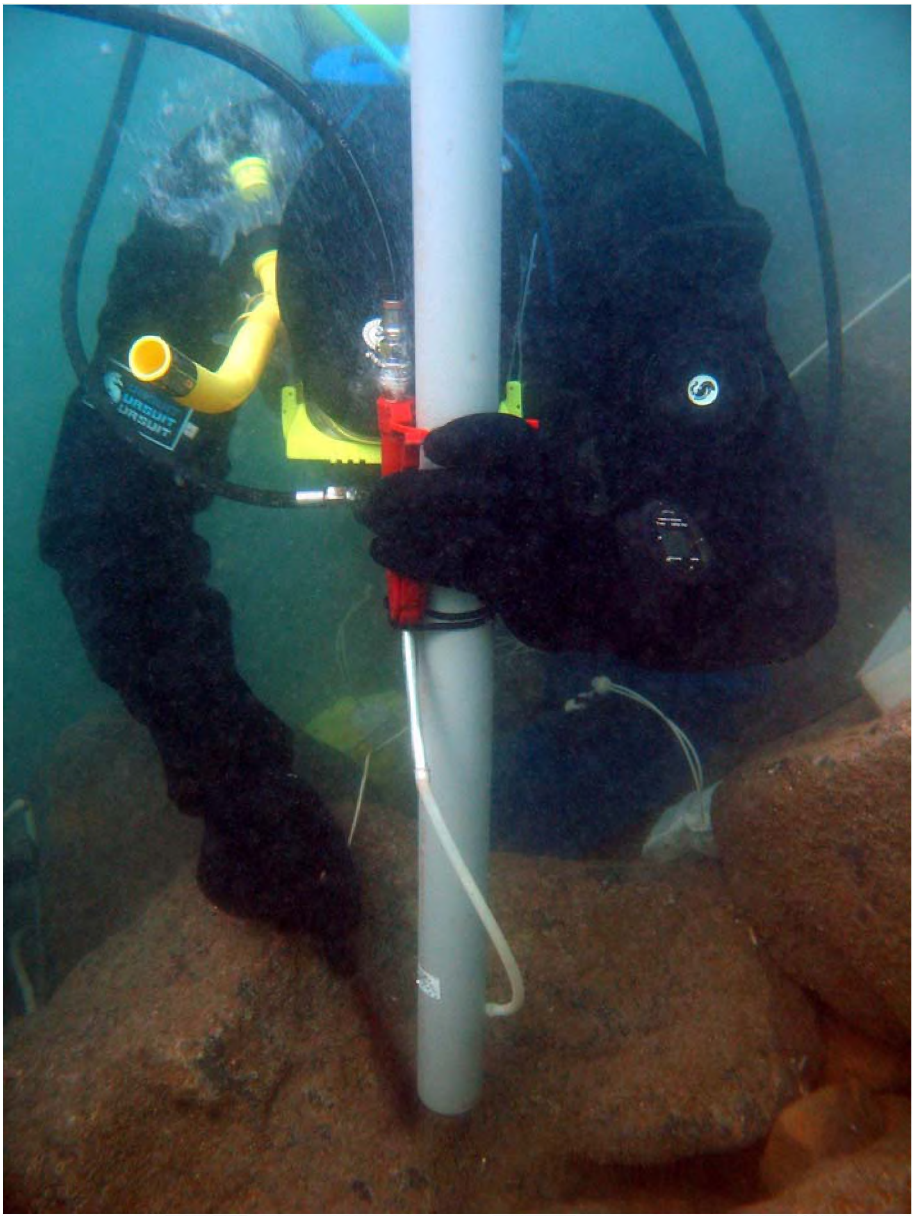


Photo 7. Diver collecting samples from scour protection.

Figure 9. MDS plot of relative abundances at mono-piles showing sites and depth distribution of the six most abundant species in March 2004. The figure shows relatively even distribution of Jassa marmorata *between turbine sites. Highest abundance for* Jassa marmorata *was found at turbine site 95. High abundance at turbine site 95 was shown for* Caprella linearis *and* Balanus crenatus *in depth zone 3-5 m and* Mytilus edulis *in depth zone 1-3 m. The giant midge* Telmatogeton japonicus *was found in depth zone 0-1m and in the highest abundance at turbine site 58.*

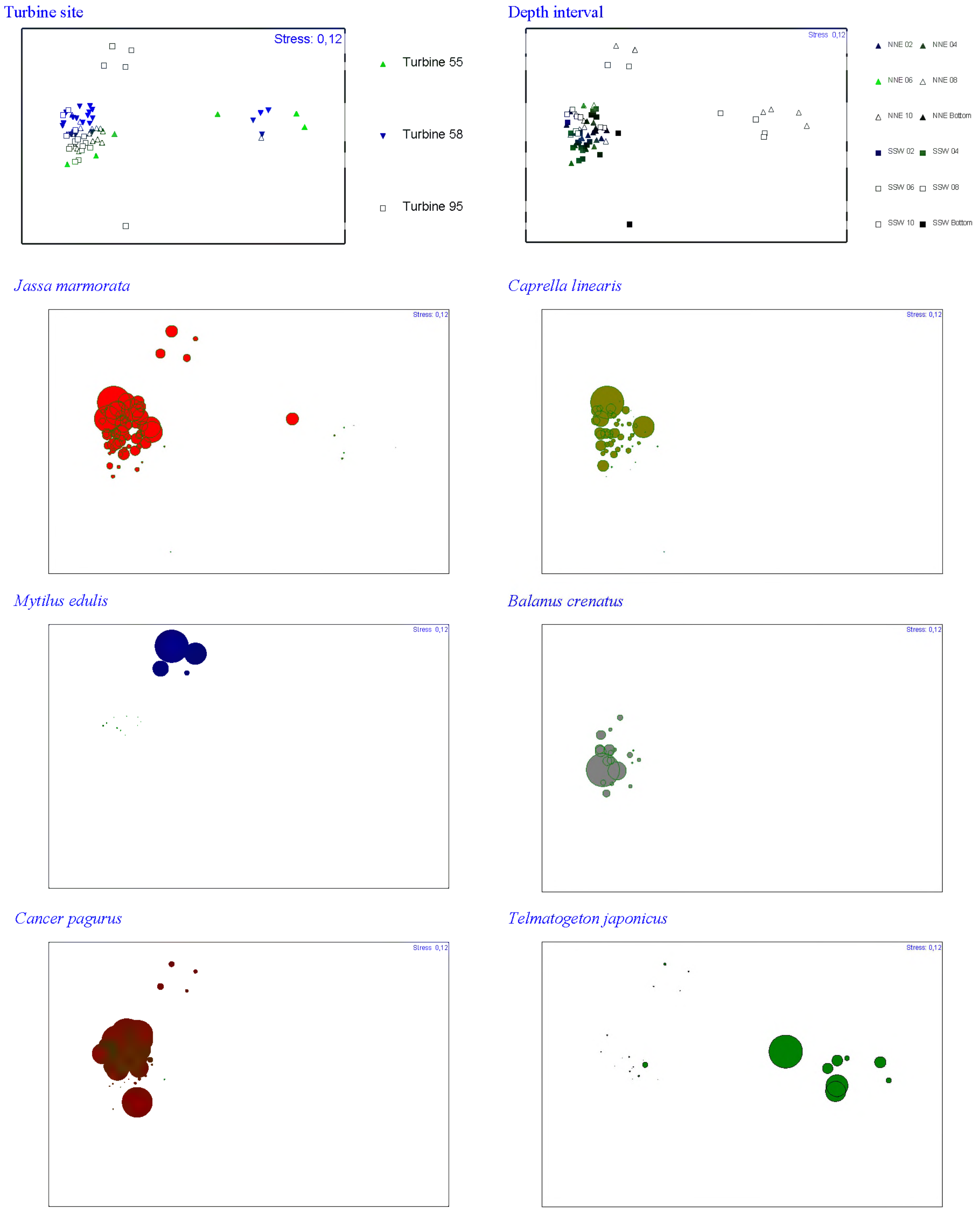


Figure 10. MDS plot of relative abundances at mono-piles showing sites and depth distribution of the six most abundant species in September 2004. The figure shows high abundances for Mytilus edulis *in depth zone 1-3 m at turbine site 95.* Jassa marmorata *was more evenly distributed among turbine sites but less numerous at turbine site 95. Although there was almost an even distribution among turbine sites,* Caprella linearis *was less abundant at turbine site 55.* Cancer pagurus *showed a rather uneven distribution among turbine sites and was most numerous at turbine site 58 in depth zone 1-3 m.* Balanus crenatus *was less numerous at turbine site 58.* Telmatogeton japonicus *was almost exclusively found in the splash zone 0-1 m and was most abundant at turbine site 55.*

A distinct zonation in the fauna communities in relation to different depth zones was observed, Figures 9-12, and a statistical difference (P<0.001) was found between the zones.

Some similarities between samples at depth zones greater than 3 m were occasionally shown (P<0.07-0.22).

The statistical analysis has shown no differences (P<0.07-0.82) between the sampling at the two sides, NNE and SSW, of the mono-piles concerning current regimes.

Five species, the crustaceans *Jassa marmorata*, *Caprella linearis*, *Balanus crenatus*, the edible crab *Cancer pagurus* and the common mussel *Mytilus edulis*, made up a total of 97.7% to 99.9 % of the total abundance at each of the depth zones. The dominance of *Jassa marmorata* was partly interposed by high numbers of the giant midge *Telmatopogon japonicus* only in the uppermost zone or the splash zone, Figure 11.

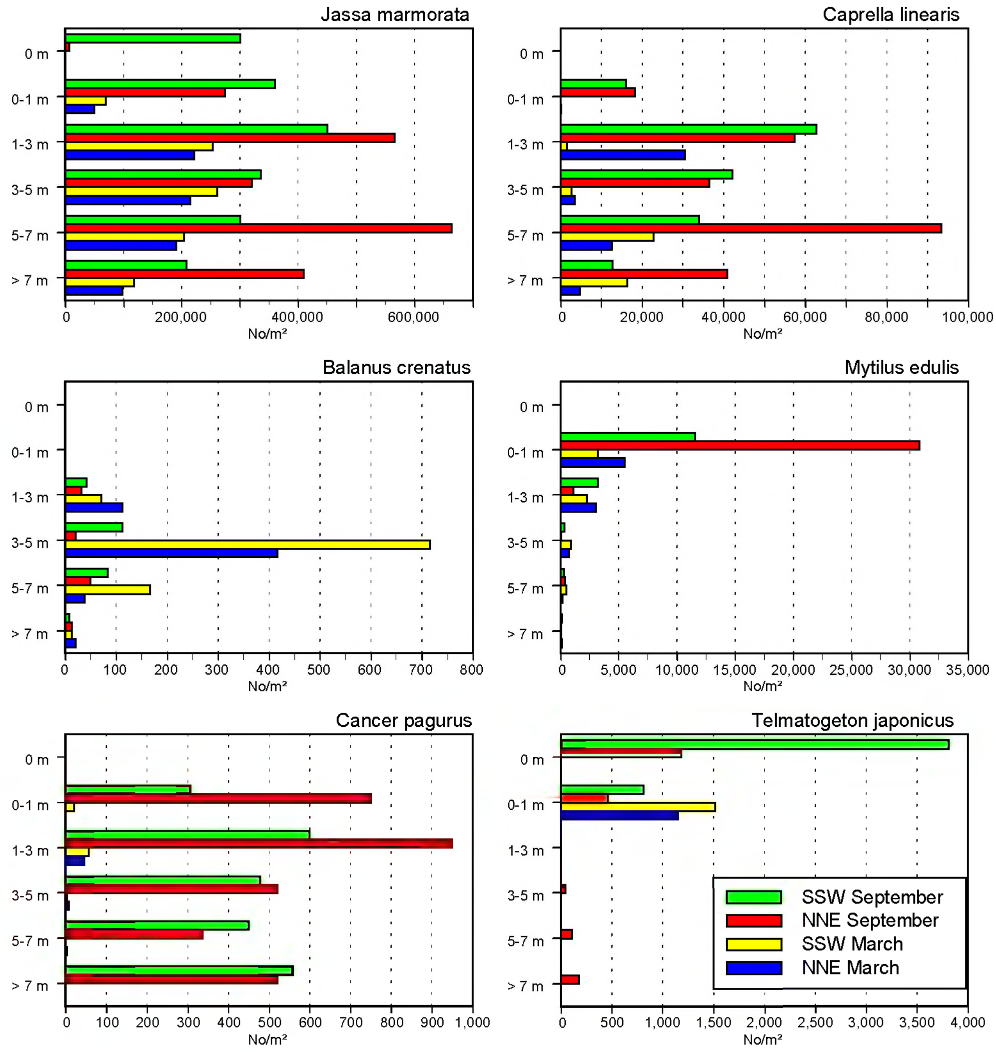


Figure 11. Depth distribution of six of the most abundant species found at the mono-piles.

In general, *Jassa marmorata* was more frequently found in the upper zones from 1-3 m, Figure 11. Although, the highest mean abundance of 664,000 ind./m^2 was found in depth zone 5-7 m in September. No general pattern in the biomass distribution was found for *Jassa marmorata*. High biomass, up to 770 g/m^2, was found in depth zone 1-3 m in September and in depth zone 3-7 m in March, Figure 12. The high biomass in September was mainly caused by the high abundance since only slight differences in average individual body weight of *Jassa* *marmorata* were found between March and September. In March, the average individual body weight of *Jassa marmorata* was 2.0 mg whereas the body weight in September was 0.9 mg.

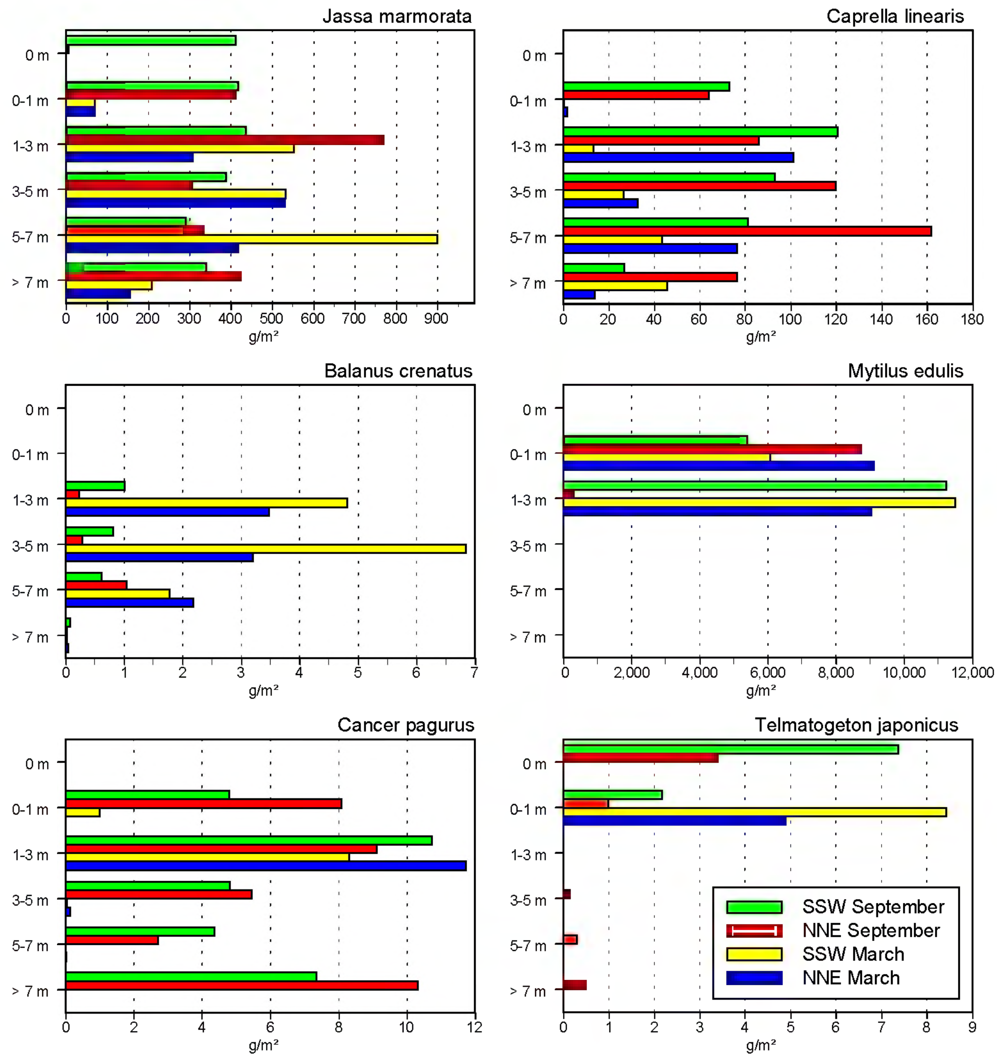


Figure 12. Depth distribution of biomass for the six most abundant species found at the mono-piles.

The distribution, abundance and biomass of *Caprella linearis* showed no clear pattern, although low abundance and biomass was generally found near the bottom and close to the splash zone, Figures 11 and 12.

A distinct difference in abundance and biomass of the barnacle *Balanus crenatus* was found between the surveys in March and September, Figures 11 and 12. The abundance and biomass of the barnacle was higher in March than in September.

The common mussel *Mytilus edulis* was found in all depth zones but was distinctly more abundant in the zone closest to the sea surface, especially at turbine site 95, Figures 9 and 11. In March, most mussels were found at turbine site 95 in the size class 30-40 mm, Figure 13. At the other turbine sites, only small mussels less than 20 mm in length were found. The average individual body weight of the common mussel was 1,118 mg in March. Average biomasses of 10,268-11,246 g/m^2 were found in March and September. In September, more juveniles between 2-4 mm in length were found, Figure 13, with an average individual body weight of 594.8 mg. At turbine site 95, very high abundances of more than 90,000 ind./m^2 and high biomasses of more than 26,000 g/m^2 were found in the most upper depth zone just beneath the sea surface. Observations from the transect survey also showed nearly 100% coverage of the common mussel in this zone. The coverage, abundance and biomass in the lower depth zones were reduced compared to the upper depth zone. In general, no larger mussels were found in the lower depth zones and the average body weight declined from 333.8-3,853.6 mg from the upper depth zones to 1.3-1.5 mg in the lower depth zones.

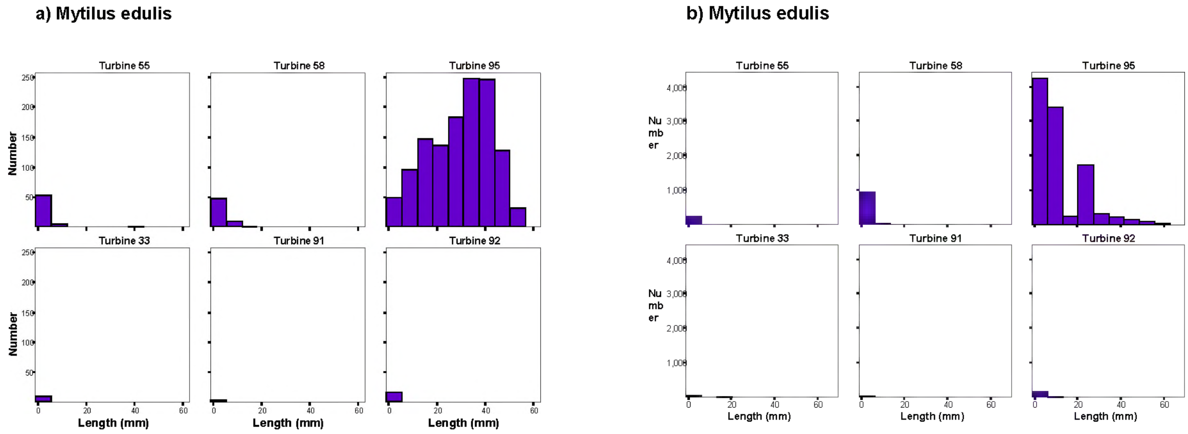


Figure 13. Length frequency diagram of the common mussel Mytilus edulis *found at turbine sites in March (a) and September (b).*

Even though the edible crab *Cancer pagurus* only constituted less than 1 % of the total abundance and biomass, this species showed some interesting characteristics. In March, *Cancer pagurus* generally showed a very scattered distribution; although juveniles were registered in low numbers in nearly all depth zones at the mono-piles, larger individuals were not observed by divers along the transect surveys. In September, larger edible crabs were observed and large numbers of juveniles were found in all depth zones at the mono-piles, Figure 11. The highest mean abundance of 950 ind./m^2 was found in depth zone 1-3 m in September and abundances over 1,900 ind./m^2 were registered at turbine site 55. The largest crabs were registered in March with average individual weights up to 256 mg compared to the population of predominantly juveniles in September with average individual weights of 12.1 mg.

The giant midge *Telmatogeton japonicus* was found almost exclusively in the splash zone in March. In September, it was registered in all zones and was significantly ($P<0.001$) more abundant in depth zone 0-1 m. In this zone the average abundance was found to be 2,500 ind./m^2 whereas the abundance in March was 1,335 ind./m^2. With an average individual body weight of 2-5 mg, this species contributed inconsiderably to the main biomass at the mono-piles. The average individual body weight was found to be highest in March.

Sea anemones found at each depth zone in relatively high coverage and numbers contributed up to 4.8% of the total biomass. No distinct pattern of the biomass distribution was found from the likely species *Metridium senile*, *Sargartia elegans* and *Sargartiogeton laceratus*.

No large specimens of the northern sea urchin *Strongylocentrotus droebachiensis* were observed during the transect surveys, but small individuals of this sea urchin were found in low numbers in both March and September with average weights of 32.3 mg and 20.9 mg, respectively.

Typical but less frequent epifaunal species that were only recorded at turbines during one of the surveys are shown in Table 12. Of these species, the wrinkled rock borer *Hiatella arctica* was not registered in September but was relatively abundant in March.

Species	Group	March	September
Hydractinia echinata	Hydrozoan		x
Alcyonium digitatum	Sea anemone		x
Harmothoe imbricata	Bristle worm	x	
Flabellina (Coryphella) lineata	Slug		x
Modiolarca tumida	Bivalve		x
Ostrea edulis	Bivalve	x	
Hiatella arctica	Bivalve	x	

Table 12. List of species recorded only at one survey in 2004.

More mobile species like the common whelk *Buccinum undatum*, the netted dog whelk *Hinia pygmaea*, the common shore crab *Carcinus maenas* and the long clawed porcelain crab *Pisidia longicornis* were occasionally found on the mono-piles.

Typically normal infaunal species like the bivalve *Thracia phaseolina* and the bristle star *Ophiura albida* were found in small numbers at the mono-piles in September.

3.4.2. Scour protection

A general statistical difference ($P<0.001$) was found between the fauna communities on the scour protections at different turbine sites, but some similarity was found between individual turbine sites. In September, some similarity was found in faunal assemblages on scour protection between turbine sites 55 and 95 ($P<0.12$) and between turbine sites 55 and 33 ($P<0.15$). In particular, abundances of the crustaceans *Jassa marmorata* and *Caprella linearis* contributed to the dissimilarities between the turbine sites but also the distribution and abundance of the common mussel *Mytilus edulis*, sea anemones *Actiniaria* and partly the common starfish *Asterias rubens* were of considerably importance.

Seven species constituted more than 99.4% of the total abundance and between 55% and 95.9% of the total biomass registered in March and September, Tables 14 and 15. At most turbine sites, sea anemones contributed with a substantial biomass up to 46.3% of the total biomass at the sites. This included the presence of the dead man's fingers *Alcyonium digitatum*, especially at turbine site 33. Only the slipper limpet *Crepidula fornicata* was represented in high biomass at turbine site 95 in September.

General statistical differences ($P<0.03$) in faunal assemblages were shown between sampling localities at different distances from the mono-pile. In September, some similarities were found between sampling sites 0.5 m NNE and 2 m NNE ($P<0.14$) and between 0.5 m NNE and 5 m SSW ($P<0.06$). Within the 5 m zone from the towers, no distinct distribution patterns for abundance and biomass were found for six of the most abundant species, Figures 14-15.

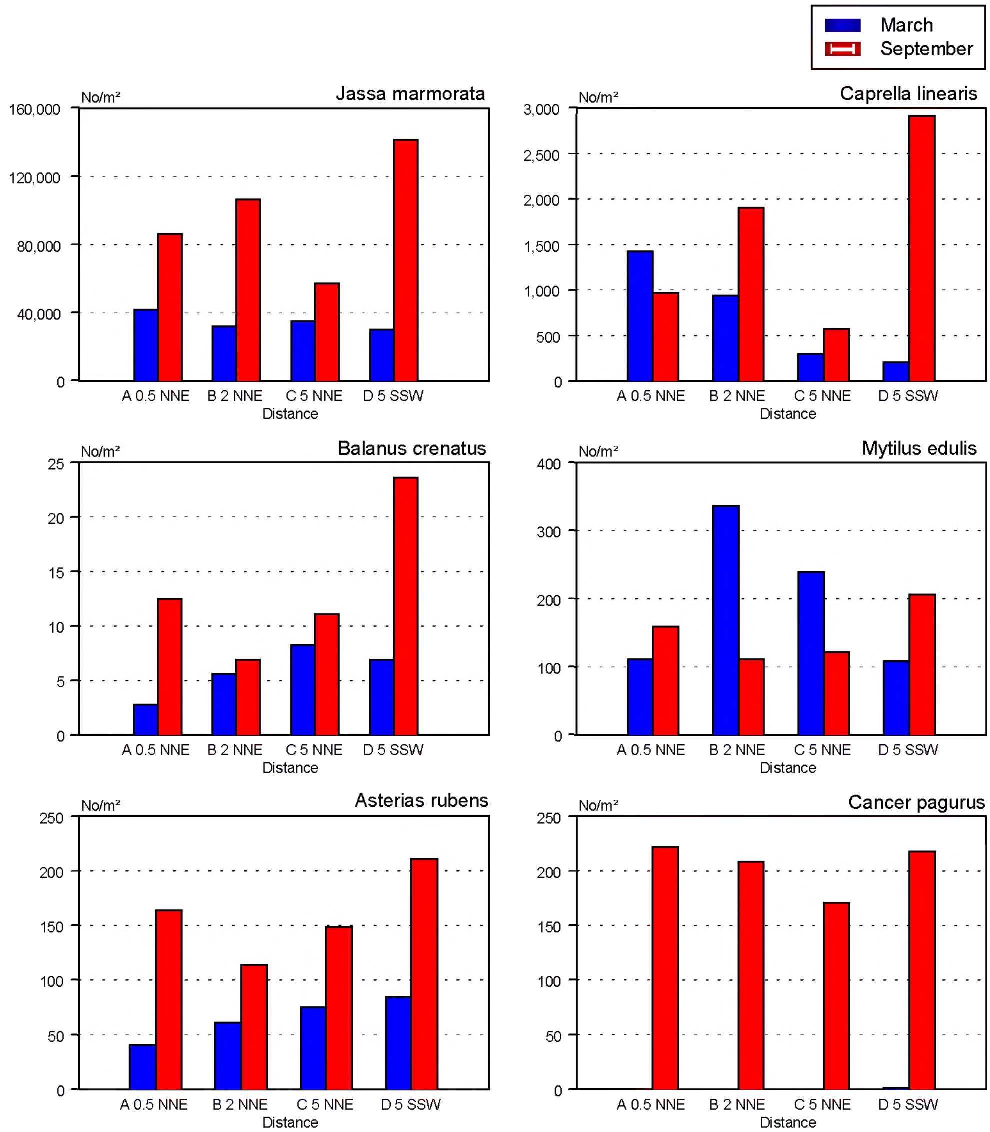


Figure 14. Distribution of the six most dominant species at the scour protections at different distances from the mono-piles shown as average abundance for all six turbine sites.

The statistical analysis of data from the transect surveys showed no differences between transect NNE and SSW. In general, statistical differences were found between the stations close to the mono-pile and stations at the edge of the scour protection. Close to the edge of the scour protections, no statistical differences were shown between stations across the zones with different size of stones. Three overlapping zones at the scour protections were identified. One distinct zone covered the distance from the mono-piles to 10 m from the towers, the second zone covered the distance from 6 m to 12 m and the last zone covered the distance from 10 m to 16 m from the mono-pile. The coverage and frequency of *Jassa marmorata* decreased towards the edge of the scour protection while the occurrence of the sand dwelling bristle worm *Lanice conchilega* at the outer edge of the scour protections contributed to the difference between the zones.

Abundance ind./m²		M[illegible]											
Turbine site		Turbine 55		Turbine 58		Turbine 95		Turbine 33		Turbine 91		Turbine 92	
Species	Group	Mean	Relative %	Mean	Relative %	Mean	Relative %	Mean	Relative %	Mean	Relative %	Mean	Relative %
Jassa marmorata	Crustacean	50,246	97.9	49,623	98.0	4,435	86.6	30,071	98.9	13,477	95.6	61,273	93.6
Caprella linearis	Crustacean	421	1.0	954	1.6	223	3.6	81	0.3	198	2.2	2,429	4.2
Mytiius edulis	Bivalve	81	0.1	50	0.1	2	0.0	21	0.1	10	0.1	1,027	1.4
Balanus crenatus	Crustacean	6	0.0	2	0.0	0	0.0	2	0.0	0	0.0	25	0.0
Asterias rubens	Echinoderm	100	0.3	40	0.1	171	4.3	29	0.1	38	0.8	15	0.0
Cancer pagurus	Crustacean	0	0.0	0	0.0	2	0.0	0	0.0	0	0.0	0	0.0
Pomatoceros triqueter	Bristle worm	48	0.1	13	0.0	2	0.1	6	0.0	0	0.0	13	0.0
Total		**50,902**	**99.4**	**50,681**	**99.7**	**4,835**	**94.6**	**30,210**	**99.4**	**13,723**	**98.6**	**64,781**	**99.3**

Abundance ind./m²		September 2004											
Turbine site		Turbine 55		Turbine 58		Turbine 95		Turbine 33		Turbine 91		Turbine 92	
Species	Group	Mean	Relative %	Mean	Relative %	Mean	Relative %	Mean	Relative %	Mean	Relative %	Mean	Relative %
Jassa marmorata	Crustacean	90,721	98.9	137,781	97.7	50,169	96.1	67,604	97.8	78,946	97.0	162,248	96.5
Caprella linearis	Crustacean	419	0.5	729	0.6	1,090	1.9	1,346	1.3	1,527	2.3	4,427	2.5
Mytiius edulis	Bivalve	40	0.0	283	0.2	125	0.3	75	0.1	69	0.1	308	0.2
Balanus crenatus	Crustacean	2	0.0	33	0.0	6	0.0	2	0.0	8	0.0	29	0.0
Asterias rubens	Echinoderm	129	0.1	213	0.2	190	0.4	140	0.2	96	0.1	190	0.1
Cancer pagurus	Crustacean	44	0.0	583	0.6	190	0.4	17	0.0	83	0.1	488	0.3
Pomatoceros triqueter	Bristle worm	23	0.0	17	0.0	13	0.0	67	0.1	0	0.0	0	0.0
Total		**91,377**	**99.7**	**139,640**	**99.4**	**51,781**	**99.0**	**69,250**	**99.6**	**80,729**	**99.6**	**167,690**	**99.7**

Table 14. Abundances of the most dominant species on the scour protections at different turbine sites in March and September 2004.

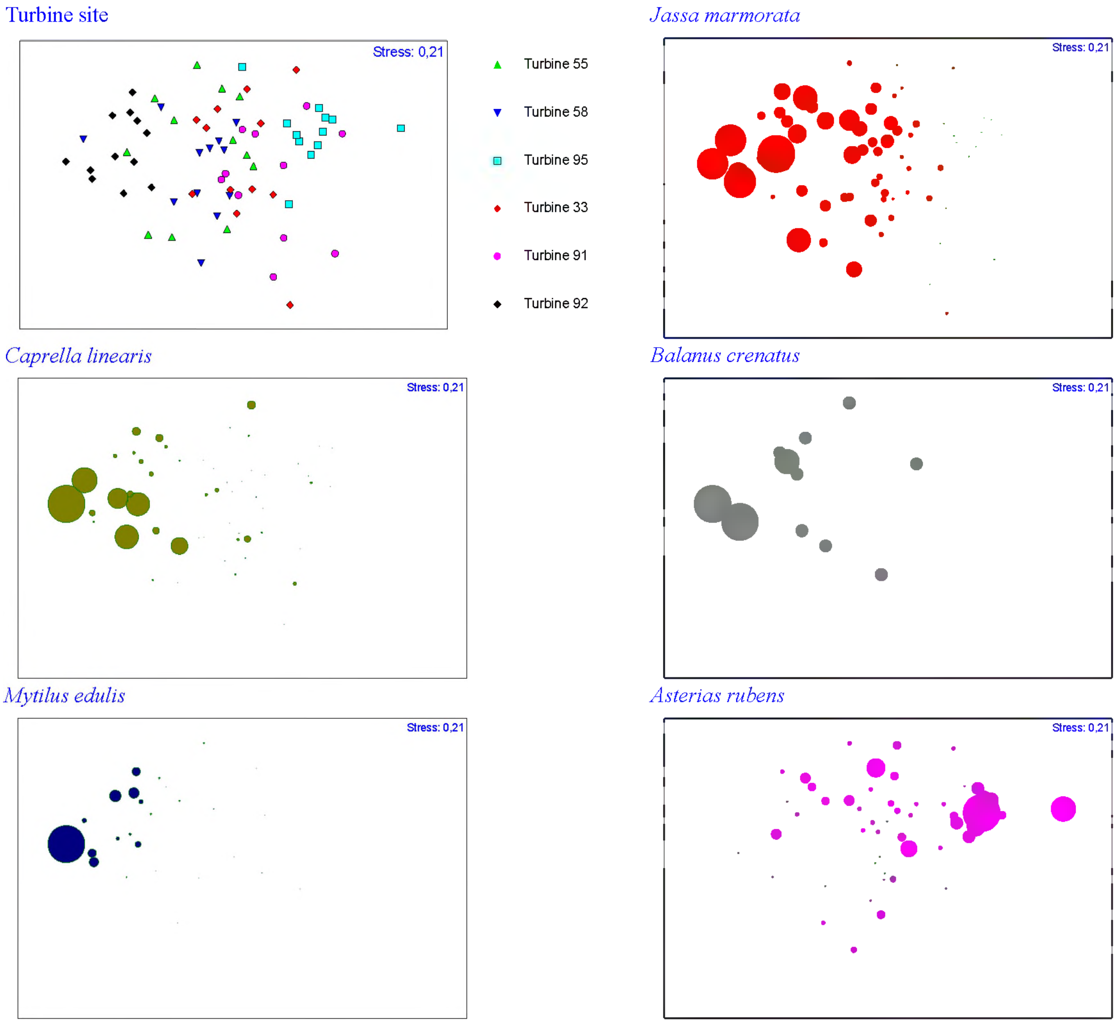


Figure 16. MDS plots of relative abundance concerning differences between turbine sites of five of the most important species on the scour protections in March 2004. The figure shows partly overlapping groups of samples for different turbine sites; scour 92 and 95 partly differentiating from other scours. High abundances of Jassa marmorata *and* Caprella linearis *are shown at turbine sites 92, 55 and 58. For* Mytilus edulis *and* Balanus crenatus, *high abundances are also shown at turbine site 92, whereas at this site the predator* Asterias rubens *is relatively low in abundance. High abundance of* Asterias rubens *is shown for turbine site 95.*

Biomass g/m²		March 2004											
Turbine site		Turbine 55		Turbine 58		Turbine 95		Turbine 33		Turbine 91		Turbine 92	
Species	Group	Mean	Relative %	Mean	Relative %	Mean	Relative %	Mean	Relative %	Mean	Relative %	Mean	Relative %
Jassa marmorata	Crustacean	94.968	42.8	367.122	75.5	9.852	6.9	57.111	55.5	32.299	48.0	146.786	68.5
Caprella linearis	Crustacean	2.143	1.0	7.188	3.4	1.104	1.1	0.171	0.1	0.912	3.6	12.229	6.9
Mytilus edulis	Bivalve	0.032	0.0	0.053	0.0	0.001	0.0	0.009	0.0	0.003	0.0	1.264	0.6
Balanus crenatus	Crustacean	0.623	0.3	0.010	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.052	0.0
Asterias rubens	Echinoderm	69.308	37.8	30.132	8.0	93.368	47.0	19.650	23.2	33.838	36.1	3.220	1.6
Cancer pagurus	Crustacean	0.000	0.0	0.000	0.0	0.019	0.0	0.000	0.0	0.000	0.0	0.000	0.0
Pomatoceros triqueter	Bristle worm	1.337	0.6	0.127	0.0	0.045	0.0	0.023	0.0	0.000	0.0	0.099	0.0
Total		**168.410**	**82.5**	**404.632**	**87.0**	**104.390**	**55.0**	**76.964**	**78.9**	**67.051**	**87.8**	**163.650**	**77.6**

Biomass g/m²		September 2004											
Turbine site		Turbine 55		Turbine 58		Turbine 95		Turbine 33		Turbine 91		Turbine 92	
Species	Group	Mean	Relative %	Mean	Relative %	Mean	Relative %	Mean	Relative %	Mean	Relative %	Mean	Relative %
Jassa marmorata	Crustacean	130.068	63.8	264.628	65.6	58.676	26.2	48.883	30.9	158.321	66.2	299.806	87.3
Caprella linearis	Crustacean	0.939	0.4	3.016	0.8	2.049	1.0	3.930	2.1	5.780	3.6	11.327	3.2
Mytilus edulis	Bivalve	0.016	0.0	0.264	0.1	0.110	0.0	0.473	0.4	0.106	0.1	0.905	0.3
Balanus crenatus	Crustacean	0.003	0.0	0.798	0.2	0.074	0.0	0.018	0.0	3.847	1.4	0.791	0.3
Asterias rubens	Echinoderm	24.171	10.7	48.497	13.2	81.433	36.5	28.601	17.6	38.321	13.2	7.525	2.6
Cancer pagurus	Crustacean	0.259	0.1	5.901	1.5	0.073	0.0	0.058	0.0	1.103	0.3	6.564	2.2
Pomatoceros triqueter	Bristle worm	0.655	0.3	0.692	0.2	0.803	0.4	1.801	1.1	0.000	0.0	0.000	0.0
Total		**156.111**	**75.4**	**323.795**	**81.5**	**143.219**	**64.2**	**83.763**	**52.2**	**207.478**	**84.7**	**326.917**	**95.9**

Table 15. Biomasses of the most dominant species on the scour protections at different turbine sites in March and September 2004.

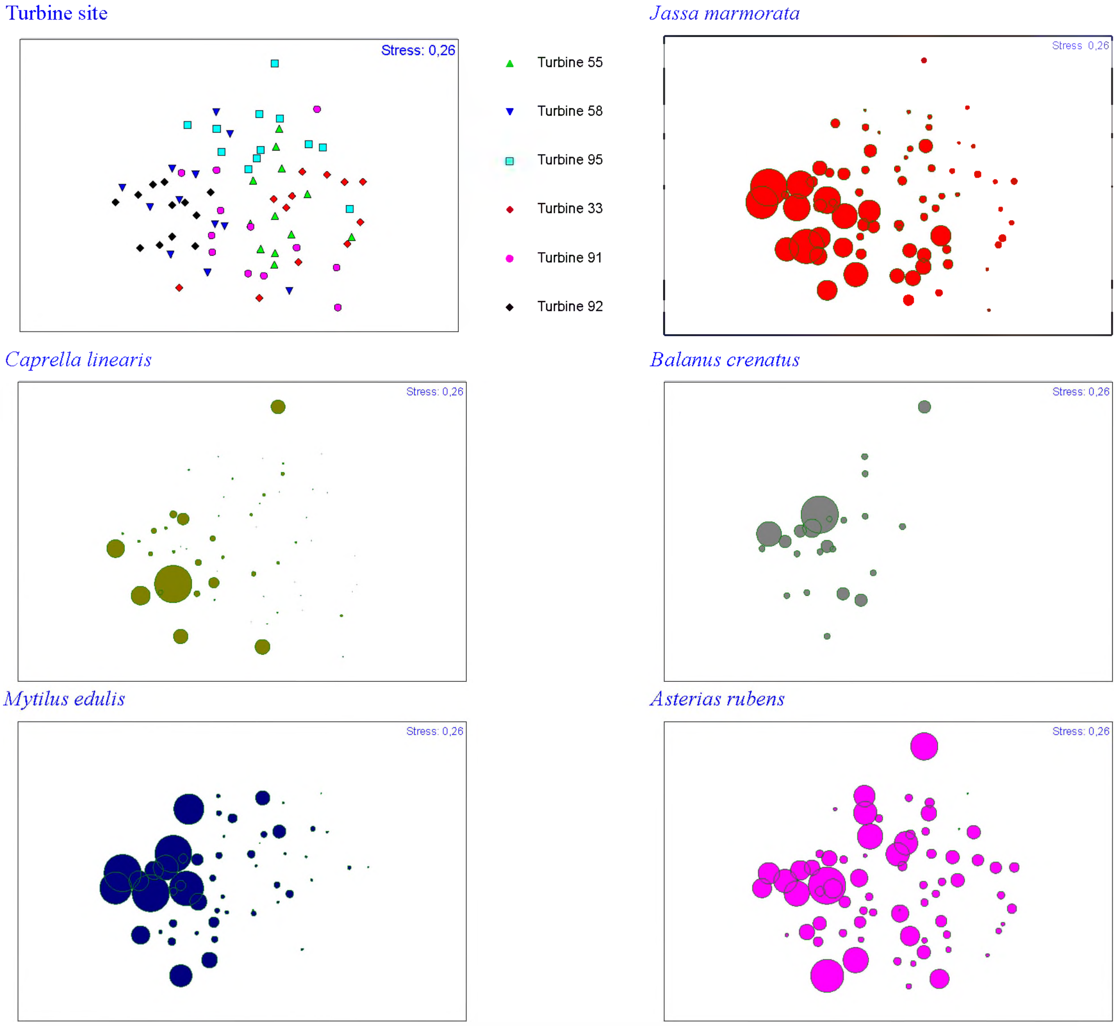


Figure 17. MDS plots of relative abundance concerning differences between turbine sites of five of the most important species on the scour protections in September 2004. The figure shows partly overlapping groups of samples for different turbine sites. High abundances of Jassa marmorata *and partly* Caprella linearis *and* Mytilus edulis *are shown at turbine sites 92 and 58. Relatively high abundance for* Mytilus edulis *is shown for turbine site 95. The starfish* Asterias rubens *shows more or less even distribution between the turbine sites.* Balanus crenatus *is mainly found at turbine site 92.*

Jassa marmorata was found most abundant at turbine site 92 with up to 263,500 ind./m^2. At most sampling sites, the abundance and biomass of *Jassa marmorata* was higher in September, Figures 14 and 15 and Table 14. The average individual body displays reproduction in summer, Figure 18.

Caprella linearis was most abundant at turbine site 92 and was found in abundance of 12,683 ind./m^2. The results indicate that this species is breeding in summer, Figure 18. Relatively most juveniles of *Caprella linearis* were found in September at sampling site 2 m NNE, Figure 18, and contributed to a characteristic distribution of abundance and biomass between the sampling sites, Figures 14 and 15.

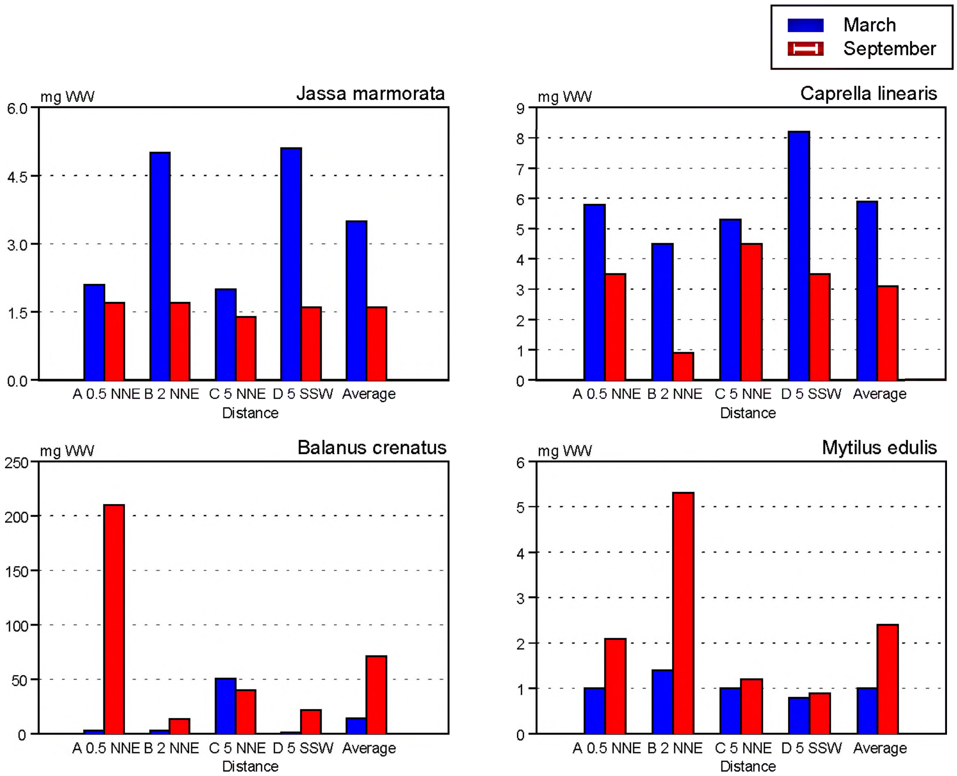


Figure 18. Average individual weights of Jassa marmorata, Caprella linearis, Balanus crenatus *and* Mytilus edulis *at the scour protections in March and September 2004.*

Balanus crenatus was absent from the line transect at scour protection sites 91 and 95 and generally low in abundance at all turbine sites. In September, *Balanus crenatus* was found, although in small numbers, at all turbine sites. The highest abundance of 58 ind./m^2 of this barnacle was found at turbine site 58. No clear distribution pattern was shown except for markedly high biomass close to the mono-pile in September where some larger specimens with an average individual body weight of 210 mg were found, Figures 14, 15 and 18.

The common mussel *Mytilus edulis* showed an aggregated distribution in March in particular. Absent or almost absent from more turbine sites, juvenile spat was substantially higher at turbine site 92 reaching local abundances up to 1,941 ind./m^2. In September, local abundances of juveniles were lower reaching 533 ind./m^2 at turbine site 58. All mussels found on scour protections were small with average weights of 1.0 mg and 2.4 mg in March and September, respectively.

In March, the starfish *Asterias rubens* was more or less aggregated in distribution. The starfish was most abundant at site 95 and less abundant at site 92, while *Mytilus edulis* was found in low abundance at site 95 and high abundance at site 92. In September, *Asterias rubens* showed a more even distribution between the turbine sites, although an aggregated distribution was found at the individual sampling stations on the scour protections. *Asterias rubens* was observed in the highest coverage and maximum abundance at up to 358 ind./m^2 at turbine sites with corresponding high abundances of *Mytilus edulis,* Figure 17.

Edible juvenile crabs *Cancer pagurus* were found more frequently in September than in March and on all turbine sites, Tables 14 and 15. During the transect surveys, mature edible crabs with carapace width up to 18-20 cm were frequently observed on the scour protections in September.

Typical epifauna species such as the sponge *Halichondria panicea* and the broyzoan *Flustra foliacea* were found exclusively in March, whereas species such as the hydrozoan *Sertularia cupressina,* the bristle worm *Sabellaria sp.* and the marbled crenella *Modiolarca tumida* were exclusively found in September. Only one small specimen of *Sabellaria* presumably *S. spinulosa* was recorded.

Other more mobile epifauna species such as the long legged spider crab *Macropodium rostrata*, the common shore crab, the masked crab *Corystes cassivelaunus* and juveniles of the northern sea urchin *Strongylocentrotus droebachiensis* were occasionally recorded on the scour protections in either March or September. The sea slug *Flabellina (Coryphella) lineata* was only recorded in September.

Other typical epifauna species such as the bristle worm *Pomatoceros triqueter* and the slipper limpet *Crepidula fornicata* were characterised as either more common or more evenly distributed on the scour protection in September compared to March.

The infauna species *Lanice conchilega* and the hermit crab *Pagurus bernhardus* were also more commonly recorded at the outer scour protection 8-14 m from the mono-piles in September. Other species normally found in the infauna such as the bivalve *Spisula solida*, *Angulus tenuis* and the bristle star *Ophiura albida* were also recorded on the scour protections. *Ophiura albida* was frequently recorded on the scour protections in September.

Green egg masses of bristle worms (*Phyllodocidae*) probably *Phyllodoce groenlandica* and eggs of sea slugs attached to stones were exclusively recorded in March.

3.5. Comparisons with results from 2003

Some comparisons with the observations and results on fish fauna, vegetation cover, fauna abundances and biomasses between the surveys in 2003 and 2004 are shown below.

3.5.1. Fish

A total of 22 species have been registered during the surveys on the hard bottom substrate at the offshore wind farm at Horns Rev since the erection of the wind turbines in 2002.

Besides the fish observed in the area close to the turbine structures inclusive of the scour protections, as presented in Table 16, whiting (*Merlangius merlangus*) was caught during the test fishing in 2003 and juvenile Atlantic mackerel (*Scomber scombrus*) were observed in the area between the turbines in 2004.

Common name	Scientific name	2003		2004	
		Number of sites	Max. Abundance	Number of sites	Max. Abundance
European sprat	*Sprattus sprattus*			1	O
Atlantic cod	*Gadus morhua*	6	R	2	R
Bib (Pouting)	*Trisopterus luscus*	4	R	3	R
Pollock (Saithe)	*Pollachius virens*	1	O	1	O
Broad-nosed pipefish	*Syngnathus typhle*			1	O
Shorthorn sculpin	*Myoxocephalus scorpius*	5	R	4	R
Hooknose	*Agonus cataphractus*	5	R	4	O
Longspined bullhead	*Taurulus bubaris*			2	O
Horse mackerel	*Trachurus trachurus*	2	R		
Stribed red mullet	*Mullus surmuletus*	1	O		
Ballan wrasse	*Labrus bergylta*			1	O
Corkwing wrasse	*Symphodus melops*	6	R		
Goldsinny-wrasse	*Ctenolabrus rupestris*	1	R	6	∞
Lumpsucker	*Cyclopteus lumpus*			1	O
Viviparous blenny	*Zoarces viviparous*	2	R	1	O
Small sandeel	*Ammodytes tobianus*			2	O
Rock gunnel	*Pholis gunnellus*	6	R	6	R
Dragonet	*Callionymus lyra*	5	O	3	R
Sand goby	*Pomatoschistus minutus*	4	∞	6	∞
Painted goby	*Pomatoschistus pictus*			2	R

Table 16. Fish species observed during the surveys in 2003 and 2004.

A few more species were registered in 2004 compared to 2003 but some of the species, for example cod and bib, were apparently less frequent and less abundant in 2004. It should be mentioned that divers subjectively have made the observations and that quantifications were not possible. Further identifications of species can be difficult during field observations.

In 2004, the broad-nosed pipefish (*Syngnathus typhle*) was observed. This species is typically found in areas with vegetation.

3.5.2. Vegetation

A smaller number of submerged vegetation species were registered in 2004 compared to 2003. In 2004, 11 different species were registered compared to 16 in 2003 indicating higher variations in the initial vegetation cover especially found on the mono-piles.

Some variations in the distribution of different groups of vegetation between 2003 and 2004 were shown for different turbine sites. The variations were apparently higher at turbine sites situated in areas with greater depths, Table 17. The vegetation in areas with greater depth was more scattered than the vegetation in more shallow areas; especially for more rare species of brown and red algae, which contributed to a higher variation.

2003-2004												
Turbine site	33		55		58		91		92		95	
Actual depth m	9.2-10.8		7.9-8.8		6.3-7.3		5.1-6.0		4.5-5.7		7.0-7.8	
Sample time	*S*	*A*	*S*	*A*	*S*	*A*	*S*	*A*	*S*	*A*	*S*	*A*
Red algae	03	03		03		04	03/04	03/04	04	04	04	
Brown Algae	04	04			03	04	03	03	03/04	03		
Green algae		03				03/04	04	03/04	04	03/04		04
No vegetation			03/04	04	04						03	03

Table 17. Groups of vegetation registered in 2003 (03) and 2004 (04) at the turbine sites in March (S) and September (A).

The brown algae *Petalonia fascia, Petalonia zosterifolia* and the red algae *Callithamnion corymbosum* seems to be typical for the mono-piles whereas different species of the green algae *Ulva* (*U.* (*Enteromorpha*) *intestinalis, U.* (*Enteromorpha*) *linza*) seems to be typical for the scour protections. The green laver *Ulva lactuca* seems to be more abundant on the scour protections.

All other species recorded during the surveys, Appendix 3.1, were only found occasionally at the mono-piles or on the scour protections.

A great variation in the species composition and coverage of the vegetation was observed between the surveys in 2003 and 2004. In the splash zone, rather dense vegetation of *Urospora penicilliformis* was observed at the towers in March 2003, but the vegetation almost disappeared and was replaced by a coating of microscopic green algae and diatoms in 2004.

Variations in the vegetation coverage of the filamentous algae in other depth zones at the mono-piles were also found, Figure 19. Almost no filamentous algae were registered in 2004, whereas the coverage of these algae was relatively high in 2003. The coverage of the green algae *Ulva (Enteromorpha) spp.* in the upper depth zones was almost unchanged between 2003 and 2004, Figure 19, but the vegetation was generally found at greater water depths in 2004.

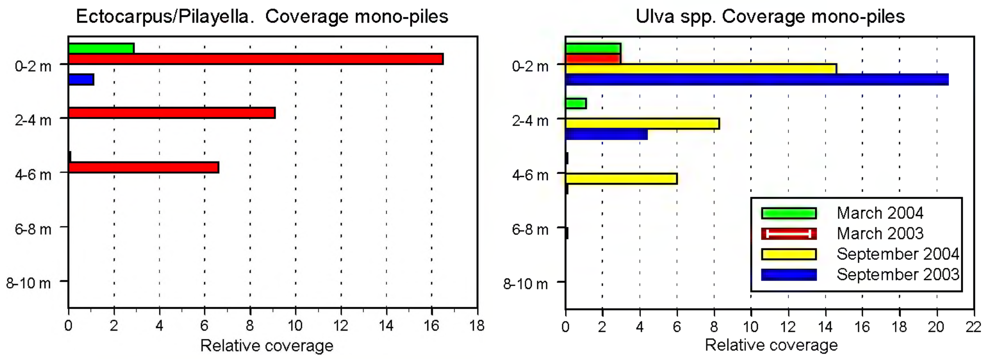


Figure 19. Depth distribution and mean relative coverage of filamentous algae (Ectocarpus/Pilayella) *and* Ulva spp. *along transects at mono-piles in 2003 and 2004.*

The coverage of green algae *Ulva* (*Enteromorpha*) *spp.* on the scour protections was considerably higher in 2004 compared to 2003 at all transects, Figure 20. The relative distribution pattern between 2003 and 2004 was almost identical from the edge of the scour protections to the base of the mono-piles.

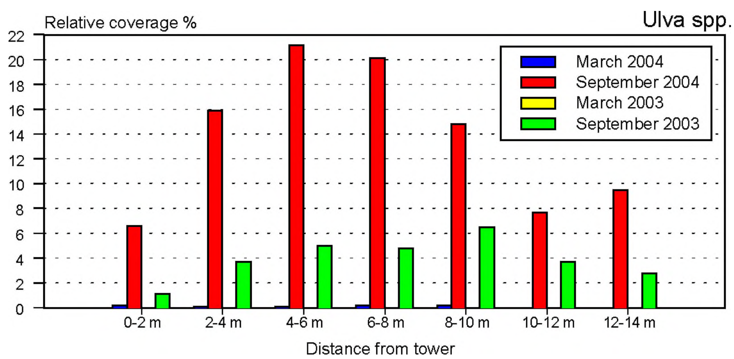


Figure 20. The mean relative coverage of Ulva (Enteromorpha) spp. *along transects on scour protections in 2003 and 2004.*

3.5.3. Fauna

Compared to 2003, five more species of different invertebrate species were registered and observed in 2004 making a total of 70 different species.

Typical epifauna species only registered in 2004 and new to the Horns Rev hard bottom fauna are shown in Table 18.

Species	Group	Sessile	Mobile
Halichondria panicea	Sponge	X	
Hydractinia echinata	Hydrozoan	X	
Sertularia cupressina	Hydrozoan	X	
Alcyonium digitatum	Soft coral	X	
Sabellaria spp. (spinulosa)	Bristle worm	X	
Macropodia rostrata	Crustacean		X
Pisidia longicornis	Crustacean		X
Polycera quadrilineata	Sea slug		X
Facelina bostoniensis	Sea slug		X
Aeolidia papillosa	Sea slug		X
Modiolarca tumida	Bivalve	X	
Flustra foliacea	Bryozoan	X	

Table 18. Epifaunal species new to the Horns rev hard bottom fauna.

Other species like the bristle worm *Ophiodromus flexuosus*, the snail *Hinia pygmaea* and the bivalve *Moerella donacina* were not previously found in the Horns Rev area (Leonhard and Pedersen, 2004), but these species are not typically associated with hard bottom substrates. *Ophiodromus flexuosus* is a free-living carnivorous worm normally associated with a soft bottom and *Moerella donacina* is typical for infralittoral gravely sand habitats (Connor et al., 2004).

Species like the brown shrimp *Crangon crangon*, the bristle star *Ophiura albida*, the thick through shell *Spisula solida*, the thin telling *Angulus tenuis* and other bivalves *Thracia phaseolina* and *Goodalia triangularis* were not previously found during the hard bottom surveys but these species are typical representatives for the native infaunal and epifaunal community in the Horns Rev area (Leonhard and Pedersen, 2004).

Compared to 2003, the total abundance and biomass was generally higher in 2004, Table 19, but considerable variation in the distribution pattern between individual species was found. The total biomass for all species found at Horns Rev in September 2003 and September 2004 was 1,493.875 g/m^2 and 1,580.927 g/m^2, respectively.

Abundance of *Jassa marmorata* was considerably higher in 2004, Table 19 and Figures 21-24. The biomass of *Jassa marmorata* was only marginally higher in March 2003 compared to March 2004, whereas the biomass in September 2004 was considerably higher than in September 2003. A considerable difference in the individual body weight between 2003 and 2004 was found, Table 20. A more uniform distribution indicating breeding in the population was found in 2004 and a similar distribution pattern was also shown for *Caprella linearis*. As a result of natural breeding and succession in the populations of *Jassa marmorata* and *Caprella linearis* in 2004, the relative number of adults was smaller compared to the relative number of juveniles than in 2003.

In addition, differences in individual body weights of species between individuals sampled on different substrate types and different turbine sites were frequently found. This was typical and markedly found for the common mussel *Mytilus edulis* but moreover for small species such as *Jassa marmorata* and *Caprella linearis*.

Growth of population was furthermore clearly shown for the common mussel *Mytilus edulis*. In March 2004, the biomass and the individual body weight were considerably higher than in March 2003, Tables 19 and 21, while in September 2004, two cohorts in the mussel populations were evident, Figure 13. Growth from September 2003 to March 2004 was also shown for the edible crab *Cancer pagurus*, Table 20. The population of the common starfish *Asterias rubens* was clearly dominated by more juvenile specimens in 2004 compared to 2003 resulting in a decline in biomass in 2004, Tables 19 and 20.

Hard bottom substrate dominants		Abundance ind./m²				Abundance ind./m²			
		March 2003		September 2003		March 2004		September 2004	
Species	Group	Mean	Relative %	Mean	Relative %	Mean	Relative %	Mean	Relative %
Jassa marmorata	Crustacean	56,169	86.5	111,891	90.7	95,563	94.0	228,081	91.0
Caprella linearis	Crustacean	927	1.4	9,491	7.7	4,743	4.7	19,119	7.6
Mytilus edulis	Bivalve	4,451	6.9	1,320	1.1	865	0.9	2,206	0.9
Balanus crenatus	Crustacean	2,982	4.6	16	0.0	74	0.1	23	0.0
Asterias rubens	Echinoderm	34	0.1	76	0.1	41	0.0	122	0.0
Cancer pagurus	Crustacean	4	0.0	78	0.1	7	0.0	350	0.1
Pomatoceros triqueter	Bristle worm	7	0.0	49	0.0	34	0.0	23	0.0
Total		**64,574**	**99.5**	**122,921**	**99.7**	**101,327**	**99.7**	**249,924**	**99.6**

Hard bottom substrate dominants		Biomass g/m²				Biomass g/m²			
		March 2003		September 2003		March 2004		September 2004	
Species	Group	Mean	Relative %	Mean	Relative %	Mean	Relative %	Mean	Relative %
Jassa marmorata	Crustacean	276.903	29.4	87.724	5.9	234.424	11.9	272.507	17.2
Caprella linearis	Crustacean	6.949	0.7	15.721	1.1	18.326	0.9	42.245	2.7
Mytilus edulis	Bivalve	41.749	4.4	1,132.353	75.8	1,624.208	82.5	1,134.795	71.8
Balanus crenatus	Crustacean	489.612	51.9	0.568	0.0	1.079	0.1	0.670	0.0
Asterias rubens	Echinoderm	67.679	7.2	101.610	6.8	32.657	1.7	36.657	2.3
Cancer pagurus	Crustacean	0.166	0.0	0.267	0.0	0.968	0.0	4.221	0.3
Pomatoceros triqueter	Bristle worm	0.154	0.0	0.913	0.1	1.266	0.1	1.103	0.1
Total		**883.212**	**93.6**	**1,339.156**	**89.7**	**1,912.928**	**97.2**	**1,492.198**	**94.4**

Table 19. Distribution pattern found for some typical hard bottom substrate dominants between surveys in 2003 and 2004.

Hard bottom substrate dominants		Mean individual weight mg			
		March 2003	September 2003	March 2004	September 2004
Species	Group	Mean	Mean	Mean	Mean
Jassa marmorata	Crustacean	4.9	0.8	2.5	1.2
Caprella linearis	Crustacean	7.5	1.7	3.9	2.2
Mytilus edulis	Bivalve	9.4	857.8	1,877.7	514.4
Balanus crenatus	Crustacean	164.2	35.5	14.6	29.1
Asterias rubens	Echinoderm	1,990.6	1,337.0	796.5	300.5
Cancer pagurus	Crustacean	41.5	3.4	138.3	12.1
Pomatoceros triqueter	Bristle worm	22.0	18.6	37.2	48.0

T*able 20. Mean individual body weight (ww) of typical hard bottom substrate dominants between surveys in 2003 and 2004.*

Statistical differences ($P<0.001$) in community structure between different sampling campaigns in 2003 and 2004 was shown for sampling at mono-piles and scour protections, Figures 21-24. It was mainly seven of the most numerous species, *Jassa marmorata*, *Caprella linearis*, *Mytilus edulis*, *Cancer pagurus*, *Telmatogeton japonicus*, *Asterias rubens* and *Balanus crenatus*, that contributed to the overall statistical dissimilarity between sampling campaigns. These species were generally more abundant in 2004 compared to 2003. Only *Mytilus edulis* and especially *Balanus crenatus* were more abundant in 2003. The giant midge *Telmatogeton japonicus* was abundant and almost exclusively found in the splash zone and was much more abundant in 2004 contributing to the dissimilarity between sampling sites, Figures 21-23.

Clear discrepancy in the distribution of the common mussel *Mytilus edulis* and partly for the barnacle *Balanus crenatus* and the predator *Asterias rubens* was shown for the different sampling sites in both survey years. In September 2004, there was massive settling of juvenile *Mytilus edulis* on the scour protection, which made this discrepancy less pronounced, Figures 23 and 24.

Mono-piles March

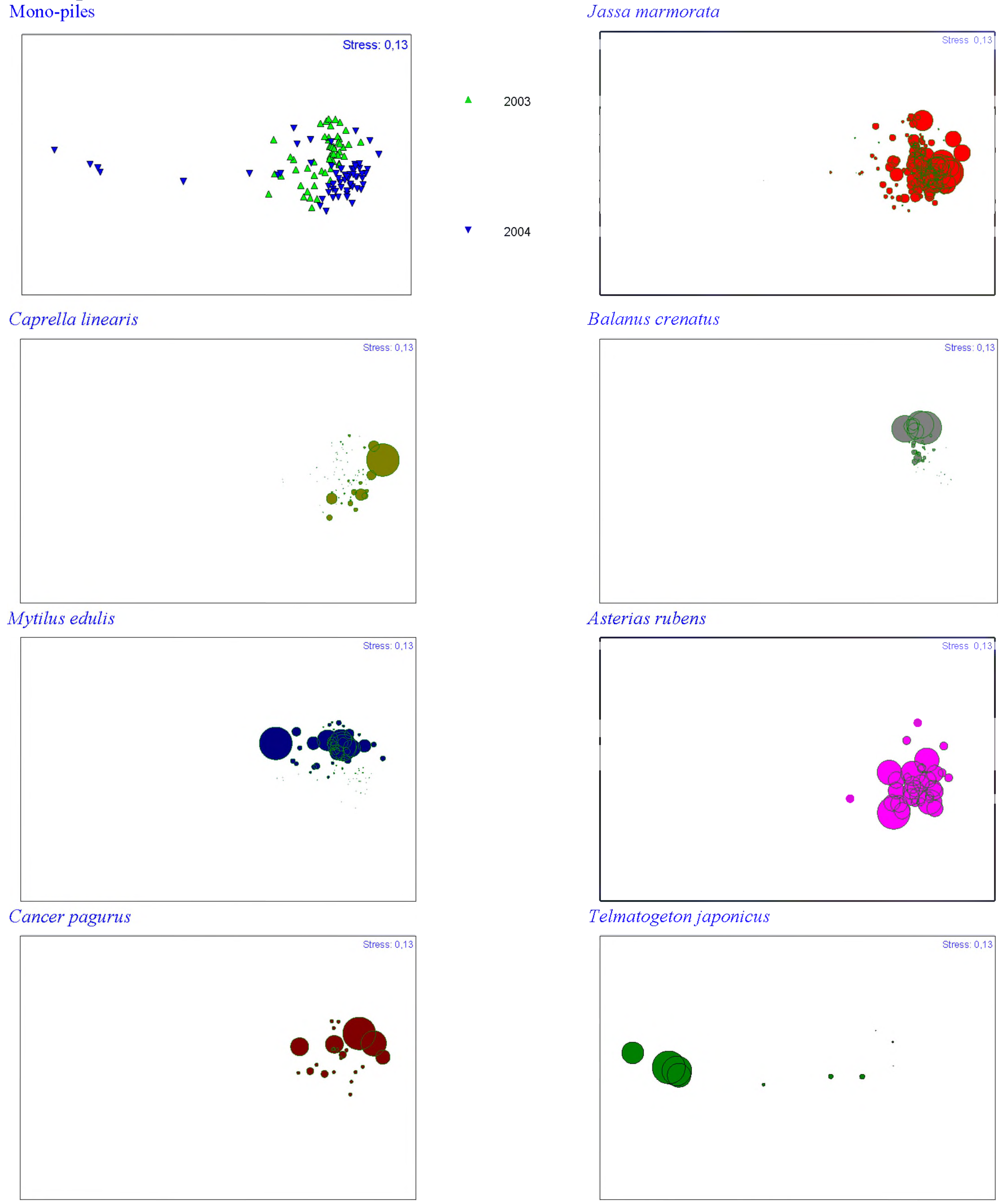


Figure 21. MDS plots of relative abundance at mono-piles concerning differences between sampling in March 2003 and March 2004 of seven of the most important species.

Mono-piles September

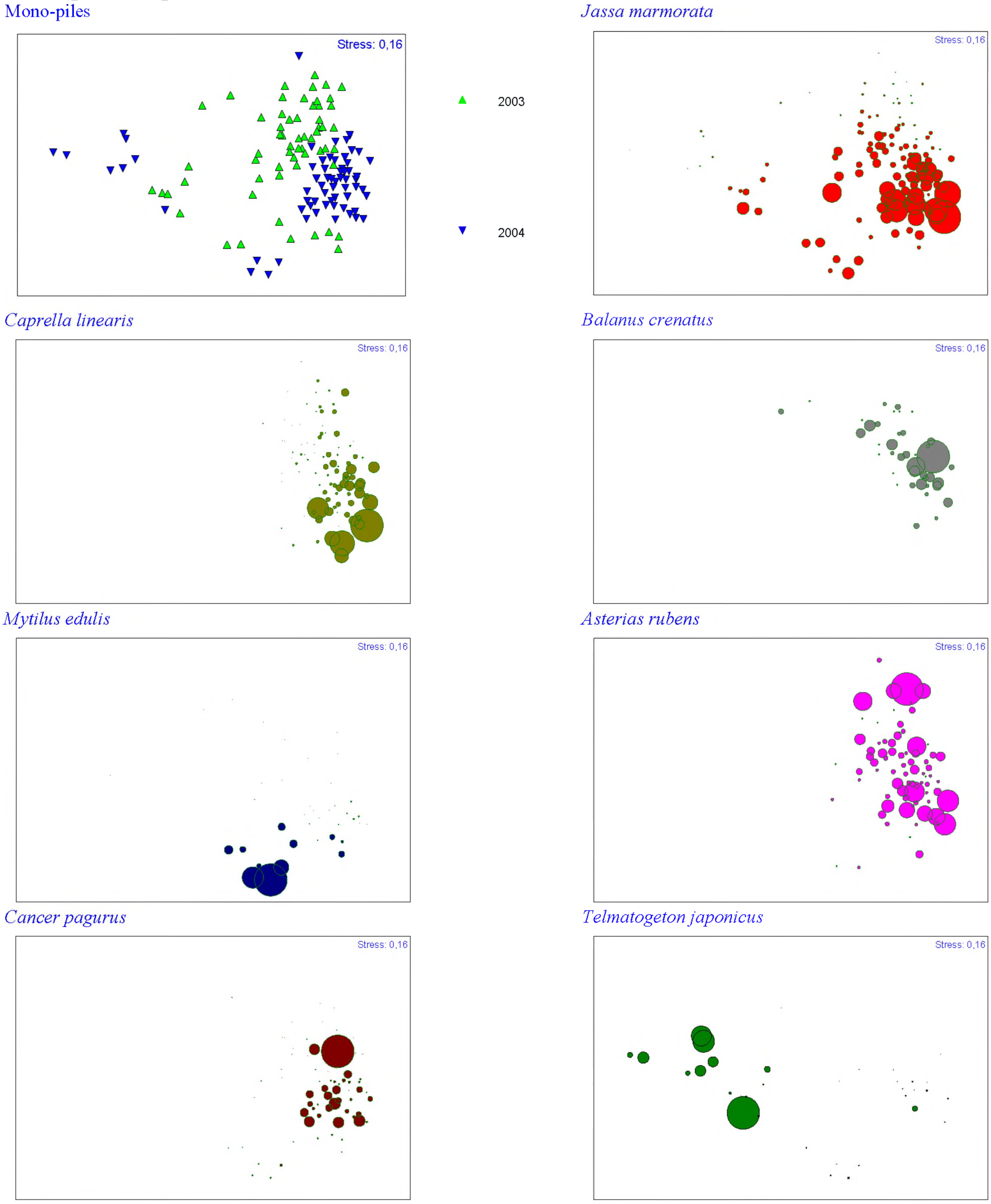


Figure 22. MDS plots of relative abundance at mono-piles concerning differences between sampling in September 2003 and September 2004 of seven of the most important species.

Scour protections March

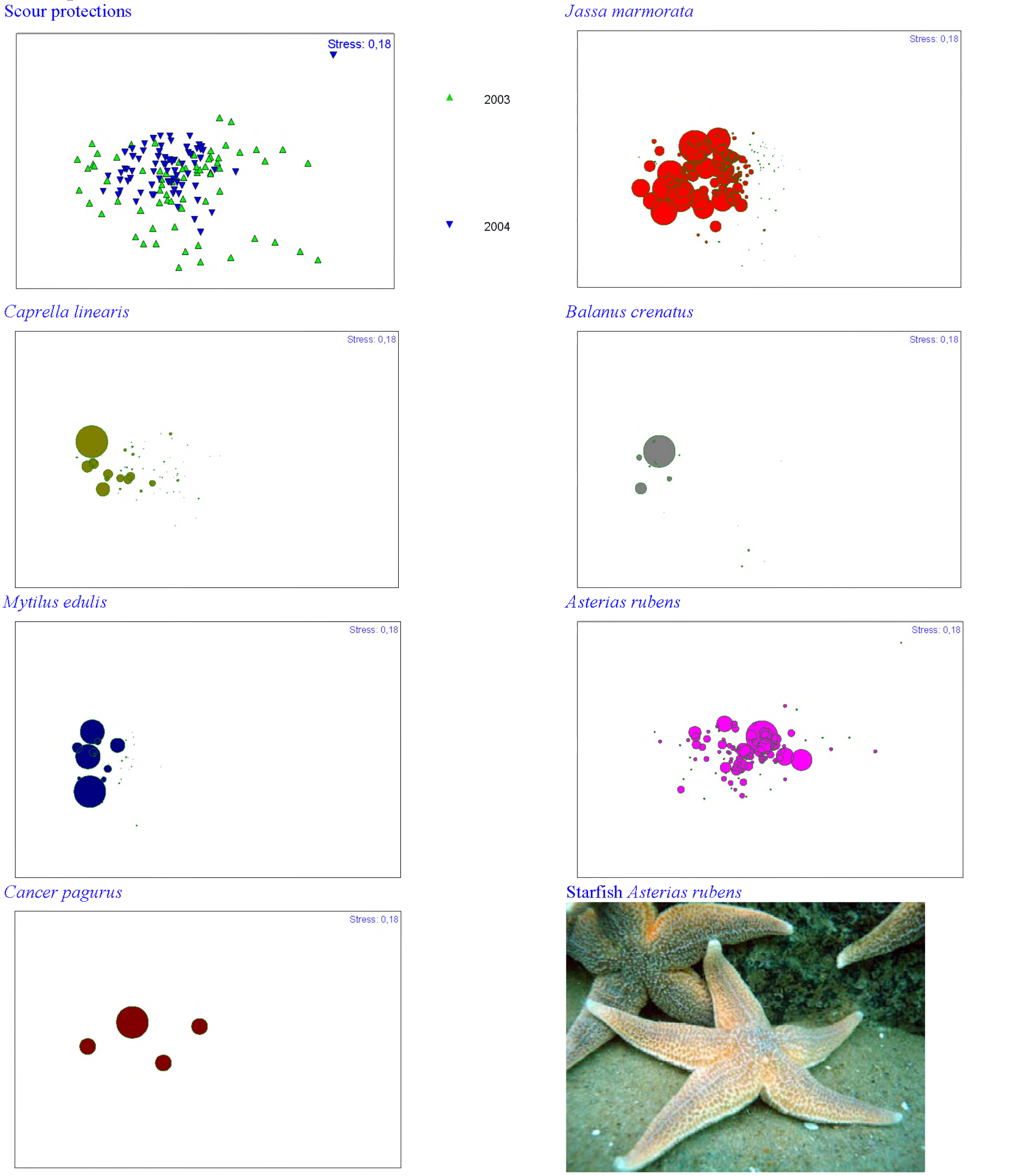
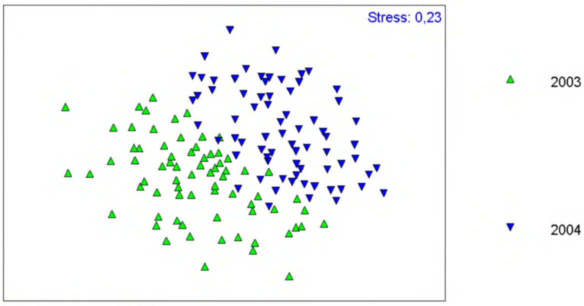


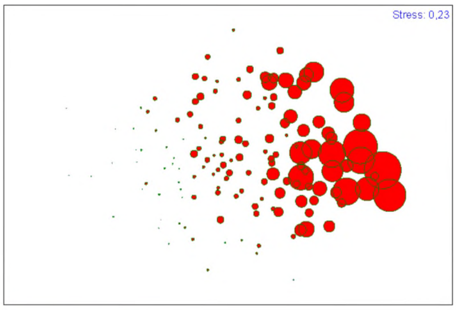
Figure 23. MDS plots of relative abundance on scour protections concerning differences between sampling in March 2003 and March 2004 of six of the most important species.

Scour protections September

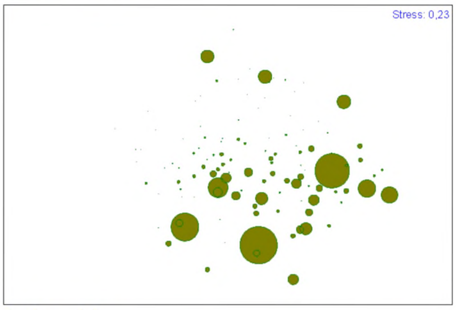
Scour protections



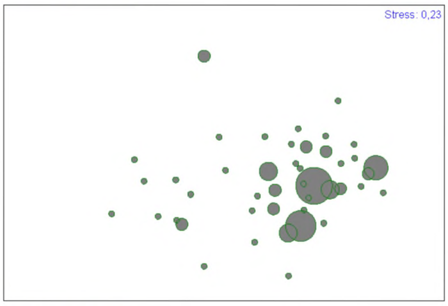
Jassa marmorata



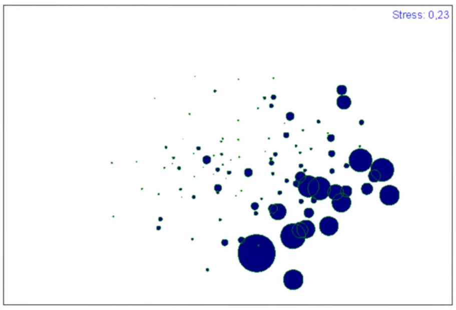
Caprella linearis



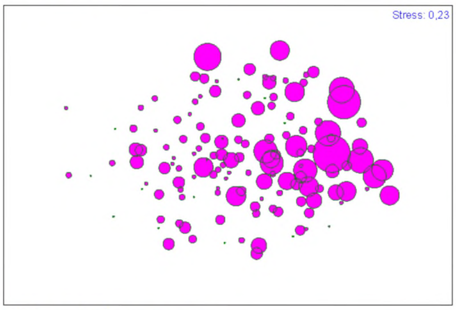
Balanus crenatus



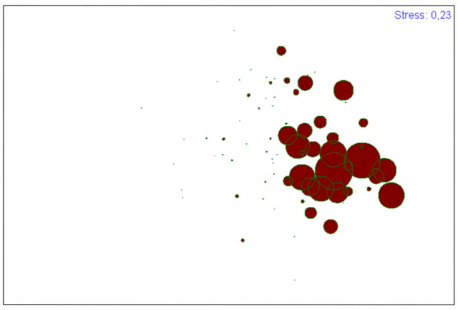
Mytilus edulis



Asterias rubens



Cancer pagurus



Edible crab *Cancer pagurus*

Figure 24. MDS plots of relative abundance on scour protections concerning differences between sampling in September 2003 and September 2004 of six of the most important species.

4. Discussion

Compared to the fauna community in the wind farm area prior to the erection of the wind turbines and the establishment of the scour protections, the fauna communities on the introduced hard substrates are completely different as shown in the status report for 2003 (Leonhard and Pedersen, 2004). No large hard structures existed in the area and the fauna inside the wind farm areas consisted mainly of typical infauna species characteristic for sandbanks in the North Sea (Leonhard, 2002). At the turbine sites, new habitats were introduced changing the substrates from pure sand to foundations of steel, gravel and stones and a typical epifaunal community has replaced the native infaunal community. Larger mobile species like the edible crab *Cancer pagurus*, hermit crab *Pagurus bernhardus*, harbour crab *Liocarcinus depurator*, brown shrimp *Crangon crangon*, common whelk *Buccinum undatum* and starfish *Asterias rubens* were occasionally observed in few numbers in the area (Leonhard, 2002).

During the surveys in 2004, all of the larger mobile epifaunal species previously observed were found on the hard substrate structures inside the wind farm area. Except for the brown shrimp *Crangon crangon*, the larger species were generally found more frequently and in higher numbers in the surveys on hard bottom substrates in 2004. More members found in the infauna *Goniadella-Spisula* community typical for the sandy sea bottom in the Horns Rev area (Bech et al., 2004) were registered at the hard bottom substrate at the turbine foundations.

It was found that the hard substrates after construction of the wind farm were used as hatchery or nursery grounds for several species and was an especially successful nursery for the edible crab *Cancer pagurus*. The number of juveniles of *Cancer pagurus* at the turbine sites has increased markedly from 2003 to 2004. The hard substrate at Horns Rev is probably an important nursery ground for the masked crab *Corystes cassivelaunus* and probably also for the northern sea urchin *Strongylocentrotus droebachiensis*. Both species were found as juveniles in 2003 and 2004. More species are breeding on the hard substrates while egg masses of the bristle worm *Phyllodoce groenlandica*, the common whelk *Buccinum undatum* and different sea slugs were found frequently in spring.

Juveniles of the edible crab were especially found in large numbers on the mono-piles in September 2004 and larger individuals were often observed in caves and crevices among stones at the scour protection. Growth in individuals of *Cancer pagurus* was demonstrated from September 2003 to March 2004 indicating that juvenile edible crabs utilise the turbine foundations as nursery grounds. It is possible that larvae and juveniles of *Cancer pagurus* rapidly invade the hard substrates at the turbine sites from the breading areas. Females of *Cancer pagurus* normally bred buried in sand in deeper areas of the North Sea and the female can be buried for a month after mating. Observations of edible crabs partly buried in sand was observed in the outer scour protections between smaller stones at Horns Rev. Studies off the Dutch coast have also shown that mature individuals of *Cancer pagurus* quickly invaded newly established artificial reefs (Leewis & Hallie, 2000).

Within newly established heterogeneous habitats such as the hard substrates structures at Horns Rev, recruitment variability and predation will influence the abundance of individuals and community structure of epibenthic assemblages (Glassier, 1979; Chiba & Noda, 2000: Worm et al., 2002), which often result in statistical differences in abundance and diversity between sites. Mosaics of sessile organisms form the faunal assemblages at each turbine site and in general the faunal assemblages at all turbine sites at Horns Rev were highly variable and shown to be different. It was also shown at Horns Rev that predation especially from the starfish *Asterias rubens* was one of the main factors to the dramatic changes in the fouling communities between sites. A discrepancy in the abundance of *Mytilus edulis* and *Asterias rubens* was also shown in both 2003 and 2004. This keystone predator controlling the area distribution, vertical distribution, population abundance and size distribution of the prey target *Mytilus edulis* was probably also the main controller of the barnacles. *Mytilus edulis* was only found as juveniles on the scour protections and though evident cohorts of more generations of the common mussels were demonstrated, larger individuals of mussels were only found on few mono-piles often on banisters outside the reach of the starfish. Other studies have shown that *Asterias rubens* often is the "keystone" predator controlling the vertical distribution and abundance in littoral and sublittoral mussel beds (Saier, 2001). Mature starfish are mainly feeding upon larger mussels whereas smaller starfish are feeding on smaller mussels and barnacles. A considerably higher number of starfish, mainly more juveniles, was found in 2004 compared to 2003 resulting in a drastic decline in the abundance of the barnacle *Balanus crenatus*.

Differences were also found in the epibenthic assemblages between vertical structures as mono-piles and horizontal structures as scour protections. Studies on shipwrecks in the North Sea have also shown some differences between communities on vertical and horizontal structures (Leewis et al., 2000). A distinct zonation and marked change in the epifouling communities at the mono-piles was observed. The splash or wash zone was characterised by marked changes in the vegetation cover and species composition. The splash or wash zone was also composed of dense mats of green algae (*Urosporia pennicilliformis*) in 2003 whereas in 2004 the vegetation cover was replaced by a coating of microscopic green algae and diatoms. Grazing on this coating, the almost monoculture population of the "giant" midge *Telmatogeton japonicus* has increased markedly since 2003. *Telmatogeton japonicus*, first recorded at Horns Rev in 2003 (Leonhard and Pedersen, 2004), was hitherto not recorded for Denmark. This midge was probably introduced to Western Europe where it was recorded in 1962 at Kiel (Germany) (Remmert, 1963) and is now known from the Baltic coastal regions of Germany and Poland (Ashe and Cranston, 1990; Murray, 1999). Personal observations of *Telmatogeton japonicus* shows that this species is widely distributed and very numerous on boulders at breakwaters and coast defence structures all over Denmark.

In the upper part of the mono-pile in the littoral zone, the community was partly characterised by a high number of common mussel *Mytilus edulis*, vegetation of the green algae *Ulva (Enteromorpha) spp.*, *Ulva intestinalis, Ulva linza* and *Ulva lactuca* and the brown algae *Petalonia fascia* and *Petalonia zosterifolia.* Also, the barnacles *Balanus crenatus* and *Balanus balanus* and filamentous brown algae *Pilayella litoralis* and *Ectocarpus* were very common, often dominating in this zone. Compared to 2003, a reduced dominance of *Balanus crenatus* was found at the mono-piles in 2004.

Apparently the primary vegetation cover of filamentous algae was replaced by a more or less permanent vegetation of different species of the green algae *Ulva* in 2004. In 2004, this vegetation cover was more established in greater depth at the mono-piles compared to 2003, which probably is the result of succession.

From the upper sublittoral zone to the scour protection, a dense layer of tube mats of the tube dwelling amphipod *Jassa marmorata,* was found. *Jassa marmorata*, often covering the total substrate surface completely, was the most numerous species recorded on the hard bottom substrate at Horns Rev. The cosmopolitan *Jassa marmorata* was until 2003 not recorded in

Denmark; although comprehensive studies on stone reefs in Kattegat and elsewhere in Denmark were conducted (Lundsteen, 2000; Dahl et al., 2004). Tube dwelling amphipods (*Jassa sp.*) were found dominating the epifauna communities at artificially submerged structures in the North Sea (Leewis & Hallie, 2000; Leewis et al., 2000). *Jassa marmorata* was found in numbers on artificial hard substratum in the Mediterranean (Athanasios & Chariton, 2000) and USA (Duffy & Hay, 2000). Compared to the Horns Rev studies, *Jassa marmorata* was found in considerably higher abundances, up to 8,000,000 per m^2, than in other studies (Tish, 2003).

Due to the large abundance, *Jassa marmorata* might contribute significantly to the diet of a number of other invertebrates and vertebrates including fish and predators as the edible crab, the common shore crab and the harbour crab. The diet of the bib (*Trisopterus luscus*) consists of small crustaceans (www.fishbase.org). Together with *Jassa marmorata*, the skeleton shrimp *Caprella linearis* are found in high numbers. A marked increase in abundance of these two dominants was shown from 2003 to 2004 and changes in population structures measured by individual body weight were found, which might be a result of a population regulation process.

In the lower zone at the mono-piles, the bristle worm *Pomatoceros triqueter* was more abundant than in the upper zones but this species was found to be less frequent in 2004 compared to September 2003. *Pomatoceros triqueter* is predominately a sublittoral species and is considered to be a primary fouling organism making use of available space quickly, (Crisp, 1965; Burnell et al., 1991). So the apparent stagnation in population size of *Pomatoceros triqueter* might be the result of competition for space from other species. The primary coloniser, hydrozoan *Tubularia indivisa*, was less abundant in 2004 compared to 2003, which could be a result of lack of space or predation from the sea slugs, among others *Facelina bostoniensis* new to the Horns Rev fauna in 2004. In other studies on artificial reefs, *Tubularia indivisa* could be found on the substrates a few weeks after deployment and together with the hydrozoans *Campanularidae* were considered to be a pioneer community (Leewis & Hallie, 2000; Leewis et al., 2000). More species, such as the plumose anemone *Metridium senile*, the sea anemones *Sargartia troglodytes* and species of *Sargartiogeton*, the dead man's finger *Alcyonium digitatum*, the sea slug *Polycera quadrilineata* and the bryozoan *Electra pilosa*, that were found colonising deployed hard substrates in other parts of the North Sea (Leewis & Hallie, 2000) were also found colonising the turbine foundations at Horns Rev.

Due to high current, wave action or sand scouring, the epifouling community will be eliminated from the substrate leaving place for new settlements, which was observed by divers. More of the species were found on the hard substrate at Horn Rev such as *Sertularia cupressina*, *Flustra foliacea* and *Alcyonium digitatum*, which are typical for sand scoured habitats categorised as "slightly scoured circalittoral rock" (Tyler-Walters, 2002). This together with impact from predation will contribute to a continuous repeating succession process until a more or less stabile community will be reached. Studies have indicated (Leewis et al., 2000; Leewis and Hallie, 2000) that community stability in fouling communities is not attained before 5-6 years after substrate deployment and that occasional events such as heavy storms and severe winters may even prolong this process. Some similarity in the succession of the epifouling community and the species present was found between the epifauna at the foundations at Horns Rev and the epifauna on shipwrecks in other parts of the North Sea (Leewis et al., 2000). More species found on wrecks are likely to be found at Horns Rev in the future.

A very high variation and a general statistical significant difference between faunal assemblages at different sampling sites on the scour protection was shown, but some similarity between different zones mainly reflecting different type of substrate was demonstrated.

At the scour protection, sea anemones and the soft coral *Alcyonium digitatum* contributed with high percentages to the total biomass. Identifications based on video recordings revealed that the sea anemones mainly found were *Sargartia elegans* and *Sargartiogeton laceratus*. In the Dutch area of the North Sea, *Sargartia elegans* and species of *Sargartiogeton* are often found on hard substrates such as shipwrecks (Leewis et al., 2000).

Of the 14 epifaunal species new to the hard bottom fauna at Horns Rev, special attention should be given to the bristle worm *Sabellaria* presumably the ross worm *S. spinulosa* (Leuckhart) and the white weed *Sertularia cupressina*. Both the ross worm and white weed, in addition to the native oyster *Ostrea edulis* in the Wadden Sea area, can be regarded as threatened or red listed species as a result of habitat loss (Lotze, 2004). *Sertularia cupressina* is the object of harvesting for decoration purposes in Europe (Gibson et al., 2001; Lotze, 2004), but this species is obviously not uncommon in Denmark as it was found frequently and in high numbers in other studies (Dahl et al. 2004). The ross worm *Sabellaria spinulosa* may form thin crusts or large biogenic reefs, up to several metres across, performing important stabilising functions on substratum (Jackson & Hiscock, 2003). *Sabellaria spinulosa* was expected to establish on the hard substrate in the wind farm area (Elsamprojekt, 2000) because it was also found on deployed hard substrates off the Dutch coast (Lewis & Hallie, 2000).

As in 2003 (Leonhard and Pedersen, 2004), a marked succession in the number of fish species was observed from the survey in March to the survey in September. This might be a result of seasonal migrations of fish species to the turbine site for foraging. Bip (pouting) was observed presumably partly feeding on the crustaceans on the scour protection together with schools of cod. Studies on fish communities around wrecks off the Dutch coast showed that more species were partly dependent on the wrecks for food (Leewis et al., 2000). Individuals of species like the rock gunnel and the dragonet were commonly found inhabiting caves and crevices between the stones. Similar observations were made in other studies (Leewis & Hallie, 2000). Compared to 2003, only a few more fish species were observed in 2004. Apparently the lumpsucker and the broad-nosed pipefish have established populations at the turbine sites but also pelagic and semipelagic fish like the European sprat, the Atlantic mackerel and the small sandell seems to be more frequently observed than previously.

More of the fish species including the benthic species such as gobies (*Pomatoschistus* spp.), the long spined bullhead (*Taurulus bubaris*) and the shorthorn sculpin (*Myxocephalus scorpius*) found at the turbine sites at Horns Rev are also typically found around wrecks in other parts of the North Sea (Leewis et al., 2000). This indicates that noise and vibrations from the turbine generators apparently have no impact on the fish community attracted to the hard bottom substrates for foraging, shelter and protection. Results from an acoustic survey at the Horns Rev also showed that more and mostly larger fish were found around the turbine foundations than in between the turbine sites (Hvidt et al., 2005).

In September 2003 and 2004, the average infauna biomass in the wind farm area was 185 g/m^2 and 23 g/m^2, respectively (Bech et al. 2004; 2005). Taking considerable variations in the infauna biomass into account, including high variations in the presence of larger infauna species, it is estimated that the availability of food for fish in the area has increased by a factor of approximately 60 compared to that of the normal soft seabed fauna in the wind farm area after the introduction of the hard substratum at Horns Rev. Therefore an increase of fish production related to the presence of the hard substratum is considered possible.

Although a number of benthic invertebrates and fish species have been "newly" recorded to the Horns Rev area and changes in community structures were detected, there are no indications that other than natural succession in communities, predation, recruitment and the presence of hard bottom substrates were regulatory factors for the observed changes.

Photo 8. The sea slug Aeolidia papillosa.

Photo 9. The sea slug Polycera quadrilineata.

Photo 10. The dead man's finger Alcyonium digitatum *and the sea anemone* Sargartiogeton laceratus.

Photo 11. The white weed Sertularia cupressina *partly covered by tubes of* Jassa marmorata.

5. Conclusion

At the turbine sites in the offshore wind farm area at Horns Rev, the indigenous benthic community characterised by infauna species belonging to the *Goniadella-Spisula* community has been changed to an epifouling community associated with hard bottom habitats since the introduction of hard bottom structures in 2002. The small crustacean *Jassa marmorata* has shown to be the most abundant species on the hard bottom substrates.

Introduction of epifouling communities have increased the general biodiversity in the wind farm area and progress succession in the benthic community and biodiversity has been observed compared to the surveys in 2003.

Evidence that the hard bottom substrates provide habitat as nursery grounds for larger and more mobile species was shown for the edible crab *Cancer pagurus*.

Significant differences between sampling in 2003 and 2004, annual variations and variations in the epifouling communities at the hard bottom substrates have been registered while the faunal assemblages at all turbine sites at Horns Rev have shown to be different too. Differences in community structures between mono-piles and scour protections were shown mainly due to differences in abundance and biomass of a few epifouling dominants.

A significant vertical zonation was found in epifouling communities at the mono-piles. The splash zone at the mono-piles was entirely dominated by the "giant" midge *Telmatogeton japonicus* with a pronounced increase in abundance since 2003. The upper investigated zones of the mono-piles were characterised by high numbers and high biomass of the common mussel *Mytilus edulis* and vegetation cover of green and brown algae. No clear distribution pattern was found in the lower zones or near the bottom apart from a general lower abundance of the dominant species.

Considerable changes in vegetation cover at the mono-piles between 2003 and 2004 were found, which might be a result of succession.

The starfish *Asterias rubens* was found to be a keystone predator mainly controlling the distribution of the common mussel and the barnacles at the hard bottom substrates in the wind farm area.

Succession in community structure was demonstrated and some primary colonisers were less abundant in 2004, which might be a result of predation and competition for space. It is anticipated that stability in fouling communities will not be attained within the next 5-6 years. Heavy storms and severe winters may even prolong this process.

Some species observed on hard bottom structures at Horns Rev are characteristic for slightly scoured circalittoral rock habitats.

Loss of infauna habitats has been replaced by hard bottom habitats providing an estimated 60 times increase in the availability of food for fish and other organisms in the wind farm area compared to the native infauna biomass.

Seasonal variations in fish fauna diversity were found with bib and schools of cod often observed at the scour protections as well as individuals of benthic fish species. Comparison with the fish fauna on shipwrecks in other parts of the North Sea showed that there was no indication that noise and vibrations from the turbine generators had any impact on the fish community at Horns Rev. Compared to 2003, a few more fish species seem to have established at the turbine sites in 2004.

Special attention should be addressed to the recording of two new species introduced to the Horns Rev area, the bristle worm *Sabellaria* presumably the ross worm *S. spinulosa* and the white weed *Sertularia cupressina*, which both are regarded as threatened or red listed in the Wadden Sea area.

There is no evidence that other regulatory factors other than natural succession in communities, predation, recruitment and the presence of hard bottom substrates have caused the observed changes in species diversity and community structure.

Photo 12. The plumose anemone Metridium senile.

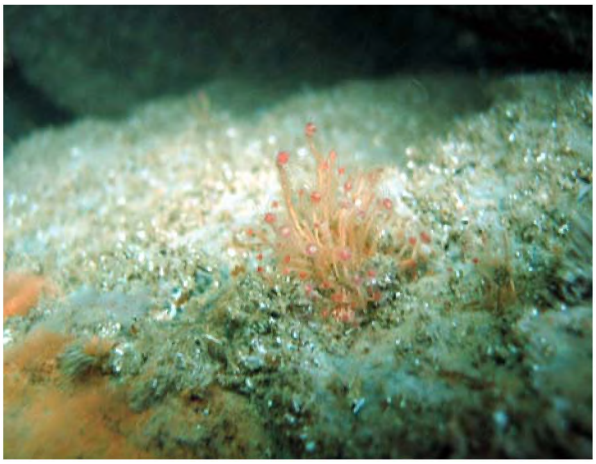


Photo 13. The Oaten pipes hydroid Tubularia indivisa.

Photo 14. The edible crab Cancer pagurus.

Photo 15. The rock gunnel Pholis gunnellus.

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Appendixes

Appendix 1. List of Positions

Sampling was performed at the following locations. Positions and actual depth are registered at the position of the sampling vessel close to the mono-pile.

March 2004

Location	Sampling date	"WGS84_MIN_Y"	WGS84_MIN_X"	Actual depth (m)	Program
Turbine 33	300304–310304	55°29.613'	07°49.522'	9.6	*
Turbine 55	300304	55°29.025'	07°50.740'	8.3–8.8	**
Turbine 58	250304-260304	55°28.129'	07°50.948'	6.5–7.3	**
Turbine 91	240304	55°30.241'	07°52.573'	5.6–5.7	*
Turbine 92	240304	55°29.827'	07°52.675'	4.5–5.0	*
Turbine 95	250304-260304	55°29.046'	07°52.854'	7.5–7.8	**

September 2004

Location	Sampling date	"WGS84_MIN_Y"	WGS84_MIN_X"	Actual depth (m)	Program
Turbine 33	030904	55°29.617'	07°49.527'	10.8	*
Turbine 55	020904	55°29.025'	07°50.740'	8.3–8.8	**
Turbine 58	020904	55°28.121'	07°50.910'	6.3	**
Turbine 91	040904	55°30.241'	07°52.573'	5.6–5.7	*
Turbine 92	040904	55°29.827'	07°52.675'	5.0	*
Turbine 95	030904	55°29.044'	07°52.856'	7.0	**

Appendix 2. Meteorological and Hydrographical Data

March 2004

Location	Date	Current		Wind		Secchi depth m	Wave height	Adjusted Secchi depth m
		Direction	m/sec	Direction	m/sec			
Turbine 33	300304	S	0.10	E	2	2.5	0.25	2.8
	310304	N	0.80	E	7-8	2.8	0.75	3.6
Turbine 55	300304	S	0.10	E	1-2	2.75	0.25	3.0
Turbine 58	250304	N-NE	0.50	NW	8	1.8	0.75	2.3
	260304	N-NE	0.50	W-SW	3-4	1.8	0.3	2.0
Turbine 91	240304	N	0.40	N-NE	5	1.75	0.5	2.1
Turbine 92	240304	S	0.40	N-NE	5	1.75	0.5	2.1
Turbine 95	250304	N-NE	0.50	NW	8	1.8	0.75	2.3
	260304	N-NW	0.50	SE	0,5	1.8	0.0	1.8

September 2004

Location	Date	Current		Wind		Secchi depth m	Wave height	Adjusted Secchi depth m
		Direction	m/sec	Direction	m/sec			
Turbine 33	030904	N	0.30	SW	2-4	3.0	0.5	3.6
Turbine 55	020904	N	0.50	S	4-6	2.5	0.65	3.2
Turbine 58	020904	N	0.50	W	4-6	2.0	0.75	2.6
Turbine 91	040904	N	0.30	S	1-3	8.0	0.25	8.8
Turbine 92	040904	S	0.40	N-NE	5	8.0	0.25	8.8
Turbine 95	030904	N	0.50	SSE	4-6	2.0	0.65	2.5

Appendix 3. Species List

Appendix 3.1. Algae

Complete list of species. Horns Rev 2003-2004								
			2003		2004		Common Names	
Group	***Taxon***	**Author**	**Mar.**	**Sept.**	**Mar.**	**Sept.**	**Danish**	**English**
Red algae								
	Hildenbrandia rubra	(Sommerfelt) Meneghini			x	x	Hav-hildenbrandia	Balanus-Hildenbrandia-mucosa
	Hildenbrandiales indet. 1			x			Rødskorper, kødede	
	Hildenbrandiales indet. 2			x			Rødkødskorp, tyk	
	Corallina officinalis	L.		x			Koralalge	Coral moss
	Coccotylus truncatus	Phallas		x			Kile-rødblad	
	Callithamnion corymbosum	Lyngbye	x	x	x	x	Tæt rødsky	
	Phyllophora pseudoceranoides	(S.G. Gmelin)				x	Fliget rødblad	
Braun algae								
	Pilayella littoralis	Kjellman	x		x	x	Duntang	
	Ectocarpus sp.			x	x	x	vatalge	
	Petalonia fascia	(O.F. Müller)	x	x	x	x	Alm. båndtang	Sea petals
	Petalonia zosterifolia	(Reinke) Kuntze			x		Græsbladet båndtang	
	Ralfsia verrucosa	Areschoug		x			Vortet ralfsiaskorpe	
	Ralfsia sp.		x					
	Desmarestia aculeata	L.		x			Alm. kællingehår	Landlady's wig
Green algae								
	Blidingia minima	Kützing		x			Lille krusrørhinde	
	Ulva (Enteromorpha) intestinalis	L.				x	Tarm-rørhinde	Gut-weed
	Ulva lactuca	L.		x	x	x	Søsalat	Green laver
c	*Ulva (Enteromorpha) linza*	L.				x	Bred rørhinde	
	Ulva (Enteromorpha) sp.		x	x	x	x	Rørhinde	
	Urospora penicilliformis	Areschoug	x				Grøn frynsealge	
	Cladophora sp.			x			Vandhår	Slobán

Appendix 3.2. Fish

Complete list of species. Horns Rev 2003-2004											
				2003			2004		Common Names		
Group	***Taxon***	**Author**	**Mar.**	**Sept.**	**Test**	**Mar.**	**Sept.**	**Test**	**Danish**	**English**	
Actinopterygii											
	Sprattus sprattus	L.					x		Brislinig	European sprat	
	Gadus morhua	L.		x	x		x	x	Alm. Torsk	Atlantic cod	
	Trisopterus luscus	L.		x	x		x	x	Skægtorsk	Bib (Pouting)	
	Merlangius merlangus	L.		x	x				Hvilling	Whiting	
	Pollachius virens	L.		x		x	x		Sej	Pollock (Saithe)	
	Syngnathus typhle	L.					x		Almindelig tangnål	Broad-nosed pipefish	
	Myoxocephalus scorpius	L.		x	x	x	x	x	Alm. Ulk	Shorthorn sculpin	
	Agonus cataphractus	L.	x	x		x	x		Panserulk	Hooknose	
	Taurulus bubaris	Euphrasen				x	x		Langtornet ulk	Longspined bullhead	
	Trachurus trachurus	L.		x					Hestemakrel	Horse mackerel	
	Mullus surmuletus	L.		x					Stribet mulle	Striped red mullet	
	Labrus bergylta	Ascaniu					x		Berggylte	Ballan wrasse	
	Symphodus melops	L.		x					Savgylte	Corkwing wrasse	
	Ctenolabrus rupestris	L.		x	x		x	x	Havkaruds	Goldsinny-wrasse	
	Cyclopteus lumpus	L.				x			Stenbider	Lumpsucker	
	Zoarces viviparus	L.	x	x		x			Ålekvabbe	Viviparous blenny	
	Ammodytes tobianus	L.				x	x	x	Kysttobis	Small sandeel	
	Pholis gunnellus	L.	x	x		x	x		Tangspræl	Rock gunnel	
	Callionymus lyra	L.		x			x		Fløjfisk	Dragonet	
	Pomatoschistus minutus	Pallas		x			x		Sandkutling	Sand goby	
	Pomatoschistus pictus	Malm					x		Spættet kutling	Painted goby	
	Scomber scombrus	L.					x		Alm. Makrel	Atlantic mackerel	

Appendix 3.3. Benthos

Complete List of species. Horns Rev 2003-2004		2003				2004				Common names	
Group *Taxon*	Author	Samples		Transects		Samples		Transects		Danish	English
		Mar.	Sept.	Mar.	Sept.	Mar.	Sept.	Mar.	Sept.		
PORIFERA											
Halichondria panicea	Pallas					x		x		Brødkrummesvamp	Breadcrumb sponge
Porifera indet.							x				
HYDROZOA											
Hydrozoa indet.		x	x	x	x			x	x		
Tubulariidae indet.		x									
Tubularia indivisa		(x)	x	x	x	x	x	x	x	Stor rørpolyp	Oaten pipes hydroid
Thecata indet.		x									
Hydractinia echinata	Fleming						x				
Campanulariidae indet.		x	x			x	x				
Sertuiaria cupressina	(L.)						x			Havcypres	White weed
ANTHOZOA											
Anthozoa indet.		x									
Aicyonium digitatum	L.					x	x	x	x	Dødningehånd	Dead man's fingers
Actiniaria indet.		x	x	x	x	x	x	x	x		
Metridium senile	L.			x	x			x	x	Sønellike	Plumose anemone
NEMERTINI											
Nemertini indet.		x	x	x	x	x	x	x			
NEMATODA											
Nematoda indet.			x			x	x				
POLYCHAETA											
Harmothoe imbricata	(L.)		x			x	x				
Harmothoe impar	(Johnston)	x	x			x	x				
Phyllodocidea indet.		x	x	x	x			x			
Phyllodoce groenlandica	Ørsted	x	x			x	x				
Eulalia viridis	(L.)	x	x			x	x				
Ophiodromus flexuosus	(Deiie Chiaje)						x				
Syiiidae indet.			x			x					
Nereididae indet.			x								
Nereis pelagica	L		x			x	x				
Neanthes virens	(Sars)		x			x					
Poiydora ciiiata	Johnston		x			x	x				
Cirratulidae indet.							x				
Chaetopterus norvegicus	Sars	x									
Capiteiia capitata	(Fabricius)	x	x			x					
Terebeiiidae indet.							x				
Lanice conchilega	(Pallas)			x	x		x	x	x		
Sabellaria sp.							x				
Pomatoceros triqueter	(L.)	x	x	x	x	x	x	x	x	Kalkrørsorm	
PYCNOGONiDAE											
Phoxichilidium femoratum	(Rathke)		x								
CIRRIPEDIA											
Verruca stroemia	O.F. Müller	x	x			x	x			Skæv rur	
Balanus balanus	L.	x	x			x	x	x	x	Stor rur	
Balanus crenatus	Bruguiere	x	x	x	x	x	x	x	x	Køiet rur	
Balanus sp.					x						
DECAPODA											
Caridea indet.			x								
Crangon crangon	(L.)							x		Aim. Hestereje	Brown shrimp
Corystes cassivelaunus	Pennant		x			x				Maskekrabbe	Masked crab
Cancer pagurus	L.	x	x	x	x	x	x	x	x	Taskekrabbe	Edible crab
Carcinus maenas	L.			x	x			x	x	Strandkrabbe	Common shore crab
Liocarcinus depurator	(L.)			x	x		x	x	x	Svømmekrabbe	Harbour crab
Macropodia rostrata	(L.)							x		Stankelbenskrabbe	Long legged spider crab
Pisidia longicornis	(L.)					x				Porcelænskrabbe	Long clawed porcelain crab
Pagurus bernhardus	L.			x	x			x	x	Eremitkrebs	Hermit crab
AMPHiPODA											
Corophium crassicorne	Bruzelius	x	x								
Aoridae indet.		x									
Stenothoe marina	Bate		x								
Jassa marmorata	Holmes	x	x	x	x	x	x	x	x		
Atylus swammerdami	Milne-Edwards		x								
Caprella linearis	L.	x	x	x	x	x	x	x	x		
Hyperia galba	Montagu		x								
CHIRONOMIDAE											
Chironomidae indet.						x					
Telmatogeton japonicus	Tokunaga	x	x	x	x	x	x	x	x		
GASTROPODA											
Gastropoda indet.				x	x						
Rissoidae indet.		x	x			x	x				
Crepiduia fornicata	(L.)	x	x	x	x	x	x	x	x	Tøffeisnegi	Slipper limpet
Poiinices sp.			x								
Buccinum undatum	L.			x				x	x	Alm. Konk	Common whelk
Hinia pygmaea	(Lamarck)						x			Dværgkonk	Netted dog whelk
Nudibranchia indet.		x	x	x	x	x	x	x	x		
Onchidoris muricata	(Møiler)	x	x	x	x	x	x	x		Hvid doride	
Poiycera quadriiineata	(Møiler)					x	x	x	x	Stribet nøgensnegl	
Facelina bostoniensis	(Couthouy)								x		
Aeoiidacea indet.				x							
Aeolidia papillosa	Order: NUDIBRANCHIA					x	x	x	x	Stor trådsnegi	Grey sea slug

Complete List of species. Horns Rev 2003-2004			2003				2004				Common names	
Group	*Taxon*	Author	Samples		Transects		Samples		Transects		Danish	English
			Mar.	Sept.	Mar.	Sept.	Mar.	Sept.	Mar.	Sept.		
BIVALVIA												
	Bivalvia indet.		x									
	Mytiius eduiis	L.	x	x	x	x	x	x	x	x	Biåmusiing	Common mussel
	Modiolarca tumida	(Hanley)						x			Opsvuimet biåmusiing	Marbled creneiia
	Ostrea edulis	L.		x			x		x		Europæisk østers	Native oysters
	Heteranomia squamuia	(L.)	x	x			x	x			Lille sadeimusiing	
	Anguius tenuis	(Da Costa)						x			Aim. taiierkenmusiing	Thin teiiin
	Moerella donacina	(L.)	x	x								
	Moereiia pygmaea	Lovén						x				
	Goodallia triangularis	(Montagu					x					
	Venerupis senegaiensis	(Gmeiin)		x								
	Spisula solida	(L.)							x		Tykskaiiet trugmusiing	Thick trough shell
	Hiatella arctica	(L.)		x			x	x			Huiemusiing	Wrinkled rock borer
	Thracia phaseolina	(Lamarck)	x					x			Papirmusiing	
	Poiypiacophora indet.									x		
BRYOZOA												
	Bryozoa indet.		x	x	x	x		x		x		
	Eiectra piiosa	(L.)	x	x	x	x	x	x				
	Flustra foliacea	(L.)							x		Bredt bladmosdyr	Hornwrack
	Aicyonidium sp.	Lamouroux					x	x	x			
ECHINODERMATA												
	Asterias rubens	L.	x	x	x	x	x	x	x	x	Aim. Søstjerne	Common starfish
	Ophiura albida	Forbes	x					x				
	Strongylocentrotus droebachiensis	(O.F. Müller)	x	x	x	x	x	x			Grønt søpindsvin	Northern sea urchin
	Echinocardium cordatum	(Pennant)			x						Sømus	Sea potato

Appendix 4. Sampling records. Fish species observed.

Lists of sample ID and depths at sample locations are presented in data reports (Leonhard, 2004 and 2005).

Turbine HORN_33			**March 2004**	**September 2004**
Fish species observed	**Common name**	**Scientific name**	**Abundance**	**Abundance**
	Atlantic cod	*Gadus morhua*		R
	Bib (Pouting)	*Trisopterus luscus*		R
	Pollock (Saithe)	*Pollachius virens*	O	O
	Broad-nosed pipefish	*Syngnathus typhle*		O
	Shorthorn sculpin	*Myoxocephalus scorpius*		R
	Hooknose	*Agonus cataphractus*	O	
	Longspined bullhead	*Taurulus bubaris*	O	O
	Ballan wrasse	*Labrus bergylta*		O
	Goldsinny-wrasse	*Ctenolabrus rupestris*		∞
	Rock gunnel	*Pholis gunnellus*	O	O
	Sand goby	*Pomatoschistus minutus*		O
	Painted goby	*Pomatoschistus pictus*		R

Turbine HORN_55			**March 2004**	**September 2004**
Fish species observed	**Common name**	**Scientific name**	**Abundance**	**Abundance**
	Shorthorn sculpin	*Myoxocephalus scorpius*	O	R
	Hooknose	*Agonus cataphractus*	O	
	Goldsinny-wrasse	*Ctenolabrus rupestris*		∞
	Lumpsucker	*Cyclopteus lumpus*	O	
	Viviparous blenny	*Zoarces viviparus*	O	
	Rock gunnel	*Pholis gunnellus*	O	
	Sand goby	*Pomatoschistus minutus*		O
	Painted goby	*Pomatoschistus pictus*		R

Turbine HORN_58			**March 2004**	**September 2004**
Fish species observed	**Common name**	**Scientific name**	**Abundance**	**Abundance**
	European sprat	*Sprattus sprattus*		O
	Atlantic cod	*Gadus morhua*		R
	Bib (Pouting)	*Trisopterus luscus*		O
	Shorthorn sculpin	*Myoxocephalus scorpius*	O	
	Goldsinny-wrasse	*Ctenolabrus rupestris*		R
	Rock gunnel	*Pholis gunnellus*	O	O
	Sand goby	*Pomatoschistus minutus*		O

Turbine HORN_91			**March 2004**	**September 2004**
Fish species observed	**Common name**	**Scientific name**	**Abundance**	**Abundance**
	Goldsinny-wrasse	*Ctenolabrus rupestris*		∞
	Small sandeel	*Ammodytes tobianus*		O
	Rock gunnel	*Pholis gunnellus*	O	R
	Dragonet	*Callionymus lyra*		R
	Sand goby	*Pomatoschistus minutus*		∞

Turbine HORN_92			**March 2004**	**September 2004**
Fish species observed	**Common name**	**Scientific name**	**Abundance**	**Abundance**
	Atlantic cod	*Gadus morhua*		O
	Hooknose	*Agonus cataphractus*	O	
	Goldsinny-wrasse	*Ctenolabrus rupestris*		∞
	Small sandeel	*Ammodytes tobianus*		O
	Rock gunnel	*Pholis gunnellus*	O	R
	Dragonet	*Callionymus lyra*		R
	Sand goby	*Pomatoschistus minutus*		O

Turbine HORN_95			**March 2004**	**September 2004**
Fish species observed	**Common name**	**Scientific name**	**Abundance**	**Abundance**
	Bib (Pouting)	*Trisopterus luscus*		R
	Shorthorn sculpin	*Myoxocephalus scorpius*	O	
	Hooknose	*Agonus cataphractus*	O	O
	Longspined bullhead	*Taurulus bubaris*		O
	Goldsinny-wrasse	*Ctenolabrus rupestris*		∞
	Rock gunnel	*Pholis gunnellus*	O	R
	Dragonet	*Callionymus lyra*		R
	Sand goby	*Pomatoschistus minutus*		R

Appendix 5. Transect description

Appendix 5.1. Transect description. Scour protection

Mean Relative coverage Scour protection Distance from tower		2004						
		Distance interval						
		0 - 2 m	2 - 4 m	4 - 6 m	6 - 8 m	8 - 10 m	10 - 12 m	12 - 14 m
Red Algae	Callithamnion corymbosum	.08	.13	.13	.13	.08	.08	.
	Hildenbrandia rubra	.08	.08	.04	.	.	.	.
Brown Algae	Ectocarpus sp.	.	.04	.	.	.	.	.04
	Pilayella littoralis	.	.04	.	.	.	.	.04
Green Algae	Enteromorpha sp.	3.38	7.98	10.63	10.15	7.50	3.86	4.52
	Ulva lactuca	.	.	.04	.00	.	.	.
Benthos	Actiniaria indet.	9.33	12.85	11.90	13.85	15.38	9.04	6.09
	Aeolidia pappilosa	.	.	.	.	.	.00	.
	Alcyonidium sp.	.73	.13	.08	.08	.04	.08	.
	Alcyonium digitatum	.21	.29	.33	.81	1.29	.17	.00
	Asterias rubens	7.77	8.29	6.17	8.29	7.25	6.21	6.98
	Balanus crenatus	.56	.	.	.00	.	.	.00
	Bryozoa indet.	.73	1.25	2.29	1.21	.69	.08	.13
	Buccinum undatum	.	.	.	.	.00	.00	.00
	Buccinum undatum (æg)	.	.	.	.	.	.	.00
	Cancer pagurus	.04	.08	.00	.04	.00	.00	.05
	Caprella linearis	.65	1.21	.65	.17	.69	.08	.
	Carcinus maenas	.	.	.	.	.	.00	.04
	Coryphella lineata	.00	.00	.00	.	.00	.	.
	Crangon crangon	.	.	.	.	.00	.	.
	Crepidula fornicata	.08	.04	.00	.08	.04	.00	.04
	Flustra foliacea	.	.	.	.	.00	.	.
	Halichondria panicea	.	.00	.04	.	.00	.	.
	Hydrozoa indet.	16.50	10.33	8.29	8.81	9.33	11.69	11.61
	Jassa marmorata	42.40	48.04	49.08	51.13	46.04	23.08	10.63
	Lanice conchilega	.	.	.	.	.	.17	1.52
	Liocarcinus depurator	.	.	.	.	.	.00	.00
	Macropodia rostrata	.	.	.00	.	.00	.	.00
	Metridium senile	3.36	1.31	1.75	2.40	3.36	2.02	1.89
	Mytilus edulis	.17	.04	.04	.00	.	.00	.00
	Nudibranchia indet. (æg).	.	.	.	.	.	.00	.
	Onchidoris muricata	.00	.00	.00	.00	.	.00	.
	Pagurus bernhardus	.	.	.	.	.	.00	.09
	Phyllodocidae indet.	.	.	.	.	.00	.00	.04
	Phyllodocidae indet. (æg)	.	.	.04	.04	.04	.04	.04
	Polycera quadrilineata	.	.00	.00	.00	.00	.00	.04
	Polyplacophora indet.	.00	.	.	.	.	.	.
	Pomatoceros triqueter	1.75	.67	.67	.63	.58	.98	.39
	Spisula solida	.	.	.	.	.	.04	.04
	Tubularia indivisa	2.42	1.42	1.50	.85	.77	.65	.00

Mean Relative coverage / Scour protection / Distance from tower		2004													
		Spring							Autumn						
		Distance interval							Distance interval						
		0 - 2 m	2 - 4 m	4 - 6 m	6 - 8 m	8 - 10 m	10 - 12 m	12 - 14 m	0 - 2 m	2 - 4 m	4 - 6 m	6 - 8 m	8 - 10 m	10 - 12 m	12 - 14 m
Red Algae	Callithamnion corymbosum	.08	.17	.17	.17	.08	.08	.	.08	.08	.08	.08	.08	.08	.
	Hildenbrandia rubra	.17	.17	.08	.	.	.	.	.	.	.	.	.	.	.
Brown Algae	Ectocarpus sp.	.	.08	.	.	.	.	.	.	.	.	.	.	.	.09
	Pilayella littorails	.	.08	.	.	.	.	.08	.	.	.	.	.	.	.00
Green Algae	Enteromorpha sp.	.17	.08	.08	.17	.17	.	.	6.58	15.88	21.17	20.13	14.83	7.71	9.45
	Ulva lactuca	.	.	.	.00	.	.	.	.	.	.08	.	.	.	.
Benthos	Actiniaria indet.	8.29	11.33	10.38	9.25	11.25	6.84	2.67	10.38	14.38	13.42	18.46	19.50	11.25	9.82
	Aeolidia pappilosa	.	.	.	.	.	.00	.	.	.	.	.	.	.	.
	Aicyonidium sp.	1.46	.25	.17	.17	.08	.17	.	.	.	.	.	.	.	.
	Aicyonium digitatum	.09	.25	.33	.33	.25	.17	.00	.33	.33	.33	1.29	2.33	.17	.
	Asterias rubens	8.29	9.33	6.13	9.33	7.25	6.21	8.29	7.25	7.25	6.21	7.25	7.25	6.21	5.55
	Balanus crenatus	.00	.	.	.00	.	.	.00	1.13	.	.	.	.	.	.
	Bryozoa indet.	.	.	.	.	.	.	.	1.46	2.50	4.58	2.42	1.38	.17	.27
	Buccinum undatum	.	.	.	.	.00	.00	.00	.	.	.	.	.	.00	.
	Buccinum undatum (æg)	.	.	.	.	.	.	.00	.	.	.	.	.	.	.
	Cancer pagurus	.00	.00	.00	.00	.00	.00	.00	.08	.17	.00	.09	.00	.00	.09
	Caprella linearis	.	.	.	.08	.08	.	.	1.29	2.42	1.29	.25	1.29	.17	.
	Carcinus maenas	.	.	.	.	.	.00	.00	.	.	.	.	.	.	.09
	Coryphella lineata	.	.	.	.	.	.	.	.00	.00	.00	.	.00	.	.
	Crangon crangon	.	.	.	.	.00	.	.	.	.	.	.	.	.	.
	Crepidula fornicata	.09	.08	.	.08	.08	.00	.	.08	.00	.00	.08	.	.	.09
	Flustra foliacea	.	.	.	.	.00	.	.	.	.	.	.	.	.	.
	Halichondria panicea	.	.00	.08	.	.00	.	.	.	.	.	.	.	.	.
	Hydrozoa indet.	13.50	12.46	10.38	13.50	12.46	15.08	7.96	19.50	8.21	6.21	4.13	6.21	8.29	15.59
	Jassa marmorata	26.46	33.58	35.67	41.83	35.75	10.58	2.42	58.33	62.50	62.50	60.42	56.33	35.58	19.59
	Lanice conchilega	.	.	.	.	.	.08	.25	.	.	.	.	.	.25	2.91
	Liocarcinus depurator	.	.	.	.	.	.00	.00	.	.	.	.	.	.	.00
	Macropodia rostrata	.	.	.00	.	.00	.	.00	.	.	.	.	.	.	.
	Metridium senile	2.83	1.88	1.88	1.88	1.71	1.29	1.21	3.88	.75	1.63	2.92	5.00	2.75	2.64
	Mytiius edulis	.34	.08	.08	.00	.	.00	.00	.00	.	.	.	.	.	.
	Nudibranchia indet. (æg).	.	.	.	.	.	.00	.	.	.	.	.	.	.	.
	Onchidoris muricata	.00	.00	.00	.00	.	.00	.	.	.	.	.	.	.	.
	Pagurus bernhardus	.	.	.	.	.	.00	.00	.	.	.	.	.	.00	.18
	Phyllodocidae indet.	.	.	.	.	.00	.00	.08	.	.	.	.	.	.	.
	Phyiiodocidae indet. (æg)	.	.	.08	.08	.08	.08	.08	.	.	.	.	.	.	.
	Polycera quadrilineata	.	.00	.00	.	.	.00	.	.	.00	.00	.00	.00	.00	.09
	Polypiacophora indet.	.	.	.	.	.	.	.	.00	.	.	.	.	.	.
	Pomatoceros triqueter	2.92	.84	.84	.75	.67	.50	.42	.58	.50	.50	.50	.50	1.46	.36
	Spisula solida	.	.	.	.	.	.08	.08	.	.	.	.	.	.	.
	Tubularia indivisa	.	.00	.17	.08	.	.	.	4.83	2.83	2.83	1.63	1.54	1.29	.00

Appendix 5.2. Transect description. Mono-piles

Mean Relative coverage Turbine tower Depth		2004 Depth interval 0 - 2 m	2004 Depth interval 2 - 4 m	2004 Depth interval 4 - 6 m	2004 Depth interval 6 - 8 m	2004 Depth interval 8 - 10 m
Red Algae	Hildenbrandia rubra	.25	.	.	.	.
Brown Algae	Ectocarpus sp.	1.46	.	.	.	.
	Petalonia fascia	2.63	.04	.00	.	.
	Petalonia zosterifolia	.17	.	.	.	.
	Pilayella littoralis	.	.	.04	.	.
Green Algae	Enteromorpha sp.	8.69	1.85	2.25	.07	.
	Ulva lactuca	.13	2.86	.77	.	.
Benthos	Actiniaria indet.	.13	.94	3.36	2.60	4.00
	Aeolidia pappilosa	.	.00	.00	.	.00
	Alcyonidium sp.	.	.08	.04	.07	.38
	Alcyonium digitatum	.	.	.	.00	.
	Asterias rubens	.29	1.27	1.00	2.67	2.56
	Balanus balanus	6.00	.25	.04	.	.
	Bryozoa indet.	4.50	14.75	11.19	6.17	5.31
	Buccinum undatum	.	.	.	.00	.
	Cancer pagurus	.00	.00	.00	.00	.00
	Caprella linearis	3.67	13.38	10.17	10.03	7.50
	Carcinus maenas	.	.	.00	.00	.
	Coryphella lineata	.08	.21	.17	.07	.00
	Crepidula fornicata	.17	.29	3.10	3.80	6.88
	Hydrozoa indet.	1.06	8.13	11.38	15.03	12.06
	Jassa marmorata	35.75	55.29	55.21	50.83	64.06
	Metridium senile	.25	1.19	1.75	1.77	1.00
	Mytilus edulis	17.00	6.38	.00	.13	.
	Nemertini Indet.	.04	.	.	.	.
	Nudibranchia indet.	.	.00	.	.	.
	Onchidoris muricata	.	.00	.04	.00	.
	Ostrea edulis	.	.	.00	.07	.13
	Polycera quadrilineata	.08	.85	.25	.20	.13
	Pomatoceros triqueter	.	.08	.25	.33	.50
	Telmatogeton japonicus	.83	.	.04	.	.
	Tubularia indivisa	5.50	5.58	5.19	6.23	8.44

Mean Relative coverage Turbine tower Depth		2004									
		Spring					Autumn				
		Depth interval					Depth interval				
		0 - 2 m	2 - 4 m	4 - 6 m	6 - 8 m	8 - 10 m	0 - 2 m	2 - 4 m	4 - 6 m	6 - 8 m	8 - 10 m
Red Algae	Hildenbrandia rubra	.	.	.	.	.	.50	.	.	.	.
Brown Algae	Ectocarpus sp.	2.92	.	.	.	.	.	.	.	.	.
	Petalonia fascia	3.00	.	.	.	.	2.25	.08	.00	.	.
	Petalonia zosterifolia	.33	.	.	.	.	.	.	.	.	.
	Pilayella littoralis	.	.	.08	.	.	.	.	.	.	.
Green Algae	Enteromorpha sp.	2.92	.00	.00	.	.	14.46	3.71	4.50	.14	.
	Ulva lactuca	.08	1.13	.08	.	.	.17	4.58	1.46	.	.
Benthos	Actiniaria indet.	.00	1.38	3.71	2.44	3.88	.25	.50	3.00	2.79	4.13
	Aeolidia pappilosa	.	.00	.00	.	.00	.	.	.	.	.
	Alcyonidium sp.	.	.17	.08	.13	.75	.	.	.	.	.
	Alcyonium digitatum	.	.	.	.	.	.	.	.	.00	.
	Asterias rubens	.25	1.79	1.00	2.56	3.88	.33	.75	1.00	2.79	1.25
	Balanus balanus	7.17	.50	.	.	.	4.83	.	.08	.	.
	Bryozoa indet.	.	.	.	.	.	9.00	29.50	22.38	13.21	10.63
	Buccinum undatum	.	.	.	.00	.	.	.	.	.	.
	Cancer pagurus	.	.	.	.	.00	.00	.00	.00	.00	.00
	Caprella linearis	1.29	6.21	3.88	7.00	1.25	6.04	20.54	16.46	13.50	13.75
	Carcinus maenas	.	.	.	.	.	.	.	.00	.00	.
	Coryphella lineata	.	.	.	.	.	.17	.42	.33	.14	.01
	Crepidula fornicata	.08	.00	1.29	.13	.26	.25	.58	4.92	8.00	13.50
	Hydrozoa indet.	.58	11.25	13.42	13.50	13.50	1.54	5.00	9.33	16.79	10.63
	Jassa marmorata	29.58	58.33	50.00	46.88	56.25	41.92	52.25	60.42	55.36	71.88
	Metridium senile	.25	1.79	1.79	.88	.75	.25	.58	1.71	2.79	1.25
	Mytilus edulis	21.33	6.42	.00	.25	.	12.67	6.33	.	.	.
	Nemertini Indet.	.08	.	.	.	.	.	.	.	.	.
	Nudibranchia indet.	.	.00	.	.	.	.	.00	.	.	.
	Onchidoris muricata	.	.00	.08	.00	.	.	.	.	.	.
	Ostrea edulis	.	.	.00	.13	.26	.	.	.	.	.
	Polycera quadrilineata	.	.	.	.	.	.17	1.71	.50	.43	.25
	Pomatoceros triqueter	.	.17	.34	.50	.50	.	.	.17	.14	.50
	Telmatogeton japonicus	.92	.	.	.	.	.75	.	.08	.	.
	Tubularia indivisa	.	.00	.08	.13	.	11.00	11.17	10.29	13.21	16.88

Appendix 6. Benthic Fauna abundance

Appendix 6.1. Total abundance.

March 2004

Abundans, number/m²		20040324 Total no./m²	Kol Sum %	N
PORIFERA	Halichondria panicea	.4	.0%	132
HYDROZOA	Tubularia indivisa	2.3	.0%	132
	Campanulariidae indet,	2.8	.0%	132
ANTHOZOA	Alcyonium digitatum	.8	.0%	132
	Actiniaria indet,	39.6	.0%	132
NEMERTINI	Nemertini indet,	17.8	.0%	132
NEMATODA	Nematoda indet,	.2	.0%	132
POLYCHAETA	Harmothoe imbricata	.2	.0%	132
	Harmothoe impar	8.9	.0%	132
	Phyllodoce groenlandica	4.7	.0%	132
	Eulalia viridis	2.1	.0%	132
	Syllidae indet,	.8	.0%	132
	Nereis pelagica	.8	.0%	132
	Neanthes virens	.2	.0%	132
	Polydora ciliata	.2	.0%	132
	Capitella capitata	.6	.0%	132
	Pomatoceros triqueter	34.3	.0%	132
CRUSTACEA	Verruca stroemia	.9	.0%	132
	Balanus balanus	14.4	.0%	132
	Balanus crenatus	73.9	.1%	132
	Corystes cassivelaunus	.4	.0%	132
	Cancer pagurus	6.6	.0%	132
	Pisidia longicornis	.6	.0%	132
	Jassa marmorata	95562.7	94.0%	132
	Caprella linearis	4742.6	4.7%	132
CHIRONOMIDAE	Chironomidae indet,	.4	.0%	132
	Telmatogeton japonicus	121.4	.1%	132
GASTROPODA	Rissoidae indet,	33.0	.0%	132
	Crepidula fornicata	8.7	.0%	132
	Nudibranchia indet,	8.7	.0%	132
	Onchidoris muricata	4.9	.0%	132
	Polycera quadrilineata	27.8	.0%	132
	Aeolidia papillosa	41.7	.0%	132
BIVALVIA	Mytilus edulis	864.6	.9%	132
	Ostrea edulis	.2	.0%	132
	Heteranomia squamula	1.5	.0%	132
	Goodallia triangularis	.2	.0%	132
	Hiatella arctica	2.8	.0%	132
BRYOZOA	Electra pilosa	20.1	.0%	132
	Alcyonidium sp,	4.2	.0%	132
ECHINODERMATA	Asterias rubens	41.5	.0%	132
	Strongylocentrotus droebachiensis	.6	.0%	132
Total		101700.8	100.0%	5544

September 2004

Abundans, number/m²		20040901 Total no./m²	Kol Sum %	N
PORIFERA	Porifera indet.	.2	.0%	136
HYDROZOA	Tubularia indivisa	10.1	.0%	136
	Hydractinia echinata	.9	.0%	136
	Campanulariidae indet.	4.6	.0%	136
	Sertularia cupressina	.7	.0%	136
ANTHOZOA	Alcyonium digitatum	2.2	.0%	136
	Actiniaria indet.	50.6	.0%	136
NEMERTINI	Nemertini indet.	3.9	.0%	136
NEMATODA	Nematoda indet.	17.3	.0%	136
POLYCHAETA	Harmothoe imbricata	1.5	.0%	136
	Harmothoe impar	2.4	.0%	136
	Phyllodoce groenlandica	5.7	.0%	136
	Eulalia viridis	57.4	.0%	136
	Ophiodromus flexuosus	.2	.0%	136
	Nereis pelagica	2.2	.0%	136
	Polydora ciliata	.2	.0%	136
	Cirratulidae indet.	1.1	.0%	136
	Terebellidae indet.	.6	.0%	136
	Lanice conchilega	.2	.0%	136
	Sabellaria sp.	.2	.0%	136
	Pomatoceros triqueter	23.2	.0%	136
CRUSTACEA	Verruca stroemia	8.8	.0%	136
	Balanus balanus	45.8	.0%	136
	Balanus crenatus	23.2	.0%	136
	Cancer pagurus	350.0	.1%	136
	Liocarcinus depurator	.2	.0%	136
	Jassa marmorata	228080.7	91.0%	136
	Caprella linearis	19118.9	7.6%	136
CHIRONOMIDAE	Telmatogeton japonicus	145.4	.1%	136
GASTROPODA	Rissoidae indet.	159.9	.1%	136
	Crepidula fornicata	22.8	.0%	136
	Hinia pygmaea	5.9	.0%	136
	Nudibranchia indet.	4.4	.0%	136
	Onchidoris muricata	3.7	.0%	136
	Polycera quadrilineata	26.5	.0%	136
	Aeolidia papillosa	21.3	.0%	136
BIVALVIA	Mytilus edulis	2205.7	.9%	136
	Modiolarca tumida	.6	.0%	136
	Heteranomia squamula	.2	.0%	136
	Angulus tenuis	1.5	.0%	136
	Moerella pygmaea	.6	.0%	136
	Hiatella arctica	.2	.0%	136
	Thracia phaseolina	.2	.0%	136
BRYOZOA	Bryozoa indet.	.4	.0%	136
	Electra pilosa	19.7	.0%	136
	Alcyonidium sp.	4.4	.0%	136
ECHINODERMATA	Asterias rubens	121.9	.0%	136
	Ophiura albida	14.2	.0%	136
	Strongylocentrotus droebachiensis	2.2	.0%	136
Total		250574.1	100.0%	6664

Appendix 6.2. Mean abundance mono-piles

March 2004

		Transect																			
		Turbine tower, vertical																			
		NNE 02		NNE 04		NNE 06		NNE 08		NNE Bottom		SSW 02		SSW 04		SSW 06		SSW 08		SSW Bottom	
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 %	no./m²	Kol Sum %	no./m²	Kol Sum %	no./m²	Kol Sum %	no./m²	Kol Sum %
HYDROZOA	Tubularia indivisa													4.2	0%					8.3	0%
	Campanulariidae indet,			4.2	0%					4.2	0%			4.2	0%						
ANTHOZOA	Actiniaria indet,	8.3	0%	8.3	0%	29.2	0%			8.3	0%	12.5	0%	20.8	0%	29.2	0%			4.2	0%
NEMERTINI	Nemertini indet,	12.5	0%	25.0	0%	112.5	0%	25.0	0%	12.5	0%	29.2	0%	8.3	0%	41.7	0%	20.8	0%	12.5	0%
NEMATODA	Nematoda indet,											4.2	0%								
POLYCHAETA	Harmothoe imbricata															4.2	0%				
	Harmothoe impar	8.3	0%	12.5	0%	58.3	0%	29.2	1%	8.3	0%	25.0	0%	8.3	0%	25.0	0%	20.8	0%		
	Phyllodoce groenlandica			8.3	0%	4.2	0%	12.5	0%			4.2	0%	4.2	0%			4.2	0%		
	Eulalia viridis	4.2	0%			8.3	0%	4.2	0%			4.2	0%	4.2	0%			4.2	0%	8.3	0%
	Syllidae indet,											4.2	0%							4.2	0%
	Nereis pelagica					16.7	0%														
	Neanthes virens							4.2	0%												
	Pomatoceros triqueter	58.3	0%	58.3	0%	4.2	0%			112.5	1%	175.0	1%	125.0	0%	12.5	0%			45.8	0%
CRUSTACEA	Verruca stroemia					4.2	0%							4.2	0%						
	Balanus balanus							250.0	4%							4.2	0%	62.5	1%		
	Balanus crenatus	37.5	0%	416.7	2%	112.5	0%			20.8	0%	166.7	1%	716.7	3%	70.8	0%			12.5	0%
	Cancer pagurus	4.2	0%	8.3	0%	45.8	0%							4.2	0%	58.3	0%	20.8	0%		
	Pisidia iongicornis					12.5	0%														
	Jassa marmorata	191441.7	93.6%	215075.0	97.7%	221529.2	86.6%	50375.0	87.3%	98529.2	94.9%	204037.5	89.5%	260800.0	98.1%	253762.5	98.3%	69912.5	93.4%	118666.7	87.6%
	Caprella linearis	12579.2	6.1%	3550.0	1.6%	30600.0	12.0%	320.8	6%	4829.2	4.7%	22775.0	10.0%	2766.7	1.0%	1687.5	7%	83.3	1%	16533.3	12.2%
CHIRONOMIDAE	Chironomidae indet,							4.2	0%									4.2	0%		
	Telmatogeton japonicus							1154.2	2.0%									1516.7	2.0%		
GASTROPODA	Rissoidae indet,							4.2	0%	4.2	0%	8.3	0%					4.2	0%		
	Crepiduia fornicata	33.3	0%	16.7	0%					4.2	0%	25.0	0%	62.5	0%	12.5	0%			4.2	0%
	Nudibranchia indet,	29.2	0%	45.8	0%	4.2	0%							4.2	0%	8.3	0%			4.2	0%
	Onchidoris muricata	33.3	0%	29.2	0%	4.2	0%			4.2	0%	12.5	0%	4.2	0%						
	Polycera quadrilineata	45.8	0%	37.5	0%	29.2	0%			12.5	0%	95.8	0%	41.7	0%	4.2	0%			8.3	0%
	Aeolidia papillosa	75.0	0%	104.2	0%	37.5	0%			20.8	0%	116.7	1%	258.3	1%	141.7	1%				
BIVALVIA	Mytilus edulis	183.3	1%	729.2	3%	3058.3	1.2%	5537.5	9.6%	145.8	1%	525.0	2%	887.5	3%	2270.8	9%	3208.3	4.3%	91.7	1%
	Ostrea edulis					4.2	0%														
	Heteranomia squamula	4.2	0%	16.7	0%									12.5	0%						
	Hiatella arctica	8.3	0%			12.5	0%	4.2	0%			8.3	0%	4.2	0%	8.3	0%	4.2	0%		
BRYOZOA	Eiectra pilosa	25.0	0%	25.0	0%	20.8	0%	4.2	0%	25.0	0%	25.0	0%	25.0	0%	16.7	0%	8.3	0%	20.8	0%
	Alcyonidium sp,	12.5	0%	12.5	0%	8.3	0%			16.7	0%	16.7	0%							12.5	0%
ECHINODERMATA	Asterias rubens	25.0	0%	20.8	0%					29.2	0%	8.3	0%	4.2	0%					41.7	0%
	Strongylocentrotus droebachiensis					4.2	0%									8.3	0%				
Total		204629.2	100.0%	220204.2	100.0%	255720.8	100.0%	57729.2	100.0%	103787.5	100.0%	228079.2	100.0%	265775.0	100.0%	258166.7	100.0%	74875.0	100.0%	135479.2	100.0%

September 2004

		Transect											
		Turbine tower, vertical											
		NNE 02		NNE 04		NNE 06		NNE 08		NNE 10		NNE Bottom	
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	Tubularia indivisa	4.2	.0%	12.5	.0%	20.8	.0%	.	.	.	.	12.5	.0%
	Hydractinia echinata	.	.	4.2	.0%	8.3	.0%	.	.	.	.	8.3	.0%
	Campanulariidae indet.	8.3	.0%	12.5	.0%	4.2	.0%	.	.	.	.	8.3	.0%
ANTHOZOA	Actiniaria indet.	25.0	.0%	20.8	.0%	16.7	.0%	8.3	.0%	.	.	29.2	.0%
NEMERTINI	Nemertini indet.	.	.	.	.	.	.	12.5	.0%	.	.	.	.
NEMATODA	Nematoda indet.	45.8	.0%	45.8	.0%	8.3	.0%	.	.	.	.	16.7	.0%
POLYCHAETA	Harmothoe impar	4.2	.0%	8.3	.0%	4.2	.0%	.	.	.	.	4.2	.0%
	Phyllodoce groenlandica	.	.	.	.	4.2	.0%	.	.	.	.	.	.
	Eulalia viridis	150.0	.0%	108.3	.0%	91.7	.0%	54.2	.0%	.	.	141.7	.0%
	Nereis pelagica	.	.	.	.	.	.	33.3	.0%	.	.	.	.
	Cirratulidae indet.	4.2	.0%	.	.	.	.	4.2	.0%	.	.	.	.
	Terebellidae indet.	.	.	.	.	.	.	.	.	.	.	4.2	.0%
	Pomatoceros triqueter	33.3	.0%	54.2	.0%	12.5	.0%	.	.	.	.	62.5	.0%
CRUSTACEA	Verruca stroemia	4.2	.0%	.	.	.	.	.	.	.	.	.	.
	Baianus baianus	.	.	.	.	20.8	.0%	266.7	.1%	450.0	5.3%	.	.
	Balanus crenatus	50.0	.0%	20.8	.0%	33.3	.0%	.	.	.	.	12.5	.0%
	Cancer pagurus	337.5	.0%	520.8	.1%	950.0	.2%	750.0	.2%	.	.	520.8	.1%
	Jassa marmorata	664066.7	87.5%	320720.8	89.5%	566629.2	90.4%	273937.5	84.2%	6837.5	80.3%	409666.7	90.6%
	Capreiia linearis	93420.8	12.3%	36454.2	10.2%	57383.3	9.2%	18345.8	5.6%	25.0	.3%	40937.5	9.1%
CHIRONOMIDAE	Teimatogeton japonicus	112.5	.0%	45.8	.0%	4.2	.0%	462.5	.1%	1187.5	14.0%	179.2	.0%
GASTROPODA	Rissoidae indet.	20.8	.0%	45.8	.0%	233.3	.0%	416.7	.1%	.	.	95.8	.0%
	Crepiduia fornicata	16.7	.0%	20.8	.0%	4.2	.0%	16.7	.0%	.	.	25.0	.0%
	Hinia pygmaea	.	.	.	.	.	.	4.2	.0%	.	.	.	.
	Onchidoris muricata	8.3	.0%	4.2	.0%	16.7	.0%	.	.	.	.	4.2	.0%
	Poiycera quadriiineata	83.3	.0%	75.0	.0%	104.2	.0%	8.3	.0%	.	.	29.2	.0%
	Aeolidia papillosa	33.3	.0%	45.8	.0%	25.0	.0%	66.7	.0%	.	.	41.7	.0%
BIVALVIA	Mytiius eduiis	391.7	.1%	112.5	.0%	1154.2	.2%	30829.2	9.5%	12.5	.1%	120.8	.0%
	Modiolarca tumida	.	.	.	.	.	.	4.2	.0%	.	.	4.2	.0%
	Heteranomia squamula	.	.	.	.	4.2	.0%	.	.	.	.	.	.
	Thracia phaseoiina	.	.	.	.	.	.	4.2	.0%	.	.	.	.
BRYOZOA	Bryozoa indet.	.	.	.	.	.	.	4.2	.0%	.	.	.	.
	Eiectra piiosa	20.8	.0%	20.8	.0%	25.0	.0%	8.3	.0%	.	.	20.8	.0%
	Aicyonidium sp.	4.2	.0%	16.7	.0%	4.2	.0%	.	.	.	.	8.3	.0%
ECHINODERMATA	Asterias rubens	175.0	.0%	50.0	.0%	45.8	.0%	16.7	.0%	.	.	133.3	.0%
	Ophiura aibida	.	.	12.5	.0%	.	.	.	.	.	.	4.2	.0%
	Strongyiocentrotus droebachiensis	.	.	.	.	8.3	.0%	.	.	.	.	.	.
Total		759020.8	100.0%	358433.3	100.0%	626816.7	100.0%	325254.2	100.0%	8512.5	100.0%	452091.7	100.0%

		Transect											
		Turbine tower, vertical											
		SSW 02		SSW 04		SSW 06		SSW 08		SSW 10		SSW Bottom	
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	Tubuiaria indivisa	20.8	.0%	8.3	.0%	4.2	.0%	4.2	.0%	.	.	12.5	.0%
	Campanulariidae indet.	4.2	.0%	.	.	8.3	.0%	.	.	.	.	8.3	.0%
ANTHOZOA	Actiniaria indet.	29.2	.0%	8.3	.0%	25.0	.0%	.	.	.	.	50.0	.0%
NEMERTINI	Nemertini indet.	.	.	.	.	33.3	.0%	33.3	.0%	.	.	.	.
NEMATODA	Nematoda indet.	4.2	.0%	12.5	.0%	29.2	.0%	.	.	.	.	12.5	.0%
POLYCHAETA	Harmothoe imbricata	.	.	.	.	33.3	.0%	.	.	.	.	.	.
	Harmothoe impar	4.2	.0%	.	.	29.2	.0%	.	.	.	.	.	.
	Phyllodoce groenlandica	4.2	.0%	.	.	8.3	.0%	.	.	.	.	.	.
	Eulalia viridis	70.8	.0%	108.3	.0%	120.8	.0%	20.8	.0%	.	.	112.5	.1%
	Ophiodromus flexuosus	.	.	.	.	4.2	.0%	.	.	.	.	.	.
	Nereis pelagica	.	.	.	.	.	.	12.5	.0%	.	.	.	.
	Cirratulidae indet.	.	.	4.2	.0%	.	.	4.2	.0%	.	.	4.2	.0%
	Pomatoceros triqueter	37.5	.0%	33.3	.0%	12.5	.0%	.	.	.	.	41.7	.0%
CRUSTACEA	Verruca stroemia	.	.	.	.	.	.	.	.	.	.	4.2	.0%
	Baianus baianus	233.3	.1%	.	.	4.2	.0%	62.5	.0%	750.0	.2%	50.0	.0%
	Balanus crenatus	83.3	.0%	112.5	.0%	41.7	.0%	.	.	.	.	8.3	.0%
	Cancer pagurus	450.0	.1%	479.2	.1%	600.0	.1%	308.3	.1%	.	.	558.3	.3%
	Jassa marmorata	300904.2	89.4%	336850.0	88.5%	450304.2	87.0%	360658.3	92.5%	301350.0	98.5%	208425.0	93.6%
	Capreiia linearis	33970.8	10.1%	42170.8	11.1%	62687.5	12.1%	16070.8	4.1%	25.0	.0%	12829.2	5.8%
CHIRONOMIDAE	Teimatogeton japonicus	.	.	.	.	4.2	.0%	816.7	.2%	3812.5	1.2%	4.2	.0%
GASTROPODA	Rissoidae indet.	104.2	.0%	120.8	.0%	229.2	.0%	345.8	.1%	.	.	191.7	.1%
	Crepiduia fornicata	37.5	.0%	41.7	.0%	20.8	.0%	8.3	.0%	.	.	16.7	.0%
	Nudibranchia indet.	.	.	41.7	.0%	.	.	.	.	.	.	.	.
	Onchidoris muricata	12.5	.0%	8.3	.0%	.	.	.	.	.	.	8.3	.0%
	Poiycera quadriiineata	45.8	.0%	50.0	.0%	50.0	.0%	8.3	.0%	.	.	37.5	.0%
	Aeolidia papillosa	29.2	.0%	66.7	.0%	120.8	.0%	4.2	.0%	.	.	.	.
BIVALVIA	Mytiius eduiis	300.0	.1%	350.0	.1%	3233.3	.6%	11570.8	3.0%	.	.	129.2	.1%
	Modiolarca tumida	.	.	.	.	.	.	4.2	.0%	.	.	.	.
BRYOZOA	Eiectra piiosa	25.0	.0%	20.8	.0%	25.0	.0%	12.5	.0%	.	.	25.0	.0%
	Aicyonidium sp.	25.0	.0%	8.3	.0%	4.2	.0%	4.2	.0%	.	.	8.3	.0%
ECHINODERMATA	Asterias rubens	70.8	.0%	91.7	.0%	120.8	.0%	12.5	.0%	.	.	133.3	.1%
	Ophiura aibida	.	.	.	.	.	.	.	.	.	.	4.2	.0%
	Strongyiocentrotus droebachiensis	.	.	8.3	.0%	.	.	.	.	.	.	.	.
Total		336466.7	100.0%	380595.8	100.0%	517754.2	100.0%	389962.5	100.0%	305937.5	100.0%	222675.0	100.0%

Appendix 6.3. Mean abundance scour protection

March 2004

Abundance, number/m²		Transect							
		Foundations, horizontal							
		A 0.5 NNE		B 02 NNE		C 05 NNE		D 05 SSW	
		no./m²	Kol Sum %	no./m²	Kol Sum %	no./m²	Kol Sum %	no./m²	Kol Sum %
PORIFERA	Halichondria panicea	.	.	1.4	.0%	1.4	.0%	.	.
HYDROZOA	Tubularia indivisa	6.9	.0%	1.4	.0%	.	.	4.2	.0%
	Campanulariidae indet,	4.2	.0%	2.8	.0%	4.2	.0%	5.6	.0%
ANTHOZOA	Alcyonium digitatum	.	.	1.4	.0%	4.2	.0%	.	.
	Actiniaria indet,	25.0	.1%	59.7	.2%	108.3	.3%	56.9	.2%
NEMERTINI	Nemertini indet,	11.1	.0%	6.9	.0%	6.9	.0%	5.6	.0%
POLYCHAETA	Phyllodoce groenlandica	1.4	.0%	6.9	.0%	8.3	.0%	5.6	.0%
	Eulalia viridis	1.4	.0%	.	.	1.4	.0%	.	.
	Syllidae indet,	.	.	1.4	.0%	1.4	.0%	.	.
	Polydora ciliata	.	.	1.4	.0%	.	.	.	.
	Capitella capitata	1.4	.0%	2.8	.0%	.	.	.	.
	Pomatoceros triqueter	15.3	.0%	16.7	.0%	11.1	.0%	11.1	.0%
CRUSTACEA	Verruca stroemia	.	.	.	.	2.8	.0%	1.4	.0%
	Balanus crenatus	2.8	.0%	5.6	.0%	8.3	.0%	6.9	.0%
	Corystes cassivelaunus	.	.	1.4	.0%	1.4	.0%	.	.
	Cancer pagurus	.	.	.	.	.	.	1.4	.0%
	Jassa marmorata	41859.7	96.0%	32056.9	95.2%	35236.1	97.3%	30263.9	98.0%
	Caprella linearis	1423.6	3.3%	943.1	2.8%	297.2	.8%	206.9	.7%
GASTROPODA	Rissoidae indet,	19.4	.0%	108.3	.3%	95.8	.3%	11.1	.0%
	Crepidula fornicata	1.4	.0%	2.8	.0%	1.4	.0%	5.6	.0%
	Nudibranchia indet,	19.4	.0%	.	.	1.4	.0%	11.1	.0%
	Onchidoris muricata	4.2	.0%	1.4	.0%	1.4	.0%	.	.
	Polycera quadrilineata	5.6	.0%	25.0	.1%	50.0	.1%	31.9	.1%
	Aeolidia papillosa	1.4	.0%	9.7	.0%	18.1	.0%	25.0	.1%
BIVALVIA	Mytilus edulis	111.1	.3%	336.1	1.0%	238.9	.7%	108.3	.4%
	Goodallia triangularis	1.4	.0%	.	.	.	.	.	.
	Hiatella arctica	.	.	.	.	1.4	.0%	2.8	.0%
BRYOZOA	Electra pilosa	22.2	.1%	19.4	.1%	20.8	.1%	19.4	.1%
	Alcyonidium sp,	2.8	.0%	1.4	.0%	.	.	.	.
ECHINODERMATA	Asterias rubens	40.3	.1%	61.1	.2%	75.0	.2%	84.7	.3%
Total		**43581.9**	**100.0%**	**33675.0**	**100.0%**	**36197.2**	**100.0%**	**30869.4**	**100.0%**

September 2004

Abundance, number/m²		Transect							
		Foundations, horizontal							
		A 0.5 NNE		B 02 NNE		C 05 NNE		D 05 SSW	
		no./m²	Kol Sum %	no./m²	Kol Sum %	no./m²	Kol Sum %	no./m²	Kol Sum %
PORIFERA	Porifera indet.	.	.	.	.	.	.	1.4	.0%
HYDROZOA	Tubularia indivisa	15.3	.0%	5.6	.0%	11.1	.0%	11.1	.0%
	Campanulariidae indet.	4.2	.0%	4.2	.0%	5.6	.0%	2.8	.0%
	Sertularia cupressina	2.8	.0%	.	.	.	.	2.8	.0%
ANTHOZOA	Alcyonium digitatum	2.8	.0%	4.2	.0%	4.2	.0%	5.6	.0%
	Actiniaria indet.	65.3	.1%	68.1	.1%	134.7	.2%	43.1	.0%
NEMERTINI	Nemertini indet.	.	.	.	.	.	.	2.8	.0%
NEMATODA	Nematoda indet.	13.9	.0%	13.9	.0%	36.1	.1%	8.3	.0%
POLYCHAETA	Phyllodoce groenlandica	6.9	.0%	6.9	.0%	16.7	.0%	6.9	.0%
	Eulalia viridis	27.8	.0%	12.5	.0%	30.6	.1%	36.1	.0%
	Nereis pelagica	.	.	.	.	.	.	1.4	.0%
	Polydora ciliata	.	.	.	.	.	.	1.4	.0%
	Cirratulidae indet.	.	.	1.4	.0%	.	.	.	.
	Terebellidae indet.	.	.	.	.	.	.	2.8	.0%
	Lanice conchilega	.	.	.	.	1.4	.0%	.	.
	Sabellaria sp.	.	.	.	.	1.4	.0%	.	.
	Pomatoceros triqueter	13.9	.0%	16.7	.0%	29.2	.0%	19.4	.0%
CRUSTACEA	Verruca stroemia	5.6	.0%	12.5	.0%	22.2	.0%	23.6	.0%
	Balanus crenatus	12.5	.0%	6.9	.0%	11.1	.0%	23.6	.0%
	Cancer pagurus	222.2	.3%	208.3	.2%	170.8	.3%	218.1	.1%
	Liocarcinus depurator	1.4	.0%	.	.	.	.	.	.
	Jassa marmorata	86323.6	97.9%	106500.0	97.5%	57236.1	97.4%	141586.1	97.1%
	Caprella linearis	966.7	1.1%	1902.8	1.7%	573.6	1.0%	2915.3	2.0%
GASTROPODA	Rissoidae indet.	93.1	.1%	129.2	.1%	102.8	.2%	281.9	.2%
	Crepidula fornicata	6.9	.0%	54.2	.0%	18.1	.0%	23.6	.0%
	Hinia pygmaea	4.2	.0%	5.6	.0%	19.4	.0%	13.9	.0%
	Nudibranchia indet.	6.9	.0%	.	.	.	.	12.5	.0%
	Onchidoris muricata	2.8	.0%	.	.	1.4	.0%	2.8	.0%
	Polycera quadrilineata	19.4	.0%	.	.	6.9	.0%	9.7	.0%
	Aeolidia papillosa	8.3	.0%	5.6	.0%	2.8	.0%	.	.
BIVALVIA	Mytilus edulis	159.7	.2%	111.1	.1%	122.2	.2%	206.9	.1%
	Angulus tenuis	1.4	.0%	5.6	.0%	1.4	.0%	2.8	.0%
	Moerella pygmaea	4.2	.0%	.	.	.	.	.	.
	Hiatella arctica	.	.	1.4	.0%	.	.	.	.
BRYOZOA	Bryozoa indet.	.	.	.	.	1.4	.0%	.	.
	Electra pilosa	22.2	.0%	15.3	.0%	19.4	.0%	23.6	.0%
	Alcyonidium sp.	1.4	.0%	1.4	.0%	2.8	.0%	.	.
ECHINODERMATA	Asterias rubens	163.9	.2%	113.9	.1%	148.6	.3%	211.1	.1%
	Ophiura albida	18.1	.0%	18.1	.0%	18.1	.0%	45.8	.0%
	Strongylocentrotus droebachiensis	5.6	.0%	1.4	.0%	4.2	.0%	.	.
Total		88202.8	100.0%	109226.4	100.0%	58754.2	100.0%	145747.2	100.0%

Appendix 7. Biomass

Appendix 7.1. Total biomass

March 2004

		20040324		
		Total		
Biomass, wet weight g/m²		g/m²	Kol Sum %	N
PORIFERA	Halichondria panicea	.026	.0%	132
HYDROZOA	Tubularia indivisa	.143	.0%	132
	Campanulariidae indet,	.017	.0%	132
ANTHOZOA	Alcyonium digitatum	.101	.0%	132
	Actiniaria indet,	25.379	1.3%	132
NEMERTINI	Nemertini indet,	1.167	.1%	132
NEMATODA	Nematoda indet,	.000	.0%	132
POLYCHAETA	Harmothoe imbricata	.071	.0%	132
	Harmothoe impar	.170	.0%	132
	Phyllodoce groenlandica	.110	.0%	132
	Eulalia viridis	.054	.0%	132
	Syllidae indet,	.002	.0%	132
	Nereis pelagica	.350	.0%	132
	Neanthes virens	.017	.0%	132
	Polydora ciliata	.000	.0%	132
	Capitella capitata	.001	.0%	132
	Pomatoceros triqueter	1.266	.1%	132
CRUSTACEA	Verruca stroemia	.013	.0%	132
	Balanus balanus	5.868	.3%	132
	Balanus crenatus	1.079	.1%	132
	Corystes cassivelaunus	.001	.0%	132
	Cancer pagurus	.968	.0%	132
	Pisidia longicornis	.013	.0%	132
	Jassa marmorata	234.424	11.9%	132
	Caprella linearis	18.326	.9%	132
CHIRONOMIDAE	Chironomidae indet,	.001	.0%	132
	Telmatogeton japonicus	.606	.0%	132
GASTROPODA	Rissoidae indet,	.046	.0%	132
	Crepidula fornicata	11.105	.6%	132
	Nudibranchia indet,	.057	.0%	132
	Onchidoris muricata	.153	.0%	132
	Polycera quadrilineata	.136	.0%	132
	Aeolidia papillosa	.381	.0%	132
BIVALVIA	Mytilus edulis	1624.208	82.5%	132
	Ostrea edulis	.036	.0%	132
	Heteranomia squamula	.050	.0%	132
	Goodallia triangularis	.000	.0%	132
	Hiatella arctica	.025	.0%	132
BRYOZOA	Electra pilosa	7.303	.4%	132
	Alcyonidium sp,	1.262	.1%	132
ECHINODERMATA	Asterias rubens	32.657	1.7%	132
	Strongylocentrotus droebachiensis	.021	.0%	132
Total		**1967.614**	**100.0%**	**5544**

September 2004

Biomass, wet weight g/m²		Total		
		g/m²	Kol Sum %	N
PORIFERA	Porifera indet.	.006	.0%	136
HYDROZOA	Tubularia indivisa	.498	.0%	136
	Hydractinia echinata	.028	.0%	136
	Campanulariidae indet.	.036	.0%	136
	Sertularia cupressina	.032	.0%	136
ANTHOZOA	Alcyonium digitatum	3.698	.2%	136
	Actiniaria indet.	21.860	1.4%	136
NEMERTINI	Nemertini indet.	.226	.0%	136
NEMATODA	Nematoda indet.	.006	.0%	136
POLYCHAETA	Harmothoe imbricata	.152	.0%	136
	Harmothoe impar	.075	.0%	136
	Phyllodoce groenlandica	.040	.0%	136
	Eulalia viridis	.152	.0%	136
	Ophiodromus flexuosus	.000	.0%	136
	Nereis pelagica	.027	.0%	136
	Polydora ciliata	.000	.0%	136
	Cirratulidae indet.	.001	.0%	136
	Terebellidae indet.	.004	.0%	136
	Lanice conchilega	.001	.0%	136
	Sabellaria sp.	.001	.0%	136
	Pomatoceros triqueter	1.103	.1%	136
CRUSTACEA	Verruca stroemia	.111	.0%	136
	Balanus balanus	26.517	1.7%	136
	Balanus crenatus	.670	.0%	136
	Cancer pagurus	4.221	.3%	136
	Liocarcinus depurator	.006	.0%	136
	Jassa marmorata	272.507	17.2%	136
	Caprella linearis	42.245	2.7%	136
CHIRONOMIDAE	Telmatogeton japonicus	.340	.0%	136
GASTROPODA	Rissoidae indet.	.113	.0%	136
	Crepidula fornicata	29.335	1.9%	136
	Hinia pygmaea	.016	.0%	136
	Nudibranchia indet.	.038	.0%	136
	Onchidoris muricata	.006	.0%	136
	Polycera quadrilineata	.315	.0%	136
	Aeolidia papillosa	.353	.0%	136
BIVALVIA	Mytilus edulis	1134.795	71.8%	136
	Modiolarca tumida	.002	.0%	136
	Heteranomia squamula	.001	.0%	136
	Angulus tenuis	.001	.0%	136
	Moerella pygmaea	.001	.0%	136
	Hiatella arctica	.000	.0%	136
	Thracia phaseolina	.007	.0%	136
BRYOZOA	Bryozoa indet.	.015	.0%	136
	Electra pilosa	3.423	.2%	136
	Alcyonidium sp.	1.253	.1%	136
ECHINODERMATA	Asterias rubens	36.657	2.3%	136
	Ophiura albida	.008	.0%	136
	Strongylocentrotus droebachiensis	.028	.0%	136
Total		1580.927	100.0%	6664

Appendix 7.2. Mean biomass. Mono-piles

March 2004

		Transect																			
		Turbine tower, vertical																			
		NNE 02		NNE 04		NNE 06		NNE 08		NNE Bottom		SSW 02		SSW 04		SSW 06		SSW 08		SSW Bottom	
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 %	g/m²	Kol Sum %	g/m²	Kol Sum %	g/m²	Kol Sum %	g/m²	Kol Sum %
HYDROZOA	Tubularia indivisa													011	0%					725	2%
	Campanulariidae indet,			006	0%					147	1%			000	0%						
ANTHOZOA	Actiniaria indet,	6 165	1 1%	17 056	2 4%	19 213	2%			12 773	4 8%	16 472	1 5%	5 494	9%	10 344	1%			5 669	1 6%
NEMERTINI	Nemertini indet,	050	0%	185	0%	15 806	2%	1 448	0%	055	0%	127	0%	047	0%	4 115	0%	3 270	1%	100	0%
NEMATODA	Nematoda indet,											000	0%								
POLYCHAETA	Harmothoe imbricata															1 565	0%				
	Harmothoe impar	015	0%	018	0%	2 929	0%	216	0%	010	0%	121	0%	013	0%	214	0%	202	0%		
	Phyllodoce groenlandica			197	0%	073	0%	369	0%			110	0%	328	1%			101	0%		
	Eulalia viridis	206	0%			183	0%	331	0%			027	0%	122	0%			295	0%	023	0%
	Syllidae indet,											018	0%							008	0%
	Nereis pelagica					7 695	1%														
	Neanthes virens							372	0%												
	Pomatoceros triqueter	4 004	7%	2 246	3%	003	0%			3 785	1 4%	7 047	6%	5 063	8%	580	0%			1 865	5%
CRUSTACEA	Verruca stroemia					120	0%							100	0%						
	Balanus balanus							78 429	8%							683	0%	49 984	8%		
	Balanus crenatus	2 180	4%	3 203	5%	3 475	0%			046	0%	1 786	2%	6 839	1 1%	4 818	0%			028	0%
	Cancer pagurus	036	0%	132	0%	11 735	1%							038	0%	8 301	1%	1 007	0%		
	Pisidia longicornis					293	0%														
	Jassa marmorata	417 598	73 6%	530 581	75 0%	307 335	3 2%	71 042	8%	155 147	57 9%	898 530	79 5%	532 073	84 9%	551 103	4 5%	70 042	1 1%	207 605	58 9%
	Caprella linearis	76 515	13 5%	32 743	4 6%	101 426	1 1%	1 688	0%	13 720	5 1%	43 493	3 9%	26 505	4 2%	13 330	1%	428	0%	45 824	13 0%
CHIRONOMIDAE	Chironomidae indet,							013	0%									010	0%		
	Telmatogeton japonicus							4 904	1%									8 432	1%		
GASTROPODA	Rissoidae indet,							008	0%	008	0%	009	0%					005	0%		
	Crepidula fornicata	13 920	2 5%	28 114	4 0%					9 432	3 5%	105 176	9 3%	36 683	5 9%	11 324	1%			8 607	2 4%
	Nudibranchia indet,	214	0%	250	0%	009	0%							273	0%	057	0%			019	0%
	Onchidoris muricata	1 824	3%	724	1%	128	0%			094	0%	213	0%	007	0%						
	Polycera quadrilineata	230	0%	131	0%	087	0%			030	0%	666	1%	156	0%	012	0%			067	0%
	Aeolidia papillosa	205	0%	5 992	8%	097	0%			149	1%	374	0%	504	1%	302	0%				
BIVALVIA	Mytilus edulis	077	0%	1 473	2%	9033 851	94 8%	9118 379	98 3%	100	0%	571	1%	1 366	2%	11503 015	94 8%	6070 800	97 8%	210	1%
	Ostrea edulis					803	0%														
	Heteranomia squamula	181	0%	635	1%									287	0%						
	Hiatella arctica	043	0%			173	0%	052	0%			035	0%	019	0%	024	0%	055	0%		
BRYOZOA	Electra pilosa	11 895	2 1%	29 016	4 1%	18 971	2%	004	0%	10 032	3 7%	44 320	3 9%	4 379	7%	18 397	2%	694	0%	1 515	4%
	Alcyonidium sp,	3 946	7%	665	1%	678	0%			7 183	2 7%	2 633	2%							12 375	3 5%
ECHINODERMATA	Asterias rubens	28 108	5 0%	53 712	7 6%					55 226	20 6%	7 953	7%	6 727	1 1%					67 693	19 2%
	Strongylocentrotus droebachiensis					070	0%									398	0%				
Total		**567.412**	**100.0%**	**707.078**	**100.0%**	**9525.151**	**100.0%**	**9277.253**	**100.0%**	**267.938**	**100.0%**	**1129.682**	**100.0%**	**627.030**	**100.0%**	**12128.582**	**100.0%**	**6205.323**	**100.0%**	**352.334**	**100.0%**

September 2004

Biomass, wet weight g/m²		Transect											
		Turbine tower, vertical											
		NNE 02		NNE 04		NNE 06		NNE 08		NNE 10		NNE Bottom	
		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	Tubularia indivisa	.041	.0%	.527	.1%	.819	.1%	.	.	.	.	.526	.1%
	Hydractinia echinata	.	.	.370	.1%	.180	.0%	.	.	.	.	.095	.0%
	Campanulariidae indet.	.062	.0%	.042	.0%	.013	.0%	.	.	.	.	.063	.0%
ANTHOZOA	Actiniaria indet.	5.772	1.0%	3.167	.5%	37.181	2.9%	21.416	.2%	.	.	.759	.1%
NEMERTINI	Nemertini indet.	.	.	.	.	.	.	.175	.0%	.	.	.	.
NEMATODA	Nematoda indet.	.015	.0%	.002	.0%	.004	.0%	.	.	.	.	.012	.0%
POLYCHAETA	Harmothoe impar	.010	.0%	.095	.0%	.064	.0%	.	.	.	.	.027	.0%
	Phyllodoce groenlandica	.	.	.	.	.026	.0%	.	.	.	.	.	.
	Eulalia viridis	.341	.1%	.208	.0%	.213	.0%	.105	.0%	.	.	.292	.0%
	Nereis pelagica	.	.	.	.	.	.	.422	.0%	.	.	.	.
	Cirratulidae indet.	.000	.0%	.	.	.	.	.002	.0%	.	.	.	.
	Terebellidae indet.	.	.	.	.	.	.	.	.	.	.	.013	.0%
	Pomatoceros triqueter	2.511	.4%	1.713	.3%	.471	.0%	.	.	.	.	3.043	.5%
CRUSTACEA	Verruca stroemia	.064	.0%	.	.	.	.	.	.	.	.	.	.
	Balanus balanus	.	.	.	.	16.172	1.3%	106.738	1.1%	373.678	97.5%	.	.
	Balanus crenatus	1.040	.2%	.295	.1%	.232	.0%	.	.	.	.	.025	.0%
	Cancer pagurus	2.710	.5%	5.451	.9%	9.117	.7%	8.089	.1%	.	.	10.329	1.7%
	Jassa marmorata	333.247	59.6%	306.401	52.7%	769.336	60.7%	410.862	4.3%	6.194	1.6%	423.737	68.0%
	Caprella linearis	161.965	29.0%	119.938	20.6%	86.020	6.8%	63.945	.7%	.083	.0%	76.624	12.3%
CHIRONOMIDAE	Telmatogeton japonicus	.293	.1%	.143	.0%	.003	.0%	.994	.0%	3.391	.9%	.495	.1%
GASTROPODA	Rissoidae indet.	.012	.0%	.041	.0%	.166	.0%	.385	.0%	.	.	.069	.0%
	Crepidula fornicata	23.038	4.1%	114.809	19.7%	.005	.0%	97.531	1.0%	.	.	.033	.0%
	Hinia pygmaea	.	.	.	.	.	.	.006	.0%	.	.	.	.
	Onchidoris muricata	.019	.0%	.006	.0%	.021	.0%	.	.	.	.	.007	.0%
	Polycera quadrilineata	.755	.1%	1.327	.2%	1.491	.1%	.375	.0%	.	.	.205	.0%
	Aeolidia papillosa	.344	.1%	1.032	.2%	.325	.0%	1.287	.0%	.	.	.339	.1%
BIVALVIA	Mytilus edulis	1.145	.2%	.190	.0%	314.058	24.8%	8743.565	92.4%	.010	.0%	.138	.0%
	Modiolarca tumida	.	.	.	.	.	.	.014	.0%	.	.	.019	.0%
	Heteranomia squamula	.	.	.	.	.031	.0%	.	.	.	.	.	.
	Thracia phaseolina	.	.	.	.	.	.	.152	.0%	.	.	.	.
BRYOZOA	Bryozoa indet.	.	.	.	.	.	.	.145	.0%	.	.	.	.
	Electra pilosa	3.331	.6%	5.825	1.0%	13.138	1.0%	1.248	.0%	.	.	7.370	1.2%
	Alcyonidium sp.	.967	.2%	3.035	.5%	2.420	.2%	.	.	.	.	.518	.1%
ECHINODERMATA	Asterias rubens	21.532	3.9%	16.949	2.9%	16.149	1.3%	5.523	.1%	.	.	98.108	15.8%
	Ophiura albida	.	.	.006	.0%	.	.	.	.	.	.	.003	.0%
	Strongylocentrotus droebachiensis	.	.	.	.	.114	.0%	.	.	.	.	.	.
Total		559.214	100.0%	581.573	100.0%	1267.768	100.0%	9462.980	100.0%	383.355	100.0%	622.846	100.0%

Biomass, wet weight g/m²		Transect Turbine tower, vertical SSW 02 g/m²	SSW 02 Kol Sum %	SSW 04 g/m²	SSW 04 Kol Sum %	SSW 06 g/m²	SSW 06 Kol Sum %	SSW 08 g/m²	SSW 08 Kol Sum %	SSW 10 g/m²	SSW 10 Kol Sum %	SSW Bottom g/m²	SSW Bottom Kol Sum %
HYDROZOA	Tubularia indivisa	1.307	.2%	.145	.0%	.060	.0%	.010	.0%	.	.	.348	.1%
	Campanulariidae indet.	.006	.0%	.	.	.031	.0%	.	.	.	.	.043	.0%
ANTHOZOA	Actiniaria indet.	7.358	1.1%	.196	.0%	16.547	.1%	.	.	.	.	1.600	.3%
NEMERTINi	Nemertini indet.	.	.	.	.	1.610	.0%	3.326	.1%	.	.	.	.
NEMATODA	Nematoda indet.	.009	.0%	.006	.0%	.012	.0%	.	.	.	.	.003	.0%
POLYCHAETA	Harmothoe imbricata	.	.	.	.	3.436	.0%	.	.	.	.	.	.
	Harmothoe impar	.036	.0%	.	.	1.478	.0%	.	.	.	.	.	.
	Phyllodoce groenlandica	.006	.0%	.	.	.054	.0%	.	.	.	.	.	.
	Eulalia viridis	.126	.0%	.625	.1%	.452	.0%	.056	.0%	.	.	.235	.0%
	Ophiodromus flexuosus	.	.	.	.	.007	.0%	.	.	.	.	.	.
	Nereis pelagica	.	.	.	.	.	.	.118	.0%	.	.	.	.
	Cirratulidae indet.	.	.	.007	.0%	.	.	.003	.0%	.	.	.000	.0%
	Pomatoceros triqueter	2.662	.4%	3.020	.5%	.667	.0%	.	.	.	.	3.015	.6%
CRUSTACEA	Verruca stroemia	.	.	.	.	.	.	.	.	.	.	.021	.0%
	Balanus balanus	90.407	13.5%	.	.	.009	.0%	34.463	.6%	643.368	60.6%	14.254	2.6%
	Balanus crenatus	.621	.1%	.815	.1%	1.010	.0%	.	.	.	.	.081	.0%
	Cancer pagurus	4.359	.7%	4.823	.7%	10.740	.1%	4.805	.1%	.	.	7.340	1.3%
	Jassa marmorata	291.334	43.5%	388.019	60.2%	436.709	3.7%	417.348	7.0%	411.700	38.7%	339.778	62.2%
	Caprella linearis	81.251	12.1%	93.085	14.4%	120.829	1.0%	72.985	1.2%	.015	.0%	26.786	4.9%
CHIRONOMiDAE	Teimatogeton japonicus	.	.	.	.	.005	.0%	2.170	.0%	7.381	.7%	.009	.0%
GASTROPODA	Rissoidae indet.	.077	.0%	.089	.0%	.195	.0%	.351	.0%	.	.	.100	.0%
	Crepiduia fornicata	130.174	19.4%	108.071	16.8%	26.125	.2%	.030	.0%	.	.	10.751	2.0%
	Nudibranchia indet.	.	.	.294	.0%	.	.	.	.	.	.	.	.
	Onchidoris muricata	.021	.0%	.018	.0%	.	.	.	.	.	.	.012	.0%
	Poiycera quadriiineata	.304	.0%	1.132	.2%	.625	.0%	.150	.0%	.	.	.171	.0%
	Aeolidia papillosa	.202	.0%	.975	.2%	2.011	.0%	.050	.0%	.	.	.	.
BIVALViA	Mytiius eduiis	.246	.0%	.776	.1%	11246.523	94.7%	5411.395	90.9%	.	.	.239	.0%
	Modiolarca tumida	.	.	.	.	.	.	.004	.0%	.	.	.	.
BRYOZOA	Eiectra piiosa	6.265	.9%	6.542	1.0%	3.860	.0%	3.493	.1%	.	.	1.992	.4%
	Aicyonidium sp.	18.778	2.8%	.399	.1%	.014	.0%	.167	.0%	.	.	1.467	.3%
ECHiNODERMATA	Asterias rubens	33.895	5.1%	35.541	5.5%	7.020	.1%	.665	.0%	.	.	138.406	25.3%
	Ophiura albida	.	.	.	.	.	.	.	.	.	.	.004	.0%
	Strongyiocentrotus droebachiensis	.	.	.234	.0%	.	.	.	.	.	.	.	.
Total		669.443	100.0%	644.814	100.0%	11880.028	100.0%	5951.591	100.0%	1062.464	100.0%	546.654	100.0%

Appendix 7.3. Mean biomass. Scour protections

March 2004

		Transect							
		Foundations, horizontal							
		A 0.5 NNE		B 02 NNE		C 05 NNE		D 05 SSW	
Biomass, wet weight g/m²		g/m²	Kol Sum %	g/m²	Kol Sum %	g/m²	Kol Sum %	g/m²	Kol Sum %
PORIFERA	Halichondria panicea	.	.	.009	.0%	.181	.1%	.	.
HYDROZOA	Tubularia indivisa	.712	.5%	.000	.0%	.	.	.089	.0%
	Campanulariidae indet,	.026	.0%	.010	.0%	.016	.0%	.020	.0%
ANTHOZOA	Alcyonium digitatum	.	.	.496	.2%	.244	.1%	.	.
	Actiniaria indet,	12.831	9.7%	40.262	15.9%	80.245	38.6%	21.714	9.0%
NEMERTINI	Nemertini indet,	.034	.0%	.024	.0%	.065	.0%	.031	.0%
POLYCHAETA	Phyllodoce groenlandica	.011	.0%	.140	.1%	.140	.1%	.128	.1%
	Eulalia viridis	.002	.0%	.	.	.001	.0%	.	.
	Syllidae indet,	.	.	.000	.0%	.007	.0%	.	.
	Polydora ciliata	.	.	.003	.0%	.	.	.	.
	Capitella capitata	.001	.0%	.009	.0%	.	.	.	.
	Pomatoceros triqueter	.173	.1%	.079	.0%	.461	.2%	.374	.2%
CRUSTACEA	Verruca stroemia	.	.	.	.	.012	.0%	.012	.0%
	Balanus crenatus	.008	.0%	.015	.0%	.424	.2%	.009	.0%
	Corystes cassivelaunus	.	.	.002	.0%	.003	.0%	.	.
	Cancer pagurus	.	.	.	.	.	.	.013	.0%
	Jassa marmorata	87.032	66.0%	159.154	63.0%	70.668	34.0%	155.237	64.5%
	Caprella linearis	8.311	6.3%	4.268	1.7%	1.562	.8%	1.690	.7%
GASTROPODA	Rissoidae indet,	.022	.0%	.143	.1%	.145	.1%	.016	.0%
	Crepidula fornicata	.001	.0%	1.124	.4%	3.448	1.7%	5.776	2.4%
	Nudibranchia indet,	.054	.0%	.	.	.024	.0%	.068	.0%
	Onchidoris muricata	.119	.1%	.003	.0%	.003	.0%	.	.
	Polycera quadrilineata	.006	.0%	.199	.1%	.263	.1%	.069	.0%
	Aeolidia papillosa	.004	.0%	.105	.0%	.113	.1%	.032	.0%
BIVALVIA	Mytilus edulis	.111	.1%	.474	.2%	.239	.1%	.084	.0%
	Goodallia triangularis	.002	.0%	.	.	.	.	.	.
	Hiatella arctica	.	.	.	.	.032	.0%	.018	.0%
BRYOZOA	Electra pilosa	1.906	1.4%	2.372	.9%	1.541	.7%	1.330	.6%
	Alcyonidium sp,	.027	.0%	.070	.0%	.	.	.	.
ECHINODERMATA	Asterias rubens	20.539	15.6%	43.715	17.3%	48.022	23.1%	54.067	22.5%
Total		**131.930**	**100.0%**	**252.675**	**100.0%**	**207.860**	**100.0%**	**240.776**	**100.0%**

September 2004

Biomass, wet weight g/m²		Transect							
		Foundations, horizontal							
		A 0.5 NNE		B 02 NNE		C 05 NNE		D 05 SSW	
		g/m²	Kol Sum %	g/m²	Kol Sum %	g/m²	Kol Sum %	g/m²	Kol Sum %
PORIFERA	Porifera indet.	.	.	.	.	.	.	.044	.0%
HYDROZOA	Tubularia indivisa	1.313	.5%	.227	.1%	.859	.4%	.101	.0%
	Campanulariidae indet.	.013	.0%	.048	.0%	.111	.1%	.010	.0%
	Sertularia cupressina	.009	.0%	.	.	.	.	.232	.1%
ANTHOZOA	Alcyonium digitatum	11.878	4.8%	2.880	1.0%	7.471	3.5%	5.708	1.8%
	Actiniaria indet.	19.497	7.9%	34.011	11.9%	70.886	33.1%	9.443	3.0%
NEMERTINI	Nemertini indet.	.	.	.	.	.	.	.006	.0%
NEMATODA	Nematoda indet.	.008	.0%	.005	.0%	.005	.0%	.005	.0%
POLYCHAETA	Phyllodoce groenlandica	.063	.0%	.018	.0%	.130	.1%	.061	.0%
	Eulalia viridis	.060	.0%	.011	.0%	.069	.0%	.122	.0%
	Nereis pelagica	.	.	.	.	.	.	.021	.0%
	Polydora ciliata	.	.	.	.	.	.	.001	.0%
	Cirratulidae indet.	.	.	.000	.0%	.	.	.	.
	Terebellidae indet.	.	.	.	.	.	.	.025	.0%
	Lanice conchilega	.	.	.	.	.009	.0%	.	.
	Sabellaria sp.	.	.	.	.	.005	.0%	.	.
	Pomatoceros triqueter	.539	.2%	.689	.2%	.922	.4%	.484	.2%
CRUSTACEA	Verruca stroemia	.063	.0%	.059	.0%	.344	.2%	.343	.1%
	Balanus crenatus	2.626	1.1%	.093	.0%	.444	.2%	.525	.2%
	Cancer pagurus	2.767	1.1%	2.348	.8%	2.053	1.0%	2.137	.7%
	Liocarcinus depurator	.045	.0%	.	.	.	.	.	.
	Jassa marmorata	150.580	61.2%	181.910	63.8%	79.928	37.3%	227.837	73.6%
	Caprella linearis	3.384	1.4%	1.746	.6%	2.573	1.2%	10.324	3.3%
GASTROPODA	Rissoidae indet.	.057	.0%	.083	.0%	.047	.0%	.172	.1%
	Crepidula fornicata	8.577	3.5%	20.774	7.3%	16.432	7.7%	5.670	1.8%
	Hinia pygmaea	.010	.0%	.012	.0%	.055	.0%	.042	.0%
	Nudibranchia indet.	.077	.0%	.	.	.	.	.115	.0%
	Onchidoris muricata	.005	.0%	.	.	.002	.0%	.006	.0%
	Polycera quadrilineata	.094	.0%	.	.	.020	.0%	.085	.0%
	Aeolidia papillosa	.161	.1%	.039	.0%	.276	.1%	.	.
BIVALVIA	Mytilus edulis	.332	.1%	.588	.2%	.144	.1%	.184	.1%
	Angulus tenuis	.001	.0%	.001	.0%	.000	.0%	.003	.0%
	Moerella pygmaea	.009	.0%	.	.	.	.	.	.
	Hiatella arctica	.	.	.003	.0%	.	.	.	.
BRYOZOA	Bryozoa indet.	.	.	.	.	.065	.0%	.	.
	Electra pilosa	2.549	1.0%	.658	.2%	1.308	.6%	3.656	1.2%
	Alcyonidium sp.	.037	.0%	.082	.0%	.096	.0%	.	.
ECHINODERMATA	Asterias rubens	41.289	16.8%	38.867	13.6%	29.984	14.0%	42.226	13.6%
	Ophiura albida	.006	.0%	.011	.0%	.015	.0%	.022	.0%
	Strongylocentrotus droebachiensis	.025	.0%	.002	.0%	.065	.0%	.	.
Total		246.073	100.0%	285.165	100.0%	214.316	100.0%	309.611	100.0%