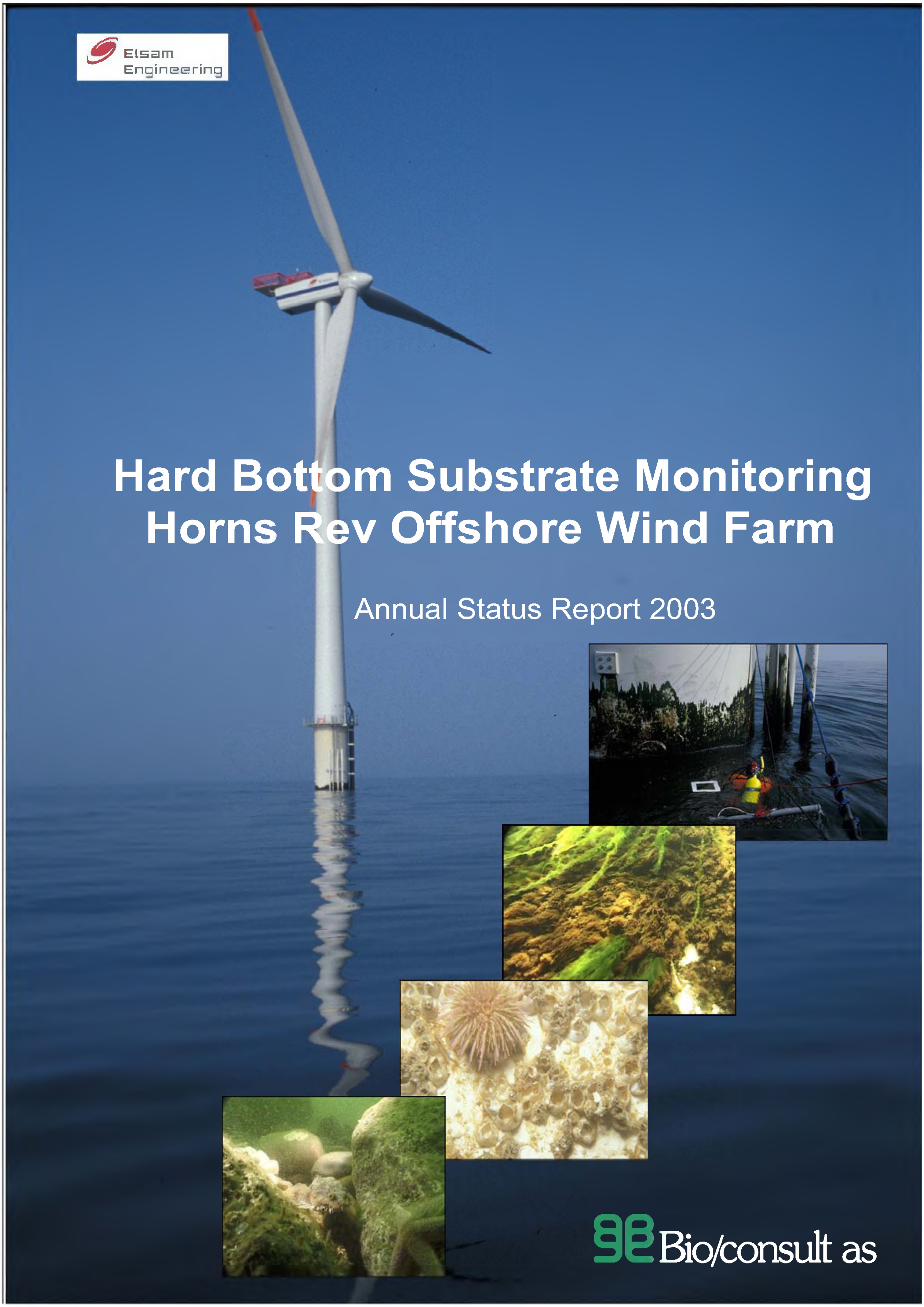

Elsam Engineering

Hard Bottom Substrate Monitoring Horns Rev Offshore Wind Farm

Annual Status Report 2003

Bio/consult as

Hard Bottom Substrate Monitoring Horns Rev Offshore Wind Farm

Annual Status Report 2003

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Summary

As part of the monitoring programme concerning the ecological impact of the introduction of hard substrate related to the Horns Rev Wind Farm, the first surveys on the fouling communities were performed in March 2003 and September 2003.

The Horns Rev is situated 15 km off Blåvands Huk, which is the most westerly point of Denmark. The water depth in the wind farm area varies from 6 to 11 m. The last of a total of 80 wind turbines was in place in August 2002.

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 three turbine towers. Epifouling communities exposed to different current regimes were studied both on the turbine towers and at the scour protection. The diameter of the monopile foundation of the turbines is 4 m. The scour protection with a diameter of approximately 20 m consists of stones up to 40 cm in diameter. At the outer edge of the scour protections, zones of up to 4 m in diameter were observed, consisting of smaller stones 10 cm in diameter.

Sampling was performed by SCUBA diving. Quantitative samples were collected from stone blocks and turbine towers and 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 turbine towers. Observations on fish species were made, and in September, specific test fishing using standard gill nets was made at turbine site 54.

In March, additional observations on specific faunal assemblages revealed the existence of the giant midge *Telmatogeton japonicus*, not previously recorded in Denmark, inhabiting and feeding on the dense mats of filamentous green algae growth in the splash/wash zone at the turbine towers.

A total of 16 taxa of seaweeds were registered on the turbine towers and scour protections, showing a distinct variation in spatial and temporal distribution. The vegetation was more frequently found on the turbine towers compared with 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 turbine towers, with *Enteromorpha, Ectocarpus* and *Pilayella littoralis* being the most frequent.

A total of 65 taxa of invertebrates were registered, and of these, 9 were mainly very mobile species exclusively observed during the transect surveys. Great variations in spatial and temporal distribution between species and communities were found. In general, community structures between sites and sample locations were statistically different. Differences in abundances of the dominant species, the amphipods *Jassa marmorata* and *Caprella linearis,* were the main factor contributing to the vertical and spatial differences. The cosmopolitan *Jassa marmorata*, not previously recorded in Denmark, was most frequently found on the turbine towers in abundances as high as 380,000 ind./m^2.

Distinct vertical zonations in the faunal assemblages on the turbine towers were observed. Dense aggregations of either spat or larger individuals of the common mussel *Mytilus edulis* were found in the sublittoral just beneath the sea surface at the turbine tower. Typically, the

vertical and spatial distribution of *Mytilus edulis* was controlled by the keystone predator, the starfish *Asterias rubens,* found in numbers on both the turbine towers and the scour protections.

Towards the sea bottom, more mobile species were found, such as the edible crab *Cancer pagurus*. Juveniles of the edible crab were found in numbers, and registration of both juveniles and egg masses of other species shows that the hard substrate structures are used as hatchery or nursery grounds for more species.

A weak significant evidence of impact of different hydraulic regimes caused by the turbine towers on the fauna community on the scour protection was shown, whereas no impact was shown on faunal assemblages due to different exposure on each side of the turbine towers.

Mosaics of faunal assemblages resulting in great variability between sites are often found in initial epifaunal communities. Greater similarities between some of the turbine sites were shown in September compared with March, which might be a result of the succession approaching stability in the fouling communities on the artificial substrates, although stable communities cannot be expected within 5–6 years.

Marked succession in the number of fish species between the survey in March and September was found. Only a few species were observed in March, the rock gunnel being the most numerous, whereas a total of 14 species were observed in September, most of these species in numbers. Shoals of bib, cod and whiting were often observed around the wind turbines and at the edge of the scour protections, probably feeding on the inhabitants of the hard substrate structures.

An estimation of the epifauna biomass revealed an eight times increase in food availability compared with the normal soft seabed fauna in the wind farm area. An increase of fish production related to the presence of the hard substrate is therefore considered possible.

Sammenfatning (in Danish)

Som et led i moniteringsprogrammet i forbindelse med etableringen af Horns Rev vindmøllepark er der i marts og september 2003 foretaget de første undersøgelser af begroningssamfundet. Undersøgelserne er foretaget med henblik på at vurdere den økologiske påvirkning som følge af introduktionen af hårbundssubstrat i området.

Horns Rev er beliggende ca. 15 km ud for Blåvands Huk, Danmarks vestligte punkt. Vanddybden i området varierer fra ca. 6 til 11 m. Den sidste af de i alt 80 vindmøller blev rejst i august 2002.

Undersøgelser af den horisontale fordeling af begroningssamfundet blev udført på 6 vindmøllefundamenter (scour-beskyttelser), mens den vertikale fordeling af begroningssamfundet kun blev udført på tre af vindmølletårnene.

Begroningssamfundet blev undersøgt i relation til eventuelle forskelle i strømforhold på både scour-beskyttelsen og på mølletårnene. Fundamentet af mølletårnene er en monopile, som er 4 m i diameter. Scour-beskyttelsen, som består af store sten op til 40 cm i diameter, er omkring 20 m i diameter. Den ydre rand af scour-beskyttelsen, som er ca. 4 m bred, består af mindre sten på omkring 10 cm i diameter.

Indsamlingen af prøver blev foretaget af dykkere. Der blev indsamlet kvantitative prøver fra både mølletårnene og scour-beskyttelsen, og langs transekter, omfattende både mølletårnene og scour-beskyttelsen, blev der foretaget semi-kvantitative (ikke komplet kvantificerede) undersøgelser af begroningssamfundet efter en modificeret Braun-Blanquet skala. Forekomsten af fiskearter blev registreret, og i september blev der ved mølle 54 udført et testfiskeri med standard undersøgelsesgarn.

I marts afslørede supplerende observationer, at en speciel fauna bestående af den ”store” dansemyg *Telmatogeton japonicus,* der ikke tidligere er kendt fra Danmark, levede i og af den tætte begroning af grønne trådlager, der fandtes i sprøjte/bølgezonen på mølletårnene.

Der blev på mølletårnene og scourbeskyttelsen i alt registreret 16 forskellige taxa af makroalger. Samfundet af makroalger udviste en tydelig tidsmæssig og rummelig variation i udbredelse. Vegetationen blev, sammenlignet med scour-beskyttelsen, hyppigst registreret på mølletårnene. Der blev kun fundet få arter på stenene på scour-beskyttelsen, og det var karakteristisk, at disse næsten udelukkende var beliggende på mollepositioner med de mindste vanddybder. Der blev registreret en tydelig vertikal udbredelse af algerne på mølletårnene, hvor taxa som *Enteromorpha*, *Ectocarpus* og *Pilayella littoralis* var de hyppigst forekommende.

Der blev registreret i alt 65 forskellige taxa af invertebrater, hvoraf 9, fortrinsvis meget mobile arter, kun blev observeret ved transektundersøgelserne. Der blev fundet en stor variation 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 amphipoderne *Jassa marmorata* og *Caprella linearis*. *Jassa marmorata*, der er en kosmopolitisk art, som ikke tidligere er registreret fra Danmark, blev hyppigst fundet på selve mølletårnene med tætheder så høje som 380.000 individer/m^2.

Der blev registreret en tydelig vertikal fordeling af faunasamfundene på mølletårnene. Tætte bestande af enten spat eller større individer af blåmuslingen *Mytilus edulis* blev registreret sublittoralt på mølletårnene lige under havoverfladen. Typisk blev det observeret, at både den vertikale og den udbredelsesmæssige fordeling af *Mytilus edulis* blev kontrolleret af "nøgle" rovdyret søstjernen *Asterias rubens*. *Asterias rubens* blev fundet i stort tal både på mølletårnene og på scour-beskyttelsen.

Tættere på havbunden blev der registreret mere mobile arter som taskekrabben *Cancer pagurus*. Yngel af taskekrabben blev fundet i stort antal, og registreringen af både yngel og ægmasser af andre arter viser, at hårdbundssubstratet anvendes som yngel- og opvækstområde for flere arter.

Faunasamfundet på scour-beskyttelsen var svagt signifikant påvirket af forskelle i strømforhold forårsaget af mølletårnene, hvorimod der ikke blev konstateret nogen effekt på faunasamfundene i relation til forskelle i eksponering alt efter placeringen med hensyn til retning på mølletårnene.

I nyetablerede epifauna-samfund findes ofte en stor variation mellem de enkelte lokaliteter forårsaget af mosaikagtige mønstre i begroningen. Større lighed i faunasammensætningen mellem nogle af møllerne i september sammenlignet med marts kan være et resultat af en succession i begroningssamfundet mod et mere stabilt samfund. Der kan dog ikke forventes et stabilt samfund inden for de næste 5-6 år.

Der blev ligeledes fundet en markant udvikling i antallet af fiskearter mellem undersøgelserne i marts og september. Der blev kun fundet få arter i marts, hvoraf tangspræl var den hyppigste, hvorimod der i september blev observeret hele 14 arter. De fleste af disse arter blev fundet talrigt. Stimer af skægtorsk, almindelig torsk og hvilling blev ofte observeret omkring møllefundamenterne og langs kanten af scour-beskyttelsen, hvor de tilsyneladende søgte føde blandt dyrene på hårdbundssubstratet.

En estimering af biomassen af epifauna viste en 8 gangs forøgelse af den tilgængelige fødemængde 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 fiskebestanden i området.

1. Introduction

Elsam and Eltra 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 off the Danish west coast. The wind farm is sited 14–20 km into the North Sea, west of Blåvands Huk. The first wind turbine was erected in May 2002 and the last wind turbine tower of a total of 80 was in place by August 2002. The construction work was completed with the last connecting cables sluiced down in September 2002. All the wind turbines were in production by December 2002.

The expected impact of the wind farm will primarily be an alternation of habitats due to the introduction of hard bottom substrates as wind turbine towers 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 Horns Rev can be characterised by infauna species belonging to the *Goniadella-Spisula* community (Elsam Engineering, 2004c). 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 substrate was conducted in March 2003 and in September 2003.

This report describes the first year results of surveys on hard substrate after the completion of the offshore wind farm at Horns Rev.

2. Methodology

Survey and sampling operations took place during two separate surveys in March 2003 and September 2003.

2.1. The research area

Horns Rev is an extension of Blåvands Huk, which is Denmark's most westerly point. The reef consists primarily of pebbles, gravel and sand. The water depth over the reef varies between 2 and 9 m, and the width varies between 1 and 5 km. 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.

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 15 km off Blåvands Huk. Surveys were performed at six turbine sites at the Horns Rev Wind Farm, see figure 1.

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

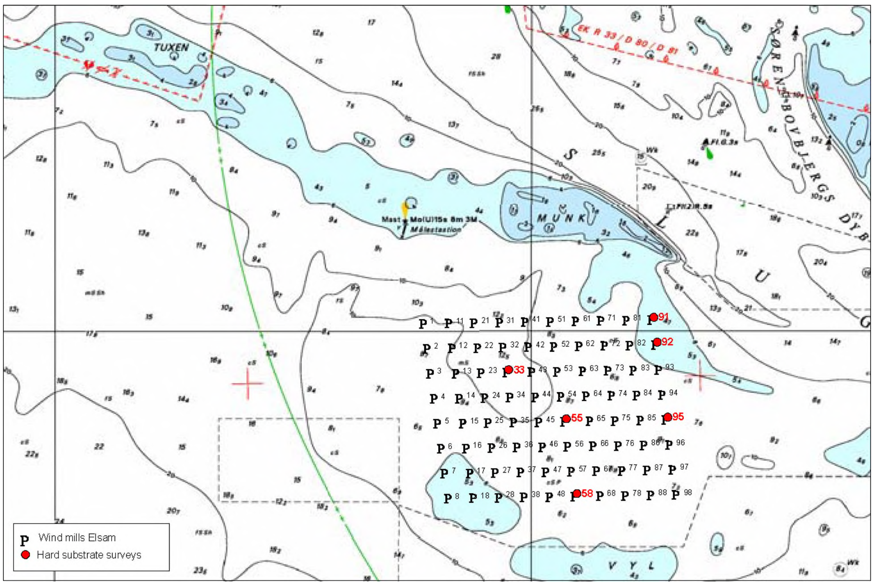


Figure 1. Map of locations sampled in March 2003 and September 2003.

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

Location	"WGS84_MIN_Y"	WGS84_MIN_X"	Depth (app. m)	Programme
Turbine 33	55°29.498'	07°49.450'	11.0	*
Turbine 55	55°28.910'	07°50.660'	10.0	**
Turbine 58	55°28.013'	07°50.881'	8.0	**
Turbine 91	55°30.126'	07°52.493'	6.0	*
Turbine 92	55°29.827'	07°52.566'	6.0	*
Turbine 95	55°28.930'	07°52.786'	9.0	**

*Table 1. Turbine positions for hard substrate surveys on scour protections *. Additional sampling of turbine towers marked with **.*

The turbines are secured in the seabed on a monopile foundation. The diameter of the monopile is 4 m, and a scour-protection of stones is placed around the monopile to avoid scouring of the bottom material due to the strong current at the site.

The scour protection, see figure 2, has a diameter of approximately 27 m varying between sites. The scour protection approximately 0.8 m in height above the original seabed generally consists of large stones up to 40 cm in diameter at distances of 0–10 m from the towers. At the edge of the area with large stones, an area up to 4 m in width consisting of small stones approximately 10 cm in diameter 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 site 92, the area with large stones was up to 14 metres from the turbine tower. Observations in March 2003 showed that large stones have been replenished at a distance from 10 to 16 metres from turbine tower 55 in the SSW direction.

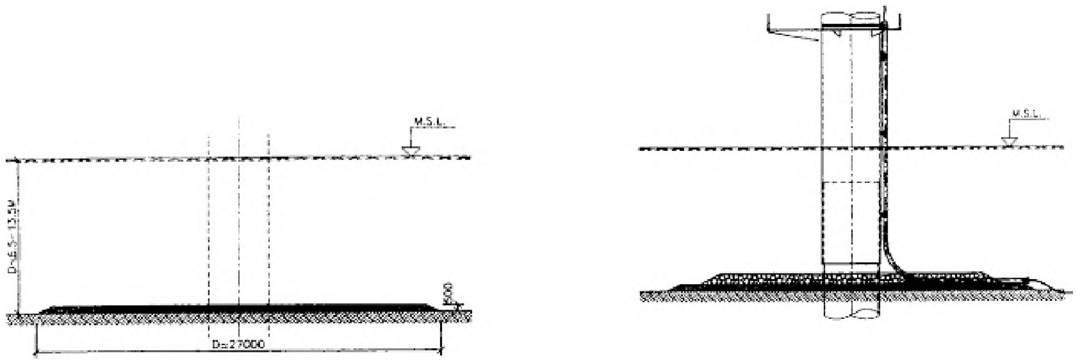


Figure 2. Wind turbine foundation and scour protection.

2.2. Field activities

At each sampling site, weather and wind conditions were recorded, as well as hydrographical data such as current direction, approximate current speed, wave height and transparency depth. 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 as the depth from the water surface to the top of the scour protection close to the turbine tower. Data are presented in appendix 2.

At different stations at the individual foundations, see 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 were selected along the transects at distances of 0.5 m, 2 m and 5 m (NNE0.5, NNE2, NNE5), respectively, from the turbine tower. As a reference, one station (SSW5) was sampled additionally at a distance 5 m upstream (SSW 200°) from the turbine tower.

At each station, samples of fouling organisms were thoroughly scraped off the stone blocks within a frame of 0.04 m^2 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 the transect upstream (SSW) and downstream (NNE), a visual determination was performed of the fouling communities and species that could be identified on site by the divers, in addition to the quantitative sampling. A semi-quantitative assessment of the frequency of each group of organisms was carried out, 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), see table 2.

Code	Degree of coverage %	Mobile species. Number of individuals
R	<0.05	<5
+	0.05–0.50	5–50
1	0.50–5	50–500
2	5–25	
3	25–50	
4	50–75	
5	75–100	

Table 2. Braun-Blanquet scores for hard substrate fouling organisms.

Fish species observed, registered and numbered according to table 3 are presented in appendix 3.

Code	Relative abundance
O	Observed
∞	Numerous

Table 3. Code for fish species observed.

The total degree of coverage for floral and faunal communities on the scour protection and the turbine towers is termed the substrate-specific degree of coverage. Certain groups of organisms were collected for species identification in the laboratory.

Sampling also included the turbine tower 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 turbine towers included the collection of quantitative samples by divers to determine the composition of species, abundance, and biomass. Two frame samples of 0.04 m^2 were taken from the turbine tower within each depth interval on each side of the turbine. 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 in each survey, 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 remarks and sampling were made at a selected number of towers, concerning the coverage of the epiflora and epifauna communities in the splash zone. In September, a test fishing procedure was performed in addition to the standard monitoring programme.

2.3. Test fishing. September 2003

For the validation of the fish species observed, one test fishing procedure using a standard gill net was carried out at turbine site 54. The gill net was set during the daytime on 15th September 2003 from 1 pm to 6.30 pm. A relatively bad weather forecast for the evening and for 16th September 2003 was the reason for the short time spent on this fishing procedure.

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 turbine tower 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, see figure 3.

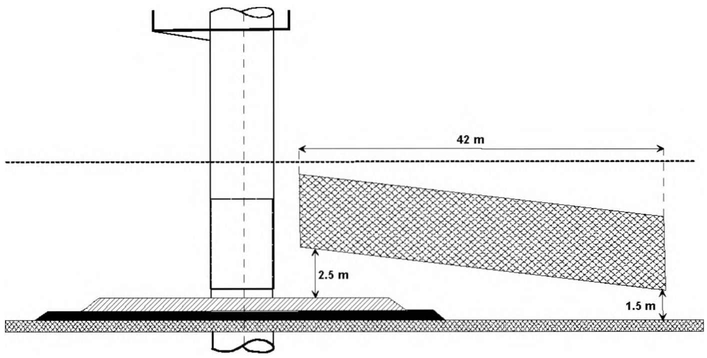


Figure 3. Schematic illustration of the placement of the gill net at the test fishing site.

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 using a pincer.

The fauna samples were sorted under a microscope and the animals identified to the lowest possible taxon. Due to the large number of individuals in the samples, standard subsampling was practised for both numbering and measuring 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 and posterior ends, and the disc diameter of the brittle stars were measured by means of an electronic slide gauge.

2.5. Statistical analyses

Differences between the faunal communities at the individual wind turbine sites, and variation in fauna communities at turbine towers 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 compositions 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 a data presentation in 2-dimensional plots using a non-metric Multidimensional Scaling (MDS) ordination. For further description of the MDS technique, see http://www.statsoft.com/textbook/stmulsca.html. In MDS plots, a *stress* factor (0–0.5) is usually 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 similarity rankings calculated and the ordination shown.

The PRIMER software package was used for statistical analysis (Clarke and 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.

3. Results

The hard bottom community at the artificial substrates at the Horns Rev represents 16 different species of macroalgae and 65 species of macroinvertebrates, see appendix 3. In addition, a total of 14 different species of fish were observed on the scour protection or in shoals on the edge of the scour protection.

3.1. Fish observed

Fish were observed at each of the turbines investigated, see appendix 4. In March 2003, only three species were recorded and each of these species was only observed in a few specimens at four of a total of six turbines. The most numerous species in March was the rock gunnel *Pholis gunnellus.*

In September, a total of 14 species were observed, often in numbers and in shoals around the wind turbines and at the edge of the scour protection. The observed abundance and the distribution of the fish species inside the wind farm area are shown in table 4. Three species, Atlantic cod, Corkwing wrasse, and the rock gunnel were all found in numbers at each of the examined turbine sites, whereas the dragonet, though relatively evenly distributed, was always found in small numbers.

Rare species in the Horns Rev area in 2003 were pollack and striped red mullet, both only observed in single individuals.

Common name	Scientific name	Number of sites observed	Max. Abundance
Atlantic cod	*Gadus morhua*	6	∞
Bib	*Trisopterus luscus*	4	∞
Pollack	*Pollachius virens*	1	O
Shorthorn sculpin	*Myoxocephalus scorpius*	5	∞
Hooknose	*Agonus cataphractus*	5	∞
Horse mackerel	*Trachurus trachurus*	2	∞
Striped red mullet	*Mullus surmuletus*	1	O
Corkwing wrasse	*Symphodus melops*	6	∞
Goldsinny-wrasse	*Ctenolabrus rupestris*	1	∞
Viviparous blenny	*Zoarces viviparous*	2	∞
Rock gunnel	*Pholis gunnellus*	6	∞
Dragonet	*Callionymus lyra*	5	O
Sand goby	*Pomatoschistus minutus*	4	∞

Table 4. Observed abundance of fish at turbine sites at Horns Rev wind farm 2003. O: observed, ∞: abundant.

The test fishing showed that in addition to the above-mentioned species, whiting was also present in the wind farm area in 2003. The whiting was caught in the test net outside the scour protection area.

Besides whiting, the presence of goldsinny-wrasse, Atlantic cod, poor cod and shorthorn sculpin was verified during the short test fishing procedure performed in the wind farm area, see table 5.

Common name	Scientific name	Number	Length cm
Whiting	*Merlangius merlangus*	6	13–16
Atlantic cod	*Gadus morhua*	1	13
Bib	*Trisopterus luscus*	1	19
Goldsinny-wrasse	*Ctenolabrus rupestris*	2	10–12
Shorthorn sculpin	*Myoxocephalus scorpius*	1	17

Table 5. Fish species caught in the gill net by test fishing.

3.2. Additional field observations

Additional observations were made on the splash zones at the turbine towers in March.

Dense green algal mats was observed in the splash zones of each turbine. It was noticed that small larval tubes of a midge identified as the giant midge *Telmatogeton japonicus* were easily recognised as green spots surrounded by a grazing zone without algae. A brief survey of a number of towers was made to observe whether the midge was evenly distributed in the wind farm area, see table 6.

Turbine number	Relative abundance of *Telmatogeton japonicus*	Sampled	Turbine erected
Turbine 55	Numerous (1,000–2,800 ind/m^2)	5 samples (20x20 cm)	30 Jul 2002
Turbine 58	Numerous		02 Aug 2002
Turbine 64	Numerous		04 Aug 2002
Turbine 65	Numerous		04 Aug 2002
Turbine 73	Numerous		06 Aug 2002
Turbine 76	Numerous		10 Aug 2002
Turbine 82	Numerous		12 Aug 2002
Turbine 87	Relatively few		15 Aug 2002
Turbine 91	Numerous (1,000–2,800 ind/m^2)		21 May 2002
Turbine 92	Relatively few, but locally numerous (1,000–2,800 ind/m^2)		19 Aug 2002
Turbine 95	None		22 Aug 2002
Turbine 98	A few		22 Aug 2002

Table 6. A semi-quantitative estimate of the abundance of Telmatogeton japonicus *at a selected number of turbine sites. The erection date of the towers is according to Global Marine Systems Ltd ,(2002).*

The radius of the grazing zone was estimated at approximately 1 cm equal to $^4/_5$ of the total length of the larvae. At a few turbines, the grazing zones of the individual larvae reached each other forming a completely grazed area at the towers, where the maximum densities of the midges were estimated at 1,000–2,800 individuals/m^2.

It is notable that *Telmatogeton japonicus* is absent or very low in abundance at towers erected in late summer (late August 2002). Both pupae and larvae were found in March.

Telmatogeton japonicus has not previously been recorded in Denmark. In Scandinavia, the species is known from Norway (Lindegaard, 1997) and was most recently recorded in Iceland (Murray, 1999)

3.3. Vegetation

A total of 16 taxa of seaweeds were registered from the turbine towers and scour protection at Horns Rev wind farm, see appendix 3.1. In March, only a relatively few species were observed.

In the splash zone on the turbine towers, generally dense mats of the filamentous green algae *Urospora penicilliformis* were observed in March. In September, *Cladophora* was observed in relatively low coverage in the splash zone and in the upper 2 m of the water column, see appendix 5.2.

The relatively sparse vegetation on the turbine towers was found down to 4–6 m below the surface. The vegetation was generally more abundant in the upper 4 m. Only the most abundant species, the green algae *Enteromorpa* and the brown algae *Pilayella littoralis*, were found in the lower part of the turbine towers down to 4–6 m.

Between the two surveys, a relatively distinct variation was also found in the species composition and coverage of the vegetation on the turbines below the water line. The algae *Callithamnion corymbosum*, *Ectocarpus*, *Blidingia minima* and *Ulva lactuca* were only found in September, whereas *Pilayella littoralis* was only registered in March. Among these, *Callithamnion corymbosum* and *Blidingia minima* were only found in low numbers. The relative coverage of the brown algae *Petalonia fascia* found at both surveys was highest in March, whereas the relative coverage of *Enteromorpha* was highest in September.

On the scour protection, the vegetation was very sparse and generally absent, especially in March. No vegetation was registered at turbine site 95. In March and September, the encrusting red algae – probably a species of the *Hildenbrandiales* group or the brown algae *Ralfsia sp.* – were found in relatively abundant numbers at turbine site 33, see table 7. In September, the encrusting algae were also found scattered on the stones at turbine site 55.

The brown algae *Pilayella littoralis* and *Ectocarpus* spp. were found in relatively high coverage at turbine sites 91 and 92, and in relatively low numbers in March at turbine site 58. These turbine sites are situated in slightly more shallow areas compared with the rest of the turbine sites. In March, the red algae *Callithamnion corymbosum* was observed in low numbers on the scour protection at turbine site 91.

Turbine site	**33**		**55**		**58**		**91**		**92**		**95**	
Actual depth m	9.2		7.9–8.4		6.3–7.6		5.1–6.0		5.7		7.0–7.5	
Sample time	S	A	S	A	S	A	S	A	S	A	S	A
Red algae	+	+		+			+	+				
Brown algae					+		+	+	+	+		
Green algae		+				+		+		+		
No vegetation			+								+	+

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

In September, the vegetation coverage was slightly more pronounced on the scour protections at most sites, but the vegetation was generally very sparse in numbers and coverage. The green algae, especially the green laver *Ulva lactua*, were relatively widespread and found on the scour protection at turbine sites 33, 58, 91 and 92, whereas another green algae *Enteromorpha* spp., was more abundant and registered at turbine sites 58, 91 and 92. In September, a few more species were added to the species list. The brown algae *Petalonia fascia* was found at turbine sites 91 and 92, and the brown algae *Desmarestia aculeata* and the red coral algae *Corallina officinalis* were found at turbine site 91.

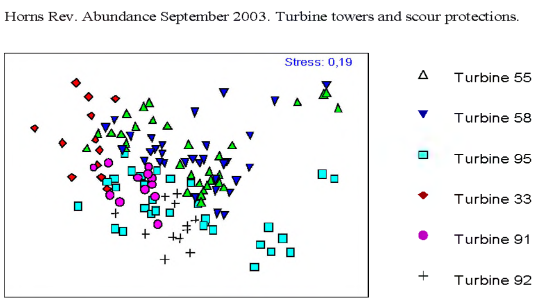
3.4. Fauna

Of a total of 65 invertebrate species registered and observed, only 9 species/taxon were not sampled and identified in the quantitative samples. These species were only observed by divers during the transect surveys, see appendix 3.3. These were mainly very mobile species such as the crabs, larger and occasionally observed species like the common whelk, infauna species inhabiting the sediment outside the sample area such as the bristle worm *Lanice conchilega* and the sea potato *Echinocardium cordatum* or species difficult to identify in the field, such as the barnacles and species of sea slugs. In contrast, sea anemones such as the plumose anemone *Metridium senile* are often more easily identifiable in the field than in the laboratory, which is why they were registered in the field survey only.

Photo 1. Transect line on scour protection. The plumose anemone Metridium senile *sessile on boulder.*

Photo 2. The sea slug Onchidoris muricata.

A total of 29 species were found in the transect surveys. Only two species/taxon, the giant midge *Telmatogeton japonicus* and Nemertini, were almost exclusively found on the turbine towers, whereas species like common whelk, common shore crab, hermit crab and the sea slug *Onchidoris muricata* were only found on the scour protections.



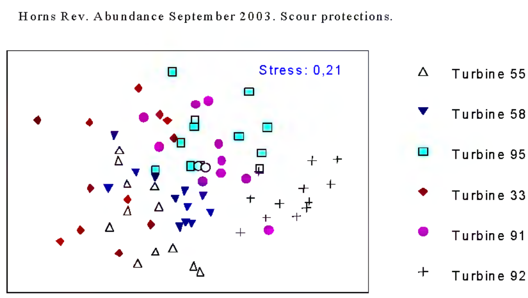


Figure 4. MDS showing abundance distribution at turbine sites in September 2003. At turbine sites 33, 91 and 92, investigations were conducted on scour protections only.

Based on the quantitative samples, the statistical ANOVA analysis showed in general that faunal assemblages at different turbine sites were significantly different. This difference in similarity between turbine sites is illustrated in figure 4, where samples from each turbine sites form groups more or less differentiated from samples matching different sites. Only two foundation sites (turbine sites 55 and 58) were slightly comparable ($P<0.1$) with respect to fauna characteristics, see figure 4, and this was only found for September. 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 2003		September 2003		March 2003		September 2003	
Species	Group	Mean	Relative %	Mean	Relative %	Mean	Relative %	Mean	Relative %
Jassa marmorata	Crustacean	56,169	86.5	111,891	90.7	276.903	29.4	87.724	5.9
Caprella linearis	Crustacean	927	1.4	9,491	7.7	6.949	0.7	15.721	1.1
Mytilus edulis	Bivalve	4,451	6.9	1,320	1.1	41.749	4.4	1,132.353	75.8
Balanus crenatus	Crustacean	2,982	4.6	16	0.0	489.612	51.9	0.568	0.0
Asterias rubens	Echinoderm	34	0.1	76	0.1	67.679	7.2	101.610	6.8
Cancer pagurus	Crustacean	4	0.0	78	0.1	0.166	0.0	0.267	0.0
Pomatoceros triqueter	Bristle worm	7	0.0	49	0.0	0.154	0.0	0.913	0.1
Total		64,574	99.4	122,921	99.6	883.212	93.7	1,339.155	89.6

Table 8. Distribution pattern found for some typical hard bottom substrate dominants in 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, and these species contributed with an average similarity of 48–63% between the sites. *Jassa marmorata* was the most numerous species and only 7 dominant species contributed to more than 99% of the total individuals found at the hard bottom substrate at Horns Rev, see table 8. Furthermore, these 7 species contributed to more than 89% of the total biomass registered.

Abundance ind./m²		March 2003				September 2003			
		Towers		Foundations		Towers		Foundations	
Species	Group	Mean	Relative %	Mean	Relative %	Mean	Relative %	Mean	Relative %
Jassa marmorata	Crustacean	93,514	84.1	24,012	87.5	208,303	91.1	31,548	92.4
Caprella linearis	Crustacean	1,280	1.2	591	2.7	18,558	7.5	1,934	5.5
Mytilus edulis	Bivalve	9,349	9.3	1,581	6.2	2,755	1.0	124	0.4
Balanus crenatus	Crustacean	5,469	4.2	660	2.3	217	0.1	11	0.0
Asterias rubens	Echinoderm	13	0.0	50	0.2	62	0.0	87	0.3
Cancer pagurus	Crustacean	8	0.0	1	0.0	146	0.1	21	0.1
Pomatoceros triqueter	Bristle worm	9	0.0	4	0.0	86	0.1	19	0.1
Total		109,641	99.0	26,899	99.0	230,126	99.8	33,744	98.8

Biomass g/m²		March 2003				September 2003			
		Towers		Foundations		Towers		Foundations	
Species	Group	Mean	Relative %	Mean	Relative %	Mean	Relative %	Mean	Relative %
Jassa marmorata	Crustacean	538.085	34.0	87.955	35.6	155.464	18.7	31.274	18.9
Caprella linearis	Crustacean	11.335	0.7	2.893	1.3	29.767	4.4	4.016	2.4
Mytilus edulis	Bivalve	98.167	5.3	2.932	1.4	2,489.882	35.2	1.078	0.7
Balanus crenatus	Crustacean	863.518	36.7	137.223	39.5	0.511	0.1	0.616	0.4
Asterias rubens	Echinoderm	90.563	10.9	47.632	19.1	154.083	20.2	57.882	34.1
Cancer pagurus	Crustacean	0.350	0.0	0.032	0.0	0.350	0.0	0.091	0.1
Pomatoceros triqueter	Bristle worm	0.245	0.0	0.065	0.0	0.245	0.0	0.271	0.2
Total		1,602.264	87.8	278.733	96.8	2,830.302	78.7	95.229	56.7

Table 9. Abundance and biomass distribution pattern found for typical hard bottom dominants at two types of substrate at Horns Rev in March and September 2003.

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 turbine towers and sampling at scour protections, see figure 5. A significantly higher abundance of these two species in particular was found at the turbine towers, compared with the abundance at the scour protections, see table 9. This contributed to the overall statistical significance ($P<0.001$) between the fauna composition at the turbine towers and the scour protections in general, see figure 5.

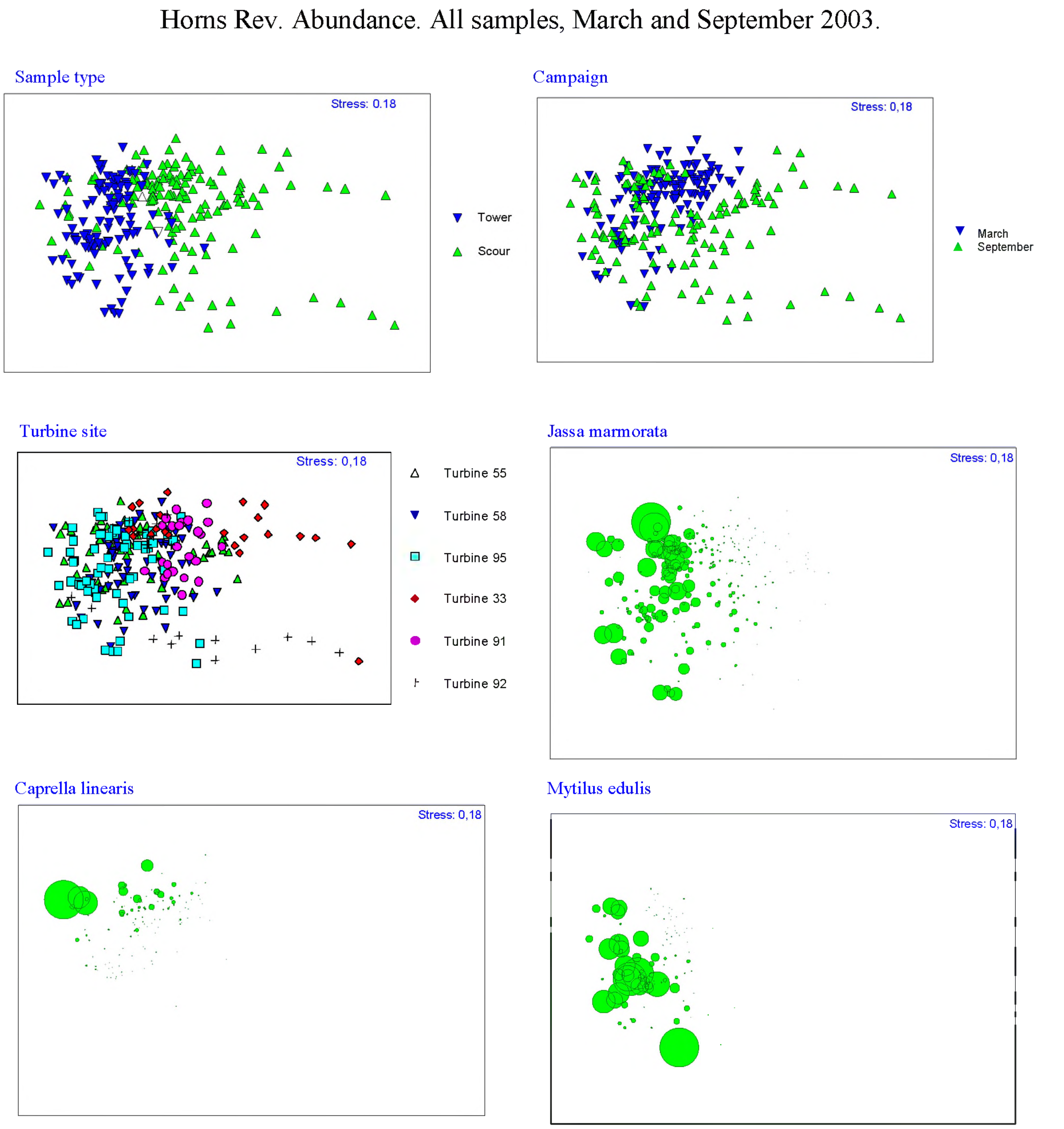


Figure 5. MDS plots of relative abundance concerning differences between sample types, sample campaigns and turbine sites of three of the most important species. The figure shows almost separate groups of samples for sample types and campaigns. Very high abundances at the turbine towers, especially at turbine site 95, compared with the abundance at the scour protections.

A considerably higher abundance of the common mussel *Mytilus edulis* and a higher abundance of the bristle worm *Pomatoceros triqueter* and juveniles of the edible crab *Cancer pagurus* at the turbine towers compared with the abundance at the scour protections also contributed to the differences between the two types of substrate. Observations from the transect surveys showed that larger, mature individuals of the edible crab were more frequently found between the stones at the scour protections than at the turbine towers. Observations and results from the samples also showed that the distribution and abundance of the edible crab were considerably higher in September compared with the results from March.

Similarly, *Jassa marmorata*, the common starfish *Asterias rubens* and *Pomatoceros triqueter* were more abundant in September, whereas the common mussel and the barnacles were more abundant in March. In contrast, the biomasses for the common mussel and *Jassa marmorata* showed the opposite result, whereas the average biomass of barnacles was higher in March, see table 8.

A general statistical difference (P<0.001) between the sampling in March and September, respectively, was shown for abundance and biomass relations, see figures 5 and 6.

Horns Rev. Biomass WW. All samples, March and September 2003.

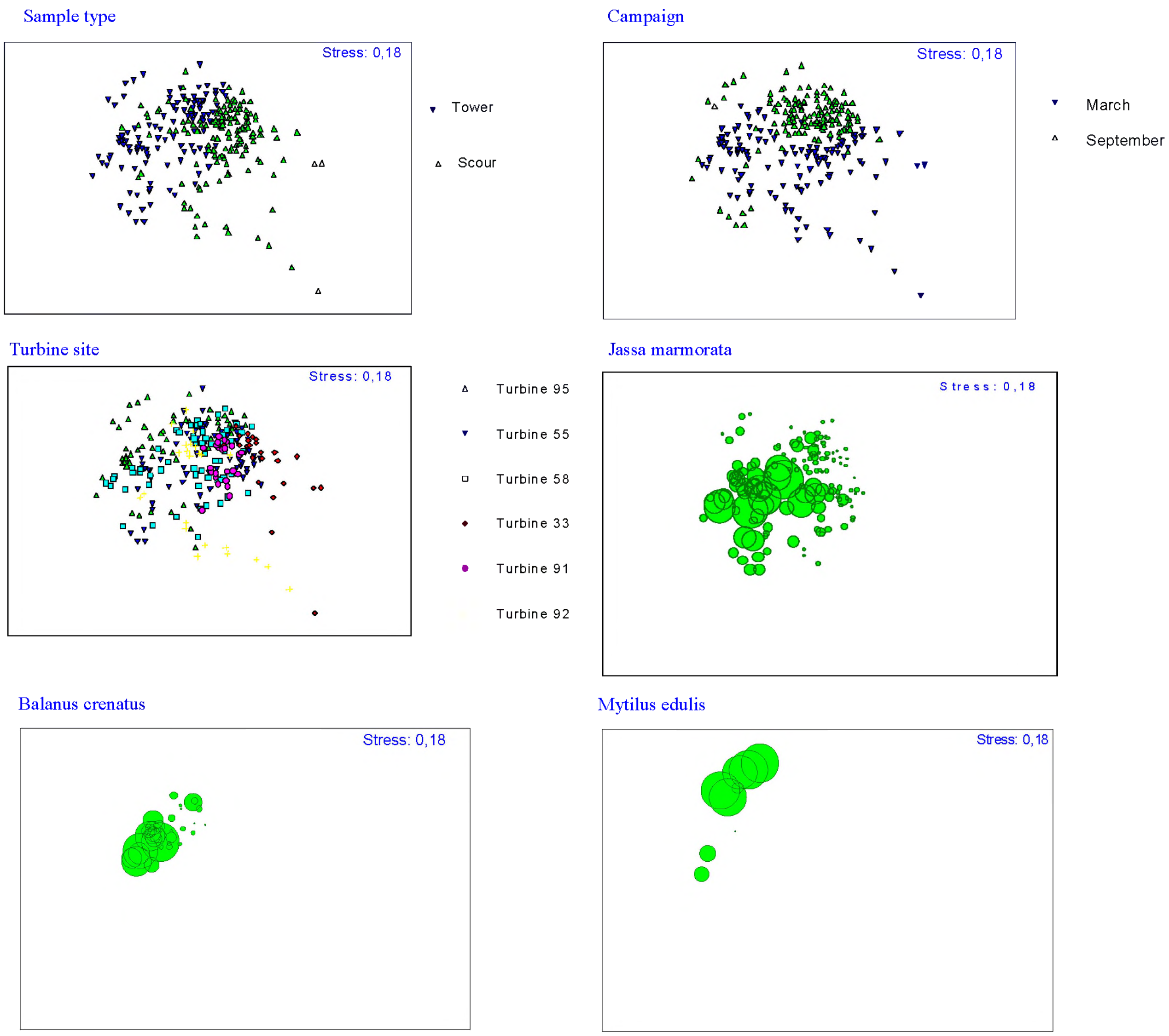


Figure 6. MDS plots of relative biomass concerning differences between sample types, sample campaigns and turbine sites of three of the most important species. The figure shows almost separate groups of samples for sample types and campaigns. Very high biomasses at the turbine towers are shown especially for Mytilus edulis *at turbine site 95 compared with the biomass at the scour protections. The biomass of the barnacle* Balanus crenatus *was exclusively recorded for March 2003.*

3.4.1. Turbine towers

A statistical difference (P<0.001) was found between the fauna communities at the turbine towers 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 turbine tower sites, but a noticeable difference in the abundance of the common mussel *Mytilus edulis* was also found. At turbine tower 95, a pronounced average abundance of *Mytilus edulis* was found compared with the two other turbine sites, see table 10. The abundance of *Caprella linearis* was higher at turbine tower 95 compared with turbine towers 55 and 58, whereas the abundance of *Jassa marmorata* showed a contrary distribution pattern between the turbine sites. This was the general distribution pattern for both March and September, see figures 7 and 8.

Abundance, ind./m²													
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	115,718	95.1	210,238	97.4	125,414	87.7	251,543	96.4	62,945	69.4	163,129	74.8
Caprella linearis	Crustacean	883	0.7	3,861	2.0	348	0.3	8,189	2.8	2,639	4.4	43,624	22.4
Mytilus edulis	Bivalve	2,275	2.0	170	0.1	2,591	1.8	518	0.3	18,234	21.0	7,576	2.4
Balanus crenatus	Crustacean	1,394	1.2	31	0.0	15,170	10.1	23	0.0	3,016	3.7	15	0.0
Cancer pagurus	Crustacean	14	0.0	20	0.0	8	0.0	326	0.2	3	0.0	91	0.0
Asterias rubens	Echinoderm	19	0.0	38	0.0	17	0.0	79	0.0	6	0.0	70	0.1
Pomatoceros triqueter	Bristle worm	17	0.0	105	0.1	8	0.0	123	0.1	6	0.0	30	0.0
Total		120,321	99.0	214,463	99.7	143,556	99.9	260,799	99.8	86,849	98.5	214,535	99.8

Biomass, g/m²													
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	590.029	60.2	149.405	37.3	646.464	51.0	226.549	43.6	379.650	20.2	90.436	13.0
Caprella linearis	Crustacean	10.600	0.8	5.093	2.4	4.704	0.6	24.042	5.1	20.059	1.0	60.165	9.7
Mytilus edulis	Bivalve	6.960	0.6	0.619	0.2	25.791	1.8	6.800	1.3	225.564	10.2	7,462.228	39.1
Balanus crenatus	Crustacean	163.157	12.6	0.818	0.4	1,629.764	43.1	0.458	0.1	1,139.901	43.0	0.257	0.2
Cancer pagurus	Crustacean	0.550	0.0	0.166	0.0	0.363	0.0	0.370	0.1	0.147	0.0	0.895	0.1
Asterias rubens	Echinoderm	77.915	7.2	21.165	7.8	21.941	3.1	101.682	21.8	167.228	13.8	339.401	21.3
Pomatoceros triqueter	Bristle worm	0.559	0.2	2.634	1.4	0.190	0.0	2.100	0.4	0.082	0.0	0.314	0.1
Total		849.770	81.5	179.901	49.6	2,329.217	99.5	362.001	72.4	1,932.630	88.1	7,953.697	83.5

Table 10. Abundance and biomass of dominant species found at turbine towers at Horns Rev in March 2003 and September 2003.

Photo 3. Male of the crustacean Jassa marmorata.

Photo 4. Starfish Asterias rubens *feeding on barnacles at turbine tower 55. March 2003.*

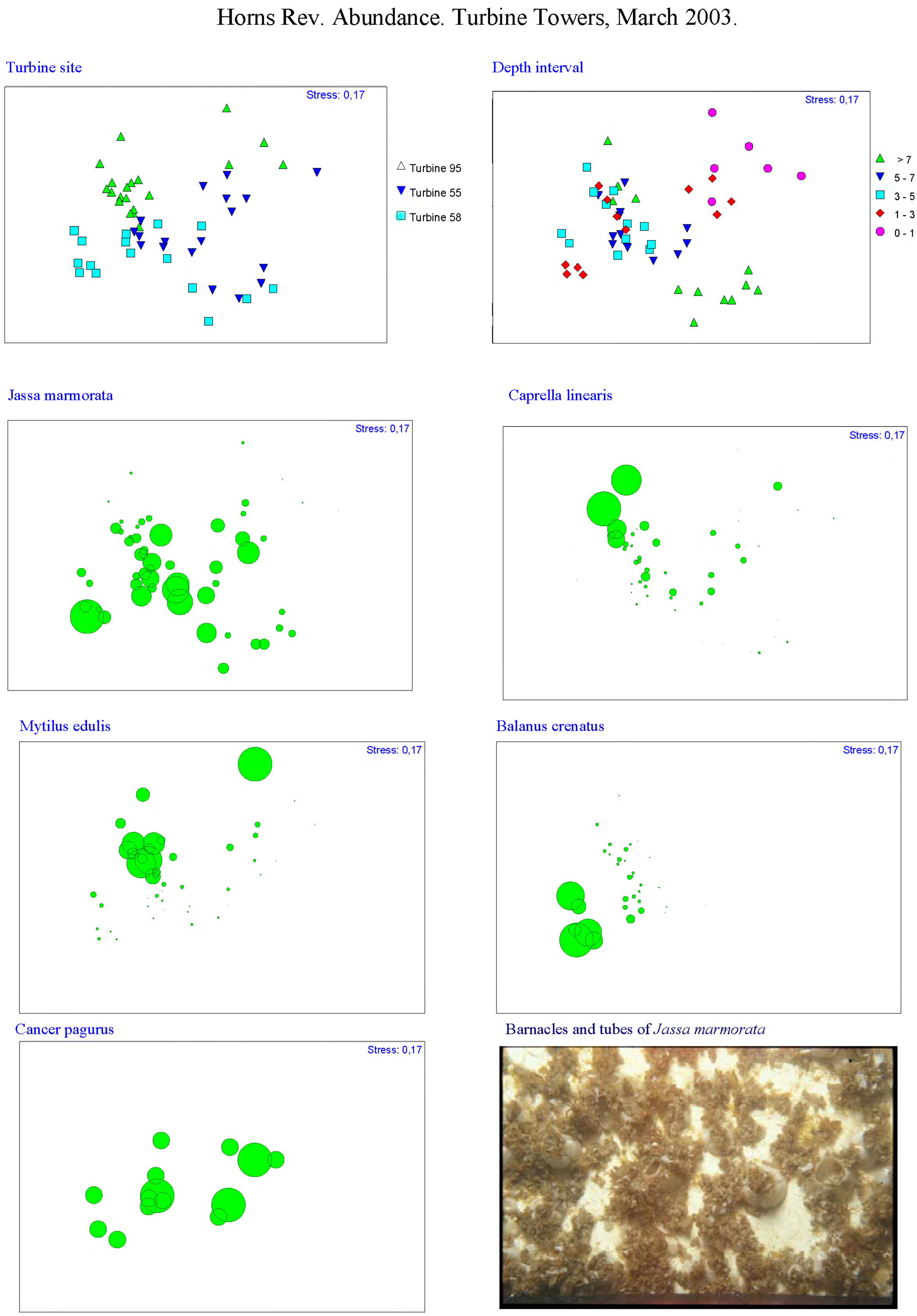


Figure 7. MDS plot of relative abundances at turbine towers showing sites and depth distribution of the five most abundant species in March 2003. The figure shows high abundances for Caprella linearis *and* Mytilus edulis *at turbine site 95 and high abundances for* Jassa marmorata *and* Balanus crenatus *at turbine sites 55 and 58.* Jassa marmorata *and* Balanus crenatus *are mainly found in depth zone 1-3, whereas* Mytilus edulis *is mainly found in three depth zones from 1 to 5 m.*

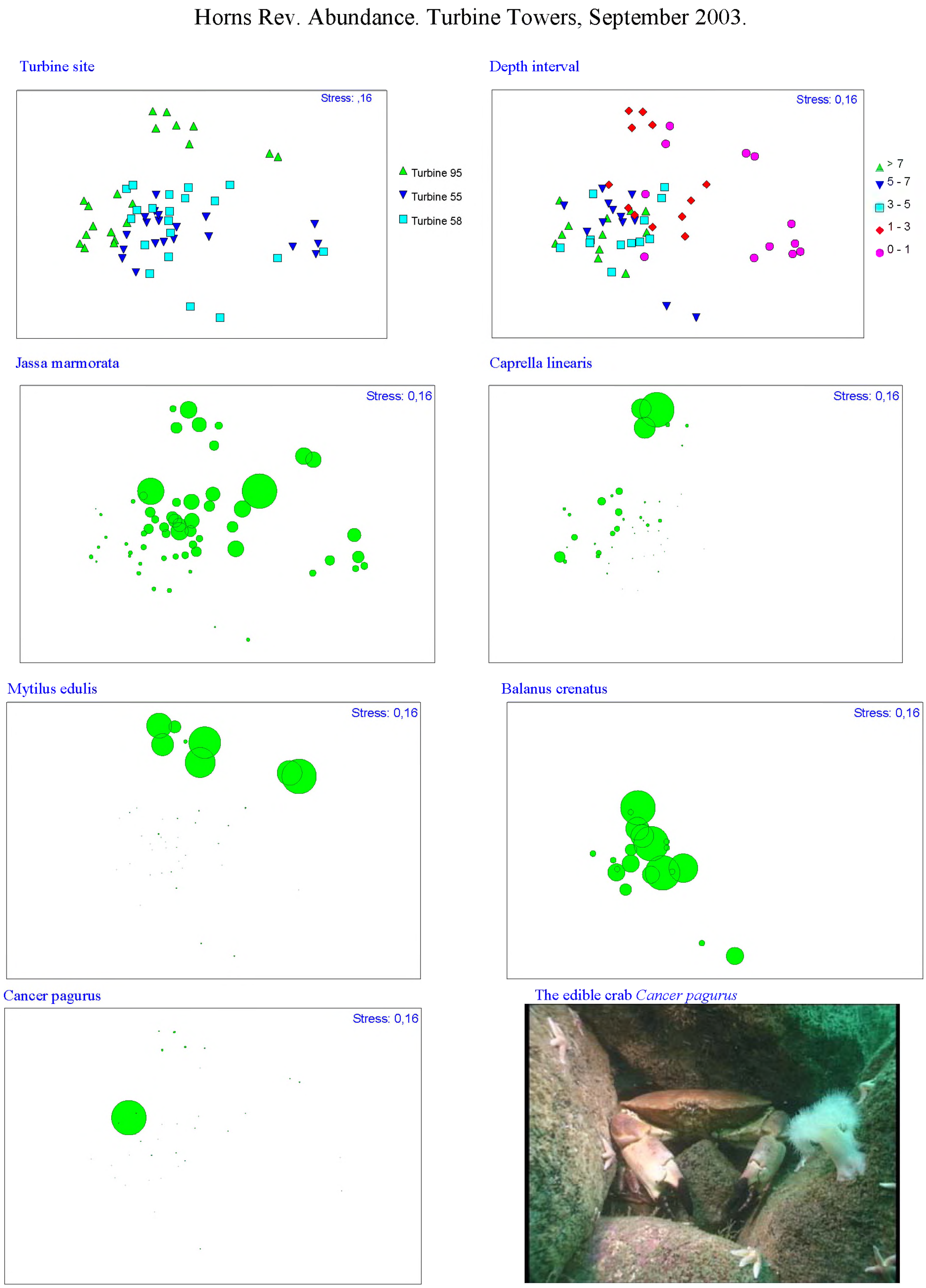


Figure 8. MDS plot of relative abundances at turbine towers showing sites and depth distribution of the five most abundant species in September 2003. The figure shows high abundances for Caprella linearis *and high abundances for* Mytilus edulis *at turbine site 95.* Jassa marmorata *is more evenly distributed in September among turbine sites. When recorded,* Balanus crenatus *is mainly found at turbine site 55.* Mytilus edulis *is almost exclusively found in depth zones from 1 to 3 m.*

A distinct zonation in the fauna communities in relation to different depth zones was observed, see figures 7–10, and a statistical difference (P<0.001) was shown between the zones in general. A small similarity (P<0.08) between the zones investigated was only shown for the depth zones from 3 to 7 m from the sea surface.

The statistical analysis showed no differences (P<0.32) concerning current regimes between the sampling at the two sides of the turbine towers – NNE and SSW, respectively.

Five species, the crustaceans *Jassa marmorata*, *Caprella linearis*, and *Balanus crenatus*, the edible crab *Cancer pagurus,* together with the common mussel *Mytilus edulis* made up a total of 95.4% to 99.9 % of the total abundance at each of the depth zones.

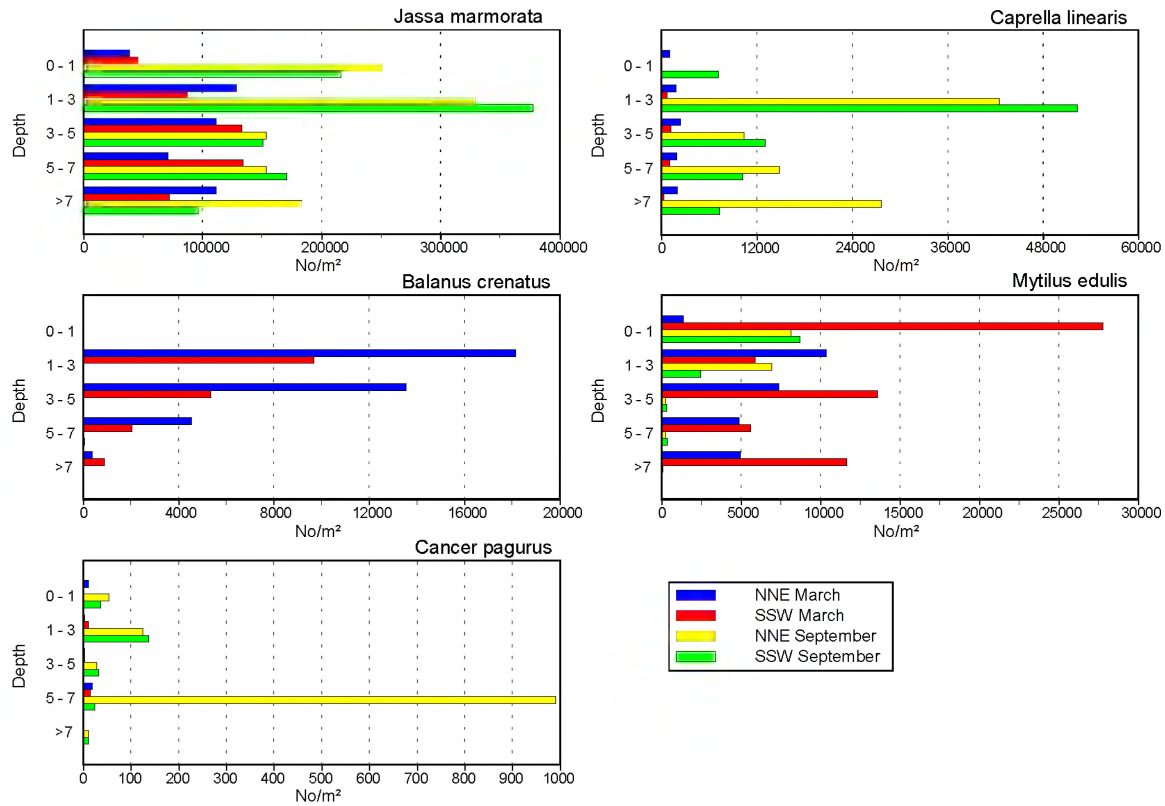


Figure 9. Depth distribution of the five most abundant species found at the turbine towers.

In March, *Jassa marmorata* was more or less evenly distributed and abundant in the depth zones from 1 to 7 m, whereas in September, this species was more frequent in the upper zones from 1 to 3 m, see figure 9. The biomass of *Jassa marmorata* was considerably higher in March than in September in all depth zones, see figure 10. In March, the average individual body weight of *Jassa marmorata* was 5.3 mg, whereas the body weight in September was only 0.7 mg. There was a general tendency towards a higher average body weight for the individuals in the uppermost depth zones, and thus a higher representation of mature individuals compared with the zones near the sea bottom.

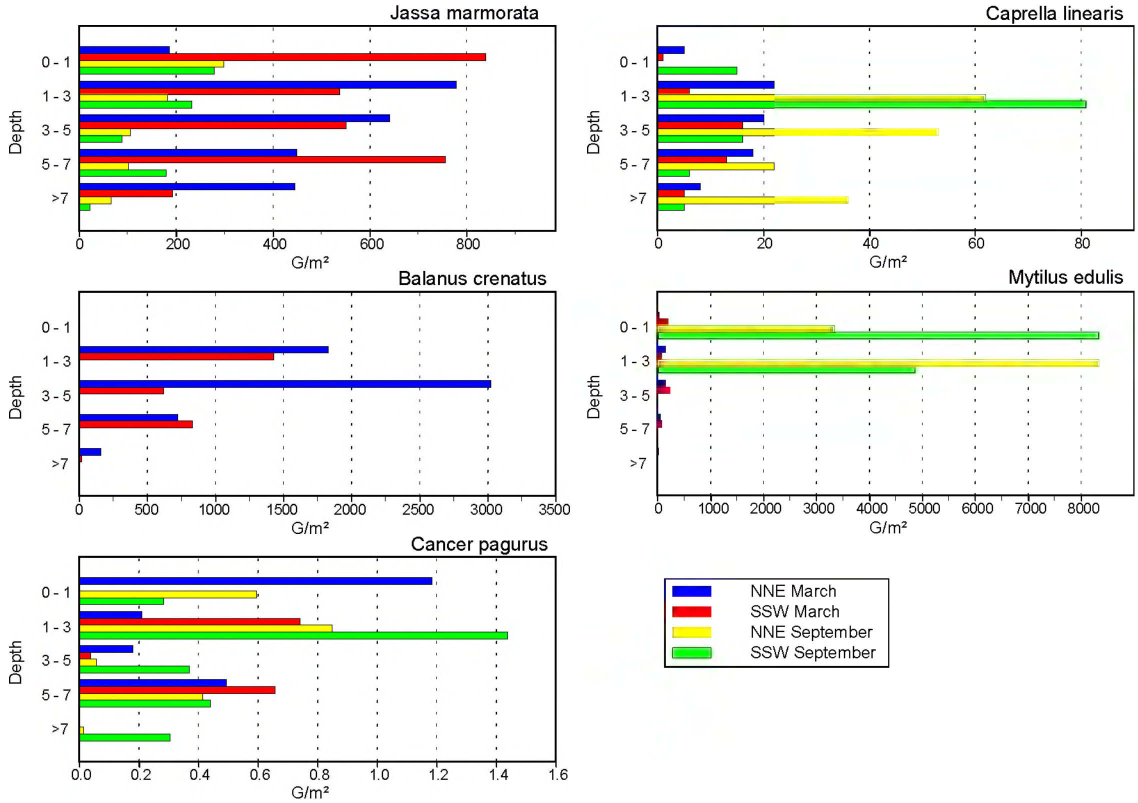


Figure 10. Depth distribution of biomass for the five most abundant species found at the turbine towers.

The distribution, abundance and biomass of *Caprella linearis* showed no clear pattern according to depth in March, whereas in September, the abundance was considerably higher in the depth zone 1 to 3 m below the sea surface than in any of the other depth zones, see figure 9. Unlike *Jassa marmorata*, the lowest abundance for *Caprella linearis* was found in the uppermost depth zone.

A distinct difference in abundance and biomass of the barnacle *Balanus crenatus* was found between the surveys in March and September, see figures 9 and 10. The barnacle was almost absent from all turbine towers in September and a large number of empty barnacles were observed on the tower surfaces. Mostly juveniles were found in September. The average individual body weight of *Balanus crenatus* was 22 mg in September compared with 207 mg in March. *Balanus crenatus* was absent in the uppermost depth zone, where a larger barnacle *Balanus balanus* was found in relatively high abundance and biomass in both of the two surveys. Unlike *Balanus crenatus*, *B. balanus* was found in the highest average body weight of 753 mg in September compared with 289 mg in March.

No clear pattern of the distribution of the common mussel *Mytilus edulis* was shown in March, although there was a tendency toward higher abundances at the sea surface, especially at turbine site 95, see figures 7 and 9. Most mussels found were juveniles 2–3 mm in length. The average individual body weight of *Mytilus edulis* in March was 11 mg. Only at turbine site 95 did some of the mussels reach a total length of more than 10 mm. In September, the distribution and abundance of *Mytilus edulis* showed a much more distinct and aggregated pattern, which was very pronounced at turbine site 95. A very high abundance of 25,000 ind./m^2 and a high biomass of 25,000 g/m^2 was found in the uppermost 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 number of *Mytilus edulis* was very high, especially on the banisters, whereas the coverage, abundance and biomass in the lower depth zones were very much reduced compared with the upper depth zone. The average body weight of *Mytilus edulis* in September was 903 mg and the mussels reached a total length of 40 mm. In September, as in March, the most abundant size class of mussels was juveniles of 3 to 4 mm in length. In general, only the smallest mussels were found in the lower depth zones, and the average body weight declined from 700–1,400 mg in the upper depth zones to 1–24 mg in the lower depth zones.

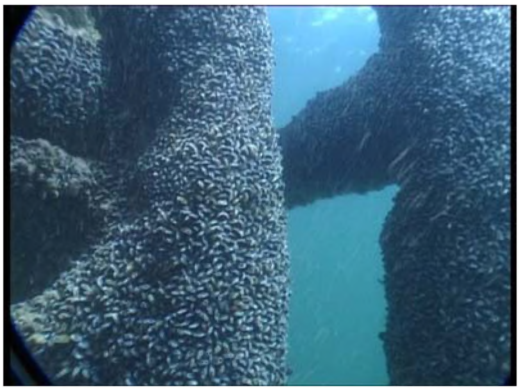


Photo 5. Growth of common mussel Mytilus edulis *at turbine tower 95 in September 2003.*

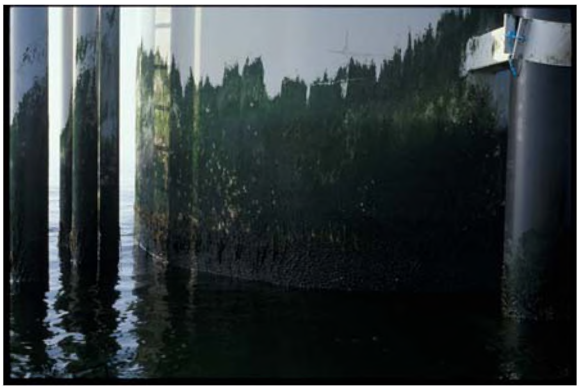


Photo 6. Green algal mats in the splash zone at turbine tower 55, inhabited by monocultures of the giant midge Telmatogeton japonicus. *March 2003.*

Just under the zone with *Mytilus edulis,* numerous starfish *Asterias rubens* were observed feeding on the mussels during the transect surveys. This was especially characteristic in September, where large *Asterias rubens* were found in the samples dominating the biomass. The highest biomass and the highest abundance of starfish, however, were in general found near the bottom of the turbine towers, locally reaching 92% of the total biomass registered. In March, the abundance of *Asterias rubens* was lower compared with the abundance in September. Single larger individuals in the samples in March caused a higher average individual body weight of 6,797 mg compared with 2,481 mg in September. As a result of the predation of *Asterias rubens*, large numbers of empty shells of *Mytilus edulis* were often observed at the seabed close to the turbine towers.

Even though the edible crab *Cancer pagurus* only constituted less than 1% of the total abundance and biomass registered, this species showed some interesting characteristics. In March, *Cancer pagurus* showed a very scattered distribution in general, and though juveniles were registered in low numbers in all depth zones at the turbine towers, larger individuals were not observed by divers at the transect surveys. In September, larger edible crabs were observed in all depth zones at the turbine towers. Edible crabs were most frequently found near the sea bottom 4 to 6 m below the sea surface. The locally registered average abundance of 508 ind./m^2 in this depth zone made this species the fifth most abundant species in the hard substrate habitats at Horns Rev in 2003. In September, the recording of some relatively larger individuals in depth zone 1 to 3 m influenced the depth distribution pattern between abundance and biomass, see figures 9 and 10. Only juveniles with an average body weight of 44 mg and 3.2 mg, respectively, were found in the samples in March and September.

The giant midge *Telmatogeton japonicus* observed in the splash zone in March was found in samples from September. Although it was registered in all zones except in the depth zone close to the sea bottom, it was significantly (P<0.001) more abundant in depth zone 0 to 1 m. In this zone, the average abundance was found to be 612 ind./m^2. In March, the abundance in the splash zone was estimated to be 1,000–2,800 ind./m^2.

Although the northern sea urchin *Strongylocentrotus droebachiensis* was observed to be relatively numerous during the transect surveys in March, juveniles were found to be relatively scarce on the turbine towers in both March and September, with average weights of 0.6 mg and 28 mg, respectively. In September, no larger sea urchins were observed.

At the turbine towers, only a few typical epifauna species were recorded as new to the hard bottom substrate fauna at Horns Rev in September. Compared with the species recorded in March, the bristle worm *Harmothoe imbricata*, and the mussels *Ostrea edulis* and *Hiatella arctica* were recorded as new epifauna species in September. These species were only recorded in relatively low numbers. In addition, the mussel *Venerupis senegalensis* and the masked crab *Corystes cassivelaunus* were recorded for the first time at Horns Rev. Only one small juvenile of the normally sand-dwelling masked crab *Corystes cassivelaunus* was recorded near the bottom at one turbine site.

The amphipod *Corophium crassicorne* and the mussels *Heteranomia squamula* and *Moerella donacina* registered from the scour protection in March were also found on the turbine towers in September.

In September, other typical epifauna species such as the slipper limpet *Crepidula fornicata* were observed in higher frequencies and recorded in larger abundance compared with March. Larger specimens of the slipper limpet were found in September than in March. The recorded average weight was 484 mg and 108 mg, respectively. The sea slug *Onchidoris muricata* was also found in higher abundance at the turbine towers in September compared with March.

Artificial differences in distribution and abundance pattern were observed for the hydrozoan *Tubularia indivisa* and the plumose sea anemone *Metridium senile* due to the fact that species identification was only possible in September.

3.4.2. Scour protection

A statistical difference (P<0.001) was found between the fauna communities at the scour protections at different turbine sites. Abundances of the crustaceans *Jassa marmorata*, *Caprella linearis* and *Balanus crenatus* contributed in particular to the dissimilarities between the turbine sites. However, the distribution and abundance of the common mussel *Mytilus edulis*, the sea anemones *Actiniaria* and to some degree the common starfish *Asterias rubens* were also of considerable importance. The five most important species constituted more than 98% of the total abundance and between 56% and 97% of the total biomass registered in March and September.

In March, an analysis showed statistical differences between the sampling localities at different distances from the turbine tower (P<0.03). Some similarities in community structure were shown between NNE 2 m and NNE 5 m (P<0.13) and between NNE 2m and SSW 5 m (P<0.06) in September. Some similarity (P<0.04) was shown between the fauna composition at NNE 0.5 m and at NNE 2 m. Within the 5 m zone from the towers, no distinct distribution patterns for abundance and biomass was found for the five most abundant species, see figures 11 and 12.

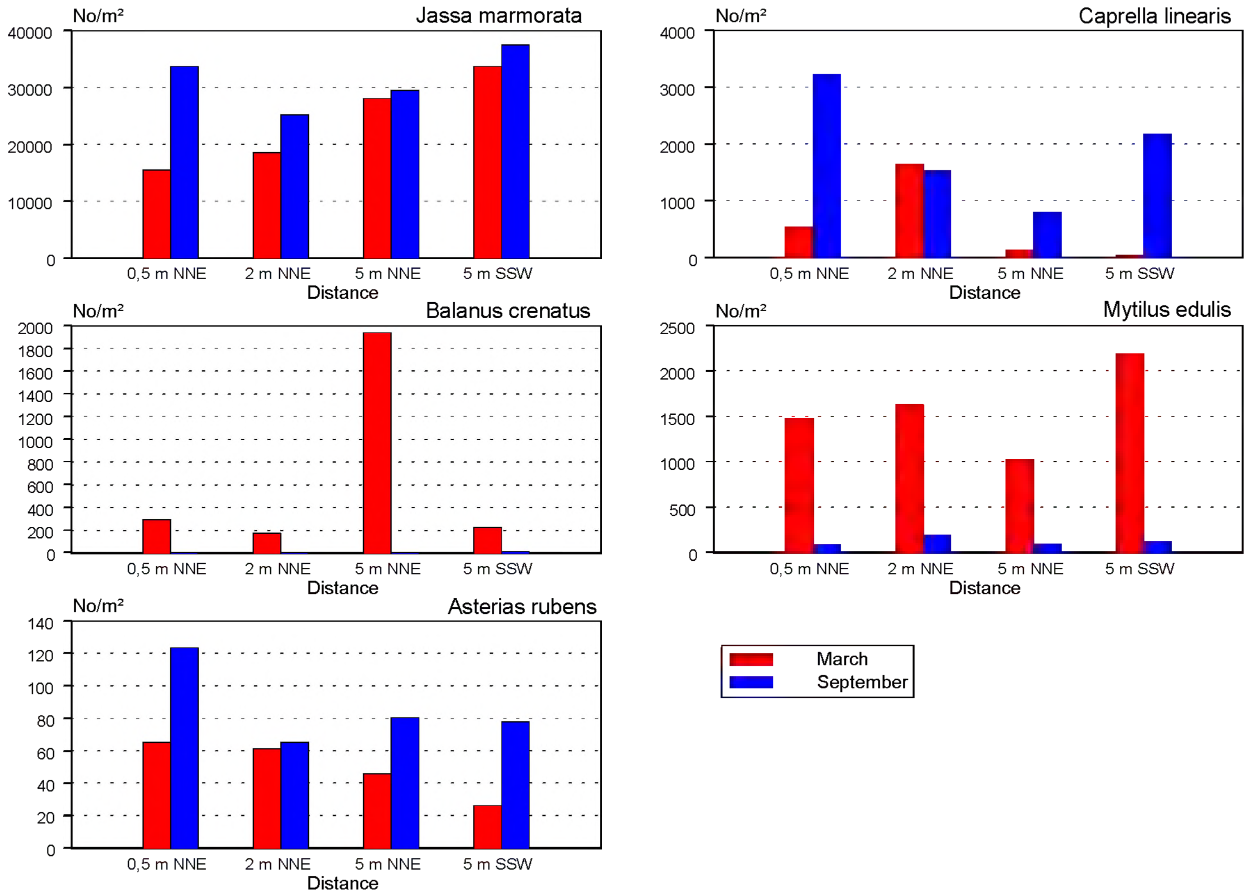


Figure 11. Distribution of the five most dominant species at the scour protection at different distances from turbine towers.

Photo 7. Boulders covered by tubes of the crustacean Jassa marmorata*. Individuals of the hydrozoan* Tubularia indivisa *are also noticeable. September 2003.*

Photo 8. Tubes of the bristle worm Lanice conchilega *in the seabed in close proximity to the scour protection. September 2003.*

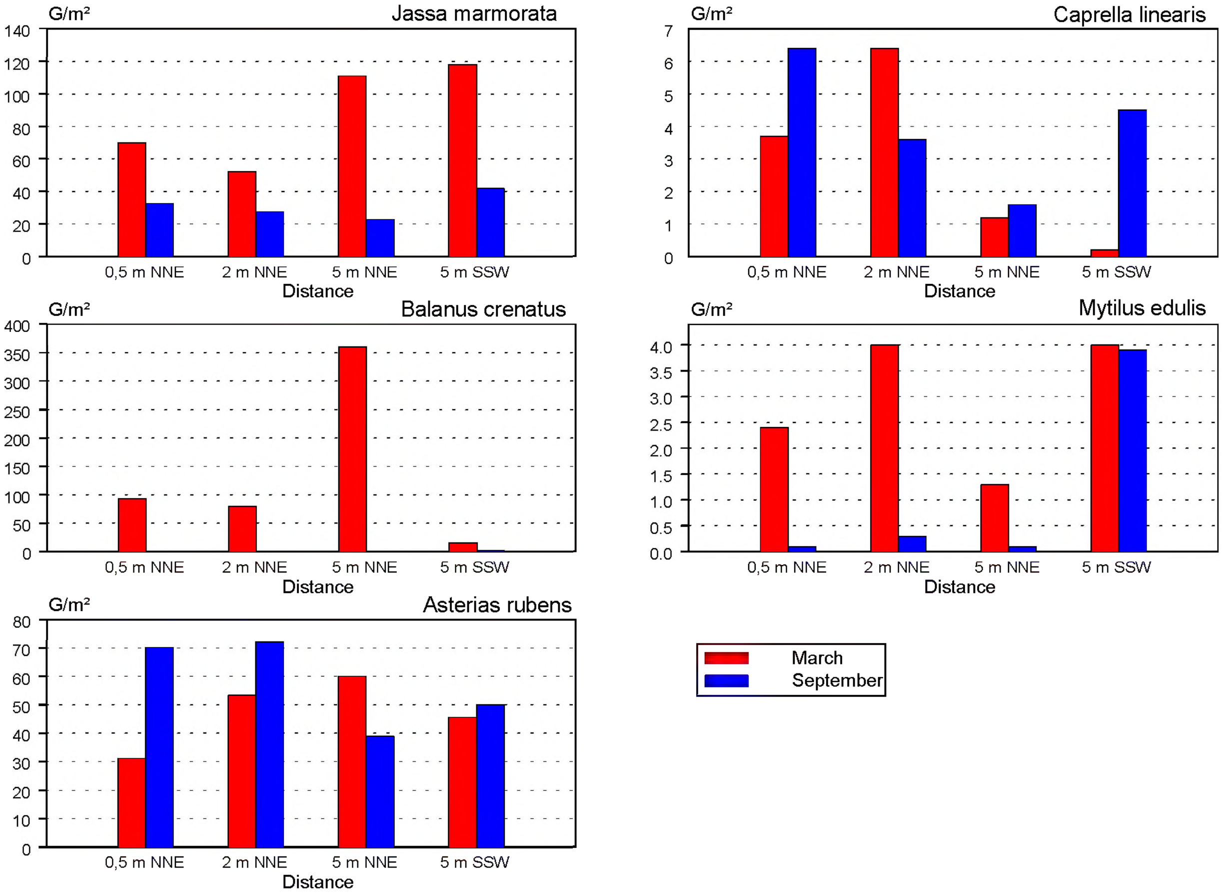


Figure 12. Distribution of biomass of the five most dominant species at the scour protection at different distances from turbine towers.

The statistical analysis of data from the transect surveys showed no differences between transect NNE and SSW. Statistical differences between the stations close to the turbine tower and stations at the edge of the scour protection were found. Close to the edge of the scour protections, no statistical differences were shown between stations across the zones with different sizes of stones. Three overlapping zones at the scour protections were identified. One distinct zone covered the distance from the turbine towers to 10 m from the towers ($P<0.58–0.98$), the second zone covered the distance from 6 to 12 m ($P<0.17–0.88$) and the last zone covered the distance from 10 to 16 m from the turbine towers ($P<0.08–0.10$). The decreasing coverage and frequency of *Jassa marmorata* towards the edge of the scour protection, and the occurrence of the sand dwelling bristle worm *Lanice conchilega* at the outer edge of the scour protection, contributed to the difference between the zones.

Abundance ind./m²		March 2003											
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	4,550	94.8	58,260	99.4	23,231	60.4	596	75.9	37,792	98.9	19,644	88.4
Caprella linearis	Crustacean	40	0.8	135	0.2	3,240	8.4	15	1.9	115	0.3	.	.
Mytilus edulis	Bivalve	6	0.1	27	0.0	7,054	18.3	.	.	17	0.0	2,379	10.7
Balanus crenatus	Crustacean	19	0.4	.	.	3,881	10.1	2	0.3	6	0.0	54	0.2
Asterias rubens	Echinoderm	77	1.6	73	0.1	8	0.0	65	8.2	75	0.2	.	.
Cancer pagurus	Crustacean	.	.	4	0.0	2	0.0	.	.	2	0.0	.	.
Pomatoceros triqueter	Bristle worm	10	0.2	2	0.0	2	0.0	8	1.1	2	0.0	.	.
Total		4,702	97.9	58,502	99.8	37,419	97.3	685	87.3	38,008	99.5	22,077	99.3

Abundance ind./m²		September 2003											
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	22,185	97.1	35,729	97.5	22,365	89.1	8,440	91.4	32,135	84.1	68,435	93.8
Caprella linearis	Crustacean	202	0.9	510	1.4	2,067	8.2	427	4.6	5,644	14.8	2,756	3.8
Mytilus edulis	Bivalve	33	0.1	73	0.2	56	0.2	40	0.4	81	0.2	463	0.6
Balanus crenatus	Crustacean	2	0.0	6	0.0	8	0.0	6	0.1	8	0.0	33	0.0
Asterias rubens	Echinoderm	100	0.4	65	0.2	127	0.5	63	0.7	85	0.2	81	0.1
Cancer pagurus	Crustacean	4	0.0	10	0.0	31	0.1	2	0.0	.	.	79	0.1
Pomatoceros triqueter	Bristle worm	58	0.3	48	0.1	4	0.0	.	.	2	0.0	.	.
Total		22,585	98.9	36,442	99.5	24,658	98.3	8,977	97.2	37,956	99.4	71,848	98.5

Table 11. Abundances of the most dominant species at scour protections at different turbine sites in March and September 2003.

Biomass g/m² WW		March 2003											
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	13.413	20.8	196.362	80.8	113.135	10.0	1.732	7.9	127.700	71.4	75.390	84.8
Caprella linearis	Crustacean	0.220	0.3	0.953	0.4	15.391	1.4	0.113	0.5	0.683	0.4	.	.
Mytilus edulis	Bivalve	0.001	0.0	0.014	0.0	13.704	1.2	.	.	0.011	0.0	3.864	4.3
Balanus crenatus	Crustacean	8.854	13.8	.	.	810.608	72.0	0.001	0.0	0.006	0.0	3.871	4.4
Asterias rubens	Echinoderm	36.943	57.4	39.722	16.4	150.717	13.4	10.068	46.1	48.341	27.0	.	.
Cancer pagurus	Crustacean	.	.	0.124	0.1	0.049	0.0	.	.	0.019	0.0	.	.
Pomatoceros triqueter	Bristle worm	0.092	0.1	0.033	0.0	0.029	0.0	0.231	1.1	0.003	0.0	.	.
Total		59.523	92.5	237.209	97.7	1,103.634	98.0	12.145	55.6	176.762	98.9	83.125	93.5

Biomass g/m² WW		September 2003											
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	14.031	11.7	28.036	23.2	17.844	4.3	4.936	8.9	30.071	25.9	92.724	50.2
Caprella linearis	Crustacean	0.196	0.2	0.646	0.5	2.416	0.6	0.544	1.0	10.775	9.3	9.519	5.2
Mytilus edulis	Bivalve	0.068	0.1	0.055	0.0	5.706	1.4	0.043	0.1	0.030	0.0	0.568	0.3
Balanus crenatus	Crustacean	0.000	0.0	0.024	0.0	1.807	0.4	0.061	0.1	0.370	0.3	1.435	0.8
Asterias rubens	Echinoderm	62.253	52.0	50.556	41.8	132.754	31.8	22.392	40.2	49.233	42.4	30.106	16.3
Cancer pagurus	Crustacean	0.068	0.1	0.032	0.0	0.117	0.0	0.005	0.0	.	.	0.325	0.2
Pomatoceros triqueter	Bristle worm	0.818	0.7	0.724	0.6	0.083	0.0	.	.	0.001	0.0	.	.
Total		77.435	64.7	80.072	66.3	160.727	38.5	27.980	50.3	90.481	77.9	134.676	72.9

Table 12. Biomasses of the most dominant species at scour protections at different turbine sites in March and September 2003.

The differences in abundance of *Jassa marmorata* and *Caprella linearis* were generally the main factor contributing to the dissimilarity between the sampling sites, see table 11 and figures 13 and 14. In March, differences in the abundance of *Mytilus edulis* also contributed to the dissimilarity between sampling sites.

Jassa marmorata was most abundant at turbine site 92, locally up to 93,883 ind./m^2. At most sampling sites, the abundance of *Jassa marmorata* was higher in September, see figure 11 and table 11, whereas the biomass was considerably higher in March, see figure 12 and table 12. In March, the distribution of *Jassa marmorata* showed a tendency towards increasing abundances and biomass with increasing distances from turbine towers. The average individual body weight in March was 3.6 mg compared with 1.0 mg in September.

In March, *Caprella linearis* was absent from samples from the scour protection at turbine site 92, but in September, it was recorded in high abundance at that site. Locally, *Caprella linearis* was found in abundance of 12,683 ind./m^2. Although most juveniles of *Caprella linearis* were found in September, with an average body weight of 2.1 mg compared with 4.9 mg in March, both abundance and biomass were highest in September, see figures 11 and 12, and tables 11 and 12.

Figure 13. MDS plots of relative abundance concerning differences between turbine sites of five of the most important species at the scour protections in March 2003. The figure shows partly overlapping groups of samples for different turbine sites; scour 33, 92 and 95 differentiating from other scours. High abundances of Jassa marmorata *are shown at turbine site 58, 91 and 95. For* Caprella linearis, Mytilus edulis *and* Balanus crenatus *high abundances are also shown at turbine site 95, whereas at this site the predator* Asterias rubens *is relatively low in abundance.*

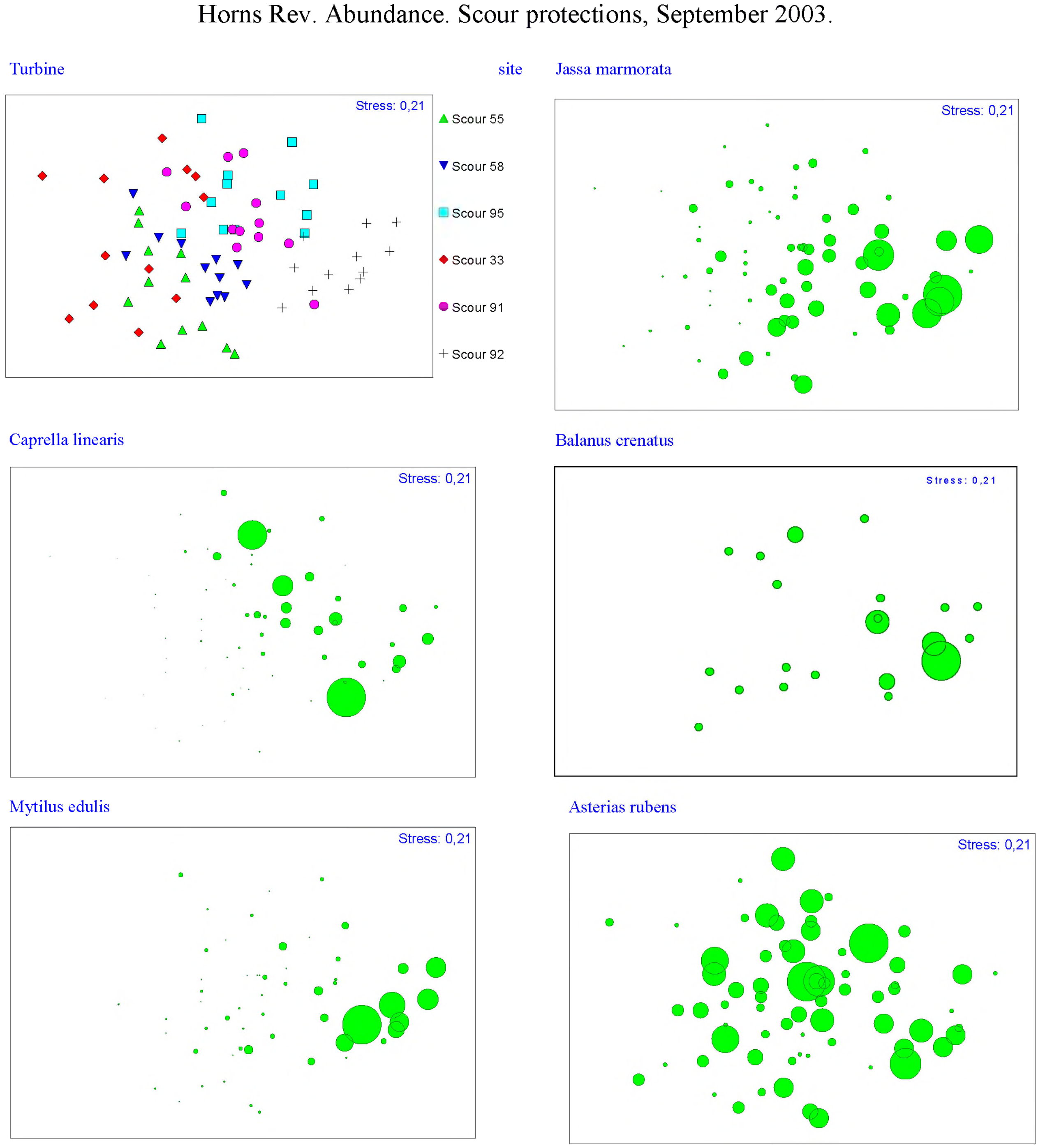


Figure 14. MDS plots of relative abundance concerning differences between turbine sites of five of the most important species at the scour protections in September 2003. The figure shows partly overlapping groups of samples for different turbine sites. High abundances of Mytilus edulis, *and some* Jassa maramorata *and* Balanus crenatus *are shown at turbine site 92, whereas the starfish* Asterias rubens *and* Caprella linearis *show no distinct distribution pattern among the turbine sites.*

Balanus crenatus was absent from the scour protections at turbine sites 58 and 92 and low in numbers at turbine sites 55, 33 and 91 in March. Only at turbine site 95, did *Balanus crenatus* reach a considerable abundance, see table 11 and figure 13. In September, *Balanus crenatus* was found, although in small numbers at all turbine sites. No clear distribution pattern was shown except for a marked difference in abundance between March and September, see figures 11 and 12. The mean average body weight varied from 207 mg in March to 57 mg in September.

The common mussel *Mytilus edulis* showed an aggregated distribution in March in particular. Absent or almost absent from most turbine sites, juvenile spat were very abundant at turbine site 95, reaching local abundances of up to 9,683 ind./m^2, see figure 13. The medium size of the mussels was 2–4 mm reaching a maximum size of 15 mm and an average weight of 1.8 mg. In September, small *Mytilus edulis* with an average weight of 8.6 mg were found at all sites, with the highest numbers at turbine site 92. No larger mussels were observed along the transects.

In March, the starfish *Asterias rubens* was aggregated in distribution, absent at turbine tower 92 and very low in numbers at turbine site 95, see figure 13. Observation from the transect surveys showed that *Asterias rubens* was found at turbine site 92, but mainly recorded at distances from 10 to 14 m from the turbine tower at the edge of the scour protection. In September, *Asterias rubens* showed a more even distribution between the turbine sites, see figure 14, although an aggregated distribution was found at the individual sampling stations at the scour protections. *Asterias rubens* was observed in high coverage, and maximum abundances from 40 to 150 ind./m^2 were found at each of the turbine sites.

Typical epifauna species such as the amphipods *Stenothoe marina* and *Atylus swammerdami*, the sea spider *Phoxichilidium femoratum* and the mussel *Hiatella arctica* were found on the scour protections in September only. Small larvae (1.6 mg) of the giant midge *Telmatogeton japonicus*, a typical member of the splash zone community, were found in surprisingly small numbers at the scour protection close to the turbine tower at turbine site 91 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 with March. The edible crab *Cancer pagurus*, the common shore crab *Carcinus maenas*, the harbour crab *Liocarcinus depurator* and the sea slug *Onchidoris muricata* were also more abundant and more widely distributed in September compared with 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 turbine towers in September.

Juveniles of the northern sea urchin *Strongylocentrotus droebachiensis* were apparently more abundant in September than in March, whereas the common whelk *Buccinum undatum* was not observed at the scour protection in September.

Green egg masses of bristle worms (*Phyllodocidae*) probably *Phyllodoce groenlandica*, most frequently attached to stones at the edge of the scour protection at turbine site 95, were only recorded in March. Egg masses of the sea slug *Onchidoris muricata* and other sea slugs were solely recorded in March.

4. Discussion

Compared with 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. No larger 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 (Elsam, 2002). A few numbers of larger mobile species like the edible crab *Cancer pagurus*, hermit crab *Pagurus bernhardus*, harbour crab *Liocarcinus depurator*, brown shrimp *Crangon crangon*, the common whelk *Buccinum undatum* and the starfish *Asterias rubens* were occasionally observed in the area (Elsam, 2002).

In the surveys in 2003, all of the larger species previously observed were found on the hard substrates structures inside the wind farm area except for the brown shrimp *Crangon crangon* (L.). The larger species were generally found more frequently and in higher numbers in the surveys in 2003 compared with the infauna surveys. *Crangon crangon* is usually found on sandy substrates and is not expected as part of a fouling community. Only a few members found in the infauna *Goniadella-Spisula* community, typical for the sandy sea bottom in the Horns Rev area (Elsam Engineering, 2004c), were registered at the hard bottom substrate at the turbine foundations.

After construction of the wind farm, it was found that the hard substrates are used as hatchery or nursery grounds for several species. These include the edible crab *Cancer pagurus*, probably the masked crab *Corystes cassivelaunus,* some bristle worms like *Phyllodoce groenlandica* and probably also the northern sea urchin *Strongylocentrotus droebachiensis*. The sea urchin is characteristic of stone reefs and well adapted to the introduced hard substrates at Horns Rev.

Numbers of the edible crab, especially juveniles, were found on the turbine towers in September, and larger individuals were observed in caves and crevices among stones at the scour protection. It is possible that *Cancer pagurus* actually bred at the turbine sites. Studies off the Dutch Coast have also shown that mature individuals of *Cancer pagurus* quickly invaded newly established artificial reefs (Leewis and Hallie, 2000).

Within newly established heterogeneous habitats such as the hard substrates structures at Horns Rev, recruitment variability influences the abundance of individuals and community structure of epibenthic assemblages (Chiba and Noda, 2000), which often results in statistical differences between sites. Mosaics of sessile organisms form the faunal assemblages at each turbine site, and the faunal assemblages at all turbine sites at Horns Rev were generally highly variable and shown to be different.

Differences were also found in the epibenthic assemblages between vertical structures such as turbine towers, and horizontal structures such 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 in the epibenthic communities at the turbine towers was observed, which in general, had some similarities with the common communities in the littoral and upper sublittoral zones on rocky shores or stony coast in the North Sea region or in the northern Kattegat. The splash or wash zone was characterised by dense mats of green algae (*Urosporia pennicilliformis*) and assemblages or almost monocultures of the giant midge *Telmatogeton japonicus*. *Telmatogeton japonicus* has not previously been recorded in Denmark and it was thought that this species might have been introduced from Germany by the piling gear. Personal observations indicated, however, that this species might be common in Denmark at breakwaters along the Danish North Sea coast. In northern Jutland, at Lønstrup, *Telmatogeton japonicus* was found on boulders at breakwaters and coast defence structures in numbers comparable with the numbers found at the turbine towers at Horns Rev. In summer 2003, observations were made on foraging swallows probably feeding on swarming adults of *Telmatogeton japonicus* close to the water surface at the turbine towers (NERI, 2003).

In the upper part of the turbine tower in the littoral zone, the community was characterised in part by a high number of the common mussel *Mytilus edulis* and vegetation of the green algae *Enteromorpha*, *Blidingia minima* and *Ulvae lactuca* and the brown algae *Petalonia fascia.* The barnacles *Balanus crenatus* and *Balanus balanus* and the brown algae *Pilayella littoralis* and *Ectocarpus* were also very common and often dominating in this zone.

In the zone just beneath the upper zone, a large number of the starfish *Asterias rubens* was often observed feeding on the mussels from beneath the tower, making the upper zones with mussel growth very distinct. Other studies have shown that *Asterias rubens* is often the key-stone predator controlling the vertical distribution and abundance in littoral and sublittoral mussel beds (Saier, 2001). The marked reduction of barnacles from March to September might also be the result of predation from smaller starfish.

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 at hard bottom sub-strate at Horns Rev. In other surveys, tube dwelling amphipods (*Jassa sp.*) were found domi-nating the epifauna communities at artificial submerged structures (Leewis and Hallie, 2000; Leewis et al., 2000). The cosmopolitan *Jassa marmorata*, not previously recorded in Den-mark, has been found on artificial hard substratum in the Mediterranean (Athanasios and Cha-riton, 2000) and the USA (Duffy and Hay, 2000). Three species of *Jassa* are known from the North Sea area, and taxonomy of *Jassa* has proved to be problematic (MarLIN database). Dif-ferent growth stages show marked variations in shape and relative proportions of the taxo-nomically useful characteristics. Some of the previous records of *Jassa falcata*, very common in Denmark, may refer to *Jassa marmorata*.

Due to its large abundance, *Jassa marmorata* might contribute significantly to the diet of a number of other invertebrates and vertebrates, including fish and predators such as the edible crab, the common shore crab and the harbour crab. The diet of the bib (*Trisopterus luscus*) is small crustaceans (www.fishbase.org). Other studies have shown even higher abundance (up to 8 million per m^2) of this species (Tish, 2003). Together with *Jassa marmorata*, the skeleton shrimp *Caprella linearis* are often found in high numbers.

In the lower zone at the turbine towers, mobile species like the edible crab and smaller star fish were often abundant together with the bristle worm *Pomatoceros triqueter*. *Pomotoceros triqueter* is predominately a sublittoral species and is considered to be a primary fouling or-ganism that quickly makes use of available space (Crisp, 1965; Burnell et al., 1991).

A significant but weak impact of different hydraulic current regimes was shown on the fauna community on the scour protection, caused by the turbine towers. Very high variations in fau-nal assemblages between the sampling sites, due to the rather immature fouling community, weakened this conclusion. In September, however, the analysis showed relatively higher similarities between fauna composition at distances away from, rather than closer to turbine towers, indicating an impact due to alteration of current regimes. No impact was shown on faunal assemblages due to different exposure on each side of the turbine towers.

A greater similarity between some of the turbine sites shown in September compared with March might be a result of the succession approaching stability in the fouling communities on the artificial substrates. Primary colonisers such as the hydrozoan *Tubularia indivisa*, most likely also found in March, showed a significantly higher abundance in September. In other studies on artificial reefs, *Tubularia indivisa* was found on the substrates a few weeks after deployment (Lewis and Hallie, 2000). A rapid initial colonisation of the common mussel *Mytilus edulis*, as shown for the turbine towers at Horns Rev, was also shown in studies in the southern Baltic (Chojnacki, 2000). It was also shown at Horns Rev that predation from the starfish *Asterias rubens* especially, was one of the main factors contributing to dramatic changes in the fouling communities between sites. This keystone predator, controlling the area distribution, vertical distribution, population abundance and size distribution of at least one prey target *Mytilus edulis*, was also one of the primary colonisers. Smaller starfish were probably the main controller of the barnacles, which showed marked variations in population size and distribution. Studies have indicated (Leewis, 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.

A marked succession in the number of fish species was also observed from the survey in March to the survey in September, indicating that an increased number of fish species have used the turbine structures as refuges and foraging places. Shoals of bip were observed presumably partly feeding on the crustaceans on the scour protection together with shoals of cod and whiting. Individuals of species like the rock gunnel and the dragonet were more often found inhabiting caves and crevices between the stones. Similar observations were made in other studies (Leewis and Hallie, 2000). It is estimated that the availability of food for fish in the area has increased by a factor of 8 compared with that of the normal soft seabed fauna in the wind farm area after the introduction of the hard substratum at Horns Rev. In September 2003, the average infauna biomass in the wind farm area was 185 g/m^2 (Elsam Engineering, 2004c) compared with an average of 1,493 g/m^2 of the fouling community at the hard substratum at the turbine sites. An increase of fish production related to the presence of the hard substratum is therefore considered possible.

Observations indicate that harbour porpoises have utilised the area close to the turbine sites as a foraging area. Searching for sand eels, they blow shallow hollows in the seabed, leaving sand tubes of the bristle worm *Lanice conchilega* exposed. Such observations have not previously been made in connection with the infauna surveys at Horns Rev.

Although observations have been made on the red mullet (*Mullus surmuletus*), normally found in the Mediterranean, and although unusually warm weather conditions characterised summer 2003, there are no indications that factors other than the change in habitat types have contributed to the introduction of the new species observed in the Horns Rev area. During the summer, the red mullet is registered even in high numbers in Norwegian waters (Moen and Svensen, 2003) and the giant midge is also known from Norway and Iceland (Lindegaard, 1997; Murray, 1999).

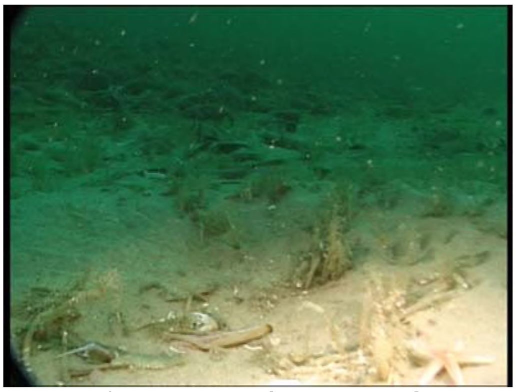


Photo 9. Harbour porpoise foraging area?

Photo 10 Dragonet on scour protection in September 2003.

Photo 11. Rock gunnel on scour protection in September 2003.

Photo 12. Shorthorn sculpin on scour protection in September 2003.

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.

The introduction of epifouling communities has increased the general biodiversity in the wind farm area.

New species have been introduced, and only a few members of the infauna community were registered at the hard bottom substrate at the turbine foundations. New species not previously recorded in Denmark were found on the turbine constructions. The giant midge *Telmatogeton japonicus* inhabited the green algal mats in the splash zones at the turbine towers and the small crustacean *Jassa marmorata* was shown to be the most abundant species at the hard bottom substrates.

The hard bottom substrate provides habitats such as hatchery and nursery grounds for larger and more mobile species like the edible crab *Cancer pagurus*, previously recorded in the area.

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

No impact from differences in hydraulic regimes around turbine towers was found on epifouling communities.

A significant vertical zonation was found in epifouling communities at the turbine towers. The upper part of the turbine towers was characterised by high numbers and high biomass of the common mussel *Mytilus edulis* and vegetation cover of green and brown algae. At the lower part of turbine towers, the starfish *Asterias rubens* and the edible crab were often found in numbers.

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

Primary colonisers dominated the epifauna communities, and 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.

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

A marked increase in fish fauna diversity was found from the survey in March to the survey in September 2003. Shoals of cod and bib were often observed at the scour protections, as well as individuals of benthic fish species.

6. References

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Appendices

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 turbine tower.

March 2003

Location	Sampling date	"WGS84_MIN_Y"	WGS84_MIN_X"	Actual depth (m)	Programme	Erected date
Turbine 33	140303–270303	55°29.613'	07°49.522'	9.2	*	150702
Turbine 55	160303–270303	55°29.025'	07°50.740'	7.9–8.4	**	300702
Turbine 58	180303–270303	55°28.129'	07°50.948'	6.3–7.6	**	020802
Turbine 91	150303	55°30.241'	07°52.573'	5.1–6.0	*	210502
Turbine 92	130303	55°29.827'	07°52.675'	5.7	*	190802
Turbine 95	170303–280303	55°29.046'	07°52.854'	7.0–7.5	**	220802

September 2003

Location	Sampling date	"WGS84_MIN_Y"	WGS84_MIN_X"	Actual depth (m)	Programme
Turbine 33	100903	55°29.613'	07°49.522'	9.2	*
Turbine 55	160903	55°29.025'	07°50.740'	7.9–8.4	**
Turbine 58	160903	55°28.129'	07°50.948'	6.3–7.6	**
Turbine 91	040903	55°30.241'	07°52.573'	5.1–6.0	*
Turbine 92	040903	55°29.827'	07°52.675'	5.7	*
Turbine 95	050903	55°29.046'	07°52.854'	7.0–7.5	**

Appendix 2. Meteorological and Hydrographical Data

March 2003

Location	Date	Current		Wind		Secchi depth m	Wave height	Adjusted Secchi depth m
		Direction	m/sec	Direction	m/sec			
Turbine 33	140303	N	0.40	SW	2	2.4	0.2	2.6
	270303	ENE	0.40	ESE	3	2.8	0.2	3.0
Turbine 55	160303	N	0.40	SW	4	2.4	0.5	2.9
	270303	SSW	0.40	N	3	4.8	0.1	5.0
Turbine 58	180303	S	0.80	NNW	5–6	2.2	0.5	2.6
	270303	NNW	0.40	NNE	3	3.5	0.2	3.8
Turbine 91	150303	N	0.40	SW	0–2	2.3	0	2.3
Turbine 92	130303	N	0.40	SE	1	1.8	1.0	2.5
Turbine 95	170303	S	0.20	NNE	4–6	2.2	0.3–0.7	2.8
	180303	NNW	0.40	NNE	2	3.5	0.2	3.8

September 2003

Location	Date	Current		Wind		Secchi depth m	Wave height	Adjusted Secchi depth m
		Direction	m/sec	Direction	M/sec			
Turbine 33	100903	NNE	-	SW	6	6	0.7	7.7
Turbine 55	160903	NNE	-	NW	8-10	4	1.2-1.5	6.4
Turbine 58	100903	NNE	-	SW	6	6	0.7	7.7
Turbine 91	040903	-	-	SW	< 5	4	< 0.5	4.8
Turbine 92	040903	-	-	SW	< 5	4	< 0.5	4.8
Turbine 95	050903	-	-	SW	< 5	4	< 0.5	4.8

Appendix 3. Species List

Appendix 3.1. Algae

Complete list of species. Horns Rev 2003

Group	Taxon	Author	March 2003	September 2003	Common Danish Name	Common English Name
Red algae						
	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	Tæt rødsky	
Braun algae						
	Pilayella littoralis	Kjellman	x		Duntang	
	Ectocarpus sp.			x	vatalge	
	Petalonia fascia	(O.F. Müller)	x	x	Alm. båndtang	Sea petals
	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	
	Enteromorpha sp.		x	x	Rørhinde	
	Ulva lactuca	L.		x	Søsalat	Green laver
	Urospora penicilliformis	Areschoug	x		Grøn frynsealge	
	Cladophora sp.			x	Vandhår	Slobán

Appendix 3.2. Fish

Complete list of species. Horns Rev 2003

Group	Taxon	Author	March 2003	September 2003	Test fishing	Common Danish Name	Common English Name
Actinopterygii							
	Gadus morhua	L.		x	x	Alm. Torsk	Atlantic cod
	Trisopterus luscus	L.		x	x	Skægtorsk	Bib
	Merlangius merlangus	L.		x	x	Hvilling	Whiting
	Pollachius virens	L.		x		Sej	Pollack
	Myoxocephalus scorpius	L.		x	x	Alm. Ulk	Shorthorn sculpin
	Agonus cataphractus	L.	x	x		Panserulk	Hooknose
	Trachurus trachurus	L.		x		Hestemakrel	Horse mackerel
	Mullus surmuletus	L.		x		Stribet mulle	Striped red mullet
	Symphodus melops	L.		x		Savgylte	Corkwing wrasse
	Ctenolabrus rupestris	L.		x	x	Havkaruds	Goldsinny-wrasse
	Zoarces viviparus	L.	x	x		Ålekvabbe	Viviparous blenny
	Pholis gunnellus	L.	x	x		Tangspræl	Rock gunnel
	Callionymus lyra	L.		x		Fløjfisk	Dragonet
	Pomatoschistus minutus	Pallas		x		Sandkutling	Sand goby

Appendix 3.3. Benthos

Complete List of species. Horns Rev 2003

Group	Taxon	Author	Samples	Transects	Spring 2003	Autumn 2003	Common Danish name	Common English name
HYDROZOA								
	Hydrozoa indet.		x	x	x	x		
	Tubulariidae indet.		x		x			
	Tubularia indivisa		x	x	(x)	x		
	Thecata indet.		x		x			
	Campanulariidae indet.		x		x	x		
ANTHOZOA								
	Anthozoa indet.		x		x			
	Actiniaria indet.		x	x	x	x		
	Metridium senile	L.		x	x	x	Sønellike	Plumose anemone
NEMERTINI								
	Nemertini indet.		x	x	x	x		
NEMATODA								
	Nematoda indet.		x			x		
POLYCHAETA								
	Harmothoe imbricata	(L.)	x			x		
	Harmothoe impar	(Johnston)	x		x	x		
	Phyllodocidae indet.		x	x	x	x		
	Phyllodoce groenlandica	Ørsted	x		x	x		
	Eulalia viridis	(L.)	x		x	x		
	Syllidae indet.		x			x		
	Nereididae indet.		x			x		
	Nereis pelagica	L	x			x		
	Neanthes virens	(Sars)	x			x		
	Polydora ciliata	Johnston	x			x		
	Chaetopterus norvegicus	Sars	x		x			
	Capitella capitata	(Fabricius)	x		x	x		
	Lanice conchilega	(Pallas)		x	x	x		
	Pomatoceros triqueter	(L.)	x	x	x	x	Kalkrørsorm	
PYCNOGONIDA								
	Phoxichilidium femoratum	(Rathke)	x			x		
CIRRIPEDIA								
	Verruca stroemia	O.F. Müller	x		x	x		
	Balanus balanus	L.	x		x	x		
	Balanus crenatus	Bruguiere	x	x	x	x		
	Balanus sp.			x		x		
DECAPODA								
	Caridea indet.		x			x		
	Corystes cassivelaunus	Pennant	x			x	Maskekrabbe	Masked crab
	Cancer pagurus	L.	x	x	x	x	Taskekrabbe	Edible crab
	Carcinus maenas	*L.*		*x*	x	x	Strandkrabbe	Common shore crab
	Liocarcinus depurator	*(L.)*		*x*	x	x	Svømmekrabbe	Harbour crab
	Pagurus bernhardus	*L.*		*x*	x	x	Erimitkrebs	Hermit crab
AMPHIPODA								
	Corophium crassicorne	Bruzelius	x		x	x		
	Aoridae indet.		x		x			
	Stenothoe marina	Bate	x			x		
	Jassa marmorata	Holmes	x	x	x	x		
	Atylus swammerdami	Milne-Edwards	x			x		
	Caprella linearis	L.	x	x	x	x		
	Hyperia galba	Montagu	x			x		
CHIRONOMIDAE								
	Telmatogeton japonicus	Tokunaga	x	x	x	x		
GASTROPODA								
	Gastropoda indet.			x	x	x		
	Rissoidae indet.		x		x	x		
	Crepidula fornicata	(L.)	x	x	x	x	Tøffelsnegl	Slipper limpet
	Polinices sp.		x			x		
	Buccinum undatum	L.		x	x		Alm. Konk	Common whelk
	Nudibranchia indet.		x	x	x	x		
	Onchidoris muricata	(Müller)	x	x	x	x		
	Aeolidacea indet.			x	x			
BIVALVIA								
	Bivalvia indet.		x		x			
	Mytilus edulis	L.	x	x	x	x	Blåmusling	Common mussel
	Ostrea edulis	L.	x			x	Europæisk østers	Native oyster
	Heteranomia squamula	(L.)	x		x	x	Lille sadelmusling	
	Moerella donacina	(L.)	x		x	x		
	Venerupis senegalensis	(Gmelin)	x			x		
	Hiatella arctica	(L.)	x			x		
	Thracia phaseolina	(Lamarck)	x		x			
BRYOZOA								
	Bryozoa indet.		x	x	x	x		
	Electra pilosa	(L.)	x	x	x	x		
ECHINODERMATA								
	Asterias rubens	L.	x	x	x	x	Alm. Søstjerne	Common starfish
	Ophiura albida	Forbes	x		x			
	Strongylocentrotus droebachiensis	(O.F. Müller)	x	x	x	x		Northern sea urchin
	Echinocardium cordatum	(Pennant)		x	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 (Elsam Engineering, 2004 a, Elsam Engineering 2004b).

Turbine HORN_33			**March 2003**	**September 2003**
Fish species observed	**Common name**	**Scientific name**	**Abundance**	**Abundance**
	Bib	*Trisopterus luscus*		∞
	Atlantic cod	*Gadus morhua*		∞
	Sand goby	*Pomatoschistus minutus*		∞
	Hooknose	*Agonus cataphractus*		∞
	Shorthorn sculpin	*Myoxocephalus scorpius*		∞
	Rock gunnel	*Pholis gunnellus*		∞
	Corkwing wrasse	*Symphodus melops*		∞

Turbine HORN_55			**March 2003**	**September 2003**
Fish species observed	**Common name**	**Scientific name**	**Abundance**	**Abundance**
	Atlantic cod	*Gadus morhua*		∞
	Sand goby	*Pomatoschistus minutus*		∞
	Rock gunnel	*Pholis gunnellus*		∞
	Corkwing wrasse	*Symphodus melops*		∞
	Viviparous blenny	*Zoarces viviparus*		∞
	Dragonet	*Callionymus lyra*		O

Turbine HORN_58			**March 2003**	**September 2003**
Fish species observed	**Common name**	**Scientific name**	**Abundance**	**Abundance**
	Rock gunnel	*Pholis gunnellus*	O	∞
	Bib	*Trisopterus luscus*		∞
	Atlantic cod	*Gadus morhua*		∞
	Sand goby	*Pomatoschistus minutus*		∞
	Hooknose	*Agonus cataphractus*		∞
	Shorthorn sculpin	*Myoxocephalus scorpius*		∞
	Corkwing wrasse	*Symphodus melops*		∞
	Dragonet	*Callionymus lyra*		O

Turbine HORN_91			**March 2003**	**September 2003**
Fish species observed	**Common name**	**Scientific name**	**Abundance**	**Abundance**
	Rock gunnel	*Pholis gunnellus*	O	∞
	Viviparous blenny	*Zoarces viviparus*	O	O
	Atlantic cod	*Gadus morhua*		O
	Sand goby	*Pomatoschistus minutus*		O
	Hooknose	*Agonus cataphractus*		O
	Shorthorn sculpin	*Myoxocephalus scorpius*		O
	Dragonet	*Callionymus lyra*		O
	Goldsinny-wrasse	*Ctenolabrus rupestris*		∞
	Corkwing wrasse	*Symphodus melops*		O
	Horse mackerel	*Trachurus trachurus*		O
	Pollack	*Pollachius virens*		O
	Whiting	*Merlangius merlangus*		O

Turbine HORN_92			March 2003	September 2003
Fish species observed	**Common name**	**Scientific name**	**Abundance**	**Abundance**
	Rock gunnel	*Pholis gunnellus*	O	∞
	Atlantic cod	*Gadus morhua*		O
	Bib	*Trisopterus luscus*		O
	Sand goby	*Pomatoschistus minutus*		∞
	Hooknose	*Agonus cataphractus*		O
	Shorthorn sculpin	*Myoxocephalus scorpius*		O
	Corkwing wrasse	*Symphodus melops*		O
	Dragonet	*Callionymus lyra*		O
	Horse mackerel	*Trachurus trachurus*		∞

Turbine HORN_95			March 2003	September 2003
Fish species observed	**Common name**	**Scientific name**	**Abundance**	**Abundance**
	Rock gunnel	*Pholis gunnellus*		∞
	Atlantic cod	*Gadus morhua*		∞
	Bib	*Trisopterus luscus*		O
	Sand goby	*Pomatoschistus minutus*		O
	Hooknose	*Agonus cataphractus*	O	
	Shorthorn sculpin	*Myoxocephalus scorpius*		O
	Corkwing wrasse	*Symphodus melops*		O
	Dragonet	*Callionymus lyra*		O
	Striped red mullet	*Mullus surmuletus*		O

Appendix 5. Transect description

Appendix 5.1. Transect description. Scour protection

Mean Relative coverage		2003								
Scour protection		Distance interval								
Distance from tower		0 - 2 m	2 - 4 m	4 - 6 m	6 - 8 m	8 - 10 m	10 - 12 m	12 - 14 m	14 -16 m	16 - 18 m
Red Algae	Callithamnion corymbosum	.	.	.	0.00	.	.	.	.	.
	Coccotylus truncatus	.	.	0.04	0.00	.	.	.	.	.
	Corallina officinalis	.	.	.	.	.	0.04	.	.	.
	Rødkødskorp, tyk	.	.	0.56	0.56	0.56	0.56	0.61	.	.
	Rødskorper, kødede	0.56	0.56	0.56	0.56	.	0.04	0.09	.	.
Brown Algae	Desmarestia aculeata	.	.	.	.	0.00	.	.	.	.
	Petalonia fascia	.	0.08	0.04	.	.	.	.	.	.
	Pilayella littoralis	0.65	0.65	2.17	0.65	0.13	0.04	0.00	.	.
	Ralfsia sp.	0.56	0.56	1.56	0.56	.	.	.	.	.
Green Algae	Enteromorpha sp.	0.56	1.17	1.77	1.77	2.69	1.77	1.36	.	.
	Ulva lactuca	0.00	0.69	0.73	0.65	0.56	0.08	0.05	.	.
Benthos	Actiniaria indet.	12.77	14.38	13.90	11.77	8.04	4.71	4.43	2.90	.
	Aeolidacea indet.	.	.	.	0.00	.	.	.	.	.
	Asterias rubens	10.85	8.21	9.25	10.38	9.77	11.29	7.77	5.80	37.50
	Balanus crenatus	5.38	3.85	3.85	3.38	2.33	0.08	0.14	.	.
	Balanus sp.	0.04	0.04	.	.	.	0.08	0.05	.	.
	Bryozoa indet.	0.17	0.73	0.13	0.69	0.21	1.81	1.98	.	.
	Buccinum undatum	0.00	0.00	0.00	0.00	.	.	0.05	.	.
	Buccinum undatum (eggs)	.	.	.	.	0.00	.	.	.	.
	Cancer pagurus	3.63	2.58	2.58	3.15	4.67	5.19	2.02	0.20	.
	Caprella linearis	2.25	1.73	1.73	1.73	1.69	1.13	1.23	.	.
	Carcinus maenas	.	.	.	0.04	0.08	0.04	0.18	0.00	.
	Crepidula fornicata	0.25	0.69	0.73	0.60	0.04	0.04	0.05	.	.
	Echinocardium cordatum	.	.	.	.	.	.	0.00	.	.
	Electra pilosa	.	.	.	.	.	0.04	0.05	.	.
	Gastropoda indet.	.	.	.	.	0.00	.	.	.	.
	Hydrozoa indet.	1.29	2.50	2.46	3.10	3.06	6.15	3.95	0.20	.
	Jassa marmorata	30.67	39.92	36.31	34.83	23.06	12.35	7.09	2.70	.
	Lanice conchilega	0.00	.	.	.	0.60	2.90	5.05	2.70	.
	Liocarcinus depurator	.	0.60	0.00	0.04	0.13	0.13	0.18	0.20	.
	Metridium senile	3.58	2.06	3.10	3.02	1.38	0.77	0.18	0.20	.
	Mytilus edulis	1.17	0.00	.	.	.	.	.	.	.
	Nudibranchia indet.	0.04	0.04	0.04	0.04	0.08	0.04	0.05	.	.
	Nudibranchia indet. (eggs).	0.00	0.04	0.00	0.00	0.00	.	.	.	.
	Onchidoris muricata	.	.	0.00	0.00	0.00	.	.	.	.
	Onchidoris muricata (eggs)	0.00	0.04	0.04	0.04	0.04	0.00	.	.	.
	Pagurus bernhardus	0.00	.	.	0.00	0.13	0.38	0.98	2.70	.
	Phyllodocidae indet.	0.00	0.08	0.04	0.04	0.08	0.60	0.66	2.70	.
	Pomatoceros triqueter	0.42	0.46	0.50	0.46	0.33	0.25	0.14	.	.
	Strongylocentrotus droebachiensis	.	.	.	.	.	0.00	.	.	.
	Tubularia indivisa	5.71	8.19	3.10	5.06	4.50	2.42	0.70	0.20	.

Mean Relative coverage		Spring 2003									Autumn 2003							
Scour protection		Distance interval									Distance interval							
Distance from tower		0 - 2 m	2 - 4 m	4 - 6 m	6 - 8 m	8 - 10 m	10 - 12 m	12 - 14 m	14 -16 m	16 - 18 m	0 - 2 m	2 - 4 m	4 - 6 m	6 - 8 m	8 - 10 m	10 - 12 m	12 - 14 m	14 -16 m
Red Algae	Callithamnion corymbosum	.	.	.	0.00	.	.	.	.	.								
	Coccotylus truncatus										.	.	0.08	0.00	.	.	.	.
	Corallina officinalis										.	.	.	.	.	0.08	.	.
	Rødkødskorp, tyk										.	.	1.13	1.13	1.13	1.13	1.23	.
	Rødskorper, kødede										1.13	1.13	1.13	1.13	.	0.08	0.18	.
Brown Algae	Desmarestia aculeata										.	.	.	.	0.00	.	.	.
	Petalonia fascia										.	0.17	0.08	.	.	.	.	.
	Pilayella littoralis	1.29	1.29	4.33	1.29	0.25	0.08	0.00	.	.								
	Ralfsia sp.	1.13	1.13	3.13	1.13	.	.	.	.	.								
Green Algae	Enteromorpha sp.										1.13	2.33	3.54	3.54	5.38	3.54	2.73	.
	Ulva lactuca										0.00	1.38	1.46	1.29	1.13	0.17	0.09	.
Benthos	Actiniaria indet.	9.08	8.21	9.25	7.08	4.83	0.25	0.09	0.00	.	16.46	20.54	18.54	16.46	11.25	9.17	8.77	7.25
	Aeolidacea indet.	.	.	.	0.00	.	.	.	.	.								
	Asterias rubens	7.25	5.00	6.04	8.29	8.13	10.13	8.95	5.17	37.50	14.46	11.42	12.46	12.46	11.42	12.46	6.59	6.75
	Balanus crenatus	10.75	7.71	7.71	6.67	4.50	0.08	0.09	.	.	.	.	.	0.08	0.17	0.08	0.18	.
	Balanus sp.										0.08	0.08	.	.	.	0.17	0.09	.
	Bryozoa indet.										0.33	1.46	0.25	1.38	0.42	3.63	3.95	.
	Buccinum undatum	0.00	0.00	0.00	0.00	.	.	0.09	.	.								
	Buccinum undatum (eggs)	.	.	.	.	0.00	.	.	.	.								
	Cancer pagurus	0.00	.	.	0.08	.	.	0.00	.	.	7.25	5.17	5.17	6.21	9.33	10.38	4.05	0.50
	Caprella linearis	1.13	0.00	.	.	.	.	.	.	.	3.38	3.46	3.46	3.46	3.38	2.25	2.45	.
	Carcinus maenas	.	.	.	.	0.08	.	0.09	.	.	.	.	.	0.08	0.08	0.08	0.27	0.00
	Crepidula fornicata	0.08	0.08	0.08	0.00	.	.	.	.	.	0.42	1.29	1.38	1.21	0.08	0.08	0.09	.
	Echinocardium cordatum	.	.	.	.	.	.	0.00	.	.								
	Electra pilosa	.	.	.	.	.	0.08	0.09	.	.								
	Gastropoda indet.	.	.	.	.	0.00	.	.	.	.								
	Hydrozoa indet.	0.17	1.29	1.29	0.25	0.17	5.21	1.23	.	.	2.42	3.71	3.63	5.96	5.96	7.08	6.68	0.50
	Jassa marmorata	23.50	28.63	25.50	23.42	11.08	0.08	0.09	.	.	37.83	51.21	47.13	46.25	35.04	24.63	14.09	6.75
	Lanice conchilega	0.00	.	.	.	.	3.21	1.32	.	.	.	.	.	.	1.21	2.58	8.77	6.75
	Liocarcinus depurator										.	1.21	0.00	0.08	0.25	0.25	0.36	0.50
	Metridium senile										7.17	4.13	6.21	6.04	2.75	1.54	0.36	0.50
	Mytilus edulis										2.33	0.00	.	.	.	.	.	.
	Nudibranchia indet.	0.00	0.00	0.00	0.00	0.08	.	.	.	.	0.08	0.08	0.08	0.08	0.08	0.08	0.09	.
	Nudibranchia indet. (eggs).	0.00	0.08	0.00	0.00	0.00	.	.	.	.								
	Onchidoris muricata	.	.	0.00	0.00	0.00	.	.	.	.								
	Onchidoris muricata (eggs)	0.00	0.08	0.08	0.08	0.08	0.00	.	.	.								
	Pagurus bernhardus	0.00	.	.	0.00	0.17	0.59	0.27	.	.	.	.	.	0.00	0.08	0.17	1.68	6.75
	Phyllodocidae indet.	0.00	0.17	0.08	0.08	0.17	1.21	1.32	4.50	.								
	Pomatoceros triqueter	0.33	0.42	0.50	0.42	0.25	0.08	.	.	.	0.50	0.50	0.50	0.50	0.42	0.42	0.27	.
	Strongylocentrotus droebachiensis	.	.	.	.	.	0.00	.	.	.								
	Tubularia indivisa										11.42	16.38	6.21	10.13	9.00	4.83	1.41	0.50

Appendix 5.2. Transect description. Turbine Towers

Mean Relative coverage Turbine tower Depth		Year 2003 Depth interval 0 - 2 m	2 - 4 m	4 - 6 m	6 - 8 m	8 - 10 m
Red Algae	Callithamnion corymbosum	.04	.04	.	.	.
Brown Algae	Ectocarpus sp.	.56	.	.	.	.
	Petalonia fascia	2.10	.00	.	.	.
	Pilayella littoralis	8.23	4.54	3.29	.	.
	Ralfsia verrucosa	.56	.	.	.	.
Green Algae	Blidingia minima	1.13	.	.	.	.
	Cladophora sp.	.04	.	.	.	.
	Enteromorpha sp.	4.79	.56	.04	.	.
	Ulva lactuca	7.02	1.65	.	.	.
	Urospora penicilliformis	.04	.	.	.	.
Benthos	Actiniaria indet.	1.73	3.75	5.96	7.72	11.94
	Asterias rubens	1.58	5.52	10.25	6.56	5.56
	Balanus crenatus	20.48	12.31	9.15	4.97	1.81
	Balanus sp.	2.90	.	.	.	.
	Bryozoa indet.	.	.60	1.17	.11	.38
	Cancer pagurus	.08	.65	4.90	.17	.25
	Caprella linearis	2.10	8.40	6.83	4.67	3.63
	Crepidula fornicata	.04	1.94	3.02	3.11	2.06
	Hydrozoa indet.	.04	.60	.65	.06	.
	Jassa marmorata	40.27	43.92	37.83	24.17	25.50
	Liocarcinus depurator	.00	.	.00	.	.13
	Metridium senile	.04	2.42	6.71	6.06	6.75
	Mytilus edulis	9.67	3.21	.13	.06	1.69
	Nemertini Indet.	.	.04	.	.00	.
	Nudibranchia indet.	.	.	.00	.00	.
	Phyllodocidae indet.	.	.	.00	.06	.
	Pomatoceros triqueter	.	.08	.17	1.19	.88
	Strongylocentrotus droebachien	.	.00	.08	.06	.
	Telmatogeton sp.	.08	.	.	.	.
	Tubularia indivisa	2.94	9.71	9.23	9.47	9.75

Mean Relative coverage Turbine tower Depth		Spring 2003					Autumn 2003				
		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	Callithamnion corymbosum	.	.	.	.	.	.08	.08	.	.	.
Brown Algae	Ectocarpus sp.	.	.	.	.	.	1.13	.	.	.	.
	Petalonia fascia	3.79	.	.	.	.	.42	.00	.	.	.
	Pilayella littoralis	16.46	9.08	6.58	.	.	.	.	.	.	.
	Ralfsia verrucosa	.	.	.	.	.	1.13	.	.	.	.
Green Algae	Blidingia minima	.	.	.	.	.	2.25	.	.	.	.
	Cladophora sp.	.	.	.	.	.	.08	.	.	.	.
	Enteromorpha sp.	3.00	.00	.	.	.	6.58	1.13	.08	.	.
	Ulva lactuca	.	.	.	.	.	14.04	3.29	.	.	.
	Urospora penicilliformis	.08	.	.	.	.	.	.	.	.	.
Benthos	Actiniaria indet.	.17	.33	.50	3.75	10.38	3.29	7.17	11.42	10.90	13.50
	Asterias rubens	1.54	2.75	5.00	4.13	.75	1.63	8.29	15.50	8.50	10.38
	Balanus crenatus	39.67	24.63	18.29	11.19	3.63	1.29	.	.	.	.
	Balanus sp.	.	.	.	.	.	5.79	.	.	.	.
	Bryozoa indet.	.	.	.	.	.	.	1.21	2.33	.20	.75
	Cancer pagurus	.	.	.	.	.	.17	1.29	9.79	.30	.50
	Caprella linearis	1.88	11.33	8.21	8.69	7.25	2.33	5.46	5.46	1.45	.
	Crepidula fornicata	.	.	.	.00	.00	.08	3.88	6.04	5.60	4.13
	Hydrozoa indet.	.08	.08	.17	.13	.	.	1.13	1.13	.00	.
	Jassa marmorata	50.08	43.75	33.50	30.06	31.50	30.46	44.08	42.17	19.45	19.50
	Liocarcinus depurator	.00	.	.	.	.	.	.	.00	.	.25
	Metridium senile	.	.	.	.	.	.08	4.83	13.42	10.90	13.50
	Mytilus edulis	.17	.17	.17	.13	.	19.17	6.25	.08	.	3.38
	Nemertini Indet.	.	.	.	.	.	.	.08	.	.00	.
	Nudibranchia indet.	.	.	.00	.00	.	.	.	.	.	.
	Phyllodocidae indet.	.	.	.00	.13	.	.	.	.	.	.
	Pomatoceros triqueter	.	.	.	.50	.75	.	.17	.33	1.75	1.00
	Strongylocentrotus droebachien	.	.00	.17	.13	.	.	.	.	.	.
	Telmatogeton sp.	.	.	.	.	.	.17	.	.	.	.
	Tubularia indivisa	.	.	.	.	.	5.88	19.42	18.46	17.05	19.50

Appendix 6. Benthic Fauna abundance

Appendix 6.1. Total abundance.

March 2003

Abundans, number/m²		20030301 Total no./m²	Kol Sum %	N
HYDROZOA	Hydrozoa indet.	.2	.0%	126
	Tubulariidae indet.	.2	.0%	126
	Thecata indet.	.2	.0%	126
	Campanulariidae indet.	1.0	.0%	126
ANTHOZOA	Anthozoa indet.	10.9	.0%	126
	Actiniaria indet.	70.4	.1%	126
NEMERTINI	Nemertini indet.	15.3	.0%	126
POLYCHAETA	Harmothoe impar	20.2	.0%	126
	Phyllodoce groenlandica	23.6	.0%	126
	Eulalia viridis	2.4	.0%	126
	Chaetopterus norvegicus	.6	.0%	126
	Capitella capitata	2.2	.0%	126
	Pomatoceros triqueter	6.7	.0%	126
CRUSTACEA	Verruca stroemia	3.6	.0%	126
	Balanus balanus	174.0	.3%	126
	Balanus crenatus	2981.7	4.6%	126
	Cancer pagurus	4.2	.0%	126
	Corophium crassicorne	.4	.0%	126
	Aoridae indet.	.2	.0%	126
	Jassa marmorata	56169.2	86.5%	126
	Caprella linearis	926.8	1.4%	126
GASTROPODA	Rissoidae indet.	7.7	.0%	126
	Crepidula fornicata	22.6	.0%	126
	Nudibranchia indet.	2.2	.0%	126
	Onchidoris muricata	1.2	.0%	126
BIVALVIA	Bivalvia indet.	.2	.0%	126
	Mytilus edulis	4451.4	6.9%	126
	Heteranomia squamula	.4	.0%	126
	Moerella donacina	10.7	.0%	126
	Thracia phaseolina	.4	.0%	126
BRYOZOA	Bryozoa indet.	.6	.0%	126
	Electra pilosa	18.8	.0%	126
ECHINODERMATA	Asterias rubens	34.3	.1%	126
	Ophiura albida	1.0	.0%	126
	Strongylocentrotus droebachiensis	.4	.0%	126
Total		64966.1	100.0%	4410

September 2003

Abundans, number/m²		20030904		
		Total		
		no./m²	Kol Sum %	N
HYDROZOA	Tubularia indivisa	22.7	.0%	132
	Campanulariidae indet.	15.0	.0%	132
ANTHOZOA	Actiniaria indet.	65.3	.1%	132
NEMERTINI	Nemertini indet.	16.3	.0%	132
NEMATODA	Nematoda indet.	3.6	.0%	132
POLYCHAETA	Harmothoe imbricata	1.7	.0%	132
	Harmothoe impar	2.8	.0%	132
	Phyllodocidae indet.	.2	.0%	132
	Phyllodoce groenlandica	18.6	.0%	132
	Eulalia viridis	4.7	.0%	132
	Syllidae indet.	.2	.0%	132
	Nereididae indet.	1.9	.0%	132
	Nereis pelagica	.8	.0%	132
	Neanthes virens	3.0	.0%	132
	Polydora ciliata	.4	.0%	132
	Capitella capitata	1.1	.0%	132
	Pomatoceros triqueter	49.2	.0%	132
PYCNOGONIDA	Phoxichilidium femoratum	.4	.0%	132
CRUSTACEA	Verruca stroemia	5.1	.0%	132
	Balanus balanus	98.7	.1%	132
	Balanus crenatus	16.3	.0%	132
	Caridea indet.	.2	.0%	132
	Corystes cassivelaunus	.2	.0%	132
	Cancer pagurus	77.8	.1%	132
	Corophium crassicorne	.2	.0%	132
	Stenothoe marina	.2	.0%	132
	Jassa marmorata	111891.3	90.7%	132
	Atylus swammerdami	.2	.0%	132
	Caprella linearis	9490.5	7.7%	132
	Hyperia galba	.2	.0%	132
CHIRONOMIDAE	Telmatogeton japonicus	18.4	.0%	132
GASTROPODA	Rissoidae indet.	104.9	.1%	132
	Crepidula fornicata	20.8	.0%	132
	Polinices sp.	.4	.0%	132
	Nudibranchia indet.	12.3	.0%	132
	Onchidoris muricata	17.0	.0%	132
BIVALVIA	Mytilus edulis	1319.9	1.1%	132
	Ostrea edulis	.2	.0%	132
	Heteranomia squamula	1.3	.0%	132
	Moerella donacina	.6	.0%	132
	Venerupis senegalensis	.2	.0%	132
	Hiatella arctica	3.6	.0%	132
BRYOZOA	Bryozoa indet.	2.3	.0%	132
	Electra pilosa	21.8	.0%	132
ECHINODERMATA	Asterias rubens	75.6	.1%	132
	Strongylocentrotus droebachiensis	1.3	.0%	132
Total		123389.4	100.0%	6072

Appendix 6.2. Mean abundance turbine towers

		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	Tubulariidae indet.											4 2	0%								
	Campanuiariidae indet.											4 2	0%							4 2	0%
ANTHOZOA	Anthozoa indet.			12 5	0%															12 5	0%
	Actiniaria indet.									41 7	0%	8 3	0%	4 2	0%					4 2	0%
NEMERTINi	Nemertini indet.	58 3	1%	25 0	0%	29 2	0%	6 3	0%			33.3	0%	45.8	0%	100 0	1%			8 3	0%
POLYCHAETA	Harmothoe impar	29 2	0%	41 7	0%	12 5	0%			33 3	0%	16 7	0%	37 5	0%	8 3	0%			20 8	0%
	Phyllodoce groenlandica	25 0	0%	16 7	0%	8 3	0%			8 3	0%	20 8	0%	20 8	0%					8 3	0%
	Eulalia viridis	4 2	0%	8 3	0%															12 5	0%
	Capitella capitata	8 3	0%	20 8	0%	8 3	0%							4 2	0%	4 2	0%				
	Pomatoceros triqueter	8 3	0%			8 3	0%			20 8	0%	16 7	0%	16 7	0%					20 8	0%
CRUSTACEA	Verruca stroemia	4 2	0%			4 2	0%			12.5	0%	8.3	0%			4.2	0%			16 7	0%
	Baianus balanus					854 2	5%	2006 3	4 6%							612 5	6%	2550 0	3 3%		
	Balanus crenatus	4554 2	5 5%	13558 3	10 0%	18162 5	11 3%			404 2	3%	2062 5	1 4%	5362 5	3 5%	9683 3	9 3%			904 2	1 1%
	Cancer pagurus	20 8	0%	4 2	0%	4 2	0%	12 5	0%			16 7	0%	4 2	0%	12 5	0%				
	Aoridae indet.															4 2	0%				
	Jassa marmorata	71487 5	86 0%	111400 0	82 5%	128737 5	80 4%	38918 8	89 7%	111533 3	93 7%	134025 0	93 8%	133079 2	86 7%	87537 5	83 7%	46137 5	60 3%	72283 3	84 6%
	Caprella linearis	1945 8	2 3%	2441 7	1 8%	1854 2	1 2%	1068 8	2 5%	1975 0	1 7%	1079 2	8%	1208 3	8%	750 0	7%	100 0	1%	375 0	4%
GASTROPODA	Rissoidae indet.	8 3	0%																	4 2	0%
	Crepidula fornicata	12 5	0%	8 3	0%					29 2	0%	16 7	0%	20 8	0%						
	Nudibranchia indet.			4 2	0%					4 2	0%			8 3	0%					4 2	0%
	Onchidoris muricata																			4 2	0%
BIVALVIA	Mytiius edulis	4900 0	5 9%	7383.3	5.5%	10370 8	6.5%	1343.8	3 1%	4937 5	4 1%	5600 0	3 9%	13591 7	8 9%	5895.8	5.6%	27787 5	36.3%	11675 0	13 7%
BRYOZOA	Bryozoa indet.									4 2	0%										
	Eiectra piiosa	25 0	0%	20 8	0%	25 0	0%	25 0	1%	25 0	0%	25 0	0%	25 0	0%	20 8	0%			25 0	0%
ECHINODERMATA	Asterias rubens			8 3	0%	8 3	0%	25 0	1%	33 3	0%	20.8	0%							37 5	0%
	Strongylocentrotus droebachiensis													4 2	0%						
Total		83091 7	100 0%	134954 2	100 0%	160087 5	100 0%	43406 3	100 0%	119062 5	100 0%	142958 3	100 0%	153433 3	100 0%	104633 3	100 0%	76575 0	100 0%	85420 8	100 0%

September 2003

		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	25.0	0%	25.0	0%	25.0	0%			25.0	0%	25.0	0%	25.0	0%	25.0	0%	12.5	0%	25.0	0%
	Campanulariidae indet.	16.7	0%	20.8	0%	8.3	0%			20.8	0%	16.7	0%	20.8	0%	8.3	0%	8.3	0%	16.7	0%
ANTHOZOA	Actiniaria indet.	79.2	0%	58.3	0%	120.8	0%			4.2	0%	70.8	0%	66.7	0%	33.3	0%	4.2	0%	16.7	0%
NEMERTINi	Nemertini indet.	4.2	0%			79.2	0%	129.2	0%	4.2	0%	8.3	0%	8.3	0%	41.7	0%	62.5	0%	8.3	0%
NEMATODA	Nematoda indet.			4.2	0%							12.5	0%			4.2	0%				
POLYCHAETA	Harmothoe imbricata					12.5	0%									25.0	0%				
	Harmothoe impar					20.8	0%									25.0	0%	12.5	0%		
	Phyllodoce groenlandica			20.8	0%	62.5	0%	4.2	0%	4.2	0%	8.3	0%	25.0	0%	37.5	0%	58.3	0%	16.7	0%
	Eulalia viridis	16.7	0%							4.2	0%	12.5	0%	4.2	0%	33.3	0%	4.2	0%	8.3	0%
	Nereididae indet.					4.2	0%	12.5	0%							20.8	0%				
	Nereis pelagica													4.2	0%			12.5	0%		
	Neanthes virens					29.2	0%	16.7	0%							4.2	0%	16.7	0%		
	Capitella capitata					8.3	0%							4.2	0%					4.2	0%
	Pomatoceros triqueter	137.5	1%	66.7	0%	20.8	0%			104.2	0%	75.0	0%	170.8	1%	104.2	0%	12.5	0%	166.7	2%
PYCNOGONIDA	Phoxichilidium femoratum													4.2	0%						
CRUSTACEA	Verruca stroemia					4.2	0%					4.2	0%	8.3	0%					12.5	0%
	Balanus balanus					25.0	0%	1650.0	6%							8.3	0%	487.5	2%		
	Balanus crenatus	29.2	0%	33.3	0%					4.2	0%	66.7	0%	45.8	0%	29.2	0%			20.8	0%
	Caridea indet.									4.2	0%										
	Corystes cassivelaunus																			4.2	0%
	Cancer pagurus	991.7	6%	29.2	0%	125.0	0%	54.2	0%	12.5	0%	25.0	0%	33.3	0%	137.5	0%	37.5	0%	12.5	0%
	Corophium crassicorne					4.2	0%														
	Jassa marmorata	153554.2	90.3%	153620.8	93.3%	329191.7	86.8%	251100.0	96.0%	183141.7	86.7%	170766.7	93.9%	150637.5	91.6%	377758.3	87.2%	216533.3	92.8%	96725.0	92.3%
	Caprella linearis	14829.2	8.7%	10400.0	6.3%	42516.7	11.2%	45.8	0%	27658.3	13.1%	10200.0	5.6%	13016.7	7.9%	52375.0	12.1%	7179.2	3.1%	7358.3	7.0%
CHIRONOMIDAE	Telmatogeton japonicus			16.7	0%	8.3	0%	283.3	1%	4.2	0%	12.5	0%					75.0	0%		
GASTROPODA	Rissoidae indet.	12.5	0%	8.3	0%	29.2	0%	4.2	0%	20.8	0%	12.5	0%	12.5	0%	145.8	0%	100.0	0%	20.8	0%
	Crepidula fornicata	16.7	0%	25.0	0%	12.5	0%			8.3	0%	33.3	0%	25.0	0%	12.5	0%	4.2	0%	16.7	0%
	Nudibranchia indet.	25.0	0%	8.3	0%	12.5	0%			29.2	0%	4.2	0%	4.2	0%					16.7	0%
	Onchidoris muricata					8.3	0%			16.7	0%			12.5	0%	4.2	0%			4.2	0%
BIVALVIA	Mytilus edulis	245.8	1%	216.7	1%	6916.7	1.8%	8137.5	3.1%	91.7	0%	375.0	2%	329.2	2%	2450.0	6%	8716.7	3.7%	66.7	1%
	Ostrea edulis															4.2	0%				
	Heteranomia squamula			12.5	0%	12.5	0%							4.2	0%						
	Moerelia donacina															4.2	0%				
	Venerupis senegalensis															4.2	0%				
	Hiatella arctica	8.3	0%	8.3	0%									12.5	0%	12.5	0%	8.3	0%		
BRYOZOA	Bryozoa indet.	12.5	0%	4.2	0%					4.2	0%			12.5	0%						
	Electra pilosa	25.0	0%	25.0	0%	25.0	0%	12.5	0%	25.0	0%	20.8	0%	25.0	0%	25.0	0%	16.7	0%	25.0	0%
ECHINODERMATA	Asterias rubens	79.2	0%	41.7	0%	37.5	0%			141.7	1%	41.7	0%	12.5	0%	37.5	0%	8.3	0%	220.8	2%
	Strongylocentrotus droebachiensis			4.2	0%											8.3	0%			4.2	0%
Total		170108.3	100.0%	164650.0	100.0%	379320.8	100.0%	261450.0	100.0%	211329.2	100.0%	181791.7	100.0%	164525.0	100.0%	433379.2	100.0%	233370.8	100.0%	104770.8	100.0%

Appendix 6.3. Mean abundance scour protection

March 2003

		Transect							
		Foundations, horizontal							
		A 0.5 NNE		B 02 NNE		C 05 NNE		D 05 SSW	
Abundance, number/m²		no./m²	Kol Sum %	no./m²	Kol Sum %	no./m²	Kol Sum %	no./m²	Kol Sum %
HYDROZOA	Hydrozoa indet.	.	.	1.4	.0%	.	.	.	.
	Thecata indet.	.	.	.	.	1.4	.0%	.	.
	Campanulariidae indet.	.	.	1.4	.0%	2.8	.0%	.	.
ANTHOZOA	Anthozoa indet.	5.6	.0%	56.9	.3%	.	.	5.6	.0%
	Actiniaria indet.	66.7	.4%	108.3	.5%	201.4	.6%	97.2	.3%
NEMERTINI	Nemertini indet.	2.8	.0%	1.4	.0%	.	.	1.4	.0%
POLYCHAETA	Harmothoe impar	8.3	.0%	22.2	.1%	29.2	.1%	15.3	.0%
	Phyllodoce groenlandica	2.8	.0%	18.1	.1%	62.5	.2%	45.8	.1%
	Eulalia viridis	1.4	.0%	1.4	.0%	5.6	.0%	.	.
	Chaetopterus norvegicus	.	.	1.4	.0%	2.8	.0%	.	.
	Pomatoceros triqueter	1.4	.0%	6.9	.0%	5.6	.0%	2.8	.0%
CRUSTACEA	Verruca stroemia	4.2	.0%	1.4	.0%	.	.	2.8	.0%
	Balanus crenatus	297.2	1.6%	176.4	.8%	1940.3	6.1%	227.8	.6%
	Cancer pagurus	1.4	.0%	.	.	4.2	.0%	.	.
	Corophium crassicorne	.	.	.	.	2.8	.0%	.	.
	Jassa marmorata	15551.4	86.1%	18606.9	83.0%	28136.1	88.5%	33754.2	92.6%
	Caprella linearis	543.1	3.0%	1643.1	7.3%	133.3	.4%	43.1	.1%
GASTROPODA	Rissoidae indet.	1.4	.0%	9.7	.0%	36.1	.1%	2.8	.0%
	Crepidula fornicata	6.9	.0%	26.4	.1%	83.3	.3%	12.5	.0%
	Nudibranchia indet.	.	.	.	.	1.4	.0%	6.9	.0%
	Onchidoris muricata	5.6	.0%	.	.	1.4	.0%	.	.
BIVALVIA	Bivalvia indet.	.	.	1.4	.0%	.	.	.	.
	Mytilus edulis	1479.2	8.2%	1627.8	7.3%	1023.6	3.2%	2191.7	6.0%
	Heteranomia squamula	.	.	1.4	.0%	1.4	.0%	.	.
	Moerella donacina	8.3	.0%	18.1	.1%	48.6	.2%	.	.
	Thracia phaseolina	.	.	.	.	2.8	.0%	.	.
BRYOZOA	Bryozoa indet.	.	.	1.4	.0%	1.4	.0%	.	.
	Electra pilosa	15.3	.1%	20.8	.1%	11.1	.0%	15.3	.0%
ECHINODERMATA	Asterias rubens	65.3	.4%	61.1	.3%	45.8	.1%	26.4	.1%
	Ophiura albida	.	.	1.4	.0%	4.2	.0%	1.4	.0%
	Strongylocentrotus droebachiensis	.	.	.	.	.	.	1.4	.0%
Total		18068.1	100.0%	22416.7	100.0%	31788.9	100.0%	36454.2	100.0%

September 2003

		Transect							
		Foundations, horizontal							
		A 0.5 NNE		B 02 NNE		C 05 NNE		D 05 SSW	
Abundance, number/m^2		no./m^2	Kol Sum %	no./m^2	Kol Sum %	no./m^2	Kol Sum %	no./m^2	Kol Sum %
HYDROZOA	Tubularia indivisa	25.0	.1%	23.6	.1%	25.0	.1%	22.2	.1%
	Campanulariidae indet.	16.7	.0%	15.3	.1%	18.1	.1%	13.9	.0%
ANTHOZOA	Actiniaria indet.	34.7	.1%	98.6	.4%	129.2	.4%	65.3	.2%
NEMERTINI	Nemertini indet.	1.4	.0%	.	.	1.4	.0%	1.4	.0%
NEMATODA	Nematoda indet.	1.4	.0%	6.9	.0%	8.3	.0%	2.8	.0%
POLYCHAETA	Harmothoe impar	.	.	.	.	1.4	.0%	.	.
	Phyllodocidae indet.	.	.	1.4	.0%	.	.	.	.
	Phyllodoce groenlandica	18.1	.0%	16.7	.1%	11.1	.0%	11.1	.0%
	Eulalia viridis	2.8	.0%	4.2	.0%	.	.	.	.
	Syllidae indet.	.	.	.	.	.	.	1.4	.0%
	Nereididae indet.	1.4	.0%	.	.	.	.	.	.
	Polydora ciliata	.	.	.	.	2.8	.0%	.	.
	Capitella capitata	.	.	1.4	.0%	1.4	.0%	.	.
	Pomatoceros triqueter	12.5	.0%	22.2	.1%	11.1	.0%	29.2	.1%
PYCNOGONIDA	Phoxichilidium femoratum	1.4	.0%	.	.	.	.	.	.
CRUSTACEA	Verruca stroemia	1.4	.0%	12.5	.0%	12.5	.0%	1.4	.0%
	Balanus crenatus	9.7	.0%	8.3	.0%	8.3	.0%	16.7	.0%
	Cancer pagurus	8.3	.0%	13.9	.1%	40.3	.1%	22.2	.1%
	Stenothoe marina	1.4	.0%	.	.	.	.	.	.
	Jassa marmorata	33765.3	89.8%	25275.0	91.7%	29565.3	95.3%	37587.5	92.9%
	Atylus swammerdami	.	.	1.4	.0%	.	.	.	.
	Caprella linearis	3220.8	8.6%	1531.9	5.6%	805.6	2.6%	2179.2	5.4%
	Hyperia galba	1.4	.0%	.	.	.	.	.	.
CHIRONOMIDAE	Telmatogeton japonicus	1.4	.0%	.	.	.	.	.	.
GASTROPODA	Rissoidae indet.	190.3	.5%	190.3	.7%	123.6	.4%	143.1	.4%
	Crepidula fornicata	23.6	.1%	33.3	.1%	16.7	.1%	27.8	.1%
	Polinices sp.	.	.	.	.	2.8	.0%	.	.
	Nudibranchia indet.	4.2	.0%	11.1	.0%	12.5	.0%	29.2	.1%
	Onchidoris muricata	6.9	.0%	12.5	.0%	19.4	.1%	70.8	.2%
BIVALVIA	Mytilus edulis	84.7	.2%	194.4	.7%	93.1	.3%	125.0	.3%
	Moerella donacina	.	.	.	.	1.4	.0%	1.4	.0%
	Hiatella arctica	.	.	1.4	.0%	2.8	.0%	5.6	.0%
BRYOZOA	Bryozoa indet.	1.4	.0%	2.8	.0%	1.4	.0%	.	.
	Electra pilosa	20.8	.1%	19.4	.1%	22.2	.1%	22.2	.1%
ECHINODERMATA	Asterias rubens	123.6	.3%	65.3	.2%	80.6	.3%	77.8	.2%
	Strongylocentrotus droebachiensis	1.4	.0%	1.4	.0%	1.4	.0%	.	.
Total		37581.9	100.0%	27565.3	100.0%	31019.4	100.0%	40456.9	100.0%

Appendix 7. Biomass

Appendix 7.1. Total biomass

March 2003

Biomass, wet weight g/m²		20030301 Total g/m²	Kol Sum %	N
HYDROZOA	Hydrozoa indet.	.000	.0%	126
	Tubulariidae indet.	.001	.0%	126
	Thecata indet.	.000	.0%	126
	Campanulariidae indet.	.003	.0%	126
ANTHOZOA	Anthozoa indet.	1.023	.1%	126
	Actiniaria indet.	2.760	.3%	126
NEMERTINI	Nemertini indet.	1.847	.2%	126
POLYCHAETA	Harmothoe impar	.552	.1%	126
	Phyllodoce groenlandica	.433	.0%	126
	Eulalia viridis	.013	.0%	126
	Chaetopterus norvegicus	.018	.0%	126
	Capitella capitata	.004	.0%	126
	Pomatoceros triqueter	.154	.0%	126
CRUSTACEA	Verruca stroemia	.032	.0%	126
	Balanus balanus	50.377	5.3%	126
	Balanus crenatus	489.612	51.9%	126
	Cancer pagurus	.166	.0%	126
	Corophium crassicorne	.000	.0%	126
	Aoridae indet.	.002	.0%	126
	Jassa marmorata	276.903	29.4%	126
	Caprella linearis	6.949	.7%	126
GASTROPODA	Rissoidae indet.	.016	.0%	126
	Crepidula fornicata	.640	.1%	126
	Nudibranchia indet.	.053	.0%	126
	Onchidoris muricata	.060	.0%	126
BIVALVIA	Bivalvia indet.	.001	.0%	126
	Mytilus edulis	41.749	4.4%	126
	Heteranomia squamula	.004	.0%	126
	Moerella donacina	.023	.0%	126
	Thracia phaseolina	.001	.0%	126
BRYOZOA	Bryozoa indet.	.017	.0%	126
	Electra pilosa	1.643	.2%	126
ECHINODERMATA	Asterias rubens	67.679	7.2%	126
	Ophiura albida	.001	.0%	126
	Strongylocentrotus droebachiensis	.001	.0%	126
Total		942.736	100.0%	4410

September 2003

Biomass, wet weight g/m²		20030904 Total g/m²	Kol Sum %	N
HYDROZOA	Tubularia indivisa	15.573	1.0%	132
	Campanulariidae indet.	.167	.0%	132
ANTHOZOA	Actiniaria indet.	43.800	2.9%	132
NEMERTINI	Nemertini indet.	3.313	.2%	132
NEMATODA	Nematoda indet.	.011	.0%	132
POLYCHAETA	Harmothoe imbricata	.183	.0%	132
	Harmothoe impar	.069	.0%	132
	Phyllodocidae indet.	.000	.0%	132
	Phyllodoce groenlandica	.059	.0%	132
	Eulalia viridis	.042	.0%	132
	Syllidae indet.	.000	.0%	132
	Nereididae indet.	.046	.0%	132
	Nereis pelagica	.026	.0%	132
	Neanthes virens	.082	.0%	132
	Polydora ciliata	.000	.0%	132
	Capitella capitata	.008	.0%	132
	Pomatoceros triqueter	.913	.1%	132
PYCNOGONIDA	Phoxichilidium femoratum	.000	.0%	132
CRUSTACEA	Verruca stroemia	.024	.0%	132
	Balanus balanus	74.354	5.0%	132
	Balanus crenatus	.568	.0%	132
	Caridea indet.	.000	.0%	132
	Corystes cassivelaunus	.000	.0%	132
	Cancer pagurus	.267	.0%	132
	Corophium crassicorne	.000	.0%	132
	Stenothoe marina	.000	.0%	132
	Jassa marmorata	87.724	5.9%	132
	Atylus swammerdami	.000	.0%	132
	Caprella linearis	15.721	1.1%	132
	Hyperia galba	.001	.0%	132
CHIRONOMIDAE	Telmatogeton japonicus	.147	.0%	132
GASTROPODA	Rissoidae indet.	.229	.0%	132
	Crepidula fornicata	5.317	.4%	132
	Polinices sp.	.003	.0%	132
	Nudibranchia indet.	.041	.0%	132
	Onchidoris muricata	.051	.0%	132
BIVALVIA	Mytilus edulis	1132.353	75.8%	132
	Ostrea edulis	.037	.0%	132
	Heteranomia squamula	.009	.0%	132
	Moerella donacina	.001	.0%	132
	Venerupis senegalensis	.008	.0%	132
	Hiatella arctica	.003	.0%	132
BRYOZOA	Bryozoa indet.	.155	.0%	132
	Electra pilosa	10.939	.7%	132
ECHINODERMATA	Asterias rubens	101.610	6.8%	132
	Strongylocentrotus droebachiensis	.022	.0%	132
Total		1493.875	100.0%	6072

Appendix 7.2. Mean biomass. Turbine towers

March 2003

		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/m^2		g/m^2	Koi Sum %	g/m^2	Koi Sum %	g/m^2	Kol Sum %	g/m^2	Kol Sum %	g/m^2	Kol Sum %	g/m^2	Kol Sum %	g/m^2	Kol Sum %	g/m^2	Kol Sum %	g/m^2	Kol Sum %	g/m^2	Kol Sum %
HYDROZOA	Tubulariidae indet.											025	0%								
	Campanuiariidae indet.											019	0%							007	0%
ANTHOZOA	Anthozoa indet.			2 760	1%															1 235	3%
	Actiniaria indet.									6 736	7%	012	0%	004	0%					073	0%
NEMERTINI	Nemertini indet.	16 003	1 3%	2 327	1%	2 504	1%	860	1%			3 660	2%	4 520	3%	8 773	4%			337	1%
POLYCHAETA	Harmothoe impar	465	0%	548	0%	474	0%			1 553	1%	312	0%	658	0%	183	0%			650	1%
	Phyllodoce groenlandica	571	0%	226	0%	048	0%			158	0%	1 021	1%	295	0%					129	0%
	Eulalia viridis	012	0%	049	0%															114	0%
	Capitella capitata	021	0%	052	0%	013	0%							002	0%	005	0%				
	Pomatoceros triqueter	356	0%			190	0%			482	0%	535	0%	343	0%					548	1%
CRUSTACEA	Verruca stroemia	052	0%			076	0%			147	0%	085	0%			063	0%			108	0%
	Balanus balanus					174 242	5 7%	588 169	60 6%							276 446	11 8%	645 328	38 3%		
	Balanus crenatus	722 158	57 1%	3024 561	78 0%	1827 500	60 3%			162 188	15 7%	831 235	48 3%	621 063	43 4%	1430 783	61 0%			15 689	3 6%
	Cancer pagurus	494	0%	181	0%	209	0%	1 184	1%			657	0%	039	0%	741	0%				
	Aoridae indet.															045	0%				
	Jassa marmorata	449 821	35 6%	640 879	16 5%	778 979	25 7%	186 671	19 2%	446 121	43 1%	756 217	44 0%	552 090	38 6%	538 175	22 9%	838 700	49 8%	193 197	44 4%
	Caprelia linearis	17 698	1 4%	19 550	5%	21 791	7%	4 830	5%	7 545	7%	13 335	8%	16 391	1 1%	6 293	3%	805	0%	5 115	1 2%
GASTROPODA	Rissoidae indet.	027	0%																	011	0%
	Crepiduia fornicata	2 287	2%	2 753	1%					242	0%	4 016	2%	183	0%						
	Nudibranchia indet.			015	0%					224	0%			003	0%					014	0%
	Onchidoris muricata																			089	0%
BIVALVIA	Mytilus edulis	53 302	4 2%	146 528	3 8%	148 933	4 9%	21 530	2 2%	14 694	1 4%	77 922	4 5%	234 615	16 4%	82 380	3 5%	199 438	11 8%	2 328	5%
BRYOZOA	Bryozoa indet.									006	0%										
	Electra pilosa	1 686	1%	837	0%	13 563	4%	187	0%	879	1%	2 826	2%	1 074	1%	1 242	1%			1 017	2%
ECHiNODERMATA	Asterias rubens			36 063	9%	64 428	2 1%	167 840	17 3%	394 842	38 1%	27 791	1 6%							214 666	49 3%
	Strongylocentrotus droebachiensis													003	0%						
Total		1264 953	100 0%	3877 328	100 0%	3032 950	100 0%	971 271	100 0%	1035 816	100 0%	1719 665	100.0%	1431 281	100.0%	2345 128	100.0%	1684 270	100.0%	435 328	100.0%

September 2003

		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	121 527	27 5%	16 653	5 6%	21 135	2%			9 936	2 6%	17 930	5 5%	63 777	28 0%	25 388	5%	2 137	0%	6 482	6%
	Campanulariidae indet.	755	2%	049	0%	106	0%			697	2%	108	0%	333	1%	038	0%	182	0%	056	0%
ANTHOZOA	Actiniaria indet.	58 962	13 3%	34 448	11 6%	23 799	3%			005	0%	48 729	15 0%	7 315	3 2%	5 960	1%	4 720	1%	24 718	2 1%
NEMERTINI	Nemertini indet.	015	0%			11 341	1%	42 138	9%	037	0%	801	2%	355	2%	9 412	2%	8 729	1%	009	0%
NEMATODA	Nematoda indet.			000	0%							219	1%			002	0%				
POLYCHAETA	Harmothoe imbricata					1 080	0%									2 935	1%				
	Harmothoe impar					836	0%									442	0%	230	0%		
	Phyllodoce groenlandica			020	0%	173	0%	023	0%	016	0%	003	0%	042	0%	188	0%	283	0%	103	0%
	Eulalia viridis	419	1%							001	0%	008	0%	002	0%	475	0%	006	0%	008	0%
	Nereididae indet.					034	0%	748	0%							232	0%				
	Nereis pelagica													004	0%			562	0%		
	Neanthes virens					391	0%	884	0%							087	0%	453	0%		
	Capitella capitata					003	0%							002	0%					140	0%
	Pomatoceros triqueter	1 962	4%	1 352	5%	408	0%			3 969	1 0%	1 110	3%	2 342	1 0%	2 221	0%	045	0%	3 420	3%
PYCNOGONIDA	Phoxichilidium femoratum													001	0%						
CRUSTACEA	Verruca stroemia					040	0%					051	0%	030	0%					083	0%
	Balanus balanus					1 431	0%	1229 002	25 0%							1 848	0%	403 500	4 4%		
	Balanus crenatus	155	0%	450	2%					027	0%	2 060	6%	173	1%	1 845	0%			400	0%
	Caridea indet.									003	0%										
	Corystes cassivelaunus																			004	0%
	Cancer pagurus	415	1%	057	0%	850	0%	595	0%	016	0%	440	1%	370	2%	1 438	0%	285	0%	307	0%
	Corophium crassicorne					000	0%														
	Jassa marmorata	101 173	22 9%	106 318	35 8%	182 488	2 1%	298 591	6 1%	65 744	17 2%	180 064	55 3%	87 678	38 6%	232 053	4 4%	278 582	3 1%	21 945	1 9%
	Caprella linearis	21 983	5 0%	53 172	17 9%	62 299	7%	010	0%	36 317	9 5%	6 488	2 0%	15 909	7 0%	81 303	1 5%	15 243	2%	4 945	4%
CHIRONOMiDAE	Telmatogeton japonicus			020	0%	022	0%	2 816	1%	014	0%	280	1%					085	0%		
GASTROPODA	Rissoidae indet.	120	0%	004	0%	040	0%	004	0%	017	0%	023	0%	014	0%	322	0%	156	0%	018	0%
	Crepidula fornicata	16 698	3 8%	13 438	4 5%	078	0%			5 790	1 5%	23 626	7 3%	5 388	2 4%	4 131	1%	5 180	1%	396	0%
	Nudibranchia indet.	140	0%	059	0%	033	0%			054	0%	061	0%	007	0%					078	0%
	Onchidoris muricata					020	0%			041	0%			017	0%	007	0%			020	0%
BIVALVIA	Mytiius edulis	581	1%	254	1%	8335 253	96 0%	3344 036	68 0%	042	0%	14 250	4 4%	537	2%	4867 761	91 5%	8335 884	91 9%	225	0%
	Ostrea edulis															806	0%				
	Heteranomia squamula			130	0%	034	0%							041	0%						
	Moerella donacina															003	0%				
	Venerupis senegalensis															180	0%				
	Hiatella arctica	005	0%	021	0%									010	0%	017	0%	005	0%		
BRYOZOA	Bryozoa indet.	1 126	3%	957	3%					044	0%			224	1%						
	Electra pilosa	37 250	8 4%	38 389	12 9%	24 744	3%	071	0%	12 735	3 3%	1 286	4%	27 843	12 2%	42 506	8%	12 808	1%	21 856	1 9%
ECHINODERMATA	Asterias rubens	79 313	17 9%	31 112	10 5%	20 232	2%			246 060	64 5%	27 949	8 6%	14 967	6 6%	38 652	7%	151	0%	1082 390	92 7%
	Strongylocentrotus droebachiensis			002	0%											472	0%			003	0%
Total		442 599	100 0%	296 904	100 0%	8686 867	100 0%	4918 919	100 0%	381 566	100 0%	325 485	100 0%	227 381	100 0%	5320 723	100 0%	9069 224	100 0%	1167 605	100 0%

Appendix 7.3. Mean biomass. Scour protections

March 2003

		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 %
HYDROZOA	Hydrozoa indet.	.	.	.000	.0%	.	.	.	.
	Thecata indet.	.	.	.	.	.003	.0%	.	.
	Campanulariidae indet.	.	.	.010	.0%	.004	.0%	.	.
ANTHOZOA	Anthozoa indet.	.622	.3%	4.929	2.4%	.	.	.278	.1%
	Actiniaria indet.	4.022	1.9%	3.373	1.6%	7.379	1.3%	2.272	1.2%
NEMERTINI	Nemertini indet.	.023	.0%	.002	.0%	.	.	.002	.0%
POLYCHAETA	Harmothoe impar	.136	.1%	.634	.3%	1.128	.2%	.353	.2%
	Phyllodoce groenlandica	.038	.0%	.278	.1%	.999	.2%	.898	.5%
	Eulalia viridis	.001	.0%	.003	.0%	.025	.0%	.	.
	Chaetopterus norvegicus	.	.	.075	.0%	.054	.0%	.	.
	Pomatoceros triqueter	.003	.0%	.139	.1%	.095	.0%	.022	.0%
CRUSTACEA	Verruca stroemia	.025	.0%	.005	.0%	.	.	.020	.0%
	Balanus crenatus	93.304	45.2%	79.610	38.4%	360.297	65.9%	15.682	8.3%
	Cancer pagurus	.033	.0%	.	.	.096	.0%	.	.
	Corophium crassicorne	.	.	.	.	.003	.0%	.	.
	Jassa marmorata	70.065	34.0%	52.311	25.3%	111.123	20.3%	118.323	62.8%
	Caprella linearis	3.730	1.8%	6.435	3.1%	1.189	.2%	.219	.1%
GASTROPODA	Rissoidae indet.	.003	.0%	.019	.0%	.069	.0%	.006	.0%
	Crepiduia fornicata	.053	.0%	.276	.1%	.929	.2%	.060	.0%
	Nudibranchia indet.	.	.	.	.	.269	.0%	.015	.0%
	Onchidoris muricata	.342	.2%	.	.	.045	.0%	.	.
BIVALVIA	Bivalvia indet.	.	.	.006	.0%	.	.	.	.
	Mytiius eduiis	2.381	1.2%	3.978	1.9%	1.348	.2%	4.022	2.1%
	Heteranomia squamuia	.	.	.010	.0%	.017	.0%	.	.
	Moerella donacina	.016	.0%	.045	.0%	.099	.0%	.	.
	Thracia phaseolina	.	.	.	.	.006	.0%	.	.
BRYOZOA	Bryozoa indet.	.	.	.099	.0%	.017	.0%	.	.
	Eiectra pilosa	.290	.1%	1.372	.7%	1.680	.3%	.411	.2%
ECHINODERMATA	Asterias rubens	31.253	15.1%	53.491	25.8%	60.071	11.0%	45.712	24.3%
	Ophiura albida	.	.	.002	.0%	.003	.0%	.002	.0%
	Strongyiocentrotus droebachiensis	.	.	.	.	.	.	.004	.0%
Total		206.339	100.0%	207.103	100.0%	546.948	100.0%	188.302	100.0%

September 2003

		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 %
HYDROZOA	Tubularia indivisa	4.765	3.0%	5.688	2.6%	2.173	1.6%	6.586	4.1%
	Campanuiariidae indet.	.142	.1%	.131	.1%	.078	.1%	.097	.1%
ANTHOZOA	Actiniaria indet.	43.808	27.1%	97.761	45.4%	68.143	49.3%	41.939	26.1%
NEMERTINI	Nemertini indet.	.003	.0%	.	.	.009	.0%	.004	.0%
NEMATODA	Nematoda indet.	.003	.0%	.001	.0%	.000	.0%	.000	.0%
POLYCHAETA	Harmothoe impar	.	.	.	.	.001	.0%	.	.
	Phyllodocidae indet.	.	.	.000	.0%	.	.	.	.
	Phyllodoce groenlandica	.047	.0%	.032	.0%	.042	.0%	.026	.0%
	Eulalia viridis	.001	.0%	.003	.0%	.	.	.	.
	Syiiidae indet.	.	.	.	.	.	.	.000	.0%
	Nereididae indet.	.001	.0%	.	.	.	.	.	.
	Poiydora ciiiata	.	.	.	.	.000	.0%	.	.
	Capiteiia capitata	.	.	.007	.0%	.000	.0%	.	.
	Pomatoceros triqueter	.080	.0%	.268	.1%	.224	.2%	.513	.3%
PYCNOGONiDA	Phoxichilidium femoratum	.001	.0%	.	.	.	.	.	.
CRUSTACEA	Verruca stroemia	.006	.0%	.036	.0%	.054	.0%	.013	.0%
	Balanus crenatus	.306	.2%	.432	.2%	.227	.2%	1.499	.9%
	Cancer pagurus	.016	.0%	.079	.0%	.183	.1%	.087	.1%
	Stenothoe marina	.002	.0%	.	.	.	.	.	.
	Jassa marmorata	32.758	20.3%	27.546	12.8%	22.944	16.6%	41.846	26.0%
	Atylus swammerdami	.	.	.001	.0%	.	.	.	.
	Caprella linearis	6.385	4.0%	3.609	1.7%	1.593	1.2%	4.476	2.8%
	Hyperia galba	.004	.0%	.	.	.	.	.	.
CHIRONOMIDAE	Teimatogeton japonicus	.002	.0%	.	.	.	.	.	.
GASTROPODA	Rissoidae indet.	.230	.1%	.214	.1%	.845	.6%	.152	.1%
	Crepiduia fornicata	.430	.3%	5.341	2.5%	1.121	.8%	7.192	4.5%
	Poiinices sp.	.	.	.	.	.021	.0%	.	.
	Nudibranchia indet.	.017	.0%	.063	.0%	.023	.0%	.057	.0%
	Onchidoris muricata	.014	.0%	.023	.0%	.024	.0%	.279	.2%
BIVALVIA	Mytiius eduiis	.090	.1%	.257	.1%	.115	.1%	3.850	2.4%
	Moerella donacina	.	.	.	.	.001	.0%	.001	.0%
	Hiatella arctica	.	.	.001	.0%	.000	.0%	.004	.0%
BRYOZOA	Bryozoa indet.	.019	.0%	.122	.1%	.210	.2%	.	.
	Eiectra piiosa	2.148	1.3%	1.410	.7%	1.221	.9%	2.279	1.4%
ECHINODERMATA	Asterias rubens	70.229	43.5%	72.237	33.6%	39.036	28.2%	50.027	31.1%
	Strongyiocentrotus droebachiensis	.002	.0%	.000	.0%	.000	.0%	.	.
Total		161.508	100.0%	215.263	100.0%	138.290	100.0%	160.929	100.0%