

Hard Bottom Substrate Monitoring Horns Rev Offshore Wind Farm 2004

Survey Report No.1





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1. Introduction

In connection with the implementation of the monitoring programme concerning the ecological implication of the effect of the introduction of hard substrate related to the Horns Rev Wind Farm, the third survey was carried out in the period 24–31 March 2004.

The survey covered collection of fauna and flora samples from the scour protection and at the wind turbine towers at six turbine sites. Video recordings were planned at different sites to provide documentation, but due to poor visibility the video recordings were postponed. On request from Elsam Engineering A/S video inspections on technical installations were made at turbine 84 and 95.

This report covers a short description of the methodology, sampling activities and site description.

2. Methodology

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

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

Depth at 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.

Samples of fouling communities were collected at six turbine sites at the Horns Rev Wind Farm by SCUBA divers.

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 table 3.

Location	"WGS84_MIN_Y"	WGS84_MIN_X"	Depth (app. m)	Program
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 **.

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

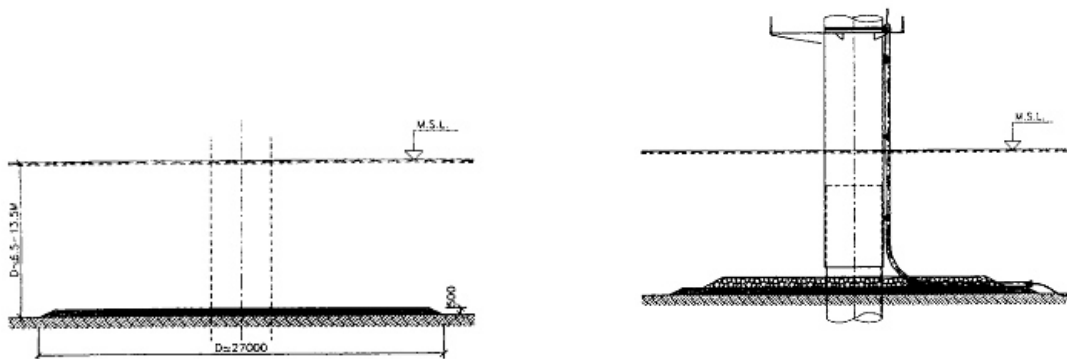


Figure 1. Wind turbine foundation and scour protection.

At each station, samples of fouling organisms were thoroughly scraped off the stone blocks within a frame of 0.04 m² using a specialised scraping tool and a specialised 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 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 as well as an evaluation of the coverage of species and substrate was carried out. The species-specific degree of coverage is the term used to describe the degree of coverage by a single species on a specific substrate based on a suitable adaptation of the Braun-Blanquet scale (Leewis and Hallie, 2000), table 2. Fish species observed were registered and numbered according to table 2.

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

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

The total degree of coverage for floral and faunal communities over the whole seabed (the turbine foundation) 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.

As well as 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 0.04 m² from the turbine tower were taken 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 60 samples from the towers were collected.

Each individual sample was sieved through a laboratory test sieve with an aperture of 1 mm. The residual was preserved in ethanol and the sample marked.

Additional collections of samples within the splash zones of the turbine towers were made at turbine site 33, 55, 91, 92 and 95. A total of 15 frame samples of 0.04 m² were collected with the objective to estimate the abundance of the giant midge *Telmatogeton japonicus*.

2.1. Test fishing

For the validation of the fish species observed, two test fishing surveys were made at turbine site 54 using standard pelagic and sinking gill nets. The pelagic gill net was set in nighttime on 25th March from 6 PM to 9.00 AM 26th March. The sinking gill net was set in daytime on 26th March 2004 from 9 AM to 5.00 PM.

The standard biological survey gill nets used was 42 m long and 1.5 m high. The nets are composed of 14 different mesh sizes from 6.25 mm to 60 mm in 14 sections. The nets were placed with the southern end close to the turbine tower in the direction of the main current towards 20° NNE covering both the scour protection and the seabed outside the scour protection. The pelagic net was placed in the approximately 1.5-2.5 m's above the seabed, figure 2. The sinking net was placed on the scour protection and the seabed.

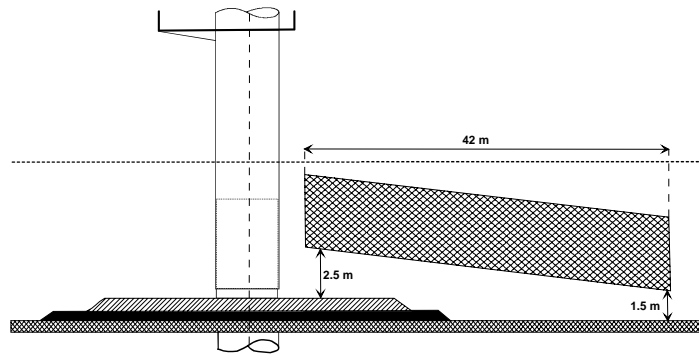


Figure 2. Schematic illustration of the placement of the pelagic gill net at the test site.

3. Results

Sampling was performed at the following locations presented in table 3. Positions and actual depth are registered at the position of the sampling vessel close to the turbine tower.

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

Table 3. Actual positions and actual depth recorded on sampling dates.

3.1. Meteorological and hydrographical data

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

Table 4. Meteorological and hydrographical data.

3.2. Sampling

Sampling at the turbine towers was difficult to perform due to wave and current exposure.

Sampling was performed at the following turbine sites.

Turbine HORN_33

Sampling	Name	Replicate no.	SampID	Depth (m)
Scour protection	NNE0.5	1	16699	9.4
		2	16700	9.4
		3	16701	9.4
	NNE2	1	16702	9.1
		2	16703	9.1
		3	16704	9.1
	NNE5	1	16705	9.0
		2	16706	9.0
		3	16707	9.0
	SSW5	1	16708	8.8
		2	16709	8.8
		3	16710	8.8
Braun-Blanquet transects		Length (m)	Depth (m)	
	NNE Scour protection	0-14		9.0-11.3
	NNE Tower			0-9.6
	SSW Scour protection	0-14		8.8-10.4
	SSW Tower			0-9.6
Mobile benthos species observed	Common name	Scientific name		Abundance
	Edible crab	<i>Cancer pagurus</i>		2 ind/m ²
	Hermit crab	<i>Pagurus bernhardus</i>		7 ind/m ²
	Long-legged spider crab	<i>Macropodia rostrata</i>		5 ind/m ²
Fish species observed	Common name	Scientific name		Abundance
	Pollack	<i>Pollachius virens</i>		0
	Hooknose	<i>Agonus cataphractus</i>		0
	Rock gunnel	<i>Pholis gunellus</i>		0
	Longspined bullhead	<i>Taurulus bubalis</i>		0

Table 5. Sampling at turbine site 33.

Turbine HORN_55

Sampling	Name	Replicate no.	SampID	Depth (m)	
Scour protection	NNE0.5	1	16770	8.2	
		2	16771	8.2	
		3	16772	8.2	
	NNE2	1	16767	8.0	
		2	16768	8.0	
		3	16769	8.0	
	NNE5	1	16764	7.6	
		2	16765	7.6	
		3	16766	7.6	
	SSW5	1	16761	8.5	
		2	16762	8.5	
		3	16763	8.5	
	Tower	NNEB	1	16759	8.8
			2	16760	8.8
		NNE2	1	16751	6.8
2			16752	6.8	
NNE4		1	16753	4.8	
		2	16754	4.8	
NNE6		1	16755	2.8	
		2	16756	2.8	
NNE8		1	16757	0.8	
		2	16758	0.8	
SSWB	1	16749	8.2		
	2	16750	8.2		
SSW2	1	16805	6.2		

Turbine HORN_55

Sampling	Name	Replicate no.	SampID	Depth (m)
		2	16806	6.2
		1	16743	4.2
	SSW4	2	16744	4.2
		1	16745	2.2
	SSW6	2	16746	2.2
		1	16747	0.2
	SSW8	2	16748	0.2
Braun-Blanquet transects		Length (m)		Depth (m)
	NNE Scour protection	0-14		8.2-9.6
	NNE Tower			0-8.3
	SSW Scour protection	0-16		8.4-9.4
	SSW Tower			0-8.8
Mobile benthos species observed	Common name	Scientific name		Abundance
	Edible crab	<i>Cancer pagurus</i>		1,5 ind/m ²
Fish species observed	Common name	Scientific name		Abundance
	Shorthorn sculpin	<i>Myoxocephalus scorpius</i>		0
	Hooknose	<i>Agonus cataphractus</i>		0
	Viviparous blenny	<i>Zoarces viviparus</i>		0
	Rock gunnel	<i>Pholis gunellus</i>		0
	Lumpsucker	<i>Cyclopterus lumpus</i>		0

Table 6. Sampling at turbine site 55.

Turbine HORN_58

Sampling	Name	Replicate no.	SampID	Depth (m)	
Scour protection	NNE0.5	1	16734	6.6	
		2	16735	6.6	
		3	16736	6.6	
	NNE2	1	16731	6.8	
		2	16732	6.8	
		3	16733	6.8	
	NNE5	1	16728	6.8	
		2	16729	6.8	
		3	16730	6.8	
	SSW5	1	16725	5.2	
		2	16726	5.2	
		3	16727	5.2	
	Tower	NNEB	1	16737	7.3
			2	16738	7.3
		NNE2	1	16719	5.3
2			16720	5.3	
NNE4		1	16721	3.3	
		2	16722	3.3	
NNE6		1	16723	1.3	
		2	16724	1.3	
NNE8		1	16741	0.3	
		2	16742	0.3	
SSWB		1	16711	7.3	

Turbine HORN_58

Sampling	Name	Replicate no.	SampID	Depth (m)
		2	16712	7.3
		1	16717	5.3
	SSW2	2	16718	5.3
		1	16713	3.3
	SSW4	2	16714	3.3
		1	16715	1.3
	SSW6	2	16716	1.3
		1	16739	0.3
	SSW8	2	16740	0.3
Braun-Blanquet transects		Length (m)		Depth (m)
	NNE Scour protection	0-14		6.6-8.0
	NNE Tower			0-7.3
	SSW Scour protection	0-14		5.2-6.5
	SSW Tower			0-6.5
Mobile benthos species observed	Common name	Scientific name	Abundance	
	Long-legged spider crab	<i>Macropodia rostrata</i>	0.5 ind./m ²	
	Harbour crab	<i>Liocarcinus depurator</i>	0.5 ind/m ²	
	Common shore crab	<i>Carcinus maenas</i>	0.5 ind/m ²	
	Edible crab	<i>Cancer pagurus</i>	0.5 ind/m ²	
Fish species observed	Common name	Scientific name	Abundance	
	Shorthorn sculpin	<i>Myoxocephalus scorpius</i>	0	
	Rock gunnel	<i>Pholis gunellus</i>	0	

Table 7. Sampling at turbine site 58.

Turbine HORN_91

Sampling	Name	Replicate no.	SampID	Depth (m)	
Scour protection	NNE0.5	1	16649	5.7	
		2	16650	5.7	
		3	16651	5.7	
	NNE2	1	16646	5.0	
		2	16647	5.0	
		3	16648	5.0	
	NNE5	1	16643	5.2	
		2	16644	5.2	
		3	16645	5.2	
	SSW5	1	16640	4.6	
		2	16641	4.6	
		3	16642	4.6	
	Braun-Blanquet transects		Length (m)		Depth (m)
		NNE Scour protection	0-14		4.6-7.0
		NNE Tower			0-5.7
SSW Scour protection		0-14		4.6-7.0	
SSW Tower				0-5.6	
Mobile benthos species observed	Common name	Scientific name	Abundance		
	Common shore crab	<i>Carcinus maenas</i>	0.5 ind/m ²		
Fish species observed	Common name	Scientific name	Abundance		

Turbine HORN_91

Sampling	Name	Replicate no.	SampID	Depth (m)
	Rock gunnel		<i>Pholis gunnellus</i>	0

Table 8. Sampling at turbine site 91.

Turbine HORN_92

Sampling	Name	Replicate no.	SampID	Depth (m)
Scour protection	NNE0.5	1	16690	5.0
		2	16691	5.0
		3	16692	5.0
	NNE2	1	16687	5.2
		2	16688	5.2
		3	16689	5.2
	NNE5	1	16693	5.4
		2	16694	5.4
		3	16695	5.4
	SSW5	1	16696	5.1
		2	16697	5.1
		3	16698	5.1
Braun-Blanquet transects		Length (m)		Depth (m)
	NNE Scour protection	0-14		3.1-5.7
	NNE Tower			0-5.0
	SSW Scour protection	0-14		3.9-6.2
	SSW Tower			0-4.5
Mobile benthos species observed	Common name	Scientific name		Abundance
	Edible crab	<i>Cancer pagurus</i>		2 ind/m ²
	Harbour crab	<i>Liocarcinus depurator</i>		2 ind/m ²
	Braun shrimp	<i>Crangon crangon</i>		0.5 ind/m ²
Fish species observed	Common name	Scientific name		Abundance
	Hooknose	<i>Agonus cataphractus</i>		0
	Rock gunnel	<i>Pholis gunnellus</i>		0

Table 9. Sampling at turbine site 92.

Turbine HORN_95

Sampling	Name	Replicate no.	SampID	Depth (m)
Scour protection	NNE0.5	1	16773	7.8
		2	16774	7.8
		3	16775	7.8
	NNE2	1	16776	7.7
		2	16777	7.7
		3	16778	7.7
	NNE5	1	16779	7.6
		2	16780	7.6
		3	16781	7.6
	SSW5	1	16782	6.4
		2	16783	6.4
		3	16784	6.4
Tower	NNEB	1	16785	7.8
		2	16786	7.8
	NNE2	1	16793	5.8
		2	16794	5.8
	NNE4	1	16791	3.8
		2	16792	3.8
NNE6	1	16789	1.8	

Turbine HORN_95

Sampling	Name	Replicate no.	SampID	Depth (m)	
	NNE8	2	16790	1.8	
		1	16787	0.8	
	SSWB	2	16788	0.8	
		1	16795	7.2	
	SSW2	2	16796	7.2	
		1	16803	5.2	
	SSW4	2	16804	5.2	
		1	16801	3.2	
	SSW6	2	16802	3.2	
		1	16799	1.2	
	SSW8	2	16800	1.2	
		1	16797	0.2	
			2	16798	0.2
Braun-Blanquet transects		Length (m)		Depth (m)	
	NNE Scour protection	0–14		7.4–7.8	
	NNE Tower			0–7.8	
	SSW Scour protection	0–14		6.3–7.7	
	SSW Tower			0–7.5	
Mobile benthos species observed	Common name	Scientific name	Abundance		
	Edible crab	<i>Cancer pagurus</i>	1 ind/m ²		
Fish species observed	Common name	Scientific name	Abundance		
	Shorthorn sculpin	<i>Myxocephalus scorpius</i>	0		
	Rock gunnel	<i>Pholis gunellus</i>	0		
	Hooknose	<i>Agonus cataphractus</i>	0		

Table 10. Sampling at turbine site 95.

3.3. Video recording

No video recordings were made as documentation due to very low visibility. Video recordings will be made when weather condition and visibility are improved.

Video inspections on technical installations were made on request from Elsam Engineering A/S at turbine site 84 and 95.

3.4. Observations

Some preliminary results from transect surveys are briefly described below.

The scour protection 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.

A distinct zonation of the fouling communities at the turbine towers was typically observed especially in the few metres below the sea surface.

3.4.1. Vegetation

Only a few species of seaweed were observed.

In the splash zone on the turbine towers, generally very sparse mats of the filamentous brown algae *Ectocarpus sp.* and the green algae *Enteromorpha intestinalis* were observed. Also very sparse, small tufts of the filamentous green algae *Cladophora* were observed. In the splash zone a green/brown coating of microscopic green algae and diatoms was very distinct on the turbine towers.

Just beneath the surface down to approximately 2 metres, the seaweeds *Ectocarpus sp.*, *Enteromorpha sp.* *Petalonia fascia* and *Petalonia zosterifolia* were observed on several turbines.

On the scour protection, the vegetation was very sparse and generally absent.

The red algae *Callithamnion corymbosum* was observed on the scour protection at turbine site 91 and 92. The encrusting red algae *Hildenbrandiales* spp. was found on the scour protection at turbine sites 91, 92 and 95. *Pilayella littoralis* was found on the scour protection at turbine site 92

3.4.2. Fauna

In the splash zones numerous giant midges *Telmatogeton japonicus* were observed at all towers. Three life stages, larvae, pupae and imago, of the midge were recognised. The imago-stage was represented by both male and female sex.

The most numerous species observed were the tube dwelling amphipod *Jassa marmorata*. *Jassa marmorata* were generally more abundant on the turbine towers than on the scour protections, covering up to 75% of the surface and reaching very high densities.

The skeleton shrimp (*Caprella linearis*), the starfish *Asterias rubens*, and the sea anemone (*Metridium* sp., *Actinaria* indet.) were locally very abundant both on the turbine towers and on the scour protections, whereas the common mussel *Mytilus edulis*, the slipper limpet *Crepidula fornicata*, and the bristleworm *Pomatoceros triqueter* in general were much less common. At turbine site 95 dense aggregations of *Mytilus edulis* were found in the sublittoral just beneath the sea surface. Dense aggregations of *Mytilus edulis* were generally also observed on banisters.

Mobile species such as the hermit crab (*Pagurus* spp.), edible crab (*Cancer pagurus*), common shore crab (*Carcinus maenas*) were observed at most turbine sites. At few turbine sites the long/legged spider crab *Macropodia rostrata* relatively numerous. More individuals of the sea slugs *Aeolidia papillosa*, *Onchidoris muricata* and *Polycera quadrilobata* were observed at the turbine sites, see photo 1 and photo 2.



Photo 1. The sea slug *Aeolidia papillosa*.



Photo 2. The sea slug *Polycera quadrilobata*.

On the seabed just outside the scour protection the bristle worm *Lanice conchilega* was locally very abundant.

Only a few species of fish were observed and only in low numbers. The most numerous – the rock gunnel – was observed at the scour protection at all six turbine sites. The hooknose and shorthorn sculpin were observed at 3-4 turbine sites, whereas only single individuals of other fish species were observed. In table 13 the individual fish species are categorized according to the number of turbine sites at which the species was observed and according to the relative abundance observed by the diver.

Numerous		Common		Observed		
Common name	Scientific name	Common name	Scientific name	Occurrence at turbine sites	Common Name	Scientific name
				O O O O O O	Rock gunnel	<i>Pholis gunnellus</i>
				O O O O	Hooknose	<i>Agonus cataphractus</i>
				O O O	Shorthorn sculpin	<i>Myoxocephalus scorpius</i>
				O	Pollack	<i>Pollachius virens</i>
				O	Lumpsucker	<i>Cyclopterus lumpus</i>
				O	Longspined bullhead	<i>Taurulus bulbaris</i>
				O	Viviparous blenny	<i>Zoarces viviparus</i>

Table 13. Relative abundance of the fish species observed at the turbine sites at Horns Rev.

Only two individuals of fish were caught during the test fishing, night and day. The results from the test fishing are shown in table 14.

Fishing	Common name	Scientific name	Number	Length cm
Night	Small sandeel	<i>Ammodytes tobianus</i>	1	13
Day	Shorthorn sculpin	<i>Myoxocephalus scorpius</i>	1	23
Day	Edible crab	<i>Cancer pagurus</i>	2	11-17
Day	Common starfish	<i>Asterias rubens</i>	24	17-15

Table 14. Species caught in the gill nets by the test fishing, night and day.

4. Preliminary conclusion

The vegetation was generally sparsely developed and restricted to the sublittoral zone just under the water line at the turbine sites. Only a few species of seaweed were recorded.

With respect to the fauna, the fouling communities found on both the turbine towers and the scour protections were generally identical, although there were distinct differences between the coverage and number of individual species. The most numerous species found were the amphipod *Jassa marmorata*, which were found in large numbers covering almost the total surface locally of both the towers and the stones.

The common mussel *Mytilus edulis* generally was found only on the turbine towers in the upper 2-3 meters under the water surface. The common mussel was locally very abundant especially where the starfish *Asterias rubens* were absent for example on the banisters.

On the turbine towers, the giant midge *Telmatogeton japonicus* was recorded numerous in the splash zones.

A total number of 7 species of fish were observed primarily being located to the scour protections. The rock gunnel was the most common on the scour protection. The majority of the fish species observed is typical associated with hard bottom substrate.

Video recordings were planned at different sites to provide documentation, but due to poor visibility the video recordings were postponed.

5. References

Leewis, R. & F. Hallie 2000. An Artificial Reef Experiment off the Dutch Coast. – In A. C. Jensen *et al.* (eds.): Artificial Reefs in European Seas: 289–305.