# INTERIM REPORT

## Benthos Recruitment $T_1$

**OWEZ_R_262_T1_20080222 draft**

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CONTENTS

## 1 INTRODUCTION

In 2006 the OWEZ Wind farm was constructed along the Dutch coast 10 -17 km offshore Egmond aan Zee just north of IJmuiden. The OWEZ Wind farm with a surface area of approximately 5*5 km encloses 36 wind turbines with distances of 600-900 m between them. According to the NSW-MEP the environmental impact of the Wind farm on the marine ecosystem is monitored.

Our main objective is to study the impact of the Wind farm on the macrobenthic fauna *i.e.* the invertebrate in- and epifauna. Considering the possible effects of the OWEZ Wind farm on this soft bottom fauna we decided to focus on the fact that this 5*5 km Wind farm is a fishery free area. According to many studies, commercial trawling leads to an increased mortality in various benthos species (Bergman & Santbrink, 2000) and to long-term effects on the composition of the benthic community (Duineveld et.al, 2007). Therefore, we assumed that in the non-fished Wind farm the species composition of benthic fauna and their settlers might become different from the surrounding normally trawled coastal zone. In the absence of trawling mortality, higher abundances of species vulnerable to trawling might be expected. Besides this direct effect, we assume that if trawling is banned there could be also indirect effects on benthos. Such indirect effects of the fishery-stop may include a lower frequency in resuspension of particles from the seabed. As stated by Witbaard et al. (2001), lower suspended matter concentrations can have an advantage for growth and survival of filter feeding fauna, as their filter efficiency is reduced by high loads. Another indirect effect is a change in sediment composition due to the lower rate of resuspension. This may have consequences for benthic settlers, who are selective with respect to the sediment type.

In our sub project we decided to focus on the impact of the non-fished Wind farm on the settlement of juvenile benthos. We focus especially on juvenile bivalves, which adults stages are a major food supply for fish and diving birds in the shallow coastal zone and a dominant factor in filtering particles from the water column enabling deposition and burial of organic material into the sediments.

To determine differences in settlement we compared the autumn densities of settled juvenile benthos in the non-fished OWEZ with the densities in the 5 surrounding reference areas which have been trawled normally during 2006 and 2007. We focused on filter feeding bivalve species. Possible differences in densities of juvenile bivalve species between the Wind farm and the reference areas will be discussed. As a contribution to the discussion, the expected densities of juvenile *Spisula subtruncata* (a bivalve species) in the Wind farm will be estimated from age converted length distributions of pre-OWEZ populations.

Differences in juvenile densities between non–fished Wind farm and trawled reference areas can possibly be explained by differences in environmental variables (*e.g.* turbidity). To measure these environmental variables *in situ* we deployed a submerged lander frame in the OWEZ Wind farm and another in one of the southern reference areas from February till October 2007. Autonomous instruments mounted at these landers measured current speed and direction, fluorescence, turbidity, salinity and temperature in five minute intervals. Their recordings are discussed in view of existing knowledge of particle transport and mud (<63 μ) dynamics along the coast (Kleinhans et al 2005). Differences in sediment composition between Wind farm and reference areas are measured by analysing median grain size and mud content in sediment collected during the juvenile benthos survey.

Differences found in juvenile densities between OWEZ Wind farm and reference areas might also be explained by changes in the sediment composition of the seabed in OWEZ due to the fishery-stop. To examine effects of sediment type on settlement of larval benthos we mounted manipulated mesocosms at the landers. In these mesocosms we offered next to normal sized coastal sediment (0.5 mm-1mm) also finer (0.2-0.5 mm) and coarser sized (>1 mm) fractions in adjacent trays. With these mesocosms we performed two *in situ* experiments during the major settling period in summer 2007.

This Interim Report presents the progress in the subproject Benthos-Recruitment up to 31 January 2008. The objectives of the study are described in the Introduction. The section

Material and Methods includes a description of the study area, the set-up of the field survey, and the landers and their instruments. In the chapter Results the progress so far of each component of the study is described, and in the Discussion the results are discussed and possible explanations are offered. In the Final Report (Q1- 2009) all results will be presented and discussed.

# 2 MATERIAL & METHODS

## 2.1 Area of investigation

The OWEZ Wind farm is situated in the coastal zone 10-17 km offshore Egmond aan Zee. Water depth varies between 17 and 20 m. The sediment in the Dutch coastal zone consists of fine to medium sands (Duineveld et al. 1990). In 2003 prior to the designation of OWEZ as an area closed for fishery and before the construction of the turbines the median grain size was measured in several sites covering an area from approx. 20 km south to 15 km north of the present OWEZ (Jarvis et al, 2004). The median grain size was on average 504 µm (s.d. = 122.8 µm) which is classified as medium sand. The median grain size within the present contours of OWEZ Wind farm was on average 466 µm (s.d.128.9) ranging from 207 to 655 µm. Mean silt (< 63 µm) content was 0.5 % (s.d. 2.25) ranging from 0 to 15% with the higher values found in a small patch in the centre of the farm. Mean gravel (> 2.0 mm) content was 0.1 % (s.d. 0.8), and mean organic matter content was 0.49 % (s.d. 0.478).

Studies on mud dynamics in the shoreface off Noordwijk by Kleinhans et al (2005) indicated that infiltration of mud into the sandy bed by pressure differences over bedforms is negligible. Mud inmixing into the bed is mostly coupled to macrobenthic activity, while re-entrainment is coupled to the sand mobilization during storms. Total suspended matter (TSM; algae and silt) is the main source of turbidity in the water column as sand is mainly transported as bed load. It determines to a large extent the underwater light climate governing primary production, the basis of the food chain. By mixing with edible food particles it determines the efficiency filter feeders sieve their food from the water phase. Suspended matter concentrations in the water column are highly variable in time and space. In the shallow coastal zone TSM concentrations appear to be mainly determined by the wave heights (Suijlen & Duin, 2002), and TSM is distributed in bands which are roughly parallel to the coastline. In summer (May – November) both OWEZ Wind farm and Ref. Lander area are in the zone with mean near-surface TSM values of 5-10 mg/l, in winter(December – April) the values around the Ref. Lander area increase up to 10-20 mg/l. Typically, the near-surface TSM concentrations vary here between 10-30 mg/l just after storms and 1-3 mg/l after a calm period (Suijlen & Duin, 2002).

The macrobenthic fauna in the Dutch coastal zone is relative rich with a strong gradient of higher values towards the coast. Biomass shows a relative stable spatial pattern over the last 20 years with ash free dry weights increasing up to 40 g/m$^2$ in the near shore zone between the OWEZ Wind farm and the coast. Abundances of macrobenthic fauna show the same relative stable gradient with densities up to 4000 individuals per m$^2$ in the near shore zone. The OWEZ Wind farm is situated between the relative rich near shore and relative poor offshore area. Despite the stable spatial gradients, large annual variations in biomass and density of species have been observed over the last 20 years in the BIOMON monitoring program (Daan & Mulder, 2006).

## 2.2 Design of the study areas

To measure the difference in density of juvenile benthos species that settled in and outside the fishery-free OWEZ Wind farm in 2007, surrounding regularly trawled reference areas were sampled. The selection of reference areas was nearly similar to those in the survey on macrobenthic fauna larger 1 mm in and outside the fishery-free OWEZ Wind farm executed in spring 2007 (see NZW-densities Interim Report). In that survey 6 surrounding normally trawled reference areas were selected: 3 north and 3 south of the Wind farm. Initially we decided to choose the same reference areas. However, because the reference lander (see next paragraph) was situated outside these reference areas we added a new ”lander” reference area (Ref Lander). Skipping the most northerly and southerly reference areas resulted in a survey design with 5 reference areas in total. North of OWEZ two reference areas (Ref 2 and Ref 3) were situated at a distance of approx 7 km, south of OWEZ three reference areas (Ref 4, Ref 5, and Ref Lander) were positioned at a distance of approx 8 km (Fig. 1).

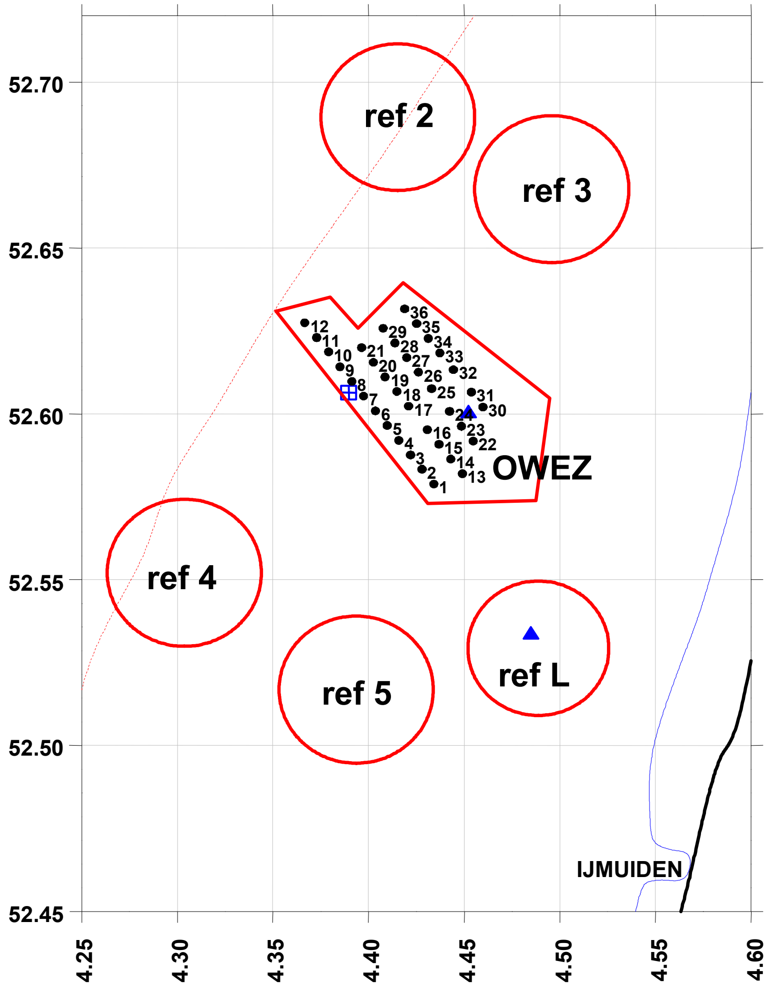



Fig. 1. Locations of the fishery closed OWEZ Wind farm enclosing the 36 turbines and the 5 reference areas. Lander positions in OWEZ and in "ref Lander" area (▲) and the Meteomast (╬) are indicated.

To get a hold on the environmental parameters that might act as steering factors in the settlement of pelagic larvae of benthos species, submerged landers with autonomous instruments were deployed both in the OWEZ Wind farm and in the southern "Ref Lander" area (Fig. 1). In the OWEZ Wind farm the lander was deployed in position 52º 36'N / 004º 27.14'E, circa 10.6 km from the coast. Initially, the reference lander was planned 7.5 km to the south at a similar distance to the coast. Unfortunately this position was not allowed by the nautical authority and we selected the first suitable site east of that position (52º32'N / 004º291'E) thus as close as possible to the original reference site selected. In fact the distance of the reference lander to the coast was now reduced to 7.6 km, whereas the OWEZ Lander position remained 10.6 km offshore. This might have had repercussions for the TSM regime both landers are subject to. Typically in winter and especially during and just after heavy storms the reference lander will be exposed to higher TSM concentrations (20-30 mg/l) than the OWEZ lander (~10 mg/l), based on long term recordings by Suijlen & Duin (2002). Along the north-south axis the landers are still approx. 7.5 km apart (Fig.1).

Jarvis et al (2004) present sediment data that were measured in 2003 in the $T_0$ reference areas some 15 to 20 km north and south of OWEZ, respectively. Mean values varied from 489 µm in the north to 604 µm in the south, with mean silt contents varying between 0 and 1.0%, respectively, mean gravel contents between 0.5 and 1.4 %, and mean organic matter between

0.44 and 0.40 %. Assuming minor gradients in sediment parameters alongshore and no clear impact of the OWEZ Wind farm on sediment up to 7 to 8 km outside the OWEZ Wind farm, the sediment characteristics in our reference areas can be expected to be roughly comparable with these 2003-data. If so, the sediment parameters of our reference areas will be well in range with those of the OWEZ Wind farm in 2003 (see 2.1) as provided by Jarvis et al (2004).

**2.3 Field survey on juvenile benthos**

In October 2007 a field survey was executed to compare the settlement of juvenile macrobenthos in OWEZ Wind farm and in the 5 reference areas. A total of 20 sample locations (sites) in OWEZ and 10 sites in each of the 5 reference areas (Fig. 2) were sampled with the boxcorer on board RV POSEIDON (IFM Geomar, Germany). This sampling equipment (Fig. 3) collects a 20 cm deep sample (diameter 30 cm) from the seabed. After removing the layer of water, 3 cores

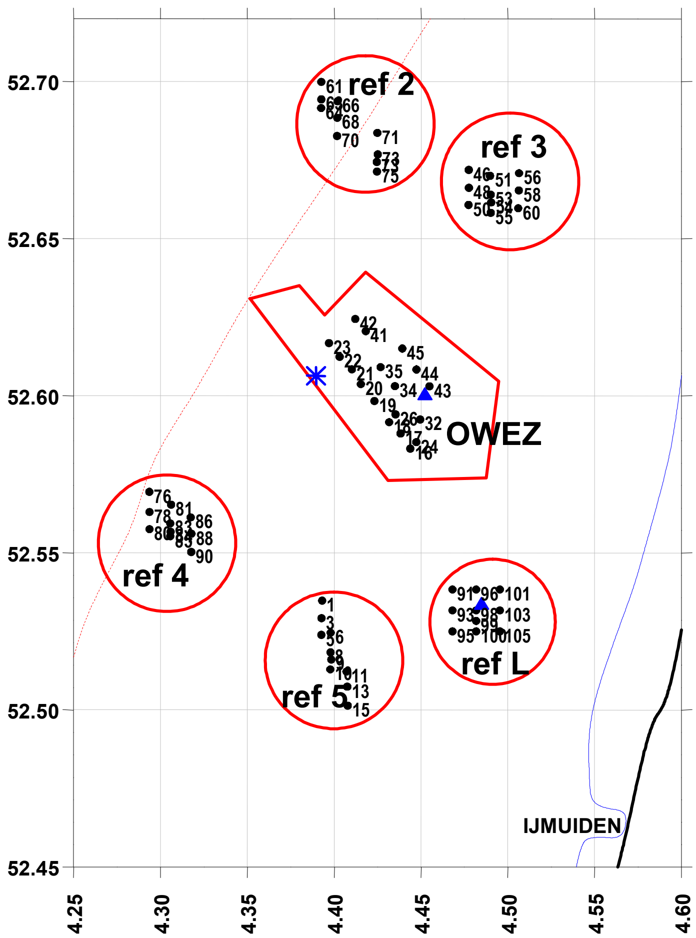



Fig. 2. Boxcore sampling locations in October survey on juvenile benthos.

(diameter 10 cm) were pushed into the sediment surface of the bottom sample. Sediments to a depth of 5 cm from each of these cores were carefully collected (Fig. 4) and stored separately in containers, with 4% buffered formalin as preservative. From each boxcore sample a small 10 cm deep core (diameter 3 cm) was collected and stored in the cooling for sediment analysis (sediment grain size and silt content). The leftovers of the boxcore samples after the core extractions were sieved over 1 mm and the residues were stored on 4% buffered formalin. The 10 cm core samples were sieved in the laboratory over 1.0, 0.5 and 0.2 mm sieves, respectively, and juvenile bivalves from each sieve fraction were counted and identified to lowest taxonomical level possible.

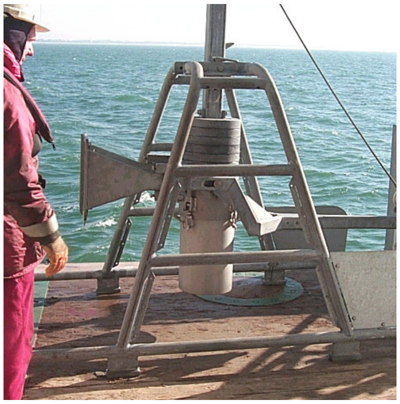


Fig. 3. Reineck boxcore (sample size 0.07 $m^2$) for sampling in- and epifauna.

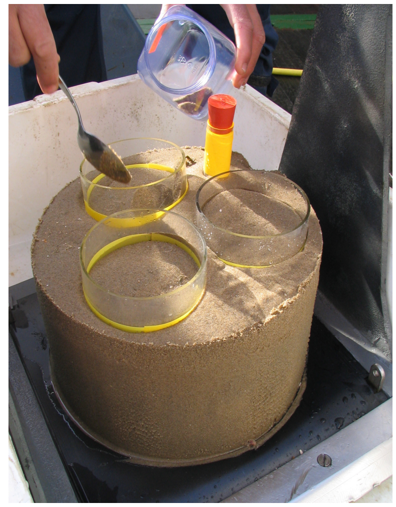


Fig. 4. Boxcore sample (depth circa 20 cm) with 3 cores (diam. 10 cm) inserted 5 cm deep for sub sampling of juvenile benthos. A fourth inserted tube is for collection of sediment.

**2.4 Landers and associated instruments**

Submerged landers were used to deploy instruments and *in situ* experimental settings (mesocosms; see next paragraph) for a period of 8 months at the seabed to collect high resolution environmental data and samples of benthic larvae settled at different types of sediment. A lander consists of aluminium tubes in the shape of an open frame (3 m *3 m, and 2.5 m high) with a weight of circa 1200 kg (Fig. 5). This frame offers space to mount various instruments for recording environmental variables (current meter, fluorescence sensor, turbidity sensor, and sensors for salinity and temperature). To collect data and samples, and to enable programming and recharging batteries, and to avoid fouling the landers have to be serviced every 3 to 4 weeks. Landers were retrieved on board using acoustically triggered releases that liberate a pop-up buoy that unrolls a cable and emerges afloat at the sea surface. Table 1 gives an overview of the intervals in which the landers have been deployed in the OWEZ and Ref Lander area.

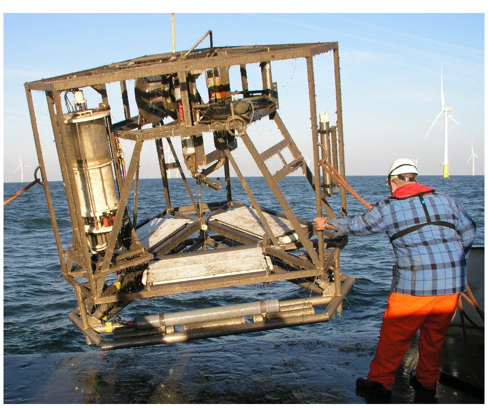


Fig. 5. Lander with autonomous sensors and experimental mesocosms ready for deploy.

The following instruments for recording environmental variables were fixed to the landers in OWEZ and the reference area:

***- Current meter***

The NORTEK Aquadopp current meter (Fig. 6a) acts by transmitting a short pulse of sound (2 MHz), listening to its echo and measuring the change in pitch or frequency of the echo. The meter has 3 sensor heads with 2 beams in the horizontal plane and one slanted 45 degrees with respect to the vertical (Fig. 6b). The measurement cell size is 0.75 m at a distance of 0.5 m from the sensors. The device also measures temperature and tilt. The instrument measures the current at a height of 1.5 m above seabed.

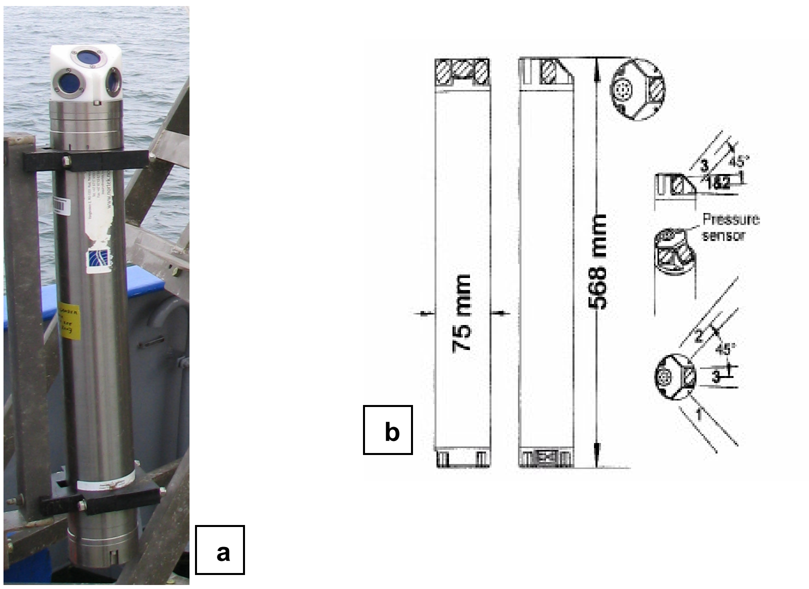



Fig. 6. a. NORTEK Aquadopp current meter ; b. three sensor heads with 2 beams in the horizontal plane and one slanted 45 degrees with respect to the vertical

***- Fluorescence and turbidity sensors***

In the Compact-CLW data logger (ALEC Electronics) (Fig.7a) a circular array of LED's emitting fluorescence and infrared, respectively, provides the excitation light for the chlorophyll-a fluorescence and the turbidity backscatter sensors. Optical filters in front of the optical receivers separate the backscattered light (turbidity) from the fluorescence signals. A wiper sweeps the optical surface before each sample to remove dirt and fouling (Fig. 7b). The instrument measures the parameters at a height of 1.5 m above seabed.

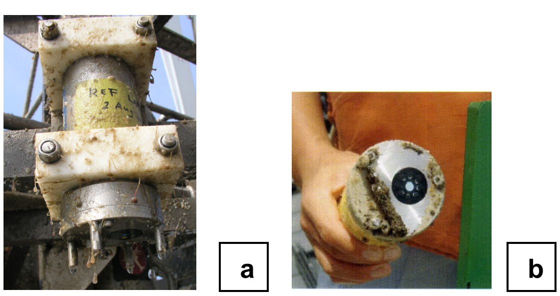



Fig. 7. a. Compact-CLW data logger (ALEC Electronics); b. a wiper sweeps the optical surface before each sample to remote dirt and fouling.

***- CTD for salinity and temperature measurements***

The Seabird  37-SPM Microcat is a high-accuracy conductivity (salinity) and temperature Recorder. (Fig. 8). The instrument measures the parameters at a height of 1.5 m above seabed.

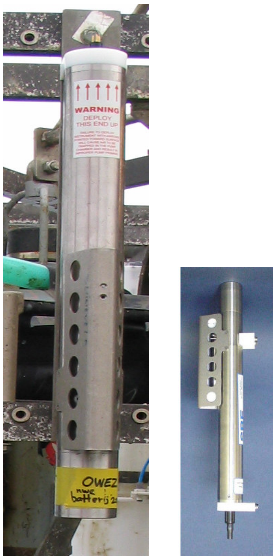



Fig. 8.  Seabird  37-SPM Microcat for recording of conductivity and temperature.

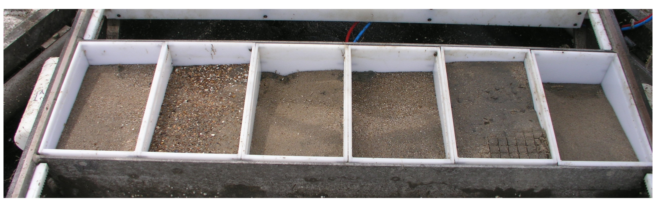
| Deployment # | Start date | Retrieval date | Mesocosm | # of days |
|---|---|---|---|---|
| 1 | 27-02-2007 | 22-03-2007 | - | 23 |
| 2 | 25-03-2007 | 16-04-2007 | - | 22 |
| 3 | 18-04-2007 | 01-05-2007 | - | 13 |
| 4 | 03-05-2007 | 22-05-2007 | - | 19 |
| 5 | 25-05-2007 | 05-06-2007 | - | 12 |
| 6 | 14-06-2007 | 02-07-2007 | - | 19 |
| 7 | 10-07-2007 | 01-08-2007 | y | 22 |
| 8 | 03-08-2007 | 21-08-2007 | y | 18 |
| 9 | 24-08-2007 | 17-09-2007 | - | 24 |
| 10 | 01-10-2007 | 09-10-2007 | - | 8 |

Table 1. Overview of intervals in which landers have been deployed in both OWEZ and Ref Lander area.

**2.5 Mesocosms**

To study the settling response of larval benthos to various types of sediment, submerged mesocosms containing manipulated sediment were developed and mounted at the landers in the OWEZ Wind farm and in the Ref lander area (Fig. 5). Each lander carried 3 mesocosms trays, each tray consisting of 6 small boxes 23*15 and 20 cm deep). In each tray the 3 middle boxes were filled with 3 different fractions of defaunated sandy sediment *i.e.* fine (0.2-0.5 mm), medium (0.5-1 mm) en coarse (>1 mm). The fractions were sieved from sand normally used as mortar in brickwork. A fourth box was filled with extreme silty sediment for test purposes, and both outer boxes of each tray contained 2 out of the 3 sand fractions in the middle boxes (Fig. 9, Fig.10). At the top of each box just above the sediment surface a 1 cm plastic lattice (holes 1.5*1.5 cm) was attached to prevent the washing out of sediment by the current. The two lids covering each tray were closed before deploy. During deployment the lids were programmed to open twice per day during the 2 hours intervals around the turn of the tide from ebb to flood. In that interval current speed is at the lowest and particles including larvae competent to settle are expected to sink to the near-bottom layers. Upon retrieval after a 3 weeks exposure period the lids were closed. On deck the lids were opened and the surface of the sediment was drained via holes in the bottom of the trays. The level of the sediment surface below the lower edge of the lattice was measured. Samples were taken from each box by pushing 2 cores (diameter 2.5 cm) into the surface to a depth of x cm. Sediment from the cores was carefully collected in separate containers and preserved in a buffered solution of 40% RCL2 + 60% ethanol. From each box a third core was taken to determine sediment grain size and silt content. Samples of the outer boxes in each tray will not be analysed because there were doubts about sediment being washed away due to their exposed position. Samples were sieved over 0.05 mm, sorted in the laboratory and benthos was identified to lowest taxonomical level possible. The mesocosm experiments were carried out during the deployments # 7(9/7/07 to 1/8/07) and # 8 (2/8/07 to 21/8/; Table 1).

a



b

c

Fig. 9. Mesocosms with manipulated sediments; a. each lander contained 3 mesocosm trays with lids; b. each mesocosm tray contained 6 settlement boxes; c. sub samples were taken with small cores for juvenile benthos and with syringes to collect sediment.

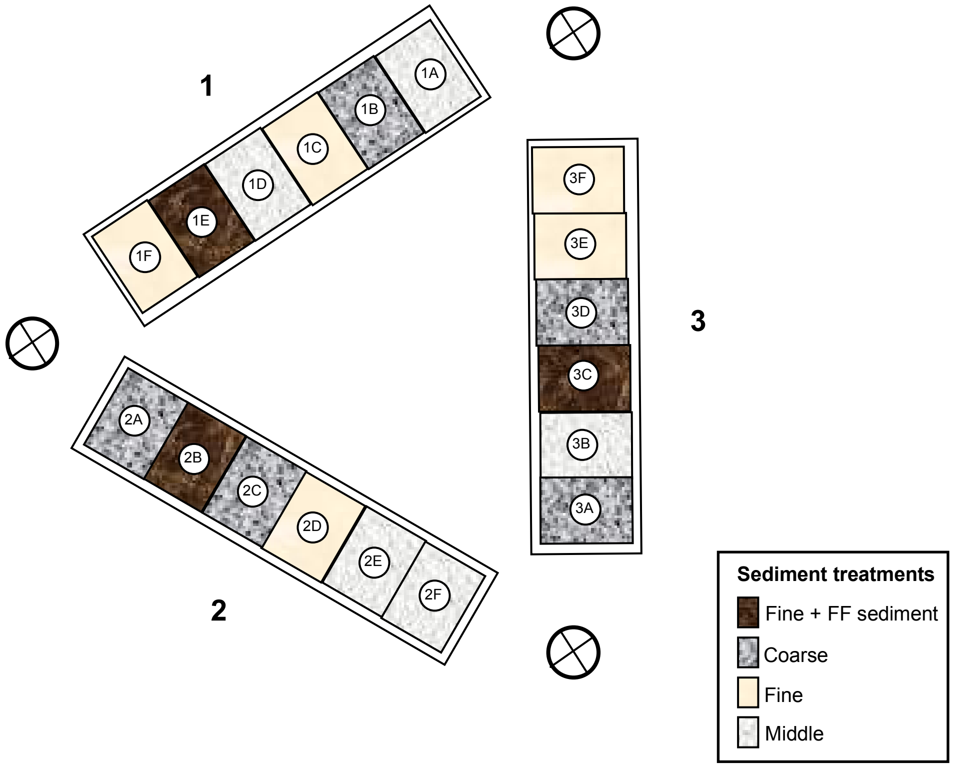



Fig. 10. Experimental design of *in situ* mesocosm experiments. The middle three boxes contain the different sediment fractions tested in this project. The outer boxes in each tray are filled with 2 out of the 3 fractions, but not used in the project. A fourth box was filled with an extreme silty fraction for test purposes.

**2.6 Sediment analyses**
To be described in Final Report (Q1- 2009)

**2.7 Statistical analyses**
To be described in Final Report (Q1- 2009)

## 3 RESULTS

### 3.1 Juvenile densities of benthos in OWEZ and reference areas

In January 2008 the sorting started of the samples of the October survey on juvenile benthos. Sorting, identification, documenting and analysis will require a large part of 2008. Sediment analyses of the boxcore samples will also be executed in 2008. Results will be discussed in the Final Report (Q1- 2009).

### 3.2 Environmental variables

To explain the possible differences in abundances of juvenile benthos between OWEZ Wind farm and the reference areas we measured various environmental parameters in 2007, since they may influence settlement and survival of settled individuals. Figs 10 to 15 show the annual variations in the parameters measured by the instruments mounted at the landers in the Wind farm and the Ref Lander area (Fig 1). The basic recordings are also presented as plots of the consecutive deployments and shown in the Appendix I. In this Interim Report we give a preliminary interpretation of the results. More details will be presented in the Final Report (Q1- 2008)

**Temperature**

Temperature influences the reproduction in adults, developmental stages of the larvae, moment of settlement and growth of the juveniles. Fig. 10 shows that seawater temperature in both lander locations seems to follow the same seasonal cycle. Starting with temperatures of 8 ºC in March, temperature rises continually until June. Maximum temperatures are reached in late August (19.5 ºC), just before the fall in temperature starts. Appendix I shows the variation in the basic recordings of temperature within each consecutive deployment.

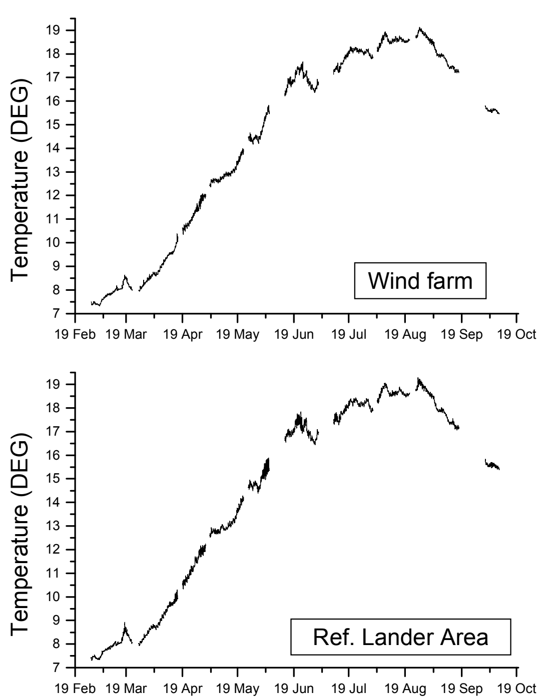



Fig.10. Annual variations of ambient seawater temperatures (ºC) at the Wind farm location (upper graph) and the Ref Lander area (lower graph) from February until October 2007.

**Salinity**

Salinity is a good indicator for the origin of water masses. It represents the dissolved salt contents of water. Salinity will be reduced in water masses containing fresh water run off from river mouths. On the other hand, more saline water originating from offshore areas enhances salinity. Salinity may affect the presence and abundance of marine species, which have their specific optimal salinity conditions, although they can live for longer periods under suboptimal conditions.

Fig. 11 indicates that salinity in the Wind farm and in the Ref. Lander area shows variations throughout the year. For at least three moments in 2007, salinity drops down (Salinity PSU < 29). The observed declines in mid March, mid July and mid-August, respectively, occurred simultaneously in both locations. Appendix II shows the variation in the basic recordings of salinity within each consecutive deployment.

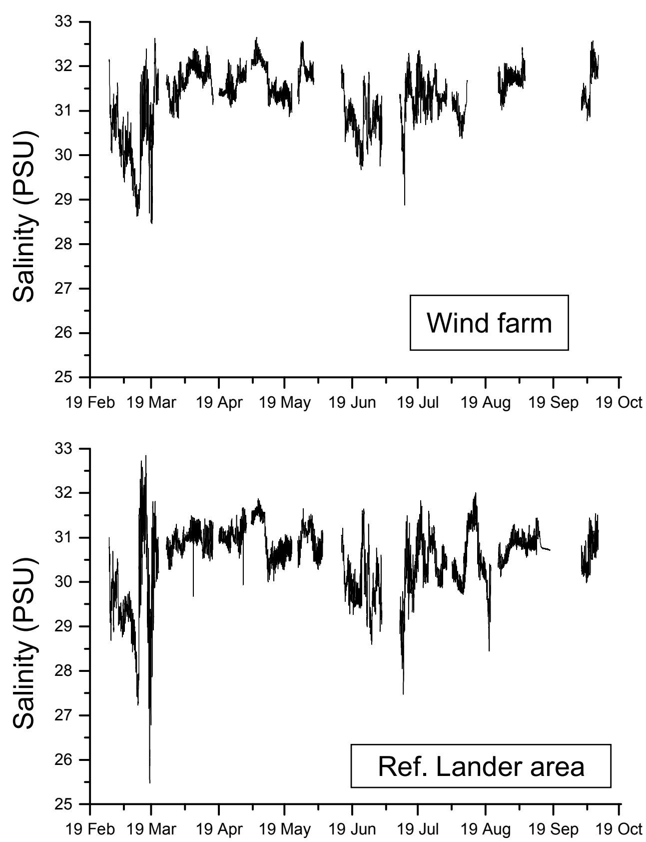



Fig. 11. Annual variations of salinity levels (PSU) at the Wind farm location (upper graph) and the reference area (lower graph) from February until October 2007

**Fluorescence**

Fluorescence has been measured to get insight in the annual and spatial differences in food particles available for filter feeding species like bivalves. Fluorescence is a measure for the presence of Chlorophyll-a in the water column. Chlorophyll-a, a pigment in algae, and is a useful proxy for phytoplankton biomass. Phytoplankton is a major food source for larvae of marine organisms.

In both lander locations, Chlorophyll-a concentrations were relatively low at the start of the first lander deployment (mid February; Fig. 12). At the start of spring, in the last two weeks of March, a rapid increase of the phytoplankton biomass occurred. Maximum Chlorophyll-a concentrations were measured in mid April. The length of the phytoplankton bloom appears to be similar for both locations (mid March – mid May). After this spring bloom, Chlorophyll-a levels remained relatively low during the rest of 2007. To compare the amount of Chlorophyll-a measured in the consecutive deployments in the Wind farm with the Ref. Lander area, the data per deploy were averaged and the integrated sum was calculated (Table 2). Although the two first deployments in the Ref. Lander area show enhanced concentrations, this trend does not seem to continue during the later deployments. The Appendix III shows the variations in the basic data of fluorescence within each consecutive deployment.

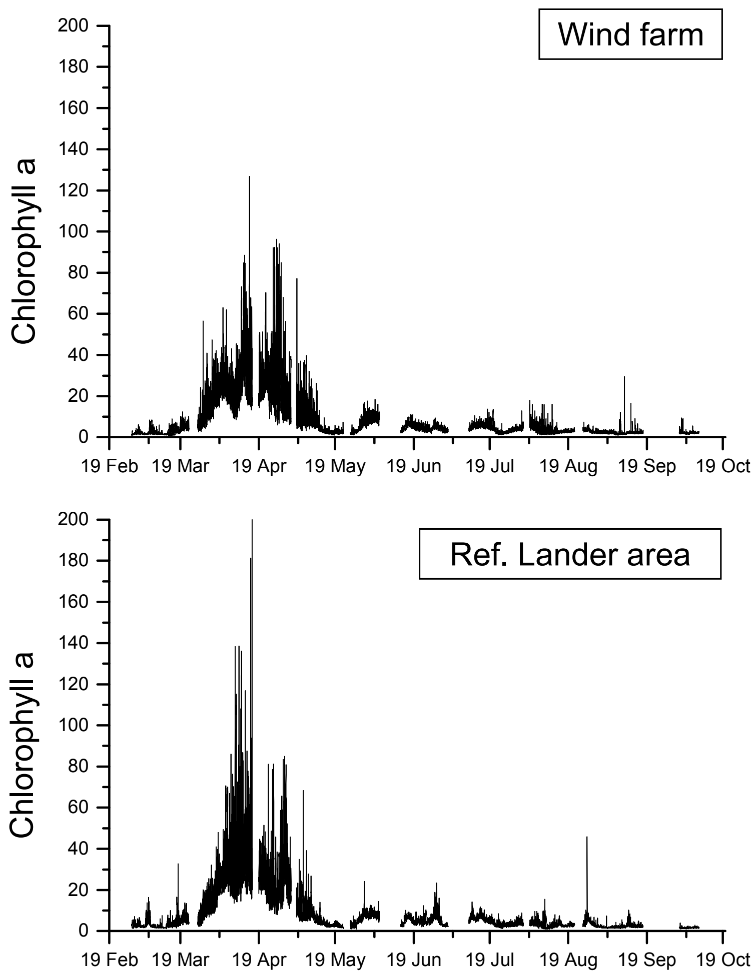



Fig. 12. Annual variations of fluorescence (in Uranine units ppb) at the Wind farm location (upper graph) and the Ref. Lander area (lower graph) from February until October 200

| Deploy # | Wind farm | | | Ref. Lander area | | |
|---|---|---|---|---|---|---|
| | **average** | **st dev** | **integr. sum** | **average** | **st dev** | **integr. sum** |
| Deploy 1 | 2.60 | 1.57 | 58.82 | 3.35 | 2.16 | 75.85 |
| Deploy 2 | 22.55 | 12.02 | 484.05 | 26.24 | 17.59 | 563.2 |
| Deploy 3 | 26.65 | 13.61 | 337.83 | 25.19 | 10.98 | 319.33 |
| Deploy 4 | 6.31 | 5.37 | 117.25 | 5.86 | 4.43 | 108.89 |
| Deploy 5 | 6.44 | 3.18 | 73.92 | 6.26 | 2.55 | 71.86 |
| Deploy 6 | 4.66 | 1.45 | 86.5 | 5.21 | 2.35 | 69.68 |
| Deploy 7 | 4.21 | 1.73 | 90.67 | 4.53 | 1.82 | 97.48 |
| Deploy 8 | 3.31 | 1.70 | 58.66 | 3.06 | 1.40 | 54.28 |
| Deploy 9 | 2.41 | 1.05 | 57.18 | 2.65 | 1.51 | 63 |
| Deploy 10 | 2.14 | 0.74 | 16.62 | 1.60 | 0.24 | 12.39 |

Table 2. Summary of fluorescence data (in Uranine units ppb) at the two locations (Windfarm and Ref. Lander area) during ten following deployments (average, standard deviation and integrated sum of the graph.

**Turbidity**

Turbidity has been measured to collect data on the concentration of suspended matter in the water column. Suspended matter is composed of phytoplankton, silt particles, and settled particles lifted from the seabed by the current (*i.e.* resuspension). The current regime governs the sedimentation and resuspension processes, grain size being one of the dominant factors in these processes. The amount of (re)suspended material in the water column may affect the efficiency of the filtering process in filter feeding benthos such as bivalves (Witbaard et al. 2001) and therefore the growth rate and survival of (juvenile) benthos. Because turbidity is often a summation of locally resuspended sediment and sediment advected into the area of investigation from elsewhere, the source of the suspended material (local/advected) is subject of discussion.

Fig. 13 shows a clear difference in turbidity levels at the two lander stations in the period February and October 2007. The concentration suspended material during the turbidity peaks in the Ref. Lander area is higher than in the Wind farm location. Table 3 shows the results for the integrated sums of the separate deployments. The area under the turbidity graphs of most of the subsequent deployments are twice to four times higher in the Ref. Lander area than in the Wind farm. Only two deployments show lower turbidity values in the Ref. Lander area. Appendix IV shows the basic data of turbidity for the consecutive deployments.

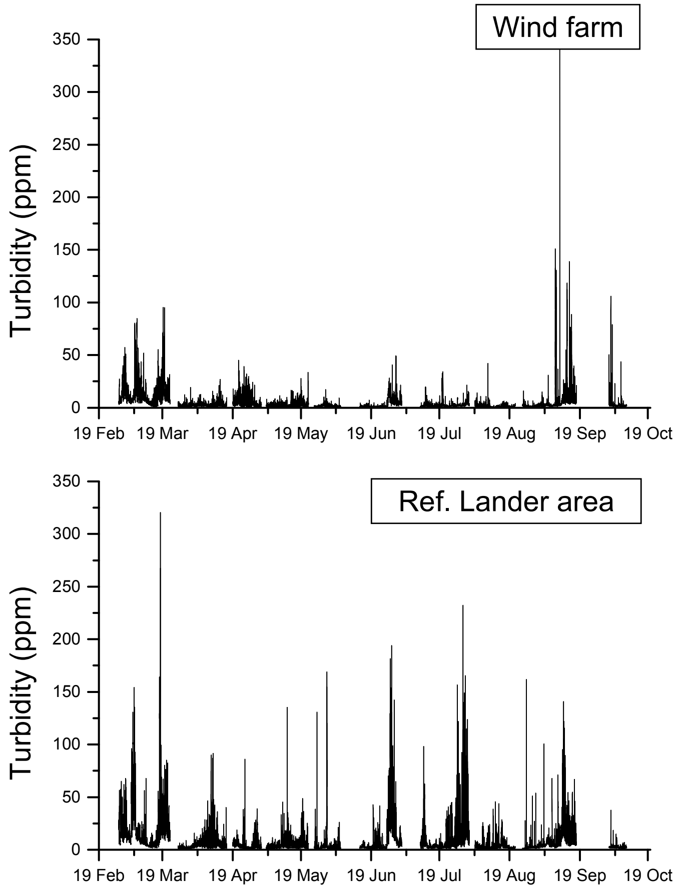



Fig. 13. Annual variations of turbidity concentrations (ppm) at the Wind farm location (upper graph) and the Ref. Lander area (lower graph) from February until October 2007.

| **deploy nr** | **Wind farm** | | | **ref. lander area** | | |
|---|---|---|---|---|---|---|
| | **average** | **st dev** | **Integr. sum** | **average** | **st dev** | **integr. sum** |
| Deploy 1 | 11.82 | 10.38 | 267.82 | 18.76 | 20.21 | 424.9 |
| Deploy 2 | 2.56 | 2.16 | 54.98 | 5.60 | 7.83 | 120.31 |
| Deploy 3 | 5.62 | 5.26 | 71.33 | 4.17 | 5.35 | 52.99 |
| Deploy 4 | 2.78 | 2.43 | 51.7 | 5.25 | 6.05 | 97.79 |
| Deploy 5 | 1.63 | 1.42 | 18.74 | 3.70 | 8.99 | 42.52 |
| Deploy 6 | 3.24 | 4.50 | 60.23 | 11.75 | 21.14 | 218.26 |
| Deploy 7 | 2.57 | 2.66 | 55.4 | 10.43 | 16.18 | 224.75 |
| Deploy 8 | 1.68 | 1.41 | 29.91 | 3.70 | 4.44 | 65.62 |
| Deploy 9 | 5.56 | 13.56 | 132.24 | 9.13 | 13.53 | 217.05 |
| Deploy 10 | 3.08 | 8.26 | 23.9 | 2.17 | 1.62 | 16.85 |

Table 3. Summary of turbidity data (ppm) in the two lander locations (Wind farm and Ref. Lander area) during ten following deployments (average, standard deviation and integrated sum of the graph.

**Current speed and direction**

As indicated above the current regime plays a dominant role in the resuspension of deposited materials. When the shear velocity of the current along the seabed remains below a critical value, there is no sediment resuspension. Increasing current speed enhances the shear velocity and if it exceeds a critical value, the smallest particles are taken into suspension. Heavier or coarser material begins to roll or starts to bounce along the seabed as bedload, until shear velocity is high enough to bring them in suspension. Reduction in the current speed results initially in settling of the larger and heavier particles. Smaller particles will settle only very slowly or not at all.
Data on current speed and direction are thus essential to explain the differences in turbidity data from the Wind farm and the Ref. Lander area**.**

Fig. 14 shows the annual variations in current speed at the two lander stations between February and October 2007. Due to a technical problem, current speed data of the first Wind farm deployment are not reliable and will not be presented in the Final Report. The graphs clearly depict the alternation in spring and neap tides in the tidal cycle with intervals in between of approximately one week in both lander stations.The semidiurnal tidal regime in the Dutch coastal zone encompasses two tidal cycles per 25 hours, covering two flood and 2 ebb periods (Fig. 15).Velocity during the flood (north-northeast going tide) is usually higher than during the ebb (south-southwest going tide), although strong northerly and easterly winds may change this pattern. Table 4 provides a summary of the current speed data in the two lander locations during the ten consecutive deployments (average, standard deviation, median and integrated sum of the graph) and illustrates that the current speed does not show differences in both lander stations. Appendix V shows the occurrence (%) of current speed classes (m/s) in the basic data of the consecutive deployments.

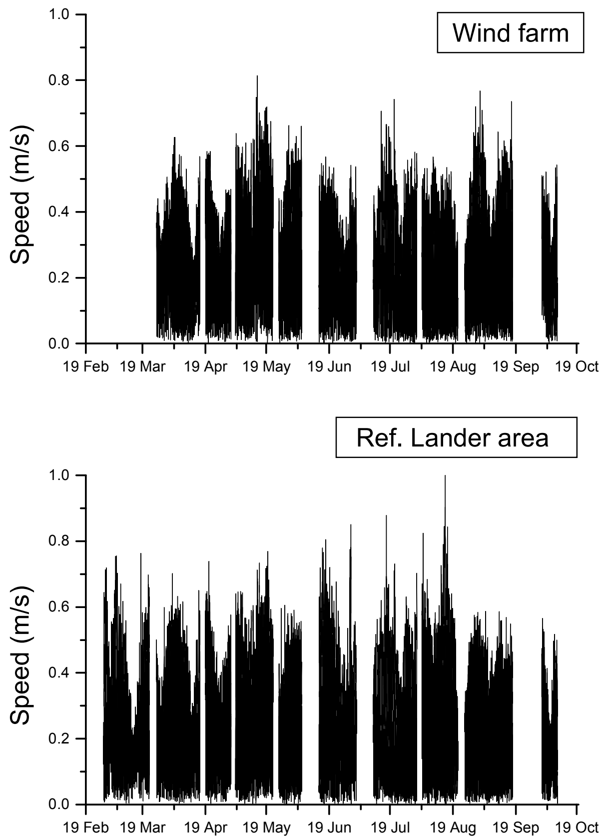



Fig. 14. Annual variations of current speed (m/s) at the Wind farm location (upper graph) and the Ref. lander area (lower graph) from February until October 2007. Due to a technical problem, current speed data of the first Wind farm deployment are not reliable and not shown in this graph.

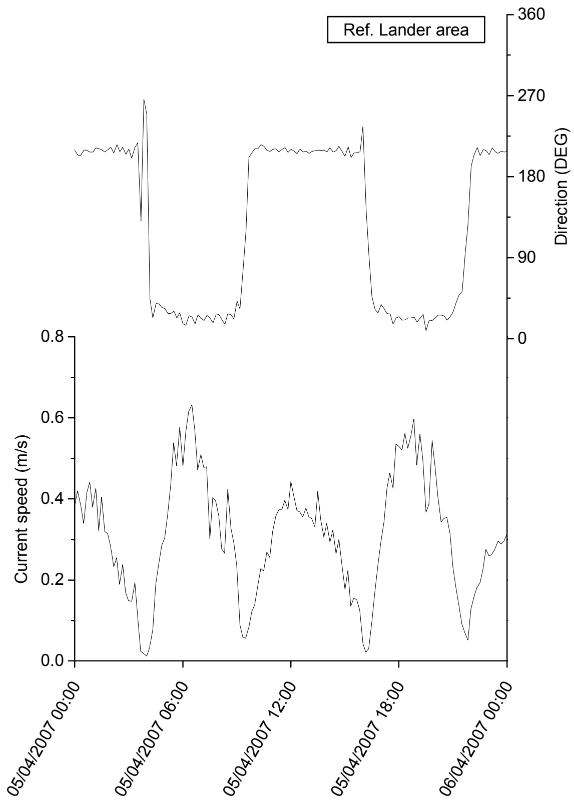



Fig. 15. Semidiurnal tidal regime in coastal zone recorded in the Ref. Lander area at 5 April 2007. Current speed (m/s) and direction towards the current flows (º) during the two flood and ebb periods are indicated.

| **Deploy nr** | **Wind farm** | | | | **Reference area** | | | |
|---|---|---|---|---|---|---|---|---|
| | **Average** | **StDev** | **Median** | **Integr** | **Average** | **StDev** | **Median** | **Integr** |
| Deploy 1 | - | - | - | - | 0.25 | 0.14 | 0.217 | 5.56 |
| Deploy 2 | 0.25 | 0.12 | 0.240 | 5.25 | 0.25 | 0.13 | 0.245 | 5.43 |
| Deploy 3 | 0.26 | 0.12 | 0.272 | 3.32 | 0.28 | 0.13 | 0.280 | 3.51 |
| Deploy 4 | 0.32 | 0.15 | 0.328 | 5.93 | 0.31 | 0.15 | 0.314 | 5.73 |
| Deploy 5 | 0.26 | 0.14 | 0.261 | 3.03 | 0.28 | 0.13 | 0.278 | 3.16 |
| Deploy 6 | 0.24 | 0.11 | 0.240 | 4.51 | 0.27 | 0.15 | 0.254 | 5.02 |
| Deploy 7 | 0.22 | 0.13 | 0.208 | 4.81 | 0.19 | 0.15 | 0.140 | 4.15 |
| Deploy 8 | 0.24 | 0.12 | 0.239 | 4.21 | 0.30 | 0.16 | 0.299 | 5.35 |
| Deploy 9 | 0.26 | 0.14 | 0.258 | 6.22 | 0.26 | 0.12 | 0.262 | 6.15 |
| Deploy 10 | 0.25 | 0.11 | 0.252 | 1.91 | 0.22 | 0.11 | 0.214 | 1.68 |

Table 4. Summary of current speed data (m/s) in the two lander locations (Wind farm and Ref. Lander area) during the consecutive deployments (average, standard deviation, median and integrated sum of the graph).

Fig. 16 shows the annual sum patterns in the current direction per compass direction of 10° classes at the two lander stations between February and October 2007. North-north-east (023º) during the flood and south-south-west (203º) during ebb tide are the dominant current directions in both lander locations. Differences in the dominant current direction between the lander stations are not evident. Appendix VI summarizes the current patterns per compass direction of 10° for the consecutive deployments.

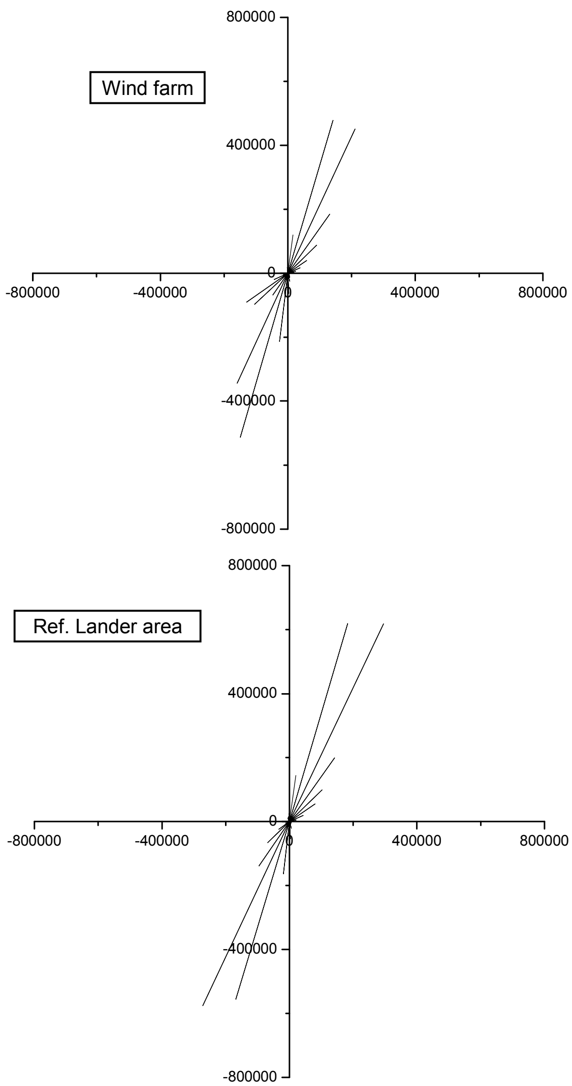



Fig. 16. Annual current patterns per compass direction (February-October 2007) for the Wind farm area and the Ref. Lander area. Lines present 10° classes and point in the direction the current is flowing to. Lengths of the lines reflect sum distances per direction (m) in 2007. The Wind farm graph doesn't include data of the first deployment since they are not reliable due to technical failure.

### 3.3 Settlement of benthos in the mesocosms

In November 2007 the sorting of the mesocosm samples started. Sorting, identification, documenting and analysis will require a large part of 2008. Results will be discussed in the Final Report (Q1- 2009).

## 4. DISCUSSION

Because the sorting of the samples of the juvenile benthos survey (October 2007) and the mesocosm experiments (July/August 2007) still need a number of months, we present only a provisional set-up of the discussion in this Interim Report. In the Final Report (Q1- 2009) the discussion will be completed. Some of the sections, however, have been worked out tentatively and are presented in this Interim Report.

**Set-up**
a - Section on differences in abundances of juvenile benthos in Wind farm and Ref. Lander area
b - Section whether abundance of *Spisula subtruncata* in Wind farm is above of below the expected value estimated from population dynamics in pre-OWEZ conditions
c - Section whether differences in abundance of juvenile benthos - if found - can be explained by differences in environmental conditions
d - Section whether differences in turbidity between Wind farm and Ref. Lander area may have been caused by the fishery-stop in the Wind farm
e- Section whether differences in abundance of juvenile benthos - if found - can be explained by differences in type of sediment based on mesocosm results

**a - abundance of juvenile benthos in Wind farm and reference areas**
A discussion based on results of sorting and analyses of samples of the juvenile benthos survey will follow in Final Report.

**b - estimate of *Spisula subtruncata* recruitment**
In this section we try to estimate the number of recruits that are required to maintain the present-day (2007) density of the bivalve *S. subtruncata*. For this estimate we calculate parameters based on the population dynamics in pre-OWEZ conditions. We made use of our own NIOZ-data on mortality and growth of *S. subtruncata* collected with the boxcore in 1991-1994. We used these data instead of the T0-boxcore data collected in 2003 (Jarvis et al., 2004), as latter do not provide population data over consecutive years and, hence, do not allow calculation of mortality rates. For this estimate we have used the following parameters:

- instantaneous mortality
- growth rate
- density 2007
- age distribution 2007

Instantaneous mortality (Z) in this case is defined as (Brey, 2001):

$$dN/dt = -Z * N_t$$

or

$$N_t = N_o * e^{-Z*t}$$

Which is equivalent to:

$$\ln(N_t) = -Z * t + c \qquad [1]$$

This model assumes that mortality in each age (year)-class is a constant proportion of the stock. Ideally mortality estimates should be based on a population with easily distinguishable year classes with sufficient numbers of individuals. This is usually not the case as growth in older individuals slows down and older year-classes tend to overlap. In populations with overlapping year-classes but where growth is known (*e.g.* from shells bands, otoliths), mortality can be estimated using size-converted catch curves (Pauly, 1990).

For the *S. subtruncata* stock near Egmond, we have used an estimate of instantaneous mortality based on annual spring surveys made in the period 1991-1994 at a nearby station (52$^o$ 45.0’N 04$^o$ 30.0’E) circa 13 km northeast of the Wind farm and 3 km northeast of the Ref. 2. The *Spisula* stock at this station consisted basically of one year-class (cohort) which grew successive years and disappeared in 1995 (Fig. 17). In 1993 and 1994 small numbers of younger age classes were found – marked with asterix in Fig. 17 - but these were excluded from the calculation. Plotting ln($N_t$) against time with 1 yr intervals (see formula 1) yields an estimate for Z of 0.51 (Fig. 18).

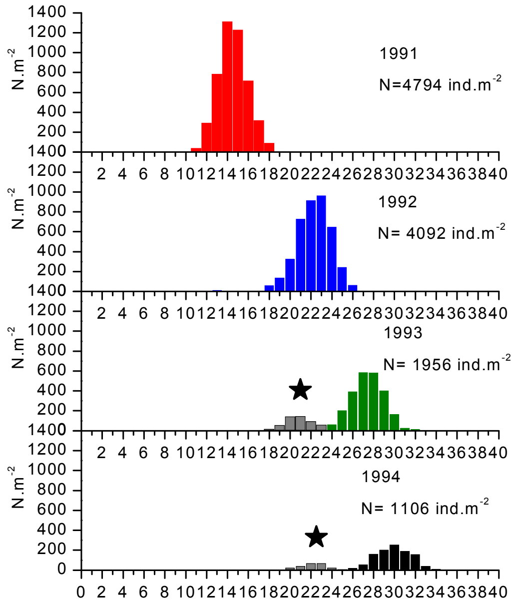



Fig. 17. Growth of *S. subtruncata* population 13 km north east of the Wind farm in 1991-1994. Younger age classes are marked with asterix.

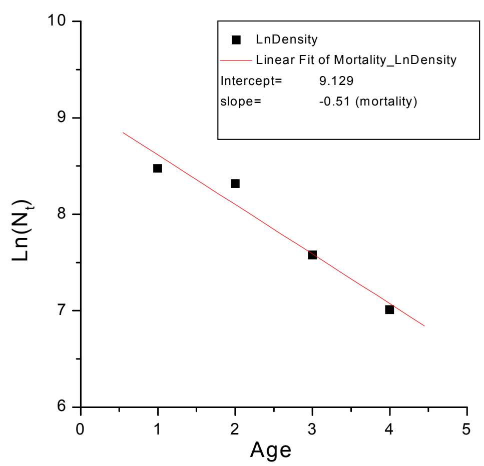



Fig. 18. Plot of $\ln(N_t)$ against time with 1 yr intervals.

Growth of the 1991-1994 cohort was modelled with a Von Bertalanffy Growth equation (VBG) being the most commonly observed type of growth among benthic invertebrates :

$$L_t=L_\infty*[1-e^{-k*(t-to)}]$$

Parameter values of the VBG were iteratively solved: k=0.51, $L_\infty$=34.4 and to=-0.05. The VBG growth curve based on these parameters (Fig.19) is very similar to the one recently published by Cardoso et al. (2007) for a *S. subtruncata* population off Petten (circa 45 km north of the OWEZ Wind farm) in 2001-2003. Because Cardoso et al. checked their growth curve against numbers of internal growth rings in the shell and both curves are similar, we are confident that length-at-age estimates in Fig. 19 are correct.

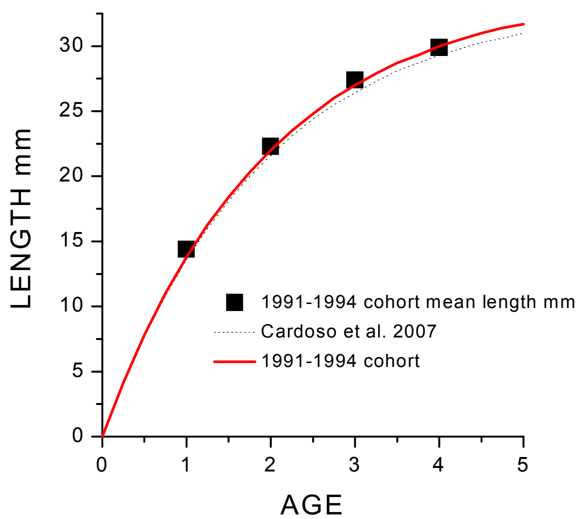



Fig. 19. Growth curves derived from Von Bertalanffy Growth equation (VBG) based on our *S. subtruncata* data 1991-1994 and based on the population off Petten (Cardoso et al, 2007). Mean length of the cohorts in 1991 – 1994 are indicated.

A comparable growth rates of *S. subtruncata* as shown in Fig. 19 has been found by Craeymeersch & Perdon (2004) during spring surveys of the coastal zone with the majority of 1-yr old animals having a length of ~15 mm, 2-yr old animals of ~24 mm and 3 yr old animals of ~27 mm.

In the Benthos-density project, the density of adult *S. subtruncata* in Wind farm and reference areas was assessed in 2007 with two different methods: boxcores and Triple-D dredge (see Interim Report Benthos-density). Earlier Bergman & Van Santbrink (1994) demonstrated that the efficiencies of the Triple-D dredge and boxcorer with respect to bivalves larger than 1 cm were similar. The Triple-D dredge samples in the Wind farm and reference areas (n=26; total sample surface 416 $m^2$) yielded a total number of 42 specimens of *S. subtruncata* . Average number within the Wind farm is 1.4 per Triple-D haul and in the reference areas 1.9 per haul. More than 85% of this number (n=38) were 2-yr old animals and the remaining ones younger. Back calculating the 2-yr old specimens to recruits taking an annual mortality of 0.51 ($N_2=N_0*e^{2*Z}$) gives a predicted number of 105 recruits in 26 dredge hauls (416 $m^2$) or less than 1 recruit per $m^2$. In the Final report the actual numbers of juvenile *S. subtruncata* found in both Wind farm and reference areas will be compared with this expected density of ~0.25 individual per $m^2$. It can be expected that with such low recruitment, differences between Wind farm and reference areas will be hard to measure or substantiate with relatively small sized boxcore samples (0.07 $m^2$).

In 2006 the stock of *S. subtruncata* in the Dutch coastal zone was at its lowest since 1995 when monitoring of the stock begun (Perdon & Goudswaard 2006). The average number of 1 yr old *S. subtruncata* in 2006 was 0.1 ind. per $m^2$. The authors further show a steady decline of 1 yr and older *Spisula subtruncata* along the coast from 2001 onwards and link this due to failing recruitment. In an earlier report, Craeymeersch & Perdon (2003) point at climate change and particularly the wind regime as probable cause for failing recruitment.

**c - impact of environmental conditions on juvenile densities**
A discussion based on the results of sorting and analyses of the samples of the juvenile benthos survey will follow in Final Report

**d - causes of turbidity events in Ref. Lander area**
The annual recordings made by the instruments mounted at the landers show that temperature, salinity, chlorophyll-a, and current regime do not differ markedly between Wind farm and reference areas between February and October 2007. Turbidity levels, however, show a clear difference at the two lander stations in this period (Fig. 13). The concentration of suspended matter during the turbidity peaks in the Ref. Lander area is higher than in the Wind farm location, which is supported by the integrated sums of the separate deployments, showing twice to four times higher values in the Ref. Lander area than in the Wind farm (Table 3). Only two of the deployments show lower turbidity values in the Ref. Lander area. In the next paragraphs differences in turbidity found between both lander stations are discussed.

One hypothesis underlying our study is that closure of the Wind farm for fishery might cause a reduction in trawling related resuspension with potential consequences for the sediment, benthos (bivalve) settlement and growth. The clear difference in total turbidity (Fig. 13) is notably due to several turbidity events in the record from the Ref. Lander area which were less pronounced or even absent in the record from OWEZ. Similarities between the two records comprise the basic turbidity levels and the prominent turbidity in the beginning of the measurement period which is probably caused by strong wind in this period (Appendix VII en VIII).

The issue is whether turbidity differences are site-specific *i.e.*, is high turbidity in Ref. Lander area due to local natural conditions (resuspension of deposited sediment, tidal and wave currents) or is it caused by advection from elsewhere? To decide whether local resuspension of sediment plays a role in the enhanced turbidity in Ref. Lander area, firstly sediment characteristics have to be known. Sediment has been sampled here only on one occasion in October 2007 and the data have not been analysed yet. It is therefore not possible to say if the events are linked to sudden changes in the sediment grain size, for instance, due to local deposition of large mud patches. Conclusions on the contribution of local changes in particle size will be formulated in the Final Report. Earlier data however suggest that the sediment off Egmond is sandy and relatively uniform with no large-scale patches of finer grains. According to Jarvis et al. (2004), who performed grain size analyses for the $T_0$ survey in 2003, the sediment off Egmond consists of medium sand (207– 655 µm median grain size) with 0 – 1% admixture of mud (< 63 µm). This corresponds with our visual observations during the sampling survey in October 2007 in which some cores had a thin veneer of fine muddy material on top of the sandy sediment. Resuspended larger sand particles are probably not important for turbidity. According to Van der Molen (2002) tides in the Southern Bight are strong enough to transport sand within 1 m of the seabed as bedload. Since we measured turbidity at 1.50 m above the seafloor our turbidity records most likely reflect mud.

A second factor explaining local resuspension of sediment is the erosion caused by tidal and wave currents. The criterion for incipient movement of particles (erosion), given the particle size, the weight and shear stress is given by the Shields parameter (θc) as

$$\theta_c \equiv \tau_c / (\rho_s - \rho_w) g d \quad \{1\}$$

With relation between shear stress **τ** and velocity $\mathbf{u_*}$

$$\tau = \rho \ u_*^{\ 2} \quad \{2\}$$

With **ρ** being the fluid density.

In the original Shields diagram θc is given as a function of the grain Reynolds number but this assumes information on critical shear velocity u*. Alternative formulations of the θc as a function of the particle grain size can, for instance, be found in Tzankov (2003) or as empirical relationships by Dorst et al. (2006). With the critical Shields parameter the critical shear velocity u* for particle movement can be calculated from {1} and {2} according to

$$u*_{cr-Shields} = \sqrt{\frac{\theta_{cr}\, g(\rho_S - \rho_W)\, d}{\rho_W}}$$

We have calculated critical shear velocity u* for both the mud fraction (median 25 um) and the sand fraction (median grain size = 466 um see Jarvis et al., 2003). By comparing the critical shear velocity estimates with the actual shear velocity measured in the field during resuspension events, we have attempted to determine if the observed turbidity can be caused by local resuspension.

For estimation of the friction velocity $u^*$ in the field, we have adopted the Von Karman-Prandtl logarithmic model for the current velocity (u) in the boundary layer

$$u(z) = u_* \kappa^{-1} \ln z/z_0 \quad \{3\}$$

with $u_*$ being friction velocity, z height above the bottom, and $z_0$ roughness length. K is the Von Karman constant (0.41). Fitting this equation to current measurements in order to be solved for $u^*$, requires current data from various heights above the seafloor. With only one height available for current measurement, $z_0$ must be approximated on basis of grain size and bedform assumptions. Different formulations for $z_0$ exist depending on whether the flow is rough or smooth. Distinction between smooth or rough flow depends on the value for the Reynolds number ($Re=u_* k_s/v$ where $k_s$=granular roughness, v=kinematic viscosity). Values for $R_e$ <5 indicate a smooth flow, $R_e$ >70 a rough flow while intermediate values indicate a transitional flow. In this case we have used an expression for $z_0$ which is applicable to all Reynolds numbers according to Ziervogel & Bohling (2003):

$$z_o = \left[1 - \exp\left(-\frac{u*k_s}{28\upsilon}\right) + \frac{10\upsilon}{3u*k_s}\right]\frac{k_s}{30} \quad \{3\}$$

Expression {3} was substituted into {2} and solved for $u^*$. The tidal variation in friction velocity can now be plotted for the periods with turbidity events. We have selected the following three events in the Ref. Lander area: 3 April - 15 April, 26 June - 2 July, and 22 July - 31 July. In this Interim Report we focus on the discussion of the first event. In the Final Report the two later events will be discussed in detail.

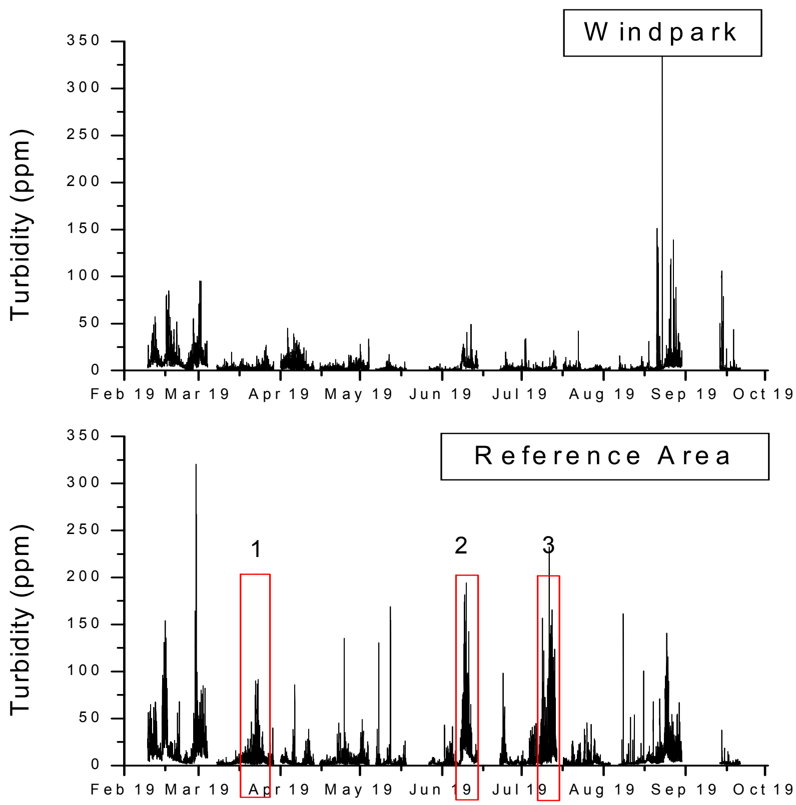



Fig. 20. Annual variation in turbidity in Wind farm and Ref. Lander area in 2007. Three events with high turbidity in the Ref. Lander area are indicated.

To examine whether local resuspension can be generated by the tidal cycle we have plotted the current speed, shear velocity and turbidity for *e.g.* the period 3 - 15 April (Fig. 21). The critical shear u* for sand and mud have been introduced in the plot as bands to accommodate for the variation in estimates caused by different approximations of the critical Shields parameter.

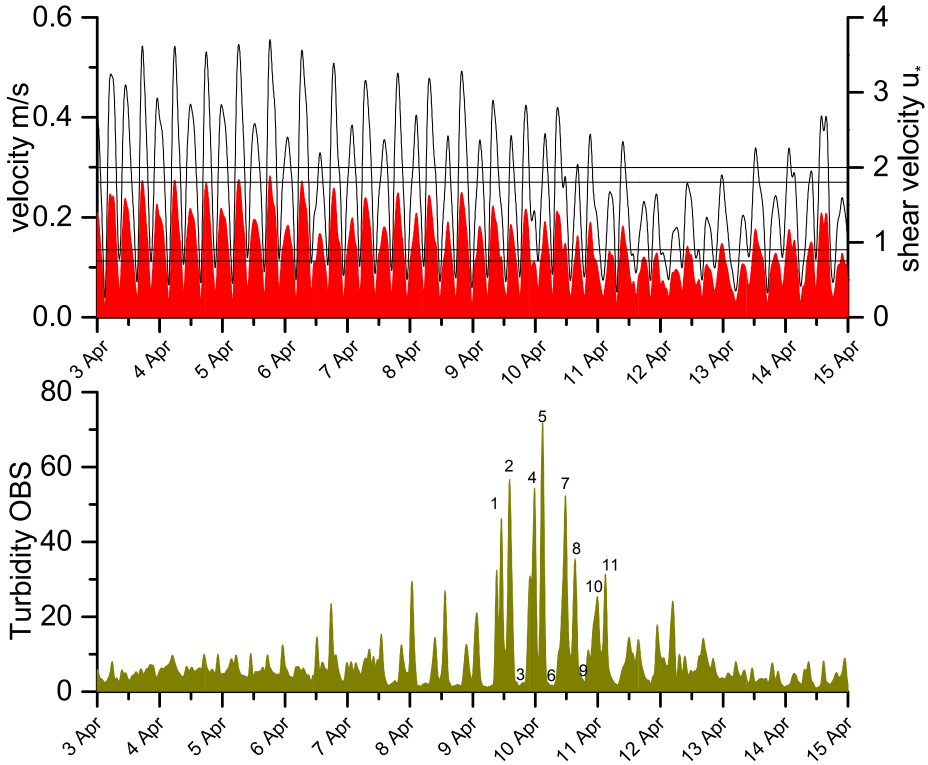



Fig. 21. Current velocity (black line) and associated shear stress (red) in the Ref. Lander area in the period 3-15 April 2007. Estimates for critical sheer velocity u* for sand (the band of highest u* values) and mud (the band of lowest u* values) are indicated. Numbers in lower panel correspond to the first event in Fig. 20. Data have been smoothed with a low-pass filter.

The semidiurnal tidal cycle clearly generates two flood and two ebb tides per ~25 hour with usually by turns higher (flood) and lower (ebb) current speeds. It can be seen that the critical shear velocity for mud is surpassed during almost every tidal period while that of sand only during a part of the spring flood tides (around 5$^{th}$ April). More importantly, the turbidity event in this period does not seem to coincide with highest current speed around peak spring tide on the 5$^{th}$ of April. We therefore conclude that the observed turbidity is not due to local erosion near the lander in the Ref. Lander area but is more likely generated elsewhere and advected. Fig. 22 shows a progressive vector plot over the period of interest. Such a plot shows the predicted travel path of the water mass from the start at the lander position. This representation assumes that the current pattern is uniform throughout the area and period covered by the plot. According to this progressive vector plot, the turbidity peaks appeared during displacement of the water in a NW direction at the end of the flood and start of the ebb. Hence the source of the plume was near the coast. Because the peaks in turbidity occurred well before the start of the rock dumping in august 2007 (Appendix IX), this activity can be excluded as source of the turbidity that was transferred by advection to the Ref. Lander area. Cable trenching, however, in the two most south westerly rows of turbines occurred in the third period of high turbidity in the Ref. Lander area (Appendix IX). Since the source of the advected turbidity most probable would be located south east of the Ref. lander area, it is unlikely that the cable trenching contributed to the enhanced turbidity. Having concluded that the April-turbidity event has been caused by advection it is not proven that the differences in turbidity between the areas can be attributed to the fishery-stop in the Wind farm. Analyses of the two later peaks in the Final Report will reveal whether this conclusion holds for all events.

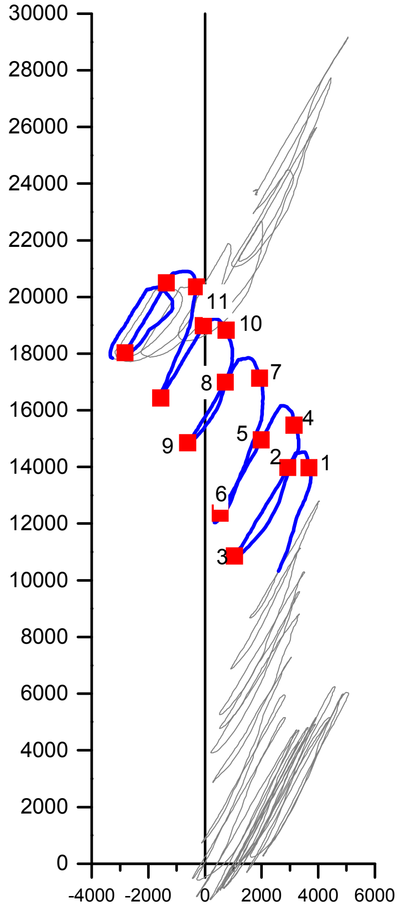



Fig. 22. Progressive vector plot of currents in the period 12 March-12 April 2007. The line represents consecutive current vectors measured at the origin (0, 0 = lander position) and predicts the travel path of the water mass in meters. Each axis represent a compass direction (x-axis positive East; x-axis negative West; y-axis North). The period with high turbidity is indicated by the blue line and the numbers correspond with the numbers plotted by the individual peaks of the turbidity event in Fig. 21.

**e - mesocosm experiments: impact of sediment type on settlement**

A discussion based on results of sorting and analyses of the mesocosm samples will follow in Final Report.

## ACKNOWLEDGEMENTS

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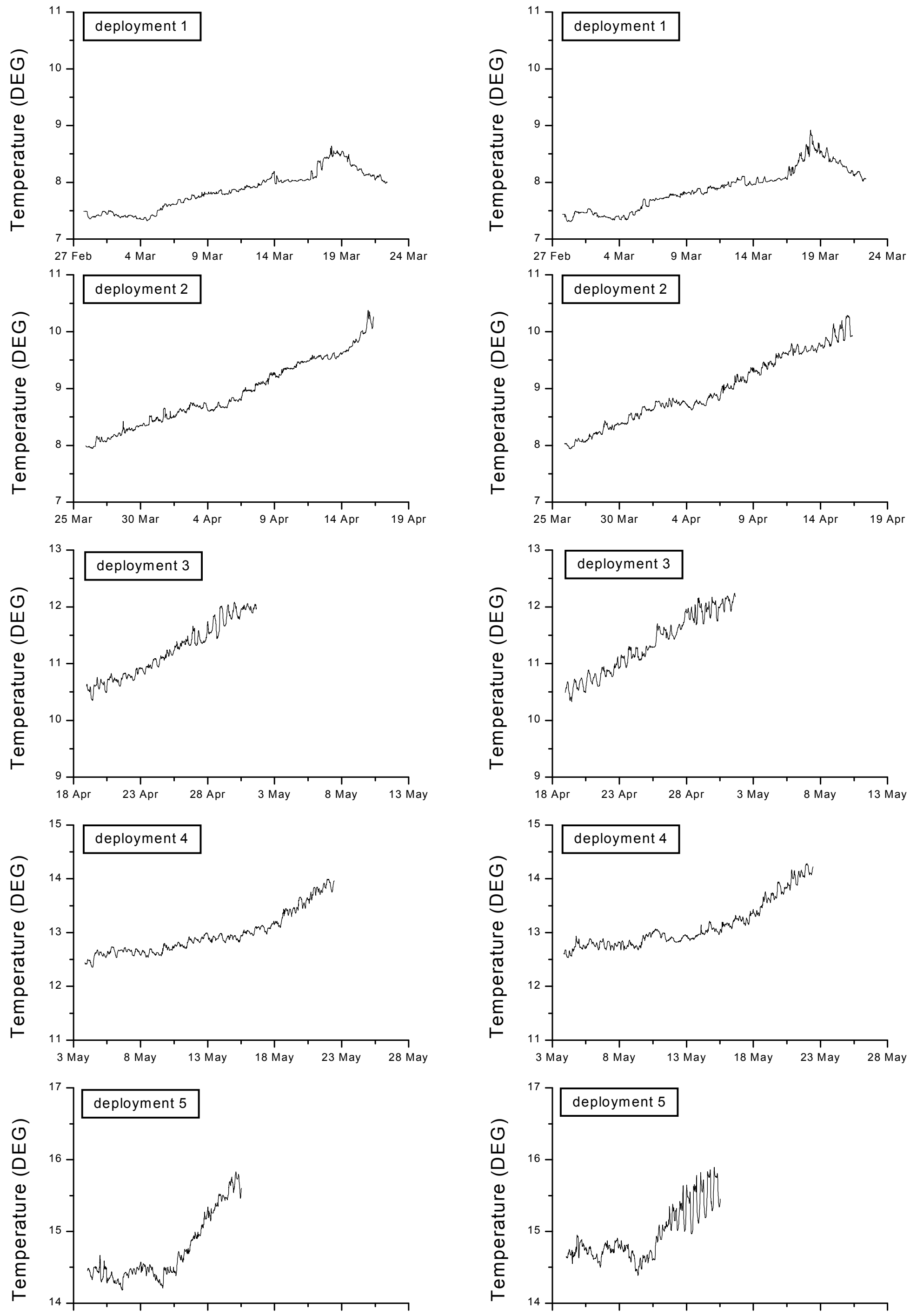
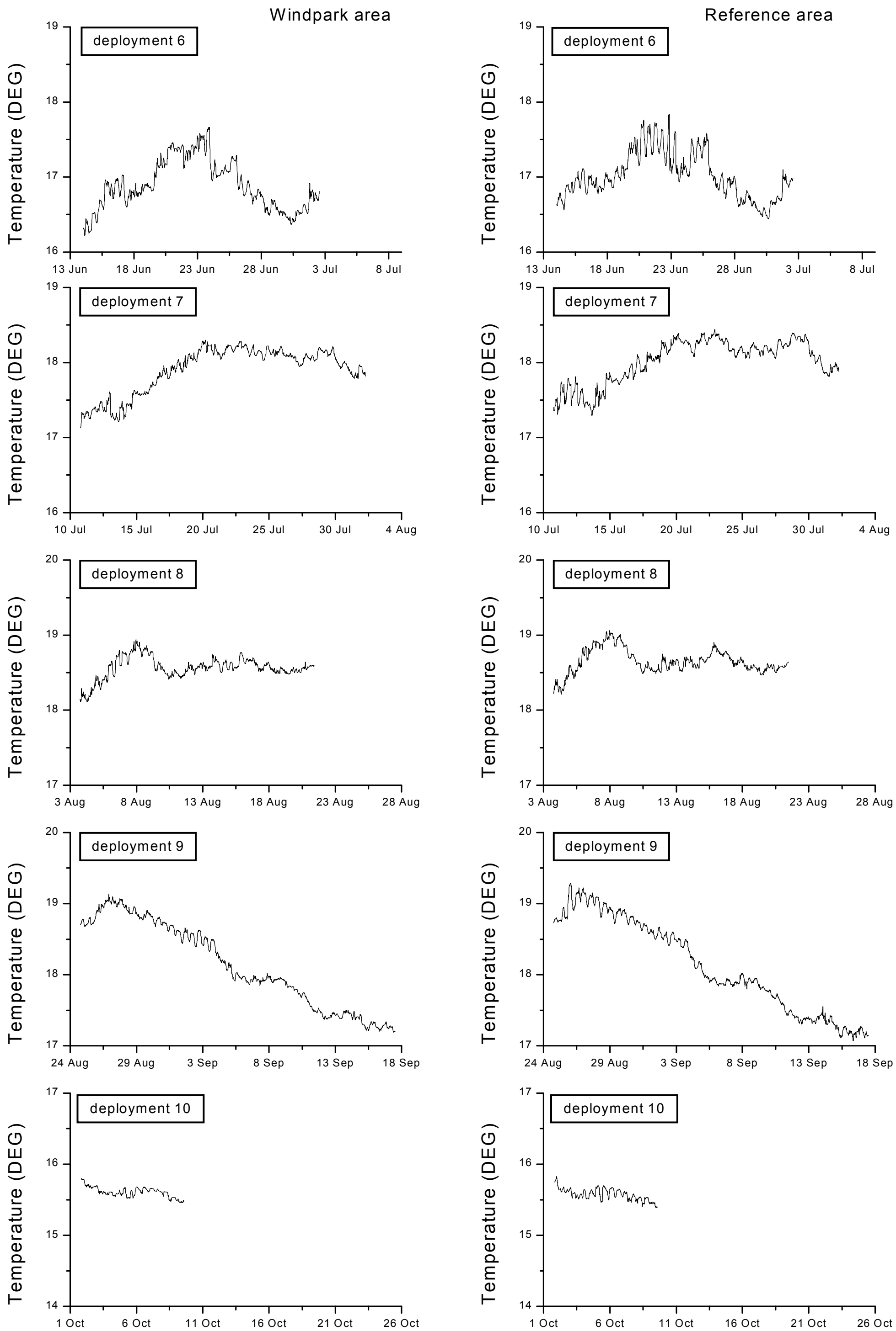
# APPENDIX

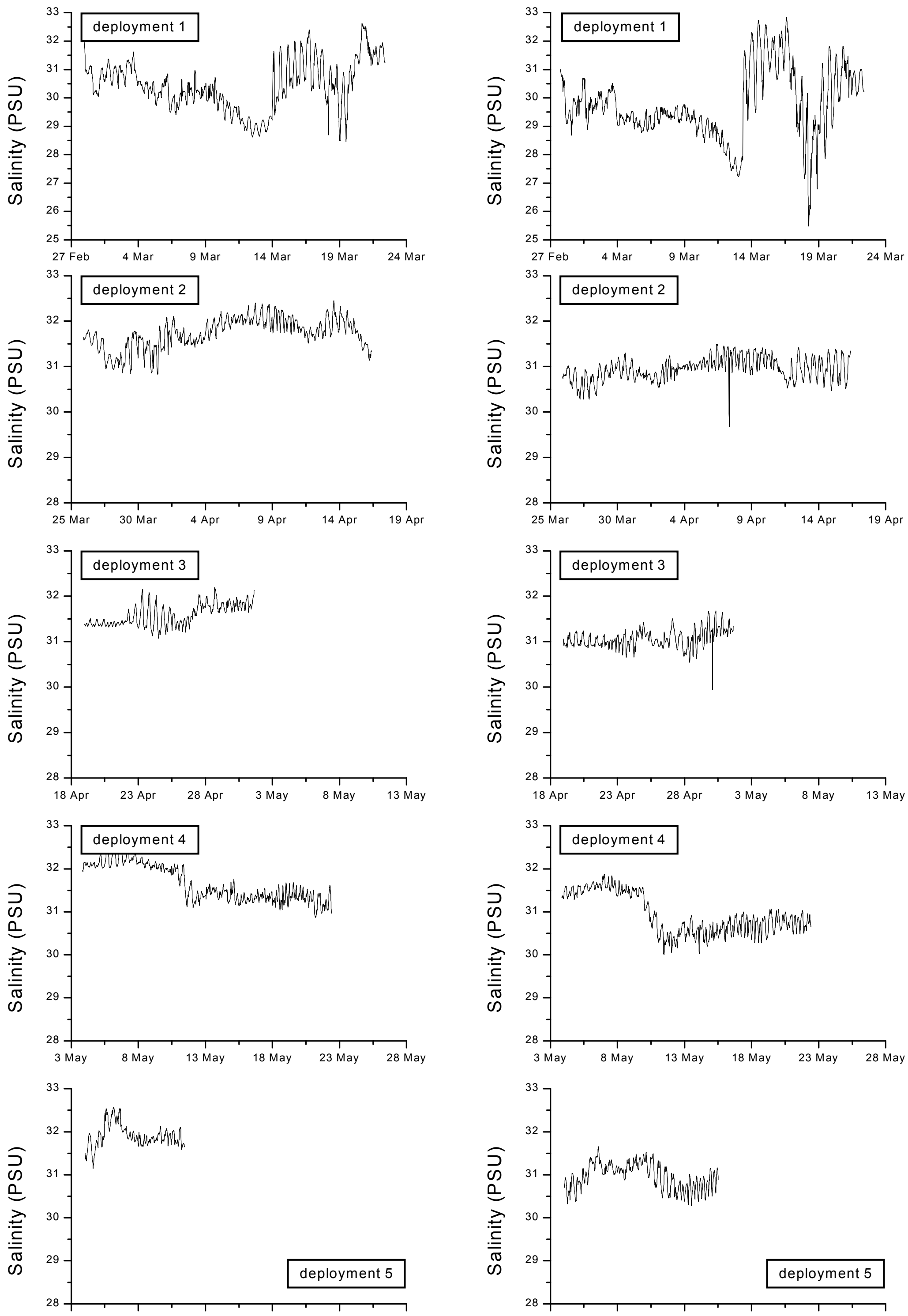
Appendix I. Variations of ambient seawater temperatures (ºC) for the first five deployments (February- June 2007). Left column graphs represent the Wind farm location, right column graphs represents the Ref. Lander area.



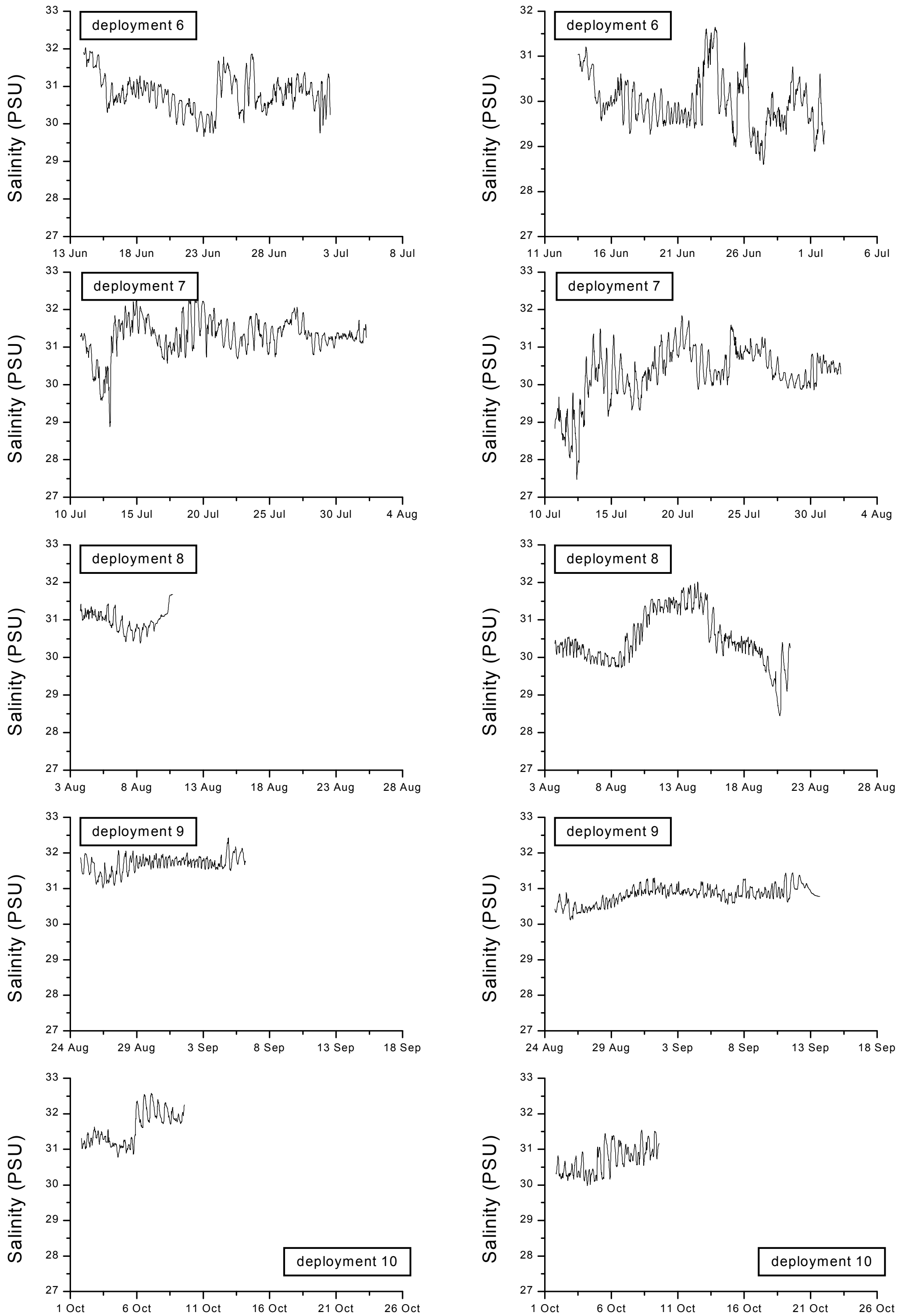
Appendix I.  Variations of ambient seawater temperatures (ºC) for the last five deployments (June-October 2007). Left column graphs represent the Wind farm location, right column graphs represents the Ref. Lander area.



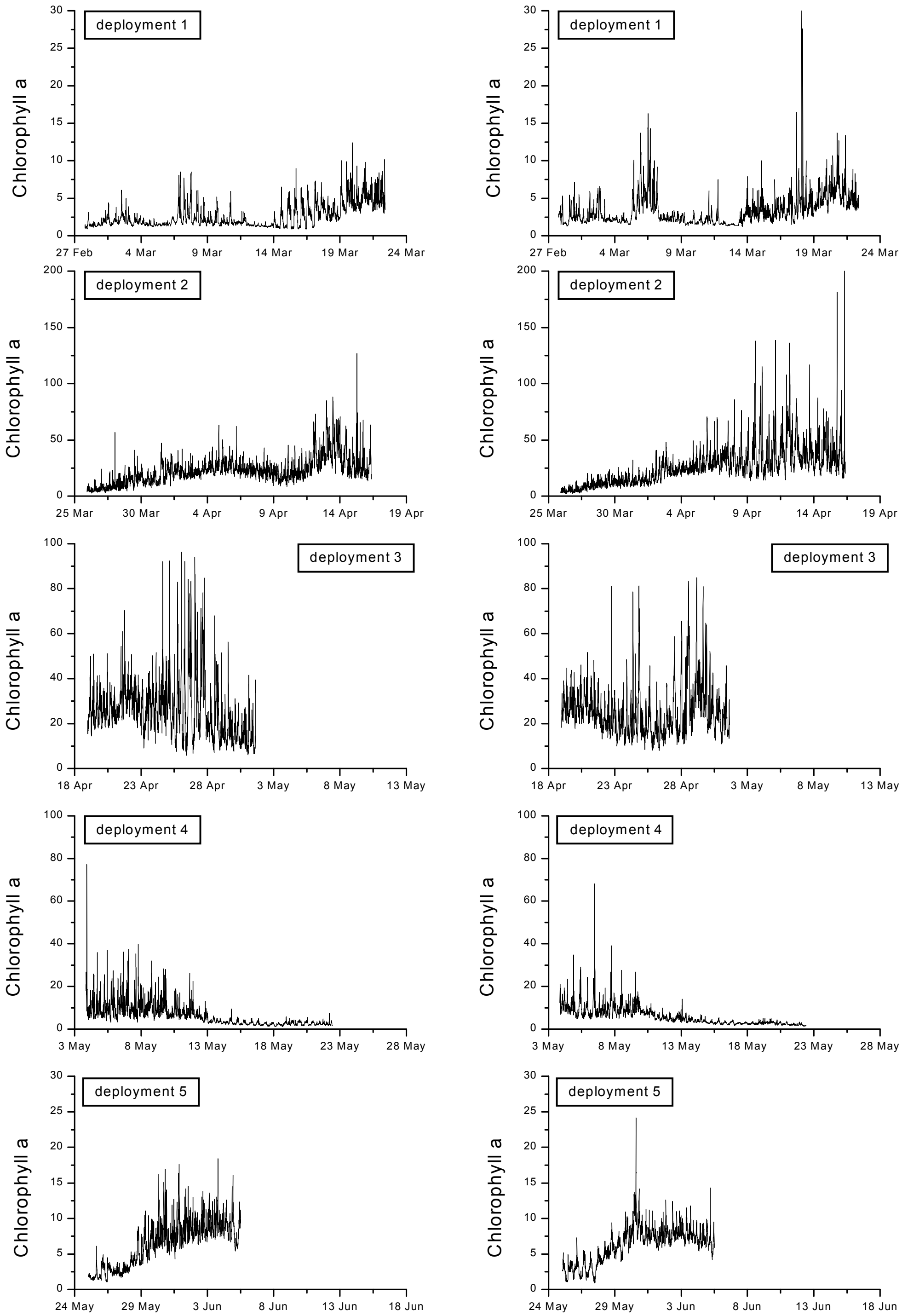
Appendix II. Variations of ambient salinity levels (PSU) for the first five deployments (February- June 2007). Left column graphs represent the Wind farm location, right column graphs represents the Ref. Lander area.



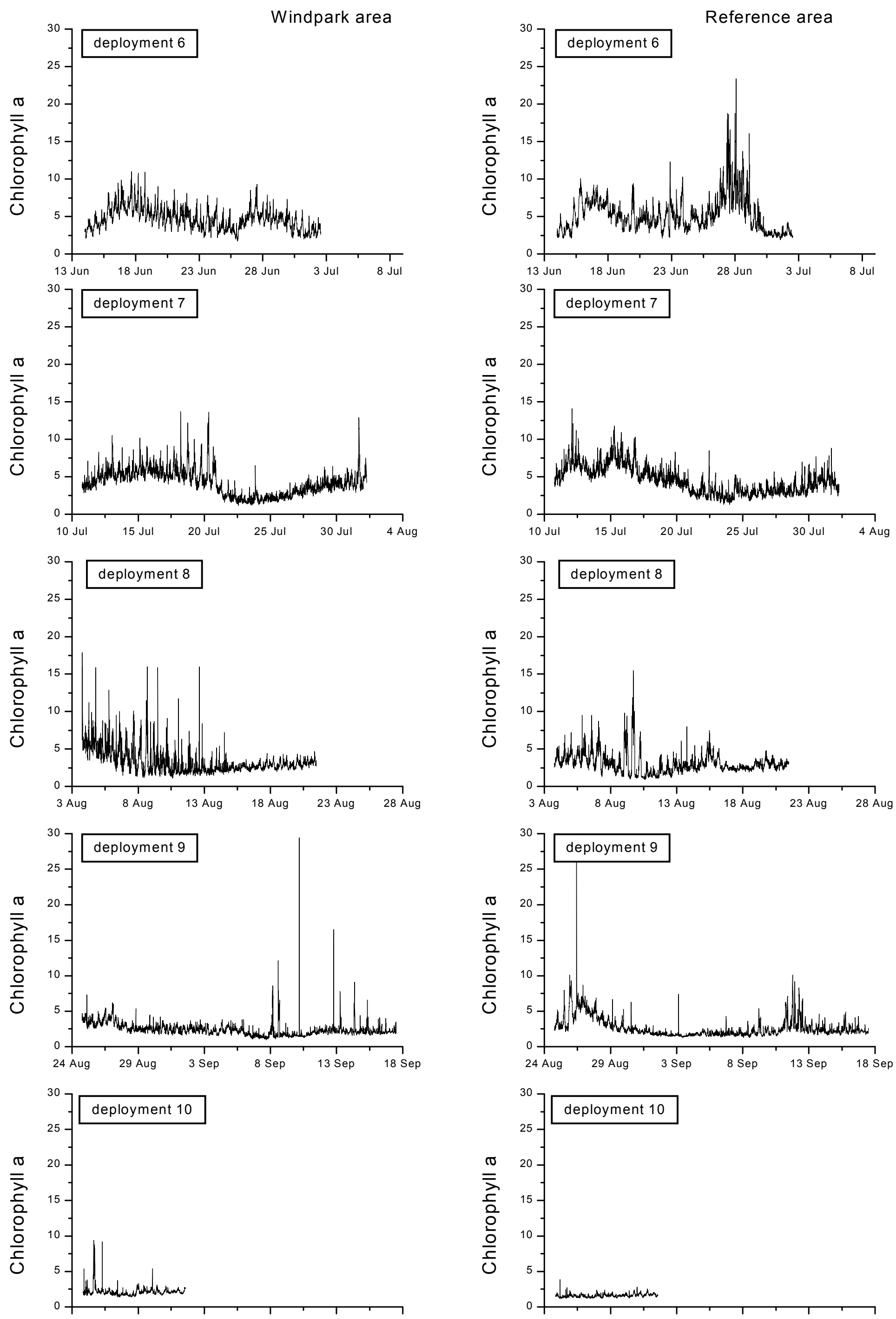
Appendix II. Variations of ambient salinity levels (PSU) for the last five deployments (June-October 2007).
Left column graphs represent the Wind farm location, right column graphs represents the Ref. Lander area.



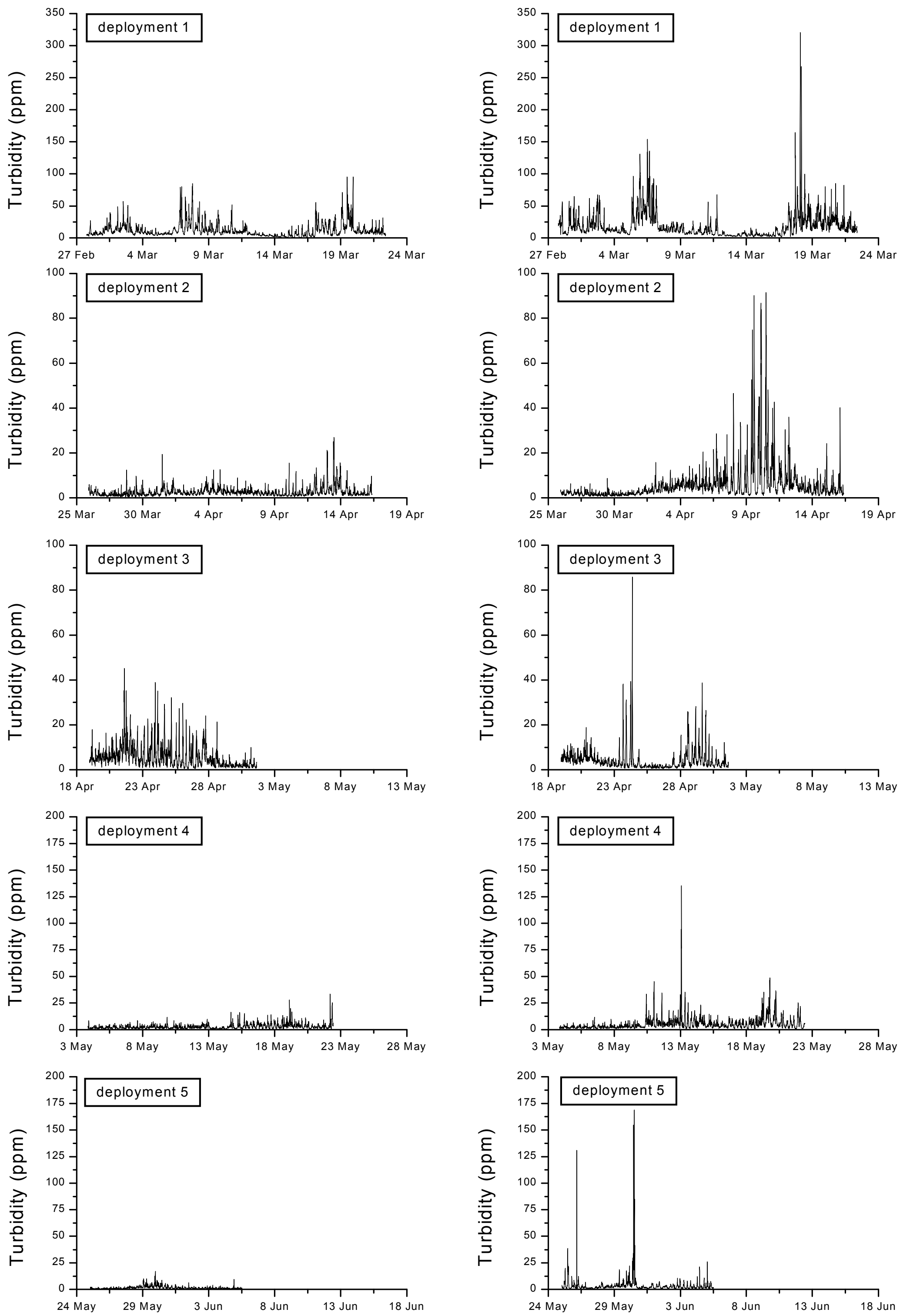
Appendix III. Variations in ambient fluorescence (in Uranine units ppb) for the first five deployments (February- June 2007). Left column graphs represent the Wind farm location, right column graphs represents the Ref. Lander area.



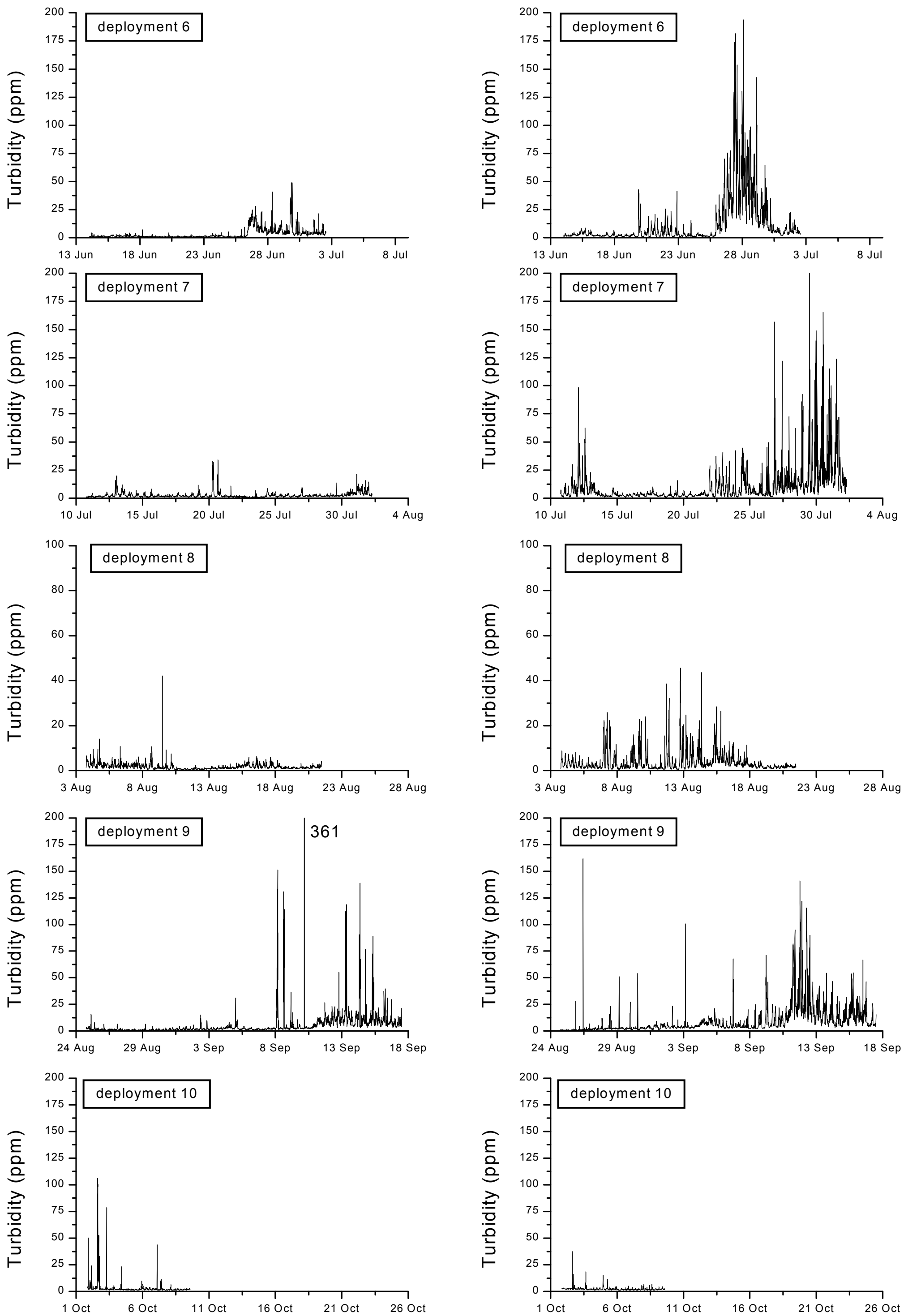
Appendix III. Variations in ambient fluorescence (in Uranine units ppb) for the last five deployments (June-October 2007). Left column graphs represent the Wind farm location, right column graphs represents the Ref. Lander area.



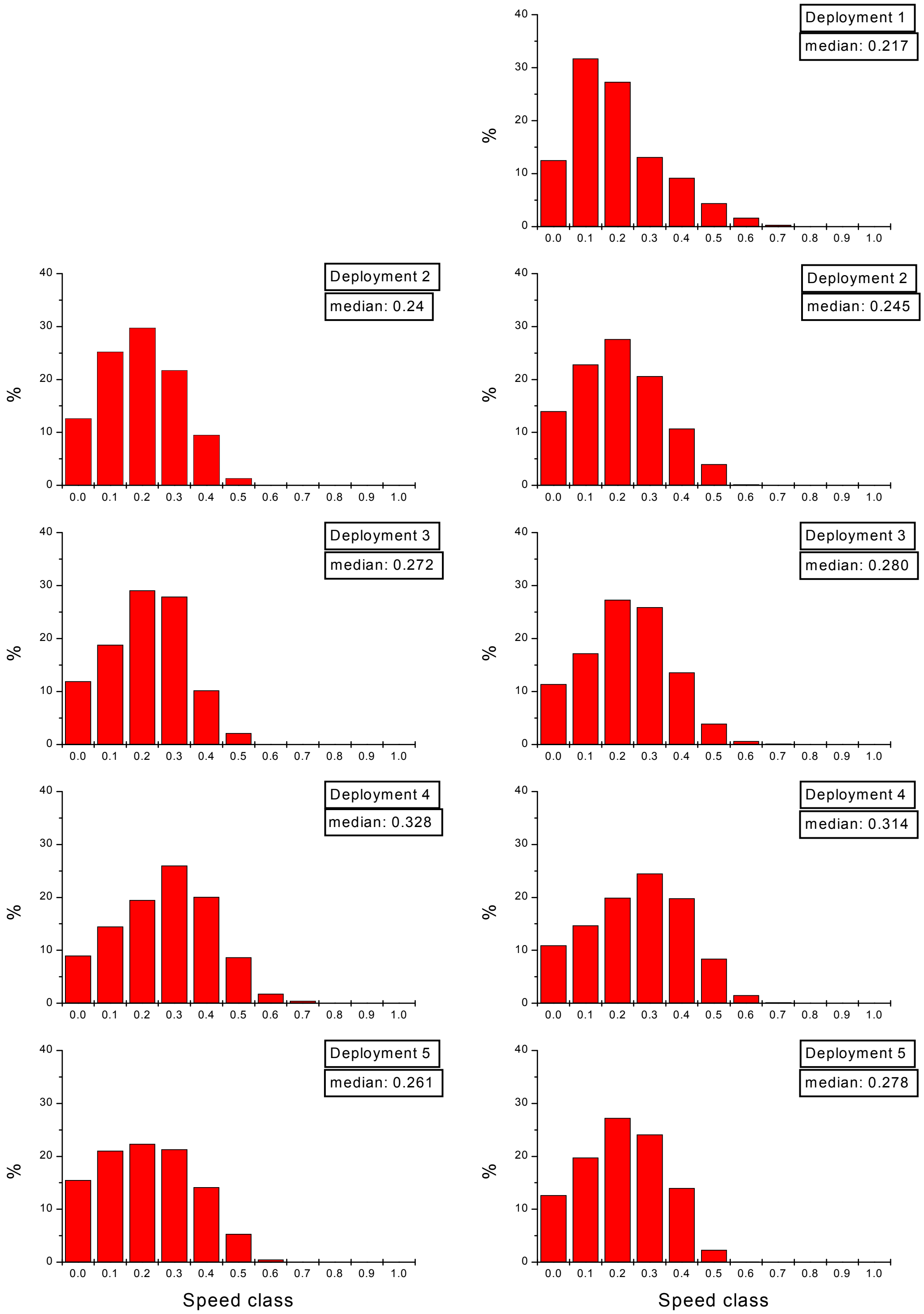
Appendix IV. Variations of ambient turbidity levels (ppm) for the first five deployments (February- June 2007). Left column graphs represent the Wind farm location, right column graphs represents the Ref. Lander area.



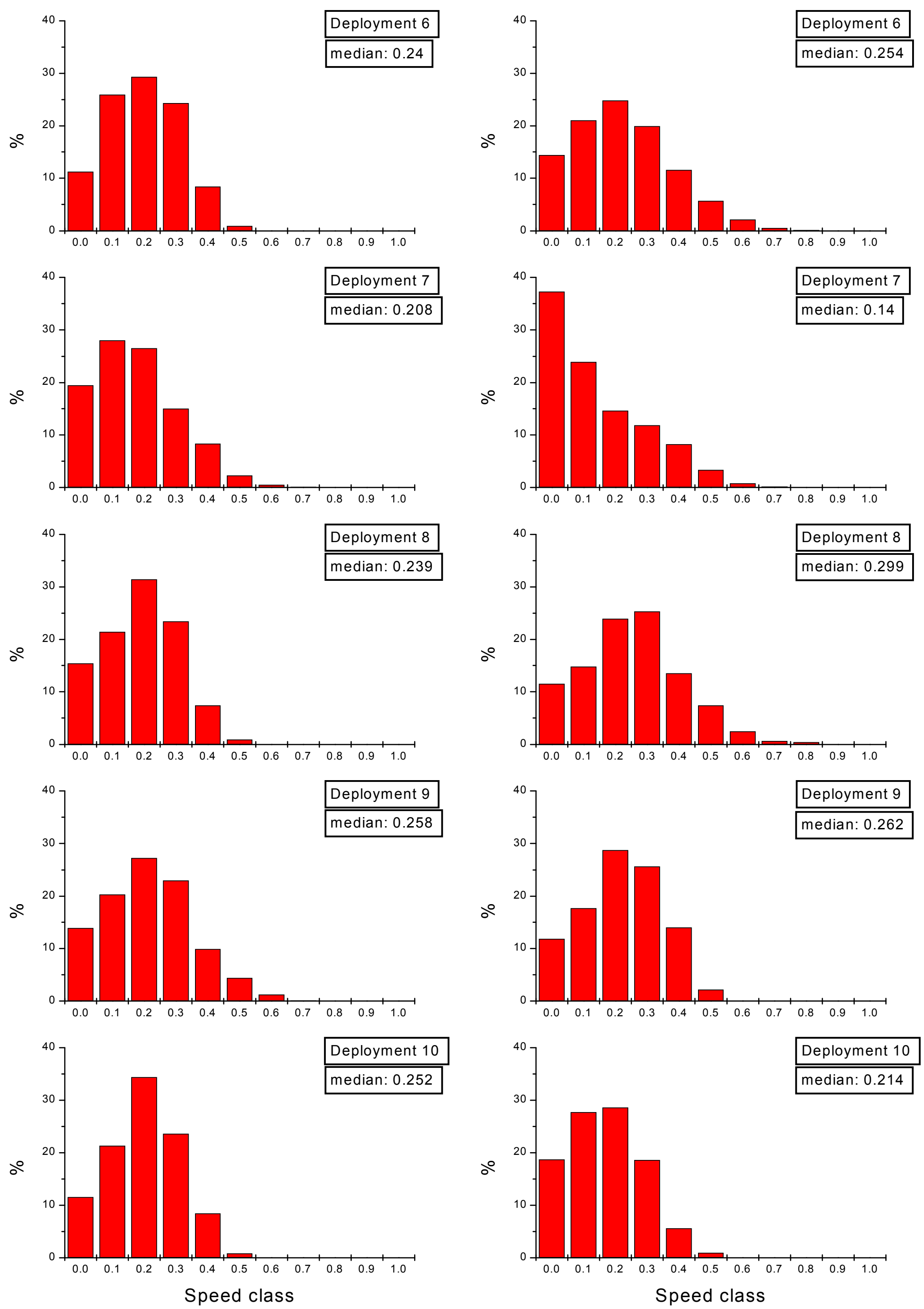
Appendix IV. Variations of ambient turbidity levels (ppm) for the last five deployments (June-October 2007). Left column graphs represent the Wind farm location, right column graphs represents the Ref. Lander area.



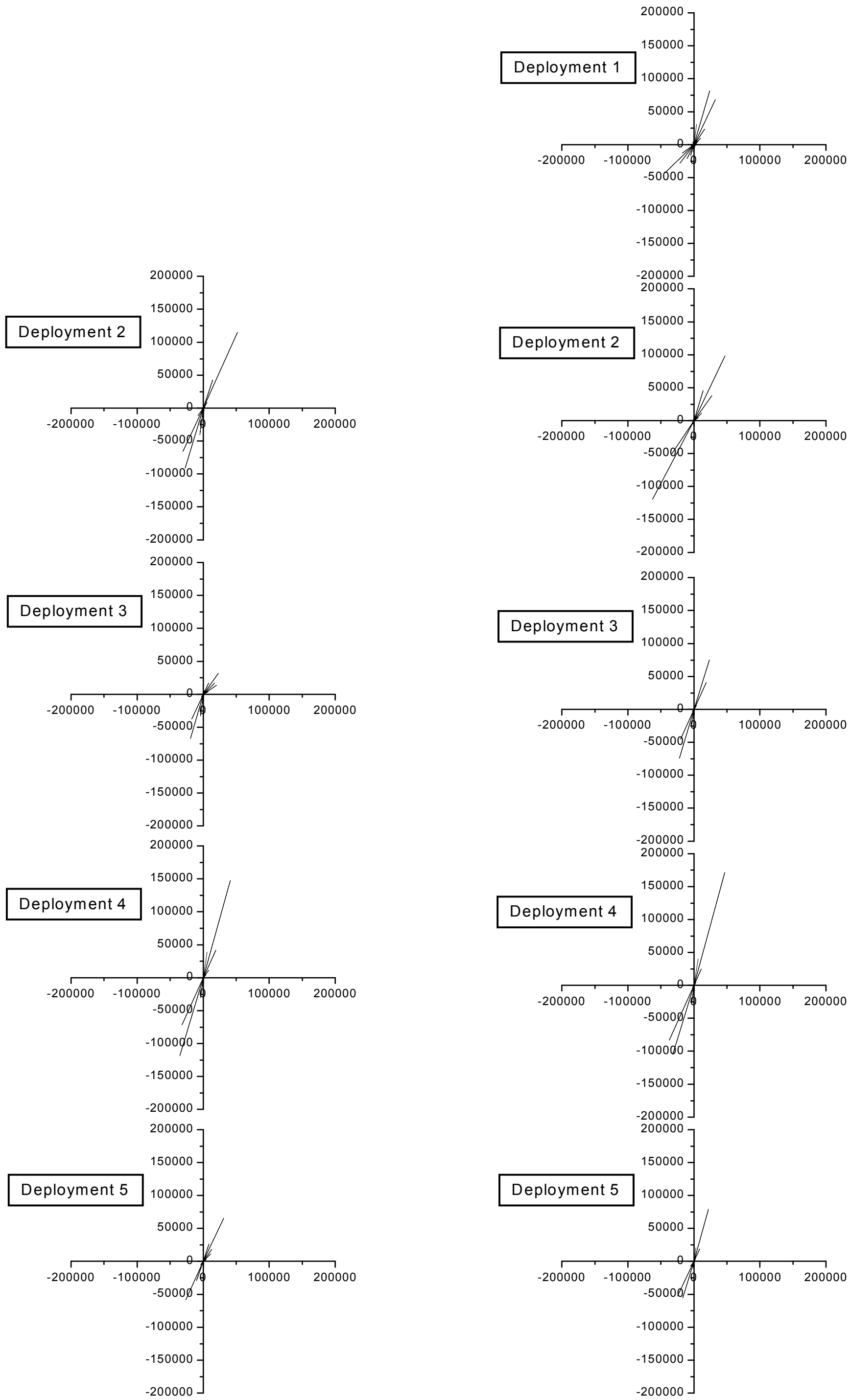
Appendix V. Occurrence (%) of current speed classes (m/s) for the first five deployments (February- June 2007). Left column graphs represent the Wind farm location, right column graphs represents the Ref. Lander area.



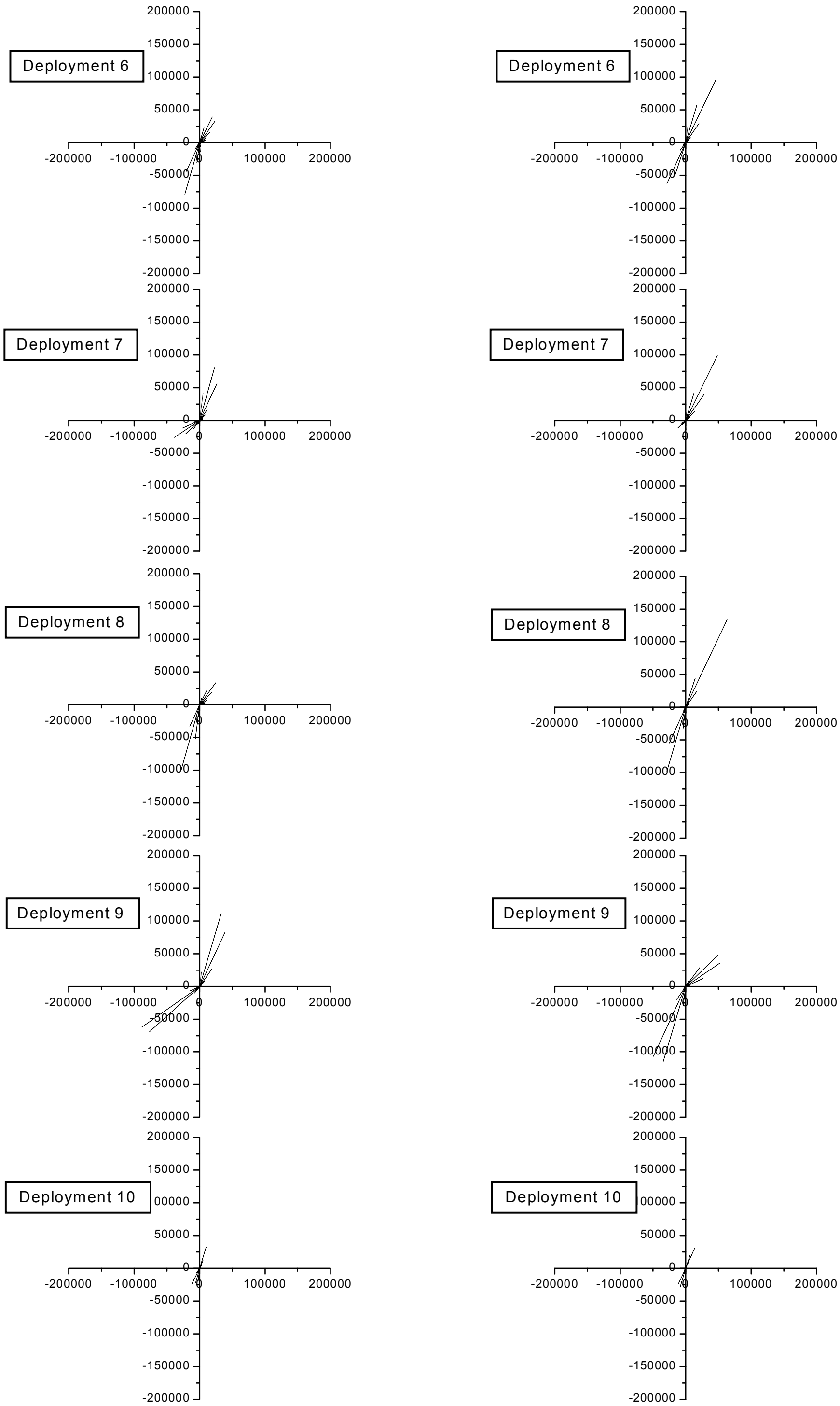
Appendix V. Occurrence (%) of current speed classes (m/s) for the last five deployments (June-October 2007). Left column graphs represent the Wind farm location, right column graphs represents the Ref. Lander area.



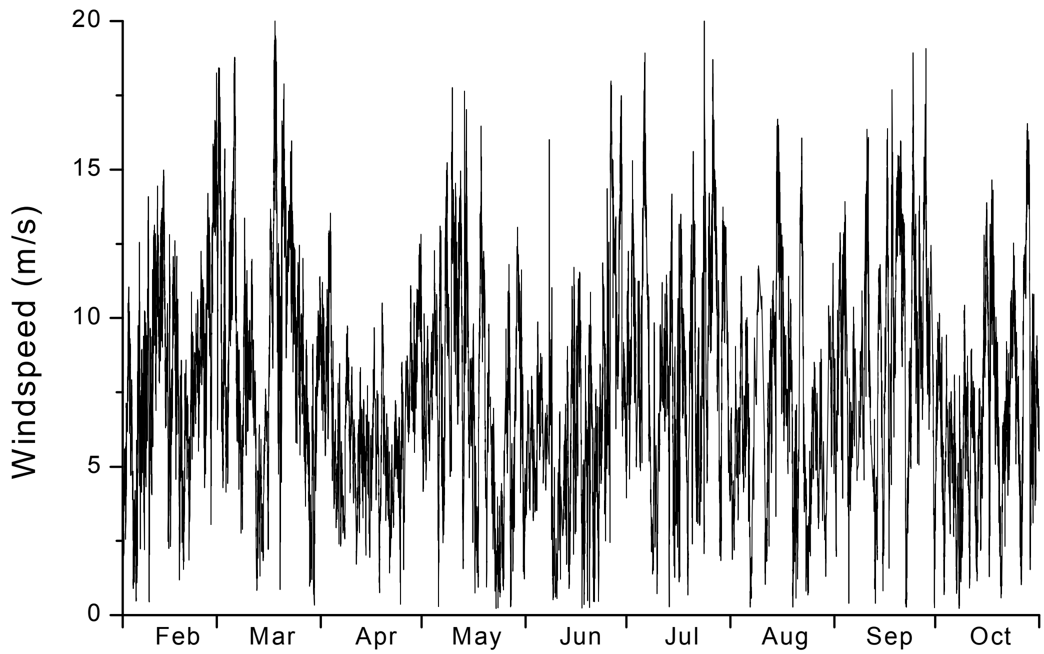
Appendix VI. Current patterns per compass direction for the first five deployments (February-June 2007). Lines are in 10° increments and point in the direction the current is flowing to. Lengths of the lines reflect total distances per direction (m) during deploy. Left column graphs represent the Wind farm location, right column graph represents the Ref. Lander area.



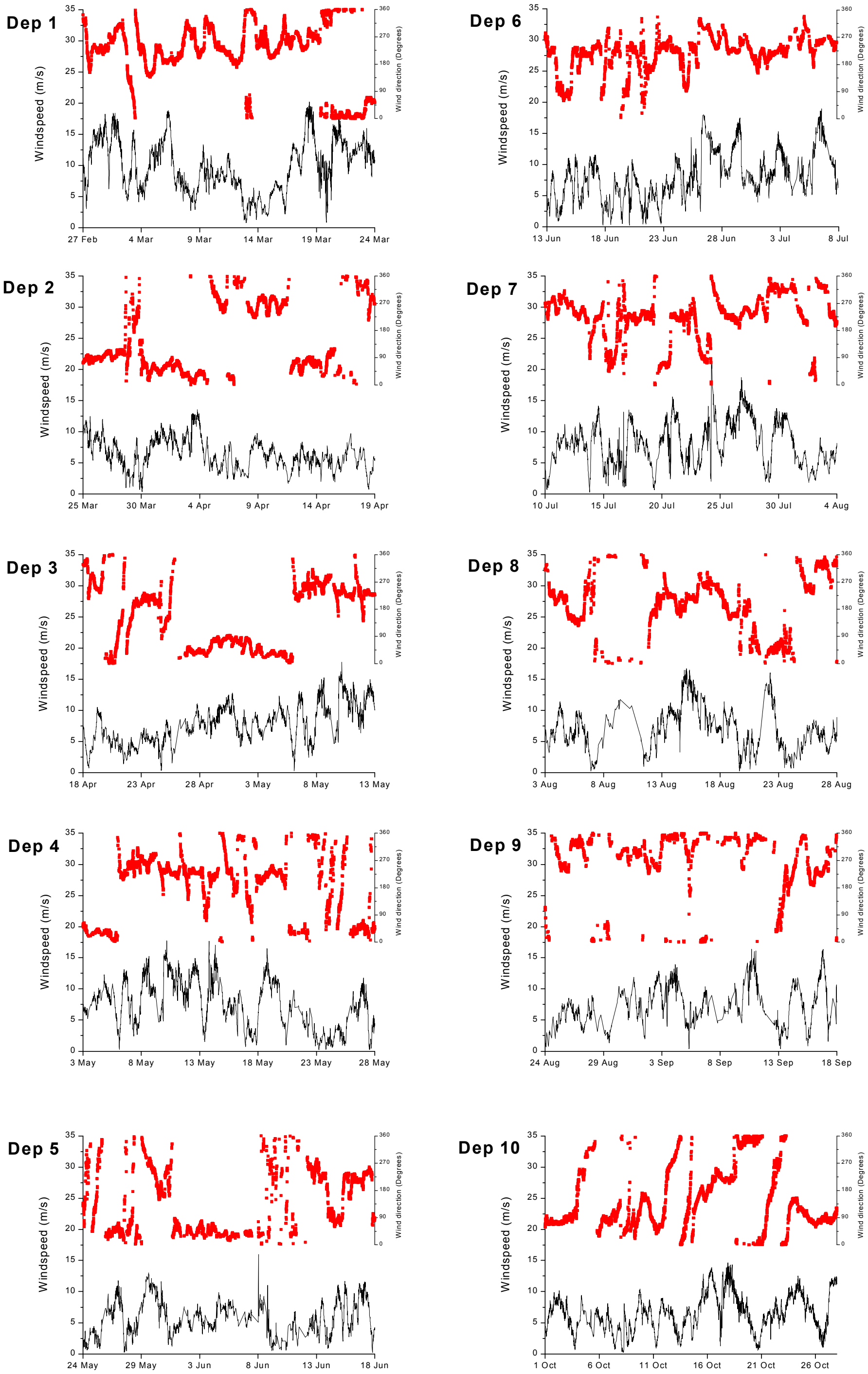
Appendix VI. Current patterns per compass direction for the last five deployments (June-October 2007). Lines are in 10° increments and point in the direction the current is flowing to. Lengths of the lines reflect total distances per direction (m) during deploy. Left column graphs represent the Wind farm location, right column graphs represents the Ref. Lander area.



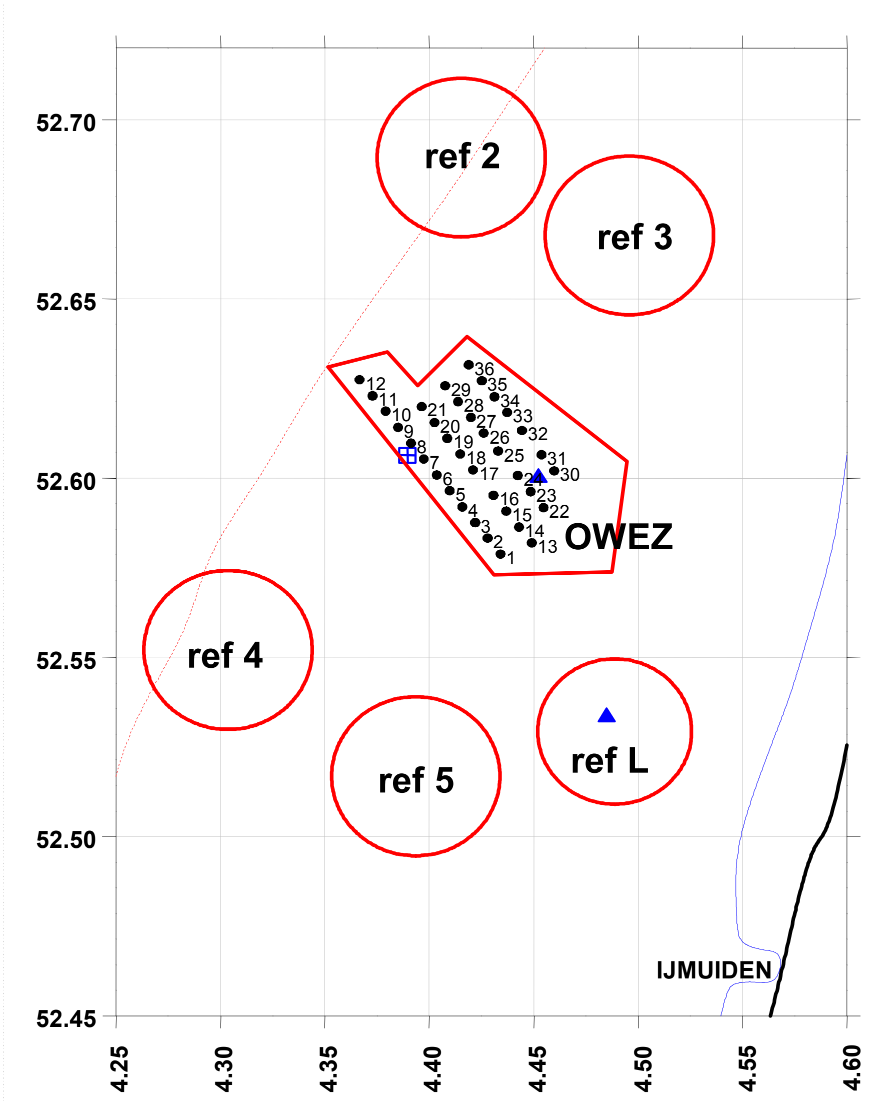
Appendix VII. Annual variation in wind speed (m/s) and direction (º) during the period of the lander deployments. Data are measured by means of an acoustic recorder (instrument code 3D WM4/NW/21) mounted at the meteorological mast of the Wind farm area 21 m above sea level. Source: www.noordzeewind.nl.



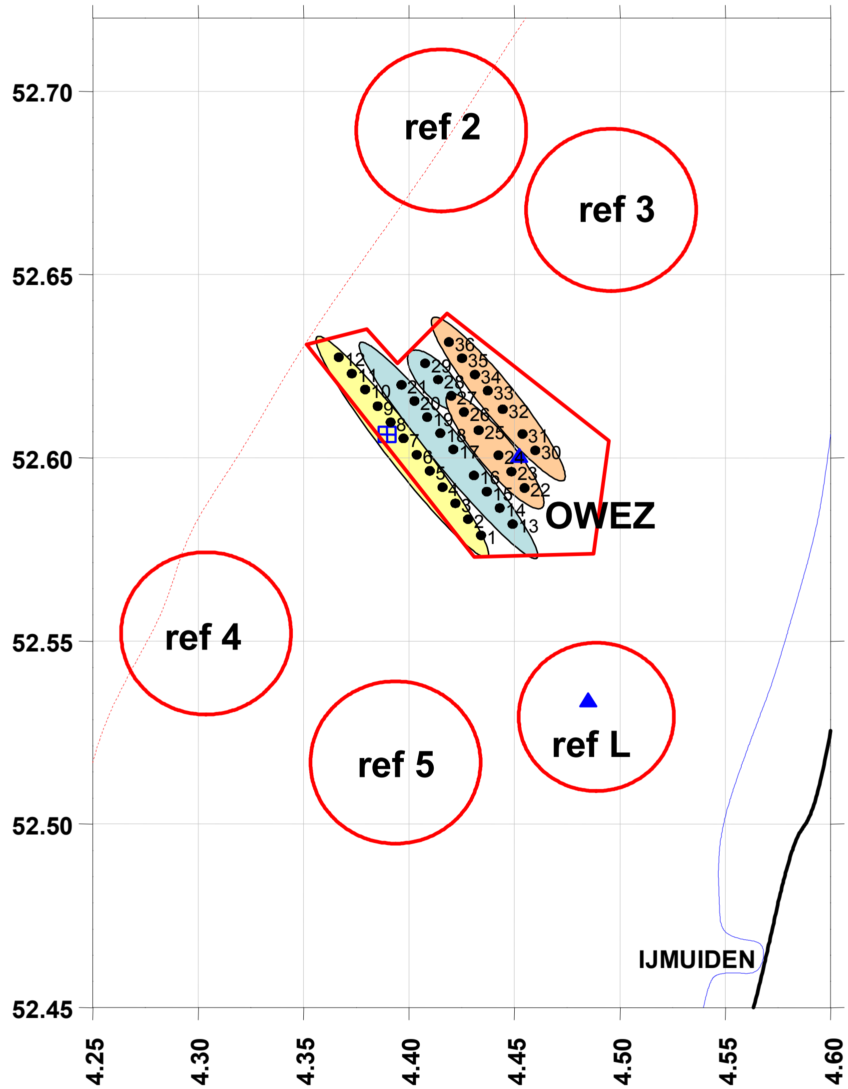
Appendix VIII. Variations in wind speed (m/s) and direction (º) during the ten deployments (February - October 2007). Wind data are measured by means of an acoustic recorder (instrument code 3D WM4/NW/21) mounted at the meteorological mast of the Wind farm area 21 m above sea level. Wind speed data are symbolized by a black line, wind direction is shown with red dots. Source: www.noordzeewind.nl.



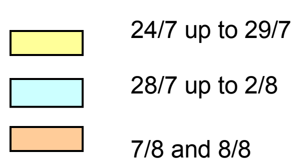
Appendix IX. Maintenance work executed in the Wind farm in 2007: rock dumping around turbines and cable trenching (dredging and burial) (source: Shell, pers. comm.)




Rock dumping around turbines # 1 to 7, 9 to 12, 14, 15, 20, 22 to 24, 26, 29, 30 in august 2007 (bleu areas).




Cable trenching (dredging and burial) between turbines in various periods in 2007.
Cables have been buried during the following intervals in 2007 (no work 27/7):



Appendix to report: OWEZ_R262_T1_20080222

To whom it may concern
Within the framework of the Off shore Wind farm Egmond aan Zee project, on the order of Dutch Government and with their financial support, an extensive environmental monitoring program is carried out. Research area's are birds, marine mammals, fish, benthos, solid substrate and public opinion.
The report at hand is written within the framework of the monitoring program and reports the work done in 2007 on one of the research topics. Before publication, the reports were reviewed by Dutch energy agency SenterNovem and the Waterdienst, a department of the Dutch water authority Rijkswaterstaat. The questions raised and comments of the researchers can be found in this appendix, however the text is available only in Dutch.

Aan de lezer van dit rapport
In het kader van het project Off shore Windpark Egmond aan Zee wordt, in opdracht van en met financiële ondersteuning van de Nederlandse rijksoverheid, een milieu monitoring programma uitgevoerd. Onderwerpen van onderzoek zijn vogels, zeezoogdieren, vis, benthos, hard substraat en publieke opinie.
Het rapport dat voor u ligt is gemaakt in het kader van dat programma en doet verslag van het werk dat in 2007 aan één van deze onderwerpen is uitgevoerd. Voorafgaand aan publicatie is dit concept rapport voorgelegd aan SenterNovem en de Waterdienst van Rijkswaterstaat die namens de overheid het monitoringprogramma begeleiden. Hun vragen bij dit rapport en de reactie van de onderzoekers treft u aan in deze bijlage bij het rapport.

*Vragen en opmerkingen van de overheid op dit rapport:*
*Voor T1 Juvenile benthos is het de vraag of met deze onderzoeksmethodiek de effecten van NSW kunnen worden bepaald, en de effecten van de refugiumfunctie. De locaties van de boxcores en de landers komen niet overeen mbt de referentiegebied met de gebieden uit T1 Dichtheden benthos en T0 Jarvis. Er zijn slechts 2 landers neergezet, 1 in het NSW-gebied en 1 op een nieuwe referentielocatie. SenterNovem en de Waterdienst zouden graag zien hoe daar in het final report meerjarenconclusies aan kunnen worden verbonden, gezien het verschil in locatie.*
*Het onderzoek is een in situ onderzoek, dat inzage geeft in de processen. Inzicht in de processen geeft echter nog niet aan of de daadwerkelijke extra settlement en recruitement als gevolg van het visserijvrij zijn van het NSW ook daadwerkelijk optreed. Eigenlijk zou er naastdit in situ onderzoek ook een meerjarige monitoring moeten plaatsvinden zodat de gevonden resultaten uit het onderzoek met veldgegevens kunnen worden gevalideerd.*
*Er moet dus nog een doorvertaling worden gemaakt naar populatie- en meerjaren niveau.*

*Reactie van de onderzoekers:*
*In het interim rapport zijn alleen conclusies genoemd die gestaafd konden worden met de gerapporteerde resultaten. In het eindrapport zullen verdere resultaten worden getoond en de daarop gebaseerde conclusies.*
*De gekozen opzet van het onderzoek geeft inzicht in de directe effecten van een voor visserij gesloten windpark op het settlement van benthos. Het effect van het ontbreken van visserij wordt gemeten door de directe vergelijking van settler-dichtheden in het visserij-vrije windpark met 5 beviste referentiegebieden. De gekozen referentiegebieden komen niet overeen met de T0 Jarvis gebieden, omdat gekozen is voor een goede opzet met meerdere (5) rondom gelegen referentiegebieden. Van deze 5 gebieden zijn er 4 identiek aan die in de T1 Dichtheden benthos studie. De jaarcycli van omgevingsvariabelen gemeten in windpark en in een van de*

*referentiegebieden geven informatie over verschillen in voor settlers relevante variabelen als o.a. voedsel en gesuspendeerd materiaal.*
*De effecten van eventuele veranderingen in sedimentsamenstelling als gevolg van het verbod op visserij worden getest in de in-situ mesocosm experimenten. Deze uitkomsten moeten inzicht bieden in de effecten van een mogelijke verfijning c.q. vergroving van het sediment op settlement van larven.*
*De gekozen opzet van het onderzoek geeft inzicht in de nu nog grotendeels onbekende processen die een rol spelen bij het initiële settlement van benthos larven. In aanvulling op de verwachte "harde" resultaten zal dit ook bijdragen aan het begrip van settlement processen in onbeviste windparken.*