Impact of windfarm OWEZ on the local macrobenthos community

report

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R. Daan, M. Mulder, M.J.N. Bergman

Koninklijk Nederlands Instituut voor Zeeonderzoek (NIOZ)

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Summary and conclusions

In this report the results are presented of a study on possible short-term effects of the construction of Offshore Windfarm Egmond aan Zee (OWEZ) on the composition of the local benthic fauna living in or on top of the sediment. The study is based on a benthic survey carried out in spring 2007, a few months after completion of the wind farm. During this survey the benthic fauna was sampled within the wind farm itself and in 6 reference areas lying north and south of it. Sampling took place mainly with a boxcorer, but there was also a limited programme with a Triple-D dredge. The occurrence of possible effects was analyzed by comparing characteristics of the macrobenthos within the wind farm with those in the reference areas. A quantitative comparison of these characteristics with those observed during a baseline survey carried out 4 years before was hampered by a difference in sampling design and methodological differences.

The conclusions of this study can be summarized as follows:

1. Based on the Bray-Curtis index for percentage similarity there appeared to be great to very great similarity in the fauna composition of OWEZ and the majority of the reference areas.
2. Overall fauna densities within OWEZ were well within the range of densities found in the reference areas. The same holds for overall biomass values.
3. Diversity within OWEZ, expressed in terms of species richness, evenness and dominance, was well within the range of values observed in the reference areas.
4. The relative fauna abundance within OWEZ was statistically not different from that in the reference areas.
5. Differences between the mean densities of individual species in OWEZ and in the reference areas were tested for statistical significance for 22 box core species. In 6 cases such a difference was significant, but the OWEZ area never showed a significant difference with more than one reference area. In other words, for all species tested the density found in OWEZ was within the range of densities of at least 5 of the 6 reference areas.
6. Differences between the mean densities of individual species inside OWEZ and outside OWEZ were tested for statistical significance for 10 Triple-D species. In none of these species the mean density in OWEZ was significantly different from that outside OWEZ
7. There is not any indication, that OWEZ differed in some way from (the majority of) the reference areas, but that statistical analysis did not confirm a significant difference.
8. There seems to be no short-term effect of the construction of the wind farm on the local benthic fauna composition

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Introduction

In 2006 an offshore wind farm has been constructed in the North Sea, at ≈7 miles off the coast near Egmond aan Zee (Fig. 1). The first years of operation of this wind farm are accompanied by an intensive monitoring and evaluation programme on the possible environmental impact of the construction of the park. This programme includes research and/or monitoring projects related to (almost) all major categories of organisms relevant to the area involved.

One of the monitoring items concerns the fate of the benthic faunal community following the construction of the energy park. Questions underlying this monitoring programme focus on the immediate effects of the presence of the park on the actual benthic community and on the long-term effects on the benthic community within the zone of the windmills. In order to obtain insight in these questions a benthic sampling programme has been carried out in 2007 on possible short term (<1 year after construction) effects on the benthic fauna. In this report the results of this effect study are presented and discussed.


Wind mills

Before the windfarm was constructed a baseline study was conducted in 2003 by the Institute of Estuarine and Coastal Studies (IECS) of the University of Hull. The results of this baseline study have been presented in a report (Jarvis et al., 2004), which describes in detail the sampling design chosen, the methods used and the distribution of the macrobenthic fauna before the construction of the windfarm started. In our report we will refer to this study as T0 whereas we will denote our own survey as T1. The windfarm itself is generally referred to as 'OWEZ' (Offshore Windfarm Egmond aan Zee).

During the T0-study the fauna in the area was sampled in three subareas: OWEZ itself and two reference areas. One area is lying north of OWEZ, the other one south of it. In the original planning of the T1-study it was foreseen to use a sampling design similar to that employed during T0. However, the sampling design should also be adequate to detect possible differences in the development of the fauna between OWEZ and the reference area in a statistically reliable way. Therefore a power analysis was carried out on the T0 data. The mathematical procedure of this analysis is given in Appendix 3 The outcome of the procedure is that continuance of the original sampling design would imply that only extremely large differences would be detectable with any statistical significance. The analysis showed that the difference in the fauna composition between the two reference areas was too large to statistically detect changes in the test area that could possibly result from the construction of the park. In other words, the number of two reference areas was too low. It was decided therefore to spread the sampling effort over more and smaller control areas. This implies that possible effects within the area of the windfarm, should be detected on the basis of instantaneous differences between the macrobenthos in the windfarm and in the reference areas at T1, with analysis of variance being the basic statistical tool. Statistical comparisons with T0 data are senseless, but qualitative comparisons will be considered in the discussion chapter.

During the T1 study the benthic fauna was sampled both with a boxcorer and a benthic dredge, but the emphasis was on the boxcore programme, to obtain insight in the possible short-term effects of the construction of the windfarm. Such short-term effects were expected to be observed most adequately in the smaller and most abundant species that are caught by the boxcorer. The dredge programme was only very limited and aimed to get an impression of possible short-term changes in the larger fauna in the windfarm, where fishery is not permitted and where the bottom fauna could develop in an environment without disturbance of trawling gear.It is anticipated, however, that a measurable change among larger benthic species can be expected only after at least several years without fisheries.

Methods

Fieldwork

Fieldwork was carried out in the period 20-26 March 2007 on board of the research vessel Pelagia. The field programme consisted of collecting benthic fauna samples within the area of the windmills as well as in six smaller reference areas (Fig. 1). Three of these reference areas were chosen north of the wind farm (R1 –R3) and the other three south of it (R4-R6). R1 and R6 correspond with the reference areas that were sampled during the T0 programme too. The benthic macrofauna was sampled with a 0.078 m^2 boxcorer and a Triple-D benthic dredge (Bergman & Santbrink, 1994). The boxcorer is used to sample the small (generally 1 to 10 mm) more or less abundant fauna species. The dredge is used to sample the less abundant and larger species, which cannot be sampled quantitatively by the boxcorer. This dredge had a cutter plate width of 20 cm and digged to a depth of 18 cm in the sediment. The net mounted on the dredge had a mesh of 7x7 mm. The dredge is equipped with a mechanism which ensures that it

takes a quantitative sapmple. This mechanism was adjusted to a sampling distance of 80 m, so each sample represented the fauna present under a 16 m^2 surface area.

Boxcores were collected at 30 stations within the area of the turbines, one boxcore per station. The stations were arranged along transects running parallel to the windmill rows. In each of the control areas 15 (14 in area R6) boxcore samples were taken on three parallel transects. On board the boxcores were washed through a 1 mm mesh sieve and the residue was preserved in a 6% neutralized formaldehyde solution for later analysis in the laboratory.

Boxcorer

Dredge hauls were made along 14 transects in the area of the windmills, and along two transects in each of the control areas. The catches were sorted and counted on board and the animals in the samples (or in subsamples) were measured. In fact all dredge sample data were collected on board.

Sample treatments

In the laboratory the boxcore samples were sorted. Before sorting, each sample was stained with bengal rose, which stains proteins present in animals that were caught alive. In this way bengal rose creates a strong contrast between living and dead material, which facilitates sorting of the samples. The stained samples were washed over a set of nested sieves, with 1 mm as the smallest mesh size, to get rid of the

formaldehyde. Then the various sieve fractions were examined under an illuminated magnifying lens to separate fauna from dead material, mainly shell grit. Subsequently the macrofauna was identified under a stereomicroscope. The most common groups, being the polychaetes, crustaceans, molluscs and echinoderms were generally identified to species level. Damaged animals and juveniles, which because of their small size could not be identified to species level, were recorded on a higher taxonomic level, usually the genus. Notoriously difficult taxa such as anthozoans, phoronids, oligochaetes and nemerteans were not further identified but counted on their taxon level.

Triple-D dredge

Biomass and production

Biomass values were calculated as ash free dry weight (afdw) per species or taxon identified. The afdw values of the different taxa were determined according to the methods used in the North Sea BIOMON programme (that were also used for the T0 data, Jarvis et al., 2004) which implied:

<u>Molluscs and echinoids</u>:

By means of length-AFDW relationships of the form $W=a*L^b$ (W=AFDW in g and L=length in mm, a and b are species specific coefficients).

Polychaetes, larger crustaceans, ophiuroids and remaining taxa:

Indirectly, by converting the (blotted) wet weight into AFDW by means of conversion factors provided by Rumohr *et al*. (1987) and Ricciardi & Bourget (1998). Wet weights were measured with a Mettler PJ300 balance to the nearest mg.

Small amphipods and cumaceans were assigned an average individual AFDW of 0.2-0.5 mg. The same value is used by Holtmann & Groenewold (1994) in their analysis of macrobenthos from the MILZON-BENTHOS project in the southern North Sea between 1991 and 1993. This estimated individual weight is based on previous determinations of the AFDW of the taxa in question (Duineveld; Holtmann, unpubl.).

Estimates of the production of the benthic community were obtained from empirical relations between production, total biomass and individual weight as presented by Brey (1990). The estimates were calculated from the model equation

$$\text{Log}(P) = a + b_1 * \log(B) + b_2 * \log(W),$$

where

P = annual production in g AFDW m^{-2} y^{-1}

B = mean annual biomass in g AFDW m^{-2}

W= mean individual weight in g AFDW

a, b_1 and b_2 are taxon-specific coefficients and have different values for polychaetes, molluscs, crustaceans and 'all taxa' respectively

Our calculation was based not on the mean annual biomasses, but necessarily on the instantaneous biomasses we found in the seven different regions. For individual species W was calculated from biomass and abundance data. For each region we calculated the production of each of the species that contributed in the top ten ranked species in biomass. All other species were lumped in one group and production was calculated from their mean individual weight. The top ten ranked species always contributed to over 85% of total biomass. Community production was calculated by adding the production of the top ten species and the lumped production of the other species.

Mathematical analyses

Differences and resemblances between the fauna composition in the various areas were quantified by calculating Bray-Curtis indexes for percentage similarity (Bray & Curtis, 1957). Among a variety of indices that have been proposed, this index was found to reflect most accurately the actual similarity (Bloom, 1981). In order to prevent that a few abundant species would disproportionally dominate the between station similarities, the method was applied to squareroot transformed abundance data of the individual species (see Gray et al., 1988).

Relative fauna abundance in the different areas was calculated according to the method described by Daan et al., 1992. The method is based on a ranking procedure. For all of the individual species the mean density is considered in each of the seven areas investigated. Per species a rank is attributed to each area: the rank is 1 for the area with the lowest density and 7 for the area with the highest density. If any densities are equal, they are given the average of the tied ranks. When this procedure is completed for all species a mean rank can be calculated for each area. Differences between mean ranks were tested for significance by applying analysis of variance.

In the literature a variety of indices have been proposed to quantify diversity (see e.g. Harper & Hawksworth, 1994). In this report we use three indices. The simplest is species richness, which here stands for the number of species per sample. The second one is the Shannon-Wiener index (Shannon & Weaver, 1949) which is one of the indices most commonly used to quantify diversity (e.g. Morin, 1999). The index takes into account both the number of species in a community and the degree of evenness, i.e. the way that individuals in a community are distributed among species. The third index is the Simpson index. This index is particularly sensitive to the abundance of the commonest species and can therefore be regarded as a measure of dominance (Hill, 1973). The index may vary between 0 and 1. A high value for the index means high dominance and hence low diversity.

Sediment

During fieldwork sediment samples were collected (from a boxcore sample) in the centre of each dredge haul. The samples were taken from the top ten cm of the sediment and immediately frozen at -20^{o} C. In the laboratory the grain size was analyzed with a Coulter LS particle counter. The method is described in detail by de Stigter et al., 2007.

Results boxcores

Fauna composition

A complete overview of the fauna composition in all individual samples is given in Appendix 1.

A comparison of the fauna composition in the seven areas sampled based on the Bray-Curtis index shows that there is very great similarity (≥ 80%) between the wind farm area and the reference areas R2 and R5 (Table 1). The similarity of these areas with R1 and R4 can also be qualified as great, whereas R3 and R6 were somewhat more different. The mutual difference between the latter two areas was relatively large. The good similarity of the windfarm area with four of the reference areas indicates that the presence of the wind mills had no effect on the overall fauna composition.

Average fauna densities in the seven areas ranged between a minimum of 534 individuals per m^2 in reference area R5 to 1138 individuals per m^2 in reference area R6. Analysis of variance applied to ln transformed values showed that there were no significant differences beteen the areas (p=0.20). The average density within the windfarm (599 individuals per m^2) was well within the range of densities in the reference areas.

Average biomass values in the 7 areas ranged between a minimum of 7.7 g AFDW per m^2 in reference area R2 to 38.6 g AFDW per m^2 in reference area R6. Biomass values in the individual samples were extremely variable in all areas. The presence or absence of a few large species strongly affected the total biomass. However, analysis of variance applied to ln transformed biomass values did not reveal significant differences between the areas (p=0.18). The average biomass in the windfarm (34.5 g AFDW per m^2) was only slightly less than the maximum biomass as found in R6.

Diversity

A total number of 92 different taxa were found in the windfarm area and the reference areas. The numbers of species per individual sample varied between 4 and 30. The average number of species per sample ranged from 11.5 in reference area R4 to 15.7 in area R6. Analysis of variance applied to untransformed data revealed no significant differences between the areas (p=0.07).The average number of species per sample within the windfarm (12.3) was well within the range of densities in the reference areas.

The Shannon-Wiener index for faunal diversity was calculated (on ^{2}log basis) for all invidual samples. The average value of the index ranged between a minimum of 2.75 in R5 to a maximum of 2.97 in R2. Analysis of variance revealed no significant differences between the areas (p=0.93). In the windfarm the index (2.79) was well within the range of values observed in the reference areas.

The average value of the Simpson's index varied within a narrow range of 0.18 (in the Windfarm area) to 0.22 in reference area R1. Analysis of variance showed no significant differences between the areas (p=0.91). The range corresponds well with the mean values of the Simpson index usually found in the Dutch coastal and offshore areas (see Daan & Mulder, 2006)

Relative abundance

Analysis of variance revealed that the relative fauna abundance was significantly not the same in all areas (p=0.005, Fig. 2). However, a complementary Tukey-HSD test showed that there were only significant differences between the reference areas R6 and R3 (p=0.002) and between R6 and R5 (p=0.016). R6 had a higher relative abundance than R3 and R5. All other pairwise comparisons revealed no significant differences between areas. The relative fauna abundance in the windfarm was well within the range of values observed in the reference areas.

Densities of individual species

For all species/taxa that were found more or less frequently (≥50 specimens) analysis of variance was applied to detect whether there were significant (p<0.05) differences in densities between areas. For those species in which such a difference was found an additional Tukey-HSD test was applied to find out which areas were different from each other. The results of this exercise are presented in Table .. Out of a total of 22 species/taxa tested, 13 species showed significant differences between areas. However, in two cases the Tukey-HSD test did not detect any significant pairwise difference between areas. In nearly all other cases there appeared to be one reference area that differed from a few or all other areas. Particularly reference area R6 often differed from at least 1 or a few other areas by having species that occurred there in significant higher numbers. It is remarkable that the windfarm area never showed to significantly differ from more than one 1 reference area. In other words, for all individual species tested the density found in the windfarm area was within the range of densities of at least 5 of the 6 reference areas.

Production

The estimates of the annual production of the benthic community range from 6.0 g afdw.$m^{-2}y^{-1}$ in R2 to 19.7 g in R6 (Table 3). In the windfarm the production estimate (13.6 g) was well within this range. A few relatively large species that largely contributed to the total community biomass generally contributed also to a substantial part of the estimated production. However, since the P/B ratio of these large species is low compared to that of smaller species, the overall P/B ratio of the community was also relatively low and did not exceed a value of 1.0 in any of the areas. In most areas production was dominated by the razor clam *Ensis americanus* and the sea urchin *Echinocardium cordatum*. To a lesser

extent the smaller polychaetes *Notomastus latericeus* and *Lanice conchilega* had a substantial share in the total community production. *L. conchilega* had a dominant position in benthic production in reference area R4, the area where the highest P/B ratio of 1.0 was found.

Results Triple-D dredge

Fauna composition

A complete overview of the fauna composition in all individual samples is given in Appendix 2. An overview of mean densities of the macrobenthos is presented in Table 4.

A comparison of the fauna composition in the 7 areas sampled based on the Bray-Curtis index shows that there was great similarity (65 to 80%) between the windfarm area and the reference areas R3, R4, R5 and R6 (Table 5). A little bit different were the areas R1 and R2 with index values generally slightly less than 65%. The good similarity of the windfarm area with four of the reference areas (and not strongly different from the other two areas) indicates that there was no effect of the presence of the wind mills on the overall fauna composition.

Dredge catch

Average densities of macrobenthos ranged from 660 individuals per 100 m^2 in reference area R2 to 1940 in R3 (Table 4). The average density in the windfarm was well within this range. However, there was quite some variability in the numbers at the individual stations (Fig. 3). In the windfarm was one station with over 7000 individuals per 100m^2. This appeared to be caused by the presence of a bank of American razor clams (*Ensis americanus*) and, to a lesser extent, by high numbers of shrimps (*Crangon crangon*). At another stations high numbers of *C. crangon* resulted in an overall fauna density of more than 3000 indiv. per 100 m^2. A similar overall density occurred at one station in R3. Here it was caused by the presence of a bank of *E. americanus*. At all other stations the fauna densities fluctuated between

400 and 2000 indiv. per 100 m^2. The data show that local high fauna densities are consistently caused by high numbers of one or a very few species, not by collective high abundance of a majority of species.

Overall abundance of fish ranged from 141 ind. per 100 m^2 in R1 to 478 in R6. The mean density of 310 ind. per 100 m^2 in the windfarm was well within this range.

Diversity

The dredge hauls yielded a total number of 36 macrobenthic species/taxa (Table 4). Per 2 dredge hauls the numbers fluctuated within a very narrow range of 18 to 21 species species in nearly all areas, except for reference area R2 where this number (14) was somewhat lower. Analysis of variance revealed no significant difference in numbers of species within the windfarm and in the reference areas ($p=0.76$). Species richness within the windfarm did not show any sign of being affected by the presence of the turbines. For fish holds the same. The numbers of species in two dredge hauls ranged from 5 In R2 to 10 in R6. The average number in two samples in the windfarm (9) was well within this range. Analysis of variance did not show significant differences between windfarm and reference areas ($p=0.66$).

Shannon-Wiener diversity was calculated for 7 paired dredge hauls in the windfarm and for the combined dredgehauls in each of the reference areas. For macrobenthos the results are presented in Fig. 4 The index varied between 2.19 and 2.91 within the windfarm and between 2.34 and 3.22 in the reference areas, so both ranges largely overlap. Analysis of variance showed no significant ($p=0.33$) difference between the values found in the windfarm and those found in the reference areas.

For fish the index ranged between 0.69 and 2.54, with both the minimum and maximun values observed within the windfarm (Fig. 5). Particularly the minimum value deviated clearly from the other values. It was caused by the fact that this (paired) sample was strongly dominated by large numbers of gobies (*Pomatoschistus spec.*). The number of species was not particularly low. Analysis of variance did not reveal a significant difference between diversity within the windfarm and in the reference areas.

Relative abundance

Relative fauna abundance was calculated for 7 paired dredge hauls in the windfarm and for the combined dredge hauls in each of the reference areas (Fig. 6). Analysis of variance revealed that there existed significant differences in the relative abundance of the macrobenthos in the various paired dredge hauls ($p=0.001$). However an additional Tukey-HSD test revealed that there was only one pair of dredge hauls that differed significantly ($p<0.05$) from a number of other pairs: The pair coded as W5 had significantly higher relative abundance than the pairs W1, W2, W4, R1 and R2. All other pairwise comparisons yielded no significant differences. Clearly there was no overall difference in the relative abundances in the windfarm and in the reference areas. This implies that the high local relative abundance at one pair of stations cannot be attributed to the presence of the turbines.

For fish the pattern of relative abundance is shown in Fig. 7. Here also the highest and lowest mean rank were observed in paired hauls in the windfarm. However, analysis of variance revealed no significant differences in the relative abundance of fish in the various paired dredge hauls ($p=0.23$).

Densities of individual species

For ten of the most abundant species in the grab hauls (including one fish species) analysis of variance was applied (on log transformed numbers) to detect whether there were significant differences between the densities within and the densities outside the windfarm (Fig. 8a-j). Nearly all species showed relatively extreme high densities in one or a very few dredge hauls, but differences between within windfarm and outside windfarm densities were in nine species non-significant. Only in the echinoderm *Ophiura albida* the difference appeared to be significant (p=0.01). However, not the means were clearly different, but the variances. The variance in the hauls from the reference areas was much higher than from those within the windfarm. All densities found within the windfarm were within the range of densities in the reference areas. So there does not seem to be any effect of the windfarm on *O. albida* or on any other species.

Hermit crab

Sediment

The coulter analyses of the sediment revealed median grain sizes within OWEZ in a range of 242 to 300 µm (Fig. 9), which on the scale of Gullentops et al. (1977) can be qualified as medium-fine sand. At most

of the stations in the reference areas the median grain size was in the same range. At two stations deviant values were found: in R5 a clearly smaller grainsize occurred (fine sand) and in R6 a larger grain size (medium-coarse sand), but in both areas only at one station. The median grain size does not seem to have changed by the establishment of the windmills. Silt was absent in most samples. In only 5 samples small fractions of 1.3 to 3.2 % silt were found. The presence of some silt may strongly depend on the moment of sampling within the tidal cycle, rather than by spatial differences.

Discussion

A comparison of the box core data collected during this T1 study with those obtained by Jarvis et al. (2004) during their T0 survey is only possible for the windfarm area itself and the two reference areas that were sampled in both studies (R1 and R6). Table 6 shows that the overall mean fauna abundance at T1 had decreased somewhat at OWEZ and R1, and increased at R6; the variance in the data seemed to be lower during the T1. However, when we compare the T0 and T1 data in a statistical way (analysis of variance), there appeared to be no significant differences in the changes observed between the three areas ($p=0.88$). In other words, there was no measurable effect of the windfarm on the fauna abundance.

Mean biomass values within the windfarm and in reference area R6 were much higher at T1 than at T0 (Table 7). Obviously, the cause of the high values at T1 was the presence of banks of adult american razor clams (*Ensis americanus*) at 3 stations in the windfarm and at 2 stations in R6. These banks were responsible for extremely high local biomass values, which strongly affected the overall mean. These banks were not yet present at T0. The increase of biomass should therefore be explained by the growth of a single generation of *E. americanus*, not by an overall increase of benthic biomass. This is also supported by the fact that at reference area R1, where no *E. americanus* banks were found, the average biomass was at T1 at a similar level as at T0.

Another remarkable difference in community biomass between T1 and T0 was the contribution of the sea urchin *Echinocardium cordatum*. At T1 *E. cordatum* belonged to the top two species ranking in biomass in all areas. Both the abundance and biomass values were at a similar level as usually found in the coastal and southern offshore area during the BIOMON program (Daan & Mulder, 2006). However, during T0 the species did not occur within the top ten species in any of the three areas investigated then. We don't have a plausible explanation for this dissimilarity between T0 and T1.

Species richness, here expressed as the number of species per sample (Table 8), appeared to be slightly greater at T1 than at T0 in each of the 3 areas. However, the difference is easily explained by the difference in sample size: 0.068 m^2 at T0 and 0.078 m^2 at T1. If we take into account this difference in sample size then there seems to be no real difference in species richness between T0 and T1.

Shannon Wiener diversity was at a slightly higher level at T1 than at T0 (Table9). Here also the use of different box cores may be responsible for the difference, since the index is sensitive to sample size. It is remarkable however that the variance was clearly lower at T1 than at T0.

At the species level there were marked differences between T0 and T1 (Table 10). If we look at the ten species that were overall the most abundant in the windfarm area and the reference areas R1 and R6 at T1, it appears that only the two most abundant species (the amphipod *Urothoe poseidonis* and the polychaete *Nephtys cirrosa*) were also among the ten most abundant species at T0. At T0 the fauna was dominated by two tube-building polychaetes, *Spiophanes bombyx* and *Lanice conchilega*. Both are relatively short-living species and their densities may strongly fluctuate from year to year (Daan & Mulder, 2006). Differences between years may easily mount up to a factor 10 to 100, so natural fluctuations may simply explain the difference in densities between T0 and T1.

The estimates of annual benthic production are based on empirical relations between production and biomass of individual species and consist of a sum of population production estimates. The value of the predicted production of different populations falls within 95% confidence limits that substantially differ between species (Brey, 1990). This makes it difficult to calculate reliable confidence limits for estimates of total community production. Moreover, the estimates are based on overall averaged production values, irrespective of abiotic parameters like geographic latitude, depth and current speeds, which influence benthic production and P/B ratio via primary production, water temperature and amount of available food. It's therefore impossible to provide any reliable confidence limits to the predicted production values. However, a comparison of the estimated community production values with the value (29.9 g afdw.$m^{-2}y^{-1}$) presented for the western Wadden Sea by de Wilde & Beukema (1984) shows that our values are slightly lower, but do not differ an order of magnitude. The difference seems to be caused partly by lower biomass values and partly by lower P/B ratios in our area, compared to values of 26.6 g afdw.m^{-2} and 1.1 respectively in the Wadden Sea.

Production estimates have been made not only for the areas sampled in the present study, but also for the three areas sampled at T0 (Table 3). In two areas, OWEZ and reference area R6, the biomass values (2.6 and 3.9 g afdw.m^{-2}) were clearly low compared to the situation at T1, apparently due to the absence of some large species like e.g. *Ensis americanus* or *Echinocardiun cordatum*. Consequently the estimated community production (3.7 and 2.6 g afdw.$m^{-2}y^{-1}$ respectively) was also relatively low, although the calculated P/B ratios in these areas (1.4 both) were higher than at T0, also due to the absence of large species. On the other hand, at reference area R1 both the biomass (15.0 g afdw.m^{-2}) and estimated production (9.0 g afdw.$m^{-2}y^{-1}$) at T0 were at a similar level as at T1. In this area the (large) bivalve *Spisula subtruncata* was the dominating species in terms of biomass at T0 and responsible for the low P/B ratio of 0.6. The loss of community biomass and (estimated) production by the disappearance of *S. subtruncata* after T0 was compensated by the appearance of a succesful *Ensis americanus* generation. All in all there is no indication that production in the windfarm area has changed between T0 and T1 as a result of a changing fauna composition.

An overall adequate comparison of the macrofauna in the dredge samples between T0 and T1 is hampered by rather strong methodological differences in dredge sampling. At T0 dredge hauls with a sampling width of 1.00 m and a haul length of approximately 100 m resulted in a sample surface of ≈100 m^2 per haul. At T1 dredge hauls of 0.20 m width and of exactly 80 m length resulted in a sampled surface

of 16 m^2 per haul. The smaller mesh size used at T0 (6 mm) compared tot that used at T1 (14 mm) will have caused that a larger fraction of small sized animals will have been retained in the net at T0. On the other hand, a few hyperbenthic species like shrimps were apparently not included in the countings at T0, whereas fish were not recorded at all, so that, for this group, there are not any data to compare our T1 data with.

The total mean fauna density in OWEZ and the reference areas R1 and R6 appeared to be slightly larger at T1 (1000 ind. per 100m^2) than at T0 (800 ind. per 100m^2). In the three individual regions there were stronger differences. In OWEZ and R6 the total densities were clearly larger at T1 (1450 and 775 ind. per 100 m^2 respectively) than at T0 (425 and 275 ind. per 100 m^2) These differences could be largely explained by the abundance of common shrimps (*Crangon crangon*) at T1, that were not included in the countings at T0. In R1 the total fauna abundance was clearly higher at T0 (2210 ind. per 100m^2) than at T1 (775 ind. per 100m^2). The difference could be completely explained by the presence of dense banks of the bivalve *Spisula subtrunacata* at T0. These banks had disappeared at T1. The disappearance is not a local event, but *Spisula* densities have been shown to decline after 2003 in the whole Dutch coastal area (Craeymeersch & Perdon, 2006, Daan & Mulder, 2006).

The overall number of taxa identified in the dredge samples at T1 (36) was lower than the number reported at T0 (46). Such a difference could be easily explained by the much larger surface sampled and the smaller mesh size used at T0, which retained such small species as the gastropod *Euspira nitida* (=*Polinices pulchellus*). However the number of 46 seems questionable, since the authors of the report suggest that these 46 taxa contained 24 mollusc species, whereas their overall species list contains only 21 molluscs, of which a few are likely to occur only in boxcore samples. This implies that the real difference in total number of species between T1 and T0 may be negligible.

The number of species found per 2 dredge hauls of together 32 m^2 at T1 (14-21) was generally higher than in one dredge haul of 100 m^2 at T0 (14-16), in spite of what could be expected in view of the difference in sampled surface and the mesh sizes used. It just shows that the dredge used at T1 performed at least as effective as the one used at T0.

The Shannon-Wiener diversity per 2 dredge hauls in the different areas at T1 (2.19 -3.22) was at a similar level as the mean values found in individual dredge hauls in OWEZ and R6 at T0 (2.58 and 2.35 respectively). However at R1 the mean Shannon Wiener diversity was substantially lower at T0 (1.37). This is easily explained by the abundance in this area of the bivalve *Spisula subtruncata* at T0, which strongly dominated the benthic fauna and substantially affected the height of the index.

When we look at the overall species composition, the top twelve most abundant species at T1 were also among the most abundant species at T0. However, at the species level there were some differences between the densities at T1 and those at T0 (Table 11). For shrimp species (*Crangon crangon* and *Pontophilus spec*.), which were among the most abundant at T1, a comparison is not possible since they were not included in the countings at T0. Other crustaceans, like the crabs *Liocarcinus holsatus* and *Thia scutellata*, and the hermit crab *Pagurus bernhardus*, seemed to be generally slightly more abundant at T1 than at T0. The same holds for three bivalve species, *Chamelea striatula*, *Donax vittatus* and *Ensis*

americanus and also the echinoderm Ophiura texturata was more abundant at T1 in all three areas. No consistent differences could be found in the densities of the bivalve *Tellina fabula* and the echinoderm *Ophiura albida* at T1 and T0. The bivalve *Spisula subtruncata* was the only species that was clearly more abundant at T0 than at T1. As mentioned before the decline of *S. subtruncata* was not surprising since this species has shown a decline in the whole Dutch coastal area after 2003.

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Tables

	R2	R5	R1	R4	R6	R3
W	80	84	70	69	55	62
R2		76	74	70	59	59
R5			64	66	55	59
R1				57	69	54
R4					47	50
R6						48

Table 1:
Box cores windfarm (W) and control areas R1 - R6
Values of the Bray-Curtis index as a measure of similarity (%) of the fauna composition in the different areas
The index was calculated after √-transformation of the densities of the individual species. Dark background colour indicates high similarity

Table 2: Box core data. Results of analysis of variance and a post hoc Tukey-HSD test to test the significance ($p<0.05$) of differences in the densties of individual species in the various areas.

	ANOVA p	Tukey HSD test significant differences between areas	high densities in area(s)
Polychaetes			
Lanice conchilega	0.119		
Magelona filiformis	0.550		
Magelona johnstoni	0.024*	no significant differences found	
Magelona mirabilis	0.005*	R4 vs. R1,R5	R1,R5
Malmgrenia marphysae	0.221		
Nephtys cirrosa	0.070		
Nephtys hombergi	0.267		
Notomastus latericeus	0.037*	R6 vs. R4	R6
Scolelepis bonneri	<0.001*	R3 vs.W,R1,R2,R4,R5,R6	R3
Scoloplos armiger	<0.001*	R2 vs.W,R3, R4 vs.W,R1,R3,R5,R6	R2,R4
Spiophanes bombyx	<0.001*	R6 vs. W,R2,R4,R5	R6
Amphipods			
Bathyporeia elegans	0.093		
Bathyporeia guilliamsoniana	<0.001*	R1 vs. W,R2,R3,R4,R5,R6	R1
Urothoe brevicornis	<0.001*	R6 vs. R1,R3	R6
Urothoe poseidonis	0.009*	R1 vs. R3,R4	R1
Bivalves			
Ensis americanus	0.219		
Mysella bidentata	0.001*	R6 vs. W,R1,R2,R3,R4,R5	R6
Tellimya ferruginosa	0.002*	R6 vs. W,R2,R4	R6
Tellina fabula	0.014*	R1 vs. R4	R1
Echinoderms			
Echinocardium cordatum	0.026*	no significant differences found	
Others			
Nemertini	0.424		
Phoronida	0.100		

Table 3: Biomass (g afdw.m-2) and production (g afdw.m-2.y-1) of the top ten taxa (biomass) and of the total community in each area.

		2007			2003	
		OWEZ			OWEZ	
		B	P		B	P
Ensis americanus		27.86	7.79	Scoloplos armiger	0.47	0.71
Echinocardium cordatum		2.82	1.28	Nephtys cirrosa	0.40	0.69
Notomastus latericeus		0.86	1.19	Tellina fabula	0.32	0.24
Anthozoa spec.		0.57	0.18	Nephtys hombergii	0.18	0.27
Nephtys cirrosa		0.37	0.66	Thia scutellata	0.17	0.07
Liocarcinus arcuatus		0.33	0.09	Nemertini	0.16	0.26
Tellina fabula		0.25	0.18	Donax vittatus	0.14	0.07
Crangon crangon		0.20	0.09	Nephtys caeca	0.13	0.15
Scolelepis bonnieri		0.14	0.22	Spisula subtruncata	0.12	0.07
Lanice conchilega		0.14	0.19	Notomastus sp.	0.12	0.16
56 other species		0.96	1.70	76 other species	0.40	0.98
	sum	34.50	13.56	sum	2.60	3.68
		R1			R1	
Ensis americanus		4.24	0.99	Spisula subtruncata	12.78	5.81
Echinocardium cordatum		1.82	0.82	Anthozoa	0.51	0.17
Notomastus latericeus		1.24	1.69	Tellina fabula	0.25	0.26
Lanice conchilega		0.55	0.73	Nemertini	0.20	0.34
Tellina fabula		0.52	0.39	Nephtys cirrosa	0.15	0.26
Nephtys cirrosa		0.32	0.58	Nephtys hombergii	0.15	0.24
Scolelepis bonnieri		0.17	0.28	Notomastus	0.14	0.21
Urothoe poseidonis		0.11	0.47	Mactra corallina	0.14	0.04
Nephtys assimilis		0.11	0.13	Scoloplos armiger	0.09	0.15
Nemertini		0.09	0.14	Donax vittatus	0.08	0.03
43 other species		1.25	1.92	67 other species	0.55	1.47
	sum	10.42	8.12	sum	15.03	8.99
		R2				
Echinocardium cordatum		3.69	1.37			
Ensis americanus		0.79	0.21			
Notomastus latericeus		0.60	0.81			
Nephtys cirrosa		0.49	0.87			
Nereis longissima		0.44	0.49			
Lanice conchilega		0.35	0.20			
Donax vittatus		0.22	0.13			
Nephtys caeca		0.16	0.18			
Scolelepis bonnieri		0.16	0.26			

Tellina fabula		0.12	0.09
43 other species		0.67	1.37
	sum	7.71	5.98

R3

Ensis americanus		8.16	2.26
Echinocardium cordatum		1.23	0.85
Notomastus latericeus		1.03	1.48
Anthozoa spec.		0.80	0.27
Scolelepis bonnieri		0.60	1.05
Nephtys cirrosa		0.54	0.98
Lanice conchilega		0.40	0.59
Nemertini		0.05	0.07
Spiophanes bombyx		0.05	0.09
Magelona johnstoni		0.05	0.08
33 other species		0.42	0.81
	sum	13.33	8.55

R4

Lanice conchilega		5.20	7.02
Echinocardium cordatum		3.25	1.12
Ensis ensis		0.67	0.18
Callianassa tyrrhena		0.46	0.14
Nephtys cirrosa		0.35	0.61
Nereis longissima		0.19	0.21
Scoloplos armiger		0.19	0.32
Scolelepis bonnieri		0.10	0.16
Thia scutellata		0.10	0.05
Malmgrenia marphysae		0.08	0.14
44 other species		0.62	1.20
	sum	11.21	11.15

R5

Ensis americanus		6.05	1.56
Echinocardium cordatum		1.96	0.97
Ensis ensis		0.33	0.11
Chamelea striatula		0.33	0.13
Notomastus latericeus		0.31	0.44
Nephtys caeca		0.31	0.38
Nephtys cirrosa		0.26	0.48
Crangon crangon		0.25	0.15
Nephtys hombergii		0.21	0.31
Tellina fabula		0.18	0.13

42 other species		0.74	1.38
	sum	10.92	6.03

	R6		
Ensis americanus	21.00	4.91	
Echinocardium cordatum	9.96	3.97	
Notomastus latericeus	3.17	4.79	
Lanice conchilega	0.96	1.38	
Liocarcinus arcuatus	0.63	0.17	
Tellina fabula	0.43	0.33	
Nereis longissima	0.30	0.38	
Nephtys hombergii	0.30	0.43	
Nephtys caeca	0.30	0.32	
Nephtys cirrosa	0.29	0.54	
50 other species	1.27	2.51	
sum	38.62	19.72	

	R6	
Ophiura albida	0.36	0.21
Nephtys cirrosa	0.27	0.48
Nephtys caeca	0.25	0.28
Thia scutellata	0.20	0.08
Notomastus	0.18	0.24
Nemertini	0.09	0.15
Nephtys hombergii	0.09	0.14
Scoloplos armiger	0.09	0.15
Lanice conchilega	0.05	0.13
Tellina fabula	0.05	0.05
61 other species	0.27	0.69
sum	1.88	2.60

Table 4: Triple-D data: Mean densities of macrobenthos in the windfarm and in 6 control areas

		densities (n per 100 m2)						
MACROBENTHOS	area→	W	R1	R2	R3	R4	R5	R6
Anthozoa	zeeanemoon	1.8	34.4		28.1			3.1
Callianassa tyrrhena		0.4	9.4		6.3	9.4		3.1
Corystes cassivelaunus	helmkrab	2.7	3.1	6.3		3.1	6.3	
Crangon almanni		4.0						
Crangon crangon	garnaal	557.6	200.0	278.1	343.8	300.0	509.4	290.6
Diogenes pugilator		6.3				3.1	9.4	
Liocarcinus arcuatus	gewimperde zwemkrab	1.3			9.4	3.1		3.1
Liocarcinus depurator	blauwpootzwemkrab	3.1	3.1					
Liocarcinus holsatus	gewone zwemkrab	71.4	15.6	21.9	21.9	31.3	59.4	18.8
Liocarcinus marmoratus	gemarmerde zwemkrab	6.3	12.5		40.6	6.3	9.4	9.4
Macropodia spec.		0.4						
Pagurus bernhardus	heremietkreeft	5.4	6.3	9.4	40.6	28.1	15.6	15.6
Pontophilus spec.		71.9	71.9	96.9	75.0	62.5	40.6	21.9
Portumnus latipes	breedpootkrab	0.9						
Processa spec.		3.1			6.3	3.1		12.5
Thia scutellata	nagelkrabbetje	30.4		56.3	9.4	46.9	6.3	28.1
Chamelea striatula	venusschelp	31.3	25.0	34.4	28.1	28.1	93.8	25.0
Donax vittatus	zaagje	23.2	12.5	50.0	21.9	21.9	25.0	6.3
Ensis americanus	amerikaanse zwaardschede	370.5	75.0	25.0	1037.5	28.1	284.4	68.8
Ensis arcuatus	grote zwaardschede	4.5						
Ensis ensis	kleine zwaardschede	0.9		3.1				
Euspira nitida	glanzende tepelhoren	2.7	9.4		12.5			
Nassarius reticulatus	gevlochten fuikhoren							9.4
Laevicardium norvegicum	noorse hartschelp	0.4						
Lutraria lutraria	otterschelp	23.7			21.9	3.1	3.1	12.5
Mactra corallina	grote strandschelp	0.9						6.3
Natica catena	tepelhoren	1.3	3.1				6.3	
Spisula elliptica	ovale strandschelp					3.1	3.1	
Spisula solida	stevige strandschelp	2.2		6.3			9.4	12.5
Spisula subtruncata	halfgeknotte strandschelp	8.5	9.4		6.3	37.5	21.9	
Tellina fabula	rechtsgestreepte platschelp	1.3	187.5			3.1		
Tellina tenuis	tere platschelp	1.3		3.1				
Asterias rubens	zeester	1.3						
Echinocardium cordatum	zeeklit	8.5	6.3	9.4	12.5	109.4	3.1	6.3
Ophiura albida		43.8	12.5			18.8	34.4	159.4
Ophiura texturata		158.5	78.1	59.4	218.8	131.3	168.8	62.5
Total abundance		1451.	775.	659.	1940.	881.	1309.	775.

		8	0	4	6	3	4	0
Number of species per 2 samples		19.0	19.0	14.0	18.0	21.0	19.0	20.0

Table 4, continued. Triple-D data. Mean densities of fish in OWEZ and 6 control areas

			densities (n per 100 m2)						
FISH		area→	OWEZ	R1	R2	R3	R4	R5	R6
Agonus cataphractus	harnasmannetje			3.1					
Ammodytes tobianus	zandspiering		21.4	18.8	156.3	18.8		21.9	40.6
Arnoglossus laterna	schurftvis		4.5	3.1		3.1	3.1	9.4	6.3
Buglossidium luteum	dwergtong		17.0	46.9	50.0	46.9	28.1	56.3	40.6
Callionymus lyra	pitvis		3.6		9.4		28.1	6.3	21.9
Ciliata mustela	meun		0.4						
Hyperoplus lanceolatus	smelt		3.1						31.3
Limanda limanda	schar		17.4			6.3	37.5	12.5	12.5
Merlangius merlangus	wijting		0.4						
Myoxocephalus scorpius	knorhaan		1.3						
Pleuronectes platessa	schol		7.6	9.4	9.4	6.3	9.4	3.1	3.1
Pomatoschistus spec.	grondel		223.7	56.3	78.1	237.5	287.5	140.6	312.5
Solea solea	tong		4.5			3.1	3.1		3.1
Sprattus sprattus	sprot		1.8						
Syngnathus spec.	zeenaald		3.6	3.1				15.6	6.3
Total abundance			310.3	140.6	303.1	321.9	396.9	265.6	478.1
Number of species per 2 samples			9.0	7.0	5.0	7.0	7.0	8.0	10.0

	R1	R2	R3	R4	R5	R6
W	64	62	75	72	80	71
R1		64	66	63	65	61
R2			60	66	66	65
R3				70	70	67
R4					72	72
R5						70

Table 5
Triple-D windfarm (W) and control areas R1 - R6
Values of the Bray-Curtis index as a measure of similarity (%) of the fauna composition in the different areas
The index was calculated after √-transformation of the densities of the individual species. Dark background colour indicates high similarity

Table 6. Comparison of fauna abundance (box cores, individuals per m2) in the windfarm area and in two reference areas at T0 and T1.

	W-T0	W-T1	R1-T0	R1-T1	R6-T0	R6-T1
mean	751	599	1350	875	1039	1138
standard deviation	641	318	765	490	1410	1016
maximum	4282	1361	2857	1592	7722	2940
minimum	0	103	0	257	148	154

Table 7. Comparison of biomass values (g AFDW per m2) in the windfarm area and in two reference areas at T0 and T1

	W-T0	W-T1	R1-T0	R1-T1	R6-T0	R6-T1
mean	2.6	34.5	15.0	10.4	1.9	38.6
standard deviation	4.2	82.7	32.3	14.7	1.8	47.2
maximum	39.7	325.3	172.3	57.9	6.7	157.2
minimum	0.0	0.7	0.0	0.8	0.1	1.0

Table 8 Comparison of species richness (numbers of species per sample) in the windfarm area and in two reference areas at T0 and T1.

	W-T0	W-T1	R1-T0	R1-T1	R6-T0	R6-T1
mean	11.8	12.3	14.1	15.1	11.4	15.7
standard deviation	4.8	4.1	5.8	4.7	3.9	7.7
maximum	26	22	23	23	21	30
minimum	0	4	0	8	5	5

Table 9 Comparison of Shannon Wiener diversity (calculated at 2log basis)in the windfarm area and in two reference areas at T0 and T1.

	W-T0	W-T1	R1-T0	R1-T1	R6-T0	R6-T1
mean	2.67	2.79	2.68	2.87	2.52	2.87
standard deviation	0.539	0.21	0.492	0.15	0.504	0.21
maximum	4.21	3.56	3.41	3.57	3.32	3.42
minimum	0.99	1.81	1.25	2.25	0.95	2.08

Table 10 Comparison of densities (n per m2) of abundant species in the windfarm area and in two reference areas at T0 and T1.
Top: the ten most abundant species in the three areas during T1
Below: the ten most abundant species during T0

	W-T0	W-T1	R1-T0	R1-T1	R6-T0	R6-T1
Urothoe poseidonis	84	169	130	361	15	360
Nephtys cirrosa	80	104	32	95	67	112
Bathyporeia elegans	13	80	<15	80	<20	19
Notomastus latericeus	<12	21	<15	25	<20	129
Urothoe brevicornis	<12	27	<15	15	<20	51
Tellimya ferruginosa	<12	12	<15	10	<20	83
Magelona mirabilis	<12	12	<15	27	<20	44
Magelona johnstoni	<12	9	<15	13	<20	50
Tellina fabula	15	12	<15	26	40	21
Bathyporeia guilliamsoniana	<12	12	<15	39	<20	4
Spiophanes bombyx	284	3	533	15	267	25
Lanice conchilega	62	3	217	10	422	30
Urothoe poseidonis	84	169	130	361	15	360
Nephtys cirrosa	80	104	32	95	67	112
Nemertea	21	9	42	9	16	8
Scoloplos armiger	28	6	29	6	21	7
Spisula subtruncata	<12	1	74	1	<20	3
Ensis americanus	<12	27	<15	3	34	11
Mysella bidentata	<12	3	29	1	<20	31
Eteone longa	26	3	<15	4	<20	1

Table 11. Triple-D data. Mean densities (n per 100 m2) of the 12 most abundant macrobenthic species in the 2007 survey in OWEZ and two reference areas compared to the densities found by IECS in 2003 in the same areas. Freq. is frequency of occurrence (%).

	OWEZ				R1				R6			
	IECS-2003 (T0)		NIOZ-2007 (T1)		IECS-2003 (T0)		NIOZ-2007 (T1)		IECS-2003 (T0)		NIOZ-2007 (T1)	
nr. of samples	25		14		9		2		6		2	
	mean	freq.	mean	freq.	mean	freq.	mean	freq.	mean	freq.	mean	freq.
Crangon crangon*	?	?	558	100	?	?	200	100	?	?	291	100
Pontophilus spec.*	?	?	72	93	?	?	72	100	?	?	22	100
Liocarcinus holsatus	7	88	71	86	<12	?	16	100	5	100	19	100
Pagurus bernhardus	<6	?	5	64	<12	?	6	100	<3	?	16	100
Thia scutellata	6	80	30	100	<12	?	0	0	<3	?	28	100
Chamelea striatula	10	100	31	100	<12	?	25	100	3	67	25	100
Donax vittatus	21	92	23	86	<12	?	13	50	<3	?	6	50
Ensis americanus	10	84	371	100	15	89	75	100	20	100	69	100
Spisula subtruncata	178	76	9	50	1778	100	9	100	14	83	0	0
Tellina fabula	16	48	1	7	34	78	188	50	3	50	0	0
Ophiura albida	122	100	44	100	45	100	13	50	64	100	159	100
Ophiura texturata	25	96	159	100	16	89	78	100	46	100	63	100

*these shrimp species were probably not considered as macrobenthos by IECS, and therefore not included in their countings.

Figures

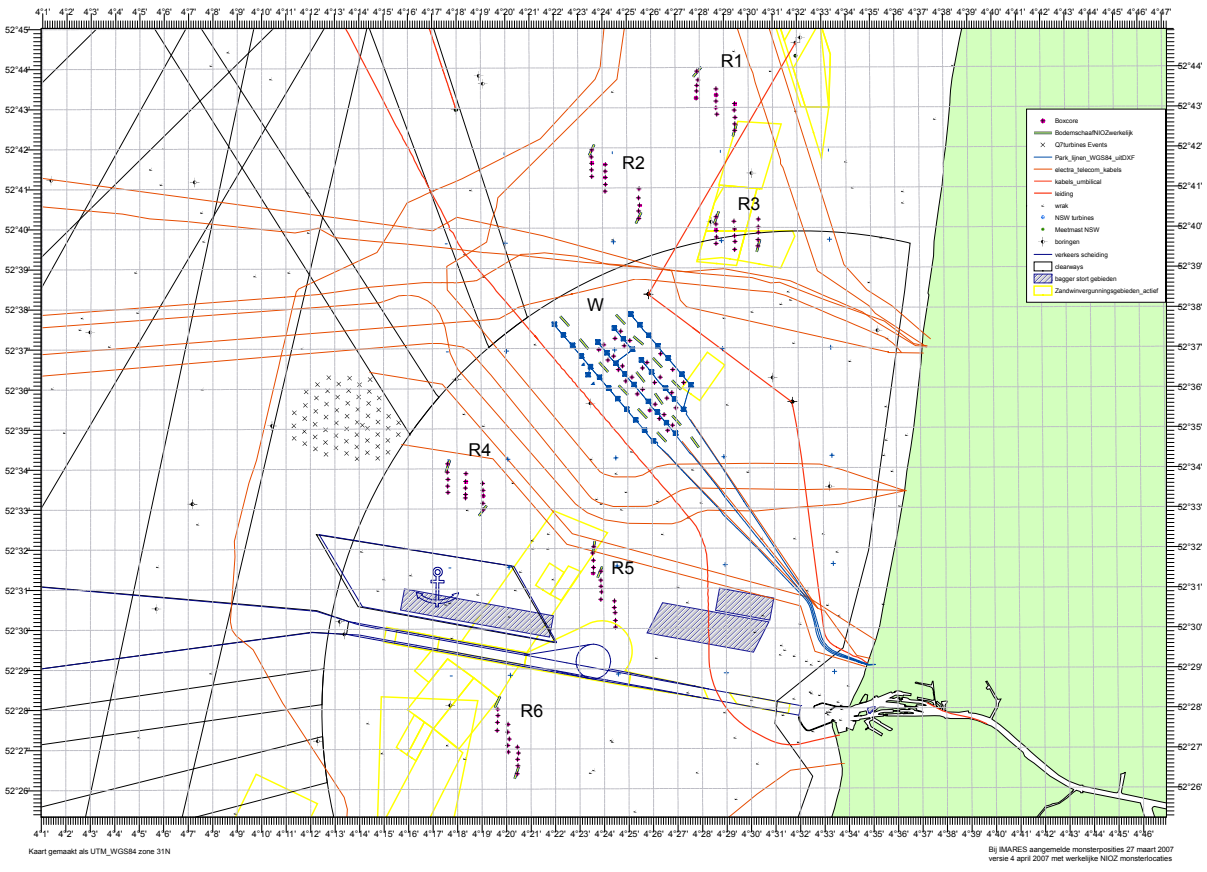

Fig. 1. Map of the wind farm area (W) with the reference areas (R1 – R6) and the sampling stations within these areas.

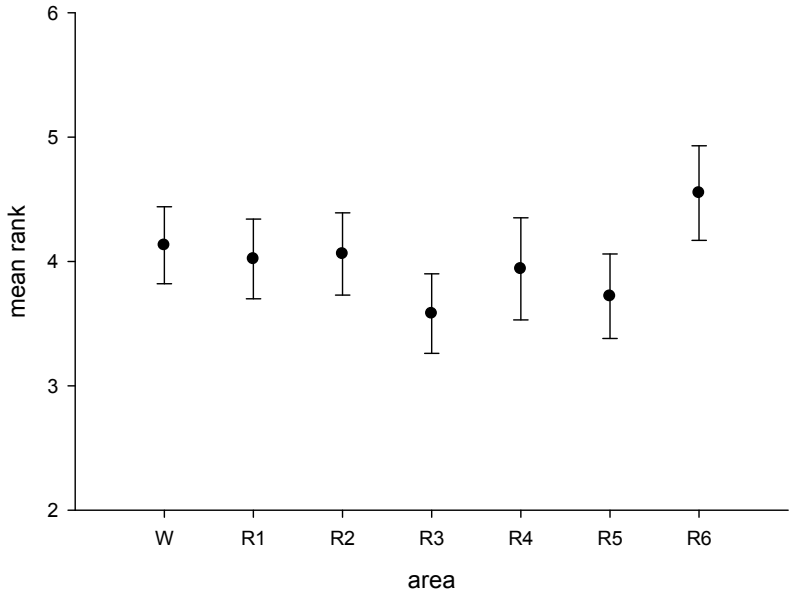

Fig. 2. Box core data. Relative fauna abundance (mean ranks and 95% confidence limits) in the windfarm (W) and the reference areas (R1 – R6).

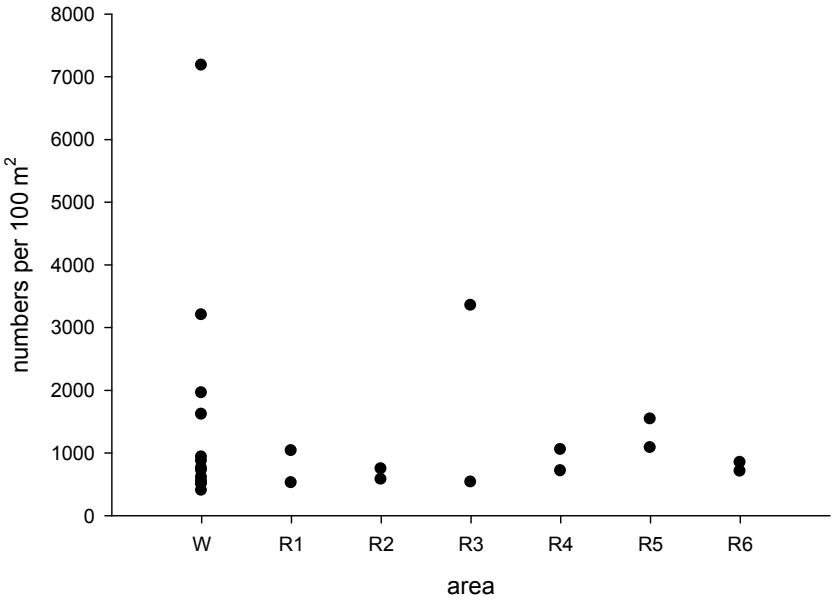

Fig. 3. Triple-D data. Total abundance of macrobenthos in the 7 areas

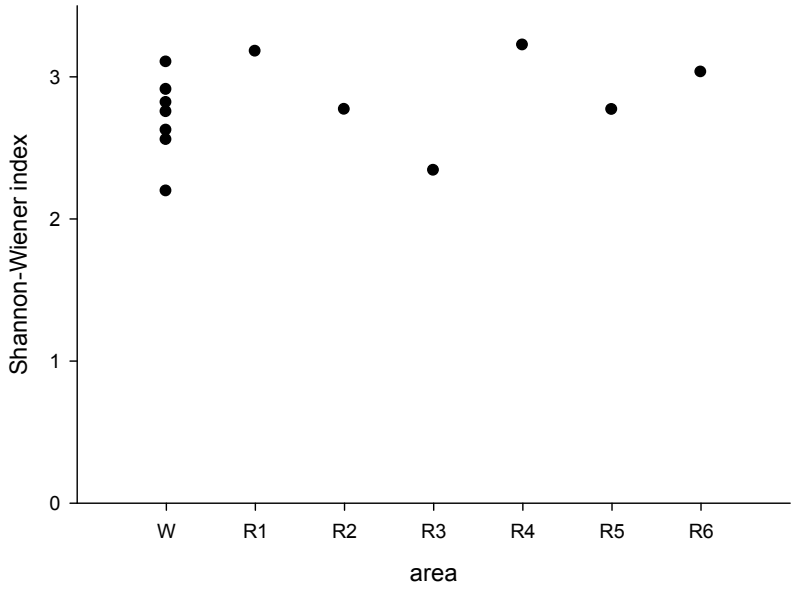

Fig. 4. Triple-D data. Shannon Wiener diversity of macrobenthos in the windfarm and the reference areas.

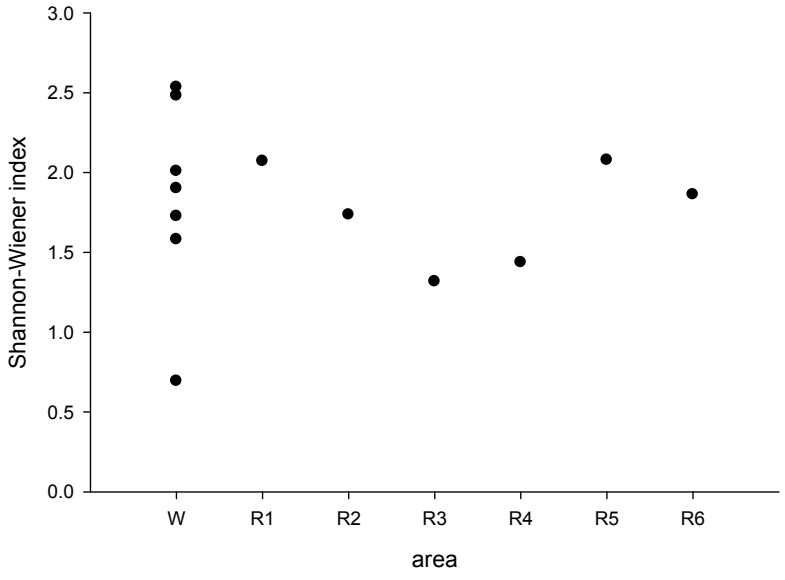

Fig. 5. Triple-D data. Shannon Wiener diversity of fish in the windfarm and the reference areas

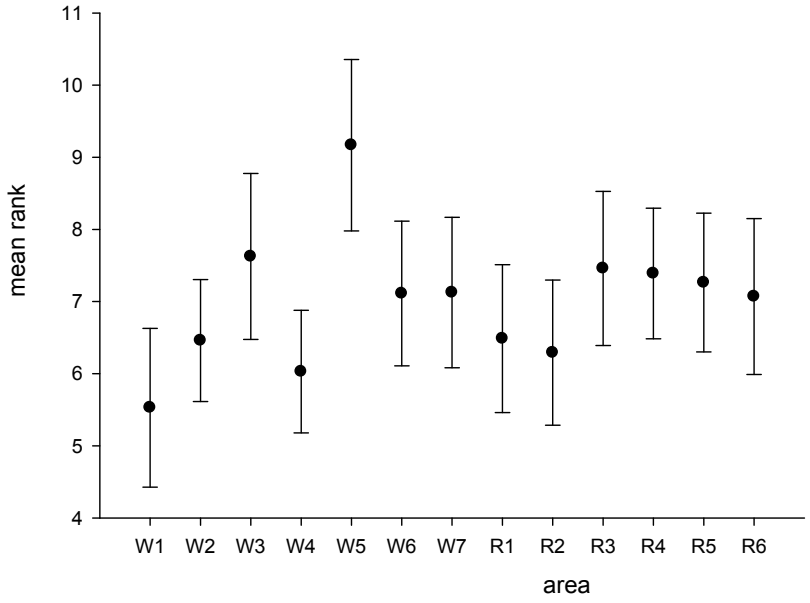

Fig. 6. Triple-D data. Relative abundance (and 95% confidence limits) of invertebrate macrobenthos on 7 paired stations in OWEZ and in the 6 reference areas.

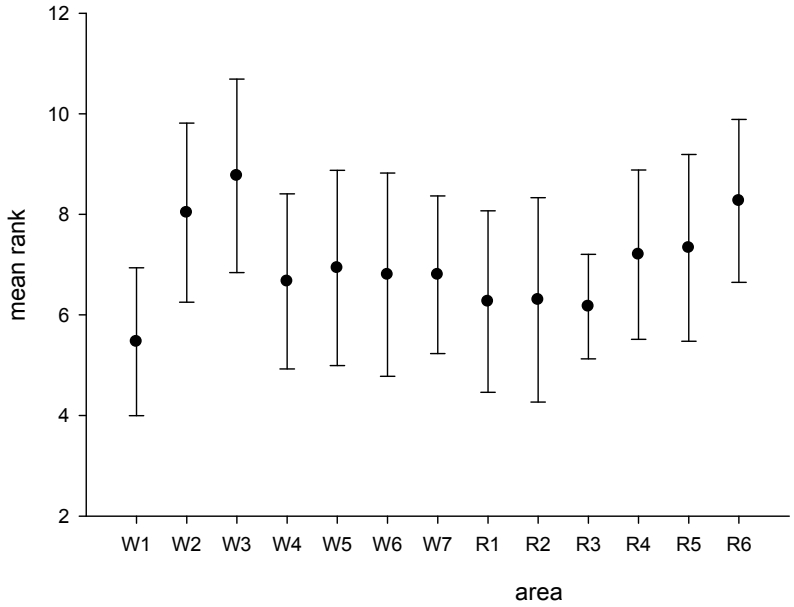

Fig. 7. Triple-D data. Relative abundance (and 95% confidence limits) of fish on 7 paired stations in OWEZ and in the 6 reference areas.

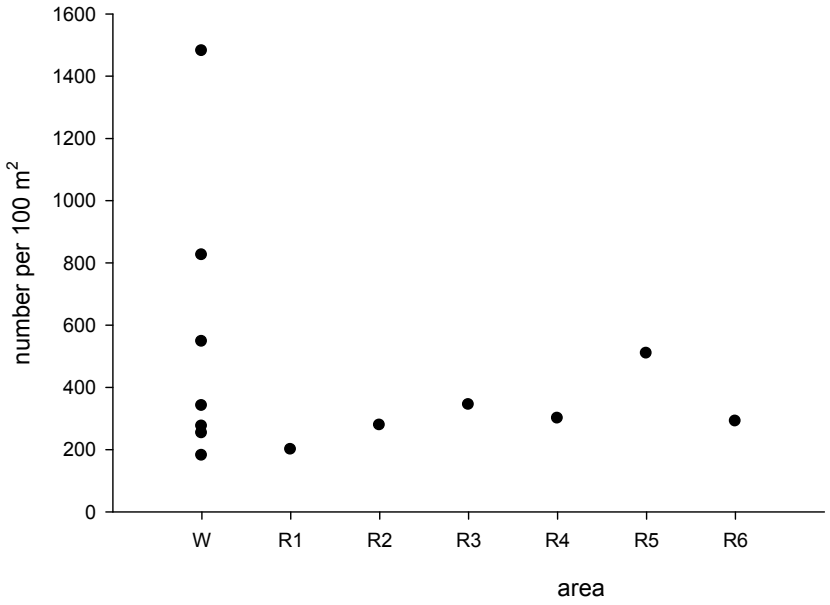

Fig. 8a. Triple-D data: densities of *Crangon crangon* (shrimp) in OWEZ and in the reference areas.

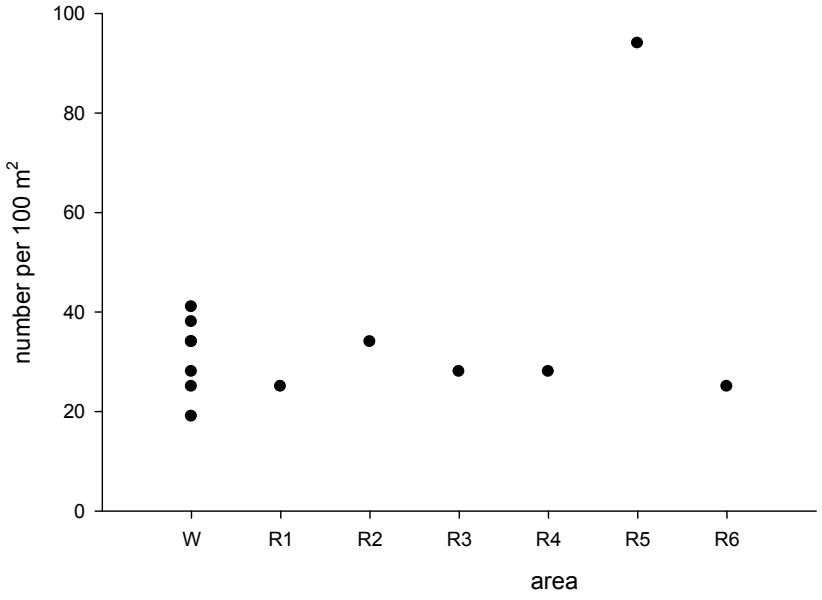

Fig. 8b. Triple-D data: densities of the bivalve *Chamelea striatula* in OWEZ and in the reference areas.

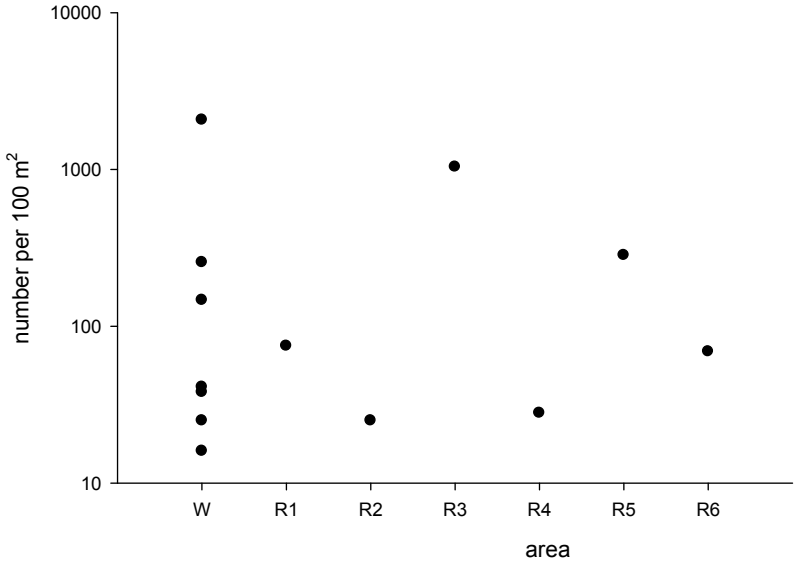

Fig. 8c. Triple-D data: densities of *Ensis americanus* (american razor clam) in OWEZ and in the reference areas.

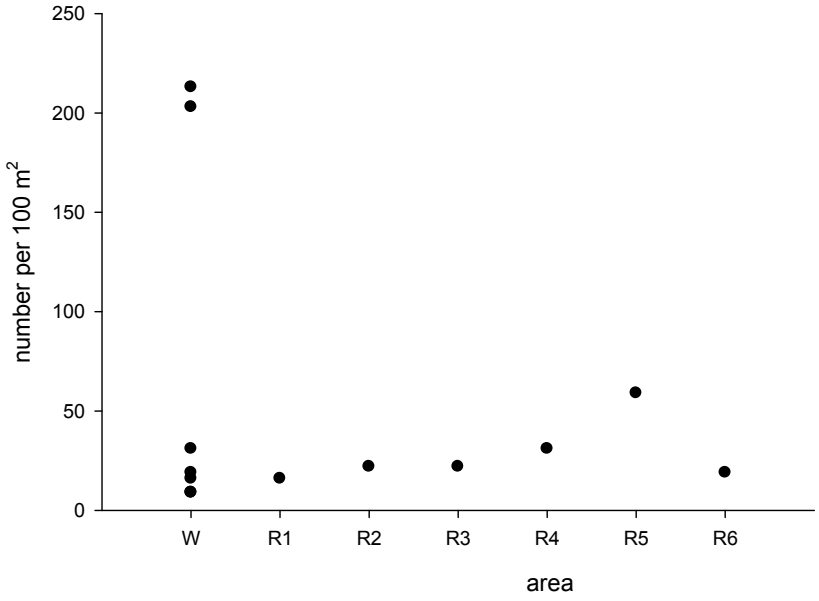

Fig. 8d. Triple-D data: densities of *Liocarcinus holsatus* (swimming crab) in OWEZ and in the reference areas.

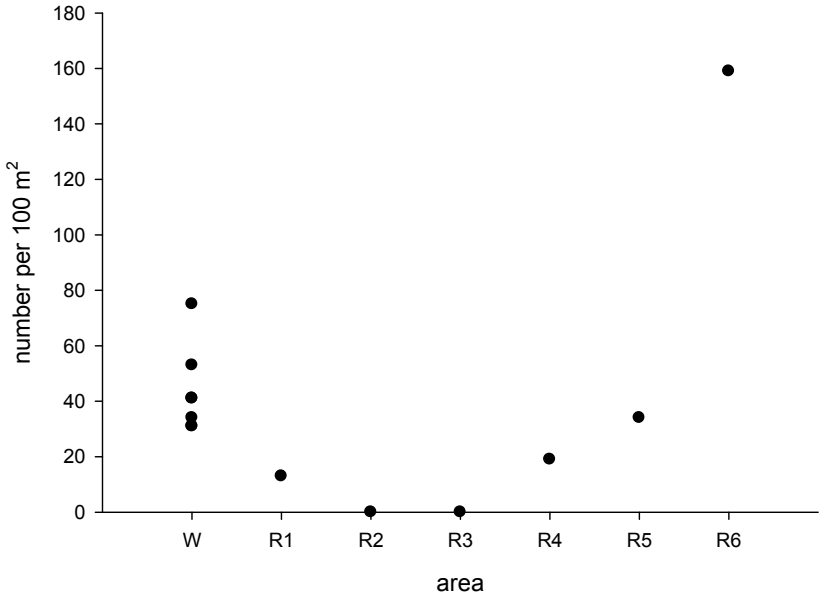

Fig. 8e. Triple-D data: densities of the echinoderm *Ophiura albida* in OWEZ and in the reference areas.

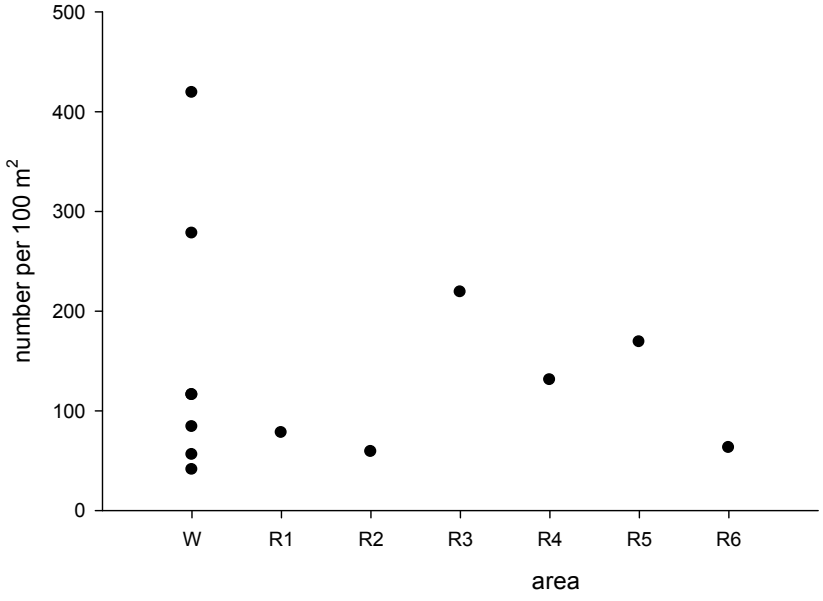

Fig. 8f. Triple-D data: densities of the echinoderm *Ophiura texturata* in OWEZ and in the reference areas.

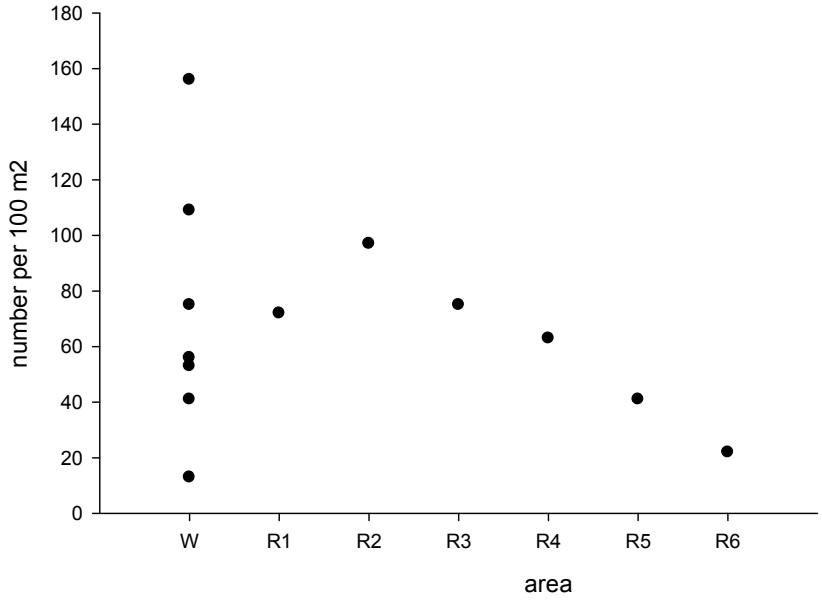

Fig. 8g. Triple-D data: densities of the crustacean *Pontophilus* spec. in OWEZ and in the reference areas.

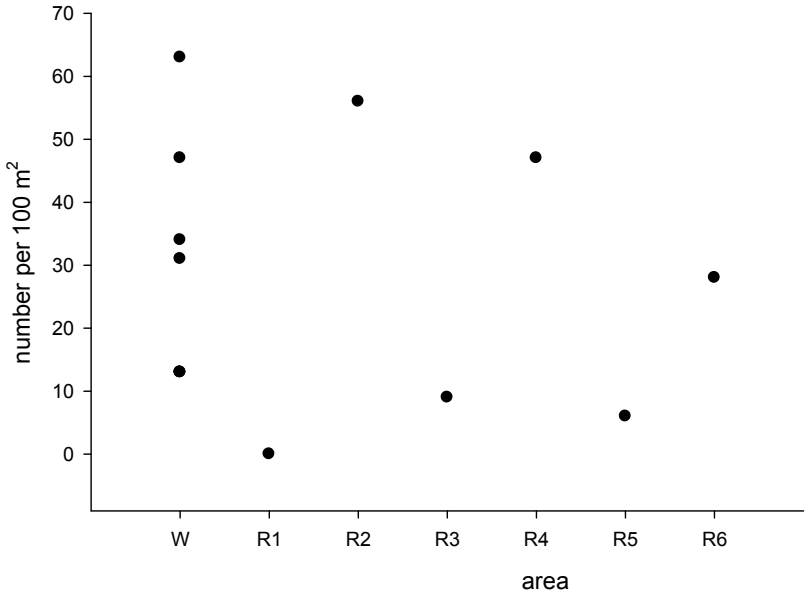

Fig. 8h. Triple-D data: densities of the thumb-nail crab *Thia scutellata* in OWEZ and in the reference areas.

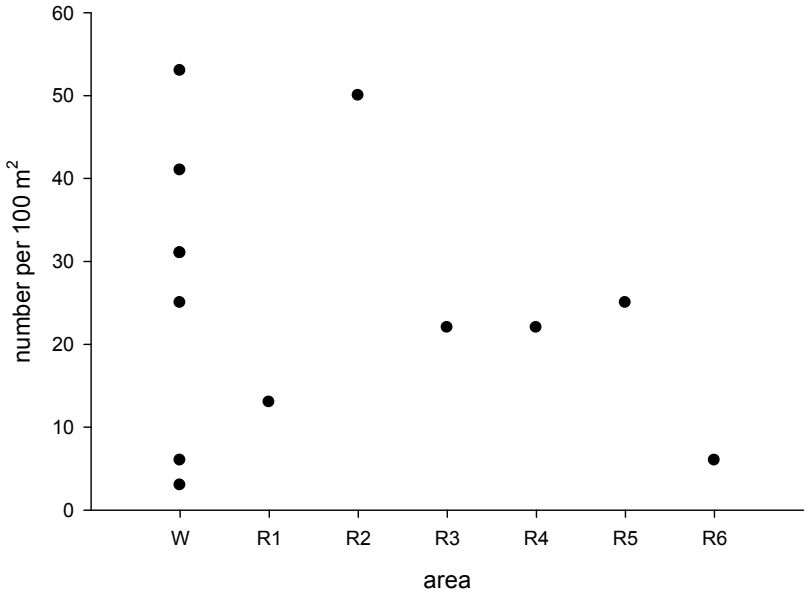

Fig. 8i. Triple-D data: densities of the bivalve *Donax vittatus* in OWEZ and in the reference areas.

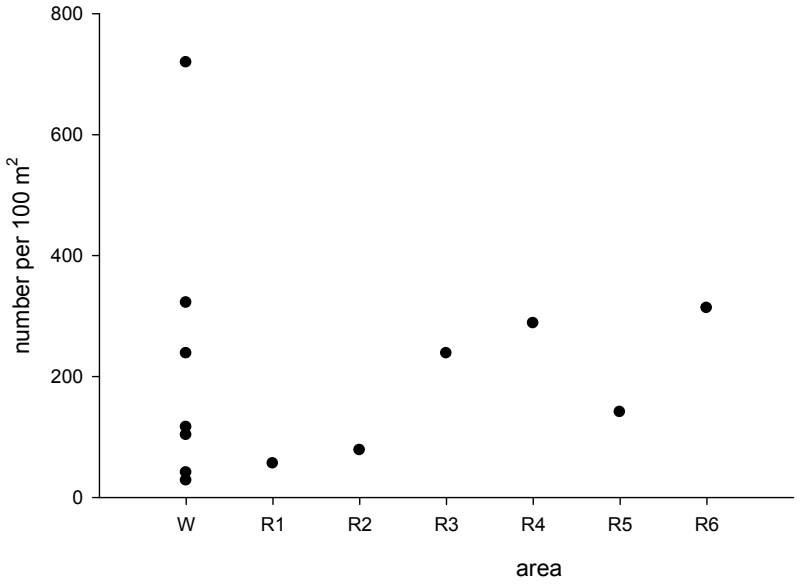

Fig. 8j. Triple-D data: densities of gobies *Pomatoschistus* spec. in OWEZ and in the reference areas.

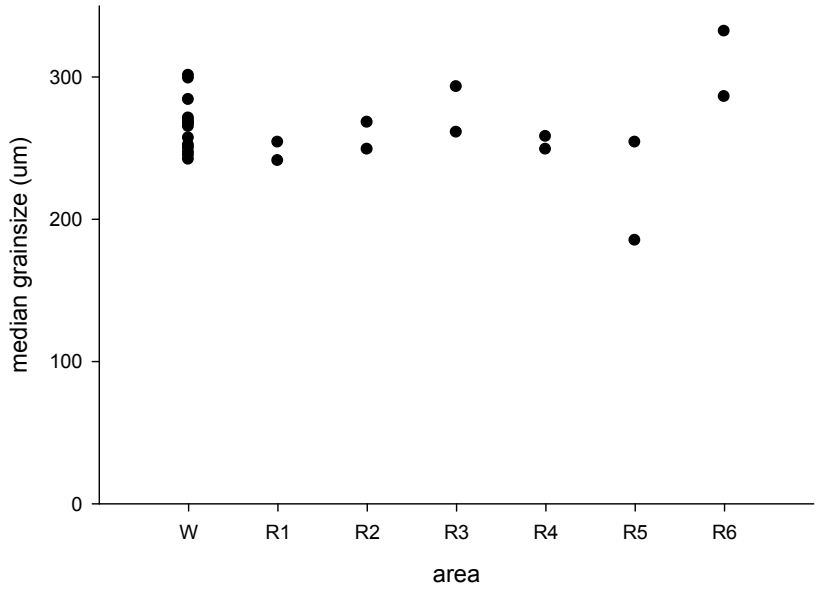

Fig. 9. Median grain sizes in the centre of the dredge hauls.

Appendix 1: Box core data. Densities (n = number per m2) and biomass (b = g afdw per m2) of individual species and overall densities, biomass, number of species per sample, Shannon Wiener index and Simpson index at the windfarm (W) and reference (R1-R6) stations.

	W1		W2		W3		W4		W5	
Species name										
Polychaeta	n	b	n	b	n	b	n	b	n	b
Harmothoe glabra									12.8	0.039
Eteone longa					12.8	0.003				
Nephtys cirrosa	166.9	0.397	12.8	0.029	38.5	0.053	77.0	0.044	128.4	0.219
Nephtys hombergii	12.8	0.036	12.8	0.332						
Nephtys incisa							12.8	0.144		
Nephtys longosetosa	12.8	0.092					12.8	0.120		
Scoloplos armiger					12.8	0.286				
Scolelepis bonnieri	25.7	0.200			12.8	0.132	12.8	0.100	12.8	0.352
Spiophanes bombyx									12.8	0.019
Magelona filiformis	12.8	0.022			12.8	0.061			12.8	0.003
Magelona mirabilis							12.8	0.024		
Magelona johnstoni	38.5	0.061			12.8	0.063	25.7	0.058		
Chaetozone christi	12.8	0.003								
Notomastus latericeus	25.7	1.034	154.0	4.936						
pol.rest		0.041		0.024		0.066		0.069		0.107
Crustacea										
Diogenes pugilator							25.7	0.060		
Pagurus bernhardus					12.8	0.027				
Megaluropus agilis							25.7	0.008		
Perioculodes longimanus	12.8	0.004								
Urothoe brevicornis	51.3	0.015	51.3	0.015	12.8	0.004	25.7	0.008		
Urothoe poseidonis	359.4	0.108	128.4	0.039	38.5	0.012	38.5	0.012	64.2	0.019
Leucothoe incisa			25.7	0.008						
Bathyporeia elegans	12.8	0.004			25.7	0.008	25.7	0.008	89.9	0.027
Bathyporeia guilliamsoniana	25.7	0.008								
Bathyporeia tenuipes							12.8	0.004		
Mollusca										
Euspira nitida									12.8	0.004
Tellimya ferruginosa	12.8	0.001	12.8	0.033						
Mysella bidentata					12.8	0.003				
Donax vittatus	25.7	2.205								
Tellina fabula	25.7	0.022	12.8	0.205						
Ensis americanus			320.9	304.594						
Echinodermata										
Echinocardium cordatum	12.8	0.104	12.8	3.951						
Others										
Nemertini			25.7	0.116						
sum	847.2	4.356	770.2	314.281	205.4	0.717	308.1	0.657	346.6	0.789
nr. of species	17		11		11		12		8	
SW-index	2.03		1.73		2.27		2.30		1.64	
Simpson-index	0.22		0.24		0.06		0.08		0.22	

	W6		W7		W8		W9		W10	
	n	b	n	b	n	b	n	b	n	b
Polychaeta										
Harmothoe glabra	12.8	0.034								
Nephtys spec. juv.	12.8	0.003			12.8	0.003				
Nephtys caeca							12.8	0.085	12.8	0.002
Nephtys cirrosa	205.4	0.942	89.9	0.224	64.2	0.656	192.6	0.241	38.5	0.005
Nephtys hombergii	25.7	0.012	51.3	0.383						
Nephtys incisa									12.8	0.247
Nephtys longosetosa			12.8	0.008	12.8	0.161				
Scolelepis bonnieri	25.7	0.181	25.7	0.102	12.8	0.073	25.7	0.110		
Spio decorata									12.8	0.003
Spiophanes bombyx							12.8	0.012		
Magelona filiformis	25.7	0.022	12.8	0.005			89.9	0.059		
Magelona mirabilis			51.3	0.015	51.3	0.112				
Magelona johnstoni			25.7	0.112			12.8	0.025	38.5	0.114
Chaetozone setosa									12.8	0.002
Chaetozone christi							12.8	0.008		
Notomastus latericeus									128.4	6.063
Lanice conchilega	51.3	2.679								
pol.rest		0.125		0.034		0.154		0.974		0.425
Crustacea										
Liocarcinus arcuatus									12.8	9.763
Crangon crangon					12.8	0.019			12.8	5.906
Pontocrates altamarinus	12.8	0.004								
Synchelidium maculatum							25.7	0.008		
Urothoe brevicornis	38.5	0.012			12.8	0.004			38.5	0.012
Urothoe poseidonis	154.0	0.046	128.4	0.039	102.7	0.031	141.2	0.042	308.1	0.092
Leucothoe incisa									12.8	0.004
Bathyporeia elegans	38.5	0.012	218.2	0.065	282.4	0.085	25.7	0.008	12.8	0.004
Bathyporeia guilliamsoniana	25.7	0.008	51.3	0.015						
Bathyporeia tenuipes			51.3	0.015						
Gastrosaccus spinifer							12.8	0.004		
Diastylis bradyi					12.8	0.004				
Mollusca										
Euspira nitida							12.8	0.004		
Tellimya ferruginosa							64.2	0.038		
Mysella bidentata							25.7	0.006		
Spisula subtruncata			12.8	0.012						
Donax vittatus							25.7	0.061		
Tellina fabula							25.7	0.794	89.9	1.686
								18.10		300.97
Ensis americanus							12.8	0	256.7	7
Echinodermata										
		11.20								
Echinocardium cordatum	12.8	6					38.5	0.462		
Others										
Nemertini					12.8	0.138	12.8	0.226		
	641.	15.28	731.		590.		783.	21.26	1001.	325.30
sum	8	6	7	1.030	5	1.440	1	7	3	4
nr. of species	12		12		10		19		15	
SW-index	2.07		2.12		1.69		2.47		2.01	
Simpson-index	0.16		0.14		0.27		0.11		0.18	
	W11		W12		W13		W14		W15	
	n	b	n	b	n	b	n	b	n	b

Polychaeta										
Malmgrenia marphysae									12.8	0.075
Eteone longa	12.8	0.002							12.8	0.003
Nephtys cirrosa	89.9	0.364	89.9	0.324	128.4	0.391	102.7	0.229	192.6	0.776
Nephtys hombergii	12.8	0.119								
Nephtys incisa							12.8	0.317		
Scoloplos armiger			12.8	0.024					25.7	0.003
Scolelepis bonnieri	12.8	0.098			25.7	0.373			38.5	0.854
Spiophanes bombyx							12.8	0.002	12.8	0.003
Magelona filiformis			12.8	0.031			12.8	0.005	12.8	0.005
Magelona mirabilis			12.8	0.031					12.8	0.042
Magelona johnstoni					12.8	0.053				
Chaetozone setosa							12.8	0.003	12.8	0.003
Lanice conchilega									12.8	0.480
pol.rest		0.008		0.049		0.059		0.275		0.188
Crustacea										
Crangon crangon									12.8	0.019
Urothoe brevicornis			12.8	0.004	89.9	0.027	38.5	0.012		
Urothoe poseidonis	38.5	0.012	38.5	0.012	282.4	0.085	385.1	0.116	128.4	0.039
Leucothoe incisa							12.8	0.004		
Bathyporeia elegans			12.8	0.004			115.5	0.035	462.1	0.139
Bathyporeia guilliamsoniana							25.7	0.008	64.2	0.019
Bathyporeia nana									38.5	0.012
Gastrosaccus spinifer	12.8	0.004								
Mollusca										
Tellimya ferruginosa							102.7	0.055		
Spisula elliptica					12.8	0.070				
Donax vittatus							25.7	0.095	12.8	0.057
Ensis americanus							12.8	11.879		
Echinodermata										
Ophiura albida			12.8	0.069			12.8	0.026		
Echinocardium cordatum							12.8	6.667		
Others										
Nemertini	25.7	0.116	25.7	0.226	38.5	0.460				
Oligochaeta									12.8	0.003
sum	205.4	0.723	231.1	0.771	590.5	1.518	898.6	19.725	1078.3	2.721
nr. of species	7		9		7		15		17	
SW-index	1.63		1.87		1.45		1.95		1.95	
Simpson-index	0.21		0.16		0.29		0.22		0.23	

	W16		W17		W18		W19		W20	
	n	b	n	b	n	b	n	b	n	b
Polychaeta										
Malmgrenia marphysae	12.8	0.022								
Sigalion mathildae			12.8	0.434						
Eteone longa									12.8	0.002
Nephtys spec. juv.							12.8	0.002		
Nephtys caeca	12.8	0.141								
Nephtys cirrosa	166.9	0.586	51.3	0.085	166.9	1.061	64.2	0.249	77.0	0.556
Nephtys hombergii									25.7	0.069
Nephtys longosetosa							12.8	0.124		
Scoloplos armiger					12.8	0.478	38.5	0.825		
Scolelepis bonnieri			25.7	0.117			12.8	0.078		
Spio filicornis			12.8	0.005						
Spiophanes bombyx			25.7	0.142	12.8	0.017				
Magelona filiformis	12.8	0.005							12.8	0.003
Magelona mirabilis	12.8	0.061	12.8	0.003						
Magelona johnstoni			64.2	0.105						
Chaetozone setosa			12.8	0.003						
Notomastus latericeus			89.9	4.677						
Lanice conchilega	38.5	1.010								
pol.rest		0.024		0.047		0.039		0.034		0.012
Crustacea										
Thia scutellata					12.8	2.028				
Pontocrates altamarinus					12.8	0.004				
Synchelidium maculatum			25.7	0.008						
Urothoe brevicornis			51.3	0.015	25.7	0.008	25.7	0.008	12.8	0.004
Urothoe poseidonis	166.9	0.050	513.5	0.154	154.0	0.046	77.0	0.023	154.0	0.046
Bathyporeia elegans	128.4	0.039	38.5	0.012	166.9	0.050	12.8	0.004	38.5	0.012
Bathyporeia guilliamsoniana			12.8	0.004	12.8	0.004				
Bathyporeia nana	25.7	0.008								
Bathyporeia tenuipes					12.8	0.004				
Gastrosaccus spinifer	12.8	0.004								
Mollusca										
Tellimya ferruginosa			89.9	0.086	77.0	0.022				
Chamelea striatula							12.8	3.631		
Donax vittatus			12.8	0.006						
Tellina fabula			154.0	3.956						
Ensis americanus			102.7	118.490						
Echinodermata										
Ophiura texturata			12.8	0.465						
Echinocardium cordatum			25.7	5.281	51.3	2.977			12.8	9.742
Others										
Nemertini	12.8	0.234					25.7	0.243	12.8	0.051
Oligochaeta									12.8	0.002
Phoronida			12.8	0.007						
sum	603.3	2.183	1360.7	134.103	718.9	6.737	295.3	5.220	372.3	10.498
nr. of species	11		21		12		9		10	
SW-index	1.84		2.31		1.44		2.05		1.81	
Simpson-index	0.19		0.17		0.08		0.12		0.21	

	W21		W22		W23		W24		W25	
	n	b	n	b	n	b	n	b	n	b
Polychaeta										
Harmothoe glabra									12.8	0.005
Eteone longa	12.8	0.003			12.8	0.017				
Nephtys cirrosa	102.7	0.593	128.4	0.429	115.5	0.539	89.9	0.268	38.5	0.237
Nephtys longosetosa	12.8	0.080			12.8	0.020				
Scoloplos armiger	25.7	0.295					12.8	0.003		
Scolelepis bonnieri	12.8	0.110	12.8	0.083	12.8	0.017	12.8	0.190		
Spiophanes bombyx					12.8	0.017				
Magelona filiformis	25.7	0.005								
Magelona mirabilis			25.7	0.015	12.8	0.017	12.8	0.005	12.8	0.007
Notomastus latericeus					51.3	0.624				
pol.rest		0.042		0.022				0.059		0.081
Crustacea										
Crangon allmanni	12.8	0.245								
Diogenes pugilator					12.8	0.029				
Urothoe brevicornis	77.0	0.023	51.3	0.015	25.7	0.008	38.5	0.012		
Urothoe poseidonis	359.4	0.108	269.6	0.081	128.4	0.039	115.5	0.035		
Bathyporeia elegans	12.8	0.004	115.5	0.035	64.2	0.019	12.8	0.004	38.5	0.012
Bathyporeia guilliamsoniana	12.8	0.004	12.8	0.004	25.7	0.008	12.8	0.004		
Pseudocuma gilsoni					12.8	0.004				
Pseudocuma longicornis							12.8	0.004		
Mollusca										
Euspira nitida					12.8	0.004				
Donax vittatus					12.8	0.013				
Ensis americanus					12.8	15.716				
Echinodermata										
Echinocardium cordatum	12.8	17.522	12.8	10.456			12.8	5.653		
Others										
Nemertini	12.8	0.220	12.8	0.093			12.8	0.172		
Nematoda			12.8	0.002						
Oligochaeta			12.8	0.003						
Phoronida							12.8	0.003		
sum	693.2	19.254	667.5	11.239	539.2	17.090	359.4	6.411	102.7	0.342
nr. of species	13		11		16		12		4	
SW-index	1.70		1.77		2.33		2.02		1.26	
Simpson-index	0.30		0.22		0.11		0.16		0.21	

	W26		W27		W28		W29		W30	
	n	b	n	b	n	b	n	b	n	b
Polychaeta										
Nereis longissima					12.8	3.003				
Nephtys spec. juv.							12.8	0.003		
Nephtys cirrosa	166.9	0.385	115.5	0.549	51.3	0.071	128.4	0.305	51.3	0.203
Nephtys hombergii					12.8	0.034	12.8	0.100	12.8	0.114
Nephtys incisa			12.8	0.141						
Nephtys longosetosa					25.7	0.190				
Scoloplos armiger							12.8	0.119	12.8	0.168
Scolelepis bonnieri					25.7	0.185	25.7	0.530	25.7	0.390
Magelona filiformis	12.8	0.036			12.8	0.015				
Magelona mirabilis	38.5	0.112	25.7	0.027			38.5	0.108	12.8	0.017
Magelona johnstoni					25.7	0.064			12.8	0.047
Capitella capitata					12.8	0.003				
Notomastus latericeus					166.9	8.472				
pol.rest		0.008		0.041		0.020		0.024		0.171
Crustacea										
Diogenes pugilator									12.8	0.006
Megaluropus agilis			12.8	0.004					12.8	0.004
Pontocrates altamarinus					51.3	0.015				
Urothoe brevicornis	38.5	0.012	25.7	0.008	25.7	0.008	12.8	0.004	12.8	0.004
Urothoe poseidonis	308.1	0.092	38.5	0.012	410.8	0.123	25.7	0.008	25.7	0.008
Leucothoe incisa					12.8	0.004				
Bathyporeia elegans	12.8	0.004	89.9	0.027	128.4	0.039	192.6	0.058	25.7	0.008
Bathyporeia guilliamsoniana	12.8	0.004	12.8	0.004	25.7	0.008	25.7	0.008		
Bathyporeia tenuipes			25.7	0.008						
Pseudocuma longicornis			12.8	0.004						
Mollusca										
Mysella bidentata					51.3	0.026				
Spisula subtruncata					12.8	0.129				
Abra alba					12.8	0.026				
Donax vittatus	12.8	0.030								
Tellina fabula					38.5	0.986				
Ensis americanus					51.3	66.080				
Echinodermata										
Echinocardium cordatum	12.8	4.338							12.8	6.146
Others										
Anthozoa spec.					12.8	17.015				
Nemertini	12.8	0.243					12.8	0.017		
Phoronida			25.7	0.005	51.3	0.015	25.7	0.007		
sum	629.0	5.262	397.9	0.828	1232.3	96.533	526.3	1.290	231.1	7.284
nr. of species	10		11		22		13		12	
SW-index	1.52		2.07		2.43		1.95		2.35	
Simpson-index	0.31		0.14		0.14		0.19		0.06	

	R1-1		R1-2		R1-3		R1-4		R1-5	
	n	b	n	b	n	b	n	b	n	b
Polychaeta										
Malmgrenia marphysae					12.8	0.042				
Sigalion mathildae			12.8	0.193						
Eteone longa							12.8	0.005	12.8	0.007
Nephtys spec. juv.	12.8	0.003					12.8	0.003		
Nephtys cirrosa	115.5	0.173	115.5	0.496	77.0	0.169	154.0	0.254	25.7	0.008
Nephtys longosetosa					12.8	0.032			12.8	0.092
Nephtys assimilis	12.8	1.622								
Scoloplos armiger			12.8	0.005			12.8	0.058	12.8	0.012
Scolelepis bonnieri	179.7	1.227	12.8	0.022			38.5	0.178	12.8	0.059
Spio armata									12.8	0.003
Spio filicornis					12.8	0.005				
Spiophanes bombyx			25.7	0.025	12.8	0.031	64.2	0.056	12.8	0.007
Magelona filiformis	12.8	0.007	25.7	0.003	38.5	0.012				
Magelona mirabilis			25.7	0.031	12.8	0.034	25.7	0.015	64.2	0.137
Magelona johnstoni	12.8	0.020	12.8	0.053	77.0	0.136	12.8	0.044	25.7	0.046
Chaetozone setosa			12.8	0.003			25.7	0.010		
Chaetozone christi	25.7	0.027	12.8	0.010	64.2	0.037			25.7	0.012
Notomastus latericeus	38.5	1.286	64.2	4.146	89.9	2.650	64.2	2.506	64.2	2.789
Lanice conchilega					12.8	0.381				
pol.rest		0.212		0.264		0.173		0.083		0.468
Crustacea										
Callianassa tyrrhena			12.8	0.414						
Crangon crangon					12.8	0.006				
Pontocrates altamarinus					12.8	0.004			12.8	0.004
Pontocrates arenarius							12.8	0.004		
Synchelidium maculatum					12.8	0.004				
Urothoe brevicornis							64.2	0.019	12.8	0.004
Urothoe poseidonis	320.9	0.096	706.0	0.212	757.4	0.227	616.2	0.185	192.6	0.058
Bathyporeia elegans	51.3	0.015	77.0	0.023	102.7	0.031			12.8	0.004
Bathyporeia guilliamsoniana	12.8	0.004	89.9	0.027	12.8	0.004	77.0	0.023	38.5	0.012
Bathyporeia nana			12.8	0.004	12.8	0.004				
Bathyporeia tenuipes			12.8	0.004						
Pseudocuma gilsoni									25.7	0.008
Diastylis bradyi					12.8	0.004				
Mollusca										
Tellimya ferruginosa	77.0	0.080			25.7	0.007	25.7	0.010		
Chamelea striatula							12.8	0.210		
Tellina fabula	38.5	0.542	25.7	0.179	166.9	4.617	64.2	0.254	25.7	1.026
Ensis americanus			25.7	51.734						
Echinodermata										
Echinocardium cordatum					12.8	0.660	12.8	0.202		
Others										
Nemertini	25.7	0.229	12.8	0.099	25.7	0.051	12.8	0.102	12.8	0.474

Phoronida							64.2	0.034		
sum	937.1	5.543	1309.4	57.94 9	1591.8	9.320	1386.4	4.255	616.2	5.228
nr. of species	13		20		23		19		19	
SW-index	2.06		1.88		2.08		2.14		2.48	
Simpson-index	0.17		0.31		0.25		0.22		0.12	

	R1-6		R1-7		R1-8		R1-9		R1-10	
	n	b	n	b	n	b	n	b	n	b
Polychaeta										
Malmgrenia marphysae			38.5	0.132						
Eteone foliosa			12.8	0.005						
Eteone longa	25.7	0.005								
Nephtys cirrosa	115.5	0.412	128.4	1.174	77.0	0.352	51.3	0.229	77.0	0.264
Scoloplos armiger	12.8	0.027	12.8	0.003						
Scolelepis bonnieri	12.8	0.061	38.5	0.120	38.5	0.415	12.8	0.014	38.5	0.159
Spiophanes bombyx			102.7	0.125			12.8	0.007		
Magelona mirabilis	25.7	0.039	25.7	0.010	12.8	0.039	25.7	0.039	38.5	0.078
Magelona johnstoni			12.8	0.042	25.7	0.039				
Chaetozone setosa					25.7	0.014				
Chaetozone christi	25.7	0.012					12.8	0.008	51.3	0.019
Notomastus latericeus	12.8	2.271	25.7	2.623			12.8	0.258		
Lanice conchilega			102.7	4.755	25.7	2.660				
pol.rest		0.027		1.439		0.036		9.020		0.178
Crustacea										
Processa parva			12.8	0.335	12.8	0.181				
Megaluropus agilis									12.8	0.004
Pontocrates altamarinus	25.7	0.008								
Synchelidium maculatum			25.7	0.008	12.8	0.004				
Urothoe brevicornis			25.7	0.008	25.7	0.008	51.3	0.015	25.7	0.008
Urothoe poseidonis	282.4	0.085	718.9	0.216	885.8	0.266	462.1	0.139	192.6	0.058
Bathyporeia elegans			102.7	0.031	102.7	0.031	38.5	0.012	77.0	0.023
Bathyporeia guilliamsoniana	12.8	0.004	102.7	0.031	51.3	0.015	38.5	0.012	51.3	0.015
Bathyporeia nana			12.8	0.004	38.5	0.012			25.7	0.008
Pseudocuma gilsoni	12.8	0.004					12.8	0.004		
Mollusca										
Euspira nitida									25.7	0.194
Tellimya ferruginosa			25.7	0.023						
Mysella bidentata					12.8	0.010				
Chamelea striatula					12.8	0.071				
Spisula subtruncata			12.8	0.080						
Donax vittatus							12.8	0.030	12.8	0.134
Tellina fabula	12.8	0.030	25.7	0.518	25.7	0.654				
Ensis americanus							12.8	11.879		
Echinodermata										
Echinocardium cordatum			12.8	9.398			12.8	0.227	12.8	9.062
Others										
Nemertini	12.8	0.082					12.8	0.020		
Phoronida	12.8	0.003	12.8	0.007	205.4	0.081			38.5	0.020
sum	603.3	3.069	1591.8	21.087	1591.8	4.887	783.1	21.910	680.4	10.224
nr. of species	14		22		17		15		14	
SW-index	1.86		2.16		1.73		1.68		2.32	

Simpson-index	0.25		0.22		0.33		0.35		0.12	
	R1-11		R1-12		R1-13		R1-14		R1-15	
	n	b	n	b	n	b	n	b	n	b
Polychaeta										
Eteone longa			12.8	0.003						
Streptosyllis websteri									12.8	0.002
Nephtys spec. juv.			12.8	0.003						
Nephtys caeca							12.8	1.013		
Nephtys cirrosa	115.5	0.495	64.2	0.224	141.2	0.478	38.5	0.054	128.4	0.066
Nephtys hombergii			12.8	0.037						
Nephtys longosetosa							12.8	0.159		
Scoloplos armiger	12.8	0.005							12.8	0.129
Scolelepis bonnieri					12.8	0.032			12.8	0.198
Magelona filiformis			12.8	0.007						
Magelona mirabilis	12.8	0.051	12.8	0.044	64.2	0.176	25.7	0.041	25.7	0.042
Magelona johnstoni									12.8	0.093
Chaetozone setosa							12.8	0.007		
Chaetozone christi							12.8	0.007		
Lanice conchilega			12.8	0.388						
pol.rest				0.046		0.158		0.083		0.188
Crustacea										
Crangon crangon					12.8	0.019				
Siphonoecetus kroyeranus			12.8	0.004						
Pontocrates altamarinus							12.8	0.004		
Urothoe brevicornis			12.8	0.004						
Urothoe poseidonis	141.2	0.042	77.0	0.023					64.2	0.019
Bathyporeia elegans	295.3	0.089	64.2	0.019	51.3	0.015	89.9	0.027	128.4	0.039
Bathyporeia guilliamsoniana	12.8	0.004	25.7	0.008	12.8	0.004	12.8	0.004	25.7	0.008
Bathyporeia nana	25.7	0.008	12.8	0.004	25.7	0.008				
Pseudocuma longicornis							25.7	0.008		
Mollusca										
Chamelea striatula					12.8	0.071				
Echinodermata										
Echinocardium cordatum			12.8	7.802						
Others										
Anthozoa spec.										
Nemertini	25.7	0.319								
Phoronida	12.8	0.007							12.8	0.005
sum	654.7	1.019	359.4	8.616	333.8	0.961	256.7	1.406	436.5	0.789
nr. of species	9		14		8		10		10	
SW-index	1.56		2.32		1.67		2.01		1.85	
Simpson-index	0.27		0.10		0.22		0.14		0.18	

	R2-1		R2-2		R2-3		R2-4		R2-5	
	n	b	n	b	n	b	n	b	n	b
Polychaeta										
Malmgrenia marphysae					12.8	0.024				
Eteone foliosa							12.8	0.061		
Eteone longa			12.8	0.002	25.7	0.003			12.8	0.002
Nephtys cirrosa	141.2	0.234	154.0	0.564	51.3	0.275	77.0	0.114	89.9	0.275
Nephtys longosetosa					12.8	0.195				
Scoloplos armiger	25.7	0.112	38.5	0.075	12.8	0.019			12.8	0.025
Aricidea minuta					12.8	0.002			12.8	0.002
Scolelepis bonnieri	25.7	0.146	12.8	0.134	38.5	0.302	12.8	0.151	12.8	0.068
Magelona mirabilis	12.8	0.025	12.8	0.034	25.7	0.176	38.5	0.476	12.8	0.019
Magelona johnstoni									25.7	0.037
Chaetozone christi					12.8	0.012				
Travisia forbesii	12.8	1.091								
Lanice conchilega					12.8	0.188				
pol.rest		0.005		0.002		0.025		0.007		0.022
Crustacea										
Crangon crangon	12.8	0.006							12.8	0.992
Diogenes pugilator					25.7	0.042				
Megaluropus agilis	25.7	0.008	12.8	0.004			12.8	0.004		
Synchelidium maculatum			12.8	0.004						
Urothoe brevicornis	77.0	0.023	141.2	0.042	38.5	0.012	12.8	0.004	51.3	0.015
Urothoe poseidonis	38.5	0.012	38.5	0.012			25.7	0.008	12.8	0.004
Bathyporeia elegans	77.0	0.023	192.6	0.058			77.0	0.023	12.8	0.004
Bathyporeia guilliamsoniana	12.8	0.004	12.8	0.004						
Pseudocuma longicornis	12.8	0.004								
Mollusca										
Euspira nitida							12.8	0.004		
Tellimya ferruginosa			12.8	0.004						
Echinodermata										
Echinocardium cordatum									12.8	1.881
Others										
Nemertini					12.8	0.192			12.8	0.215
Phoronida	12.8	0.003							25.7	0.005
sum	487.8	1.695	654.7	0.937	295.3	1.466	282.4	0.851	320.9	3.565
nr. of species	13		12		13		9		14	
SW-index	2.18		1.90		2.43		1.90		2.34	
Simpson-index	0.13		0.18		0.06		0.15		0.10	

	R2-6		R2-7		R2-8		R2-9		R2-10	
	n	b	n	b	n	b	n	b	n	b
Polychaeta										
Harmothoe spec. juv.			12.8	0.002						
Malmgrenia marphysae			12.8	0.034			25.7	0.053		
Eteone longa	25.7	0.003	12.8	0.003						
Nephtys spec. juv.	12.8	0.002								
Nephtys caeca			12.8	2.469						
Nephtys cirrosa	102.7	0.312	89.9	0.707	231.1	0.915	89.9	0.761	64.2	0.198
Nephtys hombergii							12.8	0.042	12.8	0.395
Nephtys longosetosa					12.8	0.063				
Scoloplos armiger	51.3	0.286			51.3	0.244	12.8	0.105	12.8	0.019
Aricidea minuta			12.8	0.002						
Spionidae indet. Juv.			12.8	0.002	12.8	0.002				
Malacoceros fuliginosus			12.8	0.007						
Scolelepis bonnieri	38.5	0.275	51.3	0.349	25.7	0.679	12.8	0.136	25.7	0.136
Spiophanes bombyx							12.8	0.007		
Magelona filiformis					25.7	0.019			38.5	0.064
Magelona mirabilis	12.8	0.068								
Magelona johnstoni									12.8	0.025
Chaetozone setosa									25.7	0.017
Notomastus latericeus							38.5	2.796	141.2	6.239
Ophelia limacina			12.8	0.008						
Lanice conchilega	12.8	0.559	38.5	2.310	12.8	1.357	25.7	0.803		
pol.rest		0.059		0.037		0.020		0.132		0.297
Crustacea										
Megaluropus agilis					12.8	0.004				
Pontocrates altamarinus							25.7	0.008		
Synchelidium maculatum									12.8	0.004
Urothoe brevicornis	77.0	0.023	51.3	0.015	64.2	0.019			12.8	0.004
Urothoe poseidonis	12.8	0.004			25.7	0.008	372.3	0.112	1232.3	0.370
Bathyporeia elegans					12.8	0.004			25.7	0.008
Bathyporeia guilliamsoniana	12.8	0.004					12.8	0.004	12.8	0.004
Bathyporeia tenuipes			12.8	0.004						
Mollusca										
Euspira nitida	25.7	0.009	12.8	0.002					25.7	0.038
Tellimya ferruginosa									12.8	0.006
Tellina fabula							12.8	0.401	64.2	1.387

Ensis americanus									12.8	11.879
Echinodermata										
Amphiura spec.	12.8	0.001								
Others										
Nemertini	12.8	0.090			38.5	0.201	25.7	0.246		
Phoronida	179.7	0.071	64.2	0.010	77.0	0.020	12.8	0.003		
sum	590.5	1.767	423.6	5.960	603.3	3.555	693.2	5.608	1745.8	21.088
nr. of species	13		15		13		14		17	
SW-index	2.18		2.40		2.07		1.76		1.31	
Simpson-index	0.14		0.09		0.18		0.30		0.51	

	R2-11		R2-12		R2-13		R2-14		R2-15	
	n	b	n	b	n	b	n	b	n	b
Polychaeta										
Eteone longa							12.8	0.015	12.8	0.002
Nereis longissima			25.7	6.605						
Nephtys spec. juv.	12.8	0.002								
Nephtys cirrosa	64.2	0.463	154.0	0.793	102.7	0.466	89.9	0.486	166.9	0.842
Nephtys hombergii					12.8	0.022				
Nephtys longosetosa			12.8	0.054			12.8	0.010	12.8	0.005
Scoloplos armiger	25.7	0.036			25.7	0.119	12.8	0.003		
Scolelepis bonnieri							25.7	0.146	38.5	0.151
Spiophanes bombyx	12.8	0.002			12.8	0.020				
Magelona filiformis			12.8	0.029	25.7	0.003	12.8	0.031	12.8	0.007
Magelona mirabilis	12.8	0.032	12.8	0.029	12.8	0.059	38.5	0.090	12.8	0.012
Magelona johnstoni	25.7	0.061	12.8	0.029			25.7	0.059	12.8	0.012
Chaetozone setosa			12.8	0.005						
Chaetozone christi	12.8	0.003	12.8	0.005						
Capitella capitata	12.8	0.007								
pol.rest		0.012		0.007		0.005		0.014		0.659
Crustacea										
Crangon crangon			12.8	0.004						
Diogenes pugilator			12.8	0.058						
Megaluropus agilis			12.8	0.004	12.8	0.004	12.8	0.004		
Pontocrates altamarinus			12.8	0.004			12.8	0.004		
Pontocrates arenarius					12.8	0.004	12.8	0.004		
Synchelidium maculatum	12.8	0.004							12.8	0.004
Urothoe brevicornis			12.8	0.004			12.8	0.004	25.7	0.008
Urothoe poseidonis	680.4	0.204	12.8	0.004	436.5	0.131	128.4	0.039	256.7	0.077
Bathyporeia elegans	166.9	0.050	77.0	0.023	154.0	0.046	102.7	0.031	51.3	0.015
Bathyporeia guilliamsoniana	25.7	0.008	25.7	0.008	12.8	0.004	25.7	0.008		
Bathyporeia nana					38.5	0.012	25.7	0.008		
Pseudocuma longicornis					12.8	0.004				
Mollusca										
Euspira nitida			12.8	0.009					25.7	0.009
Tellimya ferruginosa			12.8	0.002	25.7	0.005			25.7	0.005
Mactra corallina							12.8	0.003		

Spisula elliptica							12.8	0.003		
Donax vittatus	25.7	0.122	12.8	0.057	12.8	0.069	12.8	3.124		
Tellina fabula	12.8	0.064								
Echinodermata										
Echinocardium cordatum					25.7	22.801			38.5	30.646
Others										
Anthozoa spec.					12.8	0.006				
sum	1104.0	1.069	475.0	7.732	949.9	23.779	603.3	4.084	706.0	32.454
nr. of species	13		19		17		19		14	
SW-index	1.46		2.44		1.94		2.53		2.02	
Simpson-index	0.40		0.12		0.25		0.09		0.19	

	R3-1		R3-2		R3-3		R3-4		R3-5	
	n	b	n	b	n	b	n	b	n	b
Polychaeta										
Eteone longa							12.8	0.003		
Nephtys cirrosa	128.4	0.237	128.4	0.500	128.4	0.364	115.5	1.052	115.5	0.397
Nephtys hombergii					12.8	0.302			12.8	0.017
Nephtys longosetosa	12.8	0.122								
Scoloplos armiger	12.8	0.173								
Scolelepis bonnieri	12.8	0.080	359.4	1.586	77.0	0.329	231.1	1.342	38.5	0.227
Magelona filiformis	12.8	0.027	12.8	0.008						
Magelona mirabilis	12.8	0.027	38.5	0.044	12.8	0.088	25.7	0.092		
Magelona johnstoni	12.8	0.027	12.8	0.025	51.3	0.059	12.8	0.027	25.7	0.083
Notomastus latericeus					12.8	1.088				
pol.rest		0.244		0.100		0.054		0.039		0.019
Crustacea										
Pontocrates altamarinus			12.8	0.004	12.8	0.004				
Urothoe brevicornis			51.3	0.015	12.8	0.004			12.8	0.004
Urothoe poseidonis			25.7	0.008	89.9	0.027				
Bathyporeia elegans	25.7	0.008	166.9	0.050	25.7	0.008	25.7	0.008		
Bathyporeia guilliamsoniana	25.7	0.008			12.8	0.004	12.8	0.004		
Bathyporeia nana					12.8	0.004			12.8	0.004
Mollusca										
Euspira nitida			25.7	0.004						
Tellimya ferruginosa	38.5	0.011							38.5	0.011
Echinodermata										
Echinocardium cordatum	38.5	0.789					12.8	0.349	25.7	1.810
Others										
Anthozoa spec.										
Nemertini							12.8	0.184		
Phoronida									12.8	0.007
sum	333.8	1.752	834.4	2.345	462.1	2.334	462.1	3.099	295.3	2.578
nr. of species	11		10		12		9		9	
SW-index	2.01		1.69		2.07		1.51		1.87	
Simpson-index	0.16		0.25		0.14		0.30		0.17	

	R3-6		R3-7		R3-8		R3-9		R3-10	
	n	b	n	b	n	b	n	b	n	b
Polychaeta										
Malmgrenia marphysae							179.7	0.234		
Eteone longa	25.7	0.012	12.8	0.015					51.3	0.020
Nephtys spec. juv.									25.7	0.005
Nephtys cirrosa	77.0	0.329	166.9	0.351	141.2	0.557	282.4	0.774	166.9	0.593
Nephtys hombergii	38.5	0.071	12.8	0.064						
Scoloplos armiger	12.8	0.015								
Spionidae indet. Juv.	12.8	0.002								
Scolelepis bonnieri	205.4	1.030	231.1	1.217	205.4	0.827	77.0	0.313	282.4	1.366
Spiophanes bombyx	51.3	0.120	25.7	0.069	51.3	0.069	64.2	0.066	128.4	0.381
Magelona mirabilis	12.8	0.041	12.8	0.041	25.7	0.056			12.8	0.047
Magelona johnstoni	51.3	0.185	25.7	0.112	12.8	0.024	25.7	0.024	12.8	0.015
Chaetozone christi	12.8	0.010								
Capitella capitata							12.8	0.005		
Notomastus latericeus			25.7	1.289	64.2	2.645	38.5	1.062	12.8	0.176
Lanice conchilega pol.rest		0.022		0.129		0.034	282.4	6.071 1.023		0.058
Crustacea										
Callianassa tyrrhena							12.8	0.039		
Megaluropus agilis					25.7	0.008			12.8	0.004
Pontocrates altamarinus					38.5	0.012				
Urothoe brevicornis	12.8	0.004					25.7	0.008		
Urothoe poseidonis	38.5	0.012	51.3	0.015	38.5	0.012			12.8	0.004
Atylus falcatus					12.8	0.004				
Bathyporeia elegans	25.7	0.008	77.0	0.023	77.0	0.023	38.5	0.012		
Bathyporeia guilliamsoniana	25.7	0.008			25.7	0.008	12.8	0.004		
Diastylis bradyi							12.8	0.004		
Mollusca										
Euspira nitida	25.7	0.006					25.7	0.009		
Tellimya ferruginosa	25.7	0.023	64.2	0.033	12.8	0.002	128.4	0.053	64.2	0.059
Mysella bidentata	12.8	0.004					12.8	0.001		
Spisula subtruncata			12.8	0.620						
Tellina fabula							12.8	0.019		
Echinodermata										
Echinocardium cordatum	25.7	1.894	38.5	1.299			25.7	0.934	38.5	2.806
Others										
Anthozoa spec.							12.8	12.034		
Nemertini	12.8	0.011	12.8	0.192			12.8	0.119		
Phoronida							12.8	0.007		

sum	706.0	3.807	770.2	5.471	731.7	4.280	1309.4	22.815	821.6	5.534
nr. of species	19		14		13		21		11	
SW-index	2.53		2.14		2.19		2.40		1.93	
Simpson-index	0.11		0.15		0.13		0.12		0.19	

	R3-11		R3-12		R3-13		R3-14		R3-15	
	n	b	n	b	n	b	n	b	n	b
Polychaeta										
Harmothoe glabra							12.8	0.005		
Eteone longa	12.8	0.002								
Nephtys caeca			12.8	0.069						
Nephtys cirrosa	141.2	0.847	141.2	0.612	231.1	0.978	128.4	0.383	51.3	0.141
Nephtys hombergii							12.8	0.032		
Nephtys assimilis									12.8	0.330
Scoloplos armiger			12.8	0.168						
Poecilochaetus serpens									12.8	0.017
Scolelepis bonnieri	51.3	0.249	77.0	0.422						
Spio filicornis									12.8	0.005
Spiophanes bombyx			12.8	0.020						
Magelona filiformis			12.8	0.017	12.8	0.003				
Magelona mirabilis	38.5	0.090	12.8	0.008			12.8	0.031		
Magelona johnstoni	12.8	0.068	12.8	0.041						
Chaetozone christi							12.8	0.008		
Notomastus latericeus					38.5	1.993	77.0	2.584	231.1	4.641
pol.rest		0.073		0.037		0.007		0.081		0.049
Crustacea										
Pontocrates altamarinus							12.8	0.004		
Urothoe brevicornis									12.8	0.004
Urothoe poseidonis			205.4	0.062	25.7	0.008	243.9	0.073	282.4	0.085
Bathyporeia elegans	231.1	0.069	115.5	0.035	64.2	0.019	51.3	0.015	12.8	0.004
Bathyporeia guilliamsoniana							25.7	0.008		
Bathyporeia nana	12.8	0.004					12.8	0.004		
Diastylis bradyi									12.8	0.004
Mollusca										
Euspira nitida					12.8	0.171				
Tellimya ferruginosa			25.7	0.017						
Mysella bidentata							12.8	0.007		
Tellina fabula	12.8	0.064					12.8	0.011	12.8	0.024
Ensis americanus							25.7	31.455	102.7	90.994
Echinodermata										
Echinocardium cordatum			38.5	8.420	12.8	0.202				
Others										
Nemertini	12.8	0.223								
sum	526.3	1.689	680.4	9.928	397.9	3.380	654.7	34.701	757.4	96.297
nr. of species	9		12		7		14		11	
SW-index	1.59		1.97		1.35		2.01		1.67	
Simpson-index	0.26		0.17		0.36		0.19		0.24	

	R4-1		R4-2		R4-3		R4-4		R4-5	
	n	b	n	b	n	b	n	b	n	b
Polychaeta										
Harmothoe glabra					12.8	0.007				
Nephtys cirrosa	64.2	0.085	77.0	0.137	89.9	0.349	102.7	0.425	128.4	0.359
Nephtys hombergii	12.8	0.166			12.8	0.042				
Nephtys longosetosa			12.8	0.249						
Lumbrineris latreilli			12.8	0.005						
Scoloplos armiger	12.8	0.008	12.8	0.008			89.9	0.535	12.8	0.056
Scolelepis bonnieri	12.8	0.088			38.5	0.529				
Magelona filiformis	12.8	0.061								
Magelona mirabilis	25.7	0.122	12.8	0.024						
Magelona johnstoni			12.8	0.024					25.7	0.120
Lanice conchilega			12.8	0.666						
pol.rest		0.080		0.005						0.003
Crustacea										
Thia scutellata			12.8	0.932						
Pontophilus trispinosus	12.8	0.291								
Diogenes pugilator	12.8	0.019								
Megaluropus agilis					12.8	0.004	12.8	0.004	12.8	0.004
Pontocrates altamarinus	12.8	0.004					12.8	0.004		
Synchelidium maculatum	12.8	0.004								
Urothoe brevicornis	64.2	0.019					12.8	0.004	12.8	0.004
Urothoe poseidonis	38.5	0.012			12.8	0.004				
Bathyporeia elegans	218.2	0.065	128.4	0.039	12.8	0.004	25.7	0.008	12.8	0.004
Bathyporeia guilliamsoniana	25.7	0.008			25.7	0.008				
Bathyporeia nana			12.8	0.004						
Bathyporeia tenuipes	12.8	0.004								
Pseudocuma gilsoni			25.7	0.008					12.8	0.004
Pseudocuma longicornis	25.7	0.008								
Mollusca										
Euspira nitida			12.8	0.004						
Spisula elliptica			12.8	0.060					12.8	0.091
Echinodermata										
Echinocardium cordatum					12.8	14.577				
sum	577.7	1.043	359.4	2.165	231.1	15.523	256.7	0.980	231.1	0.645
nr. of species	16		13		9		6		8	
SW-index	2.21		2.08		1.87		1.41		1.53	
Simpson-index	0.16		0.16		0.16		0.26		0.30	

	R4-6		R4-7		R4-8		R4-9		R4-10	
	n	b	n	b	n	b	n	b	n	b
Polychaeta										
Malmgrenia marphysae							25.7	0.102		
Eteone foliosa	12.8	0.032								
Nephtys cirrosa	89.9	0.261	77.0	0.149	77.0	0.259	25.7	0.251	102.7	0.485
Nephtys hombergii					12.8	0.198				
Nephtys assimilis									12.8	0.046
Scoloplos armiger	25.7	0.146	154.0	1.008	38.5	0.142	38.5	0.114	12.8	0.012
Scolelepis bonnieri					12.8	0.073	12.8	0.278		
Magelona filiformis					12.8	0.054			25.7	0.078
Magelona johnstoni			12.8	0.010	12.8	0.056			12.8	0.037
Notomastus latericeus			12.8	0.058						
Travisia forbesii	25.7	0.003								
Lanice conchilega					12.8	0.086	89.9	2.516		
pol.rest		0.007		0.012		0.134		0.236		
Crustacea										
Thia scutellata					12.8	0.483				
Crangon crangon					12.8	0.008				
Diogenes pugilator	12.8	0.023								
Megaluropus agilis					12.8	0.004				
Urothoe brevicornis	12.8	0.004	77.0	0.023	51.3	0.015	89.9	0.027	12.8	0.004
Urothoe poseidonis							102.7	0.031	51.3	0.015
Bathyporeia elegans	12.8	0.004			51.3	0.015	141.2	0.042		
Bathyporeia guilliamsoniana							12.8	0.004		
Bathyporeia tenuipes	12.8	0.004								
Pseudocuma similis							12.8	0.004		
Mollusca										
Ensis ensis									12.8	10.062
Echinodermata										
Amphiura spec.							12.8	0.004		
Echinocardium cordatum			12.8	13.676					12.8	9.742
Others										
Nemertini					12.8	0.068	12.8	0.116		
Phoronida					12.8	0.003				
sum	205.4	0.484	346.6	14.937	346.6	1.600	577.7	3.723	256.7	20.481
nr. of species	8		6		14		12		9	
SW-index	1.75		1.40		2.36		2.11		1.82	
Simpson-index	0.19		0.27		0.09		0.13		0.18	

	R4-11		R4-12		R4-13		R4-14		R4-15	
	n	b	n	b	n	b	n	b	n	b
Polychaeta										
Harmothoe imbricata							25.7	0.020		
Harmothoe glabra					12.8	0.005				
Malmgrenia marphysae							346.6	0.983	25.7	0.119
Eteone foliosa			12.8	0.029						
Mystides southerni							12.8	0.010		
Eumida sanguinea	12.8	0.003								
Nereis longissima									12.8	2.881
Nephtys cirrosa	89.9	0.656	38.5	0.137	12.8	0.010	115.5	1.205	77.0	0.420
Nephtys hombergii							77.0	0.798		
Nephtys incisa							12.8	0.134	12.8	0.098
Nephtys longosetosa	12.8	0.036			12.8	0.215				
Scoloplos armiger			51.3	0.254	25.7	0.220	25.7	0.271	12.8	0.031
Aricidea minuta			12.8	0.003						
Scolelepis bonnieri			25.7	0.232	25.7	0.088			12.8	0.268
Spiophanes bombyx							38.5	0.037	12.8	0.029
Magelona filiformis			12.8	0.003						
Magelona mirabilis					12.8	0.007				
Magelona johnstoni					12.8	0.058				
Capitella capitata							25.7	0.024		
Notomastus latericeus							12.8	0.275		
Lanice conchilega			25.7	0.813			911.4	72.592	25.7	1.362
Polychaeta indet. Juv.							25.7	0.003		
pol.rest		0.230		0.117		0.022		2.060		0.613
Crustacea										
Callianassa tyrrhena					12.8	6.972				
Thia scutellata									12.8	0.054
Microprotopus maculatus	12.8	0.004								
Megaluropus agilis	25.7	0.008								
Pontocrates altamarinus									12.8	0.004
Pontocrates arenarius							12.8	0.004		
Urothoe brevicornis	38.5	0.012	25.7	0.008	25.7	0.008	38.5	0.012		
Urothoe poseidonis	51.3	0.015	25.7	0.008	64.2	0.019	1412.1	0.424	385.1	0.116
Bathyporeia elegans	64.2	0.019	12.8	0.004	269.6	0.081	308.1	0.092	64.2	0.019

Bathyporeia guilliamsoniana					12.8	0.004	12.8	0.004		
Bathyporeia nana					25.7	0.008				
Bathyporeia tenuipes			12.8	0.004						
Pseudocuma gilsoni	12.8	0.004							12.8	0.004
Pseudocuma longicornis	12.8	0.004								
Diastylis bradyi	25.7	0.008								
Mollusca										
Donax vittatus					12.8	0.134				
Echinodermata										
Echinocardium cordatum									12.8	10.827
Others										
Nemertini					12.8	0.068	25.7	0.037	25.7	0.082
Phoronida			12.8	0.005	89.9	0.047	282.4	0.149		
sum	359.4	0.998	269.6	1.618	641.8	7.967	3722.7	79.133	718.9	16.926
nr. of species	11		12		16		18		15	
SW-index	2.14		2.36		2.09		1.89		1.79	
Simpson-index	0.11		0.06		0.20		0.22		0.30	

	R5-1		R5-2		R5-3		R5-4		R5-5	
	n	b	n	b	n	b	n	b	n	b
Polychaeta										
Nephtys spec. juv.					12.8	0.002				
Nephtys cirrosa	115.5	0.376	89.9	0.285	128.4	0.252	166.9	0.366	115.5	0.198
Nephtys hombergii					12.8	0.005			12.8	0.025
Nephtys longosetosa			12.8	0.010						
Scoloplos armiger			12.8	0.180					12.8	0.071
Malacoceros fuliginosus	12.8	0.005								
Scolelepis bonnieri	12.8	0.069	25.7	0.358	12.8	0.227	38.5	0.515	12.8	0.061
Magelona filiformis					38.5	0.008	12.8	0.003		
Magelona mirabilis	12.8	0.010	25.7	0.012	38.5	0.114			25.7	0.017
Magelona johnstoni									12.8	0.008
Notomastus latericeus	12.8	0.774	51.3	1.445					12.8	0.405
pol.rest		0.032		0.064		0.308		0.059		0.037
Crustacea										
Crangon crangon							12.8	0.006	12.8	0.008
Diogenes pugilator			12.8	0.019						
Megaluropus agilis	25.7	0.008								
Pontocrates arenarius							12.8	0.004		
Urothoe brevicornis			12.8	0.004	25.7	0.008	12.8	0.004	38.5	0.012
Urothoe poseidonis	269.6	0.081	231.1	0.069	475.0	0.142	128.4	0.039	641.8	0.193
Leucothoe incisa	12.8	0.004								
Bathyporeia elegans	38.5	0.012	38.5	0.012			128.4	0.039		
Bathyporeia guilliamsoniana	12.8	0.004			25.7	0.008	25.7	0.008		
Mollusca										
Tellimya ferruginosa			12.8	0.004	12.8	0.009			38.5	0.036
Abra alba					12.8	0.086				
Donax vittatus			12.8	0.098	12.8	0.030	12.8	0.047		
Ensis americanus	25.7	36.653			25.7	15.339				
Ensis ensis							12.8	4.921		
Echinodermata										
Echinocardium cordatum							12.8	0.077	12.8	12.815
Others										
Nemertini							12.8	0.138		
Phoronida	12.8	0.003	12.8	0.005			12.8	0.002		
sum	564.8	38.032	552.0	2.565	834.4	16.538	603.3	6.227	949.9	13.886
nr. of species	12		13		12		14		12	
SW-index	1.74		1.96		1.60		2.06		1.29	
Simpson-index	0.27		0.20		0.35		0.16		0.47	

	R5-6		R5-7		R5-8		R5-9		R5-10	
	n	b	n	b	n	b	n	b	n	b
Polychaeta										
Eteone longa			12.8	0.005						
Nephtys caeca			12.8	0.078						
Nephtys cirrosa	115.5	0.334	25.7	0.188	77.0	0.176	38.5	0.124	102.7	0.183
Nephtys hombergii							25.7	0.217	12.8	0.003
Nephtys incisa					25.7	0.083	12.8	0.020		
Scoloplos armiger			12.8	0.178			12.8	0.034	12.8	0.246
Scolelepis bonnieri			12.8	0.139	25.7	0.112	12.8	0.092	12.8	0.073
Spiophanes bombyx							12.8	0.010		
Magelona filiformis							25.7	0.010		
Magelona mirabilis	51.3	0.086	12.8	0.037	64.2	0.188	25.7	0.169	12.8	0.008
Magelona johnstoni					25.7	0.017				
Capitella capitata							25.7	0.010		
Notomastus latericeus	12.8	0.064								
pol.rest						0.075		0.019		0.008
Crustacea										
Diogenes pugilator			12.8	0.017	12.8	0.295				
Pontocrates altamarinus			38.5	0.012						
Urothoe brevicornis	38.5	0.012			64.2	0.019	77.0	0.023	12.8	0.004
Urothoe poseidonis	12.8	0.004							38.5	0.012
Stenothoe marina									12.8	0.004
Bathyporeia elegans	25.7	0.008	141.2	0.042	51.3	0.015			25.7	0.008
Bathyporeia guilliamsoniana	12.8	0.004			12.8	0.004	12.8	0.004	12.8	0.004
Bathyporeia nana									25.7	0.008
Mollusca										
Chamelea striatula			12.8	1.060						
Spisula subtruncata							12.8	0.159		
Echinodermata										
Echinocardium cordatum	12.8	0.065					12.8	0.283		
Others										
Anthozoa spec.					12.8	0.302				
Nemertini	12.8	0.014							12.8	0.068
Phoronida									12.8	0.005
sum	295.3	0.591	295.3	1.757	372.3	1.286	308.1	1.174	308.1	0.633
nr. of species	9		10		10		13		13	
SW-index	1.83		1.79		2.11		2.36		2.23	
Simpson-index	0.18		0.23		0.11		0.08		0.12	

	R5-11		R5-12		R5-13		R5-14		R5-15	
	n	b	n	b	n	b	n	b	n	b
Polychaeta										
Malmgrenia marphysae									12.8	0.017
Sigalion mathildae									25.7	0.910
Sigalion squamosus									12.8	0.007
Phyllodoce mucosa									51.3	0.064
Nephtys caeca			25.7	0.173	12.8	4.340				
Nephtys cirrosa	128.4	0.449	115.5	0.361	115.5	0.163	115.5	0.354	89.9	0.039
Nephtys hombergii					12.8	0.022			64.2	2.911
Nephtys incisa			12.8	0.044						
Scoloplos armiger	25.7	0.102			25.7	0.061				
Scolelepis bonnieri	25.7	0.158								
Spiophanes bombyx					12.8	0.003				
Magelona mirabilis	38.5	0.047	38.5	0.034						
Magelona johnstoni					25.7	0.092				
Capitella capitata									12.8	0.003
Notomastus latericeus									89.9	1.916
Owenia fusiformis									51.3	0.147
Lanice conchilega									12.8	0.205
pol.rest		0.031		0.413						0.024
Crustacea										
Callianassa tyrrhena									12.8	2.316
Crangon crangon	12.8	0.006							12.8	3.743
Diogenes pugilator					25.7	0.035			12.8	0.023
Perioculodes longimanus									12.8	0.004
Urothoe brevicornis	25.7	0.008			89.9	0.027	25.7	0.008		
Urothoe poseidonis			12.8	0.004			539.2	0.162	38.5	0.012
Bathyporeia elegans	77.0	0.023	89.9	0.027	38.5	0.012	38.5	0.012	12.8	0.004
Bathyporeia guilliamsoniana			25.7	0.008			51.3	0.015		
Bathyporeia tenuipes	12.8	0.004	12.8	0.004						
Mollusca										
Euspira nitida									12.8	0.004
Tellimya ferruginosa			12.8	0.004			12.8	0.002	205.4	0.085
Mysella bidentata									77.0	0.018
Chamelea striatula	12.8	3.829								
Spisula subtruncata									12.8	0.012

Tellina fabula									128.4	2.683
Ensis americanus									25.7	38.743
Echinodermata										
Echinocardium cordatum			12.8	0.179			25.7	6.744	25.7	9.308
Others										
Phoronida			12.8	0.005	12.8	0.003				
sum	359.4	4.656	372.3	1.255	372.3	4.757	808.7	7.297	1014.1	63.201
nr. of species	9		11		10		7		23	
SW-index	1.86		2.01		1.96		1.15		2.70	
Simpson-index	0.17		0.15		0.16		0.46		0.08	

	R6-1		R6-2		R6-3		R6-4		R6-5	
	n	b	n	b	n	b	n	b	n	b
Polychaeta										
Malmgrenia marphysae					12.8	0.007				
Sigalion mathildae							12.8	0.527		
Nereis longissima			12.8	1.481			25.7	1.566		
Nephtys cirrosa	102.7	0.571	38.5	0.049	128.4	0.061	269.6	0.271	89.9	0.168
Nephtys hombergii			12.8	0.163	12.8	0.390				
Nephtys longosetosa									12.8	0.085
Nephtys assimilis					12.8	0.561	12.8	0.039		
Scoloplos armiger			12.8	0.007					12.8	0.142
Poecilochaetus serpens							25.7	0.032		
Scolelepis bonnieri	12.8	0.075								
Spio decorata			12.8	0.003			25.7	0.015		
Spio filicornis							12.8	0.005		
Spiophanes bombyx			12.8	0.007	25.7	0.031	25.7	0.047		
Magelona filiformis									12.8	0.007
Magelona mirabilis			12.8	0.008	320.9	0.105	205.4	0.044		
Magelona johnstoni	25.7	0.044	89.9	0.120	102.7	0.136	372.3	0.437		
Chaetozone setosa							12.8	0.014		
Chaetozone christi									12.8	0.010
Notomastus latericeus			89.9	2.559			25.7	0.691		
Travisia forbesii									12.8	0.397
Lanice conchilega							12.8	0.041		
pol.rest		0.005		0.092		0.264		0.100		0.025
Crustacea										
Callianassa tyrrhena							12.8	3.079		
Crangon crangon					12.8	0.008	12.8	0.004	12.8	0.008
Diogenes pugilator	12.8	0.027					12.8	0.019		
Megaluropus agilis					12.8	0.004				
Perioculodes longimanus			12.8	0.004	12.8	0.004				
Pontocrates altamarinus							12.8	0.004	12.8	0.004
Synchelidium maculatum			12.8	0.004						
Urothoe brevicornis	89.9	0.027	25.7	0.008	25.7	0.008	77.0	0.023	77.0	0.023
Urothoe poseidonis			706.0	0.212	795.9	0.239	860.1	0.258	25.7	0.008
Leucothoe incisa							38.5	0.012		

Bathyporeia elegans	12.8	0.004	64.2	0.019	64.2	0.019	51.3	0.015	12.8	0.004
Bathyporeia guilliamsoniana					12.8	0.004			12.8	0.004
Bathyporeia tenuipes			12.8	0.004						
Pseudocuma longicornis									12.8	0.004
Mollusca										
Euspira nitida			38.5	0.013			25.7	0.009	12.8	0.004
Tellimya ferruginosa			102.7	0.056	89.9	0.044	25.7	0.005		
Mysella bidentata			38.5	0.032	38.5	0.021	12.8	0.003		
Spisula subtruncata							12.8	0.052		
Donax vittatus							12.8	0.001		
Tellina fabula			102.7	2.258	38.5	0.488	38.5	1.635		
Echinodermata										
Echinocardium cordatum	12.8	0.315	51.3	31.184	64.2	55.839	12.8	14.577		
Others										
Nemertini							38.5	1.056	12.8	0.195
Oligochaeta			12.8	0.010						
Phoronida	12.8	0.003	25.7	0.010			166.9	0.049		
sum	282.4	1.071	1501.9	38.302	1784.3	58.232	2464.7	24.630	346.6	1.087
nr. of species	8		22		18		30		15	
SW-index	1.65		2.14		1.95		2.36		2.34	
Simpson-index	0.22		0.24		0.24		0.17		0.11	

	R6-6		R6-7		R6-8		R6-9		R6-10	
	n	b	n	b	n	b	n	b	n	b
Polychaeta										
Malmgrenia marphysae	25.7	0.032			89.9	0.088	38.5	0.058	12.8	0.019
Streptosyllis websteri									12.8	0.002
Nereis longissima					12.8	1.210				
Nephtys cirrosa	179.7	0.298	77.0	0.347	12.8	0.014	51.3	0.024	154.0	0.581
Nephtys hombergii	25.7	0.868	25.7	0.432	25.7	0.641	38.5	1.749		
Nephtys longosetosa					12.8	0.117	12.8	0.273		
Scoloplos armiger	25.7	0.142	25.7	0.075					12.8	0.044
Poecilochaetus serpens					25.7	0.027				
Spio decorata							12.8	0.005		
Spio filicornis					12.8	0.014				
Spiophanes bombyx	38.5	0.054	89.9	0.437	38.5	0.041	25.7	0.105	25.7	0.012
Magelona johnstoni					12.8	0.014	77.0	0.088		
Capitella capitata	12.8	0.007			102.7	0.108				
Mediomastus fragilis					12.8	0.014				
Notomastus latericeus	436.5	6.703	25.7	0.918	718.9	19.607	513.5	13.856		
Owenia fusiformis					12.8	0.168			12.8	0.010
Lanice conchilega	38.5	0.793			218.2	8.781	141.2	3.628	12.8	0.222
pol.rest		0.092		0.017		1.117		0.110		0.015
Crustacea										
Callianassa tyrrhena					12.8	0.025				
Liocarcinus arcuatus							12.8	8.819		
Crangon crangon							25.7	0.008		
Pariambus typicus					12.8					
Megaluropus agilis			12.8	0.004						
Synchelidium maculatum			12.8	0.004			12.8	0.004		
Urothoe brevicornis	38.5	0.012	25.7	0.008	51.3	0.015	115.5	0.035	64.2	0.019
Urothoe poseidonis	1091.1	0.327	115.5	0.035	449.3	0.135	962.8	0.289	25.7	0.008
Leucothoe incisa	12.8	0.004	25.7	0.008					12.8	0.004
Bathyporeia elegans	38.5	0.012								
Bathyporeia guilliamsoniana	12.8	0.004								
Bathyporeia tenuipes					12.8	0.004				
Pseudocuma longicornis							12.8	0.004		

Pseudocuma similis							12.8	0.004		
Mollusca										
Tellimya ferruginosa	115.5	0.062	102.7	0.060	218.2	0.124	513.5	0.258		
Mysella bidentata	12.8	0.003			115.5	0.023	218.2	0.076		
Spisula elliptica									12.8	0.037
Spisula subtruncata					12.8	0.695	12.8	0.143		
Tellina fabula	12.8	0.089			51.3	0.283	51.3	1.327		
Ensis americanus	25.7	53.303	25.7	38.979	38.5	71.151	51.3	102.318	12.8	28.183
Echinodermata										
Echinocardium cordatum	25.7	5.536	38.5	2.325	12.8	5.653	25.7	23.984		
Others										
Nemertini	12.8	0.048			12.8	0.181				
Phoronida	12.8	0.024			38.5	0.010			38.5	0.015
sum	2195.1	68.413	603.3	43.649	2349.2	110.258	2939.7	157.163	410.8	29.171
nr. of species	20		13		27		22		13	
SW-index	1.78		2.31		2.37		2.15		2.09	
Simpson-index	0.29		0.10		0.15		0.18		0.16	

	R6-11		R6-12		R6-13		R6-14	
	n	b	n	b	n	b	n	b
Polychaeta								
Eteone longa			12.8	0.003				
Nephtys caeca	12.8	4.226						
Nephtys cirrosa	102.7	0.207	102.7	0.654	205.4	0.508	51.3	0.275
Nephtys longosetosa					25.7	0.180		
Scoloplos armiger			12.8	0.186				
Scolelepis bonnieri			25.7	0.383	12.8	0.083	25.7	0.386
Spiophanes bombyx			12.8	0.020	51.3	0.080		
Magelona filiformis			25.7	0.044	12.8	0.002		
Magelona mirabilis	12.8	0.010			12.8	0.041	51.3	0.237
Magelona johnstoni	12.8	0.142						
pol.rest		0.069		0.015		0.217		0.051
Crustacea								
Urothoe brevicornis	25.7	0.008	25.7	0.008	77.0	0.023		
Urothoe poseidonis							12.8	0.004
Atylus falcatus	12.8	0.004						
Bathyporeia elegans					12.8	0.004	12.8	0.004
Bathyporeia guilliamsoniana			12.8	0.004				
Gastrosaccus spinifer			12.8					
Diastylis bradyi	12.8	0.004						
Others								
Nemertini	12.8	0.201	25.7	0.350				
Phoronida	12.8	0.002						
sum	218.2	4.872	269.6	1.668	410.8	1.137	154.0	0.957
nr. of species	9		10		8		5	
SW-index	1.77		1.99		1.53		1.45	
Simpson-index	0.21		0.15		0.29		0.20	

Appendix 2:Triple-D data: numbers of individuals per dredge haul (covering 16 m2)

	Windfarm													
INVERTEBRATES	W													
station→	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Callianassa tyrrhena									1					
Corystes cassivelaunus	3		1			2								
Crangon almanni										8		1		
Crangon crangon	32	26	48	33	37	227	38	50	150	324	124	51	58	51
Diogenes pugilator	1			2	3	1		1		2	1		1	2
Liocarcinus arcuatus						1			1		1			
Liocarcinus depurator						2	1	1			3			
Liocarcinus holsatus	3		3	2		65	1	2	28	40	5	1	5	5
Liocarcinus marmoratus			5			3	1			3	2			
Macropodia spec.										1				
Pagurus bernhardus	1		1	1	1	1	1		2	3			1	
Pontophilus spec.	22	13	2	16	7	6	23	1	4		5	12	29	21
Portumnus latipes					1							1		
Processa spec.									4		1		1	1
Thia scutellata	2	2	7	4	6	4	6	9	1	3	2	2	3	17
Chamelea striatula	5	6	6	5	1	5	3	6	7	6	7	1	8	4
Donax vittatus	1		8	2		1	4	4	9	8	1	1	10	3
Ensis americanus	2	3	9	4	5	77	8	4	31	632	46	1	5	3
Ensis arcuatus			2		1	3	1		2		1			
Ensis ensis		1											1	
Euspira nitida					1				3		2			
Laevicardium norvegicum		1												
Lutraria lutraria						25			9	9	10			
Mactra corallina									2					
Nassarius reticulatus														
Natica catena							1		1	1				
Spisula elliptica														
Spisula solida	1	2					1	1						
Spisula subtruncata			2	1		2			3	5	2		4	
Tellina fabula						3								
Tellina tenuis							1				1		1	
Asterias rubens									2	1				
Echinocardium cordatum			3	3					8	4			1	
Ophiura albida	7	4	12	12	11	2	8	2	5	5	13	4	7	6
Ophiura texturata	7	6	6	12	7	82	23	4	40	94	30	7	12	25
Anthozoa indet.											1		2	1
nr. of species	13	10	15	13	12	19	16	12	21	18	20	11	17	12
FISHES														
Agonus cataphractus														
Ammodytes tobianus	3	3	6		30	1	4			1				
Arnoglossus laterna		1	2	2	1		2			1			1	
Buglossidium luteum	4		6			6	3		3	4	4		7	1
Callionymus lyra						2	1			3	2			
Ciliata mustela						1								
Hyperoplus lanceolatus				1			1	1			2		2	
Limanda limanda	1		5		1	6	2	5	9	4	1	1	2	2
Merlangius merlangus											1			
Myoxocephalus scorpius		1	1			1								
Pleuronectes platessa		2		2	1	2		2			2		3	3
Pomatoschistus spec.	2	7	53	23	8	95	9	4	45	185	28	9	23	10
Solea solea	1		1	2				1	2		1	1	1	
Sprattus sprattus				1		2		1						
Syngnathus spec.						2					2	2	2	
nr. of species	5	5	7	6	5	10	7	6	4	6	9	4	8	4

Appendix 2 (continued)

	Reference areas											
INVERTEBRATES	R1		R2		R3		R4		R5		R6	
station→	15	17	18	20	21	23	24	26	27	28	30	32
Callianassa tyrrhena	3					2		3			1	
Corystes cassivelaunus	1		1	1				1	1	1		
Crangon almanni												
Crangon crangon	31	33	52	37	44	66	53	43	95	68	42	51
Diogenes pugilator							1		1	2		
Liocarcinus arcuatus					1	2		1				1
Liocarcinus depurator	1											
Liocarcinus holsatus	4	1	5	2	1	6	2	8	15	4	4	2
Liocarcinus marmoratus	4				1	12		2		3	1	2
Macropodia spec.												
Pagurus bernhardus	2		2	1	3	10	5	4	3	2	2	3
Pontophilus spec.	4	19	18	13	20	4	20		10	3	5	2
Portumnus latipes												
Processa spec.						2		1			4	
Thia scutellata			8	10	1	2	5	10	2		2	7
Chamelea striatula	3	5	11		1	8	5	4	8	22	6	2
Donax vittatus		4	7	9	3	4	4	3	4	4	2	
Ensis americanus	21	3	6	2	2	330	4	5	66	25	2	20
Ensis arcuatus												
Ensis ensis			1									
Euspira nitida	3					4						
Laevicardium norvegicum												
Lutraria lutraria					1	6		1	1			4
Mactra corallina											2	
Nassarius reticulatus											3	
Natica catena	1								1	1		
Spisula elliptica								1	1			
Spisula solida			2							3		4
Spisula subtruncata	2	1				2		12	2	5		
Tellina fabula	60							1				
Tellina tenuis			1									
Asterias rubens												
Echinocardium cordatum	2			3		4	1	34		1	1	1
Ophiura albida	4						4	2	2	9	50	1
Ophiura texturata	8	17	5	14	4	66	10	32	34	20	8	12
Anthozoa indet.	11				3	6						1
nr. of species	18	8	13	10	13	18	12	19	16	16	16	15
FISHES												
Agonus cataphractus		1										
Ammodytes tobianus	2	4	45	5	4	2			3	4	7	6
Arnoglossus laterna	1				1		1		1	2	1	1
Buglossidium luteum	14	1	10	6	3	12		9	11	7	9	4
Callionymus lyra			3				1	8	1	1	5	2
Ciliata mustela												
Hyperoplus lanceolatus											10	
Limanda limanda						2		12	2	2	3	1
Merlangius merlangus												
Myoxocephalus scorpius												
Pleuronectes platessa	3		1	2		2	1	2		1		1
Pomatoschistus spec.	9	9	12	13	10	66	23	69	31	14	74	26
Solea solea					1			1			1	
Sprattus sprattus												
Syngnathus spec.		1							3	2	2	
nr. of species	5	5	5	4	5	5	4	6	7	8	9	7

Appendix 3: Poweranalysis on the T0 data

By Jaap van der Meer

The study follows a Before-After-Control-Impact (BACI) design with 1 impact area (T) and 2 control areas (N and S). Benthos surveys are conducted before and after the impact occurs.

The observations within each area are not statistically independent. The same holds for the before and after observations. Basically, there are thus only three independent observations, one in each area (see, for example, Eberhardt and Thomas, 1991).

Assume that these three independent observations (one in each area) for each response variable Y (for example, the difference between the average per area of the density of a specific species after and before the impact) can be modelled as:

$Y_T = \mu + \delta/2 + \varepsilon_T$ Treatment area,

$Y_N = \mu - \delta/2 + \varepsilon_N$ First control area,

$Y_S = \mu - \delta/2 + \varepsilon_S$ Second control area,

where μ is the overall mean, δ the effect size of the impact, and ε an independent normally distributed error with variance σ^2.

The test statistic *t,* which is given by

$$X/\sqrt{\operatorname{var} X},$$

where

$$X = Y_T - \frac{Y_N + Y_S}{2} = \delta + \varepsilon_T - \varepsilon_N/2 - \varepsilon_S/2,$$

and

$$\operatorname{var} X = \operatorname{var}\varepsilon_T + \frac{1}{4}\operatorname{var}\varepsilon_N + \frac{1}{4}\operatorname{var}\varepsilon_N = \frac{3}{2}\sigma^2,$$

follows a Students t-distribution with one df. The estimator of σ^2 is

$$\left(Y_N - \frac{Y_N + Y_S}{2}\right)^2 + \left(Y_S - \frac{Y_N + Y_S}{2}\right)^2 = \frac{1}{2}\left(Y_N - Y_S\right)^2$$

The effect size δ that can be detected with a power of 80% equals

$$\left(t_{[1]0.025} + t_{[1]0.2}\right)\sqrt{\operatorname{var} X} = \left(t_{[1]0.025} + t_{[1]0.2}\right)\sqrt{3/2}\sigma.$$

Unfortunately, the variance of the before-after differences is not known. But estimates of the correlation between before and after measurements at the relevant spatial scale may be guesstimated.

If the response variable *Y* is the difference between the after (Z_2) and before (Z_1) measurement, then (assuming varZ_1 equals var Z_2)

$$\sigma^2 = \mathrm{var}(Z_2 - Z_1) = \mathrm{var}\, Z_2 + \mathrm{var}\, Z_1 - 2\,\mathrm{cov}(Z_2, Z_1) = 2(1-r)\,\mathrm{var}\, Z\,,$$

which can be estimated by

$$2(1-r)\frac{1}{2}(Z_N - Z_S)^2 = (1-r)(Z_N - Z_S)^2.$$

Hence, the effect size δ that can be detected with a power of 80% equals

$$\left(t_{[1]0.025} + t_{[1]0.2}\right)\frac{1}{2}\sqrt{3}\sqrt{2}\sqrt{(1-r)}(Z_N - Z_S) = (12.72 + 1.38) \times \frac{1}{2}\sqrt{3}\sqrt{2} \times \sqrt{(1-r)}(Z_N - Z_S)$$ where the

$$= 17.3\sqrt{(1-r)}(Z_N - Z_S)$$

(already known) difference in the before means of area N and area S can be used for Z_N and Z_S.

If we assume an r-value of 0.9 (which does not seem unreasonable) and so

√(1-0.9) = 0.3

than the effect size will be 17.3*0.3 ≈ 5 times the difference between N and S.

For 6 of the most abundant species the following measurable effect sizes can be calculated:

	mean densities				measurable
	T	S	N	diff. S - N	effect size
Spiophanes bombyx	284	267	533	266	1381
Urothoe poseidonis	84	15	130	115	597
Nephtys cirrosa	80	67	32	35	182
Lanice conchilega	62	422	217	205	1064
Scoloplos armiger	28	21	29	8	42
Nemertea	21	16	42	26	135