Baseline survey B11-5 on the German Continental Shelf

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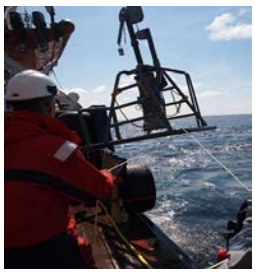
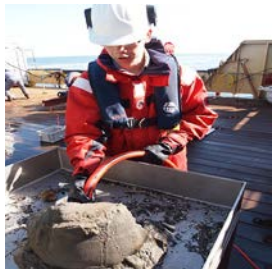

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Summary

A consortium, consisting of Wintershall Holding GmbH, GdF Suez, RWE Dea and EWE AG, is planning an exploration well in block B11-5, located within the Doggerbank (N2000 area). In order to assess any effect from this activity on the biological, physical and chemical properties of the seafloor Wintershall Noordzee BV asked IMARES to perform a baseline study prior to the drilling activities. In the baseline study the following environmental elements are included; seafloor texture and presence of any structures (including stones and boulders), the physical (grain size and organic content), chemical (oil and metal content) and biological (abundance and structure of benthic species) properties of the sediment. At 29 stations located at different angles and distances of the drill site, sediment samples were taken and video recordings of the seafloor made. In an area of 2000 x 2000 m around the centre, side scan sonar footage were made as well.

The fieldwork took place from the 2nd to the 21st of May 2012. IMARES asked DeepOcean B.V. to perform the side-scan sonar analyses and to assist in the sediment sampling and video recordings. The vessel, 'the Noortruck', from Bitunamel Feldmann GmbH c/o OPUS MARINE GmbH, was rented to assist in the survey.

The area around the drilling site can be characterized as homogeneous in biological, physical and chemical properties. The sediment consists of medium to fine sand containing low quantities of organic matter (<0.87 %). No spatial pattern in abundance, species richness, diversity and evenness was detected and also cluster analysis on the benthic species composition did not show the presence of different communities in the samples taken. This corresponds with the homogeneous character of the sediment in the survey area. The benthic community can be described as a *Tellina fabula*-association (represented by *Angulus fabula*), typically found in fine or medium coarse sediment (Rachor & Nehmer, 2003). High densities of *Spiophanes bombyx* individuals (on average nearly two third all individuals recorded) and juvenile Echinoidae were notable. On average 30 different species were found in a single sample, while 123 different species were found in all samples together. The Species Accumulation Curve didn't reach its horizontal asymptote including the 29 samples; therefore, it is likely that more species are present in the area than the 123 identified in this survey. Seven species were recorded that are included in the official red list (Nordheim and Merck, 1995). Two of those (*Glycera unicornis* and *Sigalion mathildae,* both belonging to the Polychaeta) are classified as endangered.

Barium concentrations exceeded background levels reported for Dutch and Danish shelf but were within values reported for the Norwegian shelf. From the metals analysed (barium, cadmium, cupper, iron, mercury, lead and zinc) iron showed the largest variation between stations (RSD of 29.6 %). From the 29 stations / samples taken, 16 stations show mineral oil content above detection limits (>0.2 mg/kg dm). Mineral oil concentrations were always below background levels (<10 mg/kg dm). No patches with markedly high or low metal or oil concentrations were detected.

Contents

1. Introduction

A consortium, consisting of Wintershall Holding GmbH, GdF Suez, RWE Dea and EWE AG, is planning an exploration well in block B11-5, located within the Doggerbank. The drill site is within an 'FFH-area' with a Natura 2000 designation managed through a procedure in the Habitats Directive for the assessment and subsequent decisions relating to activities that possibly have an impact on designated sites. Activities need to be judged on their possible effect on the species or habitat types for which the site is being designated as a Natura 2000 site.

Wintershall Noordzee BV, represented by Mr. Jan Himmerkus, asked IMARES to perform a baseline study that describes the environmental condition of the seafloor at the site prior to the drilling activities. In the baseline study the following environmental elements are included; seafloor texture and presence of any structures (including stones and boulders), the physical (grain size and organic content), chemical (oil and metal content) and biological (abundance and structure of benthic species) properties of the sediment.

At different angles and distances from the proposed drilling site, sediment samples were taken and video recordings of the seafloor were made. In an area of 2000 x 2000 m around centre, side scan sonar footage were made. The fieldwork took place from the 2nd to the 21st of May 2012. IMARES asked DeepOcean B.V. to perform the side-scan sonar analyses and assist in the sediment sampling and video recordings. The vessel, 'the Noortruck', from Bitunamel Feldmann GmbH c/o OPUS MARINE GmbH, was rented to assist in the survey. Unfortunately, the fieldtrip was from time to time characterized by bad weather conditions and broken sampling gear. Nevertheless, all required data and samples could be collected at the end. In a survey report the day to day events of the field work are described (Glorius, 2012).

In this report the followed method in the field- and laboratory work is described. The results of the monitor activities are described and discussed as well.

2. Location

The coordinates of the proposed drill site are: 598359 mE, 6142986 mN (UTM zone 31). The average water depth in the vicinity of the platform is around 40 meters.

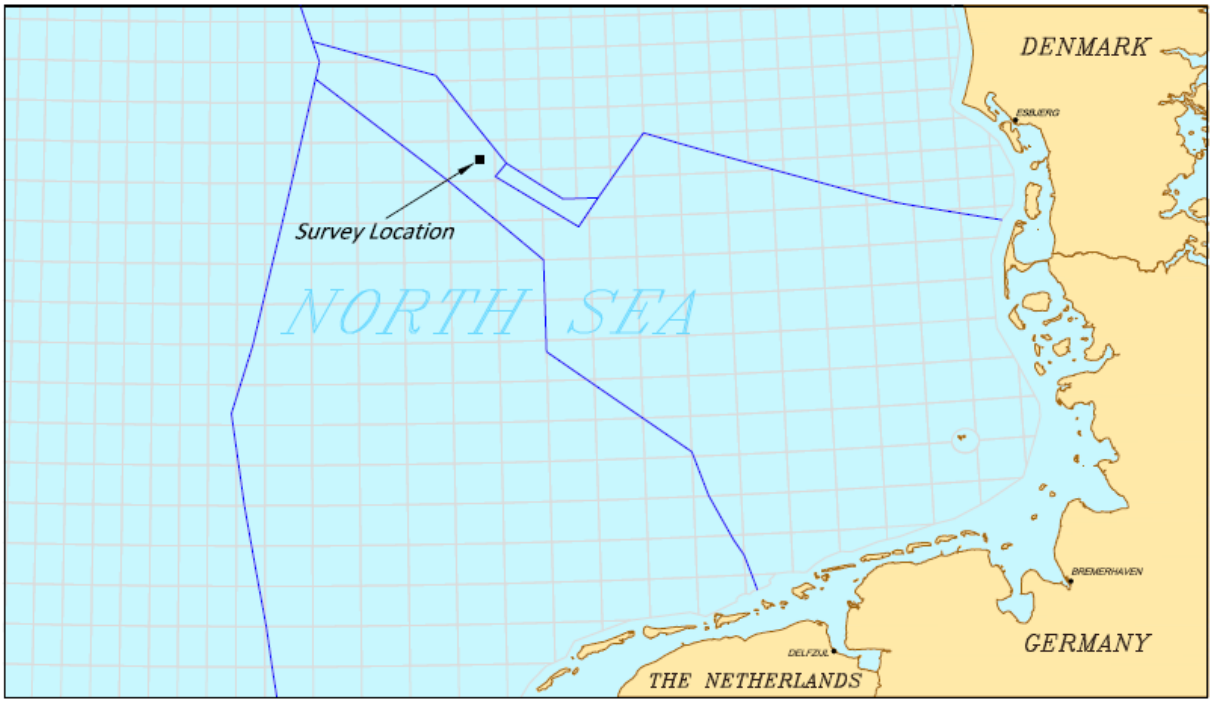

Figure 1: Proposed location B11-5 (source: DeepOcean B.V.).

Because the area has a Natura 2000 designation, assessment and subsequent decisions relating to activities that possibly have an impact are managed through procedures that are written down in the Habitat Directive. These activities need to be judged on their possible impact on particular habitat types or the species that live there. Studies on the long term impacts of discharges of drill cuttings on the Dutch Continental Shelf (Daan *et al.*, 1992) have shown that effect of these contaminated drill cuttings were traceable up to 1000 m from the discharge site, but are generally found in the close vicinity of the platform. To be able to assess the effect of the drilling activities, the environmental conditions prior to the drilling have to be determined (a so called baseline survey). Wintershall Noordzee BV, represented by Mr. Jan Himmerkus, asked IMARES to perform a baseline study for the benthos assessment and side-scan sonar analysis.

IMARES has asked DeepOcean B.V. to perform the side-scan sonar analyses. The vessel, 'the Noortruck', from Bitunamel Feldmann GmbH c/o OPUS MARINE GmbH, was rented to assist in the survey. The fieldwork took place from the 2nd to the 21st of May 2012. The following activities were carried out: side-scan monitor surveys, underwater video recordings of the seafloor and sediment sampling using a box corer. The side-scan was used to construct a map that shows the bathymetry of the area around the platform. Sediment cores were collected to analyse the benthic community, the sediment particle size distribution and the chemical characteristics of the sediment. Video recordings were conducted to obtain a clear visual impression of the seafloor. A day-to-day description of the work carried out at the Noortruck is described in IMARES report C065/12 "*Wintershall 2012 Survey report – baseline study drilling site B11"* published in June 2012.

This report describes the results of the baseline survey in order to facilitate completion of the official requests for the drilling with the German Authorities. This report includes a species list, community analysis, a description of the sediment characteristics and the results of the side-scan sonar.

2.1 Sample locations

Based on a discussion with Wintershall representative the sediment samples and video recordings around the drill site were taken according to the scheme depicted in Figure 2. At the drill site there is no highly dominant direction of water currents. Therefore, sampling effort was not condensed in a particular direction. The stations were located as followed: four stations are situated at a distance of 125m, 250m, 500m, 1000m and 2000m from the drill site at 45 – 135- 225 and 315 degrees. At distances of 1000m from the drill site four additional stations were added located at 0 – 90 – 180 and 210 degrees (station numbers 15, 17, 19 and 21). Reference locations, depicted in a grey colour are located 10.000m away from the platform at 0 – 90 – 180 and 210 degrees. At the drill site (symbol 'p' in *Figure 2*) samples were taken as well.

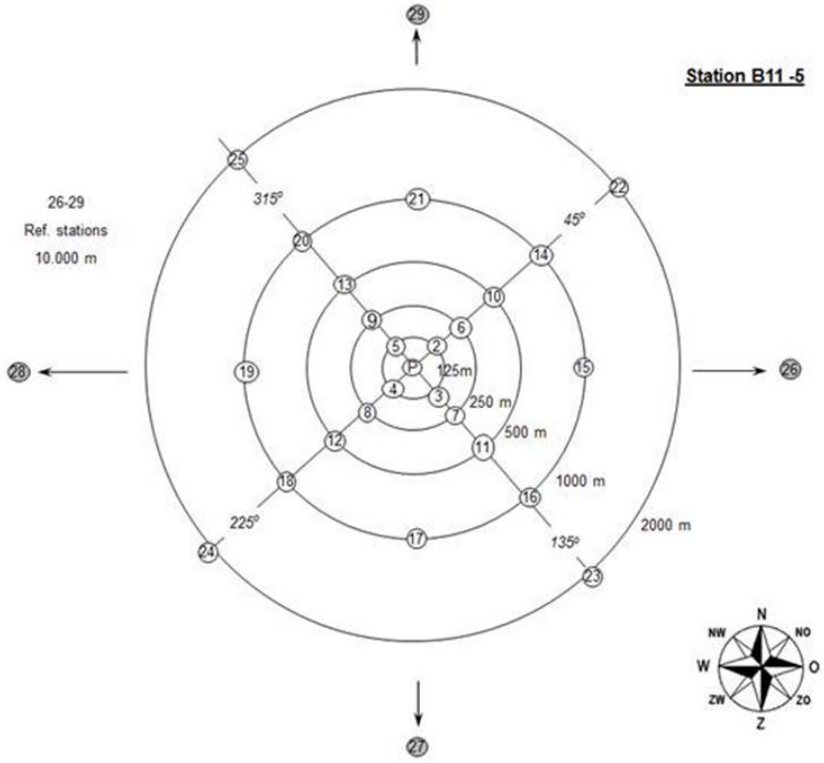

Figure 2: Schematic presentation of the sample locations around proposed drill site 'B11' (depicted with symbol 'p'). The reference locations are depicted in a grey colour.

2.2 Fieldwork

Side-scan monitoring

Side scan sonar is a technique to image the seafloor using sound. It is particularly useful, if a detailed map of the seafloor is required that covers a large area. Sound emitted by the sonar (in the frequency range of 100 – 500 kHz) is scattered and reflected against objects located on the seafloor. The strength and travel time of the sound varies due to the distance between sonar and seafloor and the scattering properties of the floor. By recording both strength and travel time an image of the sea floor can be constructed. The side-scan sonar imaging was carried out by DeepOcean B.V.

The sonar itself is located in a so called 'tow fish' towed behind the vessel by a steel cable. A data cable located in the inner parts of the steel cable was connected to a computer on deck.

An area of 2 by 2 km was surveyed with the side-scan sonar. An image was created from the different side scan sonar bands that show the structure and morphology of the seabed. It will also show the position of stones, boulders or any other solid object when present.

Box-corer for sediment sampling

Sampling of the sediment was carried out by IMARES with assistance of DeepOcean B.V. The device used to collect the sediment was a so called 'box-corer' (Figure 3). A box-corer consists of a frame in which a cylindrical pot is situated in the middle. Several weights are connected to the pot to push it into the sediment once landed on the seafloor. In order to approve the sample, a penetration depth of at least 25 cm was required. A blade, attached to a steel plate, is moved under the pot to trap the sediment after which the sample is recovered. The sampling area of the box-corer is 0.07 m^2 per sample.

Figure 3: Box-corer on deck of the 'the Noortruck' (left), employment of box-corer (middle) and sieving of a sediment sample (right).

At each station five sediment samples were taken when possible. Three sediment samples (cores) were taken to study the macrozoobenthic community. The other two sediment samples (cores) were used to collect material for chemical analysis.

The following procedure was followed:

1. The box-corer was lowered to the seafloor using the ship's main crane. Once at the seafloor the depth, current and global position was measured by the surveyor and recorded in an excel file. When the corer hits the seafloor a pin unhooks itself automatically and the pot is pushed several decimetres (with a minimum of 25 cm to approve the sample) into the sediment with the assistance of the weights. When the corer is lifted a plate is moved underneath the pot closing it during recovery.

2. On deck the pot is removed from the corer frame and placed above a sieve with a mesh size of 1 mm. Any water standing above the sediment in the pot is removed and a photograph is taken of the sediment surface together with information of the station (nr. and site). The distance between the top of the pot and sediment surface is measured and noted. The pot is removed and the depth of the oxic layer is measured based on colour differences and recorded together with the type of sediment (clay or sand, presence of shells and gravel).

3.a From the samples taken for macrofauna characterisation a small subsample was taken of the top 5 cm, using a tube. This sample was used for the determination of the sediment particle size distribution. The remaining material was rinsed with sea water over a sieve with mesh size of 1 mm to remove sand and clay particles. From the remaining material (biota, shells, stones and other particles) a photograph was taken, after which the sample was stored in a polyethylene container. The sample was preserved with 6-10 % buffered formaldehyde in seawater solution.

3.b From each of the sediment cores taken for chemical analysis the top 2 cm was scraped off, homogenized and divided over two glass jars with a Teflon cap inlay. One sample was used for analysis of the metal concentrations and one for analyses of the hydrocarbon concentration.

Video sampling and recording

Video recordings of the seafloor were carried out by IMARES with assistance of DeepOcean B.V. An underwater camera was placed in a steel housing. Led lights provided extra illumination of the seabed. A specific pyramid-shaped housing was used that allows for video sampling in turbid water (*Figure 4*). The camera was lowered by the ship's crane. Once the camera hovered above the seafloor the ship was moved slowly over a distance of around 10 – 20 meters. Whenever interesting species / sea bed structures were spotted a picture was taken and stored on a hard disk. The video image of the entire scan was recorded and stored as well.

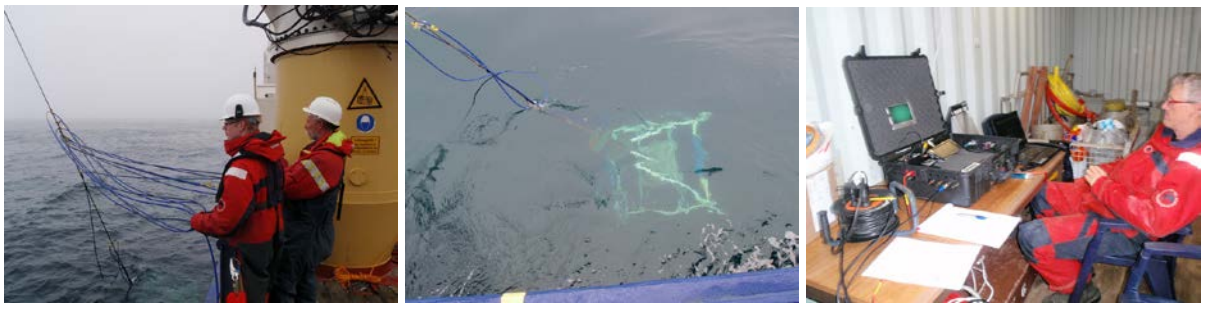

Figure 4: Employment of frame holding video equipment (left & middle), recording of video footage on deck (right).

2.3 Laboratory work

Macrofauna characterisation

One of the three macrofauna samples taken from each station was analysed. The other two samples were stored and remain available for additional examinations until the end of the project. The samples that were analysed to study species compositions are the same as the samples that were analysed for sediment characteristics (grain size distribution).

Collected macrofauna were examined and identified under a stereomicroscope. Photographs were examined and species were identified from screen. Standard taxonomic keys and references were used to identify each taxon. Macrofauna has been counted and identified at species level when possible. Data is presented as species-abundance data in this report. Species that proved difficult in its determination were kept aside for further examination. Juveniles, whose species-specific features are not sufficiently developed, are mentioned as “spec. juv.”.

Analysed samples will be stored at IMARES after enumeration for a period of 5 years after completion of the project (*i.c.* Dec 2018). This period can be prolonged to the client wishes. Examples of the benthic species were taken up in the Taxonomic Reference Collection that has been maintained for several years at IMARES as part of their QA procedures.

Chemical & physical characterisation of the sediment

Chemical analysis was conducted for a single sample of each of the stations. Duplicate samples are stored at -20°C for maximally 1 year. Chemical analyses were performed by TNO Triskelion BV situated in Zeist, The Netherlands.

Dry weight and organic content
Sediment was dried at 105 ^{0}C to constant weight for determination of the dry weight. Organic content and lime concentration was determined by thermo-gravimetric analysis using a LECO TGA 701. In the analysis the weight loss is determined by 450, 550 (for organic matter) and 800 and 1000 °C heating (for lime content).

Grain size distribution
Determination of the grain size distribution was carried out with the use of ‘Malvern 2000 mastersizer’. This device uses a laser beam to determine the grain size based upon the correlation between grain size and scatter. The procedures used were as follows: A subsample of 5 gram is placed in ultrasonic bath. This sample is pumped through a measuring tube for five minutes over a focussed laser beam. The angular intensity of the scattered light is measured by a series of photosensitive detectors. From this information the particle size distribution is calculated and classification of the grain size is done according to ISO 14688-1 (Appendix A).

Hydrocarbons
In each of the selected samples, hydrocarbons (C_{10} – C_{40}) were measured using GC-FID (Gas Chromatography Flame Ionisation Detection). Detection limits for the hydrocarbon analyses are 2 mg/kg.

Metal analysis
The sediment concentration of the following metals were determined; barium, cadmium, copper, zinc, lead, mercury and iron. A part of the sample was digested with nitric acid and hydrogen peroxide according to TNO regulation LSP/108. The concentration of the heavy metals is determined in the

produced solution with an ICP-MS according to TNO regulation LSP/055. Quantification takes place according to an external calibration standard. To correct for fluctuations within the apparatus an internal standard is used (rhodium).

2.4 Data analysis

Abundance

Total abundance was calculated by dividing the total number of species found at each location by the sampled area (0.072 m^2). Numbers are presented as the average number of species per square meter.

In Appendix C species are listed which were excluded from data analysis (Table 8). Species were excluded when they are not typical benthic, but for instance planktonic. In Appendix B the species abundance data is tabulated.

Preparation of the dataset prior to further analysis

Species that could only be identified up to genus or family level were pre-processed prior to further data analyses (diversity, evenness, richness). Especially juvenile or larval species are subject to incomplete identification because species specific characteristics are not always fully developed.

In Appendix C an overview is given of the species that were excluded prior to further data analyses (Table 9). With the given motivation the group (family, subfamily, subclass, class, order) of species is too large and overlap with other species belonging to that specific group is possible. When other species belonging to the same group were found, the juvenile species were excluded.

Diversity and evenness

The species diversity index was calculated with the use of Shannon-Wiener Index (equation 1). This index measures the order (or disorder) within a sample taking both the evenness as the number of species into account. The number increases by an increasing number of species but also with greater species evenness.

$$H = -\sum P_i(\ln P_i) \qquad \text{Equation 1}$$

H = Species diversity
P_i = Share of species compared to total amount of species

Evenness was calculated using Pielou's evenness index, see equation 2. This is a measure of how similar the abundance is distributed over the different species. When evenness has the value of 1 all individuals are distributed similar over the species. The evenness value decreases with increasing dissimilarity.

$$E = \frac{H}{\ln(S)} \qquad \text{Equation 2}$$

E = Evenness
H = Species diversity
S = Number of species

Both diversity and evenness (Pielou's) were calculated in R (R Development Core Team, 2012), making use of functions forms the "vegan" package (Oksanen *et al.*, 2012).

Richness

The amount of species found in each sample (= location) is used in the analyses to compare difference between sites. However, the observed number of species will always be a downward estimator of the complete species richness in an assemblage at any site as especially rare species are subject to exclusion in individual samples. With increasing effort (samples taken) more species will be 'discovered' increasing the observed species richness.

To obtain insight in the relation between effort and species richness a Species Accumulation Curve is constructed. In this graph the accumulation of species is plotted against sample number. Calculations are carried out in R environment (R Development Core Team, 2012), making use of available functions within the vegan package (Oksanen *et al.*, 2012).

Variation

Variation between samples is visualized with barplots, bubble plots and boxplots. The box of the boxplot contains 50% of the values and the fat horizontal line the median. Outliers (marked by circles) are outside 1.5 times the interquartile range (= difference between upper- and lower quartile). Both whiskers of the box are drawn up to the last value that is inside 1.5 times the interquartile range.

As another measure of variation, both minimum and maximum values are given. Also the standard deviation (of a sample) is calculated as well as the relative standard deviation (RSD) The RSD (similar to variation coefficient) shows the extent of variation in relation to the mean. The RSD gives the standard deviation as part of the mean value, expressed as a percentage

Multivariate analysis

A cluster analyses was carried out to identify groups of stations that show similarity in both species presence as abundance. As input for the clustering of the samples a Bray-Curtis dissimilarity matrix constructed with (none transformed and fourth root transformed) species abundance data (Equation 3) was used. The Bray-Curtis metric is bound between '0' and '1'. When two samples are identical a value of '0' is obtained, when none of the species is shared a value of '1' is obtained. The Bray-Curtis dissimilarity is directly related to the Sørensen similarity index (by 1 minus the Bray-Curtis value) and can also be expressed as a percentage.

$$BC\_dis = \frac{\sum_{j=1}^{J} \left| n_{ij} - n_{i'j} \right|}{n_{i+} + n_{i'+}}$$ Equation 3

A cluster analyses was carried out and clusters were made visible in a dendrogram (average linkage). Calculations were carried out in the R environment with functions available in the "vegan" package (Oksanen *et al.*, 2012).

3. Abiotic conditions

In the following paragraphs abiotic conditions of the survey area are described. The structure of the seafloor is described on the basis of the side scan sonar images and video recordings. Sediment and chemical characteristics, as well as depth recording are based upon local sampling at the stations.

3.1 Structure seafloor and water depth

The average water depth at the sample locations is 37.7 meter. The maximal difference in water depth between locations is around 12 meter (min 31.9m, max 43.8m). The shallowest stations are located in the North of the area, the deepest stations in the Southern parts.

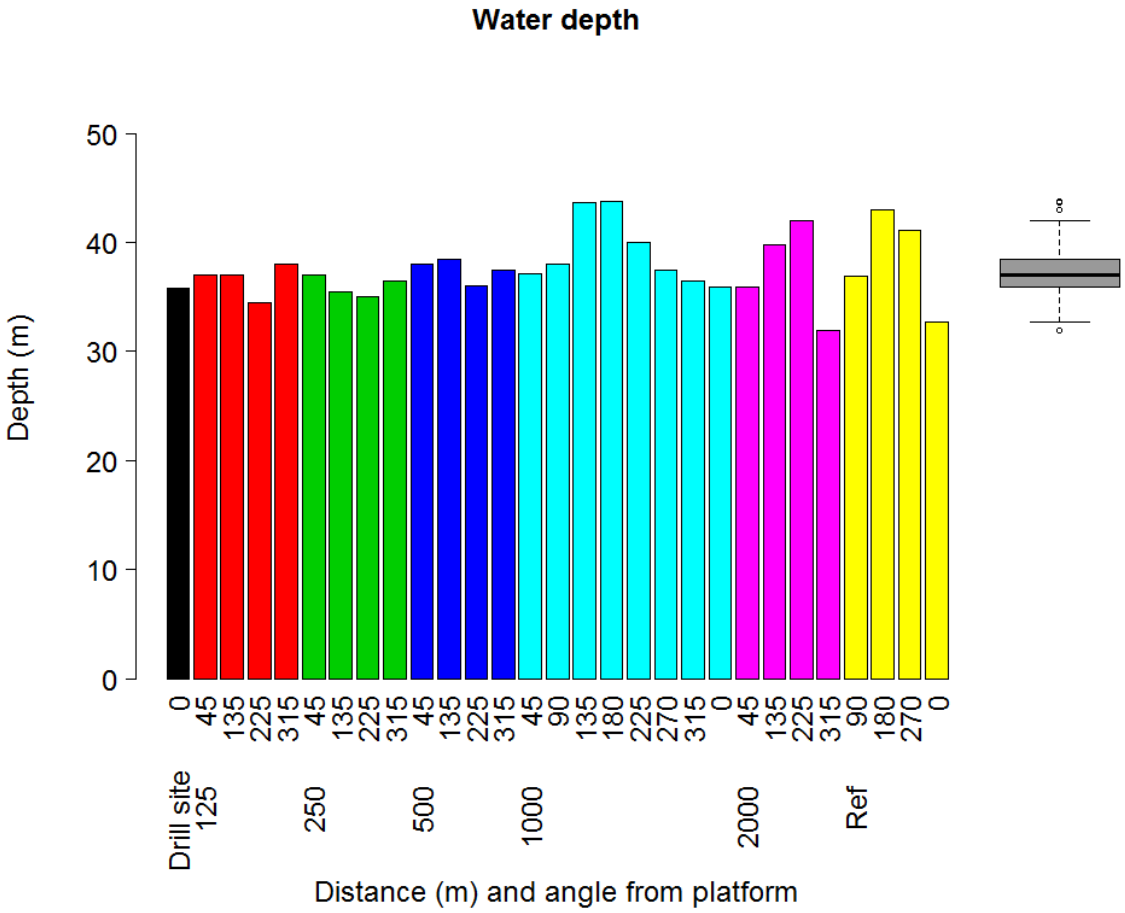

Figure 5: Water depth at the sample stations.

The surface of the seafloor surrounding the drill site surveyed with the side scan sonar can be characterized as homogenous and sandy, see *Figure 6*. In Appendix D the side scan sonar mosaic can be found in more detail. No boulders or patches of other substrate types were identified. Fishing activities, marked by trawl tracks, were found in the whole area. The homogeneous nature of the area is supported by the video recordings which also show a very homogenous sandy area, with rather evenly distributed shells on the surface. Between small sand ripples formed by currents, some fine peat remnants seem to accumulate.

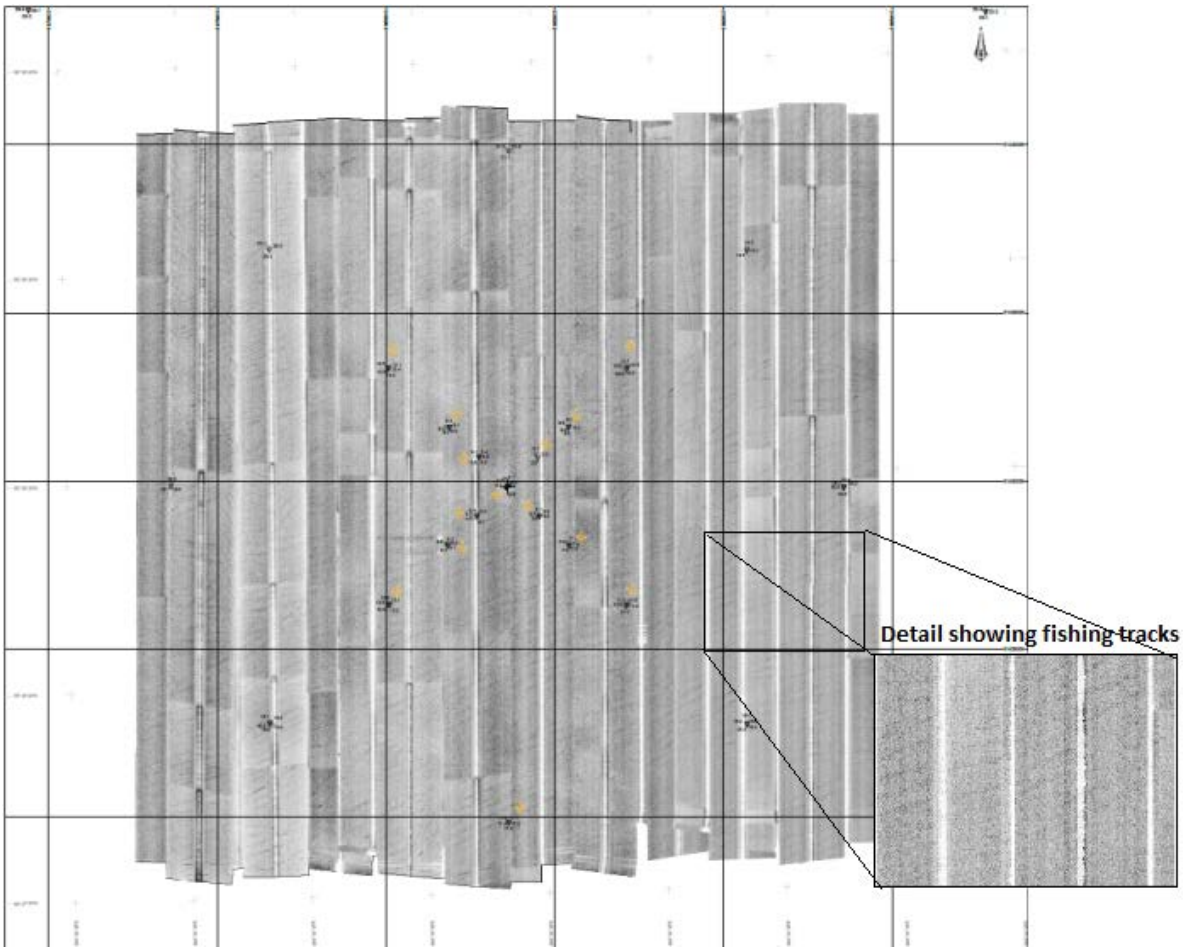

Figure 6: Side scan mosaic showing morphology (grey background) boxcorer sample locations (black spots) and video recordings (yellow spots).

3.2 Sediment characteristics

The sediment can be characterised as low organic, medium sand. The low average uniformity coefficient of 1.65 tells that sediment particles are narrow grained (consisting mainly of certain particle sizes) which can be seen in Figure 7. No particles >500 µm were found in the grain size samples. This means only very little shell fragments are present in the sediment, although large shells were visible in the video surveys. Variation between stations is limited. This limited variation is for instance shown by a relative standard deviation <4% for the median grain size and uniformity coefficient. The average characteristics are given in Table 1. The results for the individual stations are listed in Appendix E.

Table 1 *Summary of physical characteristics of the sediment. OC = Organic Carbon (Loss on ignition at 450 ^{0}C), SD = Standard deviation, RSD = Relative Standard deviation.*

	OC (%)	Fraction <63 µm (%)	Median grain size (µm)	Uniformity coefficient
Average	0.531	1.62	193.2	1.647
Maximum	0.866	4.22	207.7	1.747
Minimum	0.320	0.00	164.9	1.576
Difference max / min (factor)	2.7	-	1.3	1.1
SD (-)	0.110	1.23	8.3	0.036
RSD (%)	21	76	4	2

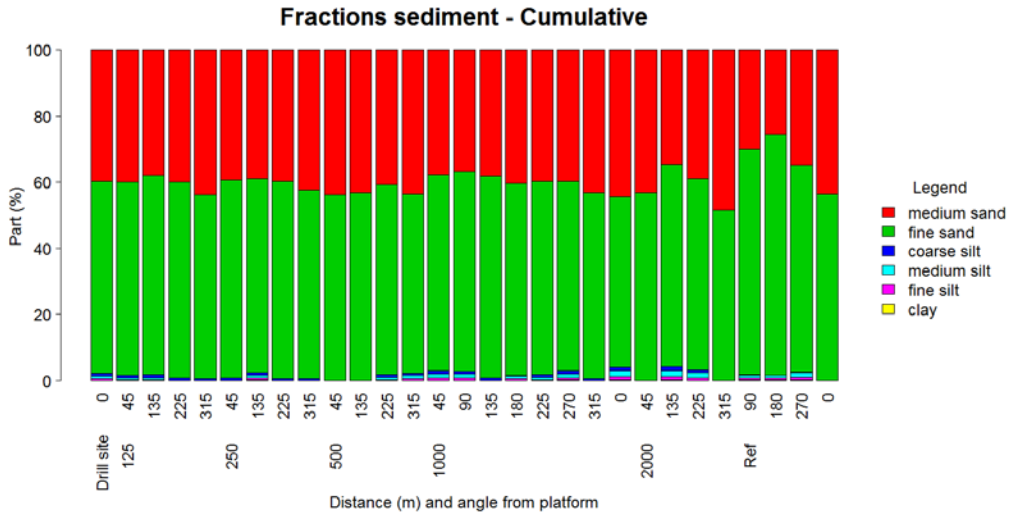

Figure 7: *Surficial sediment fractions at the different sample stations.*

3.3 Sediment chemistry

The variation in metal and mineral oil concentration in the sediment are summarized in *Table 2*. The complete list for all stations is given in Table 12 in Appendix F.

Table 2: Summary chemical characteristics of the sediment. MO = Mineral Oil content. SD = Standard deviation, RSD = Relative Standard deviation, dm = dry matter.

	Ba	**Cd**	**Cu**	**Fe**	**Hg**	**Pb**	**Zn**	**MO**
Average (mg/kg dm)	210	<0.05	1.00	2024	<0.02	7.0	11.7	3.04
Maximum concentration(mg/kg dm)	240	-	1.50	4000	-	8.7	21.0	7.40
Difference max/min (factor)	1.4	-	1.9	3.1	-	1.6	2.3	-
SD (mg/kg dm)	16	-	0.19	600	-	0.69	2.3	1.37
RSD (%)	7.5	-	19.2	29.6	-	9.9	19.9	45.0
Background levels	*20–60*[2] *7 – 160*[3] *6 – 544*[4]	*0.2*[1]	*20*[1]	-	*<0.05*[1]	*25*[1]	*90*[1]	*10*[2]

[1] *OSPAR (2009).(OSPAR region)*

[2] *Groenewoud et al., 1999. (Dutch continental Shelf)*

[3] *VKI 1999. (between 1989 – 1998 in Danish sector)*

[4] *Carrol et al., 2001 (Norwegian shelf).*

The average barium concentration was 210 mg/kg dry matter. No documentation on barium background concentrations for the German continental shelf was found. Barium concentrations measured in this study exceeded background values reported for the Dutch and Danish region. However concentrations are within the range of background barium concentrations reported for the Norwegian shelf. The other metals analysed, copper, mercury, lead and zinc, did not exceed background levels for any of the stations (Table 2). No spatial pattern in metal content was observed; see bubble plots in Appendix F.

For 17 out of 29 stations mineral oil content was above detection limits. The mineral oil content was, however, always below background levels and mainly consisted of the fraction C25-C40. The highest concentrations were found at stations 500 meter south-west of the drill site, with values of 7.4 and 5.6 mg/kg dm.

4. Benthos community

The benthos community is presented on the basis of the community indices abundance, richness, diversity and evenness in paragraph 4.1 and on the basis of cluster analysis in paragraph 4.2. In paragraph 4.3 the species occurring on available red lists of North Sea species are listed.

Organisms that could only be identified up to genus- or family level were pre-processed prior to data analyses (See paragraph 2.4). In Appendix C an overview is given of the species that were combined or excluded prior to the data analyses.

4.1 Community indices

The average abundance of the macrozoobenthos at all stations is 12.819 ind/m^2 (*Table 3*). The highest abundance was observed at station 22 (22.764 ind/m^2), while Southern reference station showed lowest abundance (3403 ind/m^2). The abundance showed considerable variability (*Figure 8*).

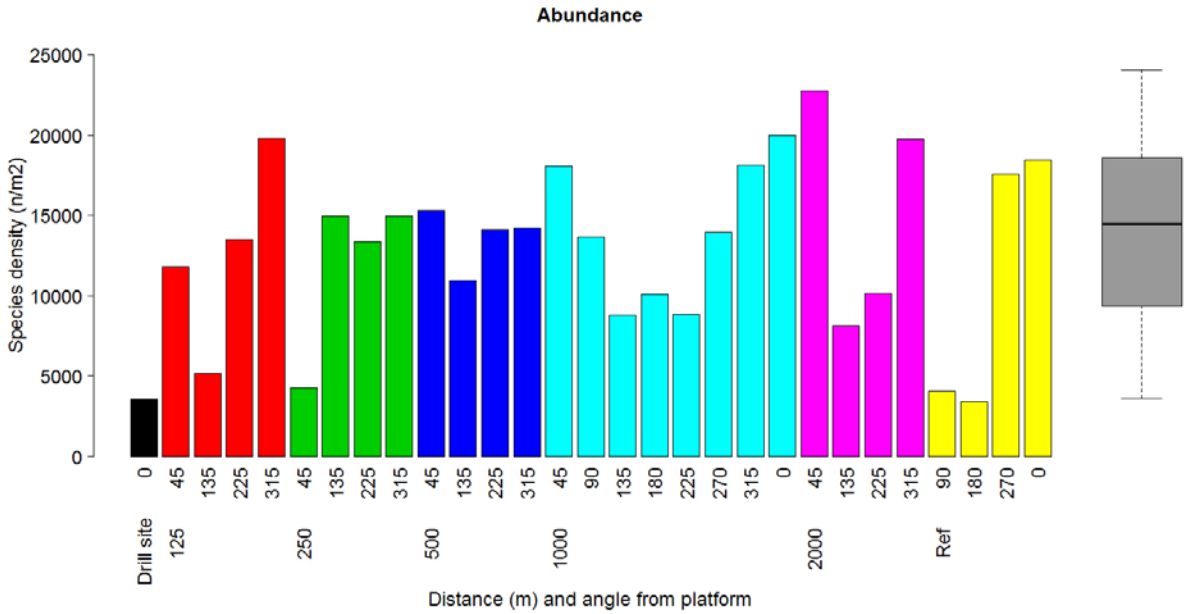

Figure 8: *Total abundance as density per square meter. The colours correspond with distance from drill site.*

The Polychaete *Spiophanes bombyx* (bristle worm) was the most abundant species, followed by juvenile Echinoidae. The Polychaetes *Magelona filliformis, Scoloplos armiger* and *Phyllodoce groenlandica* were present in almost all stations (>80%) and, compared to the other species, with relative high abundances (>6 individuals per station on average). The same is true for the Amphipod *Bathyporeia tenuipes*.

Spiophanes bombyx (*Figure 9*) was found at all stations with an average of 9079 ind/m^2, which is on average more than two thirds of all individuals! The highest numbers were found at stations 28, 22 and 5, with approximately 15.000 ind/m^2 (Appendix G, *Figure 21*). This bristle worm is typically found in high densities on fine sand substratum (Ager, 2009). It is regarded as a typical 'r' selecting species with a short life span and high dispersal potential and high reproductive rate (Krönke, 1990).

The average number of juvenile Echinoidae (*Figure 10*) was 2031 ind/m^2, which is about a quarter of the number of *S. bombyx*. The highest numbers of juvenile Echinoidae were found at station 20 (6931 ind/m^2), station 19 (5750 ind/m^2) and station 25 (5319 ind/m^2), see also Appendix G. No juvenile Echinoidae were found at stations 1 (drill site), 2 and 27.

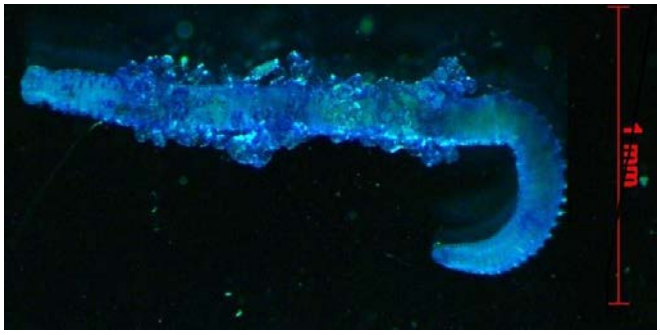

Figure 9: Spiophanes bombyx *(polychaeta)*

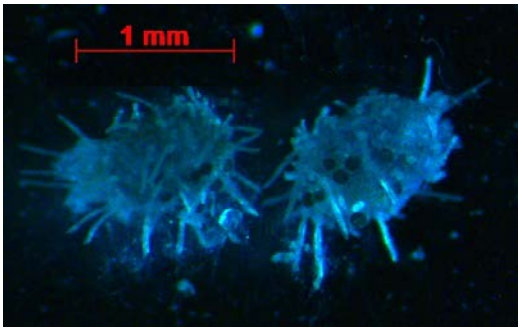

Figure 10: *Echinoidae (juvenile)*

When looking at the number of different species found at each station (Richness, *Table 3*) it can be seen that station 1 (drill site) is lowest in richness, only 20 species were recorded there. Station 4 is highest in richness with 43 different species. On average 30 different species per station were recorded. The total number of species identified (considering all stations) is 123. Stations with relative high or low species richness are not grouped together, but occur all over the survey area (*Figure 11*).

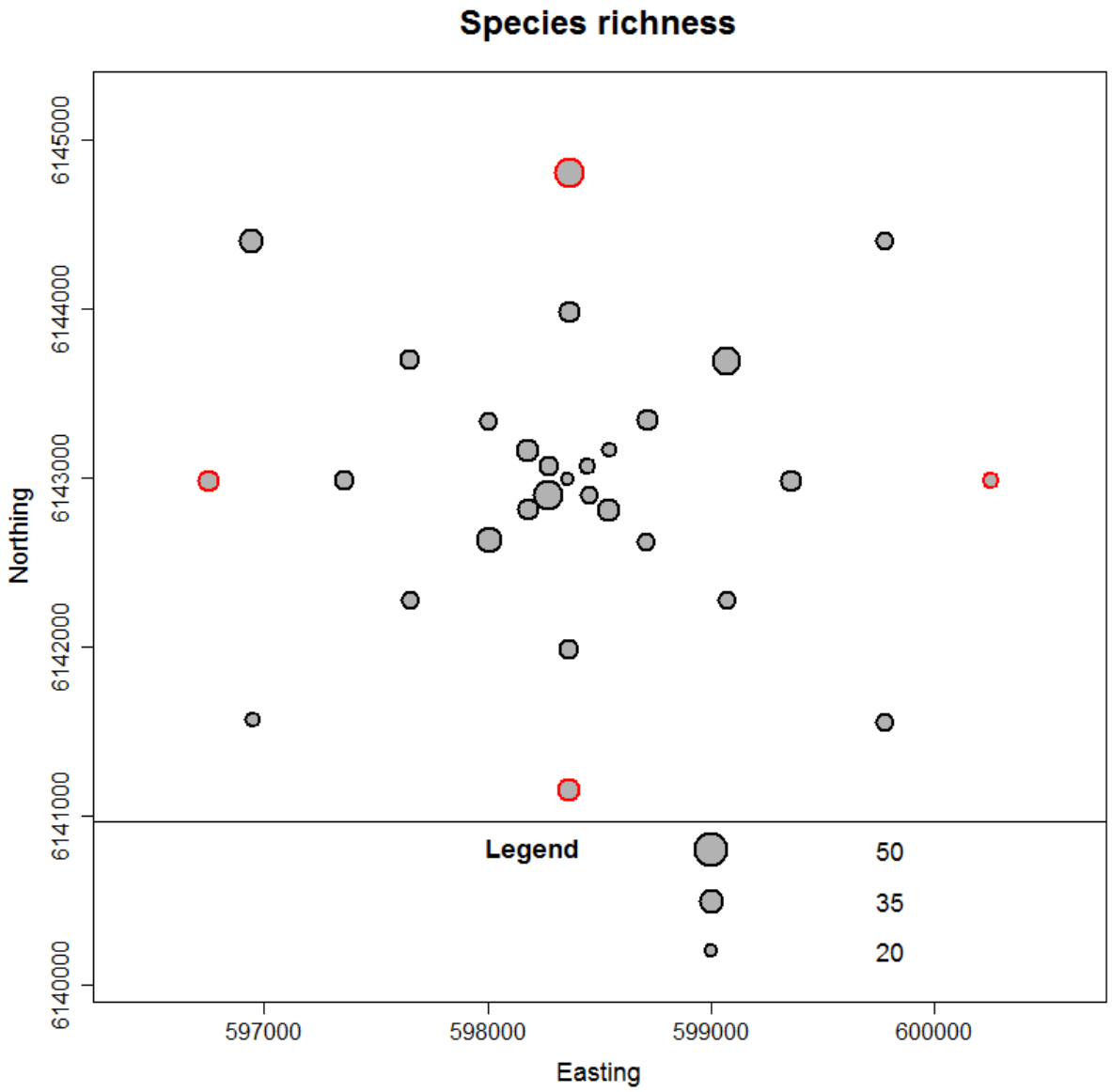

Figure 11: *Spatial distribution of species richness in the study area. Red encircled circles are the reference stations in reality further away in Northern, Eastern, Southern and Western direction from drill site.*

The diversity index (calculated as Shannon-Wiener Index H) was on average 0.98 in the area (*Figure 12*, *Table 3*). The highest diversity was found at the Eastern and Southern reference stations, with H-values of 2.06 and 2.24, followed by station 6, with an H-value of 1.70. The lowest diversity was found at Western reference station with an H-value of 0.50. At the Western reference station the lowest evenness was found as well with a value of 0.15. The highest evenness was found the Southern and Eastern reference stations, with an evenness value of 0.65 and 0.60, followed by station 6, with an evenness value of 0.55. The average evenness in the study area was 0.29. Because evenness was not close to 1 for any of the stations, species were not evenly distributed among the different taxa. Instead, stations were numerically dominated by a single species (*Spiophanes bombyx*). When this species is excluded from the dataset, diversity and evenness values increase (around threefold) and variation between the

stations decreases. The RSD decreases for both diversity and evenness from around 40% to around 5 - 6%. See also bar plots in Appendix G.

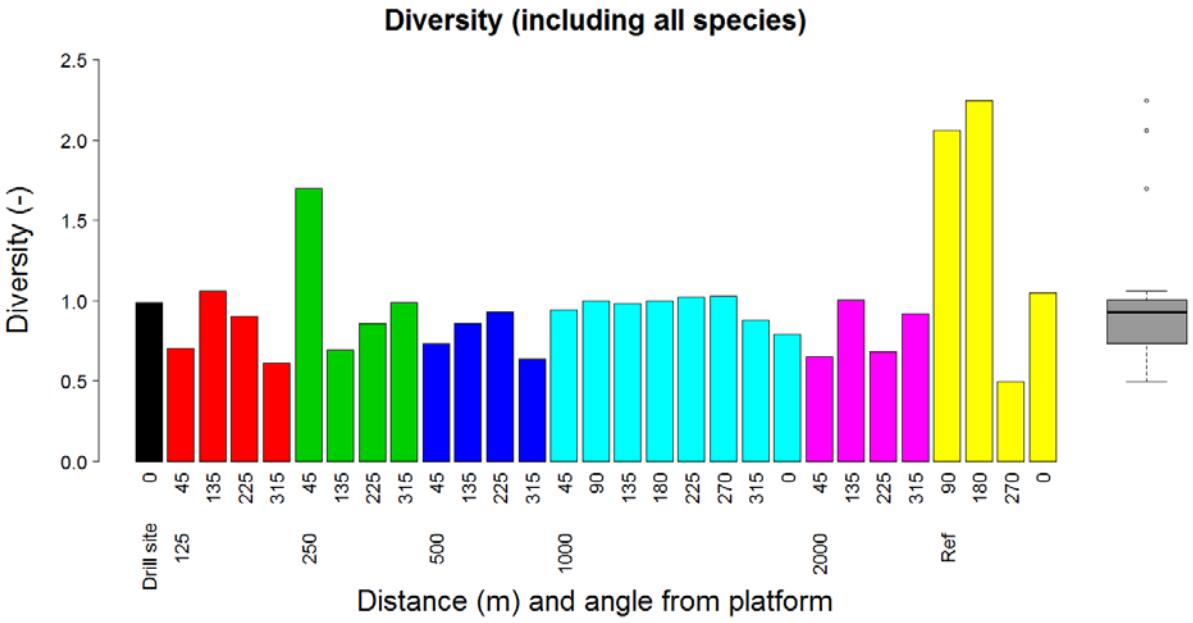

Figure 12: Diversity (calculated as Shannon-Wiener Index H). The colours correspond with distance from drill site.

Table 3: Summary of community indices B11-5, May 2012. The indices for individual locations are given in Appendix C.

	Abundance (n ind / m²)	**Species richness (-)**	**Diversity (-)**	**Evenness (-)**
Average	12819	30	0.98	0.29
Maximum	22764	43	2.24	0.65
Minimum	3403	20	0.50	0.15
Difference max / min (factor)	7	2	4.52	4.19
SD (-)	5466	6	0.39	0.12
RSD (%)	43	19	40	40

4.2 Community structure

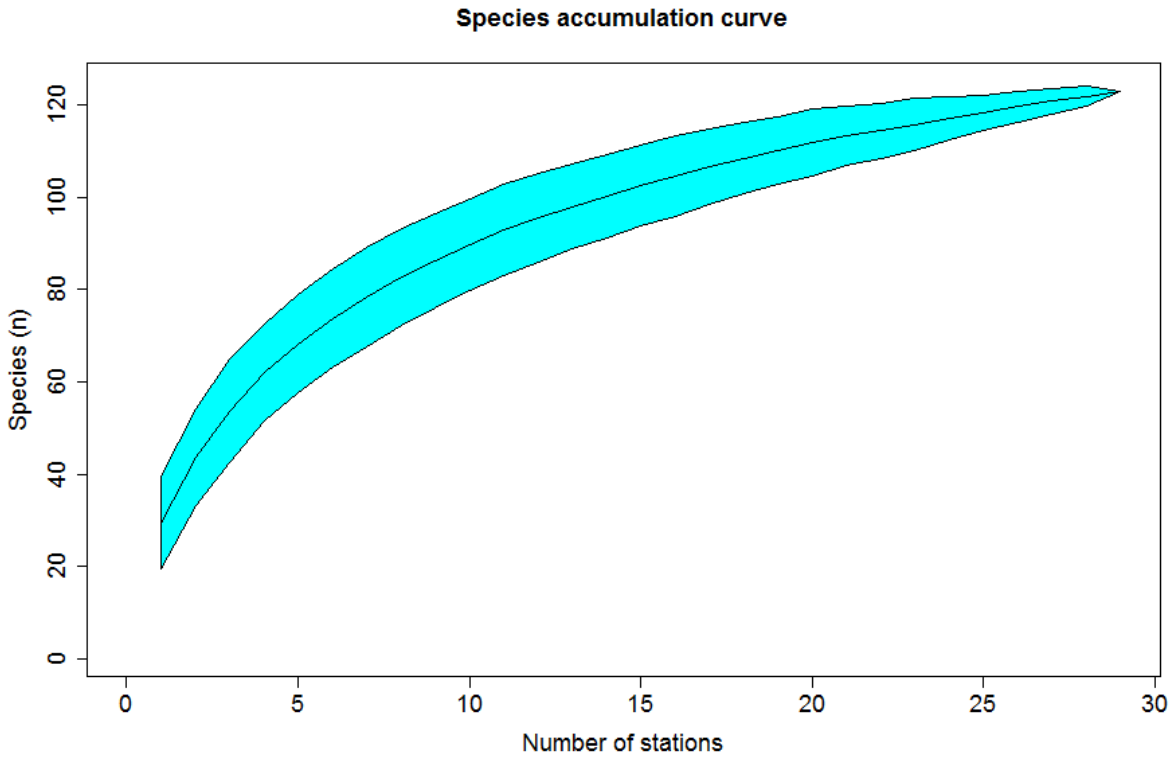

Figure 13: *Species accumulation curve showing the relation between the number of samples and the cumulative number of different species found in the samples. The line in the polygon represents the mean number of species for all possible combination, the polygon shows the standard deviation from random permutations (n=100) of the data. All 29 stations are used as input.*

In *Figure 13* the species accumulation curve (SAC) is shown that was constructed using species presence data of all sampled stations (n=29). The more species in an assemblage and the more even those species are distributed the more rapidly the curve will rise and the horizontal asymptote reached. In contrast, when species abundance distribution is highly uneven the curve will rise less rapidly.

The total number of species found was 123 while on average 29.6 species were found in single samples. This means (as a measure of beta diversity) that the whole collection of samples (n=29) contains 3.15 times the number of species of the average site. This uneven distribution of species is also reflected in the species accumulation curve shown in *Figure 13*. As the SAC has not reached its horizontal asymptote it is unlikely that all species in the community were collected by taking 29 samples.

In *Figure 14* the dominant role of *Spiophanes bombyx* and juvenile Echinoidae in the benthic community can be seen. In the left dendrogram (including both species) three clusters of similar stations can be identified more or less. Looking at the different angles and distances from the platform of the samples in each cluster, it can be seen that the clusters are not spatially ordered. When *Spiophanes bombyx* and juvenile Echinoidae are excluded from the analyses clear clusters disappear. Stations have similarity of around 50%.

A similarity of around 50% is not surprising considering a beta diversity of 3.15; each station (sample) contains just a small part of the total species present and it is likely that additional new species are collected in every subsequent sample taken making the samples less similar to each other.

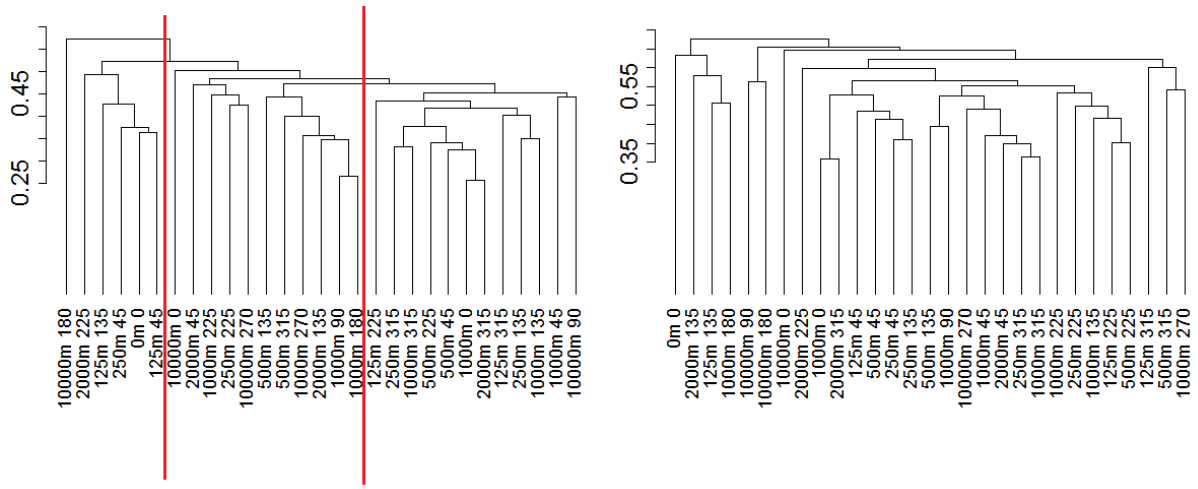

Figure 14 *Dendrograms showing the dissimilarity between samples based on species abundance data. In dendrogram on the left all species are included (abundance data was fourth root transformed). In the dendrogram on the right Spiophanes bombyx and that occurred with very high densities was excluded.*

The benthic community can be described as a *Tellina fabula*-association (represented as *Angulus fabula*), typically found in fine or medium coarse sediment (Rachor & Nehmer, 2003). Associated species are Polychaeta *Spiophanes bombyx* (*Figure 9*) and *Magelona filiformis* (*Figure 15*) and the Amphipod *Bathyporeia guilliamsoniana* (*Figure 16*).

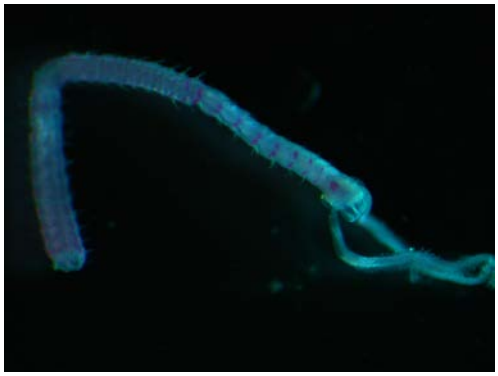

Figure 15: *Magelona filiformis (Polychaeta) (Foto: IMARES)*

Figure 16: Bathyporeia guilliamsoniana (Amphipoda) *(Foto: WoRMS)*

4.3 Red list species

Seven species found could be classified in the official red-list (Von Nordheim & Merck, 1995). The species are tabulated in *Table 4*, making explicit at which number of stations the species were found as well.

Table 4: Occurrence of species on the official red list (Von Nordheim & Merck, 1995).

Phylum	Genus	Species	Category	Nr. Stations
Annelida	*Glycera*	*unicornis*	p	1
Annelida	*Magelona*	*alleni*	II	3
Annelida	*Sigalion*	*mathildae*	p	8
Echinodermata	*Amphiura*	*chiajei*	II	1
Echinodermata	*Amphiura*	*filiformis*	3	4
Mollusca	*Corbula*	*gibba*	3	3
Mollusca	*Phaxas*	*pellucidus*	3	8

Categories are: 1= endangered, p = potential in danger, II = becoming in danger, 3 = at risk.

Much more species (24 in total) are taken up in the unofficial red-list (version 2010). Note that 12 species are categorised “D”, meaning that data is insufficient. The species are tabulated in *Table 5*, making explicit at which number of stations the species were found as well.

Table 5: Occurrence of species from the provisional red list (2010).

Phylum	Genus	Species	Category	Nr. Stations
Annelida	*Glycera*	*unicornis*	D	1
Annelida	*Eunereis*	*elittoralis*	D	2
Annelida	*Pholoe*	*inornata*	**R**	3
Annelida	*Eteone*	*spetsbergensis*	D	1
Annelida	*Malmgrenia*	*andreapolis*	D	2
Annelida	*Malmgreniella*	*castanea*	D	3
Annelida	*Scalibregma*	*inflatum*	**G**	7
Annelida	*Sigalion*	*mathildae*	**3**	8
Annelida	*Sthenelais*	*boa*	**G**	4
Annelida	*Spio*	*decoratus*	D	15
Annelida	*Exogone*	*naidina*	D	5
Arthropoda	*Hemilamprops*	*roseus*	D	1
Arthropoda	*Tryphosella*	*horingi*	**R**	1
Arthropoda	*Megaluropus*	*agilis*	**V**	11
Arthropoda	*Synchelidium*	*haplocheles*	**V**	4
Arthropoda	*Westwoodilla*	*caecula*	D	5
Arthropoda	*Pseudocuma*	*longicorne*	D	22
Echinodermata	*Amphiura*	*chiajei*	**R**	1
Echinodermata	*Astropecten*	*irregularis*	**G**	1
Echinodermata	*Echinocyamus*	*pusillus*	**G**	1
Echinodermata	*Echinocardium*	*flavescens*	**G**	1
Mollusca	*Abra*	*prismatica*	D	6
Mollusca	*Dosinia*	*lupinus*	D	5
Cnidaria	*Cerianthus*	*lloydii*	**V**	8

*Categories are: D = Data insufficient, **G** = danger of unknown dimension, **R** = extremely rare, **3** = at risk, **V** = Potential at risk/important.*

Three species are categorised as “R”, extremely rare: *Pholoe inornata* (Figure 17), *Tryphosella horingi* and *Amphiura chiajei* (Figure 18) and one species is recorded as “3”, at risk: *Sigalion mathildae (*Figure 19*)*.

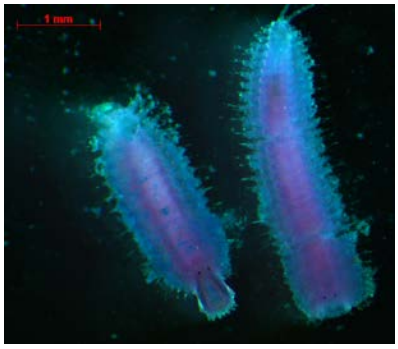

Figure 17: Pholoe inornata (Polychaeta)

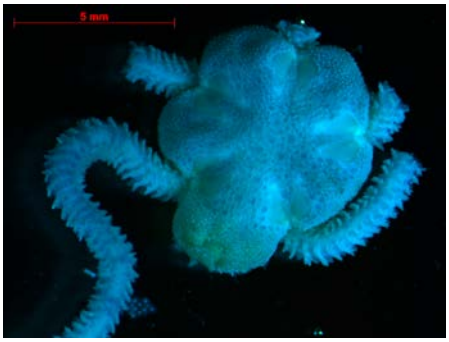

Figure 18: Amphiura chiajei (Echinodermata)

Figure 19: Sigalion mathildae (Polychaeta)

5. Conclusions

The grain size distribution of the sediment samples taken in the area of B11-5 consisted of medium to fine sand containing low quantities of organic matter (<0.87 %). There was little spatial variation in grain size distribution and no patches of different sediment types were discovered. This observation could be confirmed by both the side scan sonar mosaic and video recordings which show the homogeneous and sandy character of the seafloor as well.

No spatial pattern in abundance, species richness, diversity and evenness was detected and also cluster analysis on the benthic species composition did not show the presence of different communities in the samples taken. This corresponds with the homogeneous character in sediment type around the drill site. The benthic community could be described as a *Tellina fabula*-association (represented by *Angulus fabula*), typically found in fine or medium coarse sediment (Rachor & Nehmer, 2003). High densities of both *Spiophanes bombyx* individuals (on average nearly two third all individuals recorded) and juvenile Echinoidae were notable. The high density of *Spiophanes bombyx* also explained the variation in diversity and evenness between samples for a large part. A rather low similarity in remaining species composition, of around 50%, between the samples was found. On average 30 different species were found in a single sample, while 123 different species were found in all samples together. The Species Accumulation Curve didn't reach its horizontal asymptote including the 29 samples; therefore it is likely that more species are present in the area than the 123 identified in this survey. Seven species were recorded that are included in the official red list (Nordheim and Merck, 1995). Two of those (*Glycera unicornis* and *Sigalion mathildae,* both belonging to the Polychaeta) are classified as endangered.

Barium concentrations were within background levels reported for the Norwegian shelf but were higher than values reported for the Dutch and Danish shelf. All other metals analysed (cadmium, cupper, iron, mercury, lead and zinc) did not exceed reported background values. Iron showed the largest variation between stations (RSD of 29.6 %). From the 29 stations / samples taken, 16 stations show mineral oil content above detection limits (>0.2 mg/kg dm). Mineral oil concentrations were always below background levels (<10 mg/kg dm). No spatial pattern in metal and mineral oil content was detected.

6. Quality Assurance

IMARES utilises an ISO 9001:2008 certified quality management system (certificate number: 124296-2012-AQ-NLD-RvA). This certificate is valid until 15 December 2015. The organisation has been certified since 27 February 2001. The certification was issued by DNV Certification B.V. Furthermore, the chemical laboratory of the Fish Division has NEN-EN-ISO/IEC 17025:2005 accreditation for test laboratories with number L097. This accreditation is valid until 1th of April 2017 and was first issued on 27 March 1997. Accreditation was granted by the Council for Accreditation.

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Justification

Report number : C098/13
Project number : 430.51102.01

The scientific quality of this report has been peer reviewed by the a colleague scientist and the head of the department of IMARES.

Approved: P. de Vries
Research scientist

Signature: 

Date: 4 June 2013

Approved: M. de Wit
Head of Department

Signature: 

Date: 4 June 2013

Appendix A. Classification grain size.

Table 6: Classification of the grain sizes according to ISO 14688-1.

Name			Range
Very coarse soil		Large boulder	>630 mm
		Boulder	200 – 630 mm
		Cobble	63 – 200 mm
Coarse soil	Gravel	Coarse gravel	20 – 63 mm
		Medium gravel	6.3 – 20 mm
		Fine gravel	2.0 - 6.3 mm
	Sand	Coarse sand	0.63 - 2.0 mm
		Medium sand	0.2 - 0.63 mm
		Fine sand	0.063 - 0.2 mm
Fine soil	Silt	Coarse silt	0.02 - 0.063 mm
		Medium silt	0.0063 - 0.02 mm
		Fine silt	0.002 - 0.0063 mm
	Clay		≤0.002 mm

Appendix B. Species abundance data.

Table 7: Species abundance data.

Phylum	Family	Genus	Species	n stations	n ind / m^2
Annelida	Ampharetidae	Ampharete	species	8	27.8
	Aphroditidae	Aphrodita	Species	5	22.2
	Capitellidae	Capitella	capitata	1	55.6
	Capitellidae	Notomastus	latericeus	2	13.9
	Cirratulidae	Chaetozone	christiei	1	27.8
	Cirratulidae	Chaetozone	setosa	20	40.3
	Cirratulidae	Chaetozone	Species	1	69.4
	Fabriciidae		Species	1	13.9
	Glyceridae	Glycera	Species	3	13.9
	Glyceridae	Glycera	unicornis	1	13.9
	Goniadidae	Glycinde	nordmanni	12	25.5
	Goniadidae	Goniada	maculata	29	57.5
	Goniadidae		species	2	13.9
	Hesionidae	Oxydromus	flexuosus	3	13.9
	Hesionidae	Podarkeopsis	capensis	7	15.9
	Magelonidae	Magelona	alleni	3	18.5
	Magelonidae	Magelona	filiformis	27	151.7
	Magelonidae	Magelona	johnstoni	7	33.7
	Magelonidae	Magelona	mirabilis	1	27.8
	Magelonidae	Magelona	species	1	13.9
	Nephtyidae	Nephtys	assimilis	16	21.7
	Nephtyidae	Nephtys	caeca	8	17.4
	Nephtyidae	Nephtys	cirrosa	5	38.9
	Nephtyidae	Nephtys	hombergii	20	22.9
	Nephtyidae	Nephtys	species	23	30.8
	Nereididae	Eunereis	elittoralis	2	34.7
	Nereididae	Eunereis	longissima	1	13.9
	Nereididae	Nereis	Species	2	13.9
	Opheliidae	Ophelia	borealis	4	20.8
	Opheliidae	Ophelia	neglecta	7	59.5
	Opheliidae	Ophelia	Species	4	20.8
	Opheliidae		species	1	13.9
	Orbiniidae	Scoloplos	armiger	24	96.1
	Oweniidae	Owenia	fusiformis	2	27.8
	Oweniidae		species	1	13.9
	Paraonidae	Aricidea	minuta	3	18.5
	Pectinariidae	Pectinaria	auricoma	3	13.9
	Pectinariidae	Pectinaria	species	17	43.3

Phylum	Family	Genus	Species	n stations	n ind / m^2
	Pholoidae	Pholoe	baltica	8	19.1
	Pholoidae	Pholoe	inornata	3	37.0
	Pholoidae	Pholoe	species	4	20.8
	Phyllodocidae	Eteone	longa	3	13.9
	Phyllodocidae	Eteone	spetsbergensis	1	13.9
	Phyllodocidae	Eteone	species	3	13.9
	Phyllodocidae	Eteoninae (subfamily)	species	3	23.1
	Phyllodocidae	Phyllodoce	groenlandica	27	85.4
	Phyllodocidae		species	6	16.2
	Poecilochaetidae	Poecilochaetus	serpens	14	18.8
	Polynoidae	Enipo	species	3	13.9
	Polynoidae	Harmothoe	impar	2	13.9
	Polynoidae	Harmothoe	species	3	18.5
	Polynoidae	Malmgrenia	andreapolis	1	27.8
	Polynoidae	Malmgreniella	castanea	2	13.9
	Polynoidae	Malmgreniella	ljungmani	3	13.9
	Polynoidae		species	11	18.9
	Scalibregmatidae	Scalibregma	inflatum	7	15.9
	Sigalionidae	Sigalion	mathildae	8	17.4
	Sigalionidae	Sigalion		1	13.9
	Sigalionidae	Sthenelais	boa	4	13.9
	Sigalionidae	Sthenelais	limicola	12	17.4
	Spionidae	Scolelepis	bonnieri	9	17.0
	Spionidae	Scolelepis	species	3	23.1
	Spionidae	Spio	decoratus	15	20.4
	Spionidae	Spio	filicornis	2	13.9
	Spionidae	Spiophanes	bombyx	29	9078.5
	Spionidae	Spiophanes	kroyeri	1	13.9
	Syllidae	Exogone	naidina	5	13.9
	Syllidae	Exogone	species	1	27.8
	Terebellidae	Lanice	conchilega	9	43.2
	Terebellidae		species	19	48.2
	Spionida (Suborder)		species	2	13.9
	Hirudinea (Subclass)		species	1	27.8
	Polychaeta (Class)		species	1	0.0
Arthropoda	Acidostomatidae	Acidostoma	obesum	1	13.9
	Ampeliscidae	Ampelisca	brevicornis	8	13.9
	Ampeliscidae	Ampelisca	macrocephala	1	13.9
	Amphilochidae	Paramphilochoides	odontonyx	2	13.9
	Argissidae	Argissa	hamatipes	11	37.9
	Atylidae	Atylus	swammerdami	1	13.9
	Gammaridea (Suborder)		species	2	13.9

Phylum	Family	Genus	Species	n stations	n ind / m^2
	Hyperiidae	Hyperia	galba	2	27.8
	Lysianassidae	Hippomedon	denticulatus	9	77.2
	Lysianassidae	Lepidepecreum	longicornis	3	18.5
	Lysianassidae		species	2	20.8
	Lysianassidae	Tryphosella	horingi	1	13.9
	Megaluropidae	Megaluropus	agilis	11	26.5
	Melitidae	Abludomelita	obtusata	1	13.9
	Oedicerotidae		species	1	13.9
	Oedicerotidae	Perioculodes	longimanus	21	33.1
	Oedicerotidae	Pontocrates	arenarius	2	13.9
	Oedicerotidae	Synchelidium	haplocheles	4	13.9
	Oedicerotidae	Synchelidium	species	1	13.9
	Oedicerotidae	Westwoodilla	caecula	5	22.2
	Phoxocephalidae	Harpinia	antennaria	6	23.1
	Phoxocephalidae	Harpinia	species	2	13.9
	Pontoporeiidae	Bathyporeia	elegans	5	69.4
	Pontoporeiidae	Bathyporeia	guilliamsoniana	22	104.8
	Pontoporeiidae	Bathyporeia	pelagica	8	55.6
	Pontoporeiidae	Bathyporeia	species	12	28.9
	Pontoporeiidae	Bathyporeia	tenuipes	29	102.5
	Urothoidae	Urothoe	poseidonis	8	52.1
	Amphipoda (Order)		species	8	50.3
	Caprellidae	Pariambus	typicus	1	13.9
	Caprellidae	Phtisica	marina	1	13.9
	Diastylidae	Diastylis	bradyi	3	18.5
	Lampropidae	Hemilamprops	roseus	1	13.9
	Leuconidae	Eudorellopsis	deformis	3	23.1
	Leuconidae		species	1	13.9
	Pseudocumatidae	Pseudocuma	longicorne	22	41.0
	Pseudocumatidae	Pseudocuma	simile	2	20.8
	Cumacea (Order)		species	1	13.9
	Mysidae	Mysis	species	1	0.0
	Leucosiidae	Ebalia	cranchii	1	13.9
	Decapoda (Order)		species	1	13.9
	Crustacea (Subphylum)		species	1	13.9
	Copepoda (Subclass)		species	19	73.1
Echinodermata	Amphiuridae	Amphiura	chiajei	1	41.7
	Amphiuridae	Amphiura	filiformis	4	62.5
	Amphiuridae	Amphiura		2	13.9
	Amphiuridae (Class)			5	80.6
	Astropectinidae	Astropecten	irregularis	1	13.9
	Echinocyamidae	Echinocyamus	pusillus	1	13.9

Phylum	Family	Genus	Species	n stations	n ind / m^2
	Loveniidae	Echinocardium	cordatum	4	27.8
	Loveniidae	Echinocardium	flavescens	1	13.9
	Loveniidae	Echinocardium		2	6.9
	Echinoidea (Class)		species	26	2265.0
	Asteroidea (Class)		species	4	13.9
	Ophiuroidea (Class)		species	22	79.5
	Holothuroidea (Class)		species	2	27.8
			species	2	3013.9
Mollusca	Corbulidae	Corbula	gibba	3	13.9
	Kelliidae	Kellia	suborbicularis	1	13.9
	Lucinidae	Lucinoma	borealis	5	16.7
	Montacutidae	Kurtiella	bidentata	3	125.0
	Montacutidae	Montacuta	substriata	5	25.0
	Montacutidae	Tellimya	ferruginosa	5	50.0
	Nuculidae	Ennucula	tenuis	3	23.1
	Nuculidae	Nucula	nitidosa	1	13.9
	Pharidae	Ensis	species	5	16.7
	Pharidae	Phaxas	pellucidus	8	22.6
	Psammobiidae	Gari	fervensis	4	13.9
	Semelidae	Abra	prismatica	6	18.5
	Semelidae	Abra	species	2	20.8
	Tellinidae	Angulus	fabula	23	36.8
	Tellinidae	Tellina	species	13	70.5
	Thraciidae	Thracia	phaseolina	3	27.8
	Thyasiridae	Thyasira	flexuosa	12	19.7
	Veneridae	Dosinia	lupinus	5	19.4
	Veneridae	Dosinia	species	1	13.9
	Bivalvia (Class)		species	7	27.8
	Cylichnidae	Cylichna	cylindracea	1	13.9
	Diaphanidae	Diaphana	minuta	7	17.9
	Eulimidae	Melanella	lubrica	1	13.9
	Muricidae	Urosalpinx	cinerea	1	13.9
	Naticidae	Euspira	catena	1	13.9
	Naticidae	Euspira	nitida	14	23.8
	Philinidae	Philine	species	1	13.9
	Retusidae	Retusa	species	1	13.9
	Cephalaspidea (Order)		species	1	13.9
	Gastropoda (Class)		species	3	18.5
	Opisthobranchia (Infraclass)		species	1	13.9
Cnidaria	Cerianthidae	Cerianthus	lloydii	8	20.8
	Edwardsiidae	Edwardsia	species	24	46.3
	Anthozoa (Class)		species	5	19.4

Phylum	Family	Genus	Species	n stations	n ind / m^2
	Hydrozoa (Class)		species	20	47.2
Porifera	Clionaidae	Cliona	species	2	20.8
Chaetognatha			species	2	13.9
Nematoda			species	14	22.8
Nemertea			species	29	92.0
Phoronida			species	10	26.4
Platyhelminthes			species	1	13.9

Appendix C. Species excluded prior to data analysis

Table 8: Species excluded from data analysis - Abundance.

Phylum	Family	N.*	Motivation
Annelida	Hirudinea (Subclass)	6	Not a typical benthic species.
Arthropoda	Decapoda (Order)	2	Larvae stadium. Not a typical benthic specific species.
Arthropoda	Crustacea (Subphylum)	1	Group is to large, possible overlap with other Crustacea species.
Arthropoda	Copepoda (Subclass)	1	Not a typical benthic specific species.
Mollusca	Cephalaspidea (Order)	100	Not a typical benthic specific species.
Chaetognatha		2	Not a typical benthic specific species.
Nematoda		23	Not a typical benthic specific species.

* N = total number of individuals identified in all samples.

Table 9: Species excluded from data analysis – Richness, Evenness, Diversity.

Phylum	Species	N.*	Motivation
Annelida	Chaetozone sp.	5	More species of genera found. Possible overlap.
Annelida	Glycera sp.	3	More species of genera found. Possible overlap.
Annelida	Goniadidae (Family) sp.	2	More species of family found. Possible overlap.
Annelida	Magelona sp.	1	More species of genera found. Possible overlap.
Annelida	Nephtys sp.	51	More species of genera found. Possible overlap.
Annelida	Nereis sp.	2	More species of genera found. Possible overlap.
Annelida	Ophelia sp.	6	More species of genera found. Possible overlap.
Annelida	Opheliidae (Family) sp.	1	More species of family found. Possible overlap.
Annelida	Oweniidae (Family) sp.	1	More species of family found. Possible overlap.
Annelida	Pholoe sp.	6	More species of genera found. Possible overlap.
Annelida	Eteone sp.	3	More species of genera found. Possible overlap.
Annelida	Eteoninae (subfamily) sp.	5	More species of subfamily found. Possible overlap.
Annelida	Phyllodocidae (Family) sp.	7	More species of family found. Possible overlap.
Annelida	Harmothoe sp.	4	More species of genera found. Possible overlap.
Annelida	Polynoidae (Family) sp.	15	More species of family found. Possible overlap.
Annelida	Sigalion sp.	1	More species of genera found. Possible overlap.
Annelida	Scolelepis sp.	5	More species of genera found. Possible overlap.
Annelida	Exogone sp.	2	More species of genera found. Possible overlap.
Annelida	Terebellidae sp.	66	More species of genera found. Possible overlap.
Annelida	Spionida (Suborder) sp.	2	More species of suborder found. Possible overlap.
Annelida	Hirudinea (Subclass) sp.	2	More species of subclass found. Possible overlap.
Annelida	Polychaeta (Class) sp.	1 (0)	More species of class found. Possible overlap.
Arthropoda	Lysianassidae sp.	3	More species of genera found. Possible overlap.
Arthropoda	Oedicerotidae sp.	1	More species of genera found. Possible overlap.
Arthropoda	Synchelidium sp.	1	More species of genera found. Possible overlap.
Arthropoda	Harpinia sp.	2	More species of genera found. Possible overlap.
Arthropoda	Bathyporeia sp.	25	More species of genera found. Possible overlap.
Arthropoda	Amphipoda (Order) sp.	29	More species of order found. Possible overlap.
Arthropoda	Leuconidae sp.	1	More species of genera found. Possible overlap.
Arthropoda	Cumacea (Order) sp.	1	More species of order found. Possible overlap.

Phylum	Species	N.*	Motivation
Arthropoda	Decapoda (Order) sp.	1	More species of order found. Possible overlap.
Arthropoda	Crustacea (Subphylum) sp.	1	More species of subphylum found. Possible overlap.
Arthropoda	Copepoda (Subclass) sp.	100	More species of subclass found. Possible overlap.
Echinodermata	Amphiura sp.	2	More species of genera found. Possible overlap.
Echinodermata	Echinocardium sp.	1	More species of genera found. Possible overlap.
Echinodermata	Echinoidea (Class) sp.	4240	More species of class found. Possible overlap.
Echinodermata	Asteroidea (Class) sp.	4	More species of class found. Possible overlap.
Echinodermata	-	434	More species of phylum found. Possible overlap.
Mollusca	Abra sp.	3	More species of genera found. Possible overlap.
Mollusca	Tellina sp.	66	More species of genera found. Possible overlap.
Mollusca	Dosinia sp.	1	More species of genera found. Possible overlap.
Mollusca	Bivalvia (Class) sp.	14	More species of class found. Possible overlap.
Mollusca	Gastropoda (Class) sp.	1	More species of class found. Possible overlap.

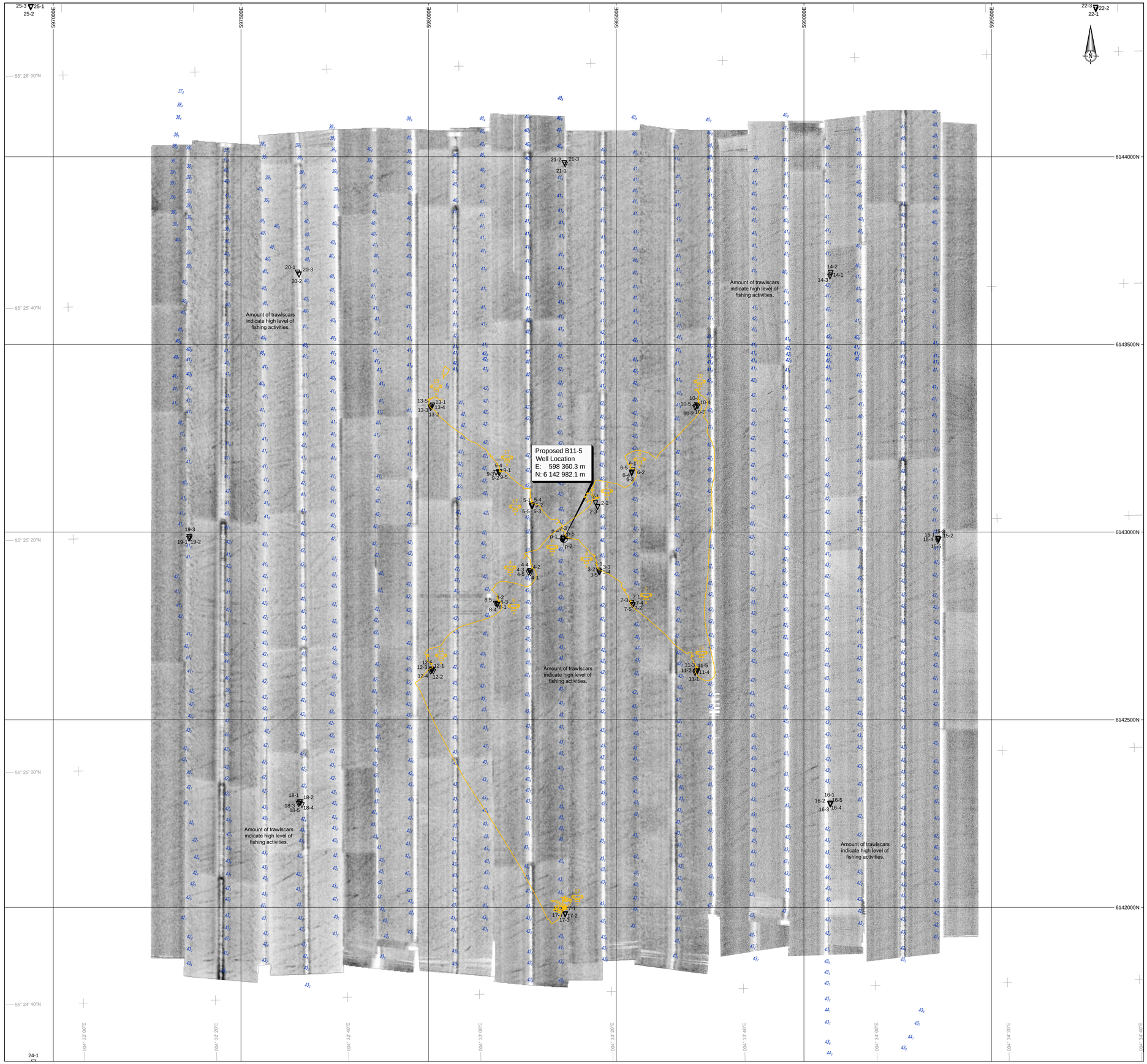
* N = total number of individuals identified in all samples.

Table 10: Abundance, richness, diversity (H) and evenness for stations in the B11-5 area, sampled in May 2012.

Station	Distance	Angle	Richness	Diversity	Evenness	Abundance
1	0	0	20	0.99	0.33	3556
2	125	45	25	0.70	0.22	11792
3		135	26	1.06	0.33	5153
4		225	43	0.90	0.24	13486
5		315	29	0.61	0.18	19792
6	250	45	22	1.70	0.55	4250
7		135	32	0.69	0.20	14972
8		225	30	0.86	0.25	13361
9		315	33	0.99	0.28	14958
10	500	45	30	0.73	0.22	15319
11		135	26	0.86	0.26	10931
12		225	36	0.93	0.26	14097
13		315	27	0.64	0.19	14222
14	1000	45	40	0.95	0.26	18097
15		90	31	1.00	0.29	13681
16		135	26	0.99	0.30	8764
17		180	28	1.00	0.30	10083
18		225	26	1.03	0.32	8819
19		270	29	1.03	0.31	13972
20		315	29	0.88	0.26	18153
21		0	30	0.79	0.23	20014
22	2000	45	27	0.65	0.20	22764
23		135	27	1.01	0.31	8153
24		225	23	0.68	0.22	10167
25		315	35	0.92	0.26	19736
26	10000	90	31	2.06	0.60	4042
27		180	32	2.24	0.65	3403
28		270	25	0.50	0.15	17556
29		0	42	1.05	0.28	18458

Appendix D. Side Scan mosaic

PLAN VIEW



LEGEND

GENERAL

- 5949000N — Grid projection co-ordinates
- 53° 39' 12"N — Geographical co-ordinates
- B11-5 centre location
- Chart matchlines
- Structures

SEABED FEATURES

- Video recording track
- Camera location with ID number
- SSS-002 — Side scan sonar contact, possible debris.
- 40 — Bathymetric sounding
- 3-1 — Grab location with ID number

PROJECTION PARAMETERS - UTM 3° North:

Latitude of Origin	: 0° (Equator)
Longitude of Origin (CM)	: 3° East
False Easting on CM	: 500 000m
False Northing	: 0m
Scale factor	: 0.9996

GEODETIC CONTROL

SPHEROID PARAMETERS - WGS84:

Semi major axis	: 6 378 137.000m
Semi minor axis	: 6 356 752.314m
Inverse flattening	: 298.257223563
Eccentricity (e ²)	: 0.00669438

SPHEROID PARAMETERS - International ED50:

Semi major axis	: 6 378 388.000m
Semi minor axis	: 6 356 911.946m
Inverse flattening	: 297.000
Eccentricity (e ²)	: 0.006722670

REFERENCE PROJECTION:

Central Meridian	: 3 Degrees East
Latitude Of Origin	: 0 Degrees
False Easting on CM	: 500 000 m
False Northing	: 0m
Scale factor on CM	: 0.9996

TRANSFORMATION PARAMETERS (from WGS84 to ED50)

Dx	: +89.5m	Rx	: 0.000"
Dy	: +93.8m	Ry	: 0.000"
Dy	: +123.1m	Dz	: +0.156"
Scale factor		: -1.200 ppm	

HORIZONTAL CONTROL

Primary positioning system	: Fugro StarFix HP
Secondary pos. system	: C-Nav
Subsea positioning system	: Easytrak Nexus USBL

VERTICAL CONTROL

All depth data are reduced to Lowest Astronomical Tide (LAT) based on predicted tides generated by the Proudman Oceanographic Laboratory software 'Polpred' using the CS3 North Sea Model database.

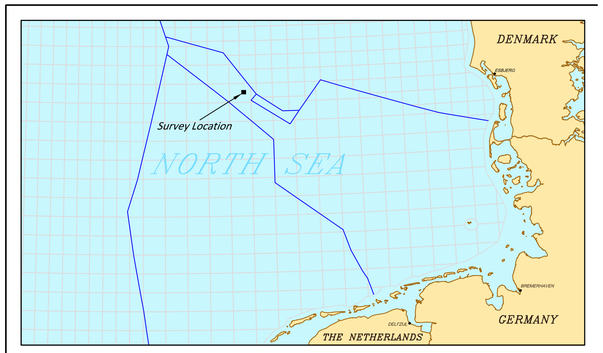
SURVEY SENSORS

NOORTRUCK (SURVEY VESSEL)

Heading & attitude sensor	: iXSEA Octans
Echo sounder	: Simrad EA400
Side scan sonar	: EdgeTech 4200 Series
Sound Velocity Probe	: Valeport 604
Geophysical systems	: Edgetech 4200S - Side scan sonar
	: CODA DA2000 - Recording system
	: GeoAcoustic - Geoprinter
Geotechnical systems	: Box corer
Environmental systems	: Drop down camera

NOTES

- All measurements are displayed in metres.



wintershall
BASF Group

IMARES
WAGENINGEN UR

B11-5 BENTHOS ASSESMENT

PROPOSED B11-5 WELL LOCATION

BENTHOS SAMPLES AND SIDE SCAN SONAR SURVEY

NORTH SEA, GERMAN CONTINENTAL SHELF - BLOCK B11-5

SITE SURVEY

B11-5

CHART SCALE 1 : 5 000

0 50 100 200 300 400 500 metres
0 200 400 800 1200 1600 feet

Revision	Date	Drawn	Checked	Approved	Clt. Appd.	Description
1	15-06-2012	MWI	LGO	RGR		Issued for Internal Discipline Check

Nijverheidskade 2
1785AB
Den Helder
The Netherlands

DEEPOCEAN

Telephone: +31 (0) 223 684156
Fax: +31 (0) 223 684160
E-mail: post.nl@deepocean.no

Survey vessel	:	M/V Noortruck	Date of survey	:	May 2012
Client drawing number	:		DeepOcean drawing Nr.	:	NL.E10526_IMA_NT_ST_001

Appendix E. Physical characteristics sediment

Table 11: Physical characteristics of the sediment in the B11-5 area. Distance = distance from platform in meters, OC = Organic Carbon (up to 450 ^{0}C). Values printed in bold are identified as an outlier.

Sample nr.	Distance (m)	Angle (°)	OC (%)	Fraction <63 µm (%)	Median grain size (µm)	Uniformity coefficient (-)
1	Drill site	0	0.608	2.29	193.5	1.653
2	125	45	0.571	1.66	194.0	1.640
3		135	0.476	1.75	190.8	1.640
4		225	0.486	0.76	194.5	1.619
5		315	0.431	0.61	200.2	1.631
6	250	45	0.472	0.78	193.5	1.613
7		135	0.583	2.48	192.0	1.668
8		225	0.433	0.67	193.7	1.623
9		315	0.465	0.63	197.6	1.643
10	500	45	0.555	0.00	200.3	1.614
11		135	0.382	0.00	199.3	1.622
12		225	0.462	1.87	195.1	1.651
13		315	0.483	2.22	199.5	1.672
14		45	0.536	3.04	190.4	1.654
15	1000	90	0.565	2.88	188.9	1.661
16		135	0.523	0.81	191.1	1.630
17		180	**0.866**	1.58	194.4	1.637
18		225	0.489	1.81	193.7	1.650
19		270	0.566	3.01	193.3	1.676
20		315	0.476	0.66	199.4	1.635
21		0	0.670	4.11	200.9	1.716
22	2000	45	0.627	0.00	199.5	1.608
23		135	0.581	**4.22**	184.1	1.747
24		225	0.530	3.24	191.5	1.711
25		315	**0.320**	0.00	**207.7**	1.576
26	Ref	90	0.696	1.74	174.7	1.656
27		180	0.509	1.71	**164.9**	1.673
28		270	0.656	2.53	185.5	1.647
29		0	0.369	**0.00**	200.0	1.603

Appendix F. Chemical composition sediment

Table 12: Chemical characteristics of the sediment in the B11-5 area. Distance = distance from platform in meters. Values printed in bold are identified as an outlier.

Distance (m)	**Angle (°)**	**Barium**	**Cadmium**	**Copper**	**Iron**	**Mercury**	**Lead**	**Zinc**	**Mineral oil**
Drill site	0	220	<0.05	1.00	1900	<0.02	7.1	12.0	3.1
125	45	230	<0.05	**1.50**	2200	<0.02	7.6	13.0	4.4
	135	210	<0.05	0.98	1900	<0.02	6.5	11.0	3.1
	225	210	<0.05	0.95	1800	<0.02	6.8	9.4	4.9
	315	210	<0.05	0.81	1700	<0.02	6.6	9.5	3.1
250	45	210	<0.05	0.86	1800	<0.02	6.7	11.0	<2.0
	135	210	<0.05	1.00	1900	<0.02	7.3	15.0	3.3
	225	210	<0.05	0.86	1800	<0.02	7.1	9.2	2.6
	315	210	<0.05	0.82	1900	<0.02	6.9	11.0	4.3
500	45	200	<0.05	0.91	1800	<0.02	6.9	10.0	4.2
	135	220	<0.05	**1.50**	1900	<0.02	7.3	9.4	<2.0
	225	230	<0.05	0.89	2100	<0.02	7.6	9.9	**7.4**
	315	210	<0.05	1.00	2000	<0.02	7.0	12.0	**5.6**
	45	200	<0.05	0.94	1700	<0.02	6.3	13.0	2.8
1000	90	220	<0.05	0.97	2000	<0.02	7.4	11.0	<2.0
	135	210	<0.05	0.97	2000	<0.02	7.5	12.0	2.1
	180	200	<0.05	0.84	1800	<0.02	6.5	11.0	<2.0
	225	220	<0.05	0.83	2000	<0.02	7.3	12.0	5.0
	270	200	<0.05	0.95	1700	<0.02	6.2	12.0	<2.0
	315	200	<0.05	0.95	1500	<0.02	6.1	11.0	<2.0
	0	200	<0.05	1.00	1600	<0.02	6.4	11.0	2.6
2000	45	200	<0.05	0.90	1700	<0.02	6.4	12.0	<2.0
	135	230	<0.05	1.20	2200	<0.02	7.7	12.0	3.0
	225	200	<0.05	0.94	1700	<0.02	6.8	10.0	2.6
	315	170	<0.05	0.85	1300	<0.02	5.3	9.7	<2.0
Ref	90	240	<0.05	1.10	**2600**	<0.02	8.2	13.0	<2.0
	180	230	<0.05	1.20	**4000**	<0.02	8.7	**21.0**	<2.0
	270	220	<0.05	**1.40**	2200	<0.02	7.8	15.0	<2.0
	0	170	<0.05	0.78	**4000**	<0.02	6.6	12.0	<2.0

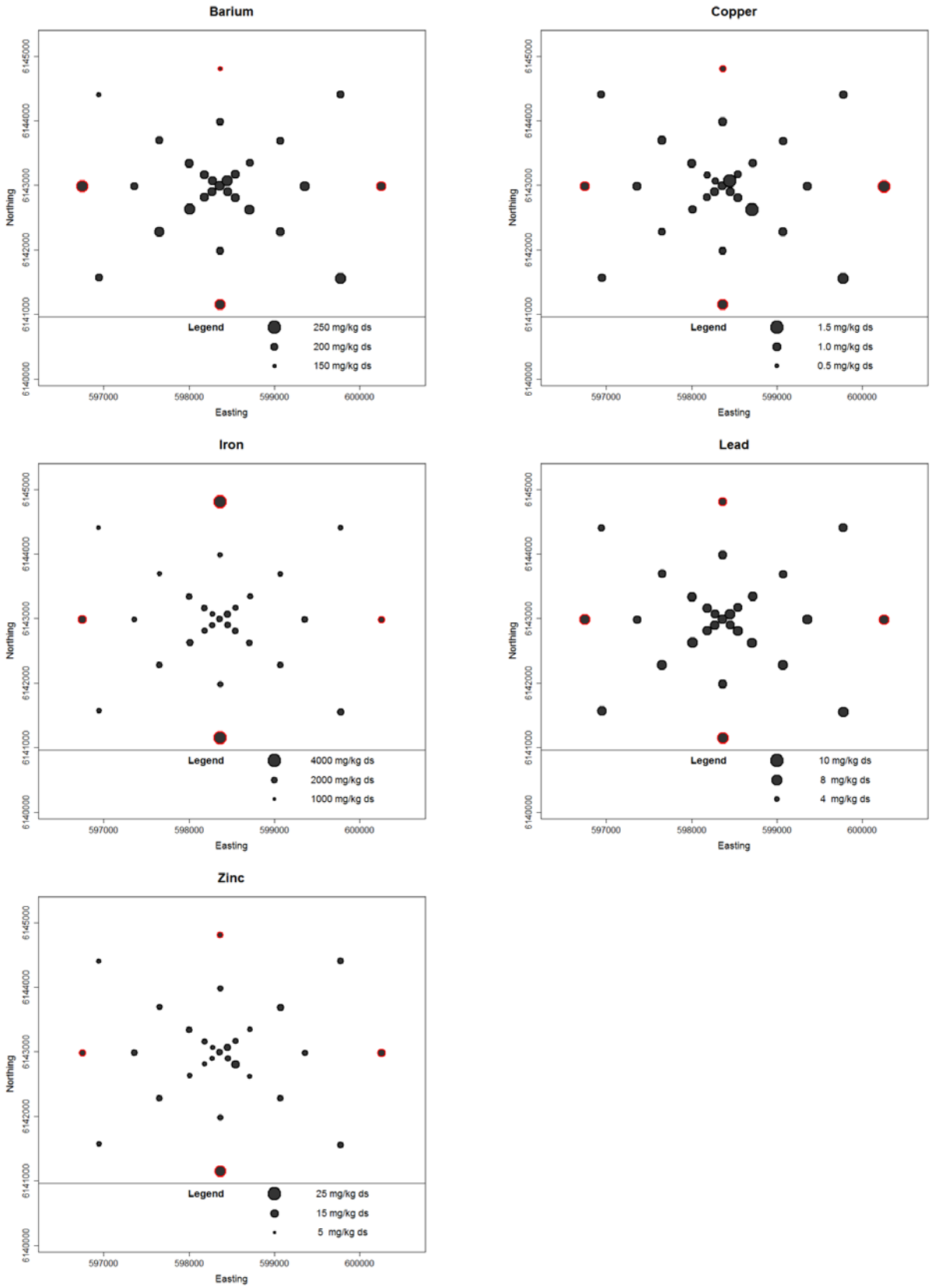


Figure 20. Spatial variation in barium, copper, iron, lead and zinc.

Appendix G. Influence of *Spiophanes bombyx* on community parameters

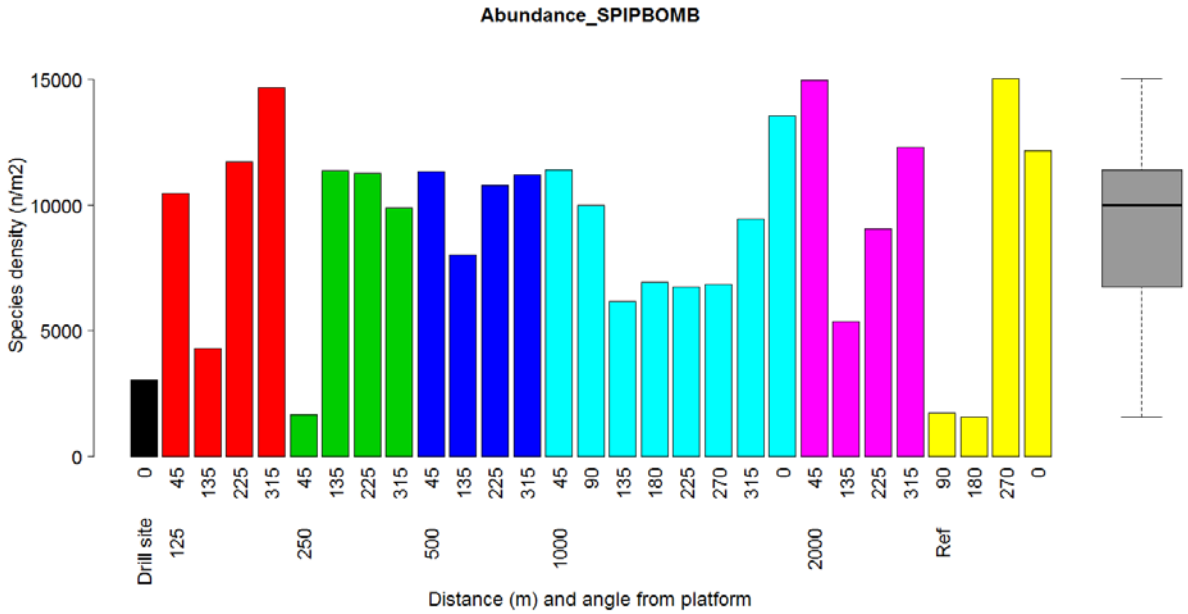


Figure 21: Spiophanes bombyx *densities per square meter. The colours correspond with distance from the centre.*

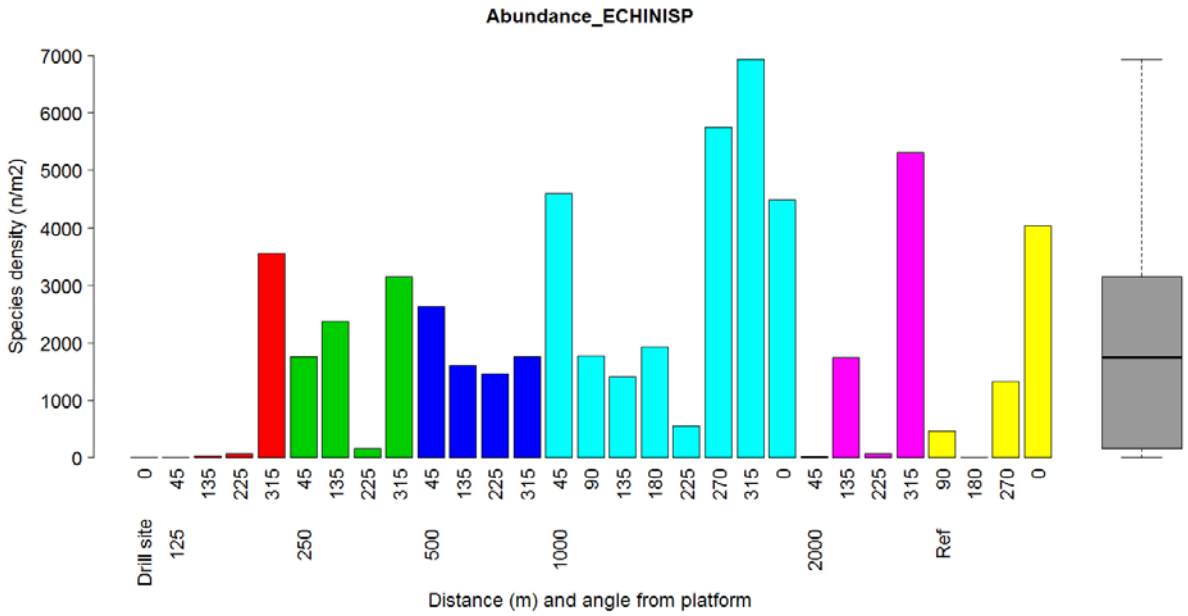


Figure 22: *Juvenile* Echinoidae *sp. densities per square meter. The colours correspond with distance from the centre.*

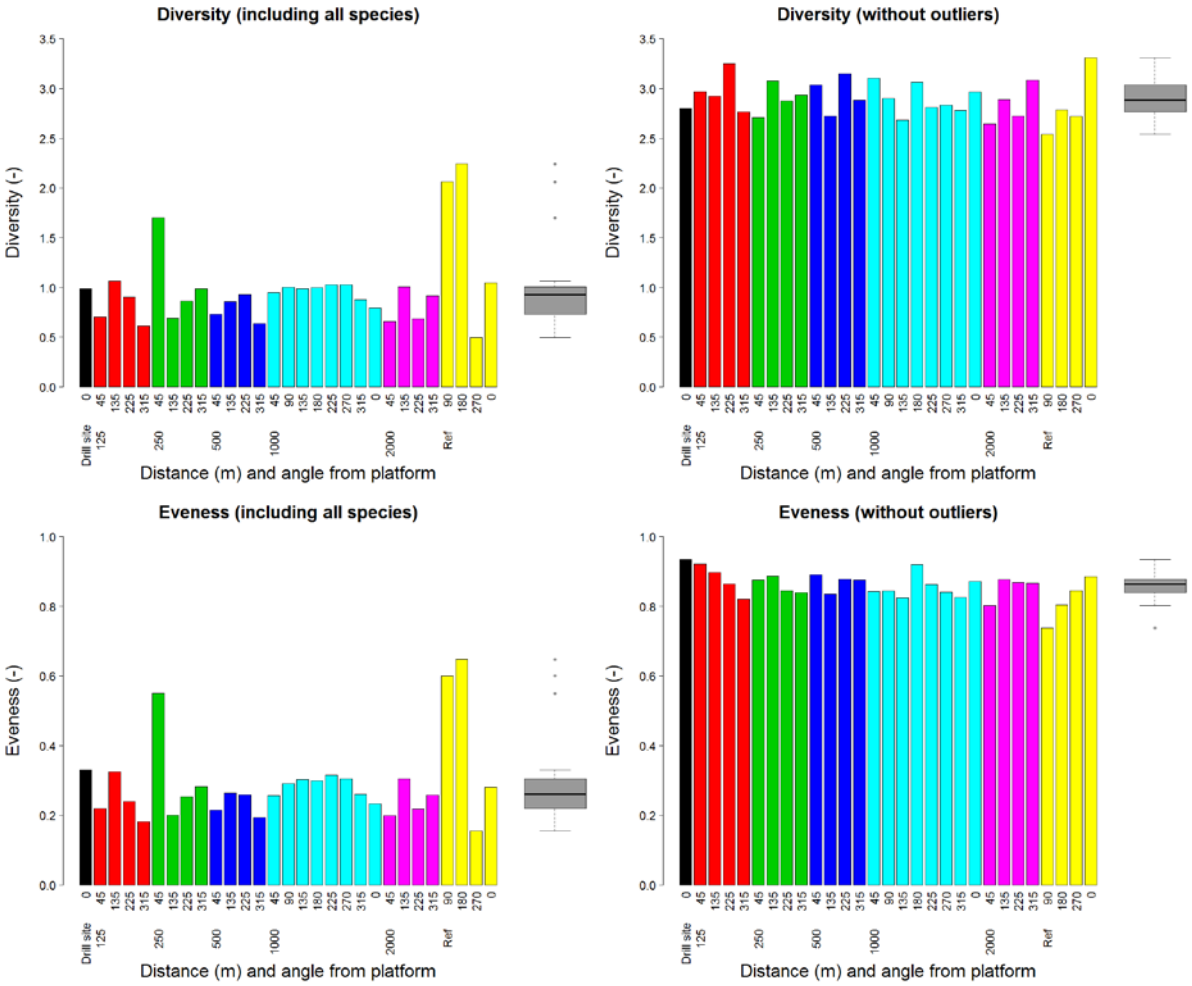


Figure 23: Variation in diversity and evenness with Spiophanes bombyx *(left) and without (right).*