Cruise Report

POSEIDON 489
(POS489)

9th September - 24th September 2015

Institute of Geosciences
Sedimentology, Coastal- and Continental Shelf Research
Christian-Albrechts-University, Kiel

Kiel, January, 7th 2016

Klaus Schwarzer, Jil Kiefer, Peter Richter

C | A | U
Christian-Albrechts-Universität zu Kiel

Table of contents

1. Participants

Institute of Geosciences (IfG), Kiel University

Chief scientist:	Dr. Klaus Schwarzer
Scientists:	Dr. Peter Richter
	M.Sc. Kerstin Wittbrodt
	Jonas Drescher
	Svantje Gottschlich
	Michelle Fiedler
	Sebastian Neumann
	Annelie Düring
	Jil Kiefer
Technician:	Andre Wagner

Abbreviations

Sidescan Sonar (towed)	**SSS**
Multibeam Echosounder (hull mounted)	**MBES**
Innomar Subbottom Profiler (Moon Pool)	**SES**
Grab Sampler	**GS**
Giant Box Corer	**GBC**
Underwater Video	**UWV**
Conductivity Temperature Depth	**CTD**
Mean Low Water Springs	**MLWS**

2. Cruise Narrative (Time in UTC)

9th September 2015

07:00 Departure from GEMOAR, IFM, east shore, Kiel
passing Kiel canal and transit to work area, installation of devices
Weather: sunny to few clouds, 1 Bft., E, small ripple waves

10th September 2015

04:38 SES installed in moon pool
04:47 CTD profile and subsequent MBES calibration
05:29 SSS released into water; start of hydroacoustic profiling
continuation of hydroacoustic profiling during the night
Weather: sunny to few clouds, 3 Bft, NW, estimated wave height <0.5m

11th September 2015

Continuation of hydroacoustic profiling (SSS, MBES, SES)
Weather: sunny, increasing cloudiness, 6 Bft, E, estimated wave height 1.0 to 1.5m
Continuation of hydroacoustic profiling during the night

12th September 2015

Continuation of hydroacoustic profiling
Weather: sunny to very cloudy toward evening, 5 Bft, SE, estimated wave height 1.0m
Continuation of hydroacoustic profiling during the night

13th September 2015

Continuation of hydroacoustic profiling
Weather: very cloudy, in the morning 3-4 Bft, increasing to 5 Bft, in the evening from S to SE, estimated wave height <0.5m
Continuation of hydroacoustic profiling during the night

14th September 2015

Continuation of hydroacoustic profiling
Weather: cloudy, in the morning 4 - 5 Bft, in the evening S to SE, estimated wave height 1.0m

15th September 2015

00:00 SSS taken out of water because due bad weather prediction
06:00 Starting of grab sampling
19:05 Termination of grab sampling due to strong wave conditions and poor visibility
Weather: In the morning partially sunny to cloudy, 3 Bft, increasing to 8 Bft in the evening, S to SE, estimated wave height 1.0 m in the morning, up to to 3.0m in the evening.

16th September 2015

04:30 Starting of grab sampling
08:07 Termination of grab sampling
08:31 one CTD profile and subsequent MBES re-calibration
09:50 SSS released into water, continuation of hydroacoustic profiling
18:00 SSS taken out of water

Weather: sunny in the morning increasing clouds from noon, 3 Bft in the morning to 8 Bft in the evening from S to SW; estimated wave height 1.0 (morning) to 3.0m (evening)

17th September 2015
Weathering in working area
Weather: very cloudy, 8 Bft from SW, estimated wave height 3.0 to 4.0m

18th September 2015
05:00 SSS released into water, continuation of hydroacoustic profiling
Weather: partially sunny and partially cloudy, 6 Bft in the morning decreasing to 4 Bft in the evening from W to NW, estimated wave height 2.0 (morning) to 0.5m (evening)
Continuation of hydroacoustic profiling during the night

19th September 2015
Continuation of hydroacoustic profiling
Weather: in the morning partially sunny and partially cloudy, increasing cloudiness in the evening and rainy, 3 Bft in the morning to 5 Bft in the evening from NW, estimated wave height 0.5 (morning) to 1.0 to 2.0m (evening)
Continuation of hydroacoustic profiling during the night

20th September 2015
Continuation of hydroacoustic profiling
Weather: partially sunny and partially cloudy, 5 to 6 Bft in the morning to 4 Bft in the evening from NW, estimated wave height 1.5 (morning) to 0.5 to 1.0m (evening)
Continuation of hydroacoustic profiling during the night

21st September 2015
05:50 SSS taken out of water
06:30 one CTD profile and subsequent MBES re-calibration
06:36 starting of grab sampling
07:14 termination of grab sampling
08:07 starting of box core sampling
08:39 video track 1 (13min) at station of box core sample 1
11:13 Video track 2 (16min) at station of box core sample 3
13:43 termination of box core sampling
14:35 video track 3 (13min) at station of box core sample 4
15:25 SSS released into water, continuation of hydroacoustic profiling
Weather: partially sunny and partially cloudy, 4 Bft in the morning to 5 Bft in the evening from S to SW, estimated wave height 0.5 to 1.0m
Continuation of hydroacoustic profiling during the night

22nd September 2015
06:00 SSS taken out of water
06:30 starting of grab sampling
16:07 termination of grab sampling
16:15 SSS released into water, continuation of hydroacoustic profiling

Weather: cloudy, rain showers from morning to noon, partially sunny in the afternoon, 6 Bft in the morning to 3 Bft in the evening from S, estimated wave height 2.0 (morning) to 0.5m (evening).
Continuation of hydroacoustic profiling during the night

23rd September 2015

07:00 SSS taken out of water
07:20 SES taken out of Moon Pool
Heading back to Kiel and de-installation of the devices
Weather: sunny, 1 to 2 Bft., N, estimated wave height <0.5m

24th September 2015

03:58 arrival in Kiel, GEMOAR, IFM, east shore
unloading of the equipment

3. Introduction

Cruise POS489 was performed in the frame of the project SEDINO II (**SED**imentdynamik **I**n **N**ord- und **O**stsee), aiming to differentiate seafloor types under consideration of the shallow subsurface and the feedback of benthic organisms on the sediment distribution and consistency. The investigation area for this cruise was Sylt outer reef, German Bight (Fig. 1). POS489 represents the most recent survey, bordering west of previously performed high resolution mapping of Sylt Outer Reef (see Fig. 1). The performed work focussed on the survey of water depth of to 35 m MLWS, whereas previous investigations covered the zone down to 20 m MLWS. The extension of mapping deeper waters is intended since the relative contribution of hydrodynamic processes, which are responsible for sediment distribution patterns, change with changing water depths. This expansion constitutes the objective of the completed cruise POS489.

The sequences of surface and subsurface sediments in the North Sea are formed through the temporally alternation of sediment build up and reworking processes since the late Pleistocene (Schwarzer et al., 2008). The main processes of sediment sources and their subsequent reworking are sea level fluctuations associated with the remnants of the Saalian and Weichselian glaciations and subsequent melting during interglacial periods. Since the Weichselian ice sheets did not reach the North Sea compared to the Saalian glaciation, the seafloor underwent two transgressions and one regression (Figge, 1981). Therefore, hydrodynamic processes namely waves, tides and frequently storms, mobilize and redistribute sediments continuously since the Saalian ice sheet retreat. The hydrodynamic processes mainly affect the fine to medium sand surface sediment, representing the Holocene sequence. Coarser grained sediment of Pleistocene origin is located in the subsurface and widely forms the base of the overlying Holocene deposits. However, Pleistocene deposits can also be found directly at the seafloor (Zeiler et. al., 2008).

The surface sediment of the North Sea shelf areas is characterized by a layer of mobile sand (Zeiler et al., 2000) with a thickness of max. 10 m near the coast, decreasing with increasing distance from the coastline, but areas of thicker young Holocene deposits are also apparent in relatively deep water depths. The net transport direction of the mobile sand layer is offshore, hence, supplying deeper parts of the North Sea with sediment.

Large-scale sediment structures in offshore waters are formed manly by tidal currents (Zeiler et al., 2008). One type of these structures are sorted bedforms also named “Rippled scour depressions” (Coco et al., 2007). These sediment structures are mainly affected during extreme storm conditions, what is suspected to cause their migration (Diesing et al., 2006).

The coastal shelf areas of the German Bight have been extensively sampled in the past, resulting in the widely accepted surface sediment distribution map BSH chart 2900 (Figge 1981, updated by Laurer et al., 2013). Additional sampling of the eastern shelf area in the North Sea has been carried out by Köster (1979). The BSH chart 2900 gives detailed information about surface sediment distribution pattern including grain size distribution. However, the comparison of high resolution hydroacoustic maps with the BSH chart reveals spatially variable correspondence. This indicates the rather coarse information provided by the BSH chart since it is based on interpolation between sample stations. Furthermore, information about sedimentary structures on various scales, e.g. sorted bedforms or ripples, is missing. The performed work during the cruise contributes to generate a comprehensive mapping of the North Sea shelf. Furthermore, repeated high resolution mapping is essential to reveal the dynamics of sediment structures. In addition, information of the variable thickness and dynamic of the mobile sand coverage is gained through the application of sub-bottom profil-

ing. During POS489 about 375km^2 were mapped by application of multiple hydroacoustic methods (SSS, SBES, MBES), complemented by 64 grab samples and 6 giant box core samples.

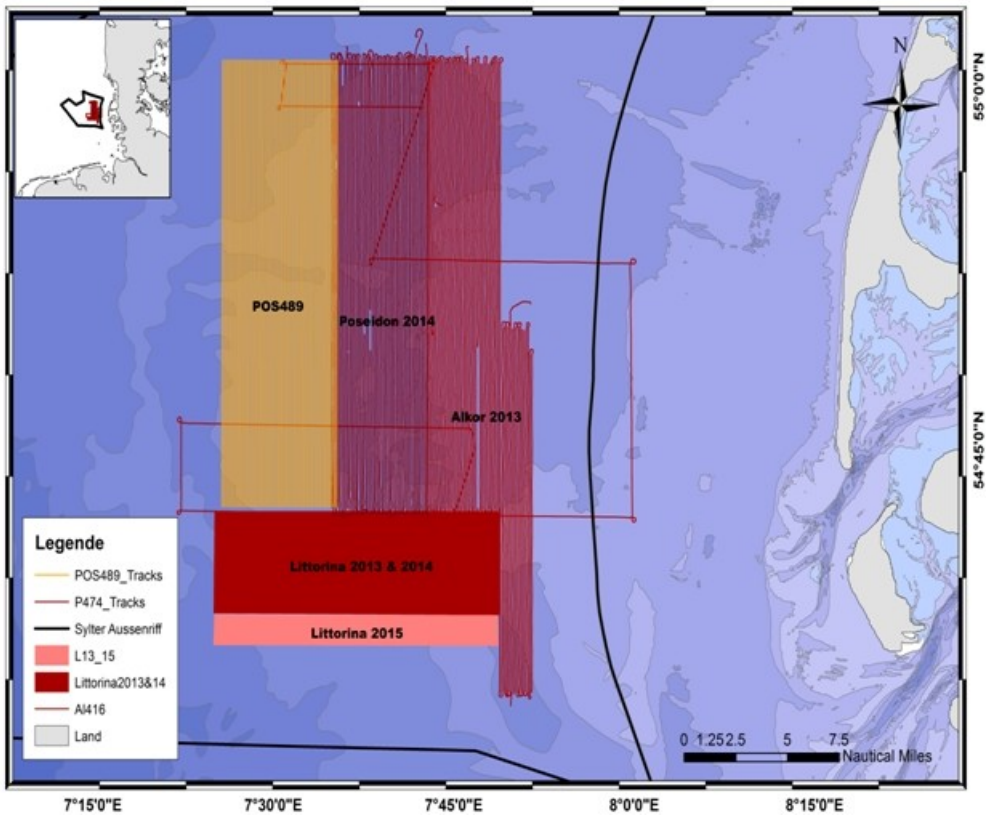

Figure 1: Overview of study area and previously performed surveys offshore Sylt Island. Ship tracks of the cruises POS489, POS474 and LITTORINA cruises from 2013 – 2015 are displayed.

4. Equipment

Sidescan Sonar (SSS)

The seafloor is imaged by using a Side-Scan Sonar, Teledyne Benthos, SIS-1624 - dual frequnecy (Fig. 2). The device is commonly referred to as “towfish” which is towed behind the vessel. Transducers on each side of the device generate and transmit acoustic beams into the water-column and record them after their reflection and refraction from the seafloor. The travel time to reach the sea-bottom is converted into water depth, whereas the energy of the reflected acoustic signal provides information about sediment surface properties. Generating acoustic signals in different frequencies display different features of the same seafloor properties. The applied frequencies during this cruise accounted for 160kHz and 400kHz. Since ships movement are reflected in the raw data of acoustic signals, the tow vehicle includes pitch, roll and heading sensors to correct the collected signals.

The range, the length of the profiled area to each side, was set to 100 m. By setting the distance between the profiles to 0.1 nautical mile (app. 185 m), overlap of approximately 20 m between neighbouring profiles was intended. The altitude of the towfish above the seafloor is adjusted to the water depth and prevailing wave conditions. The layback of the tow-

fish behind the ship during profiling was in the range of 10 to 15 m. The ship's speed was kept between 4 to 5 knots.

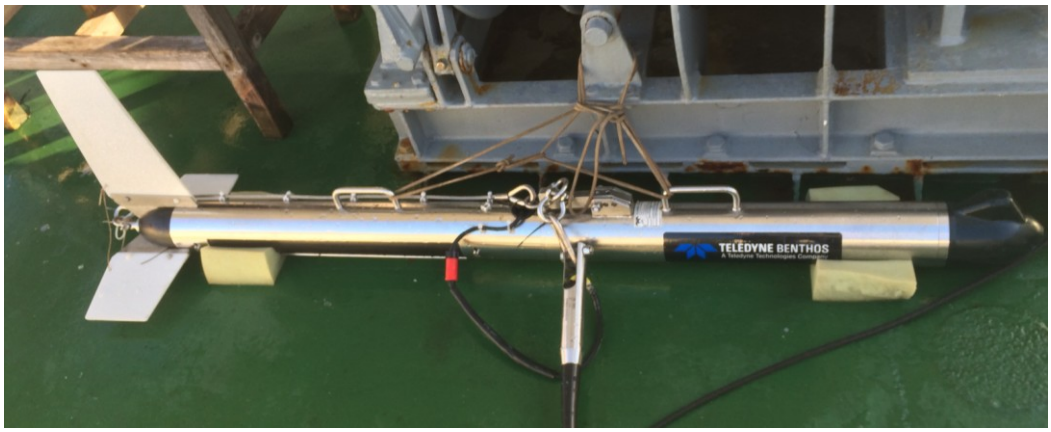

Figure 2: The employed sidescan sonar Teledyne Benthos, SIS-1624

Multibeam Echo Sounder (MBES)
The hull mounted MBS-system SeaBeam 3050 from ELAC Nautik GmbH was used to quire bathymetrical data. The MBES transmits multiple pings, which are separated into two swaths (dual swath), into the water column. The applied frequency was 53 kHz. The bathymetric data is corrected for the ships pitch and roll. CTD profiles are used to calibrate the sound velocity which depends on the actual water mass density. The water density in turn is a function of pressure, temperature and salinity.

Sediment Echo Sounder (SES)
The sub-bottom is profiled by a SES-2000 standard narrow beam parametric sub bottom profiler from Innomar Technologie GmbH. Sub-seafloor sediment structures are surveyed by the reflection of echo-signals at layers and/or objects. The travel-time of the reflected signal through the water column is converted into distances. The penetration depth of the sound signal depends on the transmitted frequency, where the lower frequency (4-15kHz) using the parametric acoustical effect is used to profile deeper structures in contrast to the higher frequency (100kHz) which primary detects the water depth. A Kongsberg-EM 3000 motion sensor is used for correction of heave, roll and pitch of the ships movement

Grab Sampler (GS)
Van Veen grab sampling (here a HELCOM grab sampler, Fig. 3) is a fast method to sample surface sediments precisely with low effort. During POS489 the sampling stations were chosen based on roughly prepared Side-Scan Sonar mosaic. The grab sampler is deployed from the ship by a. Due its own weight the shovels penetrate into the sediment. Obviously, the sediment surface gets partly disturbed under these conditions. Sediment samples are used to validate the data of the performed hydroacoustic survey. The samples are described on board and prepared for further laboratory analysis at CAU Kiel.

Giant Box Corer (GBC)
Giant box corers allow to investigate undisturbed samples from the sediment surface. The surface area which is sampled amounts to 0.25 m² (50 cm x 50 cm); the maximum penetra-

tion is 60cm in soft sediments. On a sandy seafloor the penetration is seldom more than 20 – 30 cm.

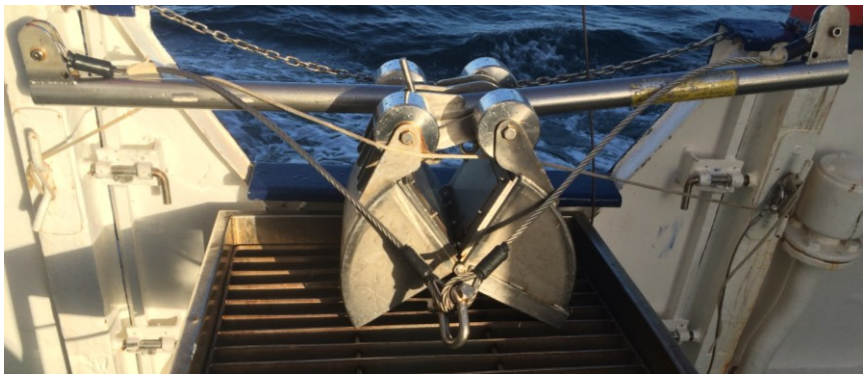

Figure 3: The HELCOM grab sampler used during the cruise POS489.

Figure 4: The employed giant box corer (box not installed) during the cruise POS489

Underwater Video (UWV)

Video tracks are recorded and displayed in real time with a Mariscope-Micro underwater video camera. Detailed images of the seafloor near giant box core stations are gained while the video camera is towed shallow above the seafloor. The ship belocity during this procedure is belom 1 nm. Underwater video survey is applied to validate the sediment properties inferred by backscatter data and for detailed imaging of marine habitat areas.

Conductivity Temperature Depth (CTD) probe

In order to calibrate the sound velocity of all hydroacoustic devides, sound-velocity profiles are taken by a CTD ("Sea & Sun Technology"), which measures the parameters pressure, salinity and temperature with depth, defining the sound velocity. The CTD probe is lowered in the water with a wire cable, where the data cable is attached, down to 1 m above the seafloor.

5. Preliminary results

The Side-Scan Sonar mosaic (Fig. 5) reveals a sediment distribution which is divided into two sections and further displays the location of sediment sample stations and video profiles, which are selected according to seafloor features displayed by the Sides-San Sonar mosaic. The change of backscatter represents difference in sediment properties, where areas dark grey backscatter is associated with coarser grained sediment while light grey represents fine grained sediment.

The northern part of the mosaic is characterized by a homogenous area of fine to medium sand. The sediment samples of fine to medium sand areas incorporate occasionally juvenile Lanice tubeworms. In addition, rarely small shell fragments and starfishes are apparent at the surface.

The appearance of large scale sediment structures increases to the south. The NE-SW orientated areas of coarser grained sediments, located in the investigated area in water depths of 15 to 30 m, are known as sorted bedforms, which are surrounded by homogenous sandy sediments. These bedforms show varying structures on different spatial scales, e.g. the northern bedforms are longitudinal shaped whereas the appearance is more complex in the south, indicated by frequent small-scale changes. Sediment samples of these areas show coarse sand and gravel which is partly covered by different shell species and larger shell fragments. The mapping of areas between sorted bedforms further show extended fields populated by tubeworms, *Lanice conchilega*, and irregular patchy structures.

In the following some of the observed sorted bedforms are described and an example for the typical structures associated with Lanice tubeworms is shown. Additionally, patchy sediment surface structures, which have not been examined until now, are shown.

5.1 Sorted bedforms

The NW-SE striking sorted bedforms located in the southern part of the mapped area (Fig. 1) are typical features of continental shelves characterised by sediment deficiency (Murray and Thieler, 2004; Coco et al, 2007). These sediment structures depend on the main current direction; close to the coast their extension is typically directed perpendicular to the shoreline (Goff et al., 2005). It was noted that wave and current induced shear stresses are able to induce small-scale changes, however, on longer time scales (26 years) these structures remained relatively stable (Diesing et al., 2006).

Two differing approaches try to explain the development of sorted bedforms: sediment sorting processes involving sediment ripples and turbulence which restricts the settling of fine grained sediment (Murray and Thieler, 2004, Coco et al., 2007a, Goldstein et al., 2011) or flow bathymetry feedback (Van Oyen et al. 2010; 2011). These different approaches indicate the complexity of explaining the development of sorted bedforms.

The SSS profile crossing a sorted bedform in the central southern part shows areas of slightly lower backscatter in the south compared to its northern part (Fig. 6). The transition from fine to coarse sediment is marked by morphological depressions about 0.5 m deep.

Furthermore, a prominent reflector is visible in the subsurface at a depth of 1 – 2 m below the seafloor. This horizon partly crops out in the southern part of the sorted bedform. The yellow arrows in the SSS and SES profiles indicate that the lower backscatter corresponds to locations where the reflector crops out on the surface in contrast to the area of higher backscatter near the end of the profile (point B), where the reflector is located in 2 m depth below the seafloor. The coarser grained material, identified through higher backscatter, is further evidenced by the according grab sample (photo of grab sample No. 63), shows coarse sand and shell fragments. In turn, the lower backscatter areas north and south of the sorted bedform represent fine grained sediment.

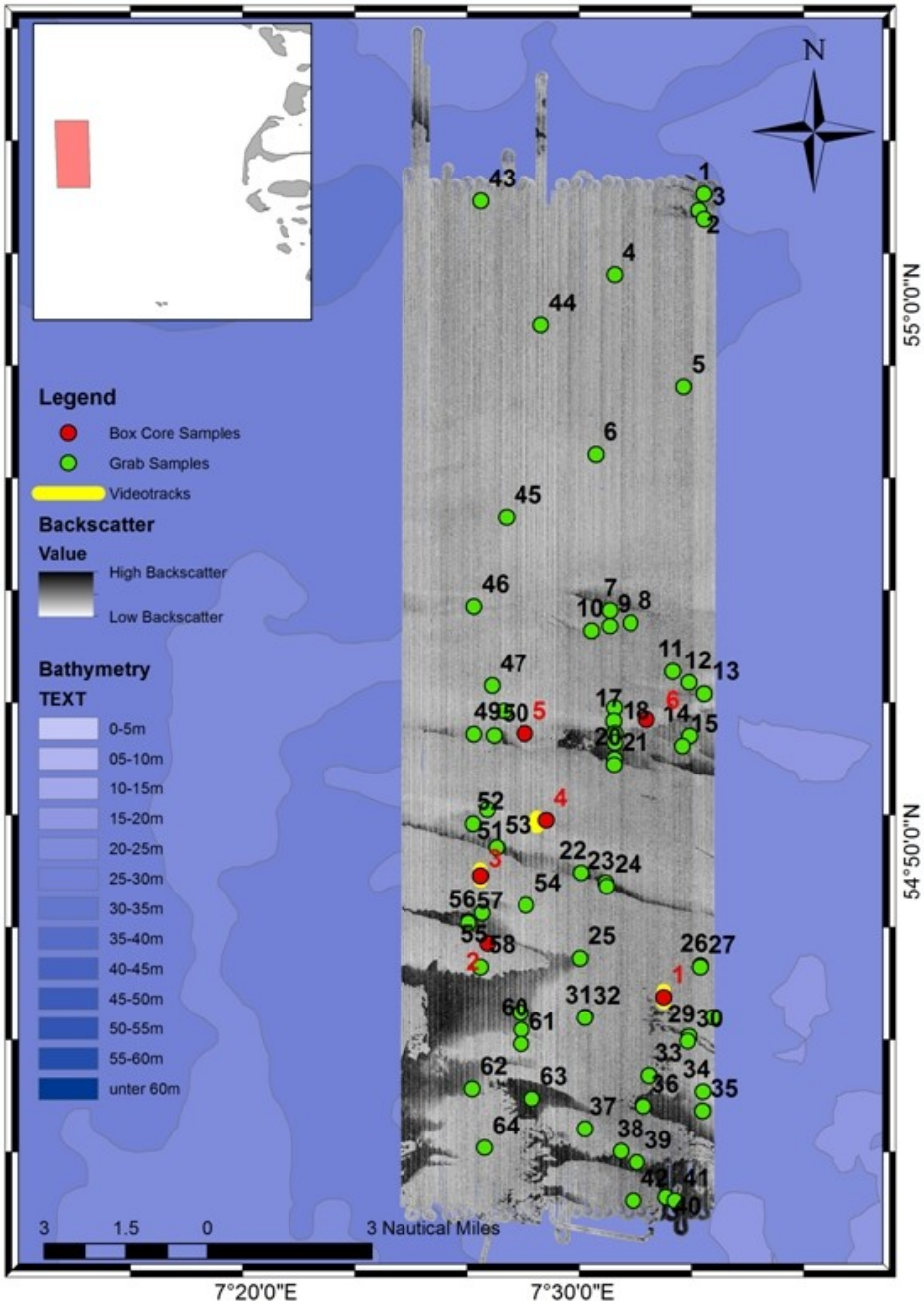

Figure 5: Side-Scan Sonar mosaic including the position of giant box cores, grab samples and under-water video track stations.

A sorted bedform of smaller spatially extended structures relative to the previously described bedform is located further in the south (Fig. 7). Its western end resembles a tree-like structure, consisting of two main branches which are thinning and further branching out westward. The main branches are crossed by the profiles, pointed by yellow arrows, and identified through the typical morphological steps. A smaller sediment structure is located in the east of the northern branch of the central bedform but remarkably is not connected to it (yellow arrow near end point A). Accordingly, the northern part of the SES profile reveals increasing interruptions of the surface. Additionally, backscatter is slightly decreased compared to the main bedform, indicating finer grained sediment. The distinct reflector is close to the sediment surface in 0.5 m depth in the southern part of the profile, whereas it is reaching 1.5 m depth at the northern end. The surface sediment of the sorted bedform consists of mid to coarse sand admixed by shell fragments (Fig 7, grab sample No. 39).

The hydroacoustic profiles of the sorted bedforms in the western area reveal three differently structured morphological features (Fig. 8). The depression of approximately 0.5 m depth in the northern branch is followed by an elevation of the same order of magnitude (arrows near end point A). The transitions from the northern to the central branch are apparently not remarkable in the SES profile. In turn, the margins of southern branch are clearly visible in both profiles (arrow). The intermediate part of low backscatter is elevated relatively to the surrounding, however, the central branch is also elevated. The intermediate part consists of fine sand (Fig. 8, photo of grab sample No. 64), whereas the sorted bedform probably consist of mid to coarse grained sand, indicated by the photo of grab sample No. 62 (see Fig. 8), taken further in the north. The prominent reflector rests in 2 – 2.5 m depth, almost throughout the profile, but rises up at the northern end (A).

The end or beginning of a sorted bedform is visible in the northern part of the study site (Fig. 9). Its spatial extent increases towards west and its northern margin is accompanied by small scaled, NE-SW striking sediment features (arrows near end point A). In turn, the southern margin appears slightly undulated and smooth. Additionally, the sorted bedform shows patchy areas of low backscatter (central arrows) correlating to the surrounding, homogenous fine to medium sand area. The according alternating morphological steps are approximately one metre. The reflector is only partly visible in shallow depths of about 0.5 – 1 m depth.

Grab samples reveal differing surface sediments in the north, No. 17, and south, No. 21, of the sorted bedform despite a similar backscatter appearance. The northern sediments consists of homogenous mid to fine sand in contrast to very fine sand with *Lanice conchilega* tubeworms in the sediment southwards of the sorted bedform.

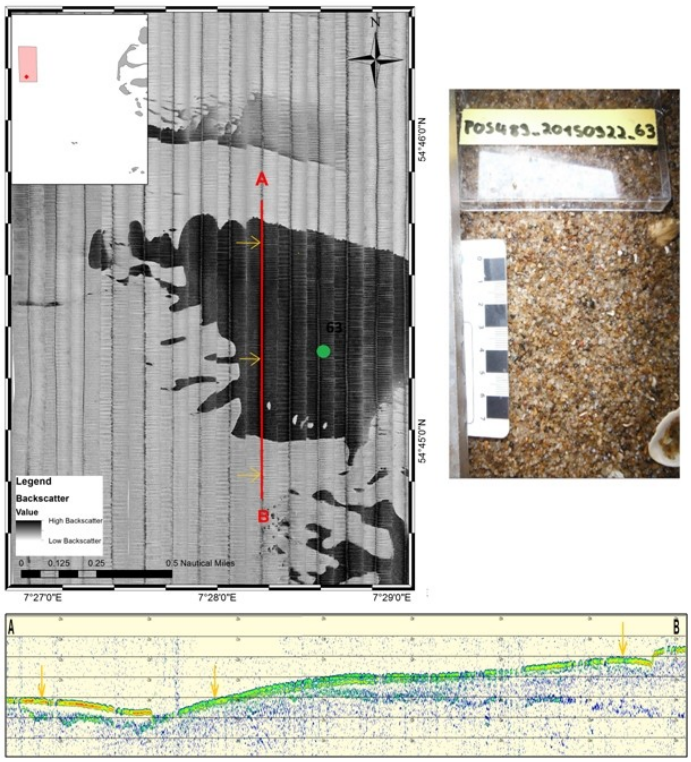

Figure 6: SSS and SES profile crossing a sorted bedform. Green marker: location of grab sample. The vertical distance between the horizontal lines in the SES image corresponds to 1 m. Coordinates A: 7°28.21E, 54°45.79N and B: 7°28.25E, 54°44.80N; profile length: 1.5 km.

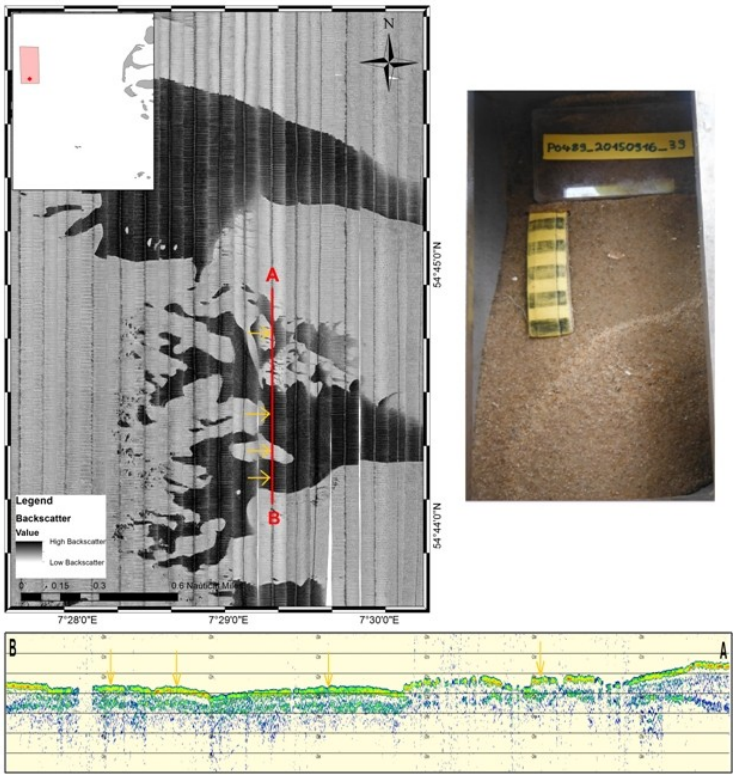

Figure 7: SSS and SES profile through a sorted bedform in the central southern part of the recorded bathymetry and photo of according grab sample; location of grab sample No. 39 further in the east (see Fig. 2); coordinates A: 7°29.23E, 54°44.91N and B: 7°29.26E, 54°44.05N; profile length: 1.6 km.

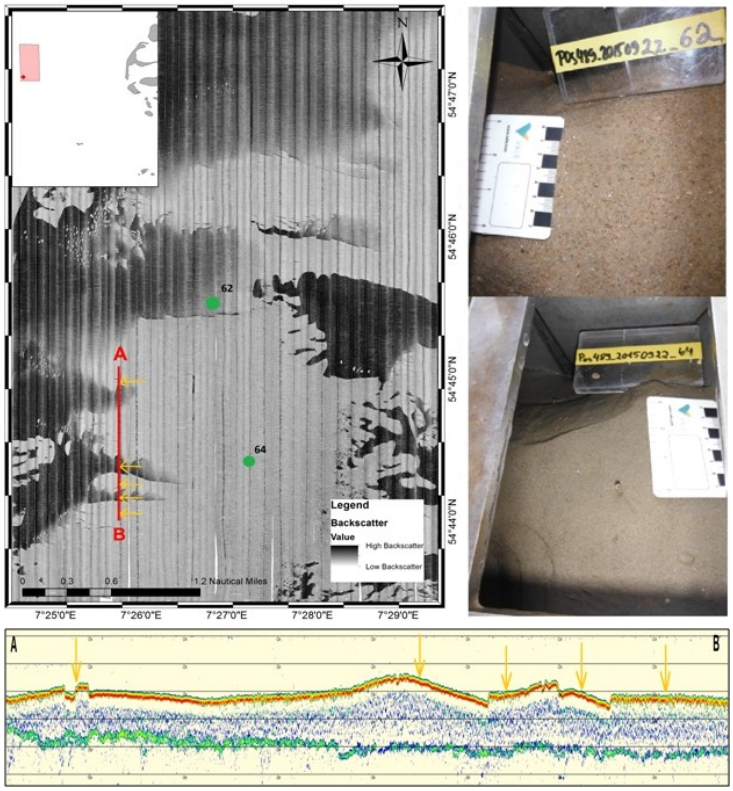

Figure 8: SSS and SES profile crossing sorted bedforms; photo of according grab samples; green marker: location of grab samples. Coordinates: A: 7°25.68E, 54°45.04N and B: 7°25.71E, 54°43.97N; profile length: 2.0 km.

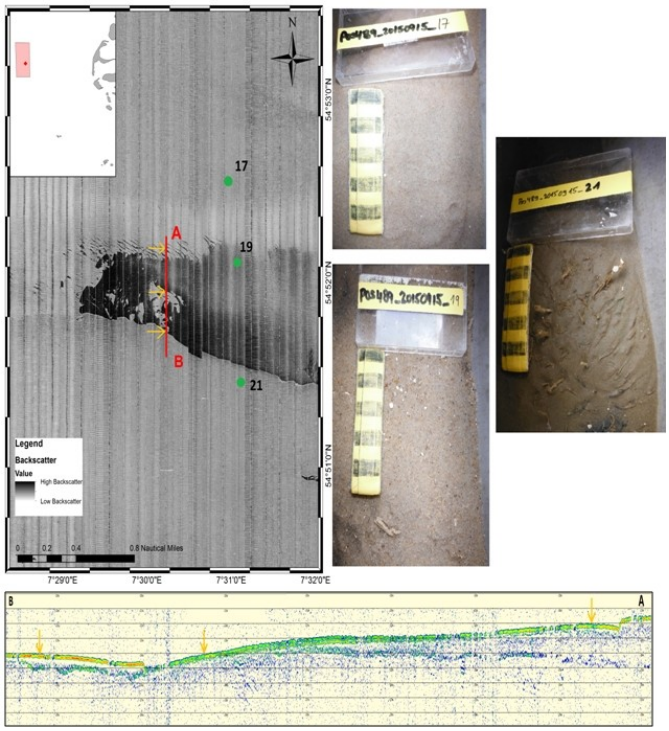

Figure 9: SSS and SES profile through crossing a sorted bedform; central eastern part of the investigation area; photo of according grab samples; green marker: location of grab samples. Coordinates A: 7°30.16E, 54°52.23N and B: 7°30.18E, 54°51.58N; profile length: 1.2 km.

5.2 *Lanice conchilega* tubeworms

Spatially extended fields of Lanice tubeworms are identified through the typical pitted structure visible in SSS and SES images indicated by alternating SSS high and low backscatter (Fig. 10). In addition, the according SES profile shows a highly irregular and rough seafloor. The giant box core sediment sample of a Lanice field showed that Lanice tubeworms live in fine grained sediment, together with the razor clam *Ensis ensis* (photo of giant box core sample No. KG5).

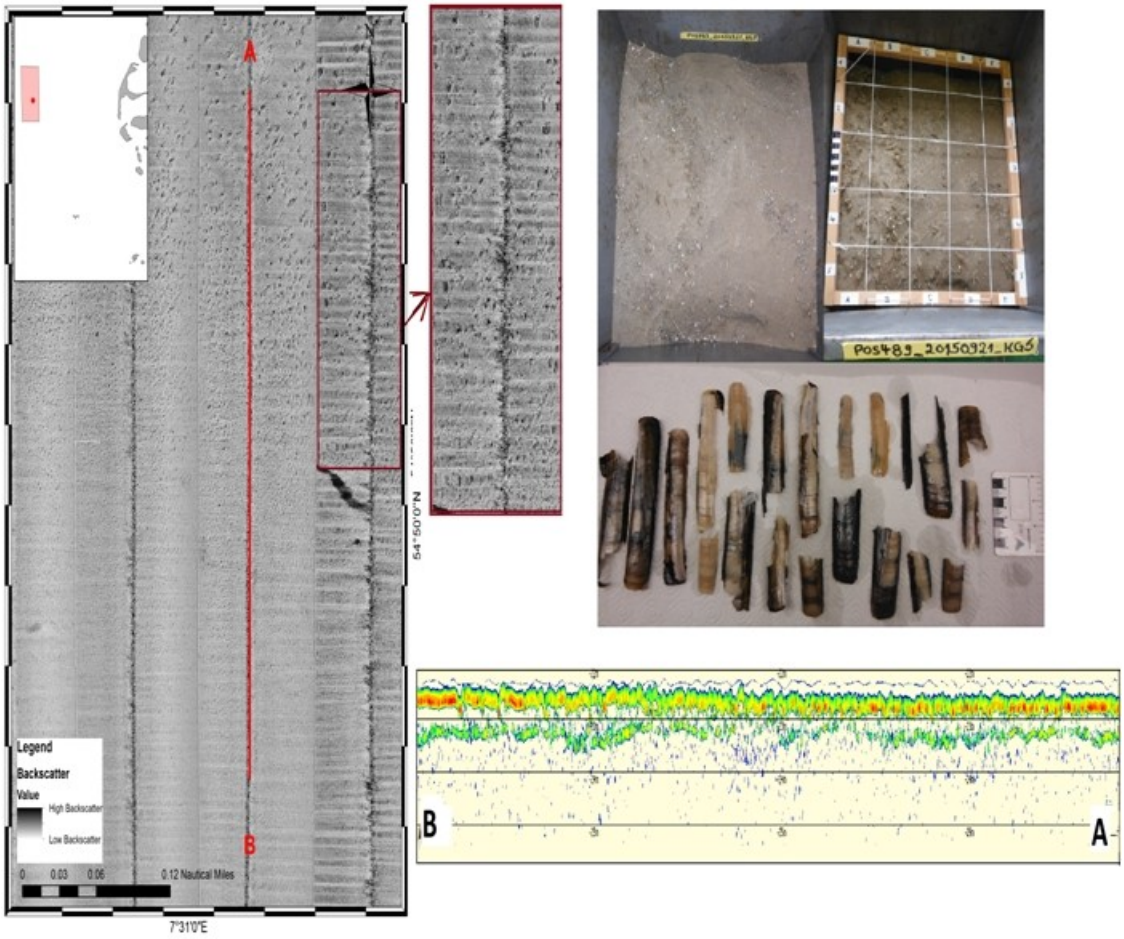

Figure 10: SSS and SES profile crossing a *Lanice conchilega* field. Photo of according giant box core sample No. 5, location see Fig. 2. SSS zoomed-in view of a part from a *Lanice* field. Coordinates A: 7°31.07E, 54°50.18N and B: 7°21.09E, 54°49.826N; profile length: 650m.

5.3 Patches

Patches of variable spatial extension and arrangement density represent another widely spreaded sediment structure in the investigation area. These patches are characterised by morphological depressions of about a few deci- to centimeters, leading to a highly irregular sea-bottom, Fig. 11. In addition, the distinct reflector of the profile is located in 1 – 0.5 m depth but rises up in northern direction. Their origin and possible interactions with hydrodynamics, underground and/or habitats is under investigation.

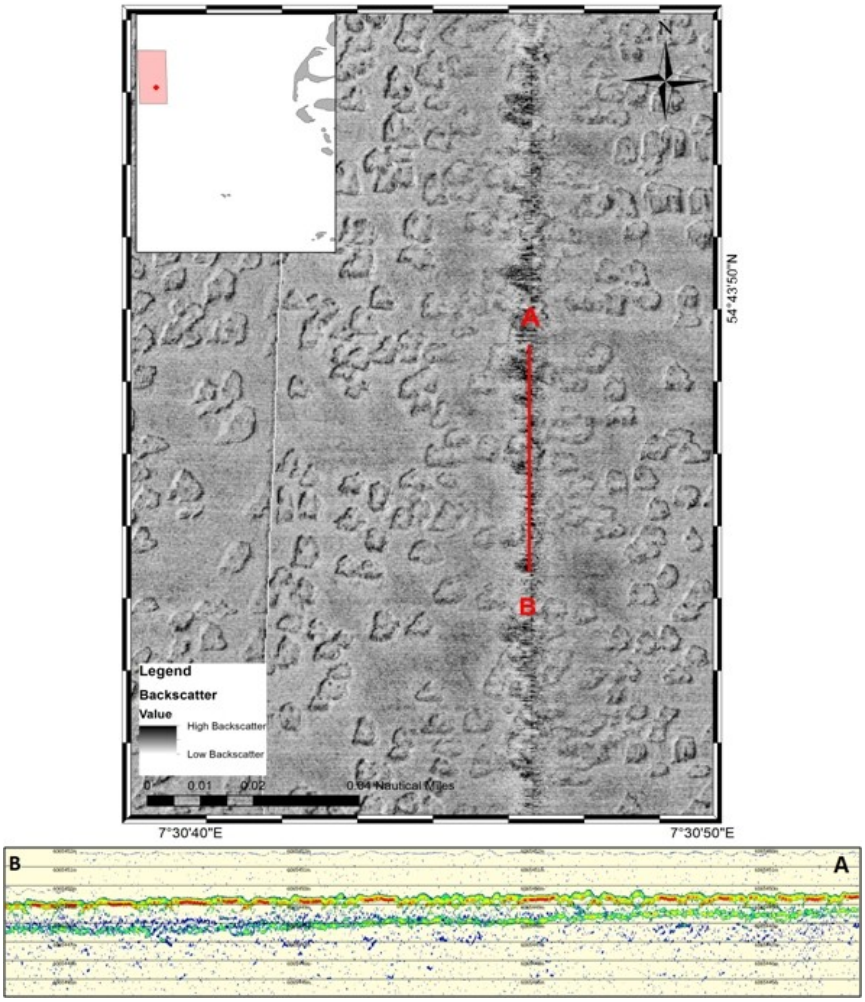

Figure 11: SSS and SES profile through a patch field in the southern part of the recorded bathymetry; coordinates A: 7°30.78E, 54°43.82N and B: 7°30.78E, 54°43.78N; profile length: 85m.

6. Summary

The performed work during cruise POS489 extends the detailed mapping of North Sea sediment distribution patterns. It was shown that sorted bedforms are apparent in water depth of up to 35 and further that the mobile sand cover above the Pleistocene base is of variable thickness in these depths.

SSS data acquired along with SES data demonstrate the very differing sedimentological build-up of sorted bedforms. The surface sediments of the here examined sorted bedforms consists of medium to coarse sand and gravel. However, their spatial appearance varies from interrupted and complex small scale changes to continuously connected structures. Taking the here examined bedforms, it appears that variably structured sorted bedforms can be associated with areas where the reflector is shallow beneath the seafloor in contrast to deeper located reflector occurring with larger and continuously connected bedforms. Interestingly, the low backscatter areas, generally associated with finer sediment relative to the coarser grained material surrounding the sorted bedforms, consists of fine sand. It should be noted that the difference of fine to very fine sand may be masked in presence of the tubeworm *Lanice conchilega*. Largely extended fields of Lanice tubeworms have been mapped and sampled revealing their preferred habitat in fine grained sediment and their ability to coexist with the razor shell *Ensis ensis*. Another widely observed sediment feature are

patches of variable size and density, however, additional investigations are necessary in order to clarify their origin.

8. References

Coco, G., Murray, A.D., Green, MoO., 2007. Sorted bed forms as self-organized patterns: 1. Model development. J. Geophys. Res., 112 (F3), doi:10.1029/2006JF000665

Coco, G., Murry, A.D., Green, M.O., Thieler, E.R., Hume, T.M., 2007. Sorted bed forms as self-organized patterns: 2. Complex forcing scenarios. – J. Geophys. Res., 12, doi: 10.1029/2006JF000666.

Diesing, M., Schwarzer, K., 2006. Identification of submarine hard bottom substrates in the German North Sea and Baltic Sea Exclusive Economic Zones by high-resolution acoustic seafloor imaging. In: von Nordheim, H., Boedeker, D., Krause, J.C. (eds.) Advancing to-wards effective marine conservation in Europe - NATURA 2000 sites in German offshore waters, Springer (Berlin), 111 – 125.

Diesing, M., Kubicki, A., Winter, C., Schwarzer, K., 2006. Decadal scale stability of sorted bedforms, German Bight, southeastern North Sea. Continental Shelf Research, 26 (8), 902 - 916.

Figge, K., 1981. Sedimentverteilung in der Deutschen Bucht. Maßstab 1 : 250.000. DHI Karte Nr. 2900 mit Begleitheft.

Goff, J.A., Mayer, L.A., Traykovski, P., Buynevich, R.W., Raymond, R., Glang, G., Evans, R.L., Olson, H., Jenkins, C., 2005. Detailed investigations of sorted bedforms, or ”rippled scour depressions”, within the Martha’s Vineyard Coastal Observatory, Massachusetts. – Continental Shelf Research, 25, 461 – 484.

Goldstein, E.B., Murray, A.B., Coco, G., 2011. Sorted bedform pattern evolution: Persistence, destruction and self-organized intermittency, Geophysical Research Letters, vol. 38, L24402, doi: 10.1029/2011GL049732.

Köster, R., 1979. Dreidimensionale Kartierung des Seegrundes vor den nordfriesischen Inseln. DFG Forschungsbericht Sandbewegung im Küstenraum, Rückschau, Ergebnisse und Ausblick, 146 – 168.

Laurer, U., Naumann, M., Zeiler, M. 2013. Geopotenziale Deutsche Nordsee, Modul B, Dokumentation Nr. 1; Erstellung der Karte zur Sedimentverteilung auf dem Meeresboden in der deutschen Nordsee nach der Klassifikation von FIGGE (1981).

Murray, A. B., and E. R. Thieler, 2004. A new hypothesis and exploratory model for the formation of large-scale inner-shelf sediment sorting and “rippled scour depressions”, Cont. Shelf Res., 24, 295–315.

Schwarzer, K., Ricklefs, K., Bartholoä, A., Zeiler, M., 2008. Geological development of the North and Baltic Sea. Die Küste, 74, 1 – 17.

Van Oyen, T., de Swart, H. E, Blondeaux, P., 2010. Bottom topography and roughness variations as triggering mechanisms to the formation of sorted bedforms, Geophysical Research Letters, vol. 37, L18401, doi: 10.1029/2010GL043793.

Van Oyen , T., de Swart, H. E, Blondeaux, P., 2011. Formation of rhythmic sorted bed forms on the continental shelf: an idealised model, J. Fluid Mech., vol. 684, pp. 475-508.

Zeiler, M.; Schulz-Ohlberg, J.; Figge, K., 2000. Mobile sand deposits and shoreface sediment dynamics in the inner German Bight (North Sea), Marine Geology, Volume 170, Number 3, 15 November 2000, pp. 363-380(18).

Zeiler, M., Schwarzer, K., Bartholomä, A., Ricklefs, K., 2008. Seabed morphology and sediment dynamics. Die Küste, 74, 31 – 44.

9. Appendix

I. SSS profiles

Latitude	Longitude	Date	Time	Description
54°72.280 N	07°57.162 E	10.09.15	05:52	Profile start, Profile 1
55°03.332 N	07°56.247 E	10.09.15	09:26	Profile end Profile 1
55°03.225 N	07°55.930 E	10.09.15	09:33	Profile start, Profile 2
54°72.522 N	07°56.907 E	10.09.15	13:10	Profile end, Profile 2
54°72.523 N	07°56.623 E	10.09.15	13:18	Profile start, Profile 3
55°03.070 N	07°55.650 E	10.09.15	14:54	Profile end, Profile 3
54°03.300 N	07°55.390 E	10.09.15	15:01	Profile start, Profile 4
54°72.523 N	07°56.360 E	10.09.15	20:43	Profile end, Profile 4
54°72.549 N	07°56.095 E	10.09.15	20:50	Profile start, Profile 5
55°03.268 N	07°55.097 E	11.09.15	00:26	Profile end, Profile 5
55°03.222 N	07°54.776 E	11.09.15	00:35	Profile start, Profile 6
54°72.476 N	07°55.810 E	11.09.15	02:09	Profile end, Profile 6
54°72.548 N	07°55.478 E	11.09.15	02:23	Profile start, Profile 7
55°03.240 N	07°54.523 E	11.09.15	08:04	Profile end Profile 7
55°03.246 N	07°55.170 E	11.09.15	08:10	Profile start, Profile 8
54°72.485 N	07°55.238 E	11.09.15	11:54	Profile end, Profile 8
54°72.494 N	07°54.918 E	11.09.15	12:02	Profile start, Profile 9
55°03.269 N	07°53.974 E	11.09.15	13:36	Profile end Profile 9
55°03.238 N	07°53.750 E	11.09.15	13:44	Profile start, Profile 10
54°43.494 N	07°32.806 E	11.09.15	19:23	Profile end, Profile 10
54°43.529 N	07°32.648 E	11.09.15	19:31	Profile start, Profile 11
55°03.224 N	07°53.407 E	11.09.15	23:09	Profile end, Profile 11
55°03.247 N	07°53.186 E	11.09.15	23:17	Profile start, Profile 12
54°72.481 N	07°54.119 E	12.09.15	02:54	Profile end, Profile 12
54°72.500 N	07°53.810 E	12.09.15	03:04	Profile start, Profile 13
54°03.206 N	07°92.893 E	12.09.15	06:41	Profile end, Profile 13
55°03.238 N	07°92.989 E	12.09.15	06:47	Profile start, Profile 14
54°72.511 N	07°53.544 E	12.09.15	10:29	Profile end, Profile 14
54°72.485 N	07°53.272 E	12.09.15	10:36	Profile start, Profile 15
55°03.218 N	07°52.282 E	12.09.15	14:15	Profile end, Profile 15
55°03.193 N	07°51.966 E	12.09.15	14:24	Profile start, Profile 16
55°72.485 N	07°53.008 E	12.09.15	17:59	Profile end, Profile 16
54°76.310 N	07°52.730 E	12.09.15	18:07	Profile start, Profile 17
55°03.221 N	07°51.713 E	12.09.15	21:42	Profile end, Profile 17
55°03.318 N	07°51.460 E	12.09.15	21:50	Profile start, Profile 18
54°72.497 N	07°52.435 E	12.09.15	01:27	Profile end, Profile 18
54°72.257 N	07°52.091 E	13.09.15	01:34	Profile start, Profile 19
55°03.224 N	07°51.160 E	13.09.15	05:14	Profile end, Profile 19
55°03.218 N	07°50.879 E	13.09.15	05:22	Profile start, Profile 20
54°72.483 N	07°51.873 E	13.09.15	08:58	Profile end, Profile 20
54°72.488 N	07°51.617 E	13.09.15	09:05	Profile start, Profile 21
55°03.213 N	07°50.584 E	13.09.15	12:42	Profile end, Profile 21
55°03.221 N	07°50.348 E	13.09.15	12:50	Profile start, Profile 22
54°72.441 N	07°51.319 E	13.09.15	16:30	Profile end, Profile 22
54°72.477 N	07°51.024 E	13.09.15	16:37	Profile start, Profile 23
55°03.220 N	07°50.024 E	13.09.15	20:18	Profile end, Profile 23
55°63.155 N	07°49.752 E	13.09.15	20:24	Profile start, Profile 24
54°72.483 N	07°50.759 E	13.09.15	00:08	Profile end, Profile 24
54°72.395 N	07°50.406 E	13.09.15	00:14	Profile start, Profile 25
55°03.189 N	07°49.462 E	13.09.15	03:55	Profile end, Profile 25
54°03.190 N	07°49.142 E	14.09.15	04:06	Profile end, Profile 26
54°72.446 N	07°50.219 E	14.09.15	07:43	Profile start, Profile 27

54°72.459 N	07°49.944 E	14.09.15	07:49	Profile end, Profile 27
55°03.202 N	07°48.676 E	14.09.15	11:28	Profile start, Profile 28
54°72.440 N	07°49.650 E	14.09.15	11:36	Profile end, Profile 28
54°72.416 N	07°49.281 E	14.09.15	15:36	Profile start, Profile 29
55°03.175 N	07°48.343 E	14.09.15	18:46	Profile end, Profile 29
55°03.150 N	07°48.066 E	14.09.15	18:52	Profile start, Profile 30
54°72.441 N	07°49.095E	14.09.15	21:58	Profile end, Profile 30
54°72.432 N	07°48.852 E	16.09.15	09:28	Profile start, Profile 31, SSS heaved to surface as ship needed to slow down
55°03.185 N	07°47.767 E	16.09.15	13:05	Profile end, Profile 31
55°02.804 N	07°47.477 E	16.09.15	13:28	Profile start, Profile 32
54°72.499 N	07°48.516 E	16.09.15	17:37	Profile end, Profile 32
54°72.463 N	07°48.260 E	18.09.15	05:29	Profile start, Profile 33
55°06.449 N	07°47.108 E	18.09.15	09:49	Profile end, Profile 33
55°06.432 N	07°46.851 E	18.09.15	09:55	Profile start, Profile 34
54°72.435 N	07°47.975 E	18.09.15	14:00	Profile end, Profile 34
54°72.441 N	07°47.775 E	18.09.15	14:08	Profile start, Profile 35
55°03.110 N	07°46.625 E	18.09.15	17:56	Profile end, Profile 35
55°03.128 N	07°46.387 E	18.09.15	18:05	Profile start, Profile 36
54°72.365 N	07°47.431 E	18.09.15	21:08	Profile end, Profile 36
54°72.448 N	07°47.154 E	18.09.15	21:15	Profile start, Profile 37
55°03.141 N	07°46.085 E	19.09.15	00:34	Profile end, Profile 37
55°03.187 N	07°45.800 E	19.09.15	00:41	Profile start, Profile 38
54°72.410 N	07°46.864 E	19.09.15	03:53	Profile end, Profile 38
54°72.416 N	07°46.555 E	19.09.15	04:00	Profile start, Profile 39
55°04.146 N	07°45.471 E	19.09.15	07:14	Profile end, Profile 39
55°03.202 N	07°45.193 E	19.09.15	07:25	Profile start, Profile 40
54°72.421 N	07°46.300 E	19.09.15	10:27	Profile end, Profile 40
54°72.434 N	07°46.050 E	19.09.15	10:36	Profile start, Profile 41
55°03.313 N	07°44.958 E	19.09.15	13:46	Profile end, Profile 41
55°03.133 N	07°44.685 E	19.09.15	13:54	Profile start, Profile 42
54°72.499 N	07°45.718 E	19.09.15	17:03	Profile end, Profile 42
54°72.402 N	07°45.449 E	19.09.15	17:15	Profile start, Profile 43
55°03.345 N	07°44.466 E	19.09.15	20:53	Profile end, Profile 43
55°03.103 N	07°44.109 E	19.09.15	20:58	Profile start, Profile 44
54°72.419 N	07°45.176 E	20.09.15	00:14	Profile end, Profile 44
54°72.341 N	07°44.916 E	20.09.15	00:24	Profile start, Profile 45
55°03.118 N	07°43.831 E	20.09.15	04:11	Profile end, Profile 45
55°03.118 N	07°43.587 E	20.09.15	04:19	Profile start, Profile 46
54°72.425 N	07°44.616 E	20.09.15	07:57	Profile end, Profile 46
54°72.373 N	07°44.313 E	20.09.15	08:06	Profile start, Profile 47
55°03.093 N	07°43.271 E	20.09.15	12:36	Profile end, Profile 47
55°03.156 N	07°43.017 E	20.09.15	12:45	Profile start, Profile 48
54°72.402 N	07°44.055 E	20.09.15	16:15	Profile end, Profile 48
54°72.372 N	07°43.809 E	20.09.15	16:23	Profile start, Profile 49
55°03.118 N	07°42.690 E	20.09.15	19:59	Profile end, Profile 49
55°03.166 N	07°42.386 E	20.09.15	20:06	Profile start, Profile 50
54°72.403 N	07°43.511 E	20.09.15	23:07	Profile end, Profile 50
54°72.394 N	07°43.261 E	20.09.15	23:17	Profile start, Profile 51
55°03.094N	07°42.136 E	21.09.15	02:54	Profile end, Profile 51
55°03.089 N	07°41.910 E	21.09.15	03:06	Profile start, Profile 52
54°72.323 N	07°42.932 E	21.09.15	06:13	Profile end, Profile 52 (SSS out of water)
54°52.145 N	07°30.758 E	21.09.15	15:31	Profile start, cross profile 1
54°32.134 N	07°28.932 E	21.09.15	15:47	Profile end, cross profile 1
54°52.177 N	07°29.003 E	21.09.15	15:55	Profile start, cross profile 2
54°52.176 N	07°30.808 E	21.09.15	16:11	Profile end, cross profile 2
54°52.204 N	07°30.712 E	21.09.15	16:23	Profile start, cross profile 3

54°52.197 N	07°28.944 E	21.09.15	16:38	Profile end, cross profile 3
54°52.197 N	07°28.944 E	21.09.15	16:38	Transit start
54°72.335 N	07°42.585 E	21.09.15	18:24	Profile start, Profile 53, transit end
55°03.132 N	07°41.588 E	21.09.15	21:30	Profile end, Profile 53
55°03.112 N	07°41.292 E	21.09.15	21:37	Profile start, Profile 54
54°72.579 N	07°42.373 E	22.09.15	01:42	Profile end, Profile 54
54°72.348 N	07°42.132 E	22.09.15	01:51	Profile start, Profile 55
55°06.958 N	07°40.867 E	22.09.15	05:58	Profile end, Profile 55
54°72.400 N	07°41.825 E	22.09.15	16:44	Profile start, Profile 56
55°07.820 N	07°40.522 E	22.09.15	20:14	Profile end, Profile 56
55°07.644 N	07°40.211 E	22.09.15	20:21	Profile start, Profile 57
54°72.375 N	07°41.550 E	22.09.15	23:54	Profile end, Profile 57
54°72.322 N	07°41.283 E	23.09.15	00:02	Profile start, Profile 58
55°03.139 N	07°40.159 E	23.09.15	03:06	Profile end, Profile 58
55°03.071 N	07°39.918 E	23.09.15	03:16	Profile start, Profile 59
54°72.324 N	07°40.969 E	23.09.15	06:24	Profile end, Profile 59

II. SES profiles

Latitude	Longitude	Date	Time	Description
54°43.453 N	07°34.330 E	10.09.15	05:52	Profile start, Profile 1
55°02.040 N	07°33.766 E	10.09.15	09:27	Profile end Profile 1
55°03.225 N	07°55.930 E	10.09.15	09:33	Profile start, Profile 2
54°43.516 N	07°34.144 E	10.09.15	13:10	Profile end, Profile 2
54°43.526 N	07°33.973 E	10.09.15	13:17	Profile start, Profile 3
55°01.847 N	07°33.394 E	10.09.15	16:54	Profile end, Profile 3
55°01.957 N	07°33.235 E	10.09.15	17:01	Profile start, Profile 4
54°43.490 N	07°33.819 E	10.09.15	20:43	Profile end, Profile 4
54°43.530 N	07°33.657 E	10.09.15	20:50	Profile start, Profile 5
55°01.955 N	07°33.057 E	11.09.15	00:26	Profile end, Profile 5
54°01.933 N	07°32.864 E	11.09.15	00:36	Profile start, Profile 6
54°43.479 N	07°33.486 E	11.09.15	04:09	Profile end, Profile 6
54°43.558 N	07°33.289 E	11.09.15	04:23	Profile start, Profile 7
55°02.050 N	07°32.756 E	11.09.15	08:04	Profile end Profile 7
55°01.929 N	07°32.574 E	11.09.15	08:10	Profile start, Profile 8
54°43.450 N	07°33.144 E	11.09.15	11:53	Profile end, Profile 8
54°43.515 N	07°32.958 E	11.09.15	12:02	Profile start, Profile 9
55°01.998 N	07°32.406 E	11.09.15	15:37	Profile end Profile 9
55°01.902 N	07°32.243 E	11.09.15	15:44	Profile start, Profile 10
54°43.494 N	07°32.806 E	11.09.15	19:23	Profile end, Profile 10
54°43.529 N	07°32.648 E	11.09.15	19:31	Profile start, Profile 11
55°01.943 N	07°32.044 E	11.09.15	23:09	Profile end, Profile 11
55°01.935 N	07°31.911 E	11.09.15	23:17	Profile start, Profile 12
54°43.480 N	07°32.471 E	12.09.15	02:55	Profile end, Profile 12
54°43.514 N	07°32.287 E	12.09.15	03:03	Profile start, Profile 13
55°01.943 N	07°31.707 E	12.09.15	06:41	Profile end, Profile 13
55°01.943 N	07°31.557 E	12.09.15	06:48	Profile start, Profile 14
54°43.493 N	07°32.134 E	12.09.15	10:29	Profile end, Profile 14
54°43.507 N	07°31.959 E	12.09.15	10:36	Profile start, Profile 15
55°01.929 N	07°31.369 E	12.09.15	14:15	Profile end, Profile 15
55°01.886 N	07°31.177 E	12.09.15	14:25	Profile start, Profile 16
54°43.472 N	07°31.805 E	12.09.15	17:59	Profile end, Profile 16
54°43.505 N	07°31.641 E	12.09.15	18:07	Profile start, Profile 17
55°01.950 N	07°31.028 E	12.09.15	21:42	Profile end, Profile 17
55°01.916 N	07°30.879 E	13.09.15	21:49	Profile start, Profile 18
54°43.479 N	07°31.418 E	13.09.15	01:27	Profile end, Profile 18

54°43.529 N	07°31.251 E	13.09.15	01:34	Profile start, Profile 19
55°01.973 N	07°30.694 E	13.09.15	05:14	Profile end, Profile 19
55°01.887 N	07°30.532 E	13.09.15	05:23	Profile start, Profile 20
54°43.476 N	07°31.123 E	13.09.15	08:58	Profile end, Profile 20
54°43.503 N	07°30.970 E	13.09.15	09:05	Profile start, Profile 21
55°01.920 N	07°30.349 E	13.09.15	12:42	Profile end, Profile 21
55°01.914 N	07°30.207 E	13.09.15	12:52	Profile start, Profile 22
54°43.473 N	07°30.791 E	13.09.15	16:30	Profile end, Profile 22
54°43.516 N	07°30.618 E	13.09.15	16:37	Profile start, Profile 23
55°02.713 N	07°30.041 E	13.09.15	20:19	Profile end, Profile 23
55°01.893 N	07°29.852 E	13.09.15	20:24	Profile start, Profile 24
54°48.469 N	07°30.457 E	14.09.15	00:08	Profile end, Profile 24
54°43.453 N	07°30.241 E	14.09.15	00:14	Profile start, Profile 25
55°01.951 N	07°29.674 E	14.09.15	03:55	Profile end, Profile 25
55°01.864 N	07°29.496 E	14.09.15	04:07	Profile start, Profile 26
55°01.864 N	07°30.132 E	14.09.15	07:43	Profile end, Profile 26
54°43.509 N	07°29.966 E	14.09.15	07:49	Profile start, Profile 27
55°01.920 N	07°29.330 E	14.09.15	11:28	Profile end, Profile 27
54°01.897 N	07°29.204 E	14.09.15	11:37	Profile start, Profile 28
54°43.424 N	07°29.792 E	14.09.15	15:19	Profile end, Profile 28
54°43.479 N	07°29.575 E	14.09.15	15:35	Profile start, Profile 29
55°01.925 N	07°29.060 E	14.09.15	18:46	Profile end, Profile 29
55°01.893 N	07°28.841 E	14.09.15	18:53	Profile start, Profile 30
54°43.438 N	07°29.456 E	14.09.15	21:58	Profile end, Profile 30
54°43.492 N	07°29.310 E	16.09.15	09:28	Profile start, Profile 31
55°01.953 N	07°28.660 E	16.09.15	13:05	Profile end, Profile 31
55°00.970 N	07°28.516 E	16.09.15	13:39	Profile start, Profile 32
54°43.458 N	07°29.112 E	16.09.15	17:37	Profile end, Profile 32
54°43.468 N	07°28.957 E	18.09.15	05:29	Profile start, Profile 33
55°03.898 N	07°28.263 E	18.09.15	09:49	Profile end, Profile 33
55°03.835 N	07°28.114 E	18.09.15	09:56	Profile start, Profile 34
54°43.436 N	07°28.785 E	18.09.15	14:00	Profile end, Profile 34
54°43.493 N	07°28.663 E	18.09.15	14:08	Profile start, Profile 35
55°01.907 N	07°27.978 E	18.09.15	17:56	Profile end, Profile 35
55°01.858 N	07°27.832 E	18.09.15	18:05	Profile start, Profile 36
54°43.350 N	07°28.467 E	18.09.15	21:08	Profile end, Profile 36
54°43.485 N	07°28.292 E	18.09.15	21:45	Profile start, Profile 37
55°01.917 N	07°27.649 E	19.09.15	00:34	Profile end, Profile 37
55°01.856 N	07°27.483 E	19.09.15	00:41	Profile start, Profile 38
54°43.418 N	07°28.107 E	19.09.15	03:54	Profile end, Profile 38
54°43.486 N	07°27.939 E	19.09.15	04:01	Profile start, Profile 39
54°02.528 N	07°27.282 E	19.09.15	07:14	Profile end, Profile 39
55°01.901 N	07°27.939 E	19.09.15	07:25	Profile start, Profile 40
54°43.416 N	07°27.784 E	19.09.15	10:28	Profile end, Profile 40
54°43.492 N	07°27.630 E	19.09.15	10:37	Profile start, Profile 41
55°01.908 N	07°26.976 E	19.09.15	13:46	Profile end, Profile 41
55°01.851 N	07°26.819 E	19.09.15	13:53	Profile start, Profile 42
54°43.475 N	07°27.433 E	19.09.15	17:02	Profile end, Profile 42
54°43.483 N	07°27.262 E	19.09.15	17:14	Profile start, Profile 43
55°02.018 N	07°26.686 E	19.09.15	20:53	Profile end, Profile 43
55°01.845 N	07°26.468 E	19.09.15	20:58	Profile start, Profile 44
54°43.416 N	07°27.108 E	20.09.15	00:14	Profile end, Profile 44
54°43.447 N	07°26.961 E	20.09.15	00:24	Profile start, Profile 45
54°01.905 N	07°26.300 E	20.09.15	04:11	Profile end, Profile 45
54°01.841 N	07°26.143 E	20.09.15	04:19	Profile start, Profile 46
54°43.424 N	07°26.770 E	20.09.15	07:57	Profile end, Profile 46
54°43.449 N	07°26.589 E	20.09.15	08:06	Profile start, Profile 47
55°01.868 N	07°25.962 E	20.09.15	12:35	Profile end, Profile 37

55°01.880 N	07°25.816 E	20.09.15	12:45	Profile start, Profile 48
54°43.370 N	07°26.440 E	20.09.15	16:15	Profile end, Profile 48
54°43.460 N	07°26.286 E	20.09.15	16:23	Profile start, Profile 49
55°01.834 N	07°25.614 E	20.09.15	19:59	Profile end, Profile 49
55°01.087 N	07°25.435 E	20.09.15	20:05	Profile start, Profile 50
54°43.407 N	07°26.107 E	20.09.15	23:07	Profile end, Profile 50
54°43.466 N	07°25.958 E	20.09.15	23:17	Profile start, Profile 51
55°01.891 N	07°25.279 E	21.09.15	02:54	Profile end, Profile 51
55°01.809 N	07°25.144 E	21.09.15	03:07	Profile start, Profile 52
54°43.377 N	07°25.761 E	21.09.15	06:13	Profile end, Profile 52 (SSS out of water)
54°52.145 N	07°30.758 E	21.09.15	15:31	Profile start, cross profile 1
54°32.134 N	07°28.932 E	21.09.15	15:47	Profile end, cross profile 1
54°52.177 N	07°29.003 E	21.09.15	15:55	Profile start, cross profile 2
54°52.176 N	07°30.808 E	21.09.15	16:11	Profile end, cross profile 2
54°52.204 N	07°30.712 E	21.09.15	16:23	Profile start, cross profile 3
54°52.197 N	07°28.944 E	21.09.15	16:38	Profile end, cross profile 3
54°52.197 N	07°28.944 E	21.09.15	16:38	Start transit
54°43.520 N	07°25.566 E	21.09.15	18:24	Profile start, Profile 53, end transit
55°01.910 N	07°24.954 E	21.09.15	21:30	Profile end, Profile 53
55°01.844 N	07°24.776 E	21.09.15	21:37	Profile start, Profile 54
54°43.401 N	07°25.427 E	22.09.15	01:42	Profile end, Profile 54
54°43.439 N	07°25.279 E	22.09.15	01:50	Profile start, Profile 55
55°04.213 N	07°24.521 E	22.09.15	05:58	Profile end, Profile 55
54°43.440 N	07°25.097 E	22.09.15	16:43	Profile start, Profile 56
55°04.750 N	07°24.326 E	22.09.15	20:14	Profile end, Profile 56
55°04.550 N	07°24.127 E	22.09.15	20:21	Profile start, Profile 57
54°43.459 N	07°24.933 E	22.09.15	23:54	Profile end, Profile 57
54°43.446 N	07°24.763 E	23.09.15	00:02	Profile start, Profile 58
55°01.923 N	07°24.094 E	23.09.15	03:07	Profile end, Profile 58
55°01.810 N	07°23.951 E	23.09.15	03:16	Profile start, Profile 59
54°43.380 N	07°24.581 E	23.09.15	06:24	Profile end, Profile 59 (SSS out of water)

III. MBES profiles

Latitude	Longitude	Date	Time	Description
54°42.139 N	07°34.276 E	10.09.15	03:51	Calibration profile 1, start
54°43.346 N	07°34.271 E	10.09.15	04.04	Calibration profile 1, end
54°34.329 N	07°34.245 E	10.09.15	04:15	Calibration profile 2, start
54°42.250 N	07°34.298 E	10.09.15	04:26	Calibration profile 2, end
54°44.340 N	07°34.293 E	10.09.15	06:02	Profile start, Profile 1
55°02.040 N	07°33.766 E	10.09.15	09:27	Profile end, Profile 1
55°01.063 N	07°33.351 E	10.09.15	09:33	Profile start, Profile 2
54°43.469 N	07°34.150 E	10.09.15	13:09	Profile end, Profile 2
54°43.526 N	07°39.973 E	10.09.15	13:17	Profile start, Profile 3
55°01.912 N	07°33.390 E	10.09.15	17:00	Profile end, Profile 3
55°01.918 N	07°33.237 E	10.09.15	17:07	Profile start, Profile 4
54°43.490 N	07°33.819 E	10.09.15	20:43	Profile end, Profile 4
54°43.530 N	07°33.657 E	10.09.15	20:50	Profile start, Profile 5
55°02.017 N	07°33.056 E	11.09.15	00:26	Profile end, Profile 5
55°01.867 N	07°32.866 E	11.09.15	00:36	Profile start, Profile 6
54°43.404 N	07°33.487 E	11.09.15	04:15	Profile end, Profile 6
54°43.604 N	07°33.294 E	11.09.15	04:30	Profile start, Profile 7
55°02.390 N	07°32.438 E	11.09.15	08:04	Profile end Profile 7

55°01.529 N	07°32.347 E	11.09.15	08:11	Profile start, Profile 8
54°43.506 N	07°33.143 E	11.09.15	11:39	Profile end, Profile 8
54°43.503 N	07°32.958 E	11.09.15	12:07	Profile start, Profile 9
55°02.034 N	07°32.390 E	11.09.15	13:36	Profile end Profile 9
55°03.239 N	07°53.750 E	11.09.15	13:44	Profile start, Profile 10
54°43.237 N	07°32.490 E	11.09.15	19:28	Profile end, Profile 10
54°43.369 N	07°32.383 E	11.09.15	19:36	Profile start, Profile 11
55°01.953 N	07°32.044 E	11.09.15	23:14	Profile end, Profile 11
55°01.935 N	07°31.911 E	12.09.15	23:22	Profile start, Profile 12
54°43.439 N	07°32.470 E	12.09.15	03:00	Profile end, Profile 12
54°43.574 N	07°32.285 E	12.09.15	03:09	Profile start, Profile 13
55°01.944 N	07°31.707 E	12.09.15	06:41	Profile end, Profile 13
55°01.834 N	07°31.561 E	12.09.15	06:54	Profile start, Profile 14
54°43.493 N	07°32.135 E	12.09.15	10:29	Profile end, Profile 14
54°43.501 N	07°31.959 E	12.09.15	10:41	Profile start, Profile 15
55°01.936 N	07°31.366 E	12.09.15	14:16	Profile end, Profile 15
55°01.876 N	07°31.174 E	12.09.15	14:25	Profile start, Profile 16
54°43.441 N	07°31.819 E	12.09.15	18:04	Profile end, Profile 16
54°43.595 N	07°31.628 E	12.09.15	18:12	Profile start, Profile 17
55°02.043 N	07°21.061 E	12.09.15	21:48	Profile end, Profile 17
55°01.738 N	07°30.883 E	12.09.15	21:56	Profile start, Profile 18
54°43.480 N	07°31.461 E	13.09.15	01:32	Profile end, Profile 18
54°43.497 N	07°31.252 E	13.09.15	01:38	Profile start, Profile 19
55°01.960 N	07°30.691 E	13.09.15	05:15	Profile end, Profile 19
55°01.905 N	07°30.533 E	13.09.15	05:23	Profile start, Profile 20
55°43.166 N	07°30.570 N	13.09.15	09:01	Profile end, Profile 20
54°43.310 N	07°30.582 E	13.09.15	09:09	Profile start, Profile 21
54°01.946 N	07°30.347 E	13.09.15	12:42	Profile end, Profile 21
55°01.914 N	07°30.207 E	13.09.15	12:52	Profile start, Profile 22
54°43.434 N	07°30.796 E	13.09.15	16:31	Profile end, Profile 22
54°43.318 N	07°30.617 E	13.09.15	16:38	Profile start, Profile 23
55°02.020 N	07°30.037 E	13.09.15	20:20	Profile end, Profile 23
55°01.861 N	07°29.865 E	13.09.15	20:25	Profile start, Profile 24
54°30.458 N	07°43.472 E	14.09.15	00:09	Profile end, Profile 24
54°30.238 N	07°30.458 E	14.09.15	00:15	Profile start, Profile 25
54°29.676 N	07°01.955 E	14.09.15	03:56	Profile end, Profile 25
55°01.893 N	07°29.490 E	14.09.15	04:06	Profile start, Profile 26
54°43.250 N	07°30.087 E	14.09.15	07:44	Profile end, Profile 26
54°43.300 N	07°29.581 E	14.09.15	07:50	Profile start, Profile 27
55°01.919 N	07°29.334 E	14.09.15	11:28	Profile end, Profile 27
55°01.894 N	07°29.205 E	14.09.15	11:38	Profile start, Profile 28
54°43.436 N	07°29.787 E	14.09.15	15:20	Profile end, Profile 28
54°43.486 N	07°29.571 E	14.09.15	15:36	Profile start, Profile 29
55°01.589 N	07°29.014 E	14.09.15	18:46	Profile end, Profile 29
55°01.540 N	07°28.504 E	14.09.15	18:52	Profile start, Profile 30
54°43.275 N	07°29.277 E	14.09.15	21:58	Profile end, Profile 30
54°43.529 N	07°29.309 E	16.09.15	09:28	Profile start, Profile 31
55°01.953 N	07°28.660 E	16.09.15	13:05	Profile end, Profile 31

55°01.472 N	07°28.497 E	16.09.15	13:32	Profile start, Profile 32
54°43.407 N	07°29.113 E	16.09.15	17:37	Profile end, Profile 32
54°43.474 N	07°28.955 E	18.09.15	05:29	Profile start, Profile 33
55°03.898 N	07°28.263 E	18.09.15	09:49	Profile end, Profile 33
55°02.552 N	07°28.156 E	18.09.15	10:10	Profile start, Profile 34
54°43.486 N	07°28.789 E	18.09.15	13:59	Profile end, Profile 34
54°43.492 N	07°22.787 E	18.09.15	14:08	Profile start, Profile 35
55°01.911 N	07°27.817 E	18.09.15	17:57	Profile end, Profile 35
55°18.130 N	07°27.817 E	18.09.15	18:09	Profile start, Profile 36
54°34.271 N	07°28.517 E	18.09.15	21:10	Profile end, Profile 36
54°43.544 N	07°28.287 E	18.09.15	21:16	Profile start, Profile 37
55°01.907 N	07°27.649 E	19.09.15	00:34	Profile end, Profile 37
55°01.890 N	07°27.483 E	19.09.15	00:42	Profile start, Profile 38
54°43.416 N	07°28.109 E	19.09.15	03:53	Profile end, Profile 38
54°43.474 N	07°27.941 E	19.09.15	04:00	Profile start, Profile 39
55°02.300 N	07°27.070 E	19.09.15	07:16	Profile end, Profile 39
55°02.531 N	07°27.073 E	19.09.15	07:26	Profile start, Profile 40
54°43.436 N	07°27.783 E	19.09.15	10:28	Profile end, Profile 40
54°43.466 N	07°27.630 E	19.09.15	10:37	Profile start, Profile 41
55°01.899 N	07°26.975 E	19.09.15	13:47	Profile end, Profile 41
55°01.862 N	07°26.862 E	19.09.15	13:54	Profile start, Profile 42
54°43.441 N	07°27.434 E	19.09.15	17:03	Profile end, Profile 42
54°43.484 N	07°27.265 E	19.09.15	17:15	Profile start, Profile 43
55°25.076 N	07°26.630 E	19.09.15	20:54	Profile end, Profile 43
55°01.765 N	07°26.466 E	19.09.15	20:59	Profile start, Profile 44
54°43.430 N	07°27.106 E	20.09.15	00:15	Profile end, Profile 44
54°43.432 N	07°27.956 E	20.09.15	00:25	Profile start, Profile 45
55°01.906 N	07°26.299 E	20.09.15	04:11	Profile end, Profile 45
55°01.840 N	07°26.143 E	20.09.15	04:18	Profile start, Profile 46
54°43.232 N	07°26.467 E	20.09.15	07:58	Profile end, Profile 46
54°43.271 N	07°26.350 E	20.09.15	08:07	Profile start, Profile 47
55°01.868 N	07°25.962 E	20.09.15	12:37	Profile end, Profile 37
55°01.858 N	07°25.820 E	20.09.15	12:42	Profile start, Profile 48
54°43.345 N	07°26.463 E	20.09.15	16:16	Profile end, Profile 48
54°43.456 N	07°26.287 E	20.09.15	16:23	Profile start, Profile 49
55°01.960 N	07°25.641 E	20.09.15	20:00	Profile end, Profile 49
55°01.762 N	07°25.450 E	20.09.15	20:06	Profile start, Profile 50
54°43.427 N	07°26.109 E	20.09.15	22:08	Profile end, Profile 50
54°43.440 N	07°25.957 E	20.09.15	22:18	Profile start, Profile 51
55°01.878 N	07°25.280 E	21.09.15	02:54	Profile end, Profile 51
54°01.833 N	07°25.144 E	21.09.15	03:06	Profile start, Profile 52
54°43.227 N	07°25.458 E	21.09.15	06:13	Profile end, Profile 52
54°52.145 N	07°30.758 E	21.09.15	15:31	Profile start, cross profile 1
54°32.134 N	07°28.932 E	21.09.15	15:47	Profile end, cross profile 1
54°52.177 N	07°29.003 E	21.09.15	15:55	Profile start, cross profile 2
54°52.176 N	07°30.808 E	21.09.15	16:11	Profile end, cross profile 2
54°52.204 N	07°30.712 E	21.09.15	16:23	Profile start, cross profile 3
54°52.197 N	07°28.944 E	21.09.15	16:38	Profile end, cross profile 3

54°52.197 N	07°28.944 E	21.09.15	16:38	Start Transit
54°43.594 N	07°25.575 E	21.09.15	18:26	Profile start, Profile 53
55°02.036 N	07°24.967 E	21.09.15	21:31	Profile end, Profile 53
55°01.733 N	07°24.791 E	21.09.15	21:39	Profile start, Profile 54
54°43.412 N	07°25.426 E	22.09.15	01:42	Profile end, Profile 54
54°43.403 N	07°25.278 E	22.09.15	01:51	Profile start, Profile 55
55°04.134 N	07°24.313 E	22.09.15	05:58	Profile end, Profile 55
54°43.444 N	07°25.093 E	22.09.15	16:43	Profile start, Profile 56
55°04.786 N	07°24.331 E	22.09.15	20:15	Profile end, Profile 56
55°04.490 N	07°24.128 E	22.09.15	20:22	Profile start, Profile 57
54°43.397 N	07°24.932 E	22.09.15	23:54	Profile end, Profile 57
54°43.405 N	07°24.767 E	23.09.15	00:02	Profile start, Profile 58
55°01.911 N	07°24.094 E	23.09.15	03:06	Profile end, Profile 58
55°01.822 N	07°23.952 E	23.09.15	03:16	Profile start, Profile 59
54°43.220 N	07°24.340 E	23.09.15	06:16	Profile end, Profile 59

IV. CTD

Latitude	Longitude	Date	Time	Description
54°41.761 N	07°34.635 E	10.09.15	04:47	Profile for soundvelocity of multi beam
54°43.462 N	07°31.894 E	16.09.15	08:31	Profile for soundvelocity of multi beam
54°43.314 N	07°24.692 E	21.09.15	06:30	Profile for soundvelocity of multi beam

V. Grab Samples

A) Van-Veen grab samples

Latitude	Longitude	Date	Time	Description
55°01.978 N	07°33.314 E	15.09.15	04:29	Sample 1, 3rd trial
55°01.647 N	07°33.066 E	15.09.15	05:00	Sample 2
55°01.506 N	07°33.458 E	15.09.15	05:20	Sample 3
55°04.490 N	07°30.631 E	15.09.15	06:00	Sample 4
54°58.430 N	07°32.981 E	15.09.15	06:42	Sample 5
54°57.175 N	07°30.191 E	15.09.15	07:24	Sample 6
54°54.550 N	07°30.840 E	15.09.15	08:10	Sample 7
54°54.095 N	07°31.400 E	15.09.15	08:30	Sample 8
54°54.035 N	07°30.796 E	15.09.15	08:56	Sample 9
54°53.958 N	07°30.136 E	15.09.15	09:17	Sample 10
54°53.221 N	07°32.759 E	15.09.15	09:52	Sample 11
54°53.036 N	07°33.270 E	15.09.15	10:20	Sample 12
54°52.820 N	07°33.746 E	15.09.15	10:45	Sample 13
54°52.056 N	07°33.327 E	15.09.15	11:12	Sample 14
54°51.877 N	07°33.112 E	15.09.15	11:31	Sample 15
54°52.542 N	07°30.909 E	15.09.15	12:08	Sample 16
54°52.302 N	07°30.894 E	15.09.15	12:27	Sample 17
54°52.070 N	07°30.957 E	15.09.15	12:44	Sample 18
54°51.903 N	07°30.966 E	15.09.15	12:59	Sample 19
54°51.607 N	07°30.933 E	15.09.15	13:18	Sample 20
54°51.487 N	07°30.952 E	15.09.15	13:33	Sample 21
54°49.313 N	07°29.991 E	15.09.15	14:21	Sample 22
54°49.334 N	07°30.763 E	15.09.15	14:45	Sample 23

54°49.267 N	07°30.814 E	15.09.15	15:01	Sample 24
54°47.953 N	07°30.200 E	15.09.15	15:35	Sample 25
54°47.859 N	07°33.817 E	15.09.15	16:41	Sample 26
54°47.830 N	07°33.817 E	15.09.15	16:45	Sample 27
54°46.924 N	07°34.261 E	15.09.15	17:13	Sample 28
54°46.549 N	07°33.494 E	15.09.15	17:35	Sample 29
54°46.477 N	07°33.352 E	15.09.15	17:58	Sample 30, 2nd trial
54°46.903 N	07°30.181 E	15.09.15	18:36	Sample 31
54°46.868 N	07°30.183 E	15.09.15	18:49	Sample 32
54°45.831 N	07°32.317 E	15.09.15	19:??	Sample 33
54°45.548 N	07°34.063 E	15.09.15	19:50	Sample 34
54°45.204 N	07°34.007 E	16.09.15	04:31	Sample 35
54°45.274 N	07°32.109 E	16.09.15	04:58	Sample 36a
54°45.273 N	07°32.144 E	16.09.15	05:13	Sample 36b, 2nd trial
54°44.828 N	07°30.307 E	16.09.15	06:01	Sample 37
54°44.426 N	07°31.434 E	16.09.15	06:28	Sample 38
54°31.973 N	07°31.973 E	16.09.15	06:48	Sample 39
54°43.616 N	07°32.899 E	16.09.15	07:13	Sample 40
54°43.560 N	07°33.168 E	16.09.15	07:33	Sample 41
54°43.813 N	07°31.881 E	16.09.15	08:07	Sample 42
55°01.736 N	07°26.295 E	21.09.15	06:36	Sample 43
54°59.485 N	07°28.346 E	21.09.15	07:14	Sample 44
54°55.965 N	07°27.354 E	22.09.15	08:05	Sample 45
54°54.326 N	07°26.389 E	22.09.15	08:36	Sample 46
54°52.882 N	07°27.032 E	22.09.15	09:04	Sample 47
54°52.432 N	07°27.455 E	22.09.15	09:20	Sample 48
54°52.002 N	07°26.501 E	22.09.15	10:00	Sample 49
54°51.988 N	07°27.148 E	22.09.15	10:28	Sample 50
54°50.625 N	07°27.061 E	22.09.15	11:03	Sample 51, 2nd trial
54°50.347 N	07°26.580 E	22.09.15	11:20	Sample 52
54°49.919 N	07°27.309 E	22.09.15	11:40	Sample 53
54°48.880 N	07°28.265 E	22.09.15	12:08	Sample 54
54°48.726 N	07°26.877 E	22.09.15	12:31	Sample 55
54°48.574 N	07°26.459 E	22.09.15	12:52	Sample 56
54°48.573 N	07°26.447 E	22.09.15	13:03	Sample 56 B
54°48.557 N	07°26.451 E	22.09.15	13:14	Sample 56 C
54°48.544 N	07°26.439 E	22.09.15	13:27	Sample 57
54°47.752 N	07°26.959 E	22.09.15	13:47	Sample 58, 2nd trial
54°46.923 N	07°28.187 E	22.09.15	14:15	Sample 59
54°46.614 N	07°28.206 E	22.09.15	14:35	Sample 60
54°46.344 N	07°28.250 E	22.09.15	14:53	Sample 61
54°45.551 N	07°26.682 E	22.09.15	15:19	Sample 62
54°45.370 N	07°28.643 E	22.09.15	15:44	Sample 63
54°44.420 N	07°27.082 E	22.09.15	16:07	Sample 64

B) Giant box core samples

Latitude	Longitude	Date	Time	Description
54°47.264 N	07°32.656 E	21.09.15	08:07	Sample 1, 2nd trial
54°58.169 N	07°27.073 E	21.09.15	09:58	Sample 2
54°49.414 N	07°26.798 E	21.09.15	10:39	Sample 3
54°50.437 N	07°28.862 E	21.09.15	11:59	Sample 4
54°52.018 N	07°28.142E	21.09.15	12:38	Sample 5
54°52.238 N	07°31.964 E	21.09.15	13:43	Sample 6, 2nd trial

VI. Video Tracks

Latitude	Longitude	Date	Time	Description
54°47.383 N	07°32.697 E	21.09.15	08:39	Profile start, video track 1, 2nd trial
54°47.242 N	07°32.697 E	21.09.15	08:52	Profile end, video track 1
54°49.260 N	07°26.843 E	21.09.15	11:13	Profile start, video track 2
54°49.349 N	07°26.111 E	21.09.15	11:29	Profile end, video track 2
54°50.359 N	07°28.581 E	21.09.15	14:35	Profile start, video track 3
54°50.464 N	07°28.533 E	21.09.15	14:48	Profile end, video track 3