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Student research project in the North Sea

A report by TINA KUNDE and JOHANNA SIMON

Within the »Women Professor Program«, a part of the program line »Academic Qualification Position«, two students of the HafenCity University Hamburg got the possibility to perform a 15-months research project. Planned as an analysis of sedimentation processes based on long-term multibeam and sub-bottom profiler surveys in Friedrichskoog, the prevailing conditions required a modification of the project after five months of preparation. The following report introduces the adjusted project realised in Büsum with the support of the Research and Technology Centre West Coast (FTZ) as well as the achieved results.

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Fig. 1: Overview of the survey area for the conducted project

HCU Women Professor Program | multibeam echo sounder | sub-bottom profiler | wreck detection

Introduction

As early as 1985, the Schleswig-Holstein Wadden Sea was declared as a National Park. One reason for this distinctive step is the fact that due to the shallowness close to the shoreline and the tidal influences some parts of the North Sea even ground and build a unique biosphere for living organisms. The tidal current also causes a lot of sediment transport – a huge problem for the local fishing companies and port operators. In Friedrichskoog, a small fishing village in the west of Schleswig-Holstein, the port even had to be closed due to the continuous siltation and thereby rising costs of dredging operations. For guiding the ships safely through these shallow areas with less than 20 m water depth, an accurate bathymetric chart is required as well as a founded knowledge about the sea-floor structure and the sedimentation processes to be aware of further port closures like in Friedrichskoog.

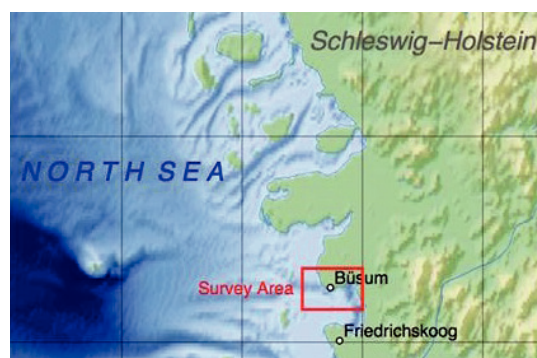
The purpose of this project was to extend the existing bathymetric measurements around the port entrance of Büsum (Fig. 1) and gather information about two wrecks close to the navigation channel to foreclose them as a possible safety hazard. Particularly with regard to the sediment flow, the investigation of the sub-bottom structures in the dock, the port entrance and also in the wreck areas were of particular interest.

Preparation and methods

Before starting with the hydrographic tasks in the area around Büsum, the sensor installation on the RV »Südfall« had to be surveyed because this was

the first official cruise for pure hydrographic purposes. Nevertheless, the vessel is fully equipped with a multibeam echo sounder R2Sonic 2024 pole-mounted over the side, an inertial measurement unit for the collection of motion data placed on top of the pole, a GPS antenna for RTK positioning, and two additional single-beam echo sounders, mainly used for navigational purposes, hull-mounted to the bow of the vessel. By using a Leica TS02 total station with an accuracy of $1.5 \text{ mm} \pm 2 \text{ ppm}$ for distance and 1 mgon for angular measurements the installed sensors were surveyed during it was dry-docked in March 2014. Based on a local rectangular coordinate system both the position and heights of the installed instruments were determined (Fig. 2). By using the free stationing survey method, four permanently fixed control points marked on the vessel were specified. This is helpful especially for the integration of possible subsequent installations. Furthermore, the waterline as future reference horizon was measured. On RV »Südfall«, the true waterline could clearly be seen so there was no need to assume the waterline first and in a second step to determine the difference between the assumption and the actual waterline. Finally, all mounted instruments were surveyed within the fixed and levelled vessel coordinate system. The analysis of the collected data and the calculation of the ship-based coordinates related to the waterline was done afterwards according to Brüggemann (2014).

After the vessel survey and the cruise planning with respect to the tidal circumstances in the area of interest, in September 2014 the bathymetric survey was performed with a previous calibration. For the investigation of the upper sediment layers, the parametric sub-bottom profiler SES-2000 compact was provided by Innomar. Due to the fact that the R2Sonic 2024 and the SES-2000 compact are mounted to the same installation pole at RV »Südfall«, it was not possible to use both systems simultaneously. Therefore, the bathymetric survey was performed on the first two days and the sub-bottom data acquisition with the SES-2000 compact the days afterwards. As both instruments use the



same mounting platform, the height difference to the surveyed multibeam echo sounder needs to be determined only once. This could easily be done by using a measuring tape.

The multibeam echo sounder used provides an across-track beamwidth of 0.5° and an along-track beamwidth of 1.0°. During the measurement it was operated with 400 kHz. A detailed line planning in advance was not possible due to the fact that the survey areas were located close or inside the navigable water and the survey profiles had to be adjusted to the actual circumstances with reference to currents and marine traffic. The survey speed was about 5 kn. The whole bathymetric survey has covered an area of about 35 ha. Inside this area several profiles were taken with the sub-bottom profiler. The SES-2000 compact provides two primary high frequencies of about 100 kHz and a secondary low frequency, which is used to gather information about the upper sediment layers. Throughout the survey, a low frequency of 10 kHz was chosen.

For acquisition, HyPack 2014 and SESWIN were used. The processing of the data was done with Caris HIPS and SIPS 8.1 and ISE.

Acoustic results and interpretation

Fig. 3 depicts the sill in the flood gate. Due to the fact that the water depth with respect to the actual water level is known, this provides a height reference to check the collected depth values. After applying the values for tide gauge zero and the actual level metering several times, there was always an offset between water level and GPS antenna of approximately 80 cm which was obviously not correct. As this offset occurs continuously it has to be assumed that there were some adjustments in the GPS configuration. Unfortunately, this assumption could not be verified because it was not possible to reset the GPS settings.

Nevertheless, the gathered bathymetric multi-beam data shows a constantly levelled sea-floor with no protruding objects except the old ship wreck close to the navigation channel north of Büsum (Fig. 4). As there were no ripples or any other structures detected, the collected data indicates that the sea-floor has a muddy and soft surface. Otherwise there would be some sand ripples caused by currents. The recorded data from the sub-bottom profiler supports these assumptions because there is no strong acoustic impedance visible. For further verification and a more detailed analysis of the sea-floor, sediment samples could be taken, e.g. by using a Frahmplot.

The investigation of the second wreck close to the port entrance just shows some weak structures, which could not clearly be identified as the charted wreck. Based on the information given by the German Maritime and Hydrographic Agency (BSH), the last survey of the barge goes back about twelve years. With respect to the currents and the knowledge of strong sedimentation rates, it

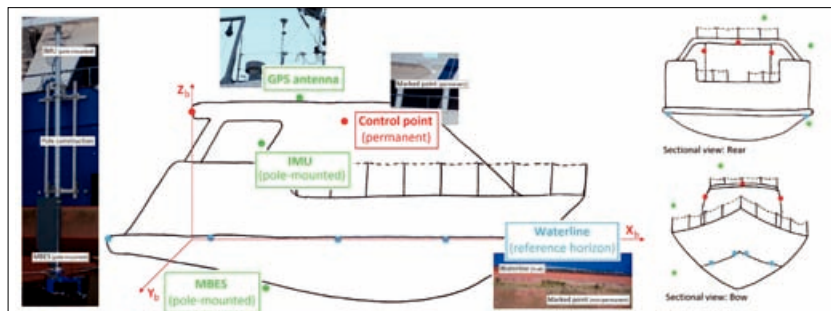


Fig. 2: Scheme of the surveyed points and the installed instruments on RV »Südfall« (sectional view: starboard). Blue marks: waterline, green marks: instruments, red marks: control point

is possible that the wreck was totally covered by sediments. As it was not visible in the sub-bottom data, it can be assumed that the sediment cover is thicker than the penetration depth of the instrument. Another reason why the wreck was not visible in the data could be the erosion of the ship's material since the last survey.

Conclusion

Within this project the sea-floor morphology proved to be very shallow and tide-influenced. Additionally, the wreck close to the navigation channel could not clearly be detected. The sub-bottom profiler data provides an overview of the upper sea-floor structure especially in the wreck area. It also indicates the fact that the sea-floor in the Wadden Sea is partly interspersed by gas. To obtain further information about the sediment transport like the flow direction and the amount of the particles, observations for longer periods with an ADCP would be very interesting. This could be an interesting future project. ⚓

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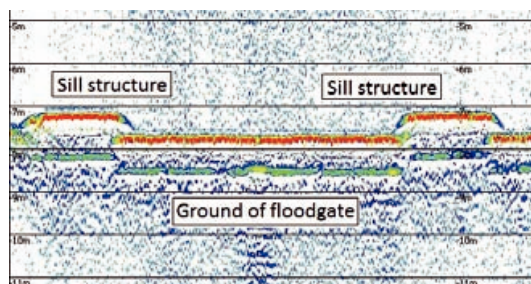


Fig. 3: Sill of the flood gate in Büsum, captured with the Innomar SES-2000 compact

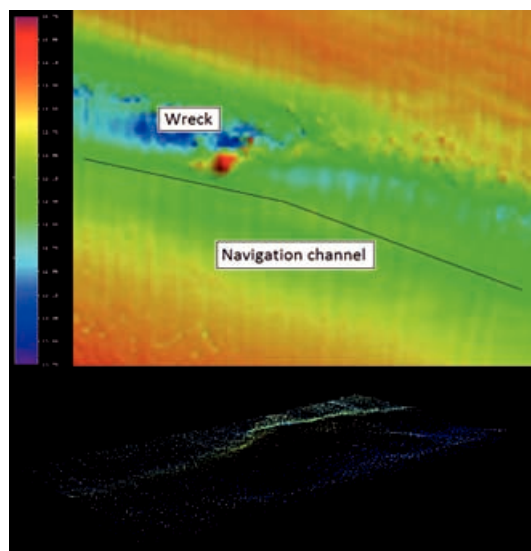


Fig. 4: Gridded surface with 1 m resolution showing the depth of the surveyed area around the wreck close to the navigation channel, created with Caris HIPS and SIPS 8.1