Seafloor mapping trial in Princess Amalia Wind Farm

Use of ME70 on board of RV Tridens

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Contents

Summary

The first wind farms in the Dutch coastal area are in operation for about 10 years now. The question is how the area of the wind farm developed in terms of marine environment in those years, as fishing activities were excluded from the area. One of the plans for evaluating this development is a benthic survey, similar to the survey that was conducted five years after the construction of the wind farms. However, a benthic survey can only sample a very small part of the wind farm area and the idea was that a prior survey using a multi-beam echosounder could provide information of seafloor structures on a larger scale. The results might be used to inform the benthic survey in sampling specific areas in order to detect and identify potential seafloor features of interest. A ship of opportunity, the RV Tridens II during the International Bottom Trawl Survey Q1 2017, was used to collect multi-beam echosounder data. Due to technical, practical and weather issues only a single afternoon was available for this work. During this afternoon, multiple lines were steamed through the Princess Amalia Wind Farm, recording data with the ME70 system in bathymetric mode. This way a small part of the wind farm area was covered. The results for the acoustic backscatter showed no specific seafloor features in this area, providing no new guidance for the benthic survey. The closest multi-beam recording was made at a distance of approximately 75 m from a monopile. As a result, the obvious hard structures (the scour beds around the monopiles) could not be sampled. This limitation is caused by the safety rules in place that vessels are not allowed closer than 100 m from the monopiles.

1 Introduction

The first Wind farms in the Dutch coastal zone were constructed in 2007 (Offshore Wind Farm Egmond aan Zee (OWEZ)) and 2008 (Princess Amalia Wind Farm (PAWP)). As a part of the development of these farms, Monitoring and Evaluation Programs (MEPs) were developed to answer questions on the impact of these farms on the marine environment. These programs, which ran until 5 years after the construction, have resulted in a large number of studies on the benthic, fish, mammal and bird community around these farms (e.g. Jarvis et al. 2004b, a, Lindeboom et al. 2011, Scheidat et al. 2011, Hartman et al. 2012, Scheidat et al. 2012, van Hal et al. 2012, Bergman et al. 2013, van Hal 2013, Bergman et al. 2015, van Hal et al. 2017).

In 2016, the Wind op Zee Ecologisch Programma (Wozep) was initiated based upon the knowledge developed and as a continuation of the MEPs. Its goal is to fill the knowledge gaps around the development of wind energy at sea and assessing the impact of the planned developments.

One of the research projects of WOZEP is the monitoring of the development of the benthic community in the sandy areas between the monopiles ten years after the construction. This is a continuation of the work done by Bergman et al. (2013). The area between the monopiles and the safety zone around the wind farms might have been influenced by the presence of the monopiles. In addition, the safety zone was closed for all fishing activities, potentially leading to the recovery of the natural benthic community. The monitoring plan is very similar to the work done by Bergman et al. (2013), e.g. sampling the area with a dredge and with a boxcore, resulting in the sampling of a small part of the total surface of the wind farms. Because only a small part of the entire area is sampled, there is a risk of missing specific features. These include first stages of shellfish beds but also other local hard structures that are of particular interest as they are the most vulnerable for demersal fishing activities.

A potential technique to fill in this knowledge gap is to map the seafloor of the wind farms using a multi-beam echosounder. Such an acoustic system is capable of mapping the bathymetry but also the acoustic backscatter, a quantity that is closely related to the type of sediment bed. Several studies made use of the acoustic backscatter to derive sediment classification on a large scale (Lamarche, Lurton, Verdier, & Augustin, 2011; Lurton et al., 2015). Such an approach would allow one to detect hard substrate structures if present in the area (Lindenbaum et al. 2008, Raineault et al. 2012). If hard structures would be detected this way, the monitoring program could be adjusted to sample these areas specifically for identification of the organisms forming these structures.

This work was however not covered in the WOZEP program budgets, and there was only limited allocated time as the benthic monitoring program had to be executed not much later than these proposals were made. This resulted in the proposal to use the time of the regular statutory monitoring program for roundfish, i.e. the 2017 International Bottom Trawl Survey (IBTS), to test the recently installed ME70 multi-beam echosounder on board of the vessel RV Tridens II. The results of this trial are presented in this report.

2 Materials and Methods

2.1 International Bottom Trawl Survey

The international bottom trawl survey (IBTS) is an internationally coordinated fish survey executed twice a year since 1969. It is directed at providing indices for fish species such as whiting, haddock, cod, herring and sprat. Multiple research vessels of a number of North Sea countries try to cover the whole North Sea by fishing twice in each grid cell of a predefined grid covering most of the North Sea, Channel and Skagerrak/Kattegat. The Dutch participate in this survey only in the first quarter of the year and cover the southern North Sea and German Bight area.

In 2017, the Dutch IBTS was done on board of the Rijksrederij research vessel Tridens II in the period 23 January - 24 February 2017. Activities occur only during weekdays, in the weekends the vessel was either in Scheveningen harbour or Leith Harbour (UK).

2.2 Planning of the wind farm work

The proposal was to map the seafloor in the wind farms OWEZ and PAWP when time was available during the IBTS, and the vessel was in the area of the wind farms. The planning of this was however harder than predicted: permission to enter the wind farms was required; this only worked for PAWP. In addition, it was required to have a toolbox meeting with one of their safety officers (23 January, with Nienke Ladage) and it was needed to contact them at least two days in advance of entering the farms. This limited the flexibility and reduced the initial ideas of crossing the wind farms areas when leaving Scheveningen and returning to Scheveningen.

The multi-beam echosounder equipment (ME70) had only recently been installed on board of the RV Tridens. To date, it was only used in the fisheries mode to detect pelagic fish in the water column. However, in this mode, the ME70 system is unable to provide bathymetric data. For seafloor mapping purposes, one needs to switch the ME70 into the bathymetric mode. This mode of operation for the ME70 was used for the first time during this study. In addition, knowledge of the system in bathymetric mode was limited for the persons on board during the IBTS.

Luckily, a PhD student of the University of Delft (Leo Koop) contacted us prior to the IBTS on possibilities to join during the survey in order to collect data with the ME70 in bathymetric mode. The plan was for Leo Koop to collect the multi-beam data during the survey period and assist WMR scientists during the mapping of the wind farm area. He would join the cruise in the first week to set up the system and in the last week which was likely the week most of the work in the wind farm could be performed.

The plan was to cover as much area as possible in the wind farm, obeying the safety restrictions of not going too close to the monopiles (safety distance of 100 m) or the Offshore High Voltage Station (safety distance of 500 m). To limit the amount of manoeuvres to be made within the farm, straight transects were planned through the area (Figure 1) where the monopiles are furthest apart from each other (~500 m). The cruising speed was planned to be 3-4 knots, and at the local depths the multi-beam will cover about 70 m of seafloor athwartship. In order to cover most of the 500 m distance between the rows of monopiles multiple transects have to be conducted.

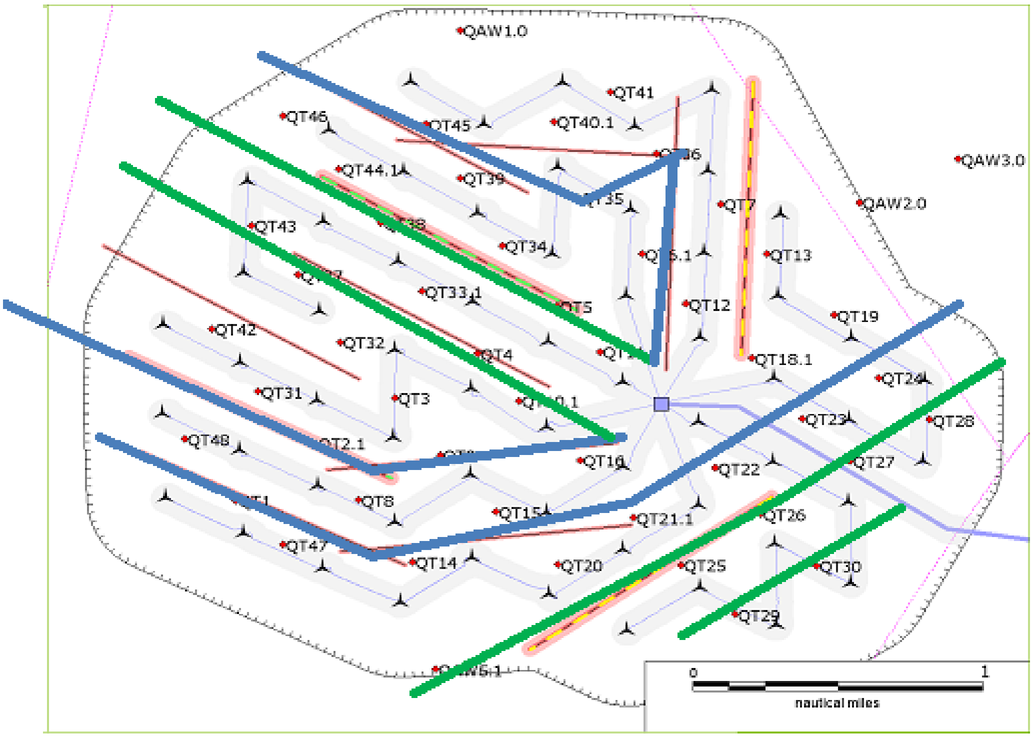

Figure 1: Princess Amalia Wind Farm area. Black triangles are the monopiles, purple square the Offshore High Voltage Station and the purple lines the electricity cables. Green lines the first priority and the blue lines the second priority proposed transects to be covered with the multi-beam survey.

2.3 Seafloor mapping in the wind farms

Multi-beam echosounders (Simmonds & MacLennan 2005) are active acoustic sonars that provide two-dimensional image of the seabed and targets in the water column in a fan region below the vessel. The ME70 system is highly modular (Trenkel et al. 2008, Kang 2011, SIMRAD 2012) and was initially designed as an imaging system for fisheries. However, it can also work as a bathymetric system. The latter use is of interest here, with the aim to give indication on seabed type. Seabed identification is very topical (Lurton et al. 2015), and multi-beam systems are popular for such an application because they are able to provide the acoustic intensity from the seafloor (backscatter) with great accuracy and at different incidence angles. The angular response is often used to infer seabed types (Kloser et al. 2010, Lamarche et al. 2011).
The ME70 system has two modes of operation:

1) fishery mode (Figure 2a)
2) bathymetric mode (Figure 2b).

The main difference between each modes is the number of beams and the frequencies of operation (70-120 kHz). In fishery mode, the number of beams is limited to 24 and each acoustic beam has a specific frequency. This offers advantages in term of noise reduction of the water column (Figure 2a). Conversely, in bathymetric mode, numerous beams are constructed digitally and only one frequency of emission is used. This configuration results in higher resolution but at the cost of higher noise in the water column, especially in the outer beam due to the contribution of the side lobes from the center beams (Figure 2b).
Though seafloor mapping can be performed in fishery mode using custom code (Cutter Jr et al. 2010), this is not optimal. When collecting data for multi-beam mapping, one should use the ME70 together with the Seafloor Information System (SIS, Kongsberg) software. This caused problems when setting up the system during the data collection for this study because the ME70 in this configuration has never been tested prior to the survey.

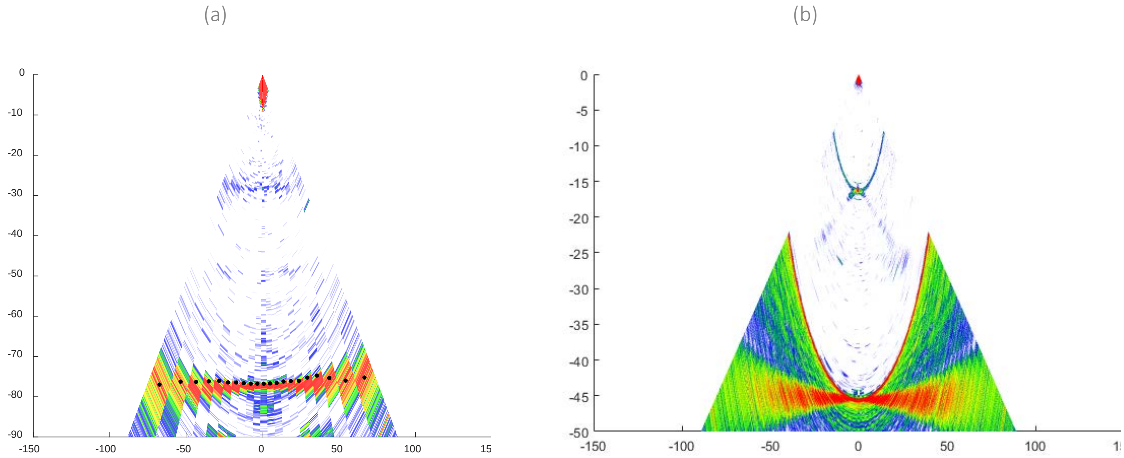

Figure 2: example of ME70 water column echogram in fishery mode (a) and bathymetric mode (b). The main difference is the lower number of beams and the use of different frequencies for each beam in fishery mode. This results in less noisy water column. In bathymetric mode, the frequency is the same across more numerous beams and zones with high noise levels appear in the outer beams because of the sidelobe effects from the middle beams.

The parameters of the survey and points of interest are:

- The ME70 is positioned on a drop keel that was lowered to a depth of 3.3 m
- Data were collected in bathymetric mode
- Vessel speed: ~4 knots
- Water depth: 19-24 m
- Number of monopiles in PAWP: 60
- Monopile diameter: 4 m
- Minimum spacing between monopiles: 550 m
- Scour beds around the monopiles

The data were further processed using CARIS HIPS and SIPS using a standard workflow in order to obtain bathymetry maps and acoustic backscatter mosaics. Such a post-processing software allows one to: (1) assess the quality of the data, (2) correct the data for sound velocity and incidence angle, (3) compute bathymetry map and acoustic backscatter mosaic.

3 Results

3.1 Planning

Prior to the start of the IBTS, we requested the Rijksrederij to ensure that the ME70 multi-beam would be operational in bathymetry mode and that the CARIS software was updated, as earlier use had shown some hiccups in the system. On the Friday prior to the start we were informed that the system was not running properly and that technicians would be looking at it at the end of the first week of the survey, when back in the harbour. As a result, the participation of Leo Koop was cancelled for the first week.
During the second day of the survey RV Tridens II had to go back to a harbour for another small technical issue. By that time the supplier of the ME70 system had decided to take out the computer units of the system of board and ship them to the manufacturer in Norway for re-installing. Finally, the system was successfully reinstalled after the third week of the survey. Leo Koop joined the survey for the fourth week in order to set up the system and test it during the survey. Unfortunately, the system did not function correctly. A lot of work in direct contact with the supplier and later with the manufacturer in Norway was done to get the system functioning, without much success for this week. On the Monday of the fifth and last week of the survey a technician of the manufacturer came on board and got the system operational, enabling one to test the system during the night time on the Bruine Banken, which is an area of interest for Leo Koop's work. During the second day the technician worked a bit more on the system and had to be brought back to a harbour. This left only three days of the survey for multi-beam mapping as the statutory tasks were completed at this point. Weather forecasts for these three days predicted rough weather in the morning, getting better during the day, but worsening into a storm during[1] night time. This was predicted to last for at least the whole day. This left only a single afternoon for effective work, with sea state conditions near the limits of entering the farm and of executing multi-beam work.

3.2 Mapping the wind farm area

Data collection was performed on 22nd February 2017 from 13:15 to 19:16 local time. During this time three different transects through the wind farm were recorded. Each transects was covered multiple times, creating overlapping lines of multi-beam data. Weather conditions and currents reduced the choice of transects to be covered safely. Furthermore, these conditions made it difficult to create limited overlap between lines in order to cover as much area as possible. At the end of the day, light conditions made it difficult to navigate through the wind farm and this motivated the end of the operations.

Results of the processing of the multi-beam data consist of bathymetry (i.e. depth) and acoustic backscatter (i.e. acoustic intensity). The bathymetry is shown in Figure 3 while results for the backscatter are shown in Figure 4 and Figure 5 (plotter over a known bathymetry of the survey area).

The bathymetry map shows a depth range of 18-29.5 meter. In Figure 3, the blue areas in the lower part of the map indicates slightly shallower areas compared to the orange areas, the dynamic range being only of a couple of meters.

Of most interest for this study is the backscatter intensity. This acoustic quantity varies significantly between different types of seafloor (APL-UW, 1994; Williams & Jackson, 1997). In Figure 4, it is interesting to note that along each survey line, the backscatter intensity does not vary significantly.

[1] http://nieuws.weeronline.nl/23-2-2017-live-blog-zware-westerstorm/

This suggests that the type of sediment is homogeneous (e.g. sand), and that no hard structures are observed.

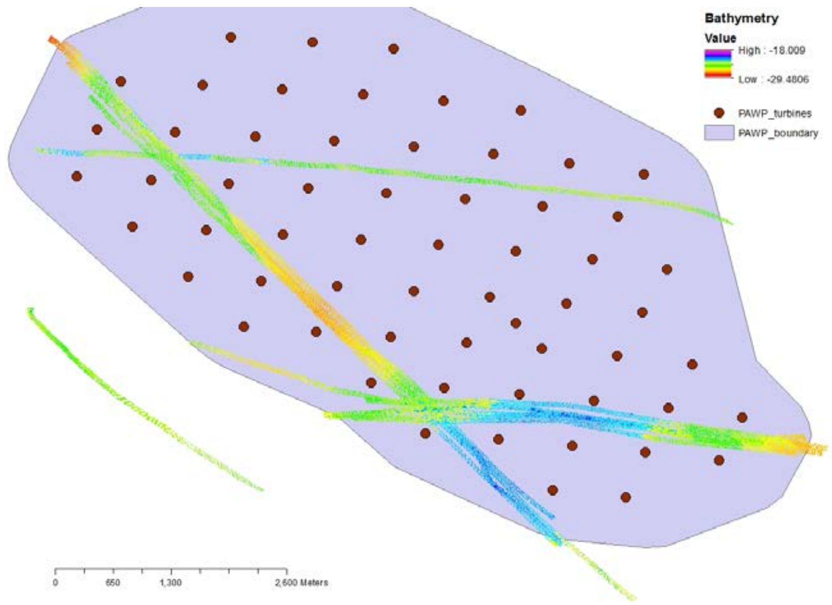

Figure 3: bathymetry along each survey lines.

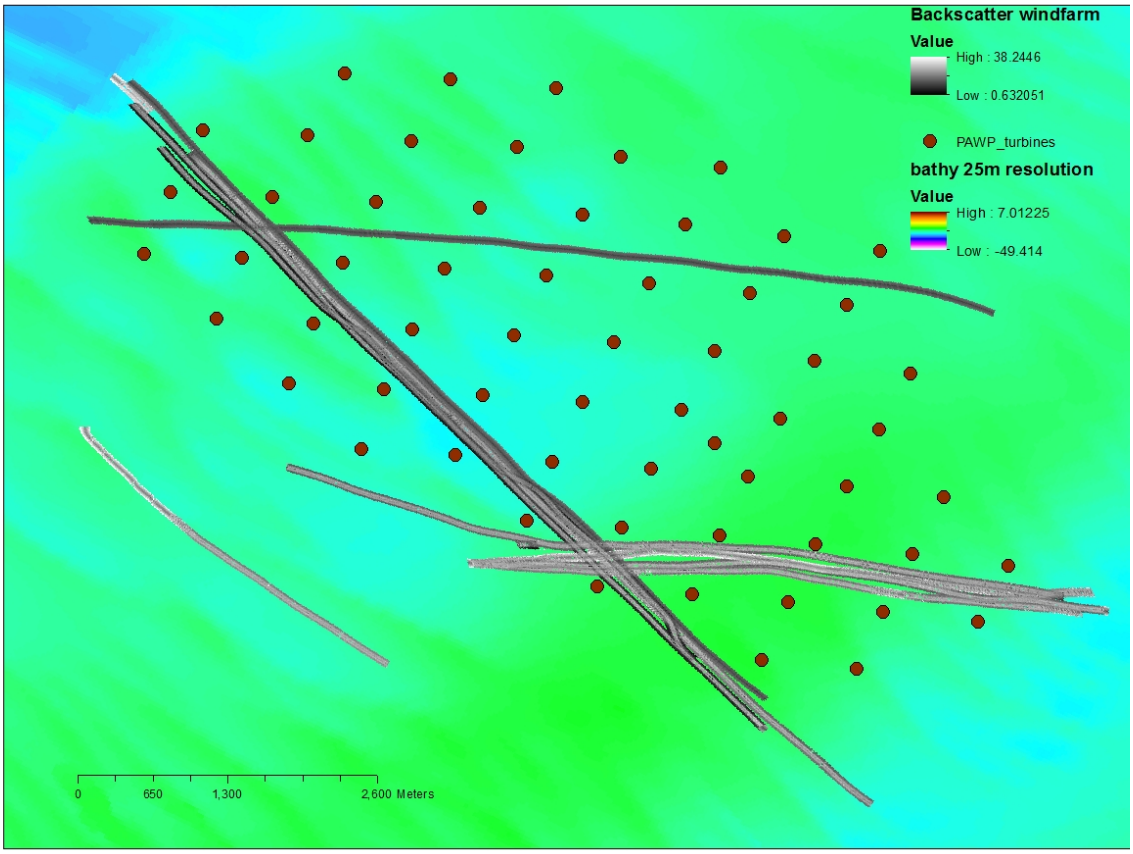

Figure 4: acoustic backscatter intensity along each survey lines.

Figure 5 is a zoomed view around 4 monopiles. This exemplifies the change in backscatter at various distances from a monopile. It can be observed that the intensity does not vary significantly. This likely means homogeneous sediment layers along the vessel track. Along this track, the echosounder coverage only extend to a distance of ~200 m from each monopiles. No seafloor features that should be characteristic around monopiles could be identified (e.g. rock seafloor around monopile). Figure 6 shows another survey line, which came closest to a monopile, ~75 m. The intensity of the backscatter is the same along the length of the line. The difference in coloration in width of the line, is due to difference between the multiple beams of the multi-beam. As the coloration along the whole length is homogenous, it exemplifies no seafloor features. Though, a distance of ~75 m is still too far to cover the scour bed, other hard or deviating seafloor features that are characteristic around monopiles.

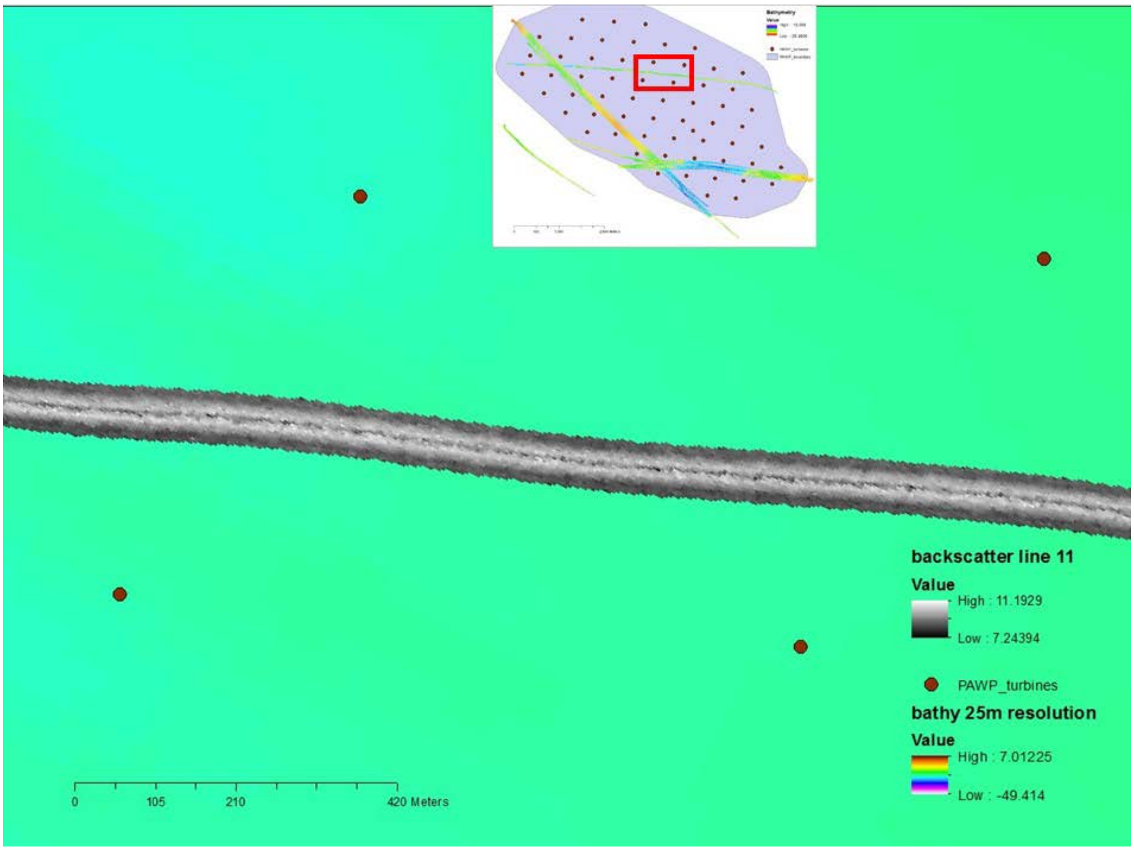

Figure 5: zoomed view of acoustic backscatter intensity along a single survey line.

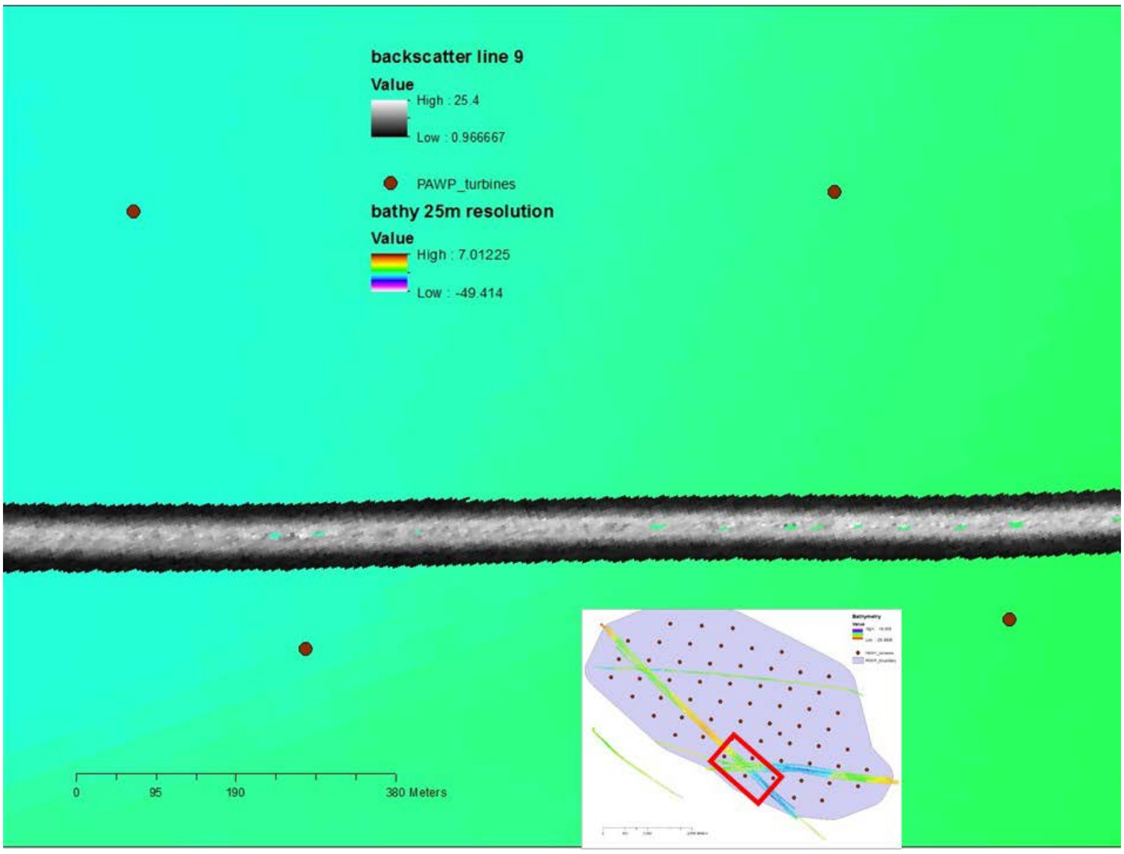

Figure 6: zoomed view of acoustic backscatter intensity along one survey line between four monopiles. This survey line was the closest to a monopile (~75 m).

Looking into more detail of Figure 4, shows that the backscatter intensity varies significantly between survey lines, including those that overlap. This is unexpected as it would mean that the sediment structure changes every time the vessel passes. As the time between passages is only minutes to max a couple of hours, this is unlikely to be the case. It is more likely to be due to changing conditions during the data acquisition between different survey lines but the operators did not change the settings. Another possibility is that something goes wrong in processing the data in the CARIS-software package. This will need further work on our side, however it does not influence the conclusion that we have not observed any seafloor features.

4 Conclusions and recommendations

This report investigated data of opportunity collected using the ME70 system (multi-beam echosounder) in the Princess Amalia wind farm. The analysis focused on the acoustic backscatter intensity in order to explore potential seafloor type changes around monopiles.

Overall, while data were collected successfully, results do not show specific features around the monopiles. However, the coverage of the echosounder only extended as close as ~75 m from a monopile, which means scour bed structures could not be observed. This distance is a result of the safety rule that vessels are not allowed closer than 100m from a monopile.

Also, change in backscatter between survey lines was observed though the settings were kept fixed. This point needs to be investigated as the echosounder should yield similar results for similar seafloor types. Further testing of the ME70 in bathymetric mode should be conducted in the future. This includes testing of the system in various configurations and over seafloors of different types.

Overall, our results did not indicate areas of specific interest for the benthic survey to focus on. However, the limited time available for this data collection (6 hours) only resulted in a partial coverage of the whole wind farm area. This means the results of this study cannot rule out that distinct harder seafloor features in non-surveyed parts of the wind farm.

5 Quality Assurance

Wageningen Marine Research utilises an ISO 9001:2008 certified quality management system (certificate number: 187378-2015-AQ-NLD-RvA). This certificate is valid until 15 September 2018. The organisation has been certified since 27 February 2001. The certification was issued by DNV Certification B.V.

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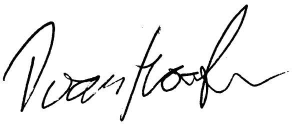
Justification

Report C098/17
Project Number: 4315100056

The scientific quality of this report has been peer reviewed by a colleague scientist and a member of the Management Team of Wageningen Marine Research

Approved: Tobias van Kooten
Researcher

Signature:



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