



Miljøministeriet
Naturstyrelsen

LIFE06 NAT/DK/000159 - Blue Reef project
Technical Final Report
Annex 15
June 2013

Post bathymetry and stability of reef structures or measurement of seafloor in the Blue Reef project area

1. Introduction and background

Measurement of the seafloor in the Blue Reef project area has a two –fold purpose:

1. To produce bathymetric data for updating the Navigational Charts for the project site in agreement with national authority on maritime safety.
2. To monitor the stability of the reef under weather conditions prevailing in the years after the construction of the reefs.

Updating of Navigational Charts where necessary as the new Reef structures will reduce the depth with several meters. The bathymetric survey was sub-contracted, using multi- and single beam and divers. The bathymetric surveys should be conducted according to the minimum standards from the International Hydrographic Organization and further comply with regulations from the Royal Danish Administration of Navigation and Hydrography. The Blue Reef area is a highly dynamic area and the new reefs (approximately 100.000 tons of boulders) and its structure itself is an integrated part of the function of the reefs. So checking if the reef structures are stable is important.

2. The national authorities for safe navigation at sea in Danish waters

From the project start until 1st of January 2012 The Royal Danish Administration of Navigation and Hydrography (RDANH) was the national competent authority responsible for the safety of navigation in Danish, Faroese and Greenlandic waters. The RDANH supported the project application and cooperated with the Blue Reef project leaders to ensure that the measurement of seafloor met the required international standards for changing Navigational Charts, and considering the establishment of the necessary buoyage in the project area. From January 2012 the Danish Maritime Authority and the Danish Geodata Agency (DGA) were the new competent authorities for e.g. aids to navigation and pilotages and hydrographic surveys respectively. Before January 2012 DGA was named National Survey and Cadastre of Denmark.

3. Methods

The practical challenges was to foresee a “weather window” on 3-4 days of calm weather for the survey ship to reach a harbor in the island of Læsø near the Blue Reef area and most importantly to have two days for the surveys itself on the Blue Reef site approximately 14 km North East of Læsø. At the first survey in 2009 the consultancy company NIRAS A/S had the supervisory tasks and the Survey Company was “Dansk Søopmåling Aps” (Danish Surveying Ltd.). The tender for

the surveys requires the use of a multibeam equipment because it provides a better data quality for the survey site than side scan.

The First survey: 23 of February 2009

The survey area (in UTM zone 32, WGS84) coordinates:

N: 636163 E: 6368588

N: 636258 E: 6368661

N: 636558 E: 6368240

N: 636492 E: 6368000

N: 636392 E: 6368000

N: 636362 E: 6368214

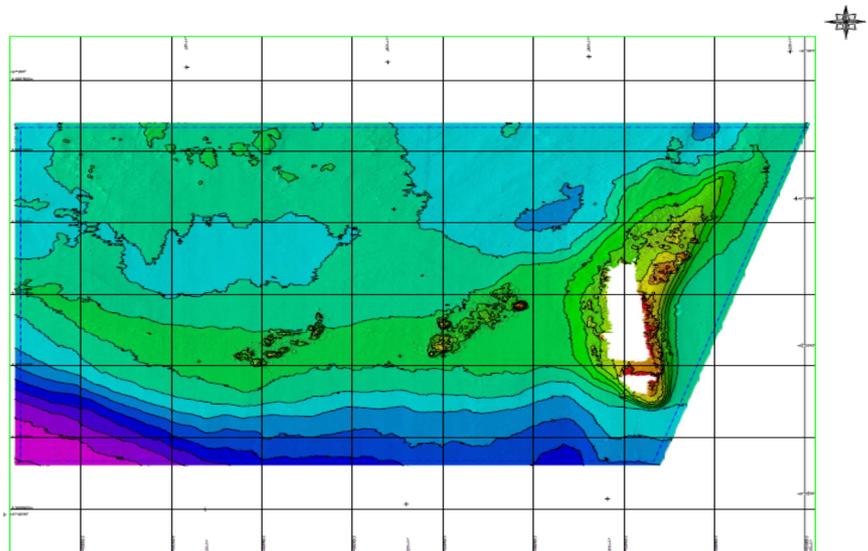


Figure 1: The first survey: The entire survey area and the results from January 2009. The survey data was adjusted for differences due to tide - Chart Datum (e.g. DVR90) and delivered to RDANH. The two white areas were in July 2009 measured for maximum and minimum depth by a diver. The minimum depths were between 1.0 - 1.6 meters and the maximum depth were between 4.0 -2.5 meters. These data were also delivered to RDANH. RDANH accepted the data and data were publicized as a navigational warning through Notices to Mariners in February 2010.

The consultancy NIRAS A/S had the supervisory tasks for the construction of the reefs and also for the survey. The survey was carried out by a subcontractor to NIRAS “Dansk Søopmåling Aps” (Danish Surveying Ltd.). The surveyor did the job, but wrecked expensive multi beam equipment on the sharp reef boulders on the eastern reef with the shallowest water depth. The surveyor where not able to get any data from the shallow part leaving two white areas. However the surveyor managed to get the bathymetric data from the Blue Reef area as described in the contract except for the two white areas. In hind sight it might have been better to delay the first survey until a calmer summer period. The equipment used by the surveyor during the first survey is found in table 1.

Table 1: The equipment used by the surveyor, during the first survey in January 2009

<p>Specifications: Positioning: Leica System 500 GPS RKT Water level correction: Leica System 500 GPS RKT Multi Beam: Reson 8101 Gyro Motion Sencor: TSS Orion Gyro Exercise Sound velocity: RESON SVP 15 prob. Survey Software: NaviPac / NaviScan Post-process software: NaviEdit / NaviModel / Plot Survey ship: "Opmåleren"</p>

In July 2009, NIRAS A/S conducted a review of the survey and the Blue Reef construction after having adjusted the reef structure and replaced several boulders. The examination was performed by diving inspection also to investigate the flora and fauna, but especially to inspect if the boulders were placed in a correct position. Parts of the diving inspection were videotaped. Most of the diving inspections were however made visually. The depth was examined with a handheld digital depth gauge. By knowing the position of the diving ship "Peter Madsen", and how far the diver was from the ship, it was possible to deliver at small data set with coordinates for minimum and maximum depths from the shallow water areas (white areas) to RDANH. The minimum depth in the white area was between 1.0-1.6 m and the maximum depth was 4.0-2.5 m.

The second survey, 12 of August 2012

During July 2012 the Danish Nature Agency sent a tender to two survey companies and the Dansk Søopmåling Aps (Danish Surveying Ltd.) got the survey job again. This time the area was somewhat reduced and focused on the three reef structures to minimize the time spent at the site and the price. A special attention was paid to the survey of the difficult and dangerous shallow water part of the reef. The survey was carried out with a normal survey ship equipped with multi beam and a shallow water boat equipped with a single beam.

The survey area (in UTM zone 32, WGS84) coordinates:

N: 634050 E: 6367500
 N:634650 E: 6367500
 N:634800 E: 6367700
 N:635100 E: 6367700
 N:634870 E: 6367050
 N:634050 E: 6367050

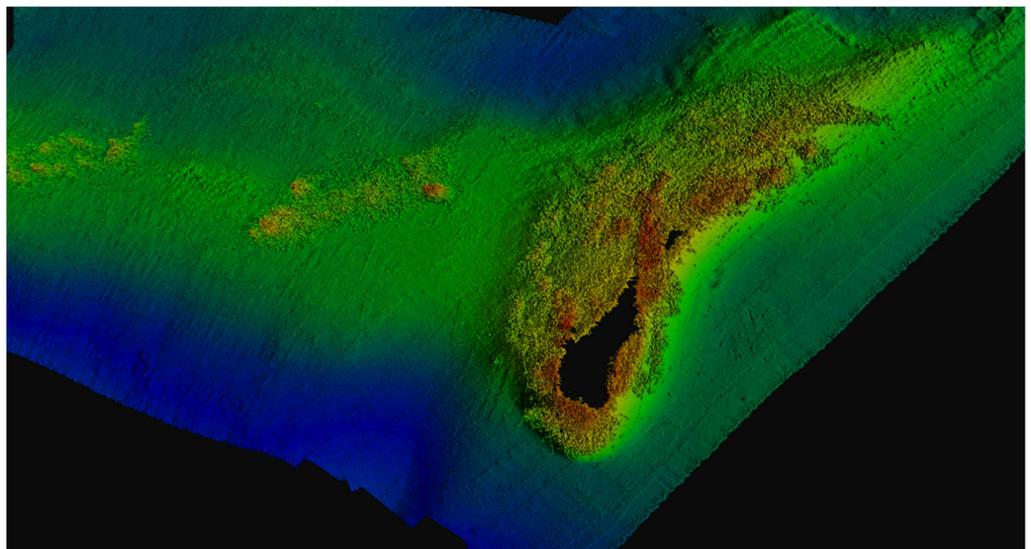


Figure 2: The second survey: The entire survey area and the results from August 2012. This is a data presentation made by DGA. The fair sheet was received from Dansk Søopmåling (just as fig.1), and the data- set was delivered to the DGA , The Danish Maritime Authority and Læsø Municipality and others. The survey data was adjusted for differences due to tide - Chart Datum (e.g. DVR90) The white area from 2009 was reduced (now black) and measured by single beam. The DMA and DGA has accepted the data set and updated the Notice to Mariners and the Navigational Charts accordingly.

Table 2: The equipment used by the surveyor, during the second survey August 2012

<p><u>Specifications – MULTI BEAM:</u> Positioning: Ashtech Z12 RKT GPS Water level correction: Ashtech Z12 RKT GPS Batymetri: Reson SeaBat 7010,240 kHz Sound velocity: GMI Svep 5001 Survey Software: Eiva NaviPac and NaviScan Post-process software: Eiva NaviEdit and NaviModel Survey ship: "Ekko"</p>	<p><u>Specifications - SINGEL BEAM:</u> Positioning: Leica system 1230 RKT GPS Water level correction: Leica System 1230 GPS RKT Batymetri: Navisound 515- B209, 200kHz Sound velocity: RESON SVP 15 prob. Survey Software: HypackMax Post-process software: : HypackMax Survey ship: "Quick Silver"</p>
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Assessment of the reef structure

The highly dynamic Blue Reef area has been visited numerous times for other reasons than surveying depth and stability of the reef construction itself. The same handful of people got familiar with the reef structures during the more than 5 years from diving, video tacks, and sampling ect. These visits confirm that the area functions well and that no (major) visible changes have occurred to the reef structure.

Furthermore the two data sets from the first and the second survey have been compared. The two data sets were made with a time span of about 4 years and 5 month. Due to the DGA it was possible in April 2013 with a DGA-model to get a visual picture and analyze the differences between the data sets. In fact it is two different data sets made by different equipment and boats (see, Table 1 and Table 2) and furthermore the growth and biomass of macro algae and fauna was naturally much bigger in August 2012 compared to February 2009. See figure 3.

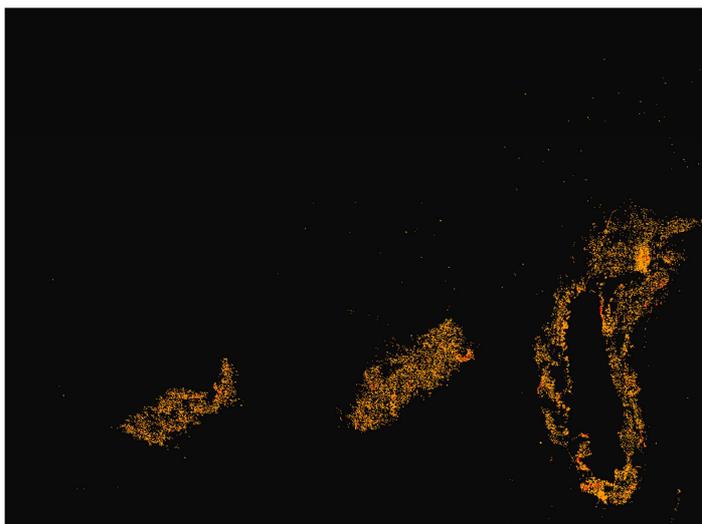


Figure 3. DGA-model showing differences between data in the two surveys made in January 2009 and August 2012. Yellow dots are minor changes and red dots major changes in seafloor. Steep slopes can be seen in the eastern part of the reef and areas of reconstruction from summer 2009 are visible. Considering the differences between the equipment used by the two survey ships (see table 1 and table 2) and the fact that the biomass of the area was dramatically increased in the period, it is concluded that the reef structures are considered stable.

When considering these facts and differences the overall picture was quite satisfactory. In the areas where there has been carried out work to adjust the reef structure in summer 2009 changes were also quite obvious, indicating that the model and the data sets were suitable for the final assessment and control. The model was developed by the hydrographic section at the DGA who kindly assisted the Danish Nature Agency in the final assessment to document if the “new” reef structure was stable or not.

4. Conclusion

The two data sets have been accepted by the Danish Maritime Authority and the Danish Geodata Agency and used for giving Notice to Mariners and to update Navigational Charts for the Blue Reef area. That means that the competent authorities have accepted the survey data and changed the Navigational Charts accordingly.

The 3 dimensional structure of the cave forming boulder reef seems unchanged in the period between February 2009 and August 2012. The replacement of boulders in the reef area in the summer 2009 can also be assessed from the comparison of the two data sets. These changes also fit with the intention of the replacement – that was to ensure an optimal 3 dimensional construction as set up in the tender.

The physical structure and function and thus the stability of the reef structures was assessed during the two surveys and found fully stable. The function and shape of the restored reef was intact 4 + years after the first inspection.

On this background it can be expected, that the reef structure will remain stable in the future. Thus when the physical structures are stable and the function of the new reef is considered stable too (see final report) Then the cavernous boulder reef can provide a basis for good and favorable conservation status in the area.