FYRSKEPPET
OFFSHORE AB

Fyrskeppet Offshore

Bilaga M7: Alum shale report

ALUM SHALE REPORT

GEOPHYSICAL SURVEY

2022062-FYR-CMS-FYR_ALUMSHALEREP

REVISION 04

FYRSKEPPET OFFSHORE AB

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REVISION HISTORY

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Responsibility	Position	Name
Content, Check	Geophysical Manager	Robin Dymlind
Approval	Project Manager	Philip Ljungström

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ABBREVIATIONS

DGPS	Differential Global Positioning System
DTM	Digital Terrain Model
ETRS	European Terrestrial Reference System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
IGS	International GNSS Service
IMU	Inertial Measurement Unit
ITRF	International Terrestrial Reference Frame
MBES	Multibeam Echo Sounder
SBP	Sub Bottom Profiler
BCS	Backscatter

1. INTRODUCTION

1.1. Project Overview

A new windfarm is planned at the Fyrskeppet area in the Bay of Bothnia. This survey acquired multibeam echo sounder (MBES), Backscatter (BCS) and Sub Bottom Profiling (SBP).

The purpose of the survey is partly to map the seabed surface and the subsoil with focus on seabed analysis, technical development, surface sediments and archaeology inventory, sediment layers and any obstacles that may affect the installation of the coming windfarm. A total area of 535 km^2 has been surveyed.

The project area is located North East of the bank 'Finngrundsbanken', in the Bay of Bothnia. The area is located North East of Gävle. There is a Natura 2000 area ('Finngrundet Östra Banken') next to the project area. Within the Natura 200 area there has been documented finding of Alum Shale, This report investigates whether the same can be done for the Fyrskeppet survey area.

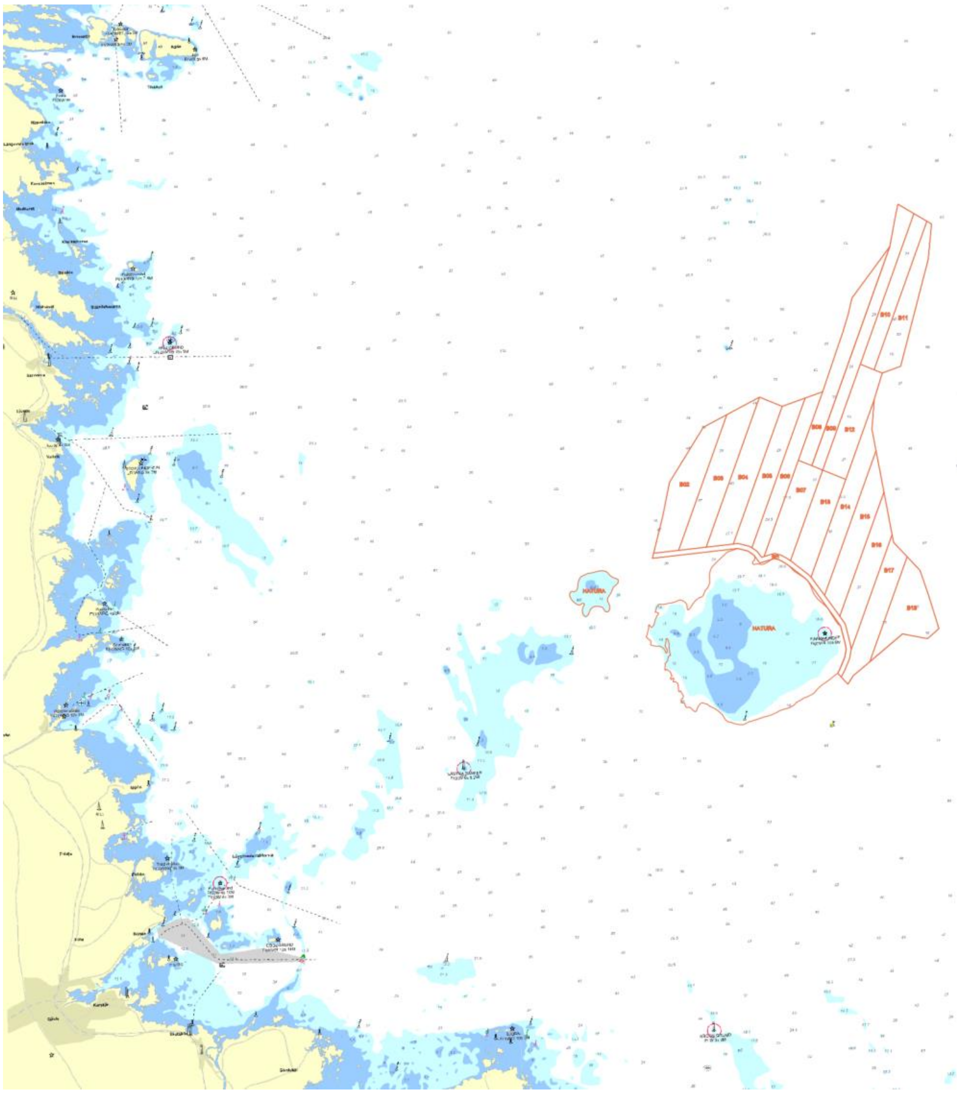

Figure 1 Location overview of the Fyrskeppet project area

1.2. Key personnel

Table 1 Clinton Key Personnel

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1.3. Purpose of Document

The purpose of this report is to summarize the Fyrskeppet survey results and interpretations, and to present the findings related to any potential alum shale in the survey area.

1.4. Reference Documents

Table 2 lists all documents that are referenced in the report and provide further information on procedures and results not presented in this report.

Table 2 Reference documents

Document Title:	Document Number:	Document Owner:
Mobilisation and Calibration Checklist	2022062_WPD_Fyrskeppet_Inspection_Test	Clinton
Mobilisation and Calibration Report	Calibration Report Skyborn Renewables Fyrskeppet 2022 Northern Wind_	Clinton
Project Manual	2022062_WPD_Fyrskeppet-PEP	Clinton
HSEQ-Manual	2022062_WPD_Fyrskeppet-HSEQMAN-	Clinton
Operations Report	2022062-FYR-CMS-FYR-OPERREP_00	Clinton
Survey Report	2022062-FYR-CMS-FYR_SURVEYREP	Clinton

2. GEODETIC INFORMATION

2.1. Geodetic Datum and Grid Coordinate System

The geodetic datum and projection parameters are presented in Table 3 and Table 4

Table 3 Geodetic Parameters

Datum Parameters ETRS89	
Spheroid	GRS 80
Semi Major Axis	6 378 137.000
Semi Minor Axis	6 356 752.314
Inverse Flattening	298.25722
Eccentricity Squared	0.0066924801

Table 4 Projection Parameters

Projection Parameters	
Projection	SWEREF 99 TM
Central Meridian	15° 00’ 00’’E
Latitude origin	00° 00’ 00’’
False Northing	0m
False Easting	500 000m
Central Scale Factor	0.9996
Units	Metres

Data has been acquired in ITRF2014 and transformed to ETRS89 in NaviEdit using a 7-parameter 3D-Helmert transformation model (Figure 2). The accuracy of the transformation formula is 1-2 cm. The transformation parameters have been calculated for epoch 2022.5, and this is the most recent epoch for which calculated transformation parameters are available based on ITRF2014. Further details on the transformation can be found in “L.Jivall Simplified transformations from ITRF2014/IGS14 to ETRS89 for maritime applications”

$$\begin{pmatrix} X \\ Y \\ Z \end{pmatrix}_{ETRS89} = \begin{pmatrix} \Delta X \\ \Delta Y \\ \Delta Z \end{pmatrix} + (1+\delta)\,\mathbf{R}\begin{pmatrix} X \\ Y \\ Z \end{pmatrix}_{ITRF}$$

$$\mathbf{R} = \mathbf{R}_Z\mathbf{R}_Y\mathbf{R}_X = \begin{pmatrix} \cos\omega_Z & \sin\omega_Z & 0 \\ -\sin\omega_Z & \cos\omega_Z & 0 \\ 0 & 0 & 1 \end{pmatrix}\begin{pmatrix} \cos\omega_Y & 0 & -\sin\omega_Y \\ 0 & 1 & 0 \\ \sin\omega_Y & 0 & \cos\omega_Y \end{pmatrix}\begin{pmatrix} 1 & 0 & 0 \\ 0 & \cos\omega_X & \sin\omega_X \\ 0 & -\sin\omega_X & \cos\omega_X \end{pmatrix}$$

$$\mathbf{R} = \mathbf{R}_Z\mathbf{R}_Y\mathbf{R}_X = \begin{pmatrix} 1 & \omega_Z & -\omega_Y \\ -\omega_Z & 1 & \omega_X \\ \omega_Y & -\omega_X & 1 \end{pmatrix}$$

Figure 2 The 7-parameter 3D-Helmert transformation

Table 5 Transformation Parameters ITRF2014 to ETRS89 Baltic Sea epoch 2022.5

Transformation from ITRF2014 epoch 2022.5 to ETRS89	
Shift X (m)	1.01673
Shift Y (m)	1.22806
Shift Z (m)	-0.85601
Rotation X (“)	0.041514
Rotation Y (“)	-0.022120
Rotation Z (“)	-0.037257
Scale (ppm)	-0.01452

2.2. Vertical Datum

Data (MBES) has been reduced to the vertical reference RH2000 by using a post-processed kinematic PPP (Precise Point Positioning) solution and the SWEN17 geoid model. A positive up, negative down frame of reference is used for all deliverables, i.e. all depths are negative below RH2000.

2.3. Time Protocol

All survey systems on board the vessels were in UTC, together with all displays, logbooks and overlays. The daily progress report was referenced to UTC.

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Survey Operation

This is a short summary of the equipment, field work and progress during the survey operation. Further information can be found in the Mobilization and Calibration Report and the Operational Report.

Vessel

More detailed information on the vessels, their reference frames and sensor alignments can be found in the Mobilization and Calibration Report.

M/V Northern Wind

The vessel Northern Wind is a high-resolution, aluminium hulled, survey vessel with a permanent spread for geophysical and hydrographical work. The vessel is 19.5 m and is well suited for surveys in shallow waters as well as offshore as it can operate 24/7.

Equipment

Table 6 includes a summary of the equipment used in the project.

Table 6 Equipment used during the project on M/V Northern Wind

Equipment	
Positioning & Attitude	Seapath 330+ with Hemisphere H10 corrections from an Atlas Link demodulator
Secondary positioning	Fugro 9205 with Fugro G2 corrections
Multibeam Echo Sounder	Kongsberg EM2040D 0.35°x0.7^0 at 400 kHz
Sub Bottom Profiler	Innomar SES-2000 Medium 100 kHz Primary Frequency
Sound Velocity Sensor	Valeport mini SVS
Moving Sound Velocity Profiler	Valeport SVX2
Sound Velocity Profiler	Valeport Swift SVP

3. PROCESSING

There were concerns that alum shale were close to the surface of the Fyrskeppet survey area. Clinton believes that this was instigated by a review of literature in the area. In (Tjernvik ,1980) there is a review and interpretation of a drillcore in the Östra banken of Finngrundet. This is in close proximity to Fyrskeppet, It shows a large stratigraphy of sedimentary rocks and fossils. More importantly it shows that there is a sequence of alum shale at depths greater than 60 meters. The existence of alum shale in the area has been encountered at alternative sources as well, (Winterhalter, 1972).

Since the Fyrskeppet survey was sloping on the sides and had a general downwards trending bathymetry progressively east there was an interest if it was enough to make the alum shale appear near surface. This was of especial interest in the eastern parts (Block 18) where there was some bedrock protruding from the surface.

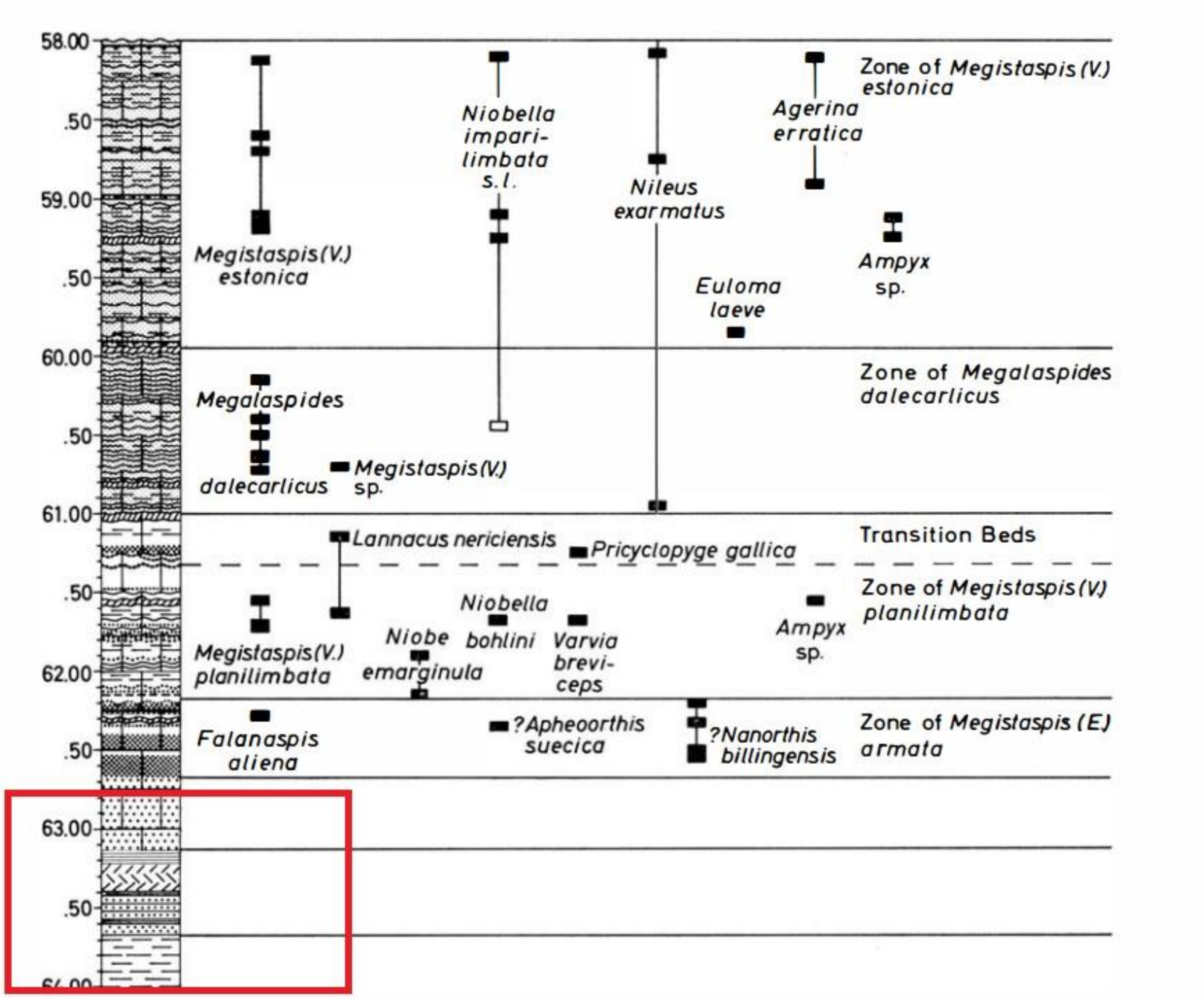

Figure 3 Sequence of Core interpreted by Tjernvik et al 1980. The middle of the red square contains a sequence which can be considered alum shale (Dictyonema shale)

4. RESULTS

There were no findings of any potential alum shale in the survey area.

5. DISCUSSION

The acoustic instruments used in the survey area did not show any indications that could be interpreted as alum shale.

Due to the very stiff and hard glacial sediment the parametric sub bottom profiler did not manage to penetrate the full extent of the glacial material as well as into any potential sedimentary bedrock.

This however does not mean the shales existence is disproven and that it cannot be near surface. The shale should be considerably closer to the surface than it is at Finngrundet, this is assuming the sequence is preserved at all within the survey area. None of the instruments used in this survey could establish the location of the alum shale.

6. CONCLUSION

Geotechnical sampling must be performed together with analogue multichannel streamer seismic in order to determine any alum shale in the survey area.

REFERENCES

Winterhalter, B. (1972). *On the geology of the Bothnian Sea, an epeiric sea that has undergone Pleistocene glaciation.* Otaniemi: Geological Survey of Finland.

Tjernvik, T. E. and Johansson, J. V. (1980). Description of the upper portion of the drill-care from Finngrundet in the South Bothnian Bay. Retrieved 2023