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(DanWEC Vaekstforum 2011)

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**Review on available information on
wind, water level, current,
geology and bathymetry
in the DanWEC area,
(DanWEC Vaekstforum 2011)**

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DCE Technical Report No. 136

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by

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January 2012

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Preface

The Danish Wave Energy Centre (DanWEC) has been established in 2009 because of participated desire to market the trial wave energy projects which are already in Hanstholm and others to come. The DanWEC is a part of Hanstholm harbour in the North-West of Denmark.

The Center will contribute at creating a local base for knowledge, education and possibly a workplace which will be leased out to trial projects. It is therefore likely that different developers will deploy their wave energy devices during the next years in this location and therefore detailed knowledge on a number of environmental and physical parameter is necessary.

The present report has been prepared by Lucia Margheritini (lm@civil.aau.dk), Post.Doc at the Department of Civil Engineering at Aalborg University. The report should function as a review and assessment of the existing documents and present knowledge on wind, current, water level, geology and bathymetry information at the DanWEC location.

The present report has been prepared under the project No. 834101 "DanWEC Vaekstforum 2011", task 3: "Collection and presentation of basic data about wind, current, water head, bathymetry and geology for the DanWEC site at the Port of Hanstholm".

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INTRODUCTION

In connection to the establishment of the Danish Wave Energy Center (DANWec) in 2009, extensive and comprehensive knowledge on the wind, current, water level, geology and bathymetry at location is desirable. The present report is a review of the existing information at the present time and includes suggestion for possible future investigations.

The data available are:

- Wind: wind statistics from 1931-1960 period [1] (measurement station 01100) and time series from the Danish Coastal Authority from 02/08/1996 - 01/11/2010, measurement station 3110 in Hanstholm. Files are in text format and are characterized by an id, date (yyyy-mm-dd), time (00:00), average wind speed [m/s], average wind direction [°], average wind pressure [hPa], average temperature [°C] and peak wind speed [m/s] over 15 minutes intervals for data until 2001-06-06, 14:00 and over 10 minutes intervals for data from 2001-06-06 at 14:00 up to today . Other report is from the Danish Meteorological Institute (DMI) on data from a nearby station exist (KLITMØLLER HUSE 21075), highlighting the importance of seasonality [2].
- Sea level variations: time series from the period 05/01/1998-23/04/2010, measurement station 3111, belonging to Hanstholm Harbour are available. Files in text format are characterized by an id, date (yyyy-mm-dd), time (00:00), and average water level variation [cm] over an interval of 15 min until 2001-06-01 at 07:15 and over 10 minutes after until today. It should be noticed the existence of the report by the Danish Coastal Authority dated 2007 on 55 stations with sea level gauge measurements along the Danish coasts, including Hanstholm for a total of 37.2 years of data from 3100 and 3111 measurement stations [3].
- Current: No data on current is available at the moment, but reports on the long-shore sediment transport, related also to the current, exist [4-6]. Nevertheless a survey in order to acquire data on current velocities and directions should be initiated.
- Geology and Bathymetry: data available from recent survey as well as from Kort & Matrikelstyrelsen, Danish Minister of the Environment (2010 [7]).

WIND DATA

For the wind data different wind roses from different data sets are presented Fig.1-5.

Prevailing wind directions are West, South-West direction and East, with dominant winds always from West, South-West or North-West; in general the strongest winds are recorded for directions included between South-South-West and East-north-East. Despite the prevailing wind direction alternates between west and South-West, it occurred for ex. in 2009 that the prevailing wind direction was East.

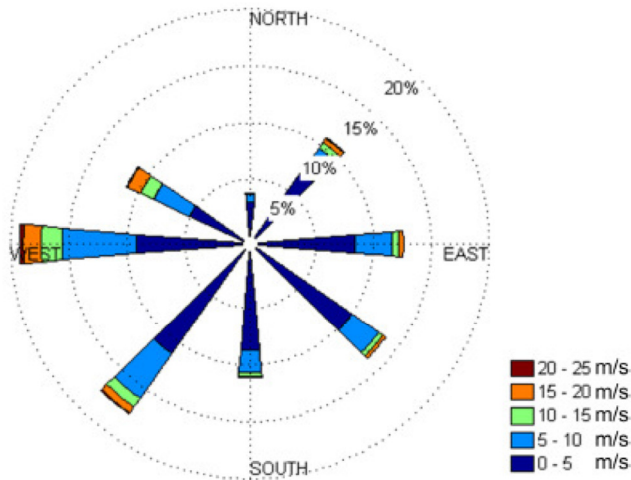


Figure 1. Wind Rose, DanWEC, data from 1931-1960 [1].

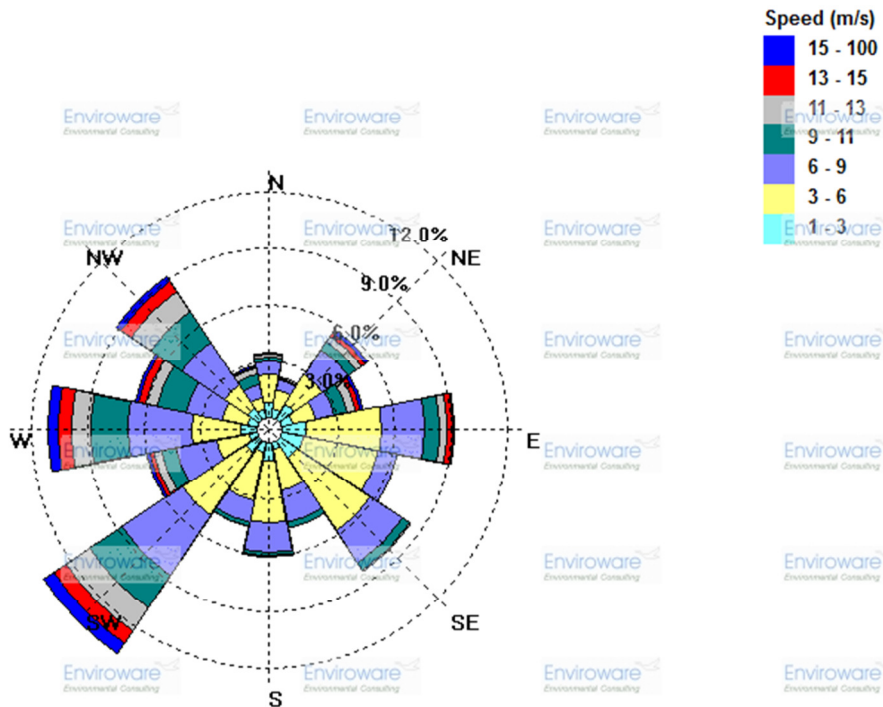


Figure 2. Wind Rose, DanWEC, data from 1996-1999.

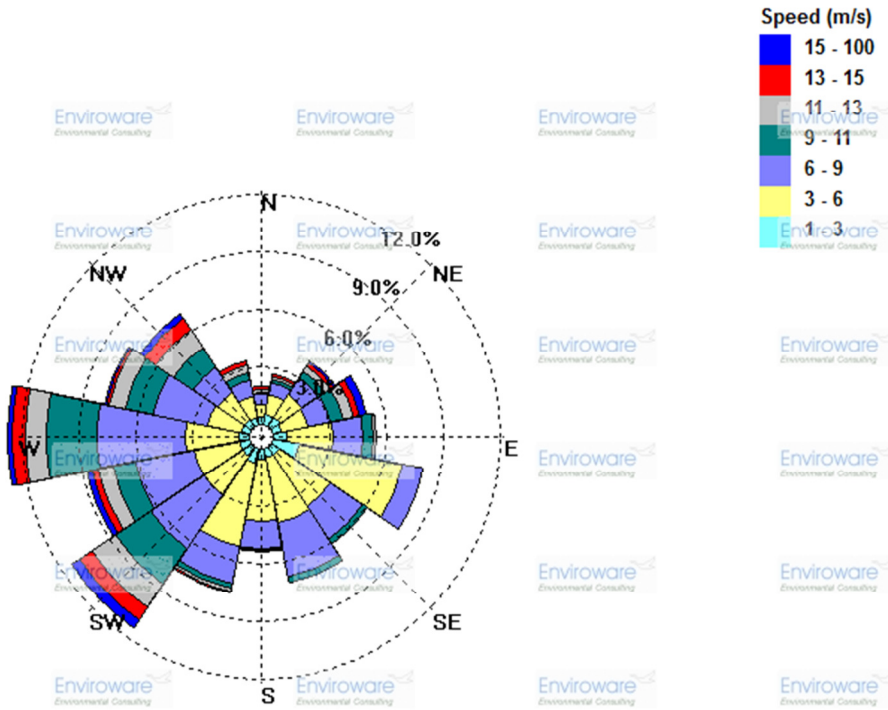


Figure 3. Wind Rose, DanWEC, data from 2000-2003.

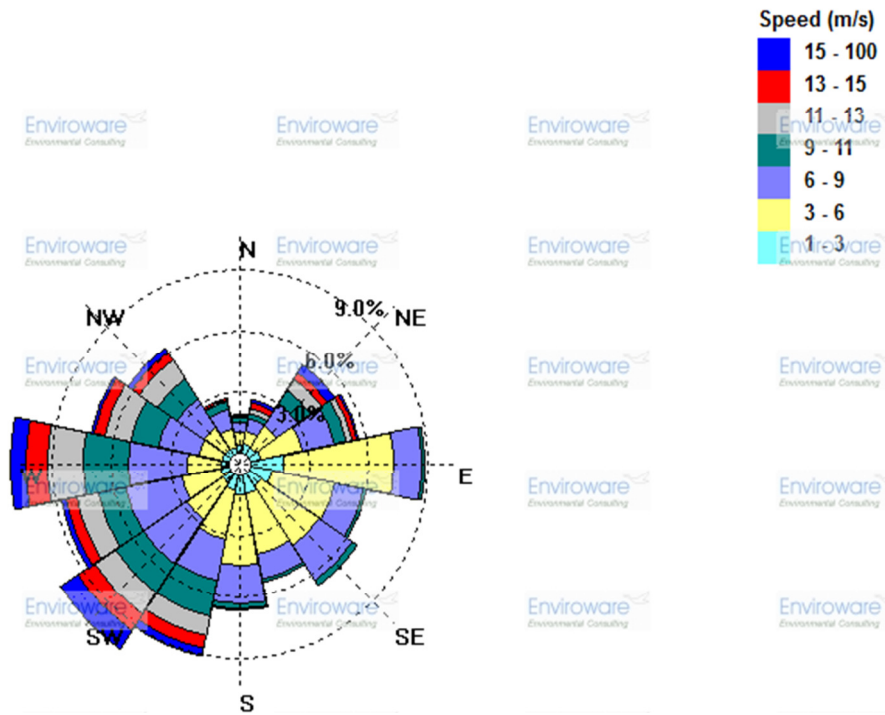


Figure 4. Wind Rose, DanWEC, data from 2004-2009.

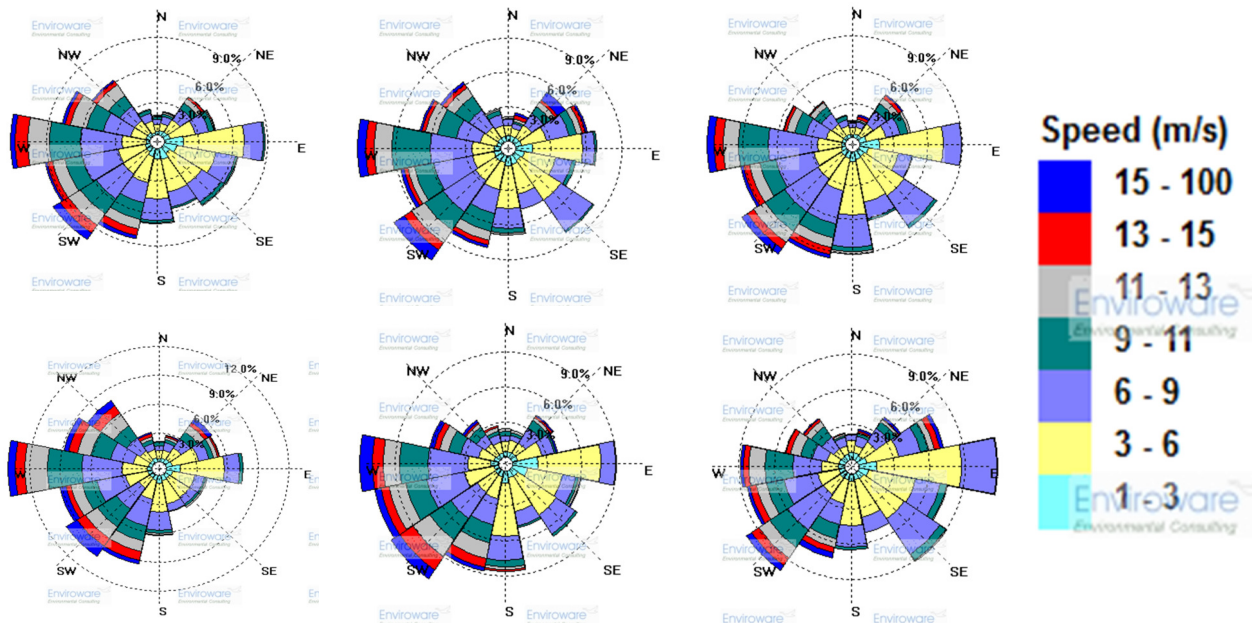


Figure 5. Wind Rose, DanWec , for individual years: from the top left, first row: 2004, 2005, 2006; second row: 2007, 2008, 2009.

WATER LEVEL VARIATIONS

The water level variations study includes data from the period 22.09.1969 - 03.12.2006 [3] and suggests the statistical extreme return heights for 100, 50 & 20 years:

VS_{100} = 167 cm with standard error of 9 cm.

VS_{50} = 161 cm with standard error of 7 cm.

VS_{20} = 152 cm with standard error of 6 cm.

VS_1 has been determined to be = 111 cm. A record of the highest water levels is reported in Table 1. Here, both DNN (old) and DVR90 (new) systems are reported related to mean water level. The first was introduced in late 1800 but after phenomena of both subsidence and water level rise it was necessary to introduce a new reference (DVR90) in 1990. If the difference between DNN and DVR90 at location is (+)4 centimeters it means that from 1891 to 1990 there has been a relative water level rise of 4 cm.

Table 1. Highest water level, DanWEC.

DATO	DNN (cm)	DVR90 (cm)	TRENDFRI (cm)
25. november 1981	177	173	173
6. november 1985	166	162	162
27. februar 1990	158	154	154
8. januar 2005	144	140	139
21. januar 1976	140	136	137
13. november 1973	140	136	137
18. januar 1983	140	136	136
30. oktober 2000	138	134	134
16. december 1982	138	134	134
26. oktober 1998	137	133	133
11. januar 1993	137	133	133
30. januar 2000	135	131	131
16. oktober 1987	135	131	131
14. februar 1989	134	130	130
6. november 1996	132	128	128
4. december 1999	131	127	127
1. januar 1984	130	126	126
20. december 1993	129	125	125
19. november 1982	127	123	123
14. januar 1993	126	122	122
26. januar 1990	126	122	122
18. januar 1990	126	122	122
1. januar 1981	124	120	120

CURRENT

No direct current measurement is available to us at the moment. The sources that we have are related to the solid, long shore sediment transport in the area and in general in the West coast of DK. Derived average velocities reported are in the range 0.5-1.5 m/s [4].

GEOLOGY and BATHYMETRY

Geological data are well known [7]. Recent investigations in connection to the feasibility study for the construction of a new breakwater utilized seismic equipment with potential resolution of app. 1 m down to 20-30 m into the seabed. Sidescan sonar would be able to give information on the seabed structures producing detailed data on sand thickness, chalk depth and bathymetry (Fig.6-8).

The investigated area consists of a thin Holocene marine sand layer that is overlaying an upper cretaceous chalk or a Danian limestone. In the project area it is believed that mainly Danian limestone occurs in the top meters of the pre-quaternary sediments. There are no major erosive structures in the limestone surface and no signs of mayor occurrences of other materials than sand in the project area above the limestone.

With regard to the bathymetry out of this area, less detailed and older maps are available from the Kort & Matrikelstyrelsen, Danish Minister of the Environment (Fig. 9-13).

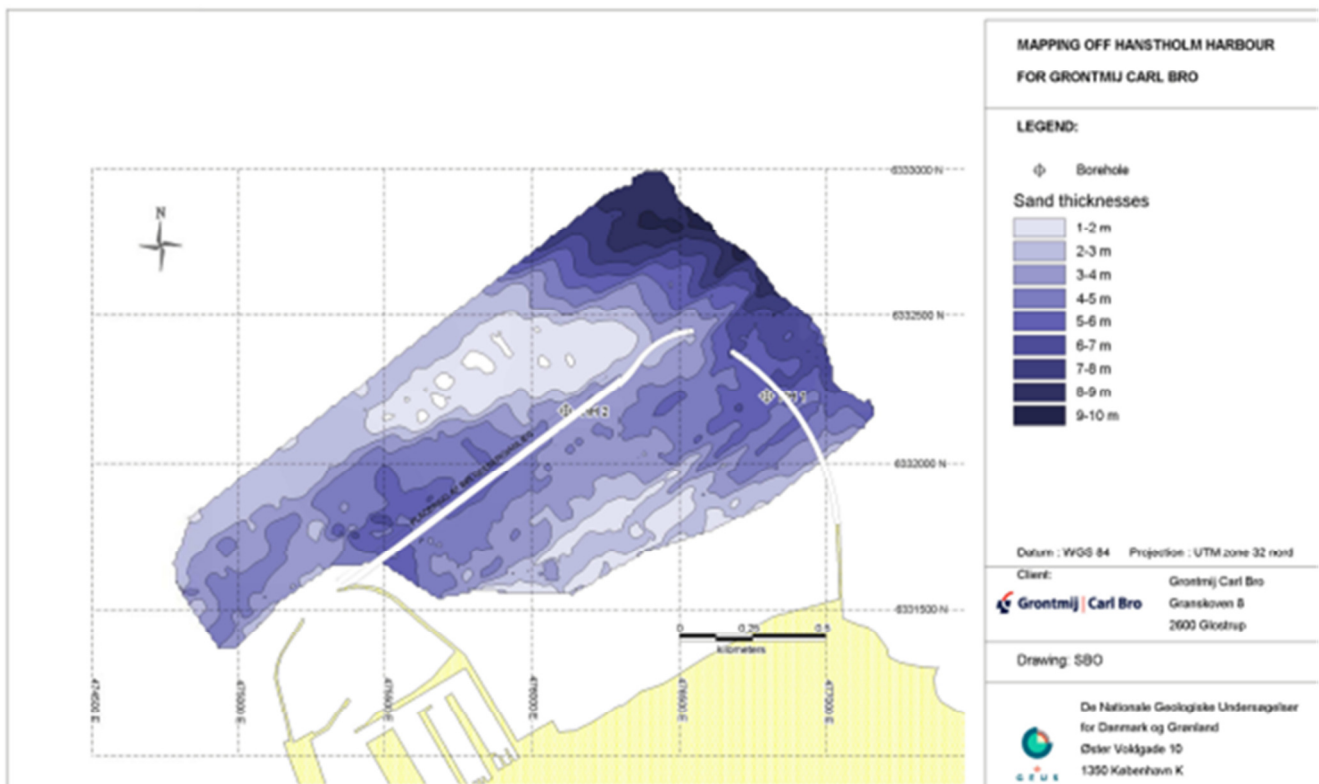


Figure 6. Bathymetry close to Hanstholm Harbour.

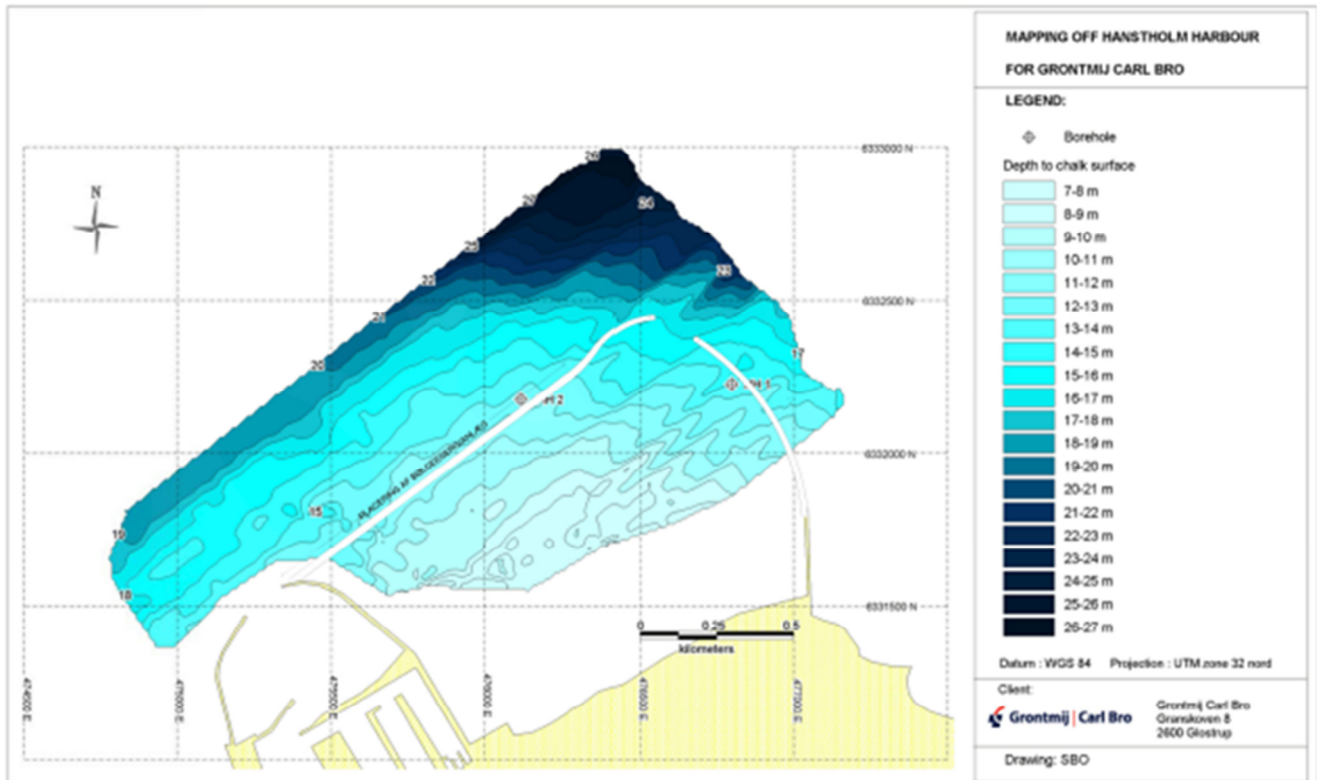


Figure 7. Sand thickness close to Hanstholm Harbour.

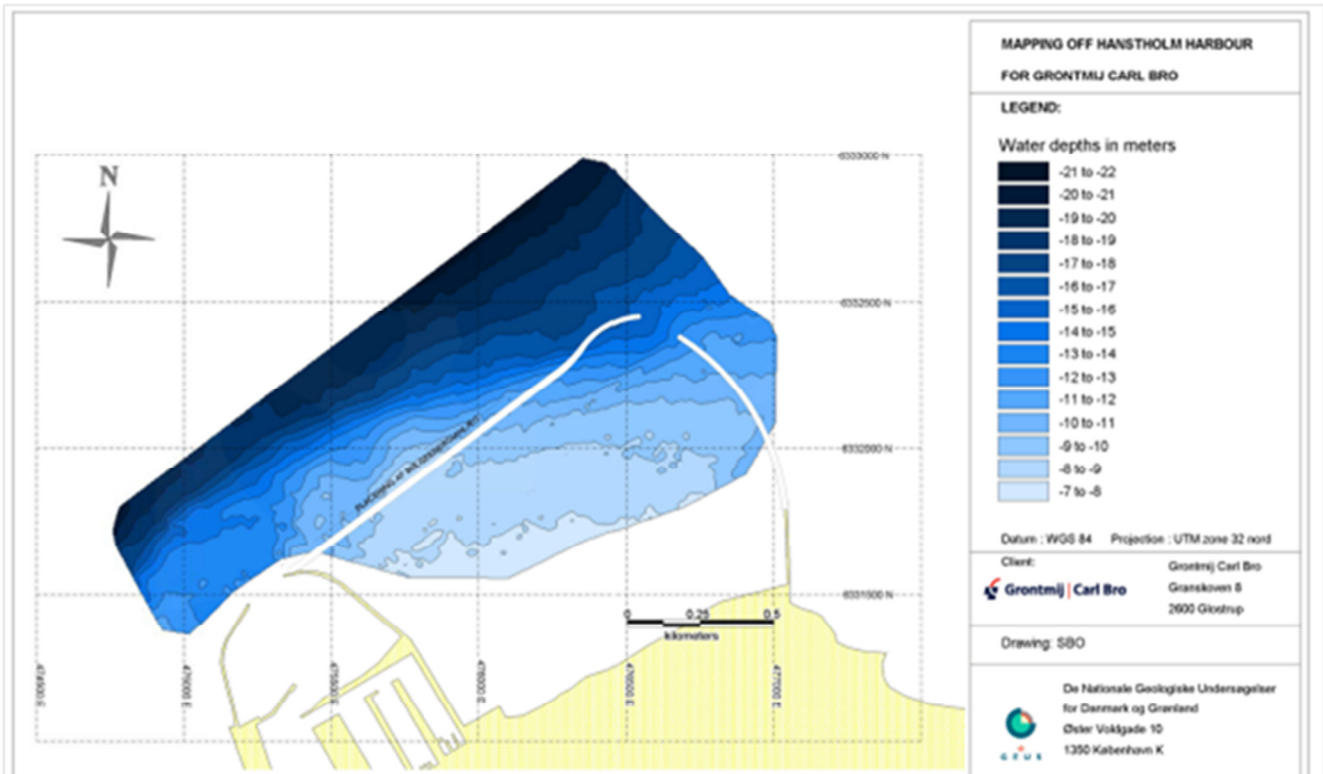
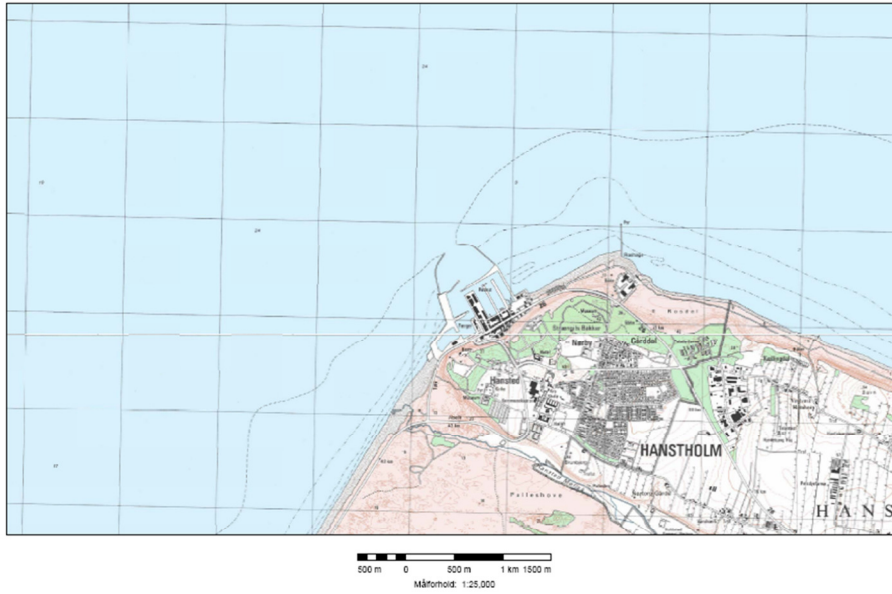


Figure 8. Depth of the hard chalk surface close to Hanstholm Harbour.

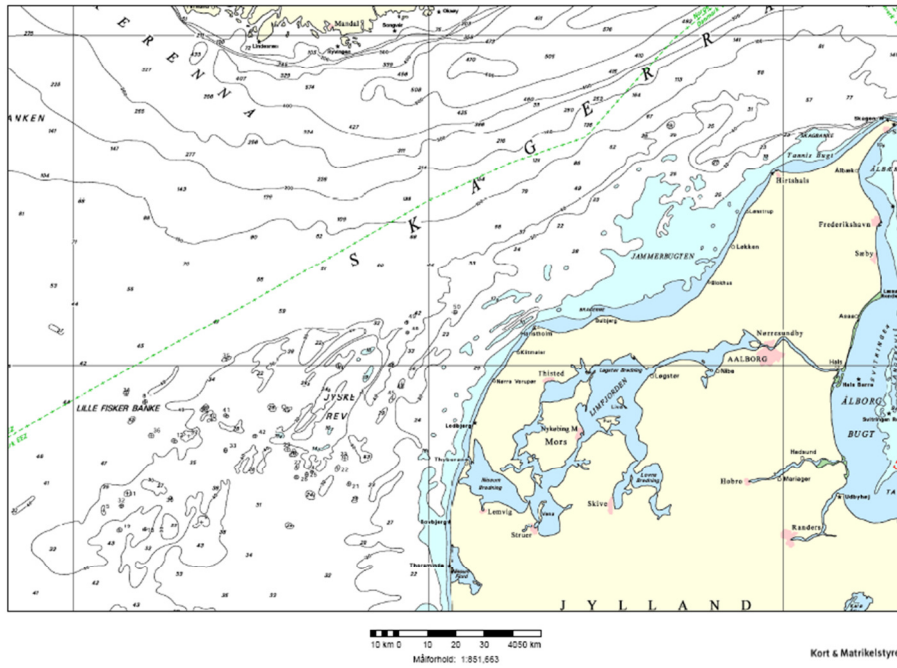
DK 1:25.000



Kort & Matrikelstyrelsen

Figure 9. Bathymetry DanWEC area.

S/850000 C - DANMARK OVERSIGTSKORT



Kort & Matrikelstyrelsen

Figure 10. Bathymetry offshore DanWEC area.

S/360000 92 - Skagerrak

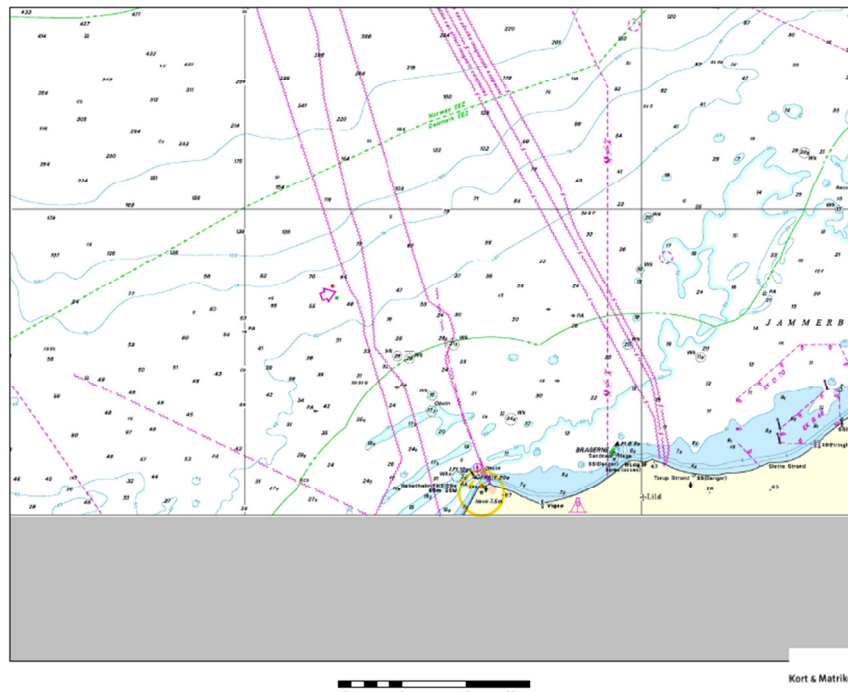


Figure 11. Bathymetry North and East offshore DanWEC area.

S/3/50000 93 - Nordsoen, Jyllands vestkyst

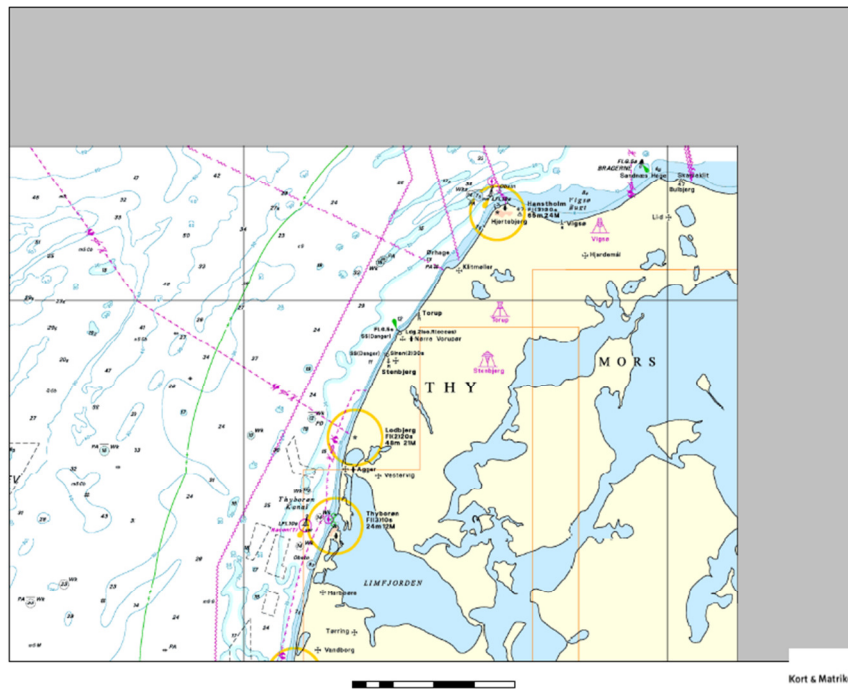


Figure 12. Bathymetry West offshore DanWEC area.

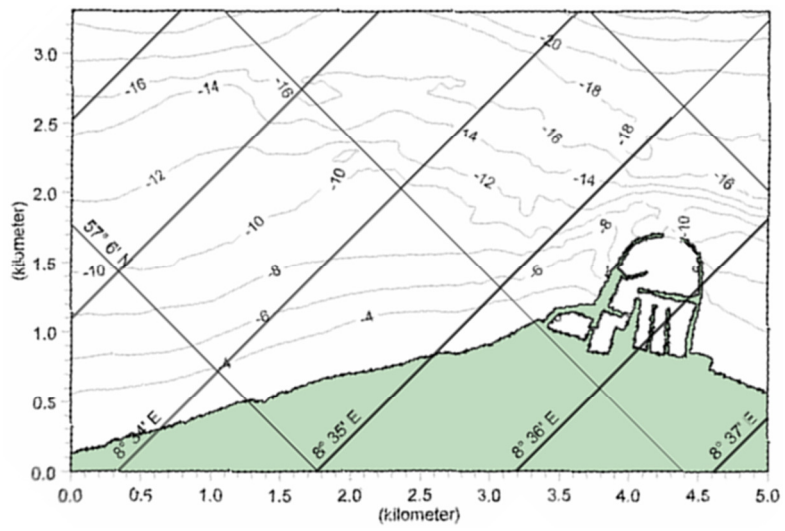


Figure 13. Zoom-in West side, Hanstholm Harbour.

FUTURE WORK

Wind: information on wind condition from 1931-1960 is available in a report (no raw data). Long data record is available from more recent years (raw data), from 1998 to today. A statistical analysis of wind data including the recent information should be undertaken. This analysis should also explore seasonality and correlation with wave data.

Water level variations: detailed report for water level variation exists, dating year 2007 and considered to be quite recent. Therefore it is estimated that there are enough information on the topic.

Current: no time series of current velocities at location are available. It is therefore suggested that a survey is scheduled and a measuring station established.

Geology and Bathymetry: recent data from 2010 are available in an area of around 4 km² North-East the harbour. In addition, older bathymetry maps for wider areas around Hanstholm location are available from the Kort & Matrikelstyrelsen. Therefore it is not consider a priority to undertake further surveys.

CONCLUSIONS

Wind seems to have high seasonal variations. Prevailing wind directions are West, South-West direction and East, with dominant winds always from West or South-West.

Water level variations show a rise in sea level of 4 cm from 1891 to 1990. Statistical extremes are:

VS_{100} = 167 cm with standard error of 9 cm.

VS_{50} = 161 cm with standard error of 7 cm.

VS_{20} = 152 cm with standard error of 6 cm.

No time series on current are available. Studies on sediment transport suggest average current speeds to vary between 0.5-1.5 m/s.

The area North-East the harbour has recently been scanned. The investigated area consists of a thin Holocene marine sand layer that is overlaying an upper cretaceous chalk or a Danian limestone. In the area it is believed that mainly Danian limestone occurs in the top meters of the pre-quaternal sediments. No major sign of other materials than sand are present above the limestone.

The bathymetry was also scanned within the above geotechnical study and comprehends an area of around 4 Km² and depth varying between -21 m to less than -8 m.

Older bathymetry maps exist for wider areas around the harbour.

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