

Data on the Danish West Coast



**PEM - Pressure Equalizing Modules
and their performance on the
high energy Danish West Coast.**

The Danish West Coast

To whom it may concern.

This document provides basic data on sites in Denmark where the PEM system - Pressure Equalizing Modules - has been tested or installed.

1. Background and major projects

EcoShore Int'l, Inc. is the US licensee for PEM. The PEM system is used to reduce or prevent beach erosion or retain sand from beach nourishment.

EcoShore has presented a number of PEM studies to interested parties in the USA. Most of the projects are situated on the Danish West Coast, a coastline with substantial hydraulic energy. To illustrate the energy, the 100 year wave in California is equal to the 10 year wave on the Danish West Coast, where PEM has been performing successfully for many years. To be able to judge if the PEM solution is likely to match the climatic conditions on your particular part of the US coast, EcoShore here presents basic data from the actual coast where the PEM systems were installed.

Most of the information derives from The Danish Coastal Authorities (DCA) or Danish Metrological Institute (DMI).

A. Old Skagen North

Old Skagen North was one of the first major test installations that challenged the established system of hard structures.

A hard structure may cause leeside erosion, and with no suspended sand, the PEM will normally have limited effect.

However as can be seen from the photos below, in this case where a lot of sand was in littoral drift, the PEM system produced a beach extending beyond the groins.



Before PEM



15 months into test



After removal of PEM

The PEM system was tested for a period of 4 years.

After the end of the test the PEM system was removed and the erosion started again.

The inventor forgot to remove one row of PEM (by the arrow) and here the beach is still wide several years later.



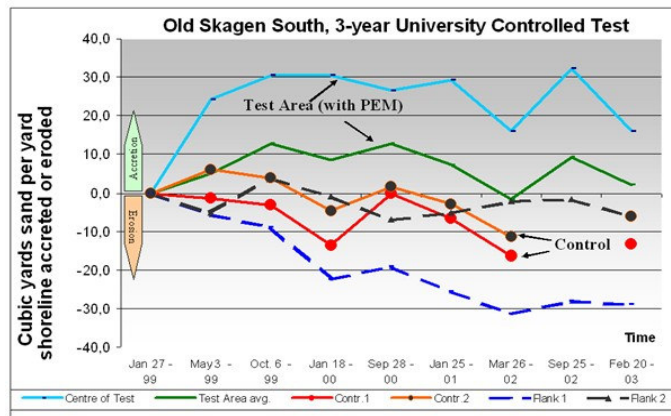
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B. Old Skagen South

A University controlled 3 year project on an eroding beach in Northern Jutland, Denmark.

The PEM area gained 8-10 cu.yds per yd of shore in less than a year (dark green graph) . In the middle of the test area (light blue graph) gains were over 20 cu.yds per yd of shore, while all other areas lost sand.

The modules have now been installed in the beach for over 5 years without maintenance and the beach is approx 2 ft. higher in the PEM area than the controls.



A report from the Danish professor Hans Burcharth is available. Contact EcoShore Int'l.

C. Lønstrup

The beach between the breakwaters at Lønstrup has been drained with PEM several times.

In October 2004 when PEM had been installed for 7 months the avg. elevation of the sea floor between the end of the breakwaters was increased by 132 cm. The beach elevation was increased by 41 cm and the sea depth of 1m had moved 20m out. (Source: DCA)



Lønstrup

D. Mårup

The bluff in front of Mårup church was eroding at rate of 4-5 ft a year and the 900 year old church was in danger of falling down. After the installation of PEM the beach has widened 45 ft and the cliff erosion reduced to max. 30 in. a year. The furniture in the old church that had previously been removed were re-installed as the church was now considered safe for decades



Mårup Church

E. Skodbjerg

The largest test of PEM was initiated in January 2005. 7 miles of coastline and sea floor is monitored of which half is fitted with PEM modules. The project is sponsored by the Danish Government and monitored by two independent professors.

The first official project report is due Oct. 2005, however after only 2½ months the effect was visible with the naked eye.



Skodbjerg

The project sites are marked in fig. 1.

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2. General description of the Danish West Coast

The Danish West Coast can be divided into three types of coast (colors refer to fig. 1)

- North - Clay and sand cliffs. Tide 1-2 ft. Area marked - - - - -
- Central - Low sandy dunes. Tide 2-3 ft. Area marked —————
- South - Sandy beaches and low hinterland. Tide 3-5 ft. Area marked

3. Site location and Erosion along the Danish West Coast

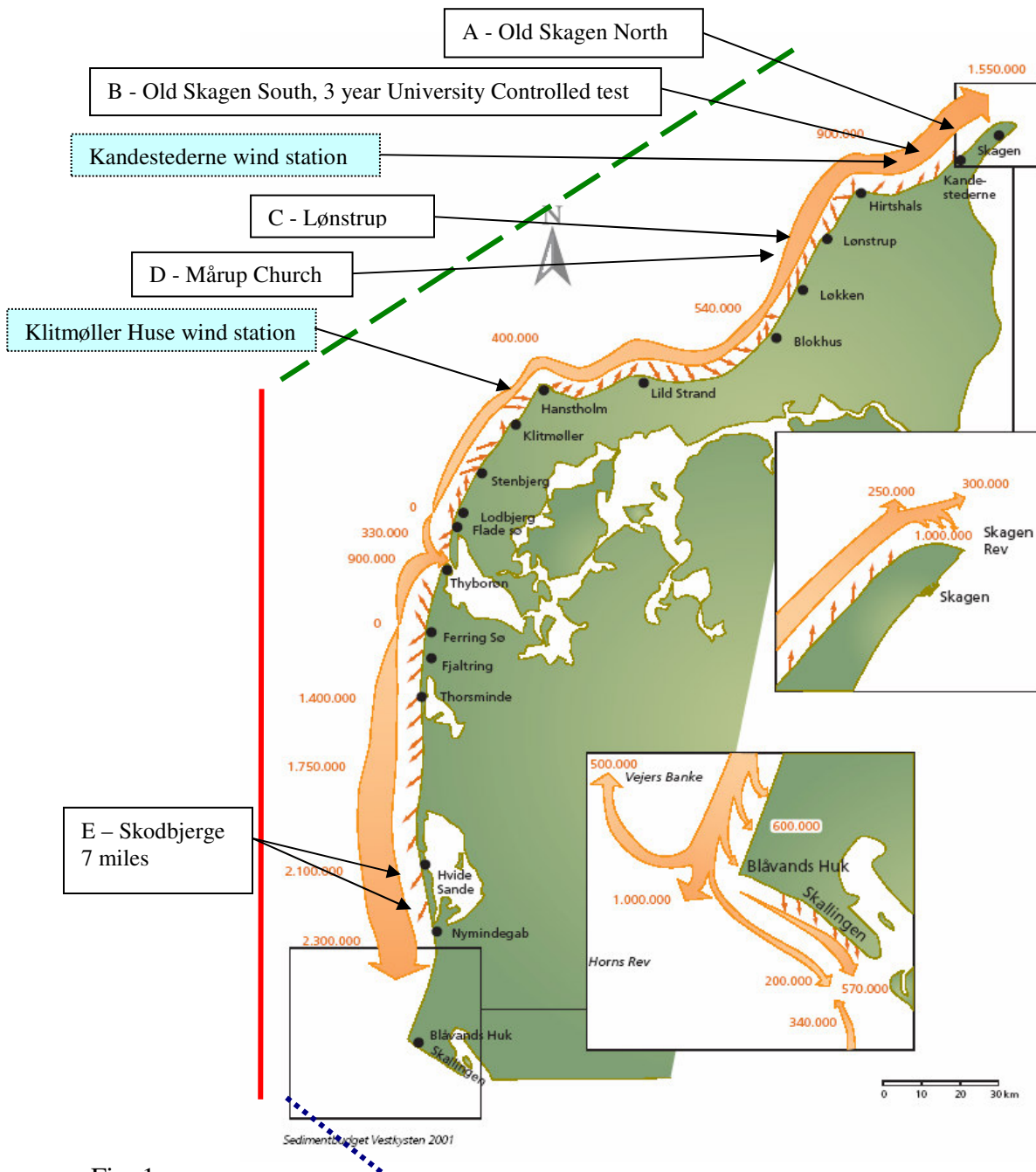


Fig. 1

Location of the major sites where PEM has been tested and the wind stations.

The types of coastline (marked in color)

The annual erosion along the Danish West Coast in m^3 per year (Source: DCA)

3. Sand information

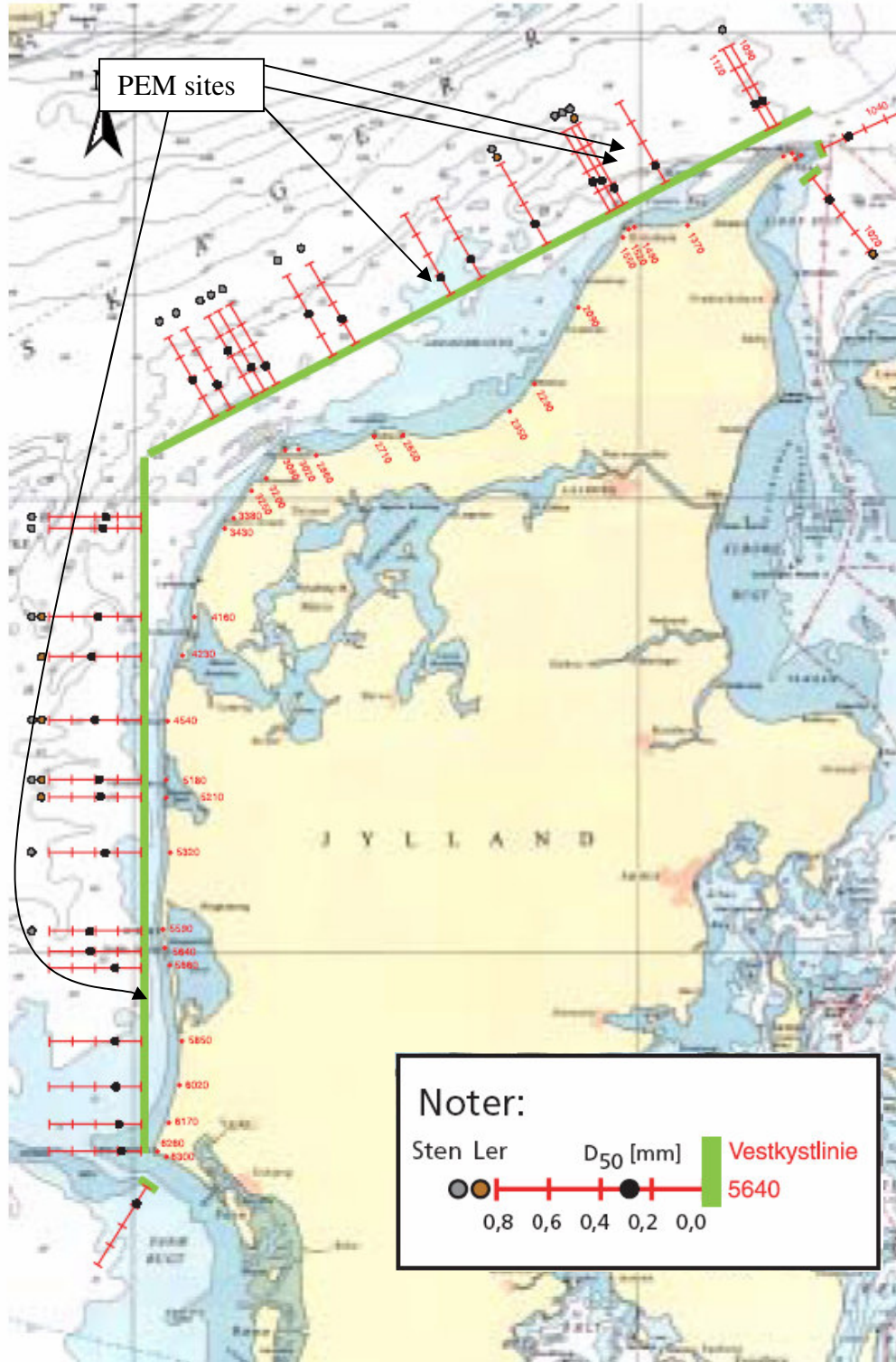


Fig. 2 The size of sand grains (Source: DCA)

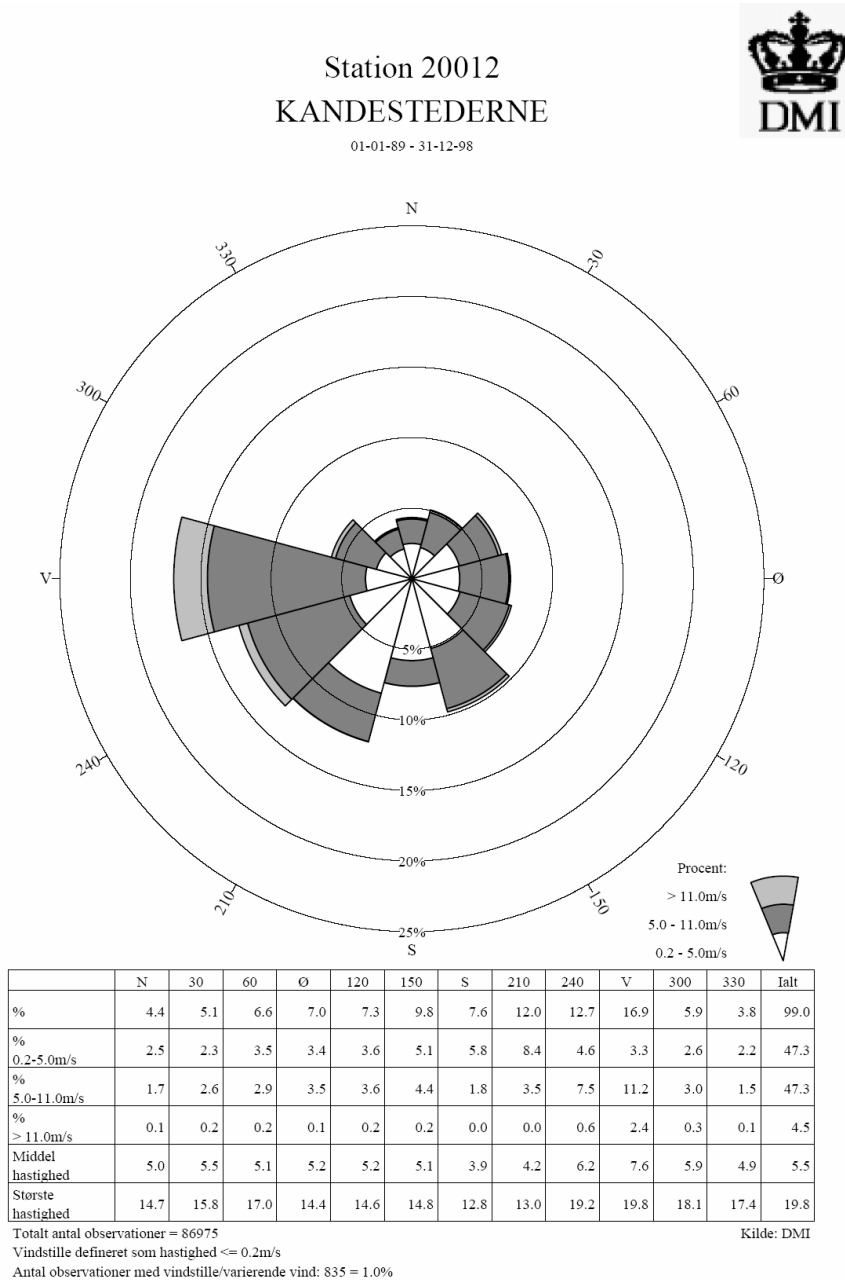
Avg. diameter of sand grains in the PEM test sites Lønstrup, Mårup, Old Skagen North and Old Skagen South is 0.2 – 0.25 mm.

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4. Wind information

14/1	1993	Hurricane-like, the southern parts and Bornholm	14/1-1993	w3
22/1	1993		22/1-1993	W2
3/12	1999	Hurricane, mostly the southern parts of Denmark	3/12-1999	W4
17/12	1999		17/12-1999	sw1
29-30/1	2000	Strong storm	30/1-2000	W2
28-29/1	2002	The southernmost parts of Denmark	29/1-2002	W2
27-28/10	2002	The southern parts of Denmark	28/10-2002	nw4

Fig 3. Storms in Denmark over the past ten years (Source: DMI)



Translation: "Middel hastighed": Mean wind speed, "Største hastighed": Max. wind speed

Fig. 4 Wind rose from Kandestederne near the test site in Old Skagen South, 1/2 mile inland.(Source: DMI)

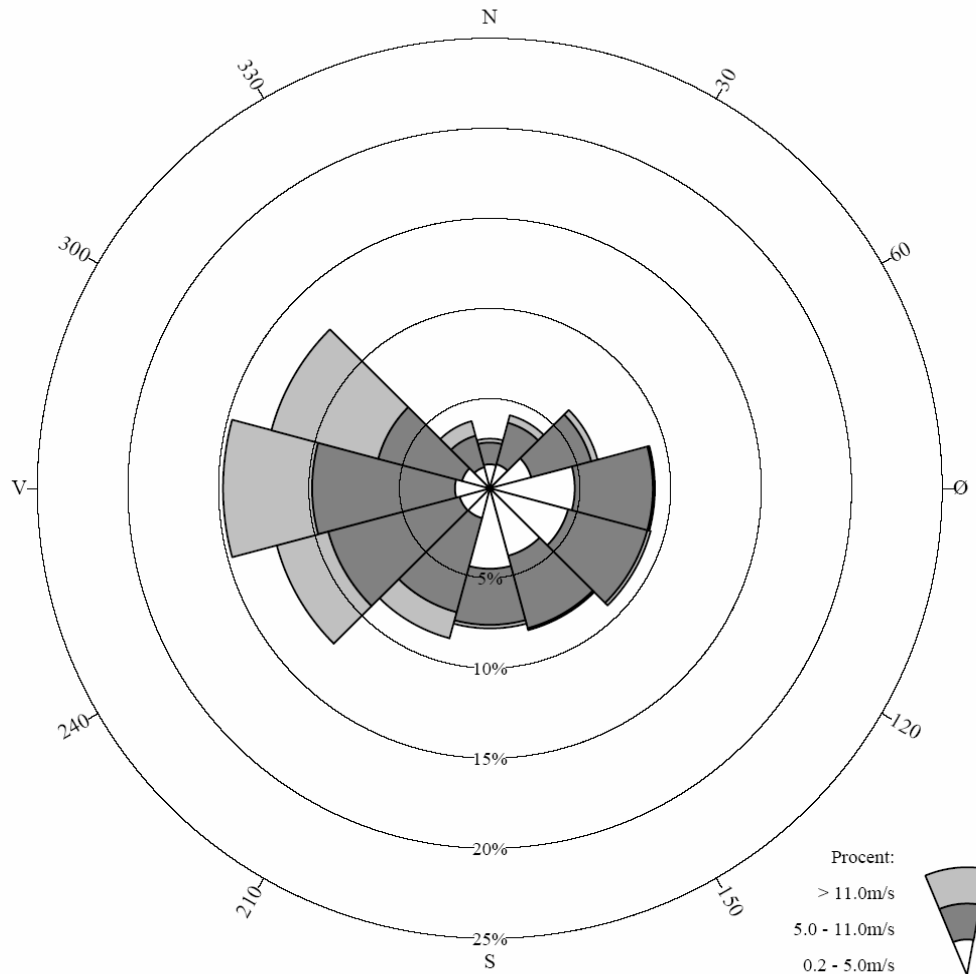
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Station 21075 Klitmøller Huse

01-01-89 - 31-12-98

Hele perioden



	N	30	60	Ø	120	150	S	210	240	V	300	330	Ialt
%	2.8	4.2	6.2	9.1	9.2	8.2	7.8	8.6	12.2	14.7	12.5	3.9	99.4
% 0.2-5.0m/s	1.3	1.4	2.4	4.7	4.5	3.9	4.5	1.7	1.7	1.9	1.6	1.2	30.9
% 5.0-11.0m/s	1.2	2.4	3.4	4.3	4.5	4.2	3.1	5.4	7.5	7.9	4.8	1.8	50.6
% > 11.0m/s	0.2	0.4	0.4	0.1	0.2	0.1	0.2	1.5	3.0	4.9	6.1	0.8	17.9
Middel hastighed	5.8	6.5	6.1	5.3	5.4	5.3	5.1	7.9	8.7	9.4	10.6	7.5	7.4
Største hastighed	19.5	19.8	18.8	14.3	13.6	14.0	17.5	19.8	24.6	27.6	26.4	21.5	27.6

Totalt antal observationer = 85205

Vindstille defineret som hastighed $\leq 0.2\text{m/s}$

Antal observationer med vindstille/varierende vind: 552 = 0.6%

Kilde: DMI

Fig 5. Wind rose from Klitmøller Huse, south of the test sites in Lønstrup and Mårup. The wind station is placed on the shore (Source: DMI)

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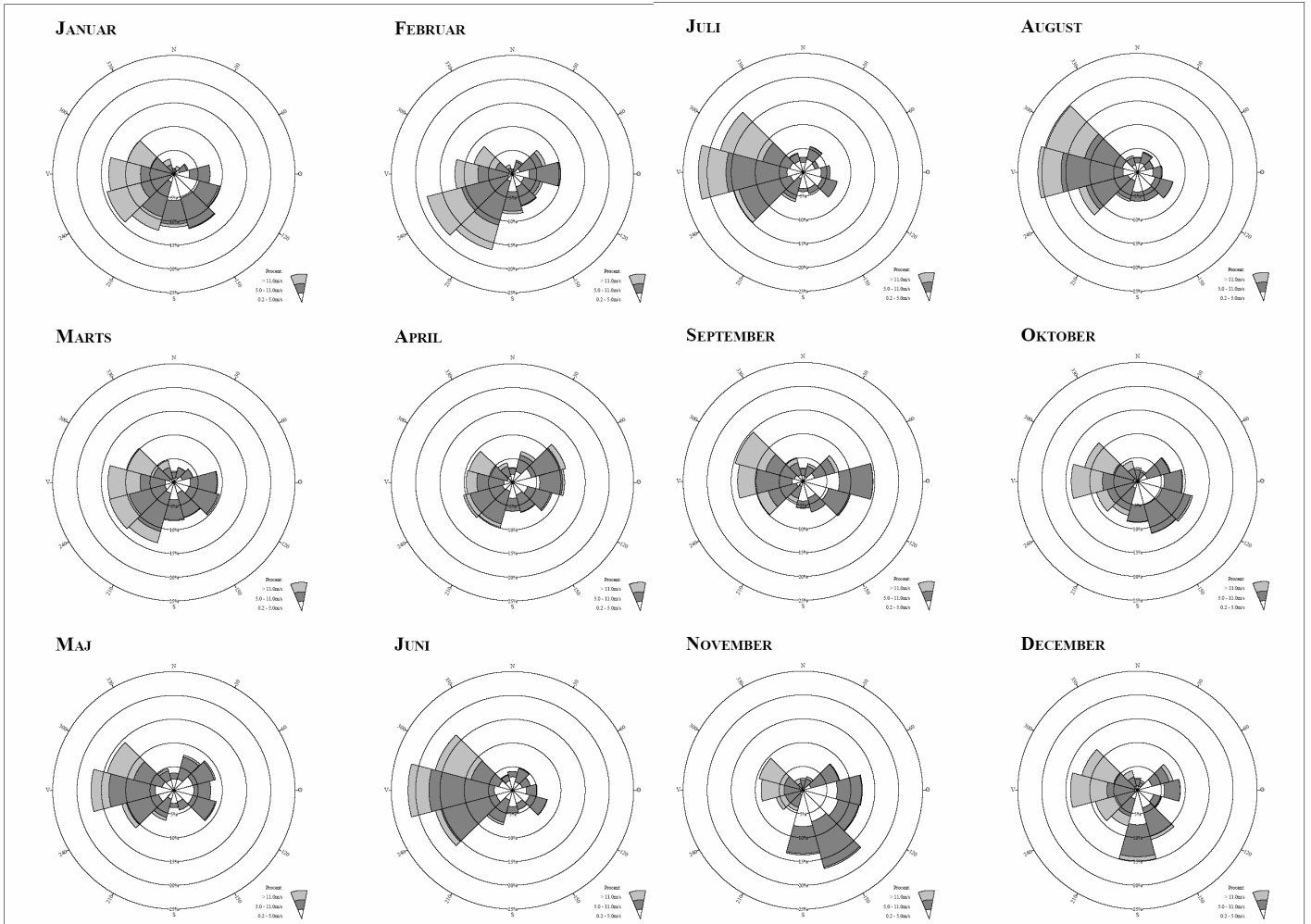


Fig 6. Wind roses from each month from Klitmøller Huse, South of the test sites in Lønstrup and Mårup. (Source: DMI)

5. Sea information



Fig 7. Net currents in the North Sea

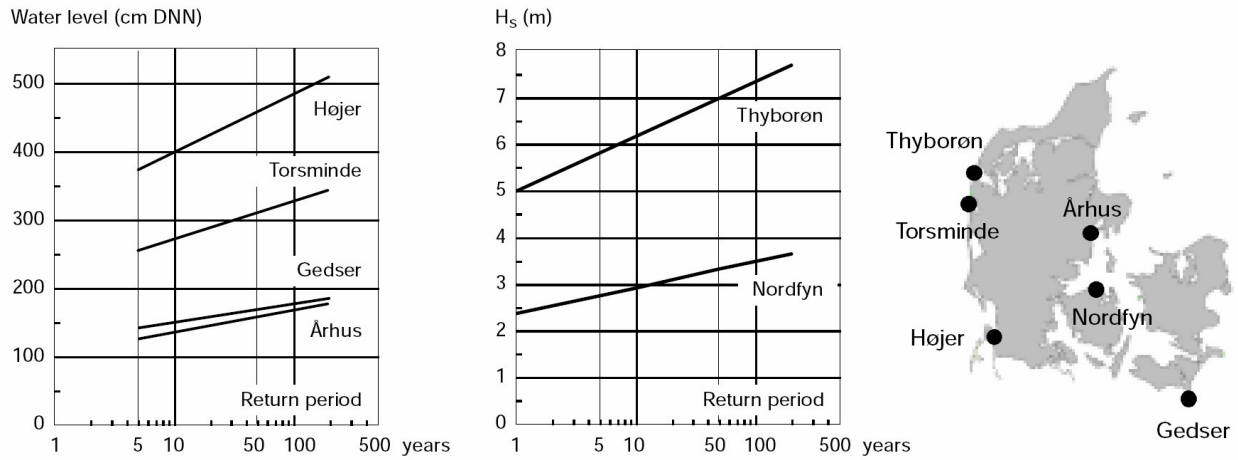


Fig.8. Water level and wave height statistics (centuries) (Source: DCA)

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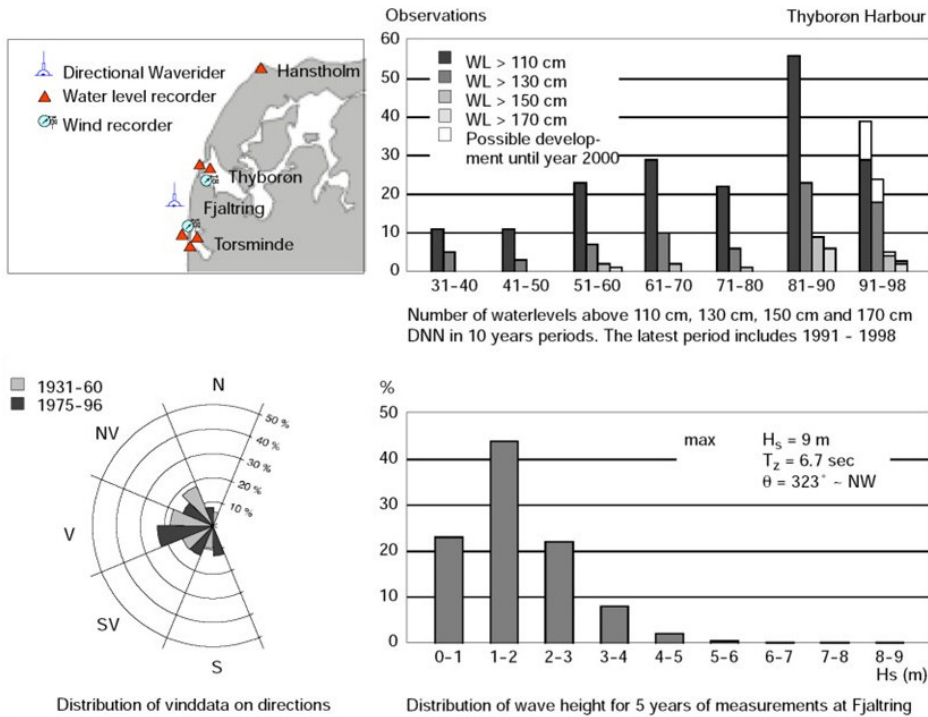
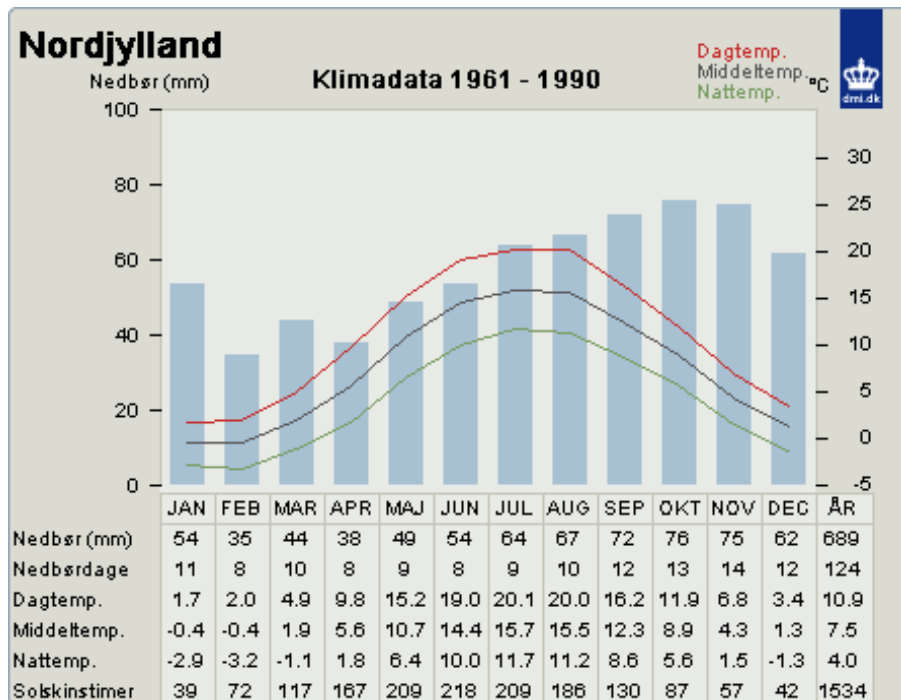


Fig 9. Water level, wave heights and wave frequency over 10 and 5 years

6. Temperatures and Precipitation



Dagtemp. = Day temp
Middeltemp- = Mean temp
Nattemp = Night temp
Nedbør = Precipitation
Nedbørsdage = Rainy days
Solskinstimer = Hrs sunshine

Fig. 10 Climatic data from Northern Jutland 1961 - 1990 (Source: DMI)

June 20, 2006