



**Dmi**

Ministry of Transport and Energy

## **Technical Report 07-09**

# **Hourly values of sea level observations from two stations in Denmark.**

## **Hornbæk 1890-2005 and Gedser 1891-2005**

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# Colophon

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## **Abstract**

This report contains available hourly values from tide gauges in Hornbæk and Gedser from 1890-1891 up to and including 2005.

## **Resumé**

Denne rapport indeholder tilgængelige timeværdier fra vandstandsmålere i Hornbæk og Gedser 1890-1891 til og med 2005.



## Introduction

In the end of the 19th century Danish Meteorological Institute (DMI) established 10 tide gauge stations scattered along the Danish coast with this only objective: To calculate and define a national reference level (Chart datum). This network of stations were in the 20<sup>th</sup> century supplemented with additional stations (more or less permanent in time and location) resulting in a present network of 15 stations.

Until around 1970 the instruments were connected to a pen recorder where continuous measurements were drawn on analogue charts. Afterwards hourly values were manually extracted and written on papers. Around 1970 the pen recorder was replaced with a potentiometer and a paper tape puncher enabling automatic transfer of data to a computer at DMI afterwards. Around 1990 all stations changed to automatic real time data transmission allowing on-line communication of data to a computer at DMI.

All tide gauges have been attended almost daily by a trained observer, who has collected ancillary tide gauge information.

Until 1910 heights of the visual tide poles were measured and, after establishment of a chart datum, recalculated. From around 1920 datum of the visual tide poles has been measured app every 3<sup>rd</sup> year by the National Survey and Cadastre.

With real-time data the main objective has changed towards primarily an operational issue: Storm surge warning. Historical data is used for tidal analysis, determination of mean sea level (MSL) and long-time trends, estimation of extremes and so on, but still the redefinition of a national chart datum about every 50<sup>th</sup> years is an important objective.



## Meta-data

The tide gauge in Gedser was established in 1891 and operational from January 1892  
The tide gauge in Hornbæk was established during the summer of 1890 and operational from September 1890.

### **Position**

<u>Gedser</u> :	Latitude 54° 34' N	Longitude 11° 56' E
<u>Hornbæk</u> :	Latitude 56° 06' N	Longitude 12° 28' E



## Instruments and measuring methods

Many different types of instruments have been available during time. In Denmark the first sea level measurements started at Christianshavn in 1739 with a very primitive method: A Visual Tide Pole where an observer read the pole. This simple method enables relative measurements and is still in use in all harbors where skilled and experienced personnel can obtain measurements with an accuracy of 1 cm. This method has always been and is still used as a reference for all measurements at DMI – see Fig. 1.

A former manager at DMI had developed and constructed an instrument with one advantage, it was cheap. This instrument was tested at Toldboden in 1888. Unfortunately this instrument demanded a lot of work and care and the measurements were not reliable. However, at that time it was the only experience in Denmark with respect to automatic water level recording, why DMI was chosen as manager of tide gauges in Denmark.

A new instrument was developed and constructed – a pneumatic gauge – much more expensive but more reliable and effective. This instrument was in the period from 1886 – 1890 established in Copenhagen, Fredericia, Århus, Slipshavn, Esbjerg, Korsør, Hornbæk and Hirtshals.

In Esbjerg the pneumatic gauge failed and was replaced with a float in a stilling well in 1888. A float in a stilling well was a well-known and reliable type of instrument already established in other countries - see Fig 1. This new type of instrument was soon afterwards established in Gedser and Frederikshavn.

During the 20<sup>th</sup> century additional permanent stations were established: Mommark in 1949 (moved to Fynshav in 1967). Rødbyhavn in 1954, Hanstholm in 1968 and Tejn in 1992.

In 1952 – 1959 all pneumatic gauges were worn-out and replaced with a float in a stilling well. The float in a stilling well turned out to be very stable method. But due to the fact that it was very expensive, the well is a costly construction and not easily moved, and the fact that the well suffered from “freshening”, fresh water entering the well at low water was never able to get out, DMI changed to CTD’s in the very beginning of the 21<sup>th</sup> century.

### Gedser

Float in stilling well from 1892.

Differential pressure transducer - CTD (Conductivity, Temperature, Depth) – from June 2001.

### Hornbæk

Pneumatic gauge from 1890.

Float in stilling well from app. 1959.

Differential pressure transducer - CTD (Conductivity, Temperature, Depth) – from June 2000.

## Methods

### Principle

**Sealevel = measurement - control + datum of VTP**

Where control is an average of daily synchronous readings of the Visual Tide Pole (VTP) and the instrument:  $\text{control} = \Sigma (\text{measurement} + \text{board}) / n$

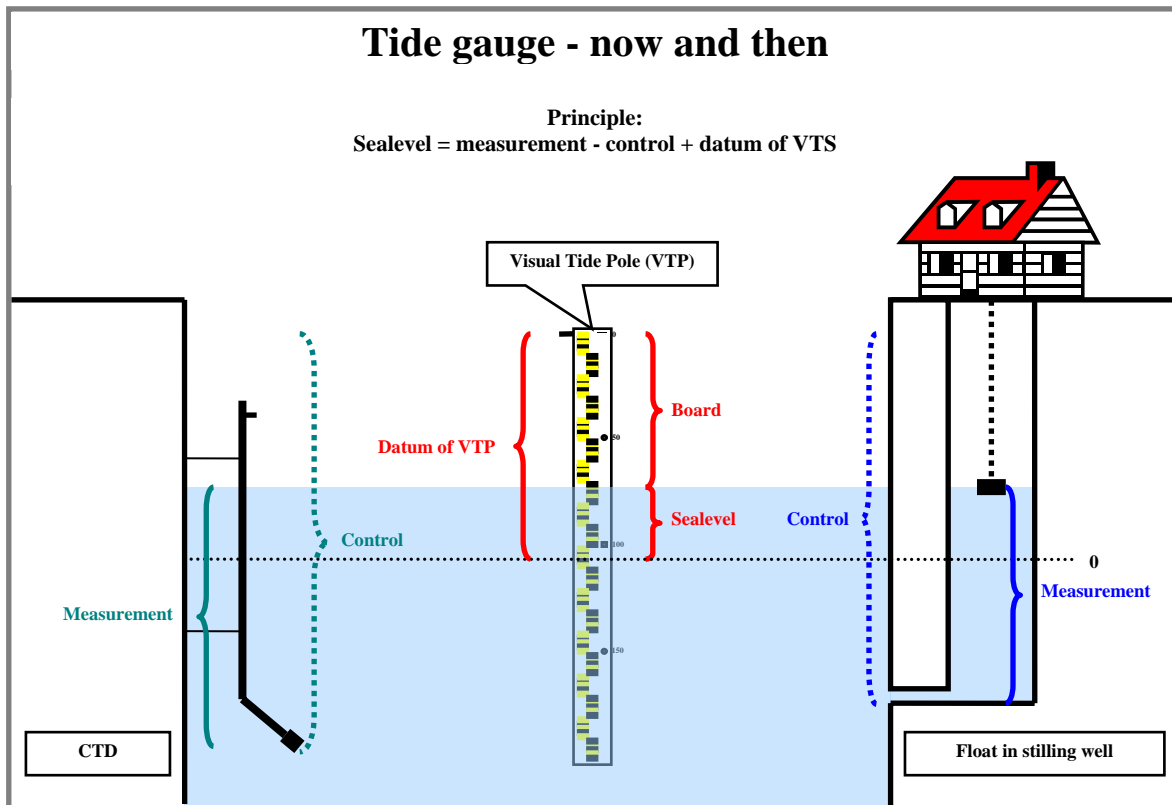


Fig. 1 Tide gauge





## Digitization of data

Data until 1972 have been digitized at IOW (Institut für Ostseeforschung in Warnemünde) by Dr. Rainer Feistel and his colleges as part of a joint work between IOW and DMI. Data from 1973 and onwards have been digitized at DMI.



## Quality control

Data have been checked for different types of errors; spikes and highs or lows with constant value over time, and these data have been removed. Other obvious spurious data have also been removed.

Criteria:	Spike	Constant over time
<u>Gedser</u>	> 35 cm or < - 35 cm	More than 6 hours
<u>Hornbæk</u>	> 41 cm or < - 41 cm	More than 6 hours

Gaps in data occur due to removed erroneous data, malfunction of the instrument or pen/paper, interruption in the communication system etc.



## Reference system – levelling datum

Tide gauge measurements are relative measurements reflecting the movements of the sea level with respect to the land. Long term changes of the land (vertical movements caused by glacial processes, seismic activity, plate tectonic, ground water pumping etc.) and long term changes of the sea (variation in currents, salinity and/or temperature, variation in weather, etc.) are effects coupled with the actual sea level in the measurement. With improved technology from GPS in the near future it is expected to be possible to decouple these effects from the sea level measurement.

Datum, benchmarks on land and benchmark on the Visual Tide Pole are established and maintained by the National Survey and Cadastre.

Sea level data are referenced to LN (local zero) which is the original local MSL (Mean Sea Level) calculated in app. 1910.

Conversion from LN to DVR (Danish Vertical Reference\*) or DNN/GI (Danish Normal Zero\*)

Gedser:        DVR = LN – 5,0 cm                                DNN/GI = LN + 2,7 cm

Hornbæk:     DVR = LN - 1,8 cm                                DNN/GI = LN + 3,9 cm

\* Danish height systems established by the National Survey and Cadastre.



## Data file description

The zip-file includes two files named hornbaek.dat and gedser.dat.

### Format

Position	Format	Description
1-4	I4	Year
5-6	I2	Month
7-8	I2	Day
9-10	I2	Hour UTC
11-14	I4	Sealevel in cm. (range -999 cm. to 999 cm.)

## Previous reports

Previous reports from the Danish Meteorological Institute can be found on:

<http://www.dmi.dk/dmi/dmi-publikationer.htm>