

One-hundred-and-forty years of daily observations in a tidal inlet (Marsdiep)

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From 1861 to 1962 daily observations of temperature and salinity were carried out in the Marsdiep tidal inlet near Den Helder. Since 1947 similar measurements have been made in the Marsdiep on the coast of the island of Texel. Monthly mean differences for temperature and salinity were determined from the overlapping years. With these differences the Den Helder series could be extended to a homogeneous series from 1861 until 2001. The seasonal and annual mean salinities and temperatures are presented. The years 1999 and 2000 were the two warmest since 1861, and 1996 was among the five coldest years. The mean annual temperatures reflect the West European climatic variability and are highly correlated with the annual mean air temperature in Den Helder. Ice winters with monthly mean temperatures below 0°C occur generally in winters with a low NAO index. The salinity shows a persistent decreasing tendency related to increased river discharge since the beginning of the observations.

Keywords: salinity, temperature, time-series, Wadden Sea.

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The Marsdiep is a tidal inlet between Den Helder and the island of Texel in the northwestern part of The Netherlands (Figure 1). It connects the western basin of the Wadden Sea with the North Sea. Up until 1932 the large brackish Zuiderzee was connected directly with the Wadden Sea. In that year an enclosure dyke was built, and the former Zuiderzee became the freshwater lake IJsselmeer. The Dutch Wadden Sea forms an extensive estuarine environment, characterized by high productivity, high energy fluxes, and strong hydrographic variability. It is a nursery for several commercial fish species, and a feeding ground for a number of seabirds and waders. In the western basin of the Wadden Sea the main exchange with the North Sea takes place through the Marsdiep. The main source of freshwater in the western basin is the River Rhine and its branch, the IJssel, via the outlet sluices in the enclosure dyke. Additional Rhine Water enters the Marsdiep via the Dutch coastal waters between Hoek van Holland and Den Helder.

Halfway through the 19th century, scientific interest in fisheries emerged in The Netherlands, when it was decided to monitor hydrographic parameters at a series of coastal stations. One of these stations

was situated on the Den Helder sea dyke along the Marsdiep and has resulted in a 140-year time-series of daily hydrographic observations carried out successively by different institutes.

From 1861 to 1962, daily observations of temperature and salinity were carried out on the Den Helder side of the Marsdiep. Water samples were taken with a bucket at 08:00. The temperature was determined with a calibrated seawater thermometer. For determination of the salinity areometer measurements, chemical titration and conductivity measurements were used successively. Since 1947, similar measurements have been made in the Marsdiep on the coast of the Island of Texel, allowing determination of a monthly mean offset to relate observations on both sides of the inlet. Until 1981 the data set was quality controlled and described by van der Hoeven (1982). In 1982, NIOZ took over responsibility for the Marsdiep series. Since March 2000 temperature and salinity have been measured continuously by means of electronic sensors.

Annual mean values are given in Figure 2. The water temperature in the Marsdiep is determined by the fast response of the air–sea interaction in the shallow Wadden Sea and the slower response in the

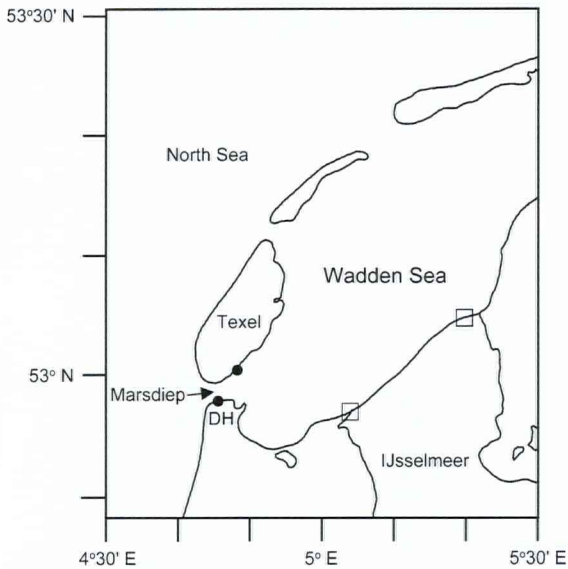


Figure 1. Map of the western Wadden Sea. The observation points in Den Helder (DH) and Texel are marked with black dots. The positions of the outlet sluices in the enclosure dyke between Wadden Sea and IJsselmeer are indicated with squares.

deeper North Sea. The typical thermal response time of the Wadden Sea is less than 2 weeks (J. Ettema, pers. comm.). The annual mean temperature correlates well with the annual mean air temperature in Den Helder. The five warmest years were 1999, 2000, 1868, 1989, and 1863, the five coldest 1888, 1963, 1879, 1909, and 1996. The mean annual salinity has a significant correlation of -0.72 with time. This decreasing trend is related to the long-term increasing trend in the discharge of the river IJssel and the outlet sluices in the enclosure dyke. This is due to a changing hydrological management of the Dutch waters, since such a trend is absent in the discharge of the River Rhine as it enters The Netherlands. Since the enclosure of the Zuiderzee, the interannual variability has increased, probably because of the decreased buffer capacity of the Wadden Sea following the enclosure.

On average, the lowest temperatures are observed in December to March and the lowest salinities from January to April. Since 1947, ice winters, with at least one monthly mean temperature near Texel below zero, occurred in 1947, 1954, 1956, 1963, 1979, 1986, 1996, and 1997, characterized by a

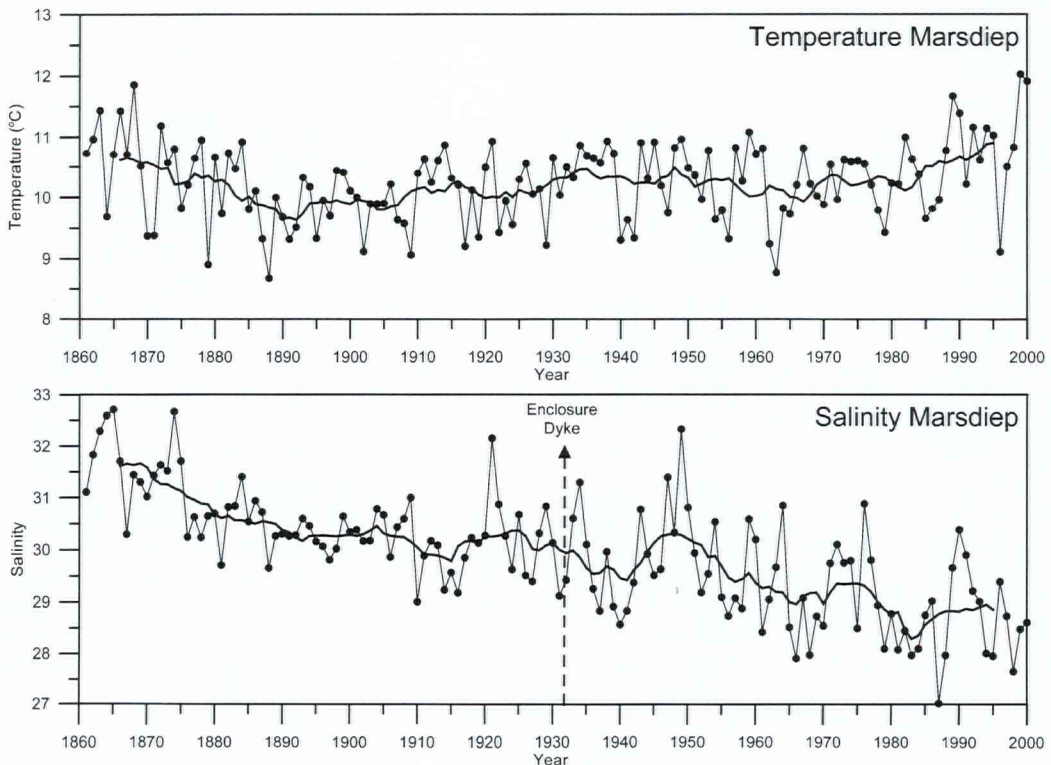


Figure 2. Plot of the annual mean sea surface temperature and salinity in the Marsdiep tidal inlet from 1861 to 2000 (dotted line). The 10 years running mean is shown with a thick line.

North Atlantic Oscillation index of -0.54 ± 0.32 . In comparison, the winter NAO index for the period 1947 to 2000 was $+0.36 \pm 0.14$. Of 30 months with a mean salinity below 25.0 only 4 were not found in the period January to April.

The Marsdiep time-series is the last surviving of a number of time-series in Dutch coastal waters, started in the 19th or early 20th century. Other series have been terminated because of budget cuts, and because responsible institutes lost interest in maintaining the series. The temperature–salinity time-series from the Marsdiep is used regularly for biological and environmental research in the western Wadden Sea. NIOZ intends to maintain this series in the future as one of a number of environmental time-series in the western Wadden Sea.

Acknowledgements

This publication is dedicated to the memory of the late Henk Beumkes, who took care of the Marsdiep observations for tens of years. The monthly mean data are freely available on request for scientific research (aken@nioz.nl, see also <http://www.nioz.nl/en/deps/fys/niozteso/enhtml/master.html>). This is NIOZ contribution 3626.

Reference

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