

140 years of daily observations in a tidal inlet (Marsdiep).

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Abstract

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 were made in the Marsdiep at the coast of the Island Texel. From the overlapping years monthly mean differences for temperature and salinity were determined. With these differences the Den Helder series could be extended to a homogenous series from 1861 till present. The seasonal and annual mean salinities and temperatures are presented. The years 1999 and 2000 are the two warmest years since 1861, 1996 is among the five coldest years. The annual mean 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 since the beginning of the observations, related to increased river discharge.

The Marsdiep is a tidal inlet between Den Helder and the island Texel in the north-western part of the Netherlands (Figure 1). It connects the western basin of the Wadden Sea with the North Sea. 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 a high productivity, high energy fluxes, and strong hydrographic variability. It is a nursery for several commercial fish species, and feeding ground for a number of sea birds 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 fresh water in the western basin is the river Rhine and its branch 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 19-th century scientific interest in fisheries emerged in the Netherlands. It was decided to monitor hydrographic parameters at a series of coastal stations in the Netherlands. One of these stations was situated on the Den Helder sea dyke along the Marsdiep. This has resulted in a 140 years 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 at the Den Helder side of the Marsdiep. Water samples were taken with a bucket at 8 AM. The temperature was determined with a calibrated sea water thermometer. For the determination of the salinity areometer measurements, chemical titration and conductivity measurements were used successively. Since 1947 similar measurements were made in the Marsdiep at the coast of the Island Texel, allowing the determination of a monthly mean offset to relate observations on both sides of the inlet. The data set until 1981 has been quality controlled and described by van der Hoeven (1982). In 1982 NIOZ took over the responsibility for the Marsdiep series. Since March 2000 temperature and salinity are 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 deeper North Sea. The typical thermal response time of the Wadden Sea is less than two weeks (J. Ettema, pers. com.). The annual mean temperature correlates well with the annual mean air temperature in Den Helder. The five warmest years are 1999, 2000, 1868, 1989 and 1863, the five coldest 1888, 1963, 1879, 1909 and 1996. The annual mean 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. After the enclosure of the Zuiderzee the interannual variability has increased, probably due to the decreased buffer capacity of the Wadden Sea following the enclosure.

On average the lowest temperatures are observed in December to March, the lowest salinities from January to April. Since 1947 ice winters, with at least one monthly mean temperature near Texel below zero, were 1947, 1954, 1956, 1963, 1979, 1986, 1996 and 1997, characterized by a North Atlantic Oscillation index of -0.54 ± 0.32 . In comparison the winter NAO index for the period 1947 to 2000

amounts to $+0.36 \pm 0.14$. 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 one of a number of time series in Dutch coastal waters, started in the nineteenth or early twentieth century. Other series have been terminated because of budget cuts, and because responsible institutes lost their 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 free available on request for scientific research (aken@nioz.nl). This is NIOZ contribution 3626.

References

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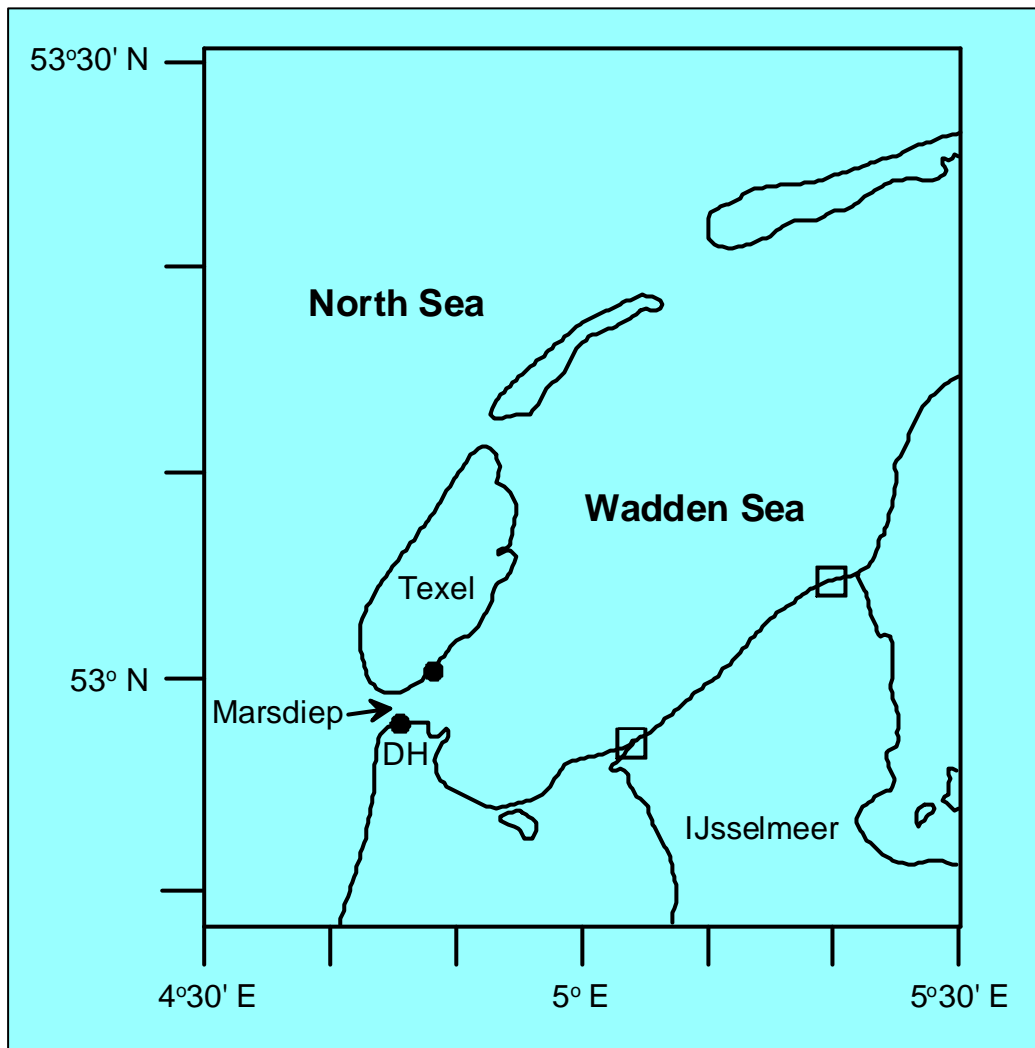


Figure 1. Map of the western Wadden Sea. The observation points in Den Helder (DH) and Texel are marked with black dots. The positions of the outlet sluices in the enclosure dyke between Wadden Sea and IJsselmeer are indicated with squares.

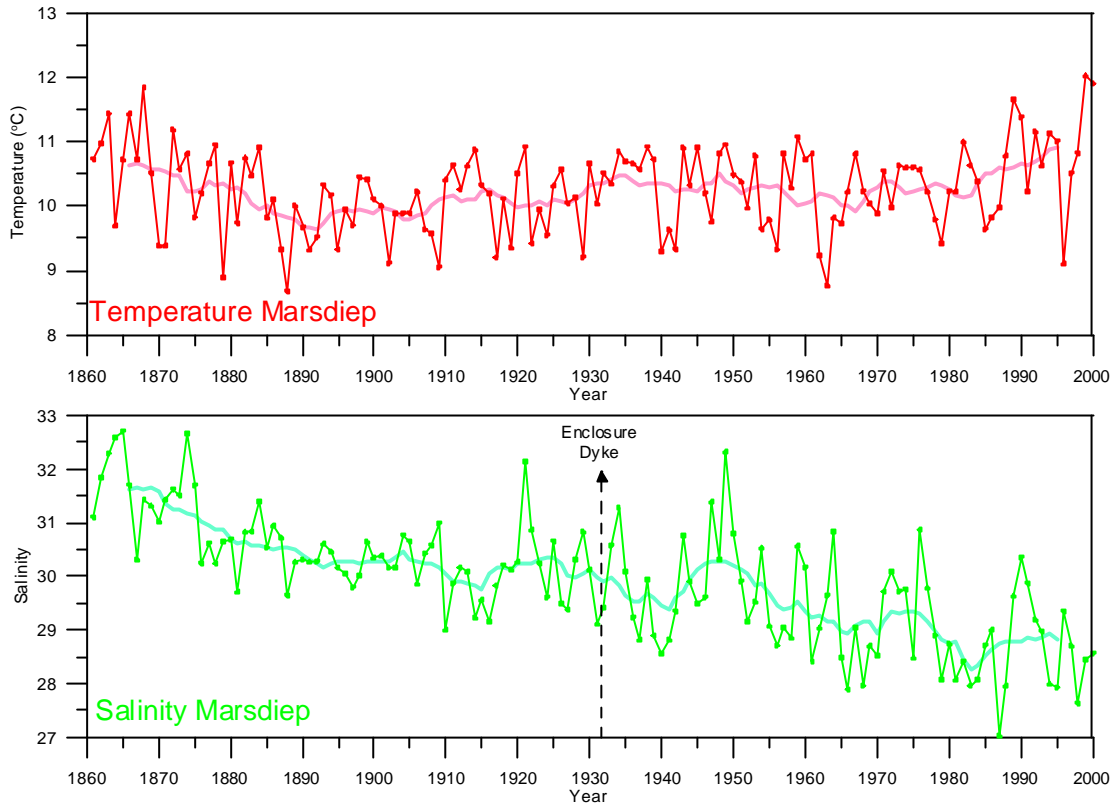


Figure 2. Plot of the annual mean sea surface temperature and salinity in the Marsdiep tidal inlet from 1861 to 2000 (dotted line). The 10 years running mean is shown with a thick line.