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N-loads to the Baltic Sea and Danish coastal waters. Chlorophyll-a and secchi depth. Technical note.

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N-loads

This note demonstrates a correlation between yearly loads of nitrogen to Danish coastal waters and yearly loads of nitrogen to the Baltic Sea. A correlation is found between yearly N-loads from all catchments to the Baltic Sea (see fig1 & 2) and Danish loads ($r^2=0,45$). The best correlation is found between N-loads from southern Denmark/smaller part of North Germany (see fig1 & 3) and Danish loads ($r^2=0,92$). A correlation is also seen between N-loads from Northern Denmark/part of Sweden (see fig1 & 4) and Danish loads ($r^2=0,79$). The explanation for these correlations would probably be that the weather in northern Europe is correlated due to the controlling low and high pressures. In other words, if it is a rainy or dry season in Denmark this is mostly also the case for rest of the Baltic Sea region and N-loads are significantly correlated to runoff. A complication of these correlations is for example that it is not obvious to what extent it is local N-loads or neighboring N-loads affecting a specific coastal water body when using statistical modelling for N-loads and impact (chlorophyll).

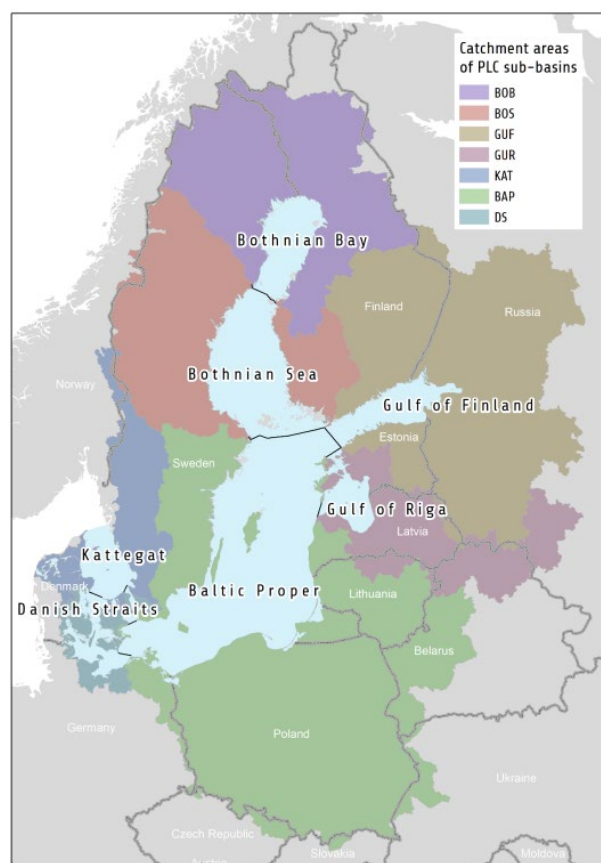


Figure 1. The catchment of the Baltic Sea divided into seven sub-basins and the nine catchment countries (Svendsen & Gustafsson, 2022).

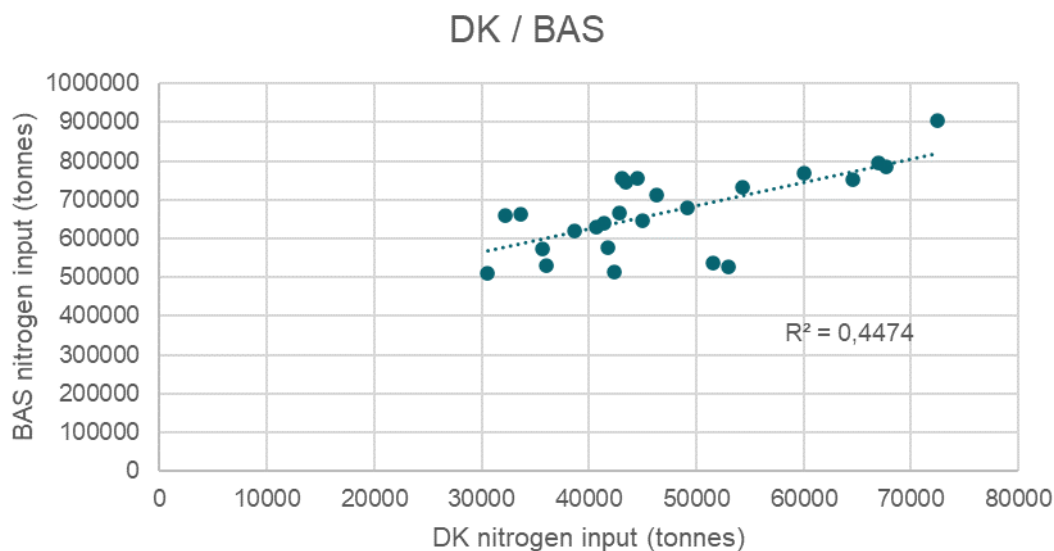


Figure 2. Correlation of the Danish waterborne total nitrogen input to the Danish Straits/Kattegat/Baltic Proper and the waterborne total nitrogen input from the nine catchment countries to the whole Baltic Sea (BAS). The inputs are correlated as annual tons from 1995-2020. The level of correlation between the nitrogen inputs are specified as a R-square.

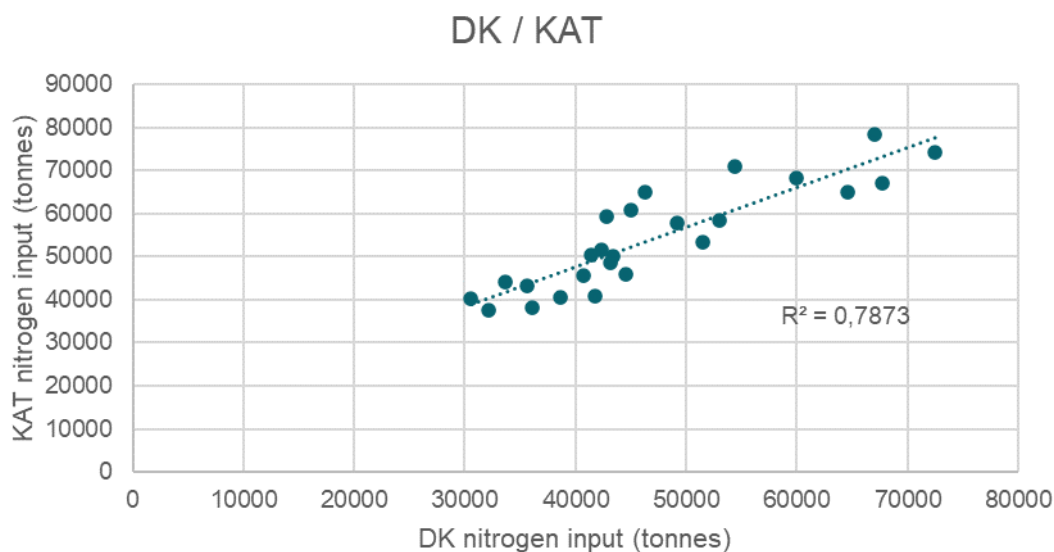


Figure 3. Correlation of the Danish waterborne total nitrogen input to the Danish Straits/Kattegat/Baltic Proper and the waterborne total nitrogen input from the catchment countries to Kattegat (KAT). The inputs are correlated as annual tons from 1995-2020. The level of correlation between the nitrogen inputs are specified as a R-square.

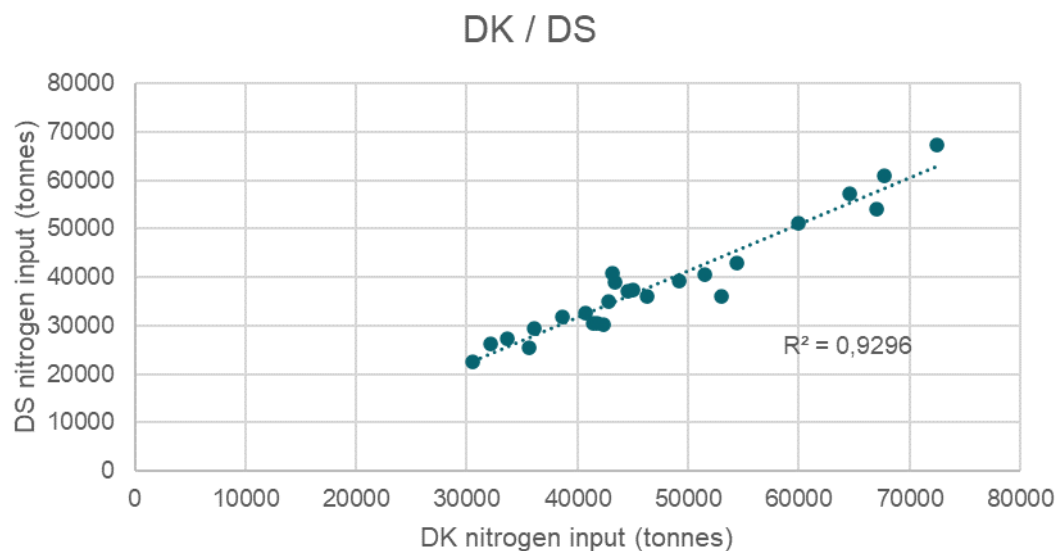


Figure 4. Correlation of the Danish waterborne total nitrogen input to the Danish Straits/Kattegat/Baltic Proper and the waterborne total nitrogen input from the catchment countries to the Danish Straits (DS). The inputs are correlated as annual tons from 1995-2020. The level of correlation between the nitrogen inputs are specified as a R-square.

Chlorophyll-a and secchi depth – open water stations

Data from the national monitoring program have been used to illustrate correlations for summer (May-Sep) chlorophyll and summer (May-Sep) secchi depth for 8 different stations representing “open inner Danish waters”. In general, the stations have chlorophyll values within a range of 1 µg/l within a year except from the station placed in the most enclosed water body (“Syd for Fyn”) where the chlorophyll concentration typically is a little higher. The stations have the same year to year signals both regarding secchi depth and Chlorophyll (fig 6 & 7). Most clear in years with high chlorophyll and low secchi depth like 2004 or the opposite like 2013. At all 8 stations there is a correlation between chlorophyll and secchi depth in a range between $r^2 = 0,14$ and $0,51$ (fig8-15).

Data from stations sited in the Danish straits and Kattegat demonstrates a correlation to a degree where it is obvious that the water environment at the different sites react to the same pressures. Both concerning same levels and same year to year variation and same long-time trends.



Figure 5. Danish open water stations.

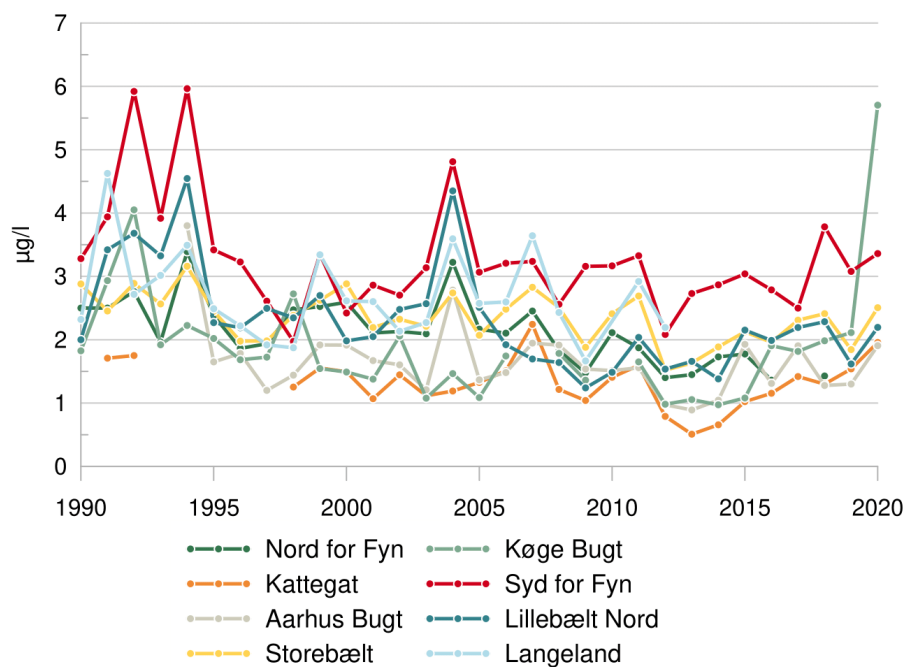


Figure 6. The annual chlorophyll concentration (μl) of the eight Danish open water stations.

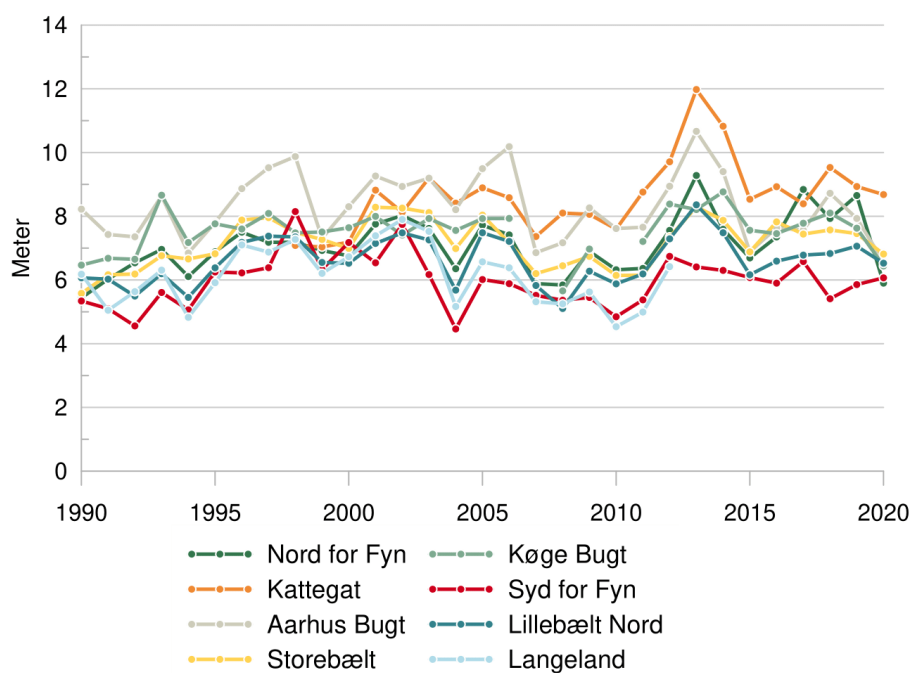


Figure 7. The annual Secchi depth (meter) of the eight Danish open water stations.

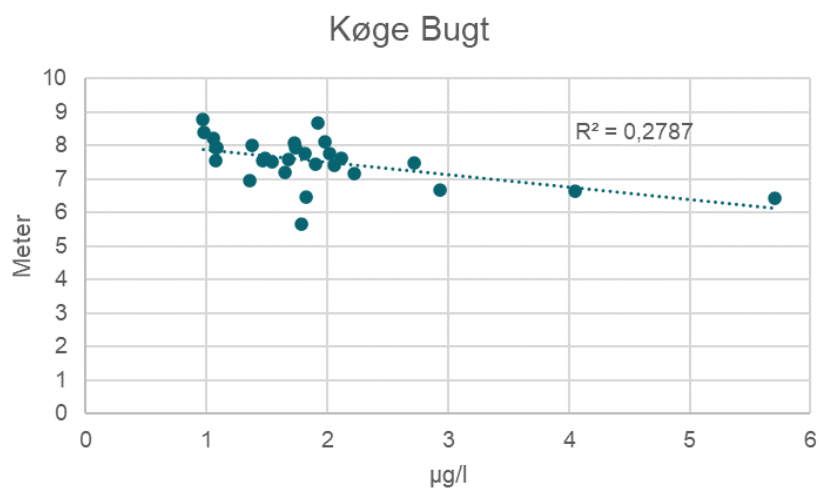


Figure 8. Correlation of Chlorophyll concentration (μl) and Secchi depth (meter) at the station Køge Bugt. The level of correlation is specified as R-square.

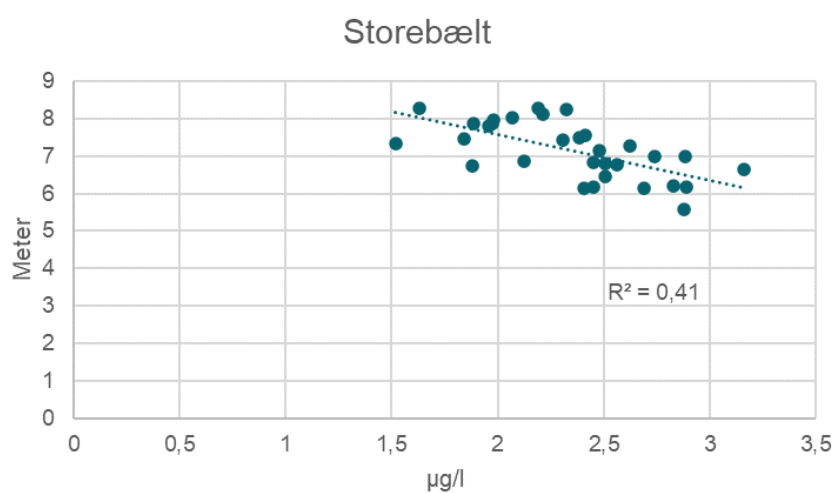


Figure 9. Correlation of Chlorophyll concentration (μl) and Secchi depth (meter) at the station Storebælt. The level of correlation is specified as R-square.

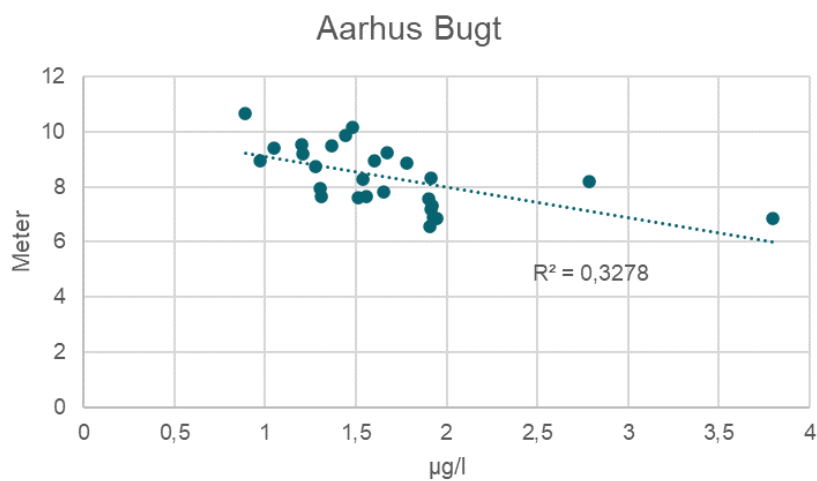


Figure 10. Correlation of Chlorophyll concentration (μl) and Secchi depth (meter) at the station Aarhus Bugt. The level of correlation is specified as R-square.

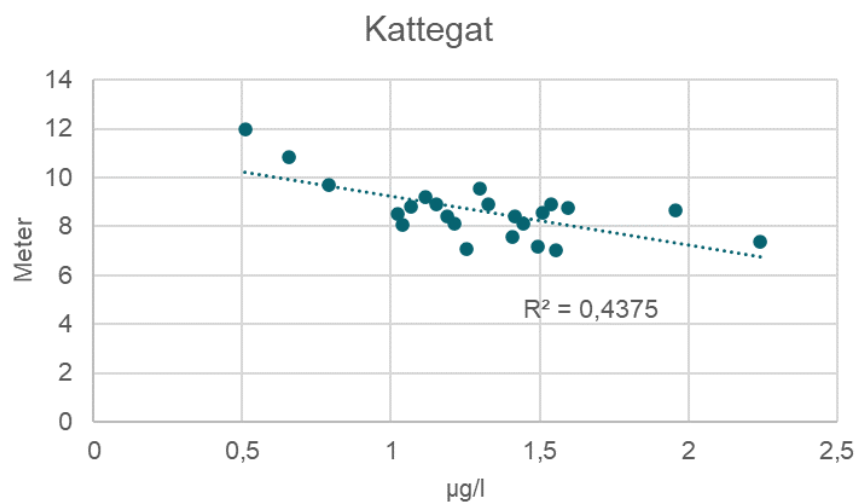


Figure 11. Correlation of Chlorophyll concentration (μl) and Secchi depth (meter) at the station Kattegat. The level of correlation is specified as R-square.

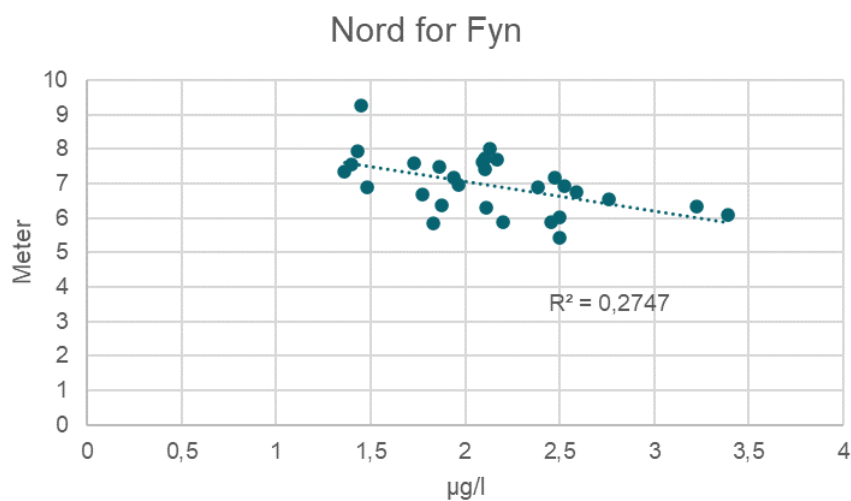


Figure 12. Correlation of Chlorophyll concentration (μl) and Secchi depth (meter) at the station Nord for Fyn. The level of correlation is specified as R-square.

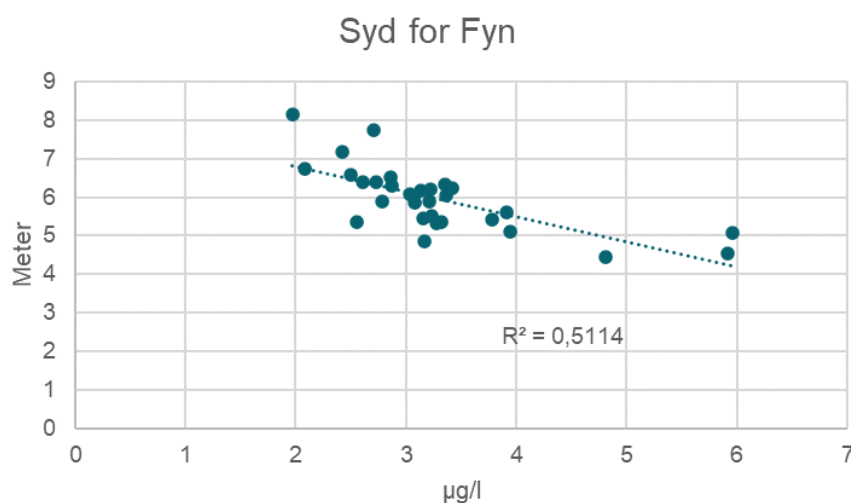


Figure 13. Correlation of Chlorophyll concentration (μl) and Secchi depth (meter) at the station Syd for Fyn. The level of correlation is specified as R-square.

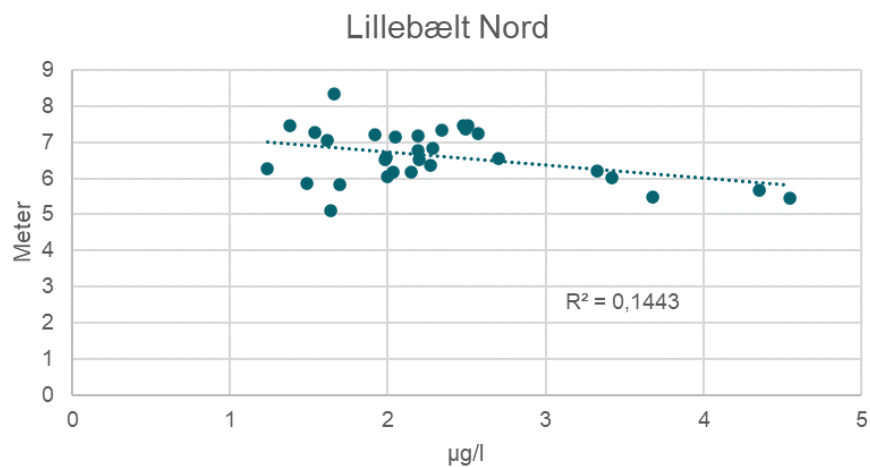


Figure 14. Correlation of Chlorophyll concentration (μl) and Secchi depth (meter) at the station Lillebælt Nord. The level of correlation is specified as R-square.

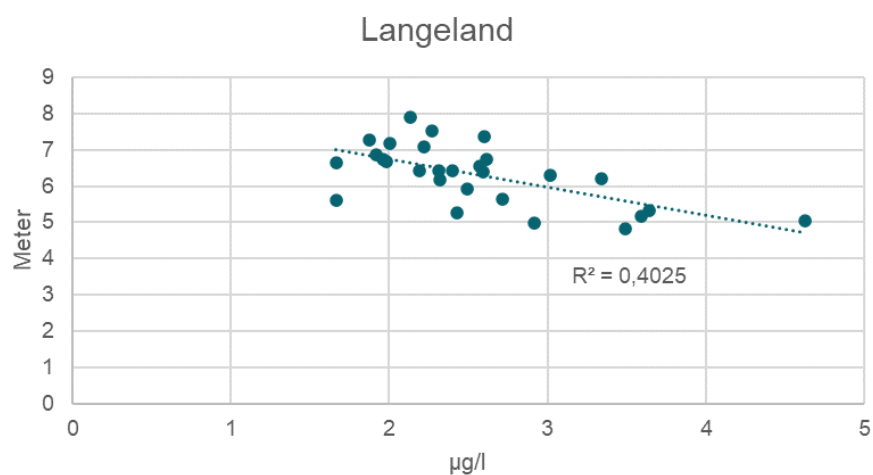


Figure 15. Correlation of Chlorophyll concentration (μl) and Secchi depth (meter) at the station Langeland. The level of correlation is specified as R-square.