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Characterization of Ringkøbing Fjord catchment. Technical note.

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Geology and land use

Ringkøbing Fjord has a catchment area of 347.950 hectares and covers an area that includes Denmark's largest river – Skjern Å. 90% of the catchment is located west of the last ice age's main residence line - the Weichselian glaciation - and the landscape is shaped by the melting of the ice. The catchment area here is partly flat and consists mainly of sandy deposits and partly shaped by the even older moraine landscape from the Saale glaciation as so-called eroded and weathered "hill islands" in the landscape, which rise in the landscape and typically have a higher content of clay (Figure 1). To the far east, the landscape is elevated, moraines are forming the landscape, and the deposits - glacial till contain more clay. The near fjord areas are flat, and several areas have been claimed for agriculture use and pumps are used to keep the fields dry.

Drainage

Drainage is important for transporting nutrients to the aquatic environment. Aarhus University has calculated the drainage probability for the whole of Denmark, and Figure 1 shows a section of the drainage probability map for the Ringkøbing Fjord's catchment area. The majority of the catchment has according to the model a low probability of drainage due to mainly sandy soils. Local information contradicts this map and fields are in general more drained than indicated by the drainage probability map (Figure 1).

Agriculture

Agricultural land use makes up most of the total area. The number of livestock productions, cattle, pigs, and poultry is distributed more in the western part of the catchment (Figure 3). This is also indicated by the manure production (Heat map Figure 3) but due to regulations for manure, the heatmap does not reflect the total use of fertilizer including manure on the fields.

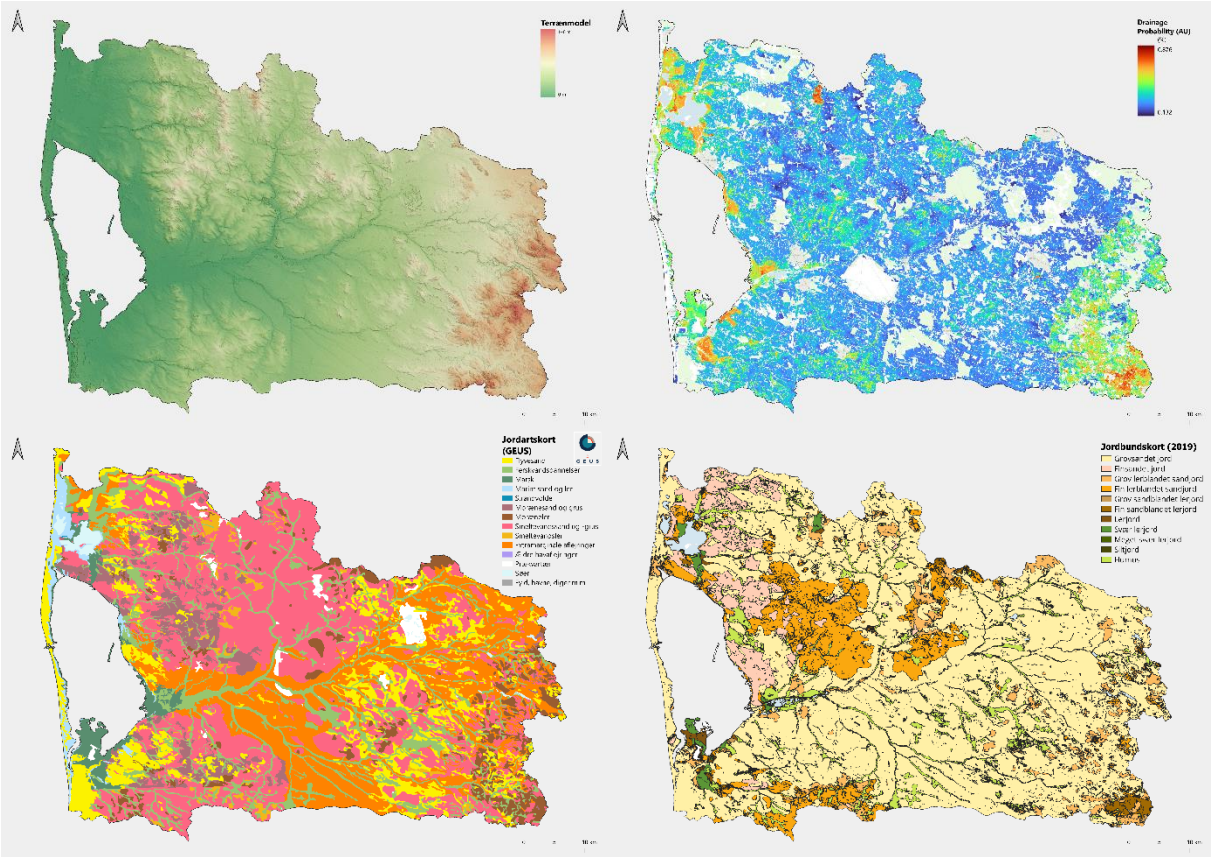

Figure 1. Upper L: Terrain model (Geodatastyrelsen). Upper R: Calculated potential drainage (Aarhus University). Bottom L: Soil type map 1 (GEUS). Bottom R: Soil type map 2 (Aarhus University).

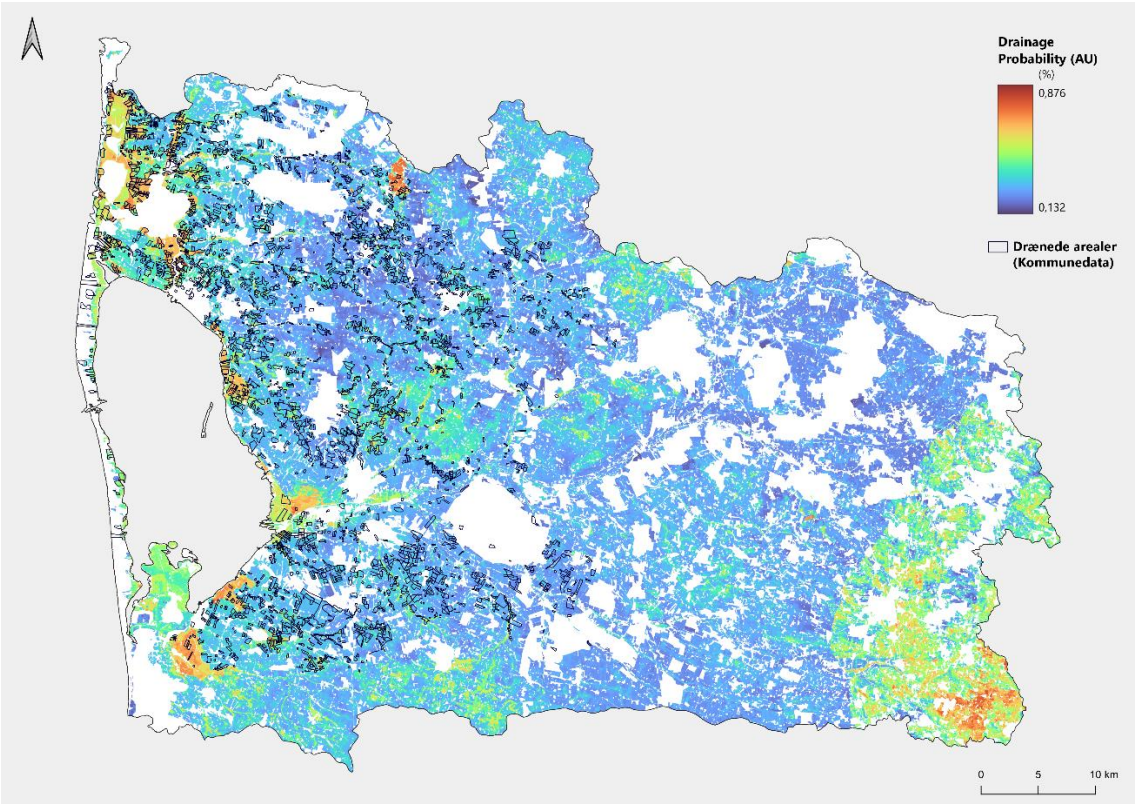

Figure 2. Calculated potential drainage (Aarhus University) but included drained fields – information from farmers – this information is only available in western part of the catchment.

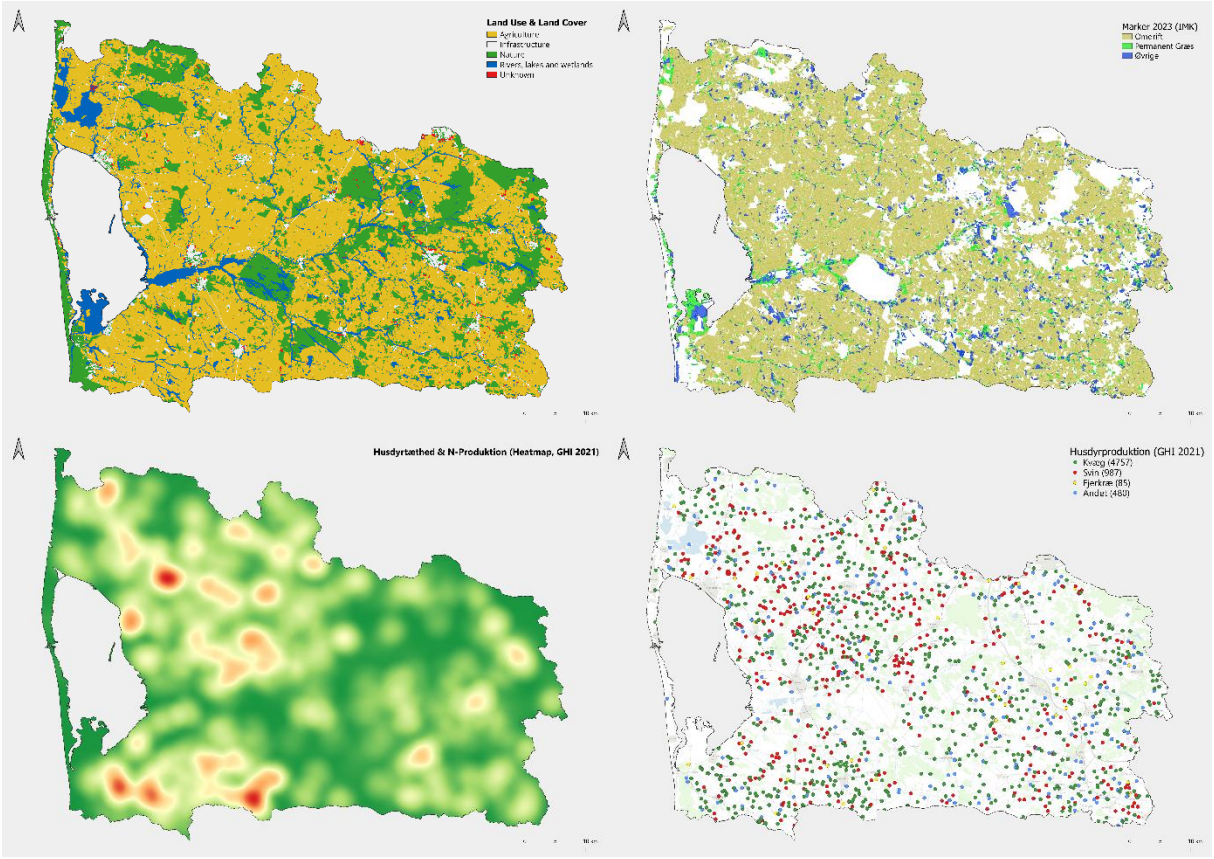

Figure 3. Upper L: Land use. Upper R: Agriculture divided into cultivated area and permanent grass. Bottom L: The area-distributed livestock production of nitrogen (Heat map). Bottom R: Area distribution of agriculture with livestock production.

Sewage

In the catchment of Ringkøbing Fjord, there are according to the national database for wastewater (PULS) 131 sewage overflows, 551 rainwater overflows, and 32 treatment plants (Figure 4). Half of the treatment plants are very small and together they make up less than 1 % of the total point source discharge. The largest point source discharge is from Arla industrial treatment plant. Discharges from treatment plants deliver the highest point source contribution 70% and 56% respectively for N and P (Figure 5).

Emissions from properties that are not connected to the wastewater system are not included in the calculation as point sources but as diffuse sources, because they are not included in the PULS database. It is generally estimated that these emissions make up a small part of the total wastewater discharge from the catchment area.

The biggest uncertainty is overflowing incidents, as these have not always been reported with sufficient care by the municipalities to the national database. However, this has been improved over recent years and reported data after 2021 is significantly better than in previous years. But still, there is some uncertainty concerning how much and how often overflows occur.

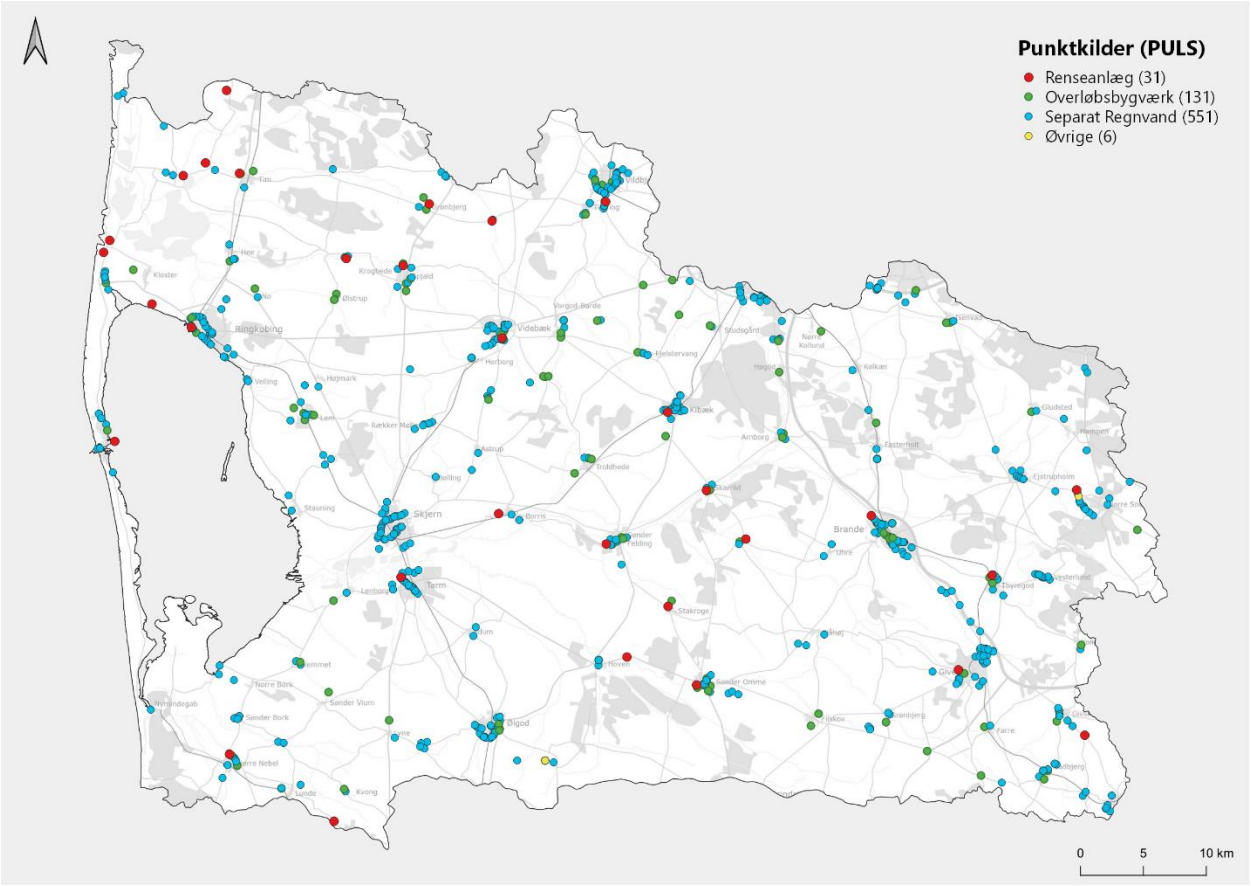

Figure 4. Point sources. Location of treatment plants (red), overflow from wastewater (green) and rainwater outlets (blue), other (yellow). Data 2022 from the PULS database.

Figure 5. Point sources. Discharge distribution between treatment plants, overflow from sewage and overflow rainwater.

Total transports of nutrients to the fjord

The calculations of nutrient transport from the catchment to Ringkøbing Fjord are based on Aarhus University's calculations and include both measured and unmeasured catchment. The measured catchments are sub-catchments where both water transport and nutrient concentrations have been measured. The unmeasured catchments are the parts of the catchment with no monitoring for flow and nutrient concentration. Calculations have been made for these catchments to estimate the total loads of nitrogen and phosphorus to the fjord.

The total nutrient transport to Ringkøbing Fjord have decreased since 1990. Total nitrogen has decreased from approx. 6-7000 ton TN to approx. 4500-5000 Ton TN (Figure 6). In winter month the diffuse contribution is up to 97 % of the total TN loads and in the summer months the diffuse sources contribute with 90-85 % (Figure 7).
Total phosphorous has decreased from approx. 140 ton TP to approx. 120 Ton TP (Figure 8). In winter months the diffuse contribution is up to 85 % of the total TP loads and in the summer months, the diffuse sources decrease to a level equal to point sources (Figure 9).
In reality point sources also vary over time with the highest discharge in winter but not to the same extent as diffuse sources. The point here is that nitrogen from the point source contributes insignificant to the total loads in winter and minor in summer. Phosphorous from point sources on the other hand contributes relatively more in the summer period and is close to the same level as diffuse sources but phosphorous stays in the fjord for a longer time than nitrate so it makes most sense to look at yearly loads of phosphorous to the fjord. On a yearly basis point sources contribute with approx. 20-25 % of total phosphorous to the fjord and therefore will reductions in phosphorous from point sources not be insignificant.

The discharge of water from the catchment varies from year to year but there is an overall increasing trend. Long-term trends indicate a 25% increase over the last 75 years. The increase in water runoff will increase the loss of nutrients from the catchment and counteract the efforts made to reduce nutrients from the catchment.

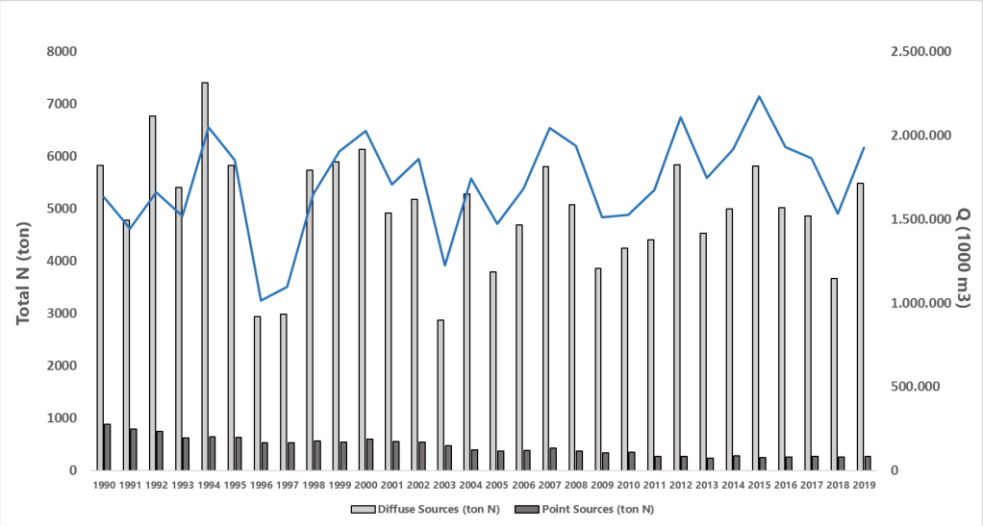

Figure 6. Total, annual nitrogen loads to Ringkøbing Fjord, distributed between diffuse sources and point sources. Water transport is marked with a blue line and unit on the right y-axis. Data from Aarhus University.

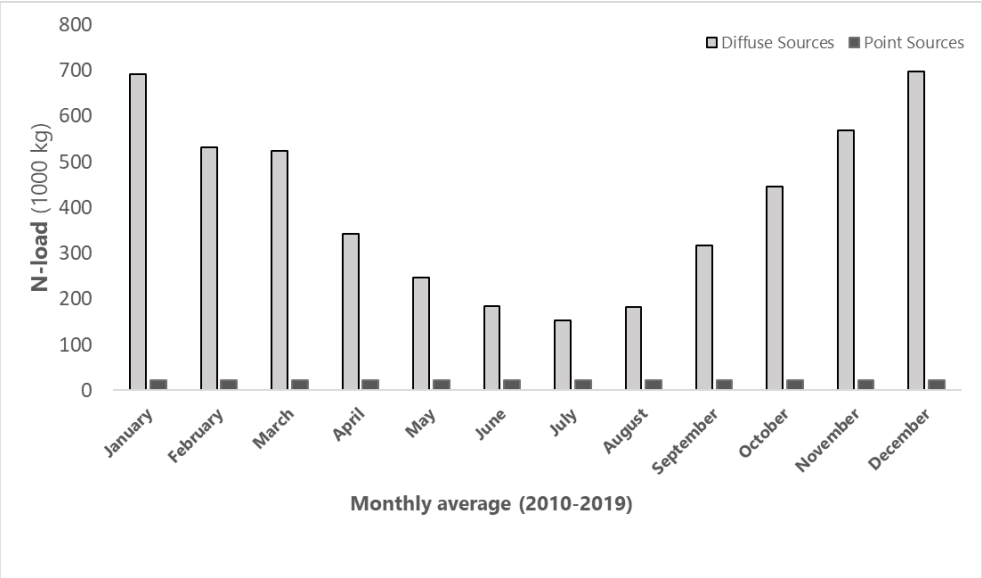

Figure 7. Monthly nitrogen supply to Ringkøbing Fjord, distributed between diffuse sources and point sources. Average for the years 2010-2019. Data from Aarhus University.

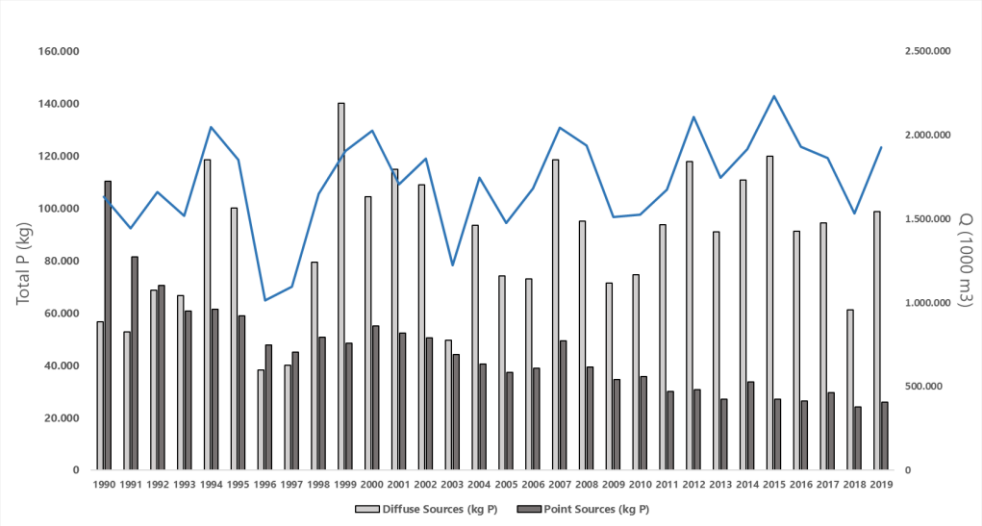

Figure 8. Total, annual phosphorous loads to Ringkøbing Fjord, distributed between diffuse sources and point sources. Water transport is marked with a blue line and unit on the right y-axis. Data from Aarhus University.

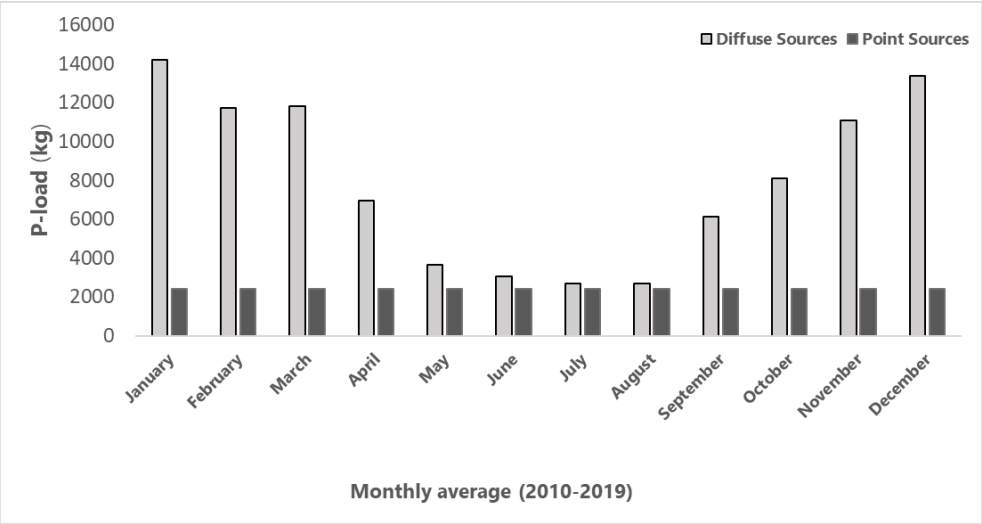

Figure 9. Monthly phosphorous loads to Ringkøbing Fjord, distributed between diffuse sources and point sources. Average for the years 2010-2019. Data from Aarhus University.