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Chemicals and nutrients in grey water from ships

Chemical risk assessment of grey water contaminants and grey water nutrient contribution to eutrophication of Baltic Sea basins

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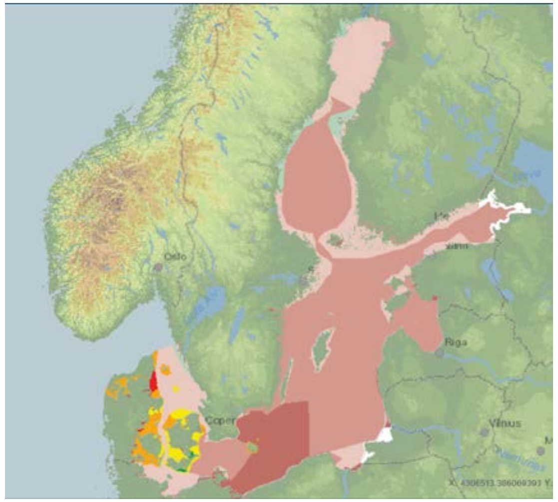
The status of the Baltic Sea do not fulfill ”Good Environmental Status” with respect to eutrophication and contamination

Integrated **eutrophication** status assessment



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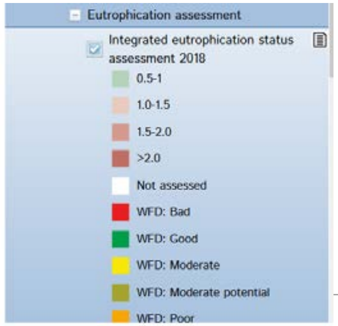
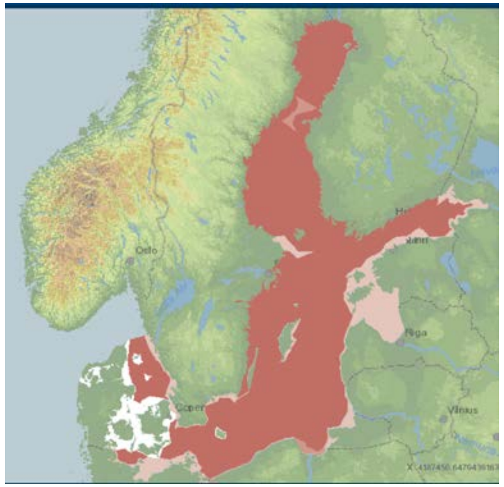


Integrated **contamination** status assessment



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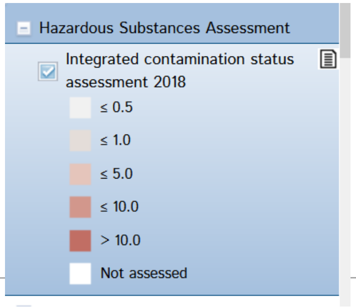


- Limited knowledge about how shipping and in particular grey water contributes to the degradation of the environmental status via discharge of nutrients and contaminants?
- *Grey water* is the drainage from dishwater, shower, laundry, bath and washbasin drains.
- Discharge of grey water is not regulated by the IMO, but grey water may pose an environmental threat since it contains contaminants as well as nutrients.

Aims of the study

1. **Determine the total volume of grey water emitted into the Baltic Sea, per ship segment and sea basin**

2. **Quantify the annual load of different a) contaminants and b) nutrients reaching the Baltic Sea environment**

3. **Determine the a) cumulative environmental risk presented by chemical contaminants, and b) the environmental impact of nitrogen and phosphorus emitted with ship-generated grey water into the Baltic Sea**

4. **Identify current knowledge gaps regarding grey water from ships.**

Material and method - Shipping emissions to water from BONUS SHEBA

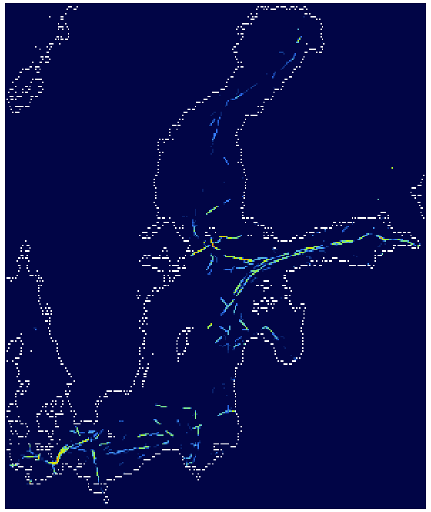
Ship types





Ship type discharge volumes:
Grey water
Sewage
Food waste

Activity (AIS) data



Year 2012

STEAM model

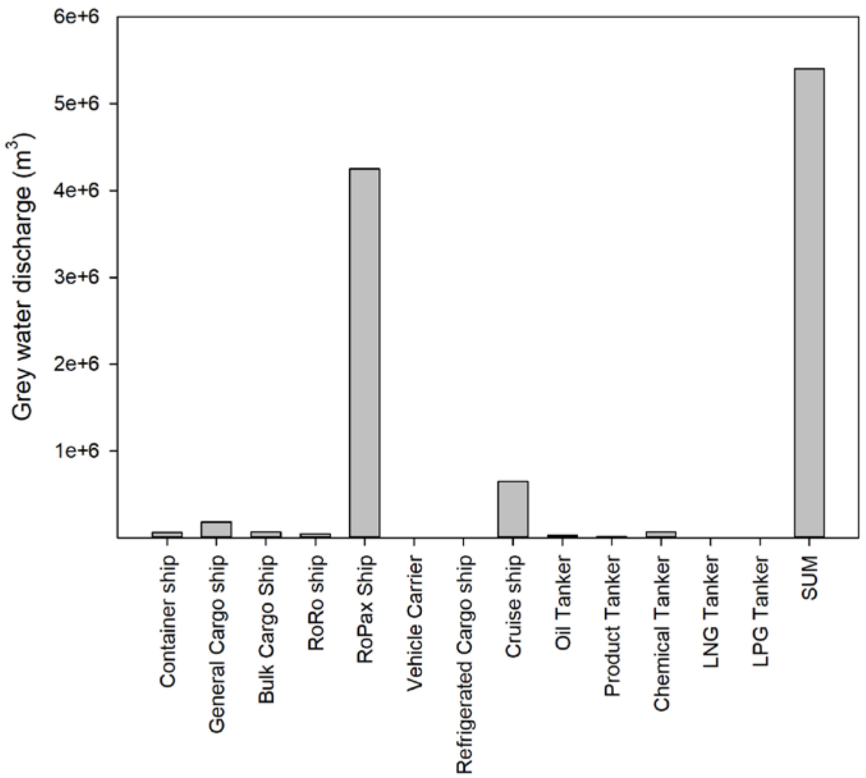
Shipping emissions

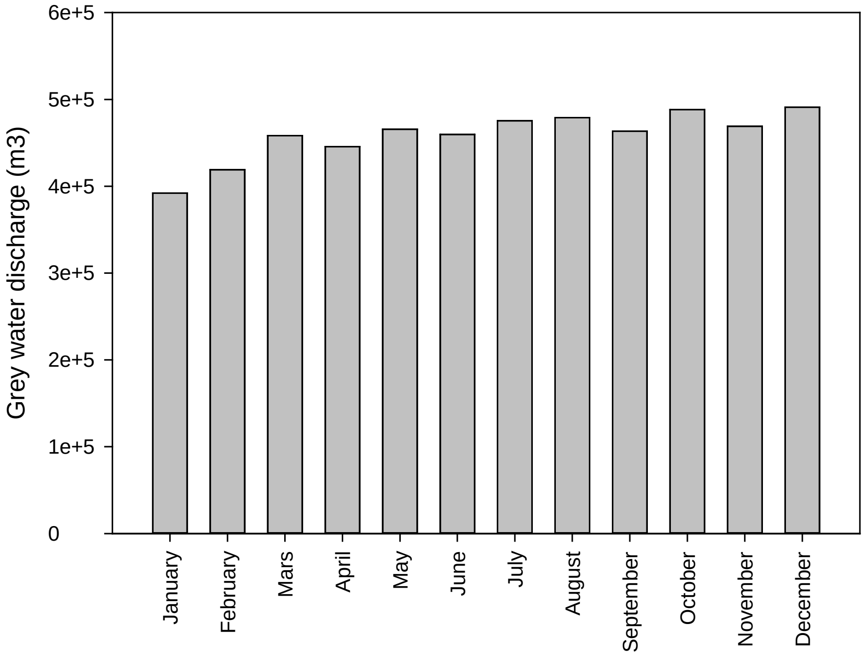
Discharge volumes
Grey water
Sewage
Food waste

Concentrations
Nutrients
Contaminants

Loads (kg/year)
Nutrients
Contaminants

Aim 1) Determine the total volume of grey water emitted into the Baltic Sea, per ship segment and sea basin

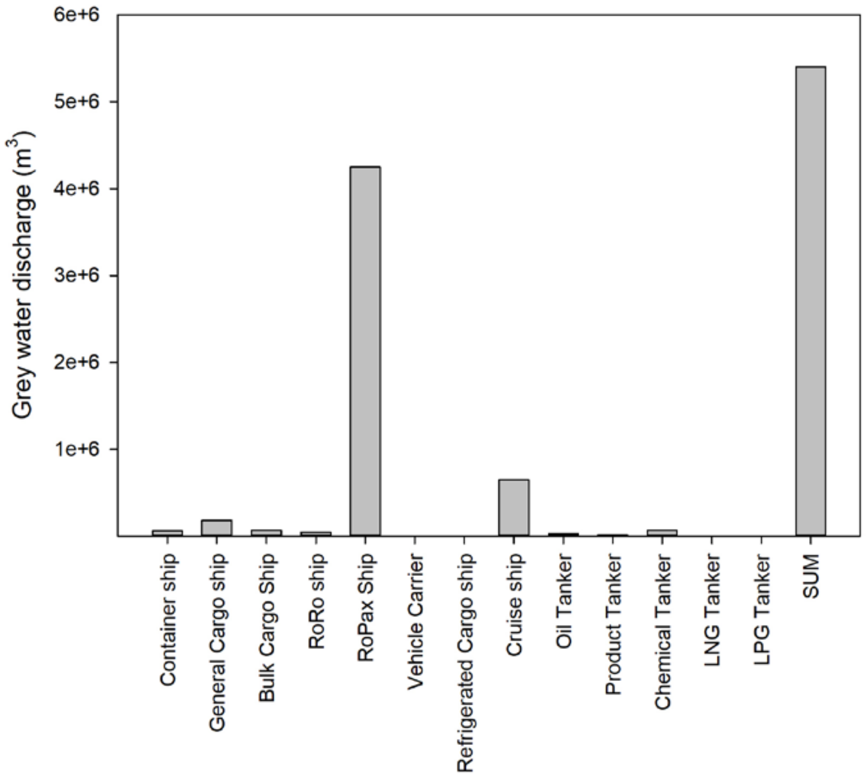




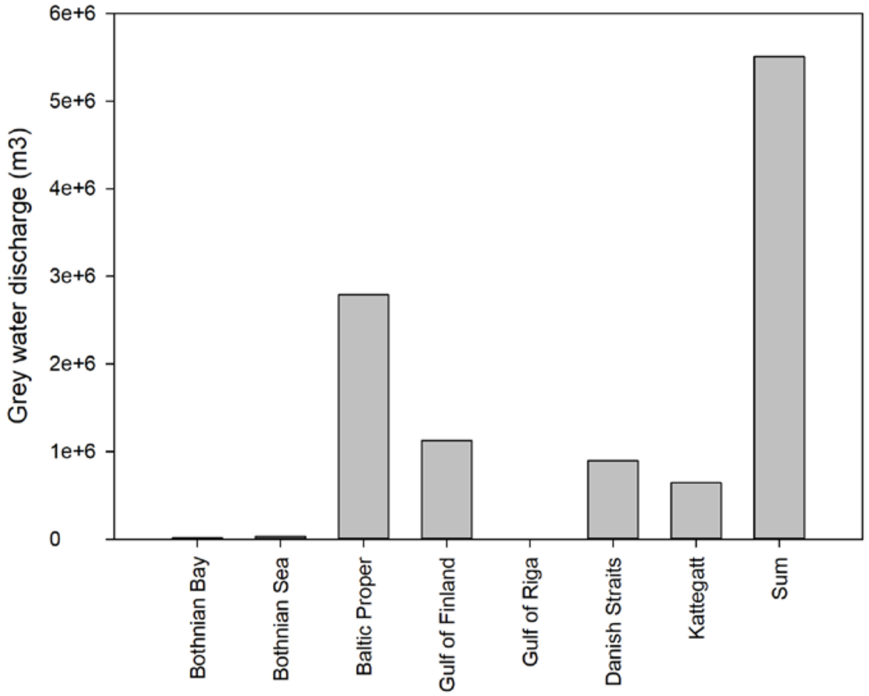
Tot 5,4 million m^3 (SUM), ship segment RoPax followed by cruise contribute most.

Evenly spread throughout the year

Aim 1) Determine the total volume of grey water emitted into the Baltic Sea, per ship segment and sea basin



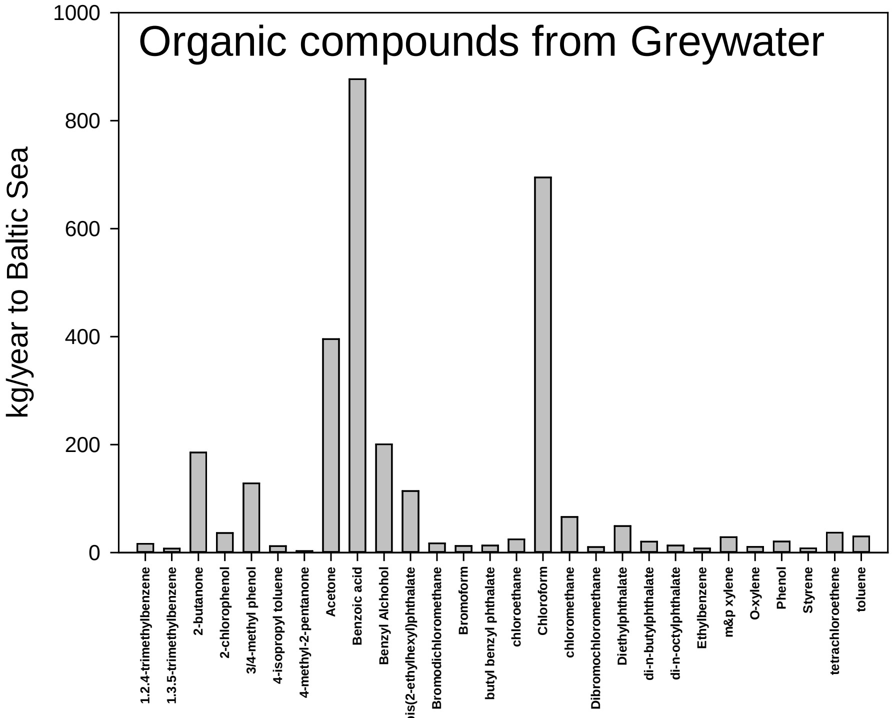
Tot 5,4 million m^3 (SUM), ship segment RoPax followed by cruise contribute most.

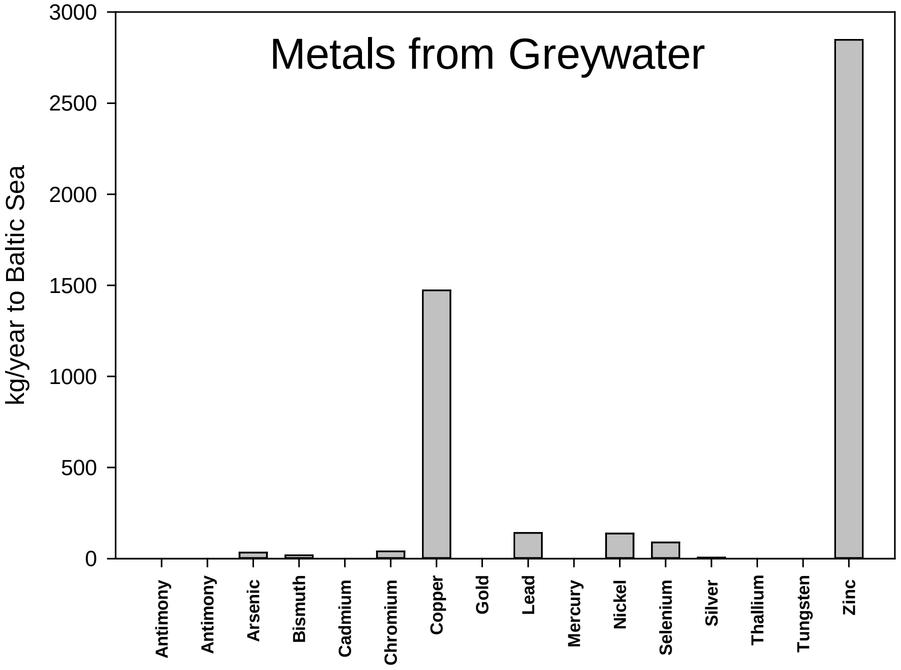


Largest volume in basins with most traffic (Baltic Proper, Gulf of Finland, Danish Straits, Kattegatt)

Aim 2a) Quantify the load (in kg) of different contaminants reaching the Baltic Sea environment

Method: Multiply the grey water volume with the average concentrations of contaminants in greywater. 44 different contaminants identified. Based on 69 different measurements found in literature, mainly from ships in Alaska



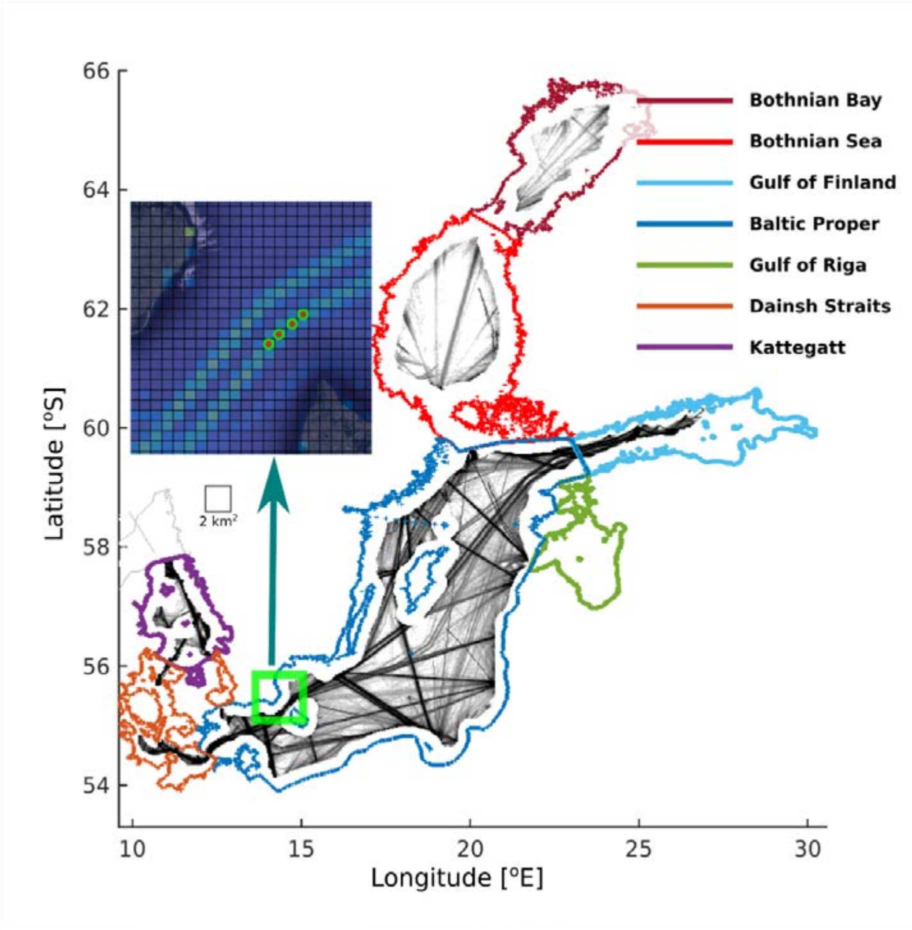


For comparison:
Zinc **21,9 på tons** from wastewater treatment plants in Sweden
Copper **11,2 tons** from wastewater treatment plants in Sweden

280 tons from antifouling paints

Total waterborne copper input to the Baltic Sea is **886 tons** annually (both natural and anthropogenic sources).

Aim 3a) Determine the cumulative environmental risk presented by chemical contaminants emitted with ship-generated grey water into the Baltic Sea



Environmental risk assessment performed at a Baltic Sea ship lane.

1. Predicted concentrations of contaminants in the ship lane due to grey water discharge (PEC)
2. Compared the predicted concentrations with a threshold value of what the organisms in the Baltic Sea can tolerate without negative effects (PNEC)
3. If the PEC/PNEC ratio exceeds 1, i.e. if the PEC is higher than the PNEC, means we have a risk of adverse effects on the environment

Aim 3a) Determine the cumulative environmental risk presented by chemical contaminants emitted with ship-generated grey water into the Baltic Sea

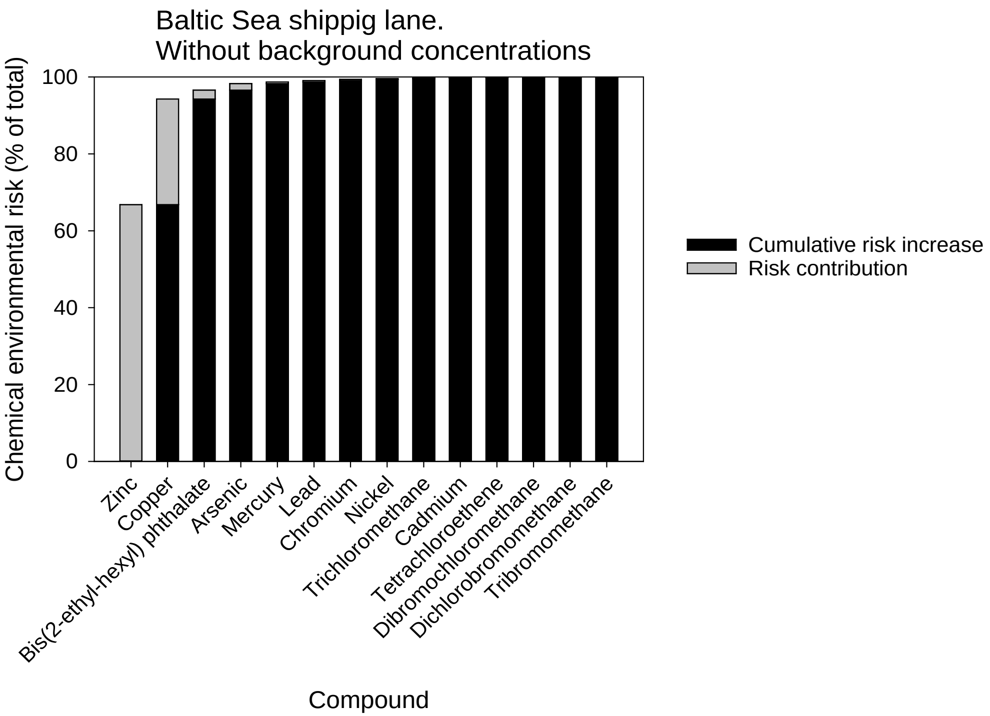
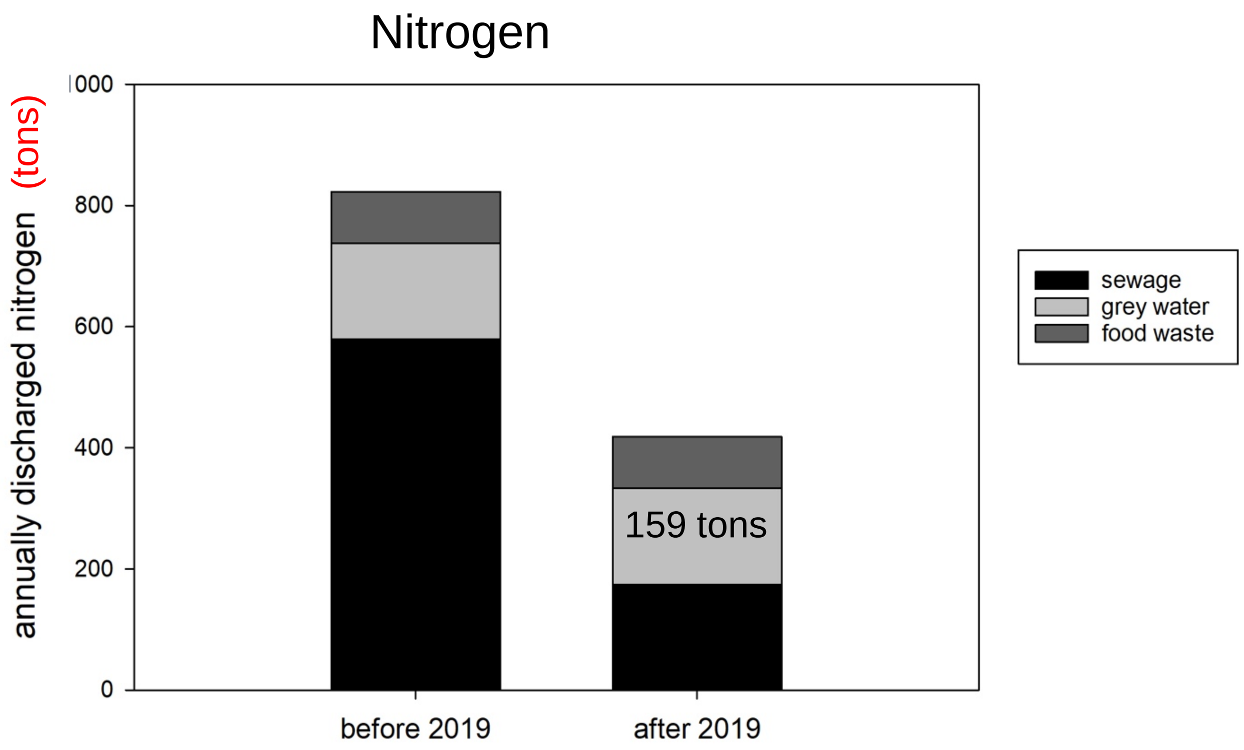
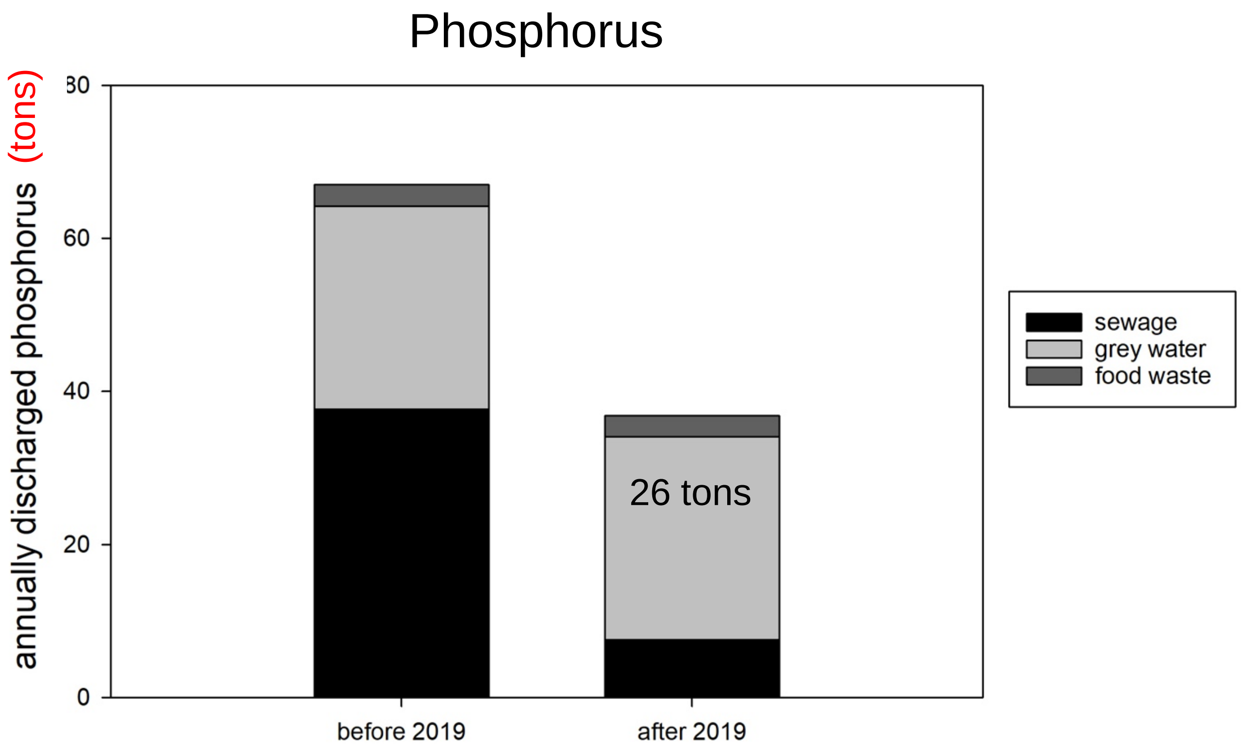


Table 5. Total cumulative risk ratios for the following scenarios; *grey water only, Baltic Sea background concentrations* and *grey water + Baltic Sea background concentrations*.

Scenario	Total cumulative risk ratio
Grey water only	0.000006
Baltic Sea background	0.568748
Grey water + Baltic Sea background	0.568753

Aim 2b) Quantify the load of nutrients in grey water reaching the Baltic Sea environment





Aim 3b) Determine the environmental impact of phosphorus and nitrogen emitted with ship-generated grey water into the Baltic Sea

To reach Good Environmental Status according to Baltic Sea Action Plan the annual input of nutrients need to decrease with:

62 000 tons for N (159 tons from grey water)
10 600 tons for P (26 tons from grey water)

Grey water contribution to the reduction required is
0.25% for N (Table 6)
0.25% for P (Table 7)

For grey water contribution to eutrophication of Baltic Sea basins,
the largest load of both nutrients is seen in Baltic Proper (highest traffic)

Uncertainties due to how the study was conducted and its assumptions

Alaska data for 30 cruise ships used (due to lack of data from Baltic Sea)

Fullness of passenger 50% for all ships (assumption in STEAM model)

The risk assessment was only based on 14 contaminants as PNEC values were lacking for the other 30 contaminants

Mixing and dilution ratio in the present study is higher than reported by US EPA (2002).
This has implication on the modelled concentrations of contaminants in the ship lane
However we consider the model used (MAMPEC) to be more representative for comparing average concentrations during continuous discharge.

Aim 4) Identify current knowledge gaps regarding grey water from ships

Knowledge gaps due to lack of data

Lack of information regarding grey water content for ships in the Baltic Sea

Lack information regarding whether ships discharge greywater untreated or if it is delivered to shore and if discharge is continuous or in pulses

Lack of information regarding the fraction of grinded food waste that can be included in the grey water

Conclusions

- **5.4 million m^3 grey water discharged annually to Baltic (4.25 million m^3 RoPax)**
- **44 contaminants identified in grey water (highest load from Cu and Zn)**
- **The environmental risk assessment showed grey water discharge to the Baltic Sea ship lane pose low environmental risk**
- **Grey water contributes with 159 tons of nitrogen and 26 tons of phosphorus discharged to the Baltic Sea annually.**
- **The amount of nitrogen in grey water is about equal as from sewage after 2019 regulations and the amount of phosphorus is larger than from sewage**
- **Grey water contribution to the reduction required to reach GES is for N and P 0.25%**