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NUTRIENT LOAD TO SEA FROM CARGO HANDLING AT PORT

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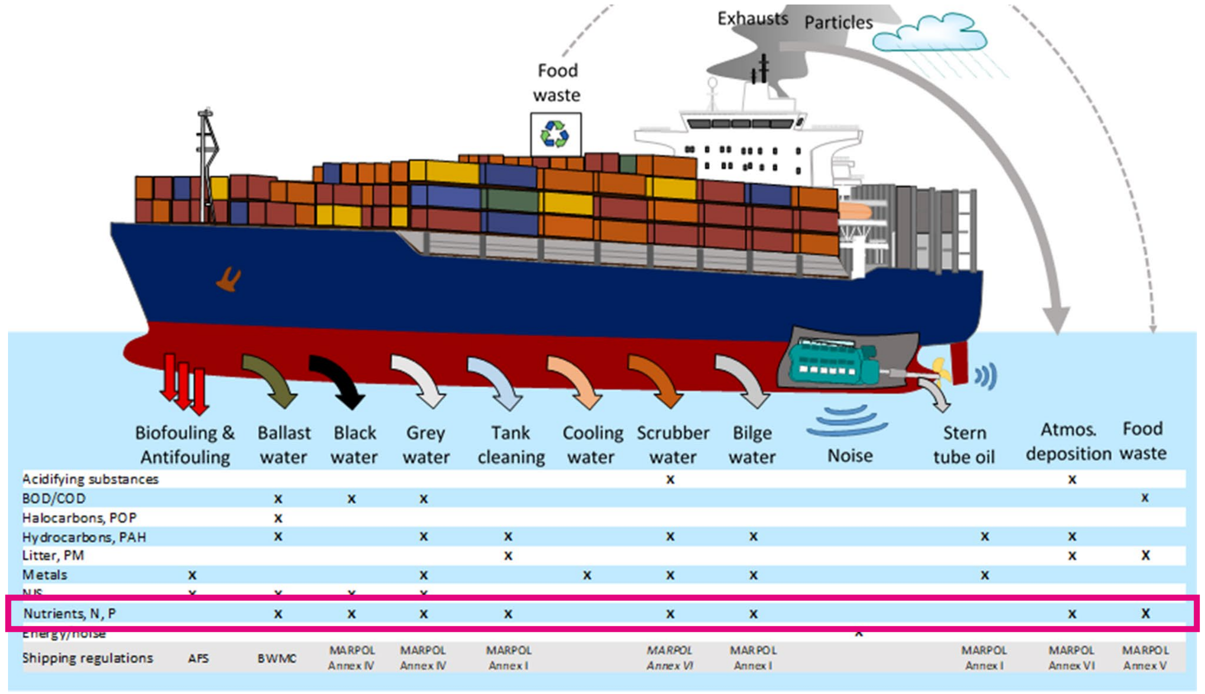
NUTRIENT DISCHARGES FROM MARITIME ACTIVITIES: SOURCES AND SIGNIFICANCE

BACKGROUND

- The Baltic Sea suffers from severe eutrophication.
- Emissions from ships are strictly regulated by MARPOL and national legislation, whereas nutrient emissions from ports are generally underregulated.
- Main identified nutrient contributors are agriculture and industrial sources ashore, maritime is a contributor as well.



RESEARCH GAPS

- Nutrient discharges from shipping have been widely studied, particularly regarding food waste, grey water, and black water.
- In contrast, cargo hold washing waters remain understudied due to limited data.
- Nutrient loads from ports have not been comprehensively investigated.
- There is a widespread lack of understanding about which emissions are most significant and how to reduce them effectively and cost-efficiently.

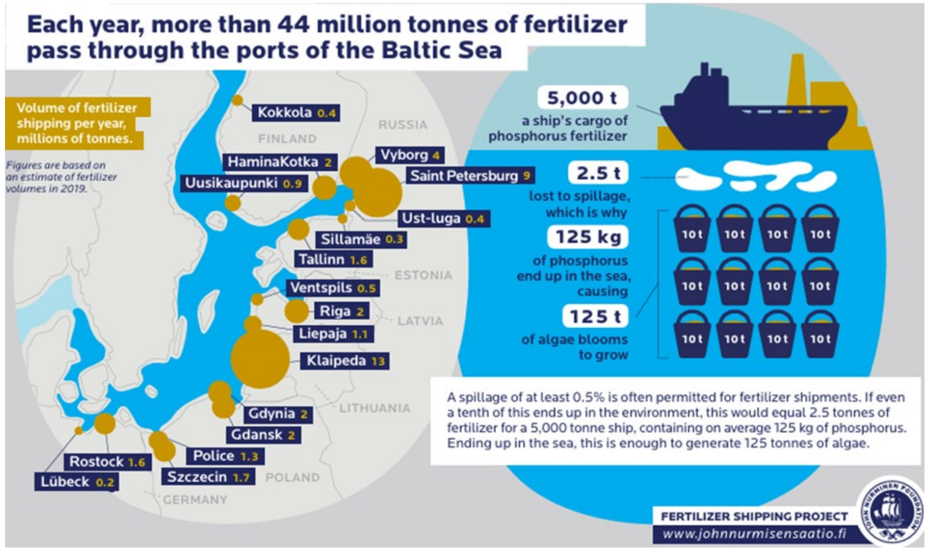
THESIS FOCUS AND METHODOLOGY

- The study focuses on nutrient discharges to the sea from shipping activities and port operations, comparing them to other sources and exploring efficient emission reduction methods.
- The research methodologies are quantitative case studies, machine learning methodology and literature reviews.

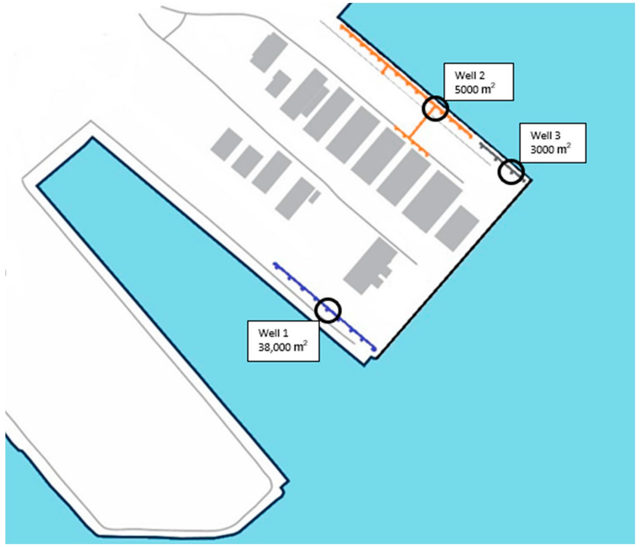
Jalkanen et al. 2021: Modelling of discharges from Baltic Sea shipping.

FIRST ARTICLE

- Lappalainen, S.-T., Kotta, J., Tombak, M.-L., & Tapaninen, U. (2024). Using Machine Learning Methodology to Model Nutrient Discharges from Ports: A Case Study of a Fertilizer Terminal. Journal of Marine Science and Engineering, 12(1), 143. https://doi.org/10.3390/jmse12010143



John Nurminen Foundation 2021: Fertilizer Shipping Project.

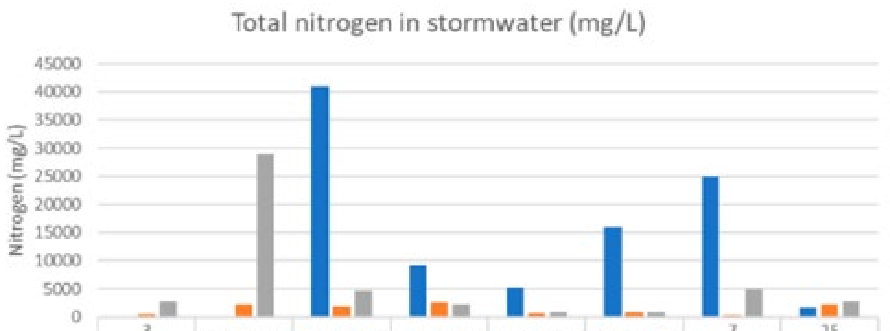


Focus	Main Methods	Data Sources	RQs	Contributions
To evaluate nutrient input from fertilizer loading operations	Sampling Machine learning modelling	Storm water sample results Port cargo and berth data Literature	RQ1 RQ2 RQ3	Demonstrates the significance of a nutrient point source

RESULTS

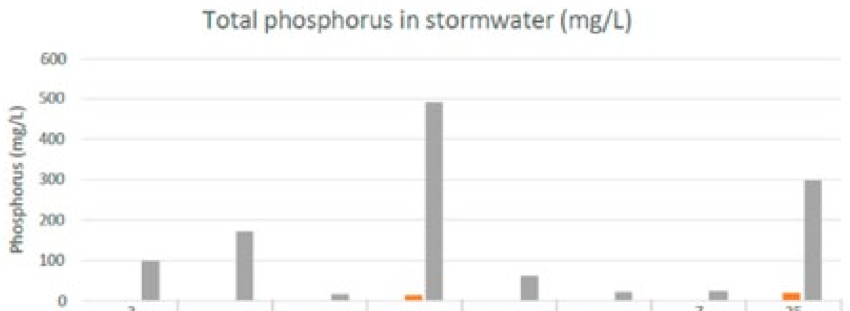
- During fertilizer cargo handling, 273 tons of nitrogen and 0,2 tons of phosphorus were discharged to the sea in 2021.

Figure 2. Total nitrogen concentration in stormwaters (mg/L). Well 1 displays highest nitrogen concentrations.



	3 September 2021	5 October 2021	12 October 2021	14 October 2021	20 October 2021	27 October 2021	7 November 2021	25 November 2021
Well 1	150	0	41 000	9200	5200	16 000	25 000	1700
Well 2	470	2200	1900	2500	540	760	250	2200
Well 3	2700	29 000	4600	2200	800	750	4800	2800

Figure 3. Total phosphorus in stormwaters (mg/L). Well 3 displays highest concentrations as most of the phosphorus fertilizers are loaded in that area.



	3 September 2021	5 October 2021	12 October 2021	14 October 2021	20 October 2021	27 October 2021	7 November 2021	25 November 2021
Well 1	1.2	0	1.8	0.7	0.2	0.4	0.7	1.2
Well 2	0.5	0.7	0.7	12.7	2.1	0.5	0.5	18.2
Well 3	98	171.4	17	489.7	63	21.9	23.1	298.3

SECOND ARTICLE

- Lappalainen, S.-T., Tapaninen, U., & Kotta, J. (2024). Nitrogen and Phosphorus Discharges from Cargo Ships' Black and Grey Waters—A Case Study of a Baltic Sea Port. Oceans, 5(3), 560-570. https://doi.org/10.3390/oceans5030032

Table 1. Data of vessels calling the port in 2021.

Ship Type	Number of Ships [25]	Ships' Speed [27]	Persons On Board [28]	P in GW [10]	P in BW [10]	N in GW [10]	N in BW [10]
Container	431	20	19	1.9	1.6	4.4	16
Tanker	501	15	17	1.9	1.6	4.4	16
Bulk carrier	151	14	15	1.9	1.6	4.4	16
Tug	6	10	4	1.9	1.6	4.4	16
General cargo	1042	12	10	1.9	1.6	4.4	16
Roro	414	19	17	1.9	1.6	4.4	16

×

Table 2. Amount of nitrogen and phosphorus in cargo ships' wastewaters in 2021.

2021	Nitrogen (kg)	Phosphorus (kg)
Black water (sewage)	612.9	61.3
Grey water	168.5	72.8
TOTAL	781.4	134.1

Focus	Main Methods	Data Sources	RQs	Contributions
To evaluate nutrient input from ships' black and grey waters	Quantitative estimation and calculation	Port ship call data Literature	RQ2, RQ3	Demonstrates that waste waters are a minor contributor in terms of nutrient input.

RESULTS

- 2500 ships' theoretical maximum amount of produced nutrients in sewage and grey water were 0,8 tons nitrogen and 0,1 tons phosphorus (during the whole voyage).

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THIRD ARTICLE

- Comparison of different nutrient sources from shipping and port operations compared to main contributors, agriculture and industrial sources. Regulatory review. Authors Lappalainen, Kotta, Aiken, Tapaninen. https://doi.org/10.3390/su18083983

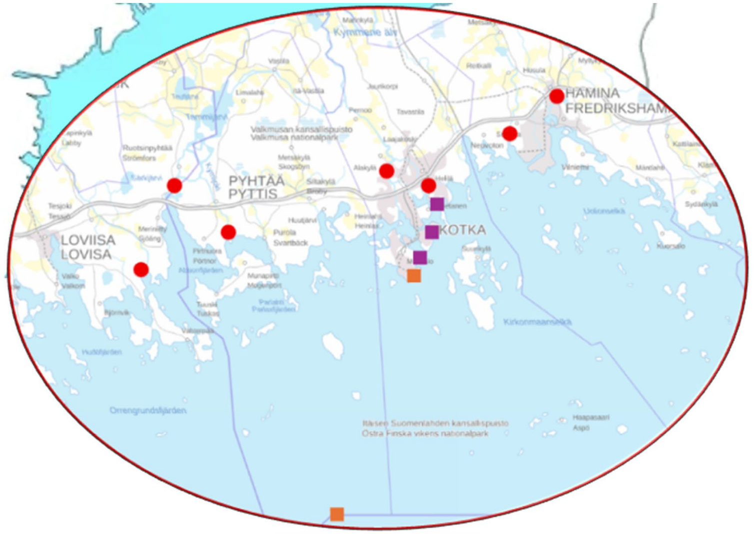


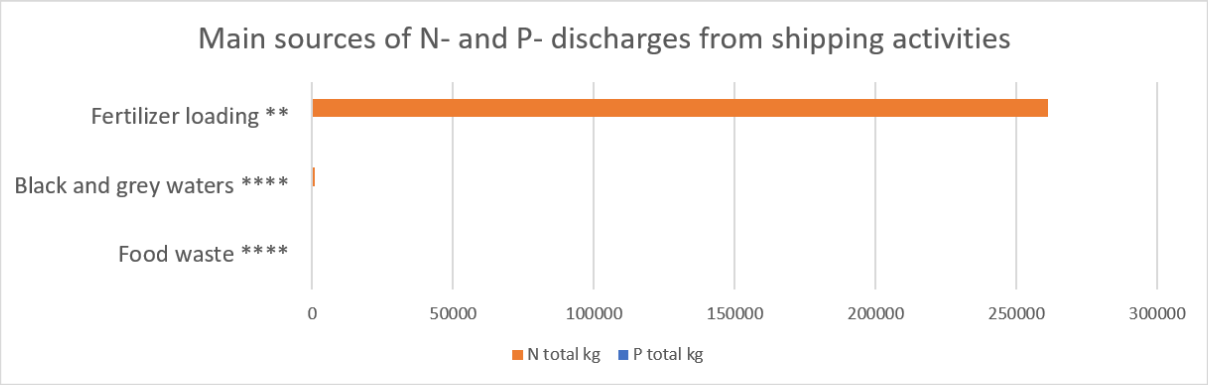
Table 1. Qualitative regulatory classification scale.

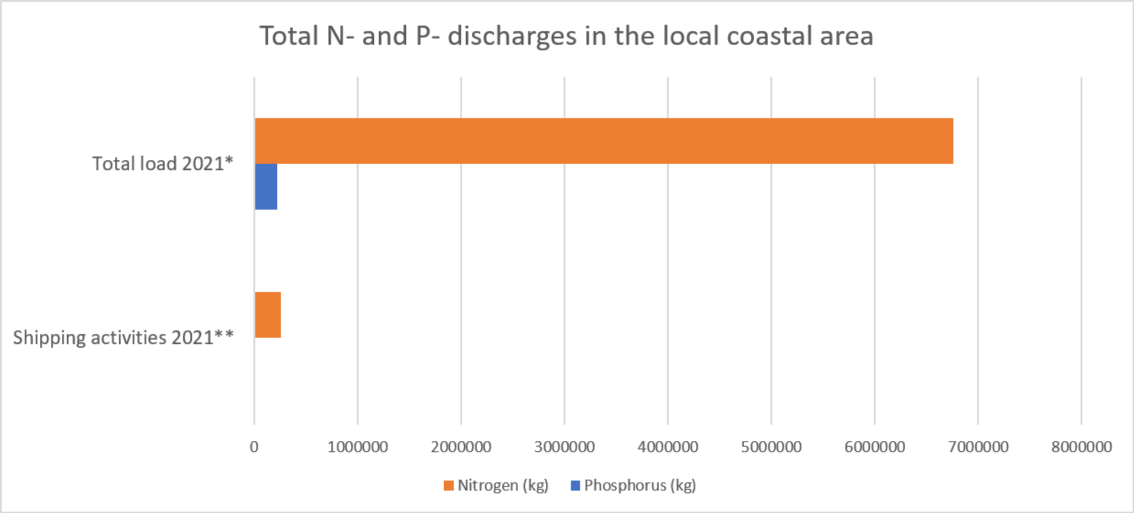
Regulatory Level	Criteria
0	No restrictions
1	No numerical discharge limits Monitoring and mitigation requirements
2	Numerical discharge or input limits by regulations in general Monitoring and mitigation requirements
3	Specific numerical discharge limits by environmental permits Monitoring and mitigation requirements
4	Discharge prohibited

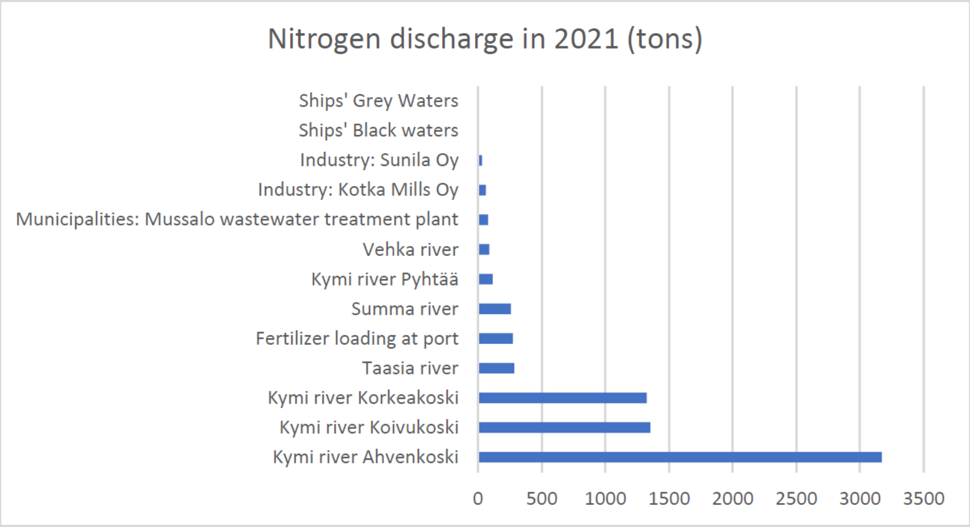
Focus	Main Methods	Data Sources	RQs	Contributions
To assess all nutrient input sources in the studied area	Literature review Quantitative analysis	Publications Sample analyses	RQ1 RQ4	Study gives an overview to all nutrient sources and their significance.

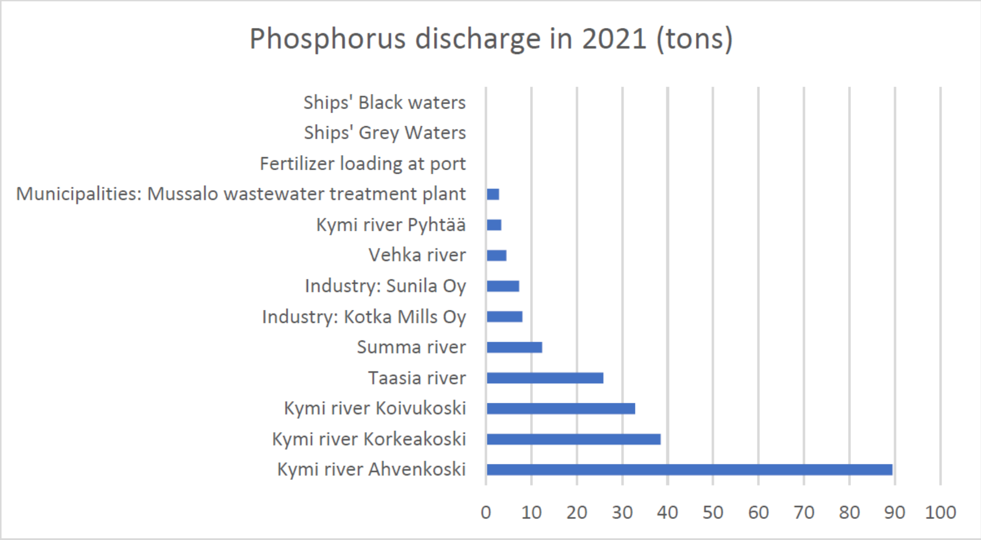
RESULTS: CONTRIBUTOR COMPARISON

- Riverine input was 94% N and 92% P.
- Port cargo handling 4% N and 0,1% P.
- Ships wastewaters <0,1% N and <0,1% P

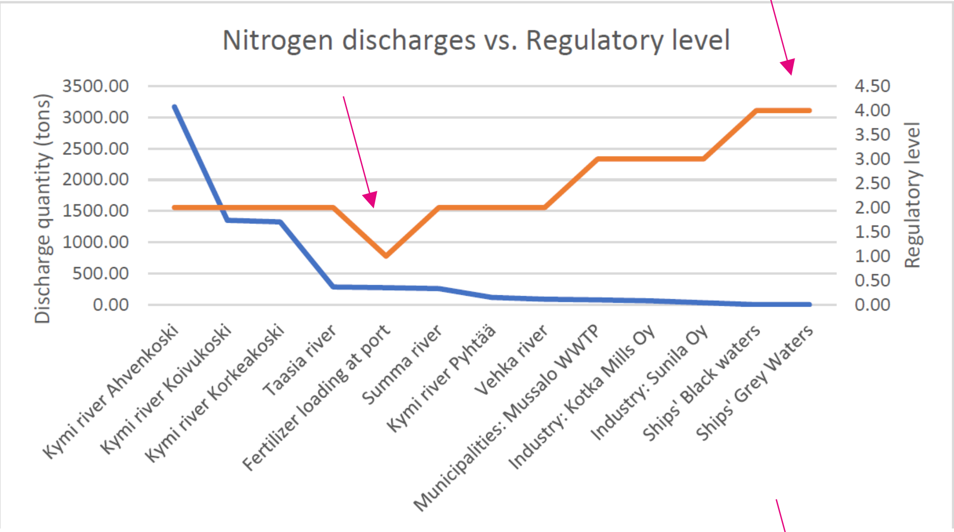


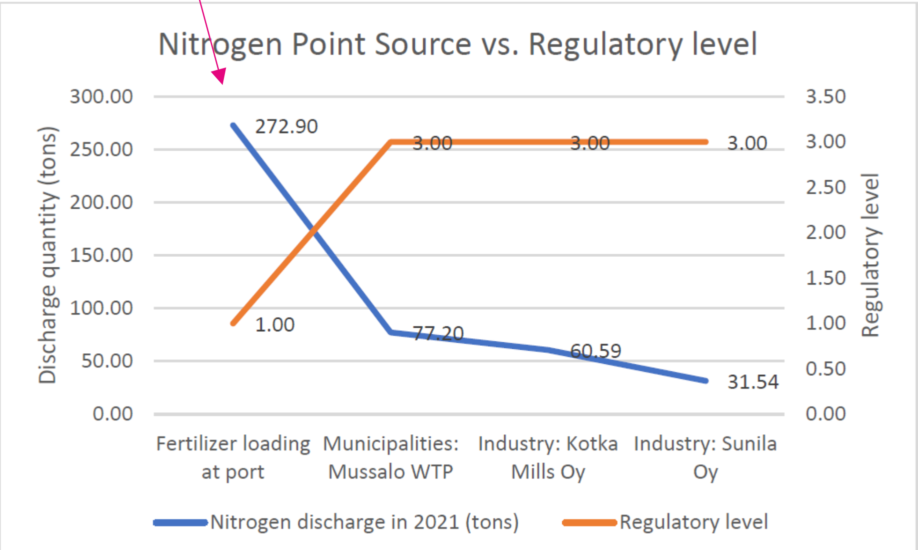


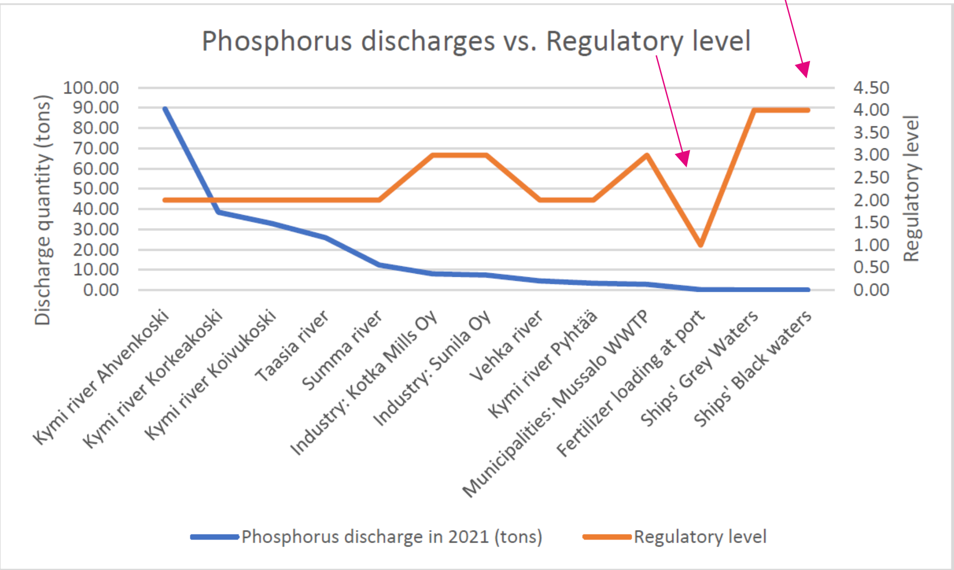


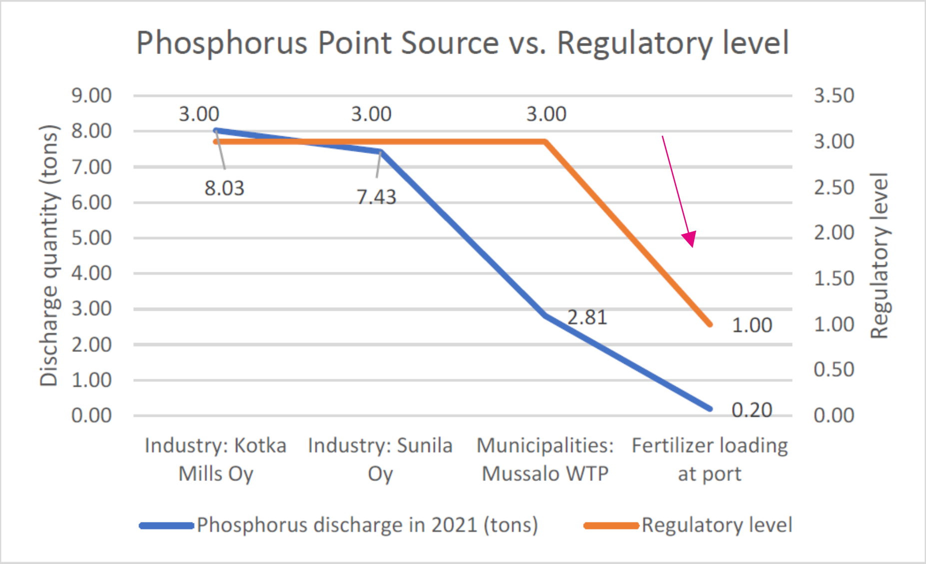


RESULTS: REGULATORY FRAMEWORK









PRACTICAL IMPLICATIONS

1. Inefficiency of Additional Ship Wastewater Restrictions

- Even if all ships wastewaters were delivered ashore, it would only reduce the nitrogen and phosphorus load to the sea by <0,1%.
- In addition, the wastewater discharge is distributed in the open seas, it is not a point source.
- In addition, transportation to WWTP by vacuum trucks is expensive and adds up to climate change.

2. Fertilizer Cargo Handling: An Overlooked but Manageable Source

- If fertilizer discharge from port cargo handling was effectively mitigated, it would decrease 4% of the total nitrogen load to the local area (point source).
- Cost-effective methods exist.

3. Regulatory Guidance is not aligned

- Wastewaters are strictly regulated but cargo handling residues are not -> guides the ports to focus on wastewater reception rather than cargo residue mitigation.
- Dominant diffuse sources (agriculture, forestry) are not regulated effectively.

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THANK YOU!

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