

Supplementary Materials: Assessment of the Effect of International Maritime Regulations on Air Quality in the Southern North Sea

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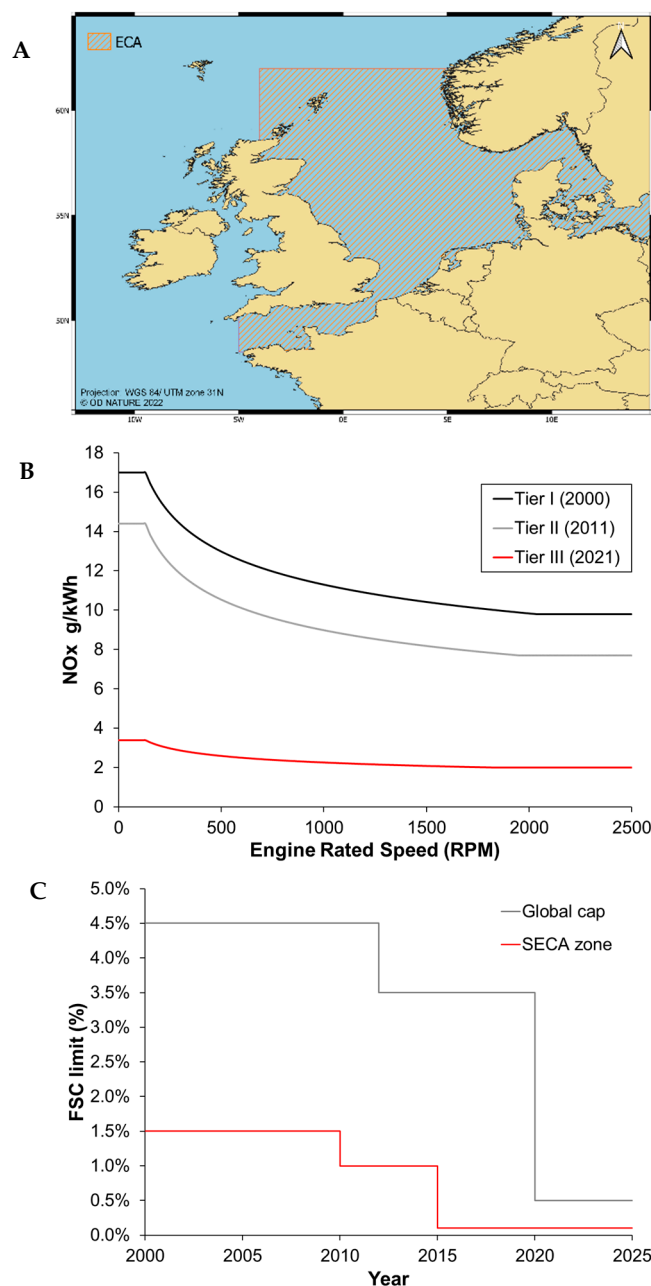


Figure S1. Emission Control Area (ECA) as defined by MARPOL Annex VI (A). Limits on the Fuel Sulfur Content of marine fuels according to the MARPOL Annex VI regulation 14 (B). NO_x emission limits according to MARPOL Annex VI Regulation 13 (C).

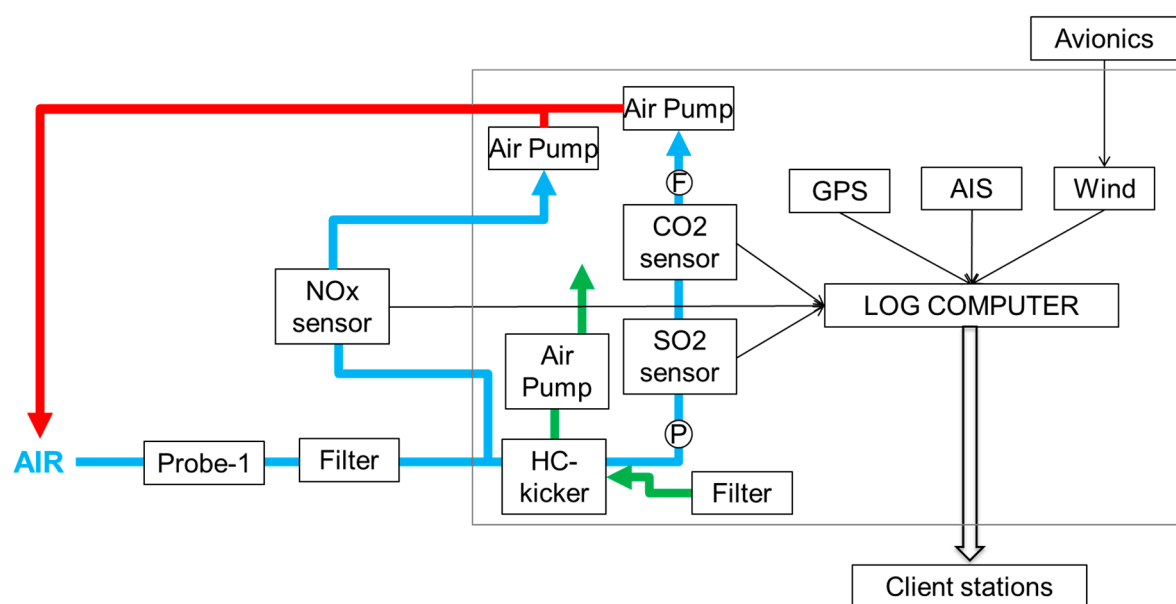


Figure S2. Schematic overview of the updated sniffer sensor system, with NO_x sensor and HC kicker.

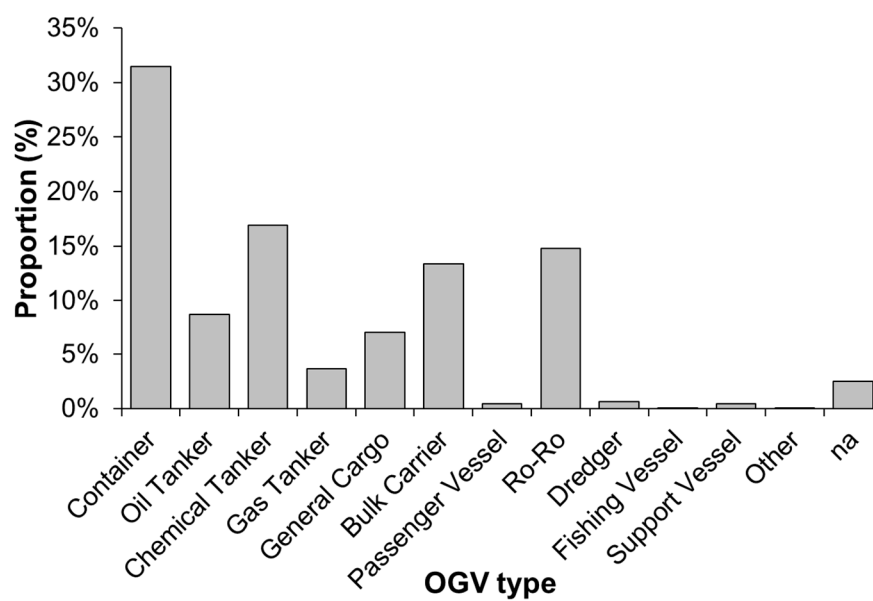


Figure S3. Distribution of the observed OGVs according to OGV type.

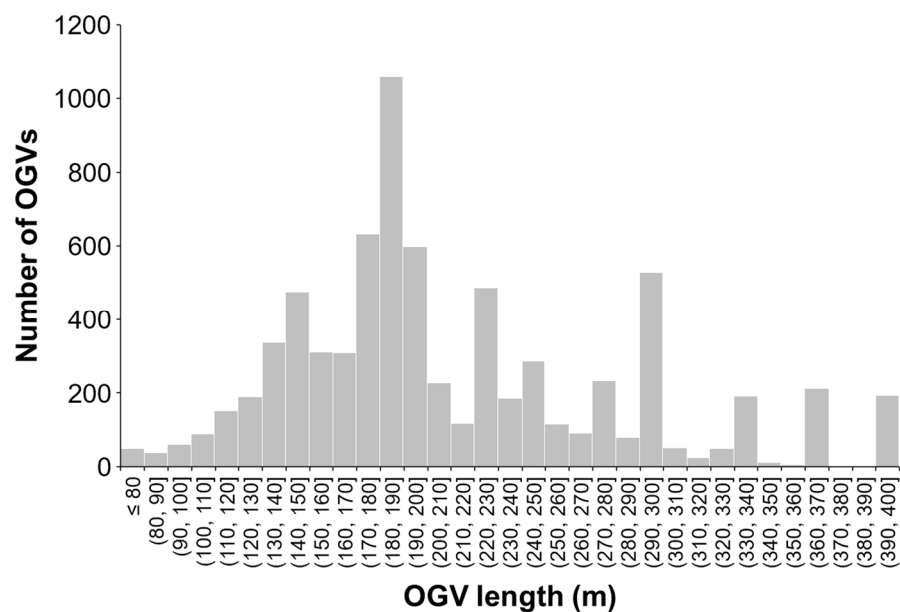


Figure S4. Distribution of the observed OGVs according to OGV length (m).

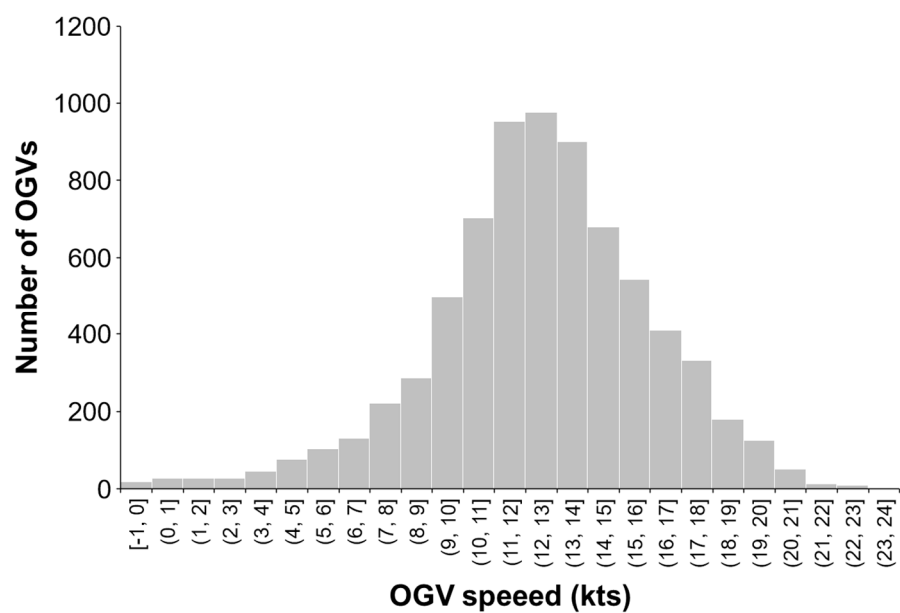


Figure S5. Distribution of the speed of the observed OGVs.

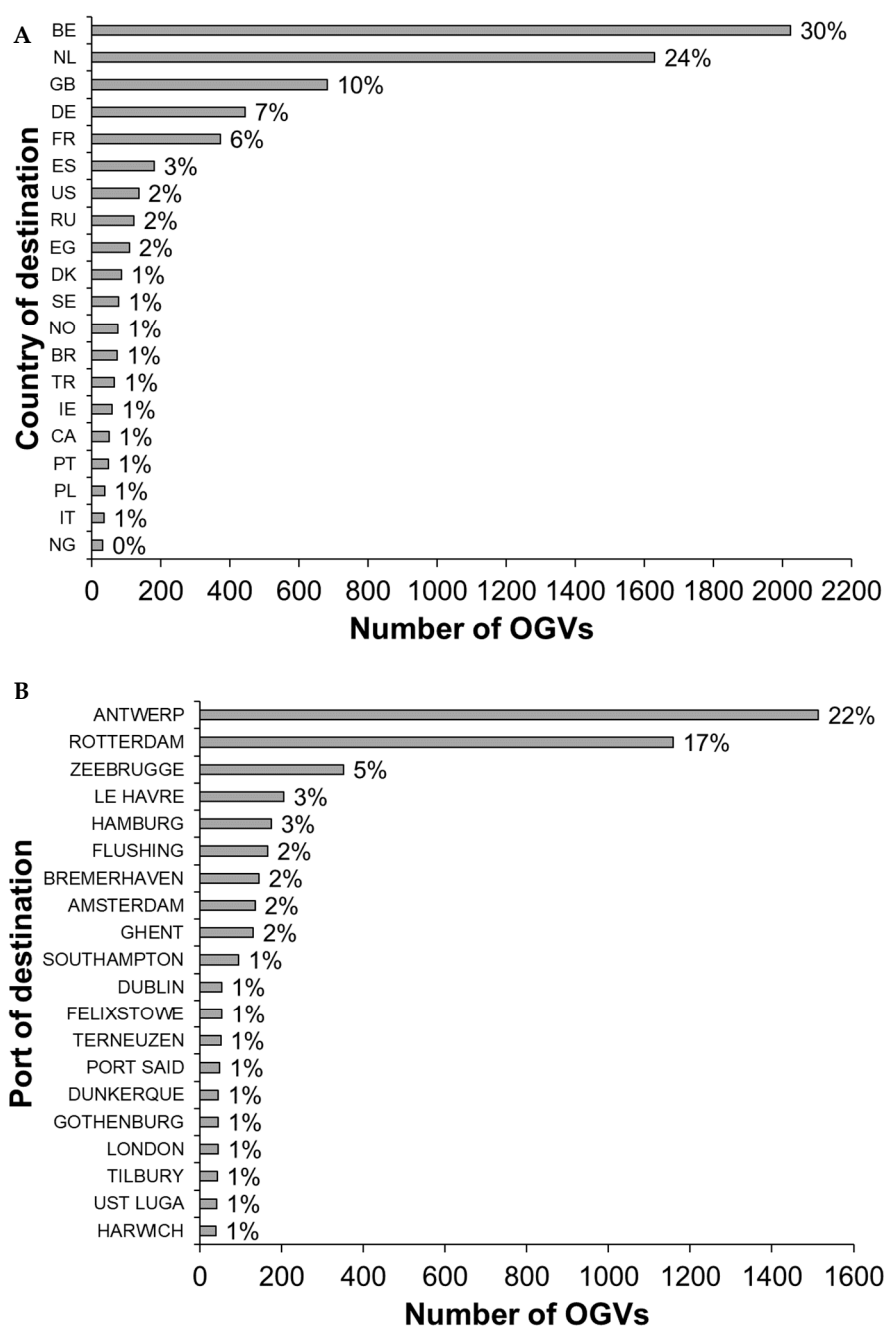


Figure S6. Distribution of 20 most observed countries (A) and ports of destination, based on the AIS information transmitted by the OGVs (B).

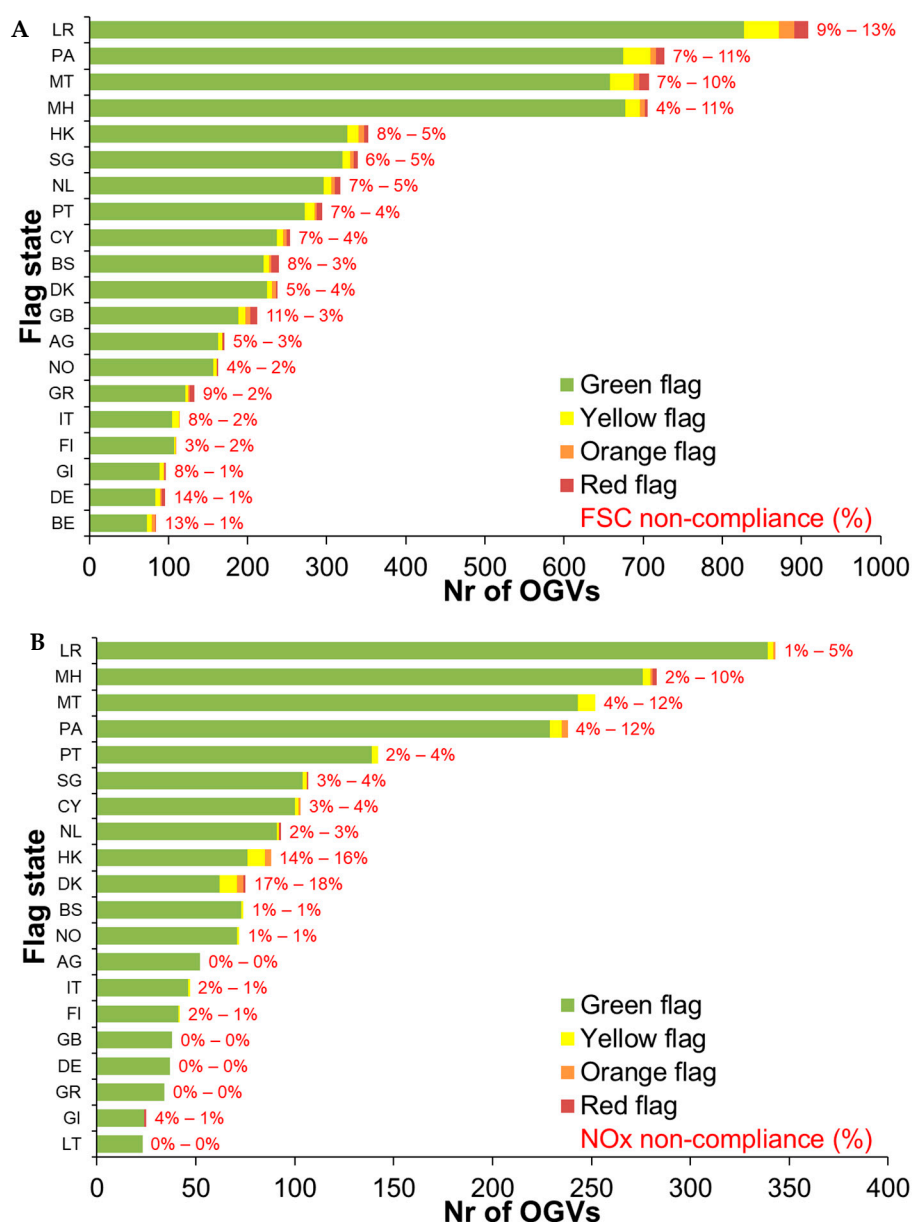


Figure S7. Non-compliance for FSC (A) and NO_x (B) according to flag state. The left non-compliance rate (%) is based on the non-compliance rate per flag state, the right percentage is the proportion of the number of non-compliant OGVs per flag state compared to the overall number of observed non-compliant OGVs.

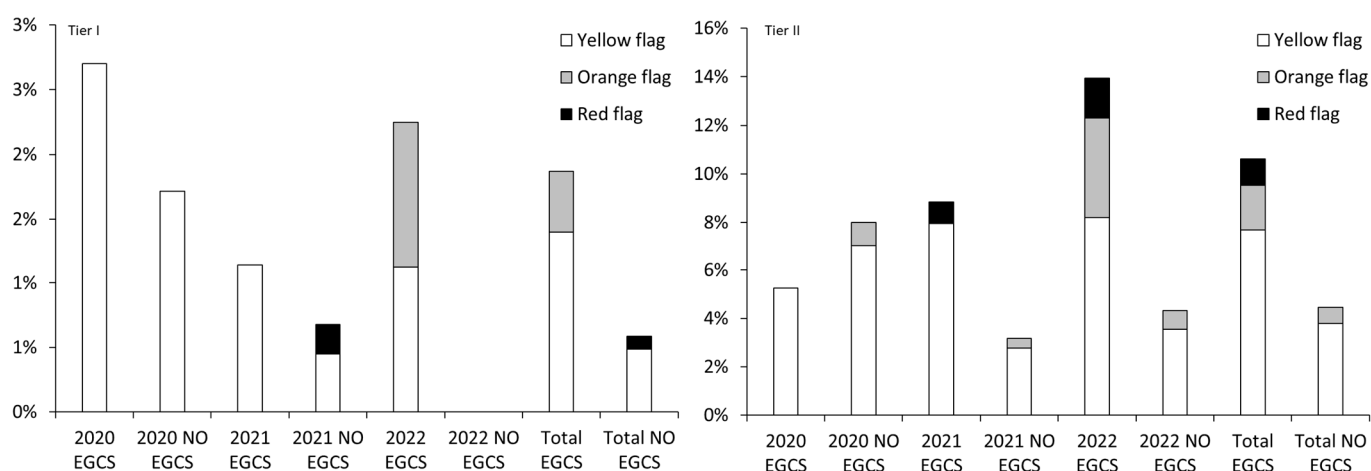


Figure S8. Difference in compliance levels for EGCS OGVs versus non-EGCS OGVs for Tier I (left) and Tier II (right) OGVs.

Table S1. Test cycles and weighting factors according to the NO_x Technical code.

E2	Speed	100%	100%	100%	100%
	Power	100%	75%	50%	25%
	WF	0.2	0.5	0.15	0.15
E3	Speed	100%	91%	80%	63%
	Power	100%	75%	50%	25%
	WF	0.2	0.5	0.15	0.15

Table S2. SO₂ and CO₂ concentrations of the ordered plume simulation mixtures and effective FSC value.

Mixture	FSC	SO ₂ (ppm)	CO ₂ (%)
Low	0.59	25ppm	1%
Medium	0.85	5ppm	0.1%
High	2.38	100ppm	1%

Table S3. Intra-Assay Coefficient of Variability, freedom of degrees and total uncertainty for FSC and NO_x.

	2020 FSC range (%)			>2020 FSC range (%)			NO _x range (g/kWh)		
	<0.2%	0.2-0.4	>0.4	0.13-0.2	0.2-0.3	>0.3	0-10	10-20	>20
CV_{RW}	18.3%	11.6%	13.7%	18.0%	8.04%	4.82%	16.1%	14.9%	18.6%
n	109	49	29	20	12	14	24	79	45
u_{tot}	19%	13%	15%	25%	20%	18%	21.9%	21.1%	23.9%
$ b $	4%	1.33%	0.66%	15%	14%	12%	13.4%	13.4%	13.4%
$U (\sigma = 1.96)$	42%	27%	30%	64%	52%	48%	29.6%	28.0%	33.4%