Supplementary Materials

Assessment of the Effect of International Maritime Regulations on Air Quality in the Southern North Sea.

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# Supplementary Figures

# Supplementary Tables



**A**



**B**



**C**

Figure S.1. 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). NOx emission limits according to MARPOL Annex VI Regulation 13 (C).



Figure S.2. Schematic overview of the updated sniffer sensor system, with NOx sensor and HC kicker.



Figure S.3. Distribution of the observed OGVs according to OGV type.



Figure S.4. Distribution of the observed OGVs according to OGV length (m).



Figure S.5. Distribution of the speed of the observed OGVs.



**A**



**B**

Figure S.6. Distribution of 20 most observed countries (A) and ports of destination, based on the AIS information transmitted by the OGVs (B).



**B**

**A**

Figure S.7. Non-compliance for FSC (A) and NOx (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 S.8. Difference in compliance levels for OGCS OGVS versus non-EGCS OGVs for Tier I (left) and Tier II (right) OGVS.

Table S.1. Test cycles and weighting factors according to the NOx 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 S.2. SO2 and CO2 concentrations of the ordered plume simulation mixtures and effective FSC value.

|  |  |  |  |
| --- | --- | --- | --- |
| Mixture | FSC | SO2 (ppm) | CO2 (%) |
| Low | 0.59 | 25ppm | 1% |
| Medium | 0.85 | 5ppm | 0.1% |
| High | 2.38 | 100ppm | 1% |

Table S.3. Intra-Assay Coefficient of Variability, freedom of degrees and total uncertainty for FSC and NOx.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | 2020 FSC range (%) |  | >2020 FSC range (%) | NOx 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 |
| *CVRW* |  | 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 |
| *utot* |  | 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 (σ* = 1.96*)* |  | 42% | 27% | 30% |  | 64% | 52% | 48% |  | 29.6% | 28.0% | 33.4% |