THE SCIPPER PROJECT

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Shipping Contributions to Inland Pollution Push for the Enforcement of Regulations

Challenges with NOx emissions control of late technology vessels

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ERMES Plenary Day 2
Air Quality & Remote Sensing
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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement Nr.814893

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  - Onboard monitoring
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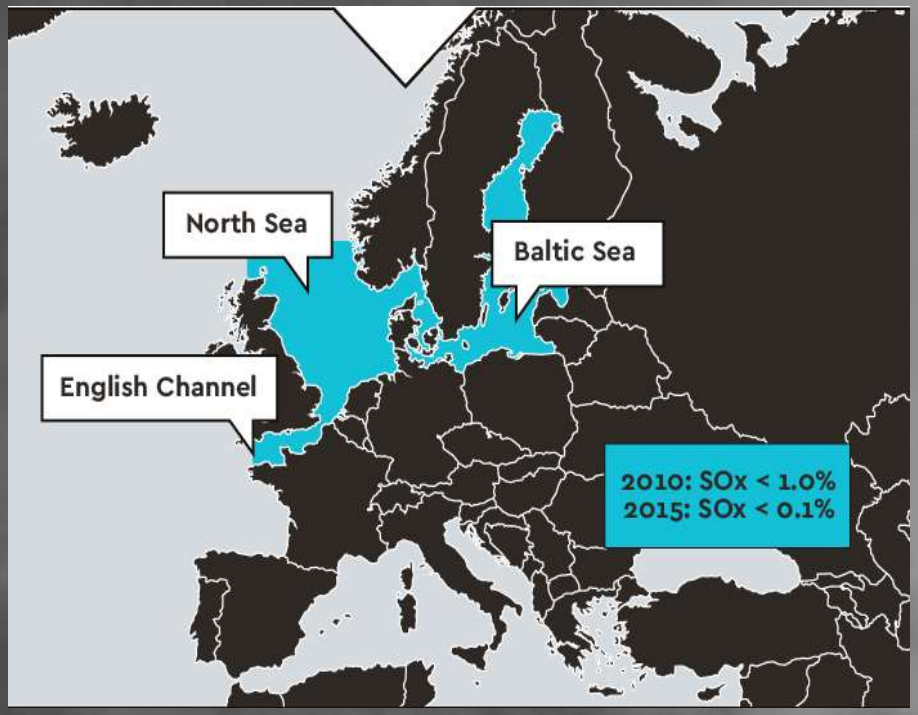
Background:

Current and future needs for shipping emissions monitoring



SO_x

2015: 0,1% FSC in three SECA regions
2020: 0,5% FSC globally and 0,1% in EU ports
2025: Mediterranean SECA

NO_x

2021: Tier III Baltic & North Sea ECAs

Black Carbon

2022: Voluntary use of LFOs in the Arctic Region
202X: Periodic on-board monitoring of BC

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2. The SCIPPER project

2.1 Consortium

SCIPPER was a Horizon 2020 funded European research project with partners originated from different fields, including public enforcement authorities, policy support institutes, Academia, research providers and SMEs. SCIPPER partners covered the range of organizations required to materialize scientific and research findings to pragmatic policies and technical solutions.

ARISTOTLE UNIVERSITY OF THESSALONIKI (COORDINATOR)

hereon

Tampere University

ivl SVENSKA MILJÖINSTITUTET

CHALMERS

TNO innovation for life

FMI

HelmholtzZentrum münchen
Deutsches Forschungszentrum für Gesundheit und Umwelt

PML | Plymouth Marine Laboratory

exactEarth Europe

Fraunhofer CML

BSH
BUNDESAMT FÜR SEESCHIFFFAHRT UND HYDROGRAPHIE

AtmoSud

Aix+Marseille université

EXPLICIT

Aeromon

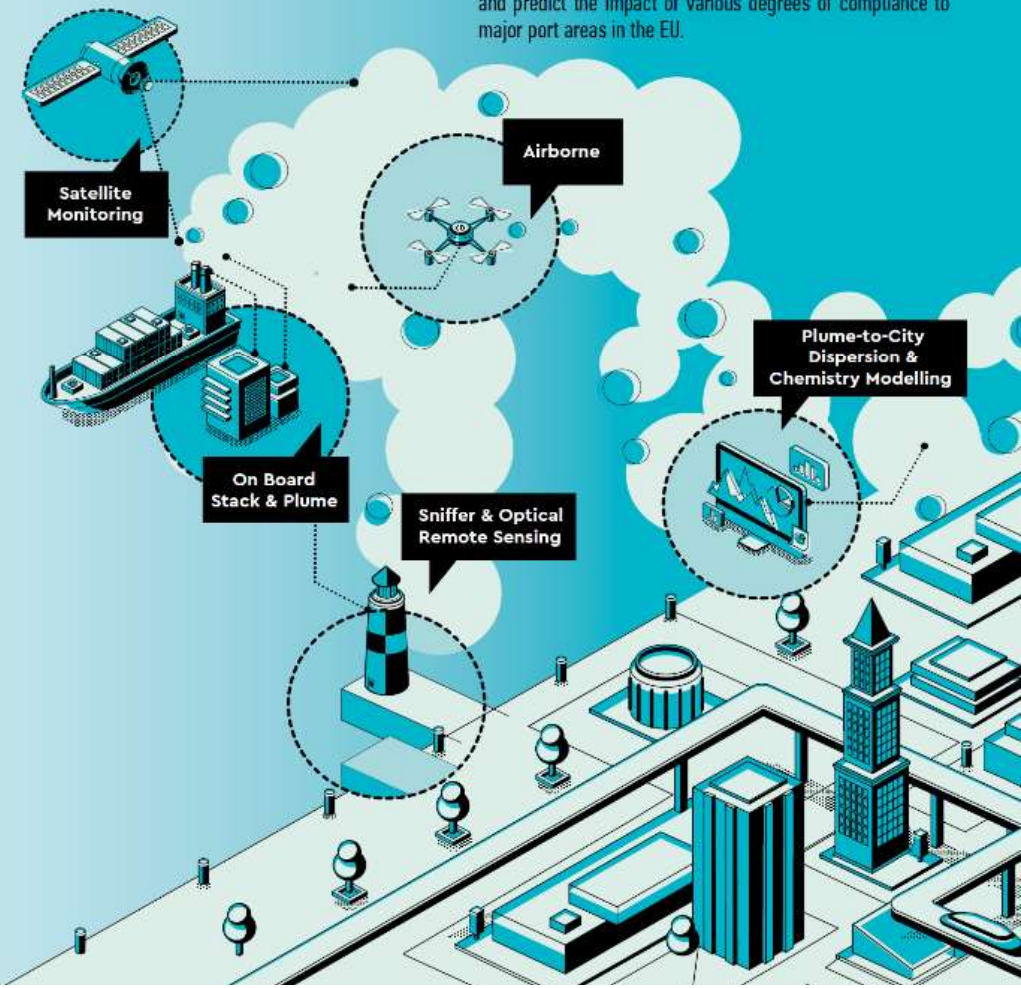
Human Environment and Transport Inspectorate
Ministry of Infrastructure and Water Management

THE HONG KONG UNIVERSITY OF SCIENCE AND TECHNOLOGY

2.2 Methodology

In order to address the many and largely unexplored problems related to vessels emissions monitoring, SCIPPER deployed state-of-art and next-generation measurement techniques to monitor emissions of vessels under their normal operation. Techniques include on-board sensors, sniffers, optical remote techniques, Unmanned Aerial Systems (UAS) and satellite detection.

Different measurement techniques were implemented in five real-world campaigns over main shipping areas in EU. Together with SOx and NOx, which are the current regulatory priorities, techniques to characterize PM, were also applied. Experimental information in the campaigns was combined with advanced plume dispersion and chemical transport models (CTMs) to estimate current ship-induced air pollution and predict the impact of various degrees of compliance to major port areas in the EU.



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Drone taking off from patrol vessel
Marseille, Jul 2019

Two instrumented ‘sniffer’ vans on board Stena Germanica
Gothenburg-Kiel, Sep 2021

Sniffing cruise ship port emissions
Port of Marseille, 2021

Fully instrumented patrol vessel
Marseille, Jul 2021

Sampling passing by vessel plumes
Wedel, Sep 2020

sAIS data transmission on board RV *Plymouth Quest*
English Channel, May 2022

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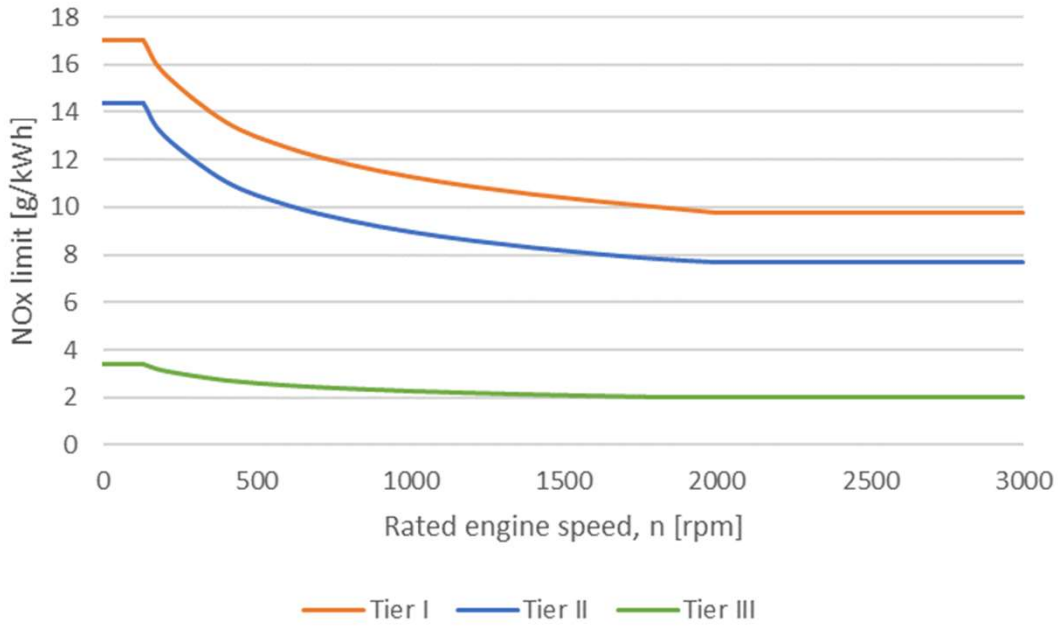
IMO NOx regulation

NOx technical code, MARPOL Annex VI:

- Limit value in g/kWh, dependent on max engine speed
- Weighted average of 4 points: 25%, 50%, 75%, 100% load, heavily weighted towards high/max load
- Tier III load points < 150% limit value
- No monitoring requirements



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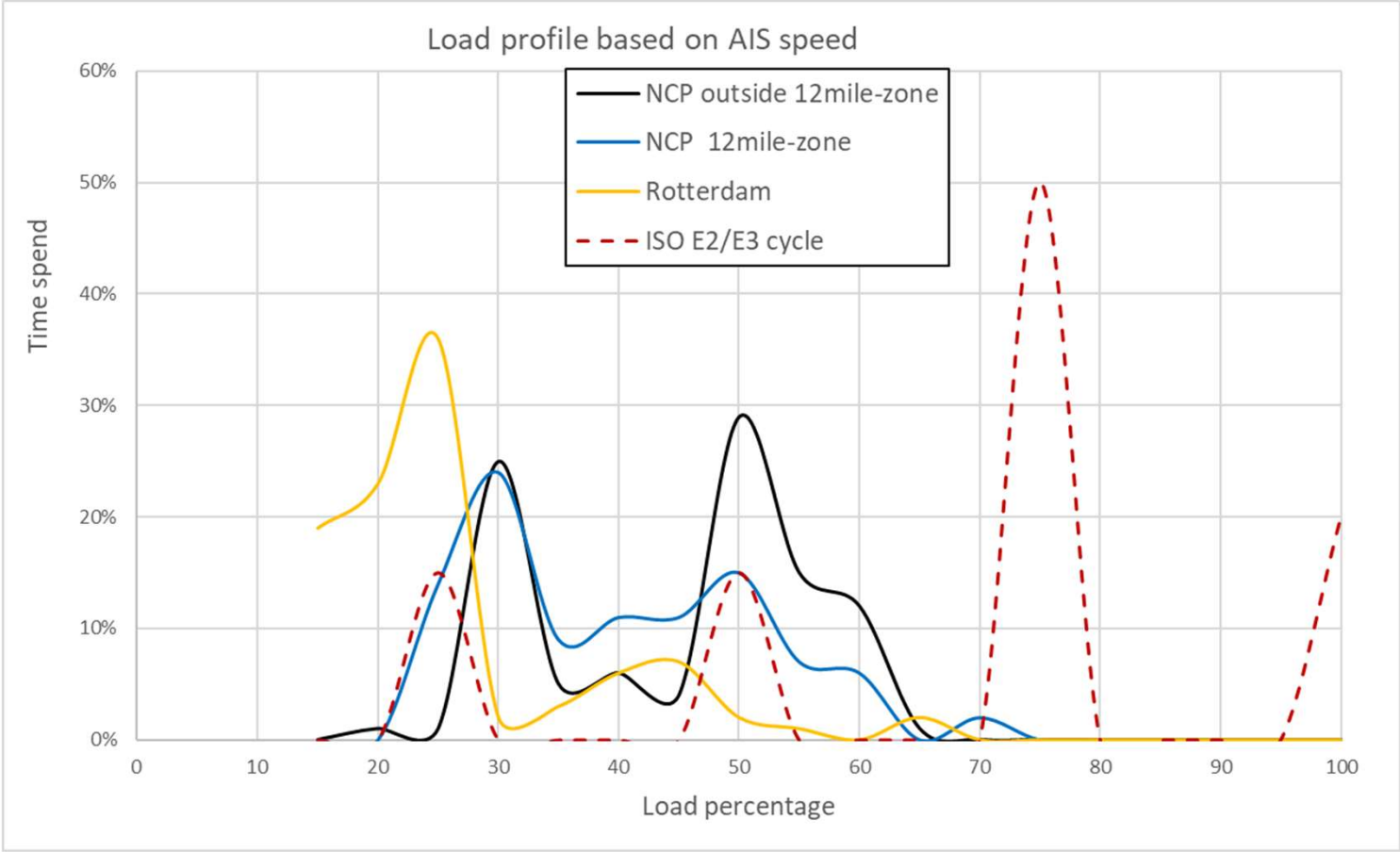
Engine load ECA zone

Low engine loads ECA zones (NCP-Netherlands Continental Plat)

ISO E2, E3 engine load cycles are not representative for use in ECA areas and port areas

Source: SCIPPER D5.5



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Plume sensing & onboard monitoring

NOx emissions are based on exhaust concentrations, fuel carbon content and specific fuel consumption:

Gram NOx per gram CO_2

$$\frac{NO_x}{CO_2} = \frac{NO_x^{ppm}}{CO_2^{\%} \cdot 10000} \cdot \frac{M_{NO_x}}{M_{CO_2}}$$

Gram NOx per gram fuel

$$\frac{NO_x}{m_{fuel}} = \frac{3{,}15 \,.\, NO_x^{ppm}}{CO_2^{\%} \cdot 10000} \cdot \frac{M_{NO_x}}{M_{CO_2}}$$

Gram NOx per kWh

$$\mathrm{NO_x} = SFC \,.\, \frac{3{,}15 \,.\, NO_x^{ppm}}{CO_2^{\%} \cdot 10000} \cdot \frac{M_{NO_x}}{M_{CO_2}}$$

Refer to SCIPPER reports

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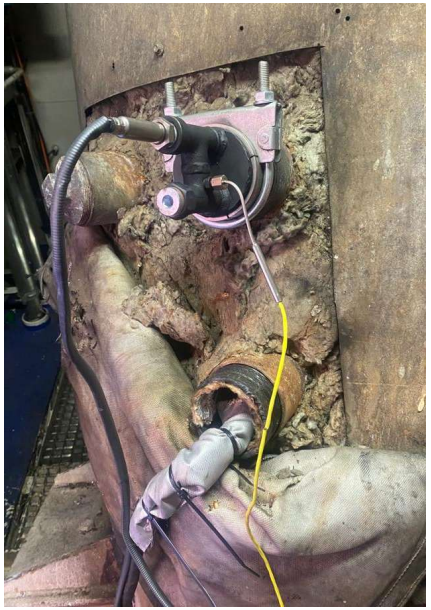
Campaigns with onboard sensor testing



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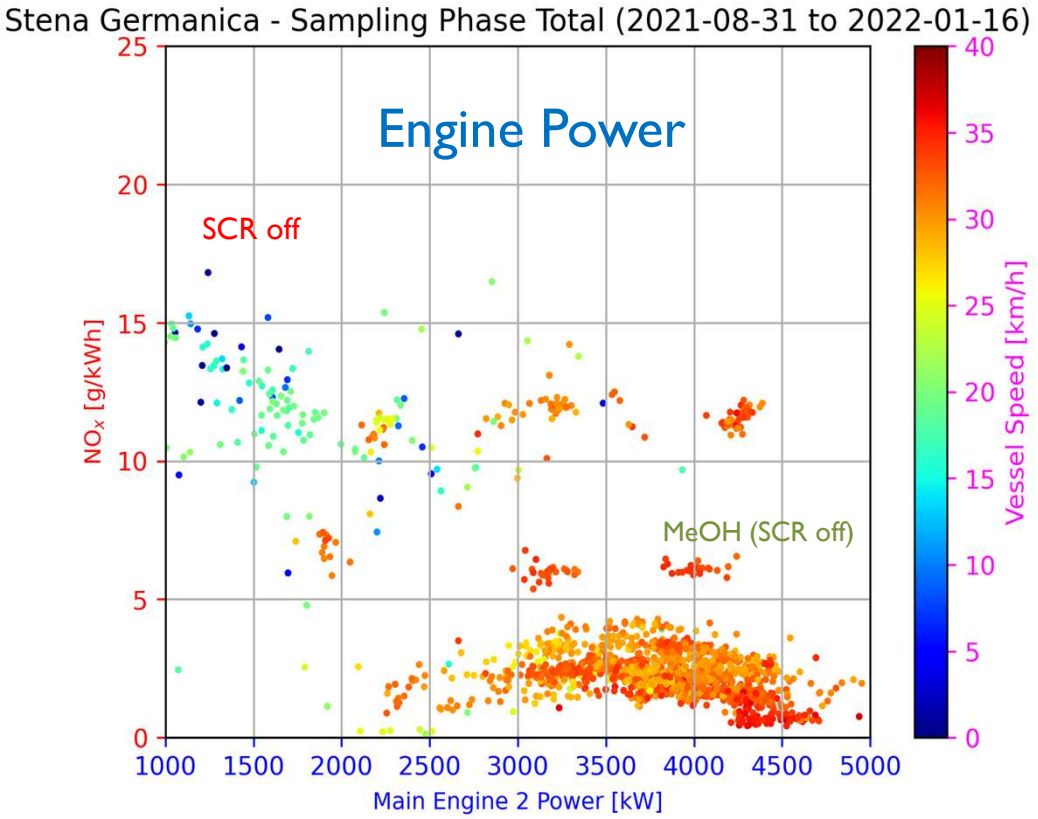
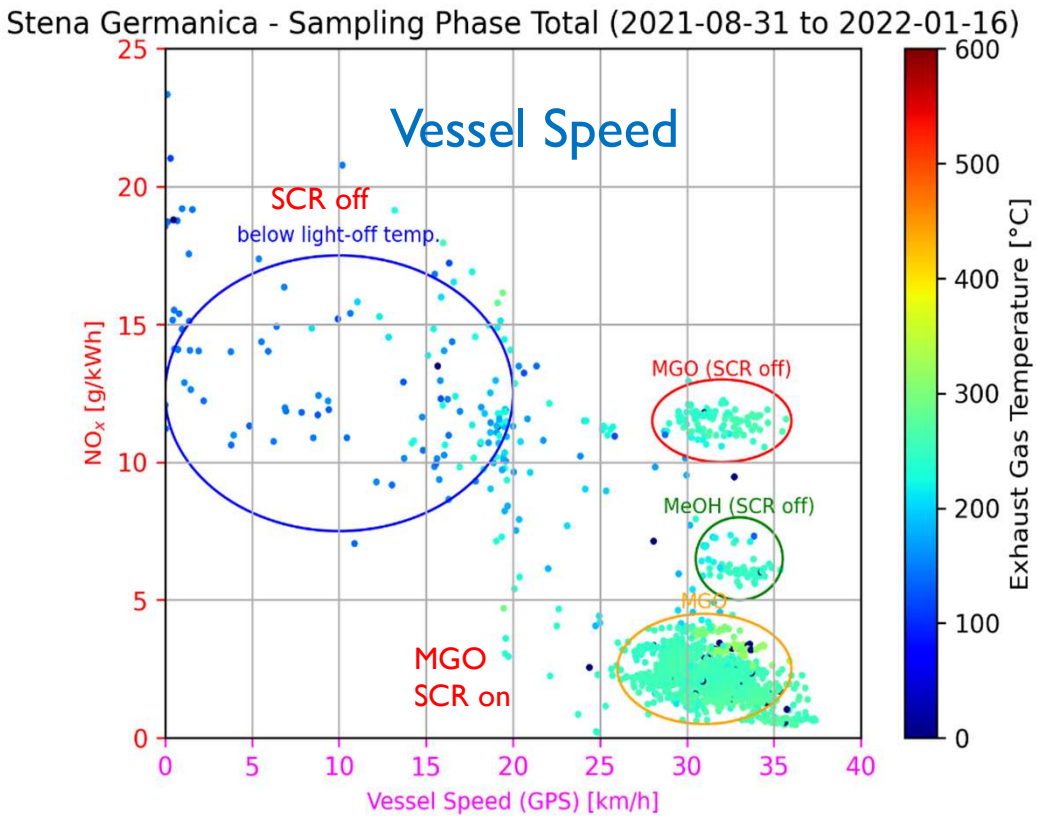
NOx emissions with onboard montoring

NOx (g/kWh) with TNO SEMS system on STENA Germanica ≈ 4 months





Source: SCIPPER Deliverable D1.6

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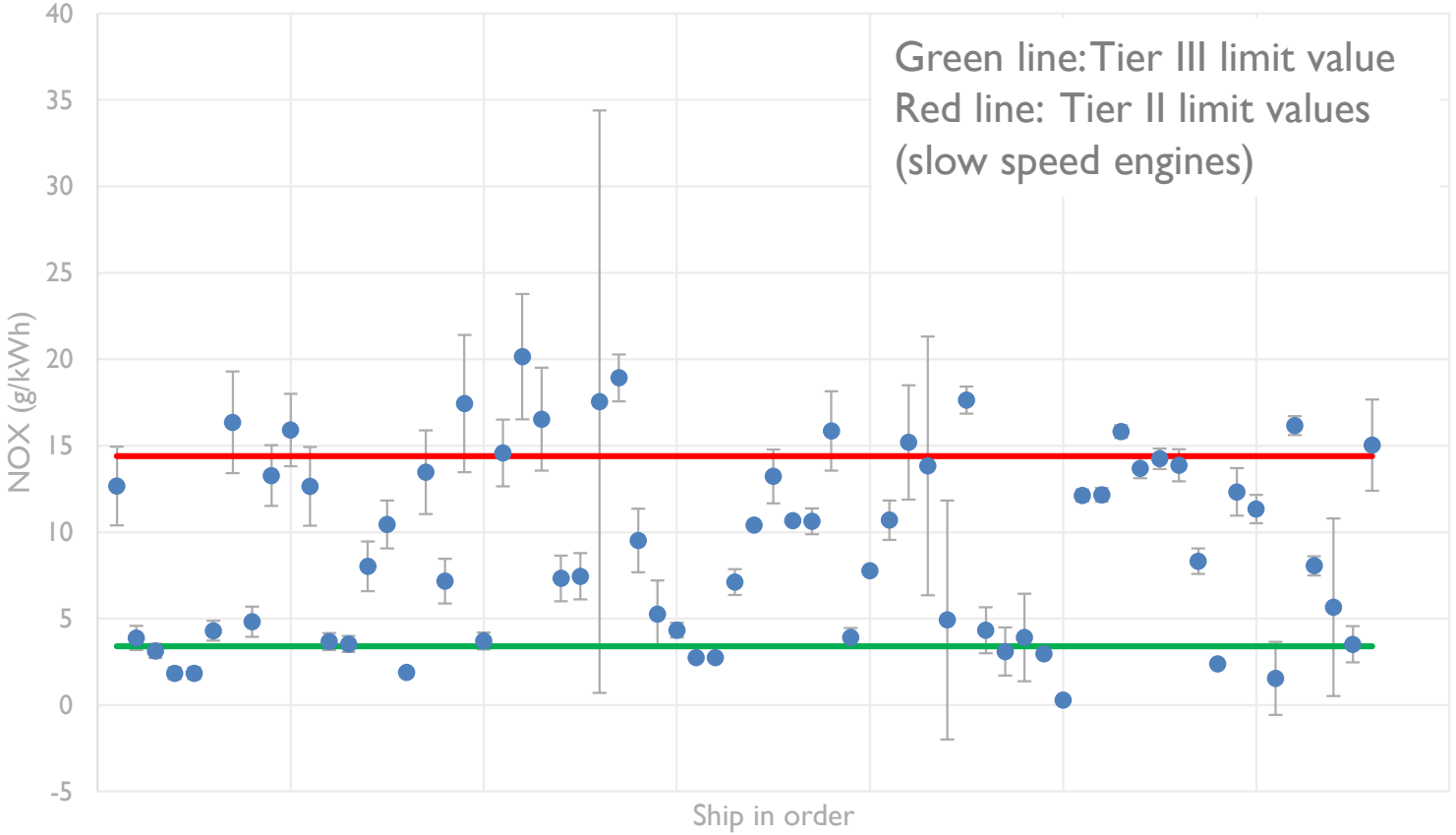
Plume sensing Tier III North & Baltic sea

Plume measurements at Rotterdam (TNO), Belt bridge (Chalmers), Hamburg (BSH), and airborne measurements in Danish and French waters (Explicit).

66 remote measurements from 39 vessels:

- Only 1/3 was within expected Tier III level
- About 50% indicate factor two to five higher emission level.



Source: SCIPPER Deliverable D 5.5 and SCIPPER press release 06.03.2023

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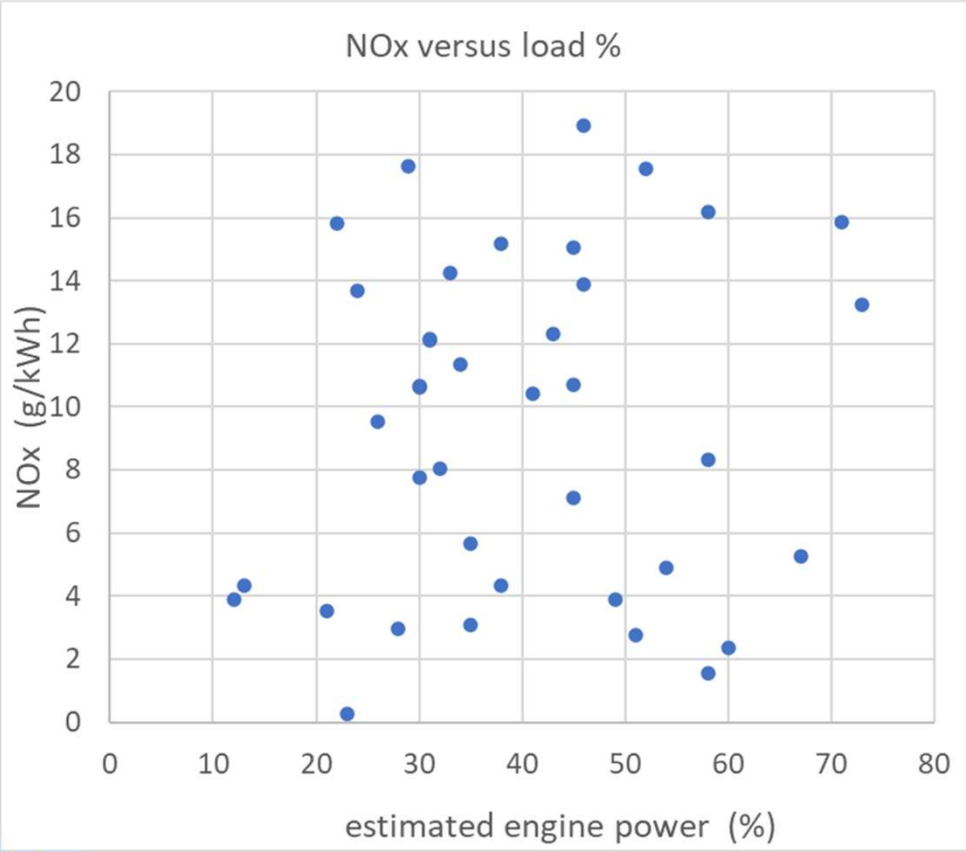
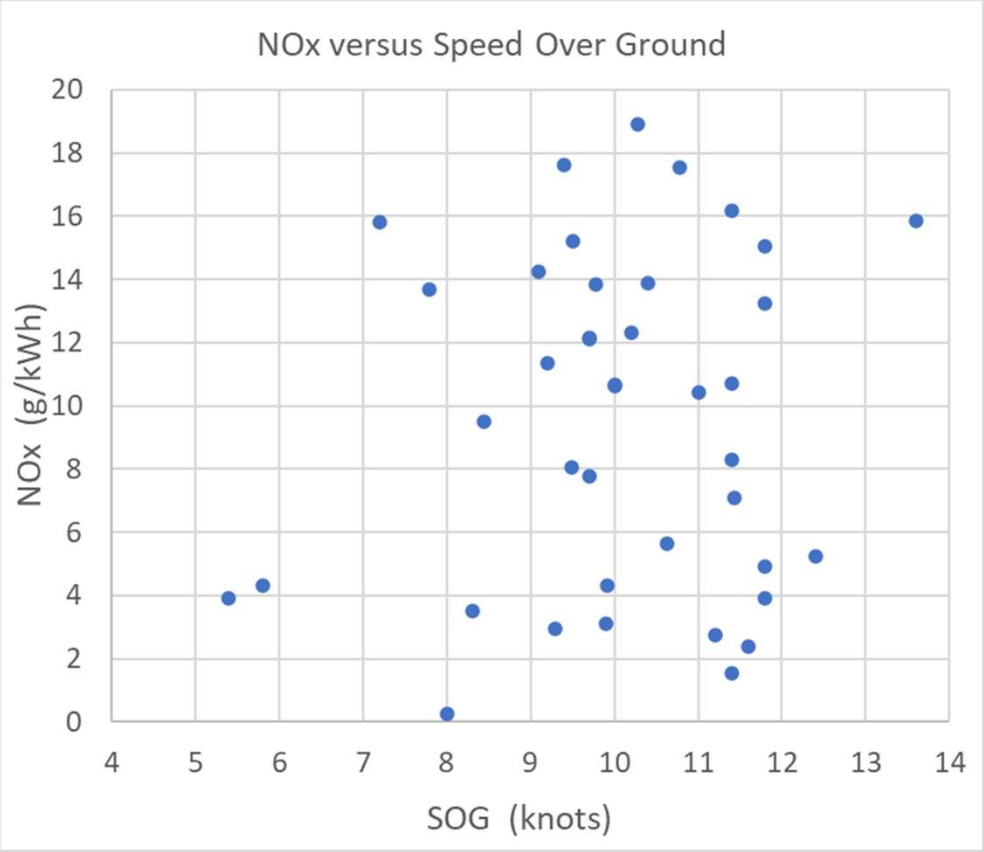
NOx emissions Tier III vessels

Plume measurements at Rotterdam, keel laying date 2021 onwards

No correlation with engine power or vessel speed.





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Regulatory measures to reduce NOx emissions

- Addition of 10% load point including NTE (150%) for whole load range down to 10% for E2, E3 and D2 test cycles
- Adapt weight factors E2, E3 to load profile of ECA zones
- Consider NTE in g/kg fuel, down to 0% load (instead of g/kWh)
- Require a Continuous Emissions Monitoring System (CEMS) with sensors or analysers and access to this data by authorities
- Consider ship rather than engine Real Sailing Emissions requirement.

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Technical measures to reduce NOx emissions at low load

- Engine air control to increase exhaust temperature at low load
- SCR catalyst tuned to more to low temperature and/or larger catalyst
- Switching to fuel with lower Fuel Sulphur Content: max 10ppm instead 1000ppm
- Add EGR system for low load NOx reduction
- EGR instead of SCR for whole load range
- Different type of reagent: e.g. NH3 instead of urea.

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Thank you for your attention

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