THE SCIPPER PROJECT

EMERGE

Impacts of new fuels and emissions controls on emissions of regulated and unregulated pollutants

Insight from onboard measurement campaigns of the SCIPPER and EMERGE projects

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This projects have received funding from the European Union's Horizon 2020 research and innovation programme under grant agreements Nr.814893 and 874990

Background

Emission Control Areas (ECAS) in EU waters

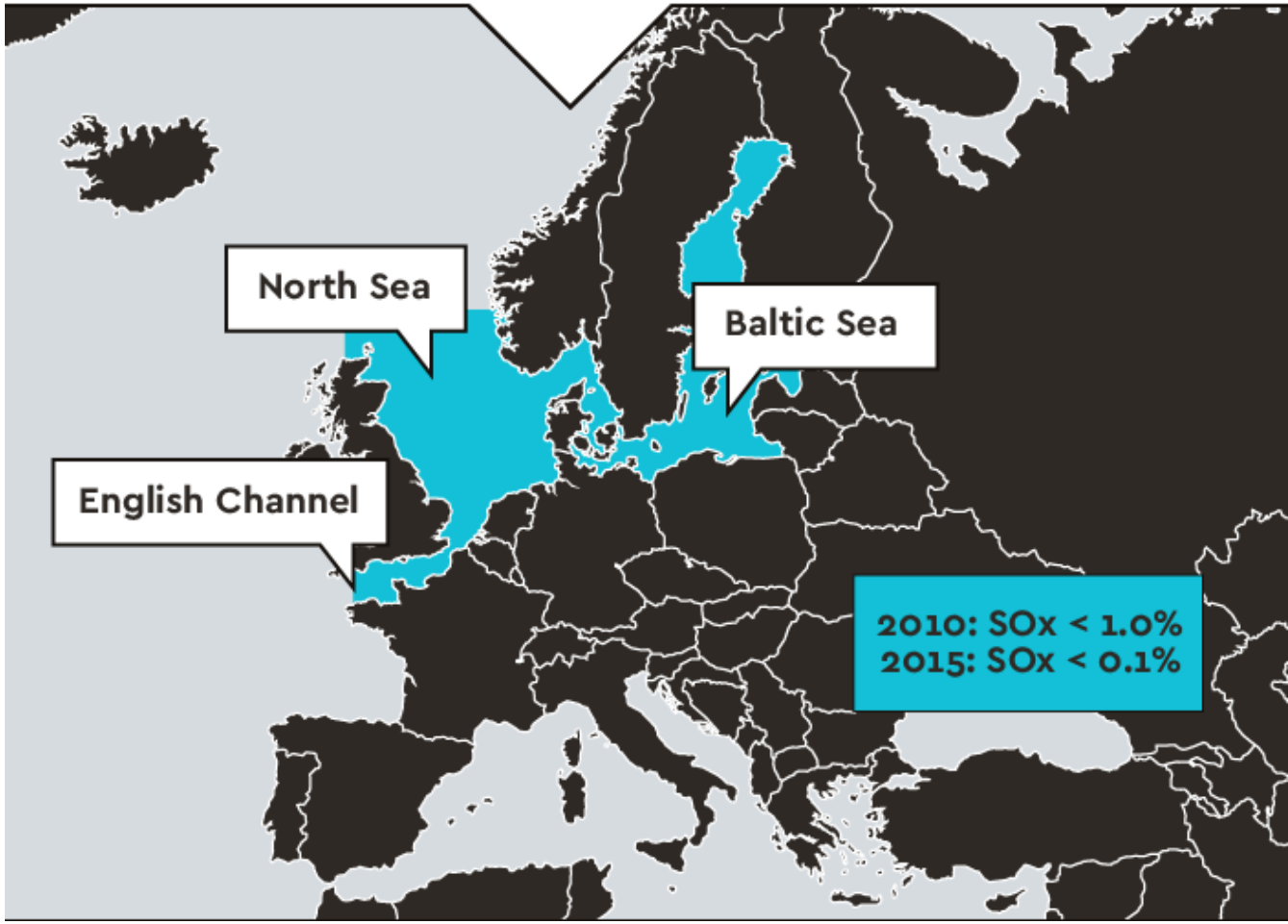
- Currently three regions

Limits

- 0.1% max fuel S since 1.1. 2015
- Globally outside SECAs 0.5% fuel S limit since 1.1. 2020
- Baltic and North Seas NO_x Tier III ECAs from 1.1.2021

Developments

- On-going discussion for inclusion of the Mediterranean region as a SO_x – ECA
- 50 % reduction of greenhouse gas emissions from ships by 2050 compared with 2008 levels



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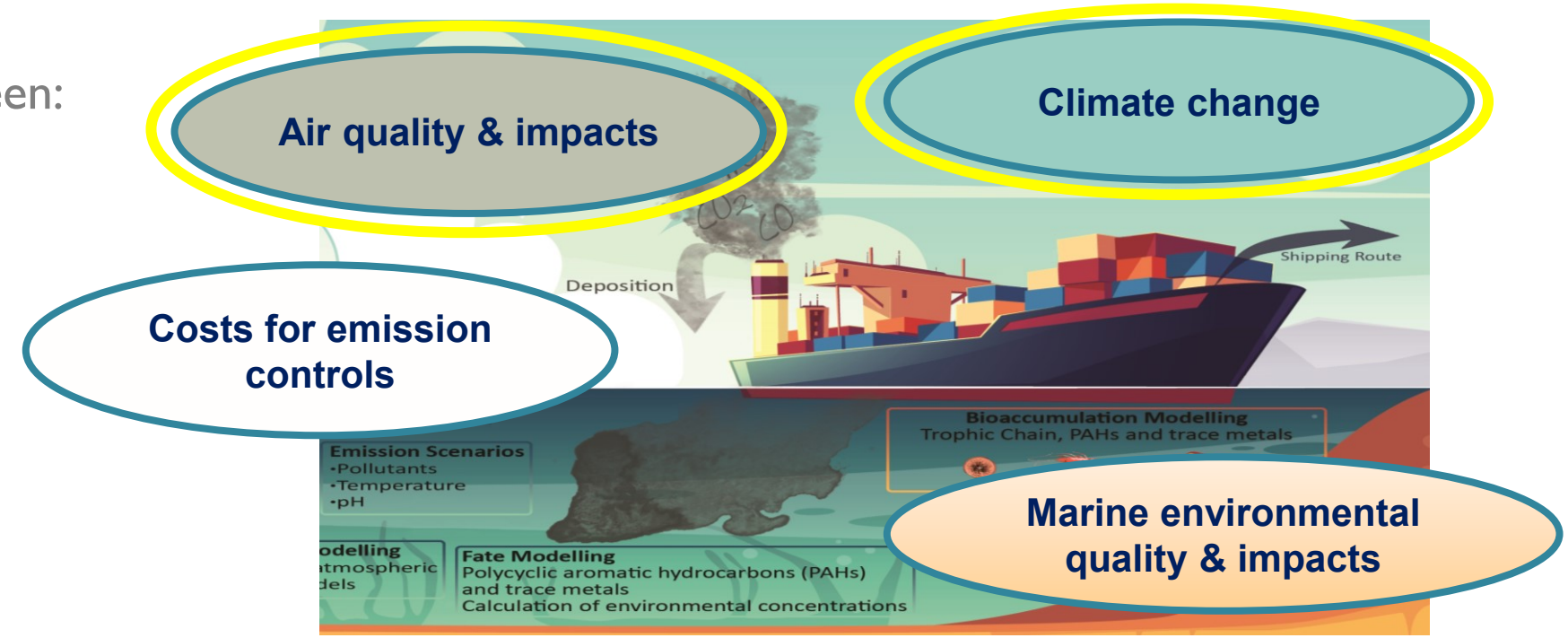
Response

Some options to meet new emission standards:

- Low sulfur fuel and NO_x aftertreatment
- Heavy fuel and both NO_x and SO_x aftertreatment
- LNG
- Other fuels, like methanol, ammonia, electrification, etc.

SCIPPER & EMERGE
assessing trade-offs between:



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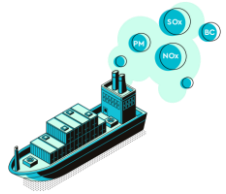
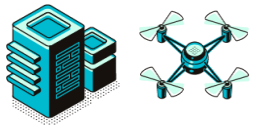
Measurement campaigns

SCIPPER Measurement Campaign on RO-PAX ferry (4-stroke diesel engine with SCR)

- **On-board exhaust sampling to obtain physicochemical data**
  - **Assessment of NOx abatement and MeOH fuel**
- Testing of onboard compliance monitoring,
  - Selection and testing of equipment & sensors
  - Performance assessment , including uncertainty characterization for SO_2, NOx and PM/PN
- Intercomparison of different onboard and remote monitoring techniques
- Verification of monitoring techniques with high-end instruments



12 combinations of fuel – aftertreatment – engine load point investigated



3 mobile laboratories, 15 high-end instruments, 7 in-stack sensors, 5 remote monitoring systems

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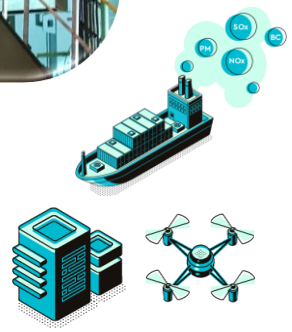
Measurement campaigns

EMERGE Measurement Campaign on container ship (2-stroke engine equipped with scrubber)



- **On-board exhaust sampling to obtain physicochemical data**
  - **Assessment of HFO & Scrubber, comparison to ULSFO**
- Onboard sampling of scrubber water to assess emissions of water contaminants
- Assessment of mass closure between air emissions and water discharges downstream the scrubber

10 sampling points air emissions, 4 combinations of fuel and/or aftertreatment investigated

8 high-end instruments, 5 exhaust conditioning instruments

Offline sampling of exhaust and effluent for further laboratory analyses – 34 exhaust samples, 39 effluent samples, 3 ecotox samples (& replicas)

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Insights from the onboard measurement campaigns

Fuels/abatements investigated:

SCIPPER

- MGO engine-out
- MGO + SCR, urea off
- MGO + SCR, urea on
- E-methanol: engine-out & postcatalyst, SCR off

EMERGE

- HFO engine-out
- HFO downstream scrubber
- ULSFO downstream deactivated scrubber

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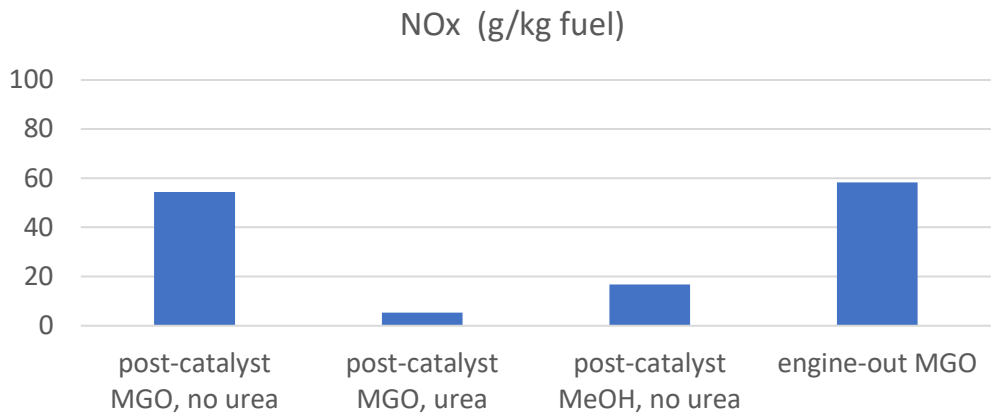
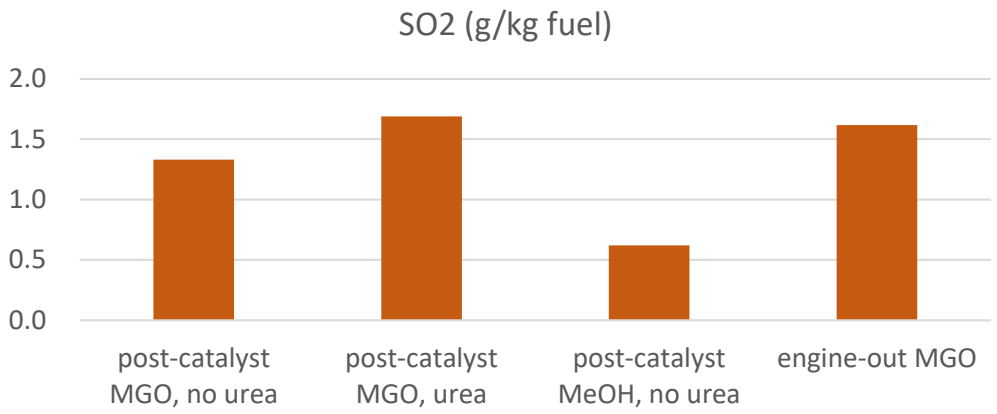
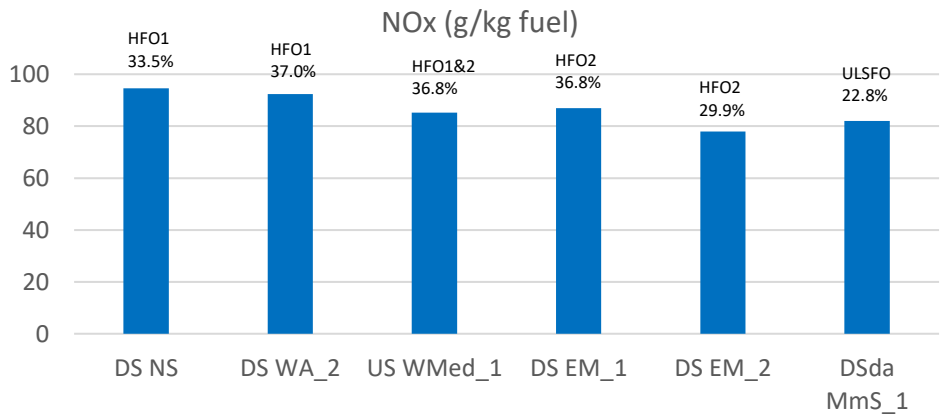
Gas emissions measurements

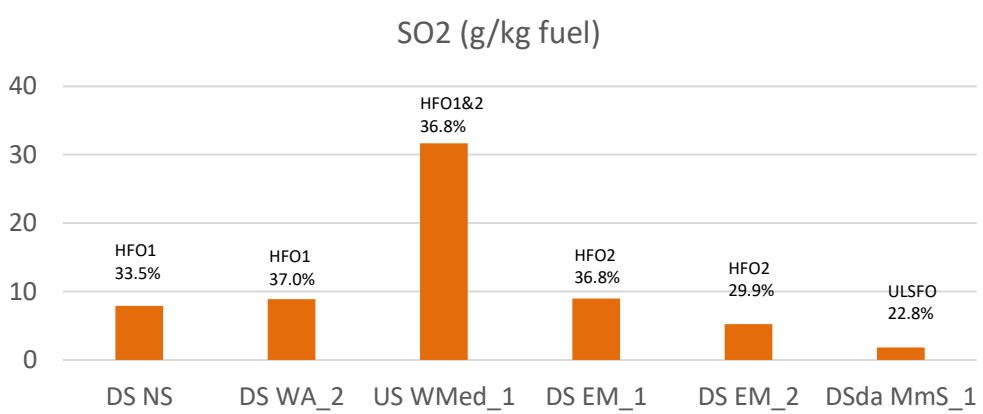
RoPAX ferry, MGO/E-methanol, SCR





Container ship, HFO/ULSFO, scrubber





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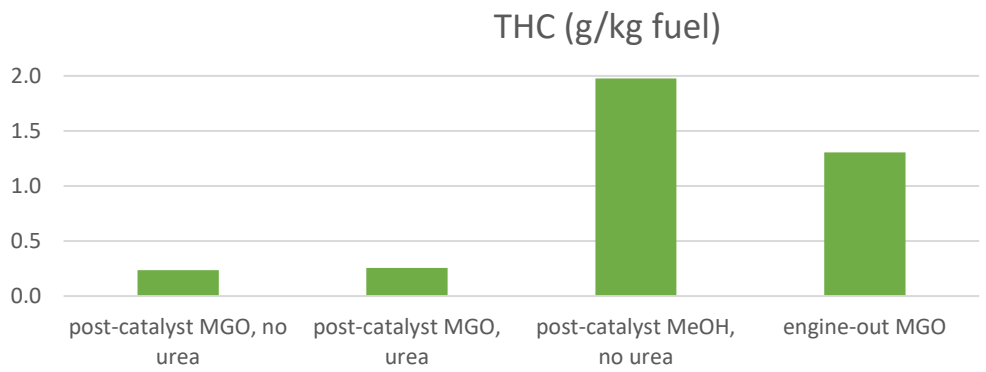
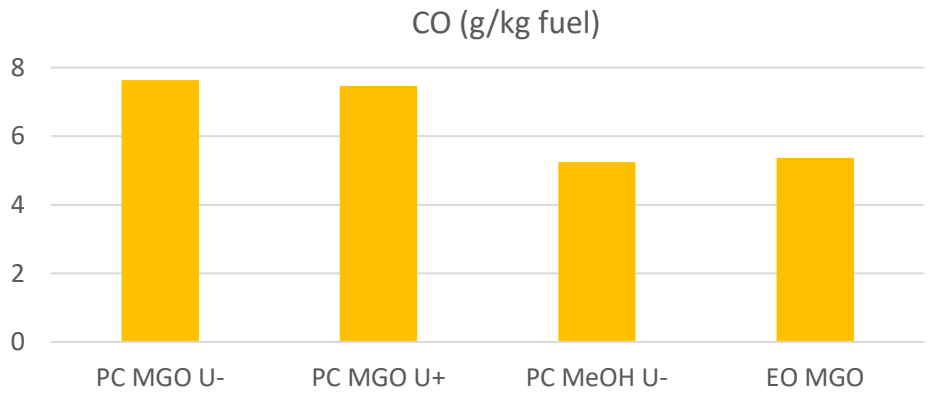
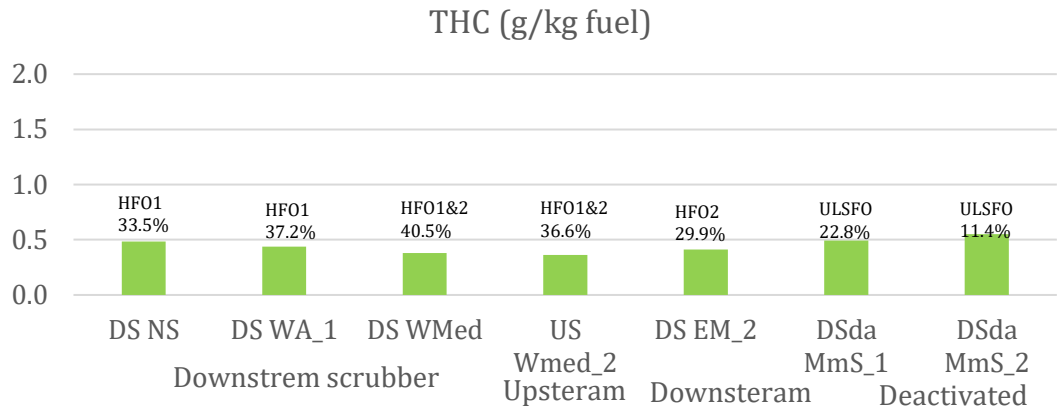
Gas emissions measurements

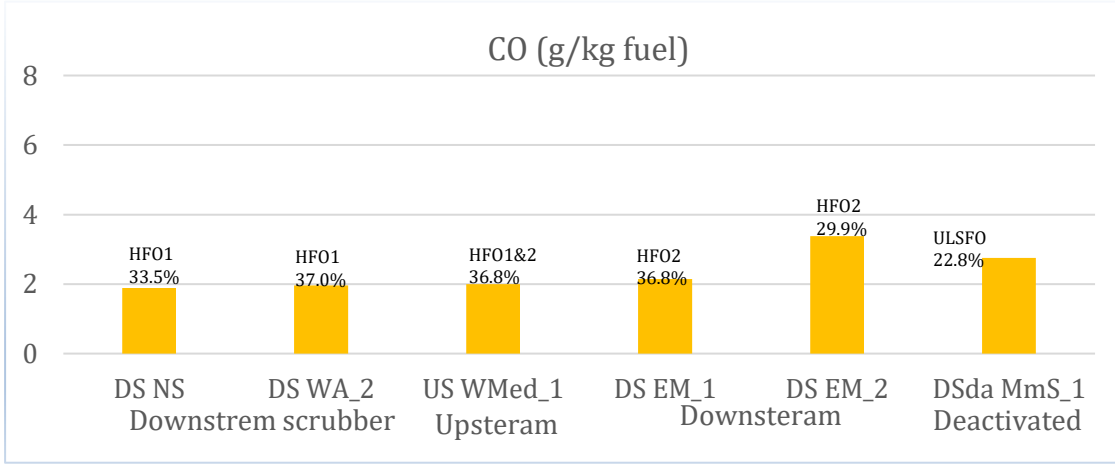
RoPAX ferry, MGO/E-methanol, SCR





Container ship, HFO/ULSFO, scrubber





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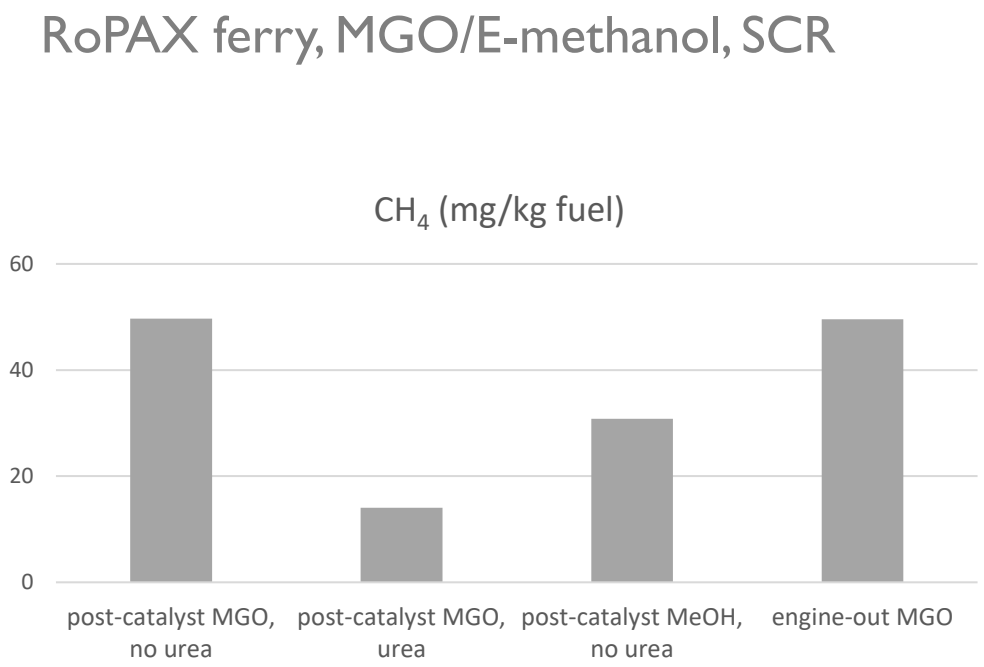
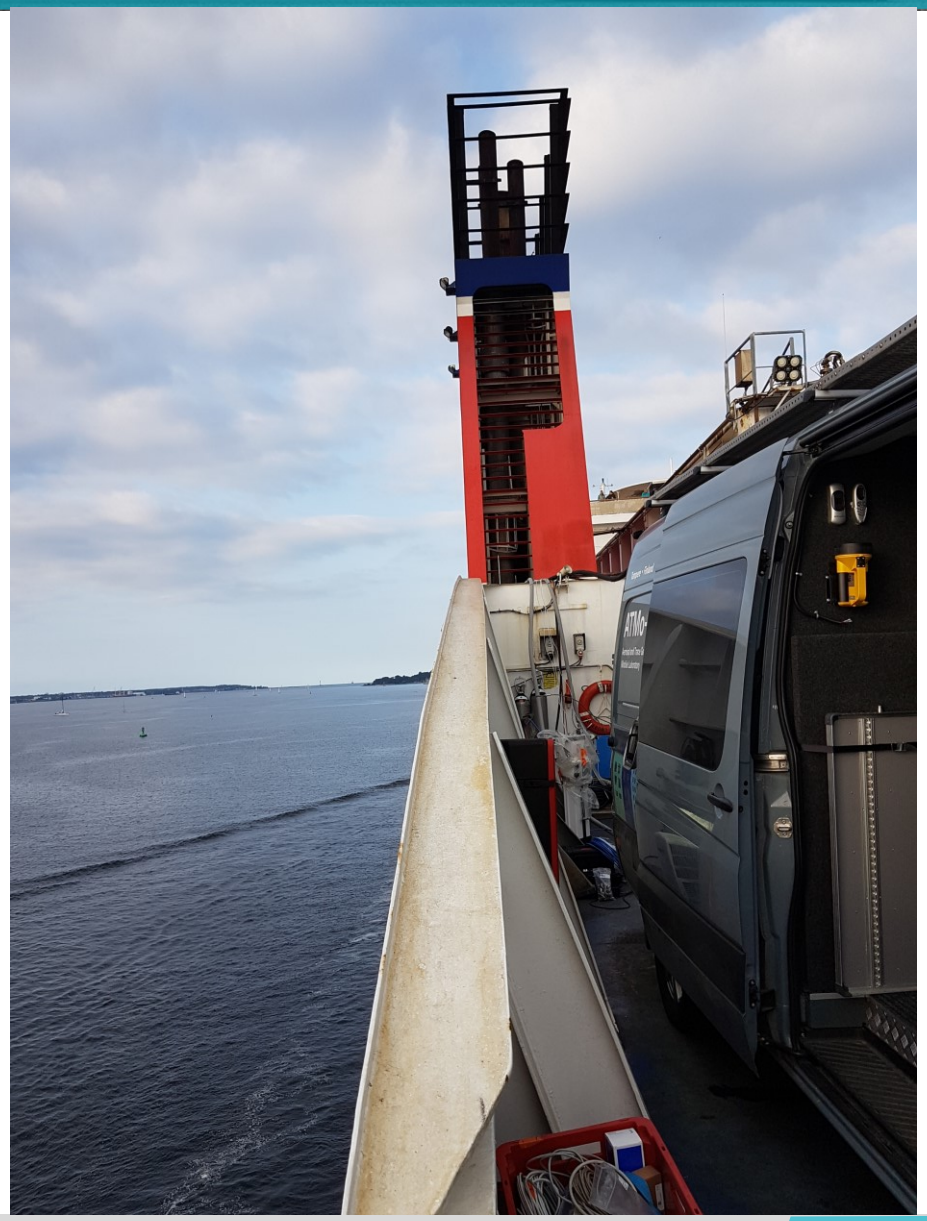
Gas measurements





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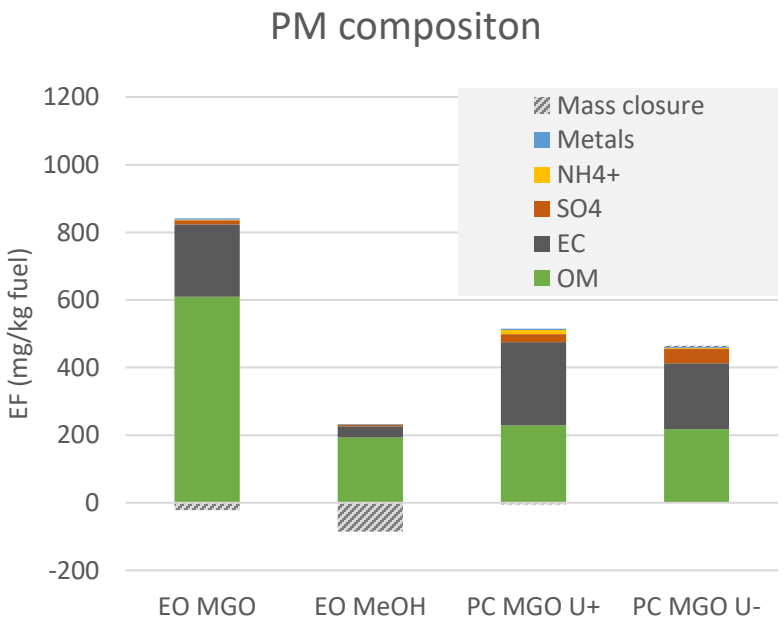
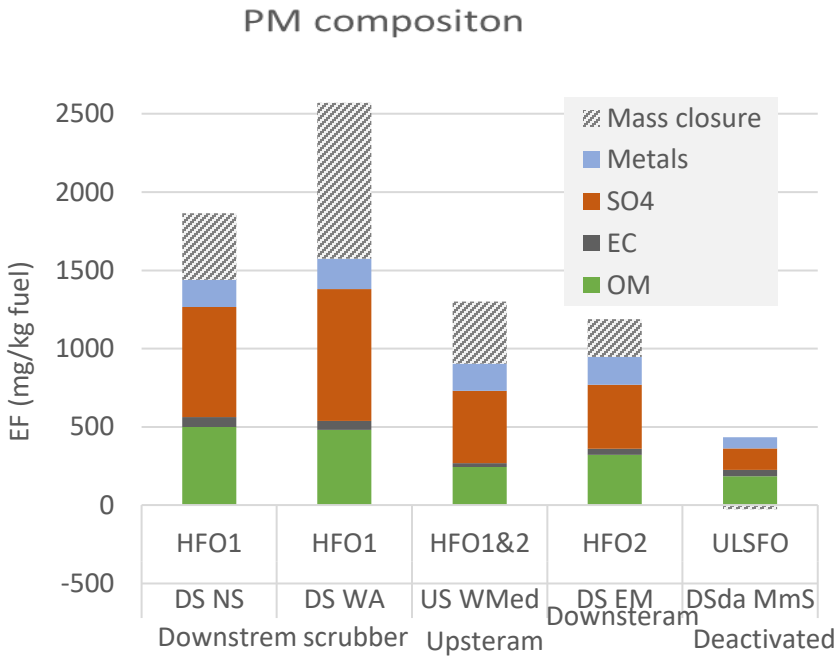
Particle measurements

RoPAX ferry, MGO/E-methanol, SCR



Container ship, HFO/ULSFO, scrubber



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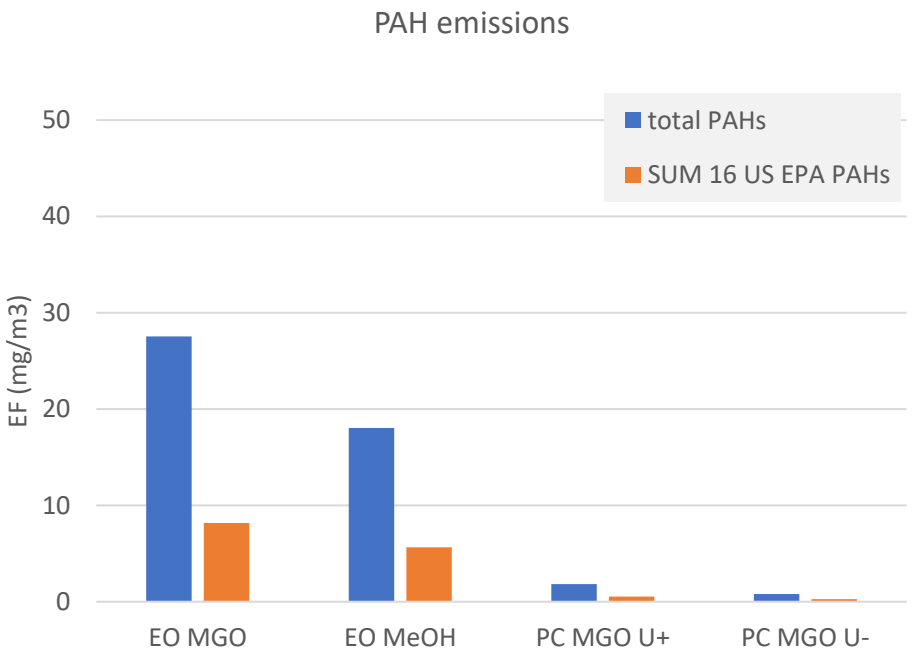
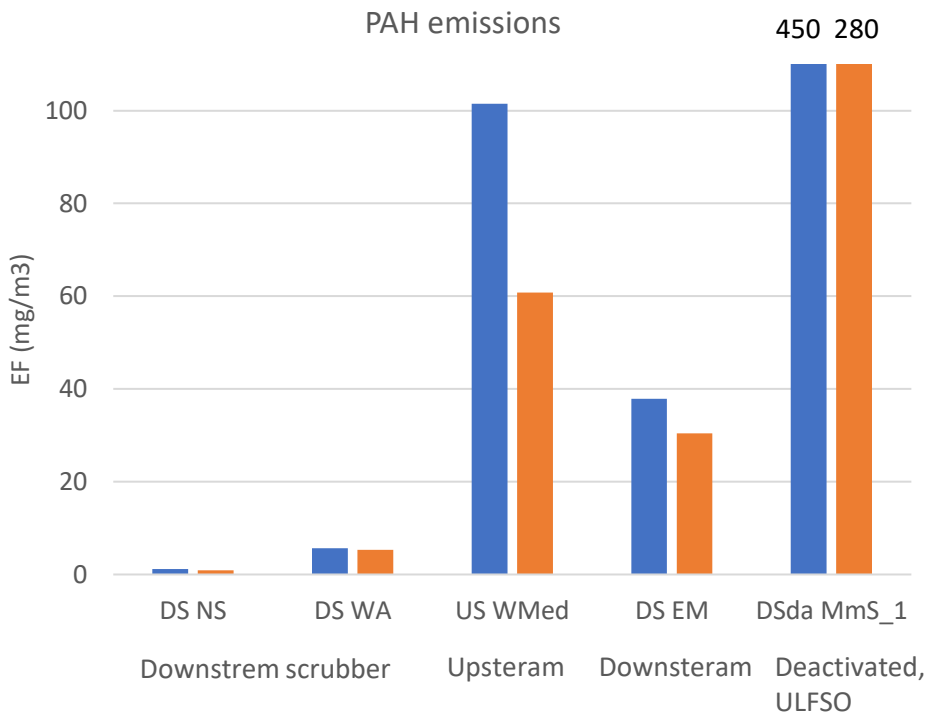
PAH measurements

RoPAX ferry, MGO/E-methanol, SCR



Conteiner ship, HFO/ULSFO, scrubber



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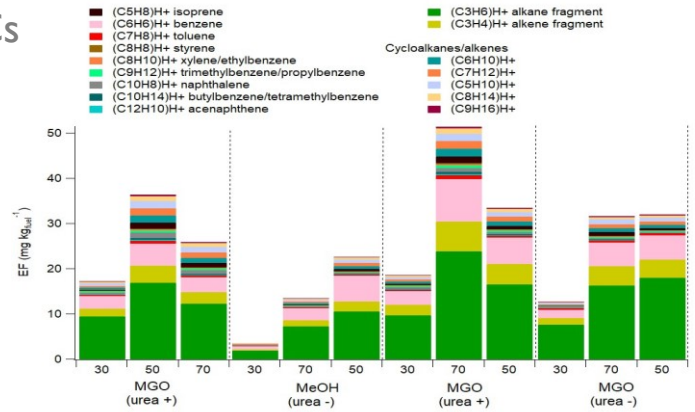
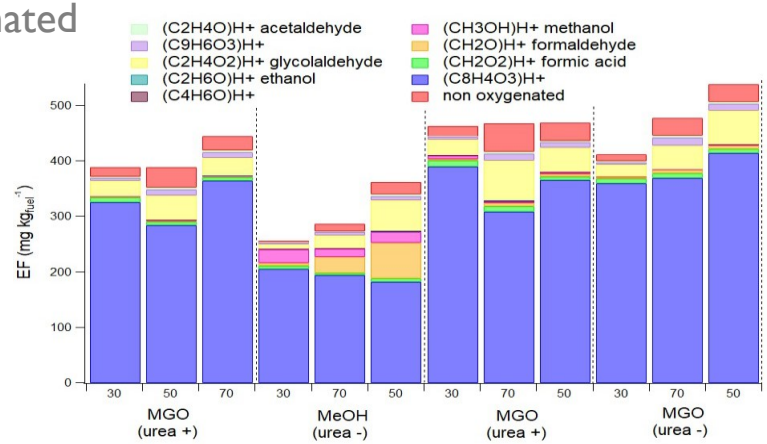
VOC speciation – hydrocarbons and oxygenated VOCs

RoPAX ferry, MGO/E-methanol, post-catalyst

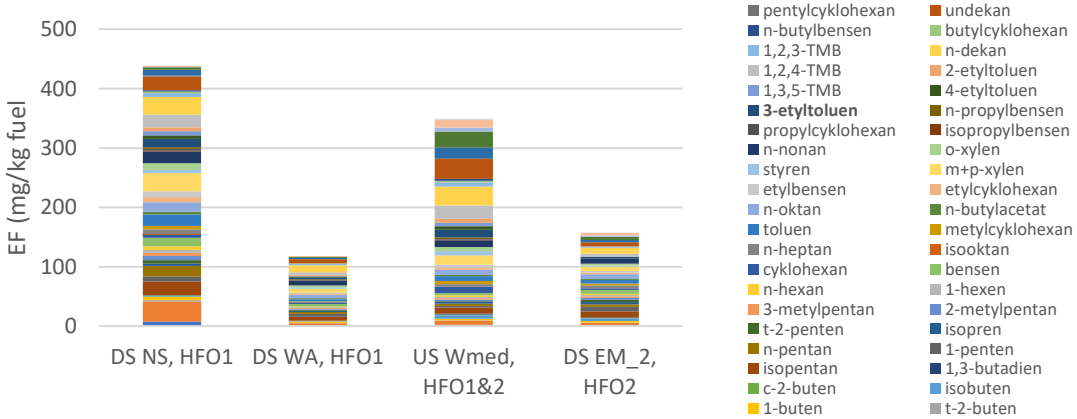
NMHCs

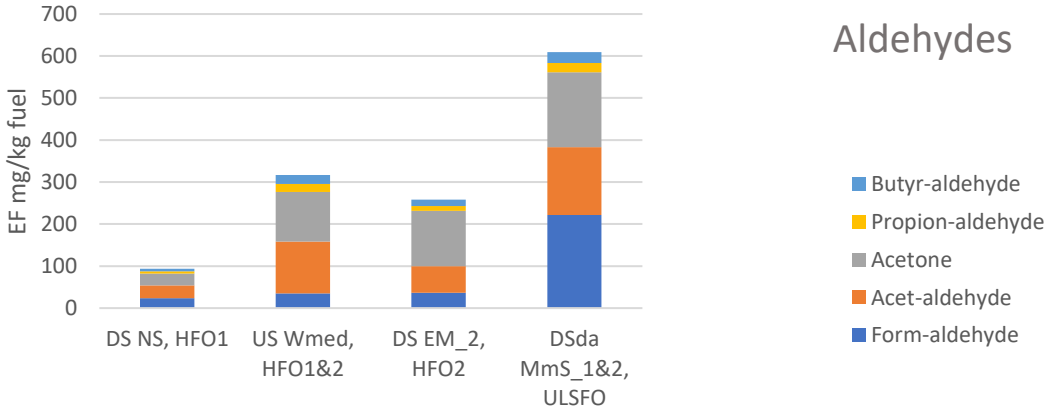


Oxygenated VOCs



Conteiner ship, HFO/ULSFO, scrubber





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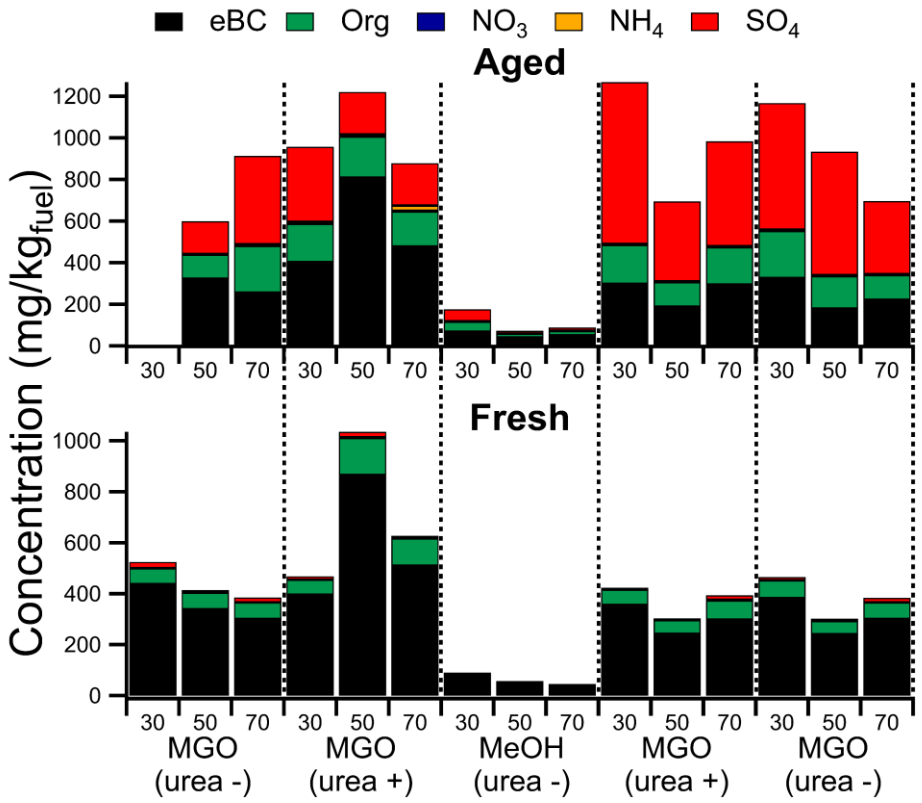
Exhaust aging – secondary particle formation potential



Oxidation flow reactor experiments & aerosol mass spectrometer analyses - RoPAX ferry

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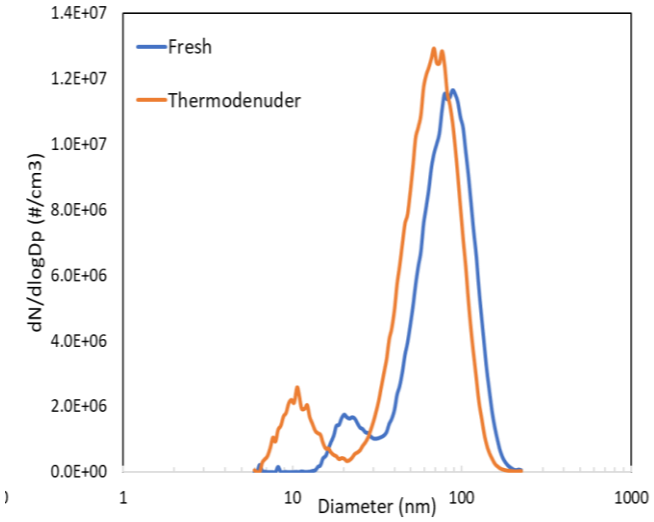
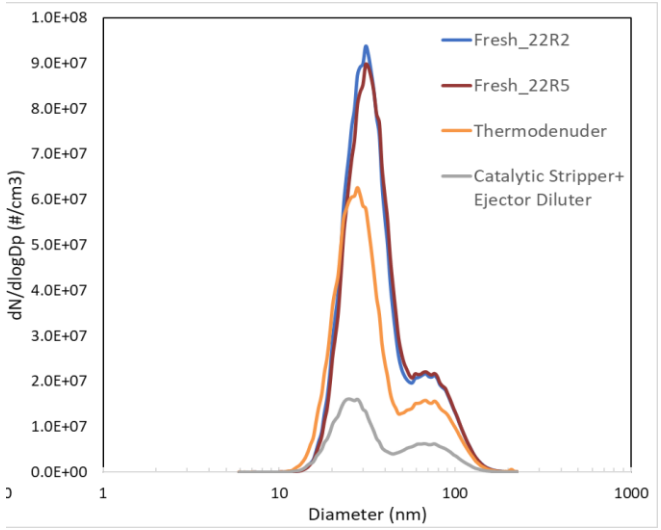
Particle size distribution

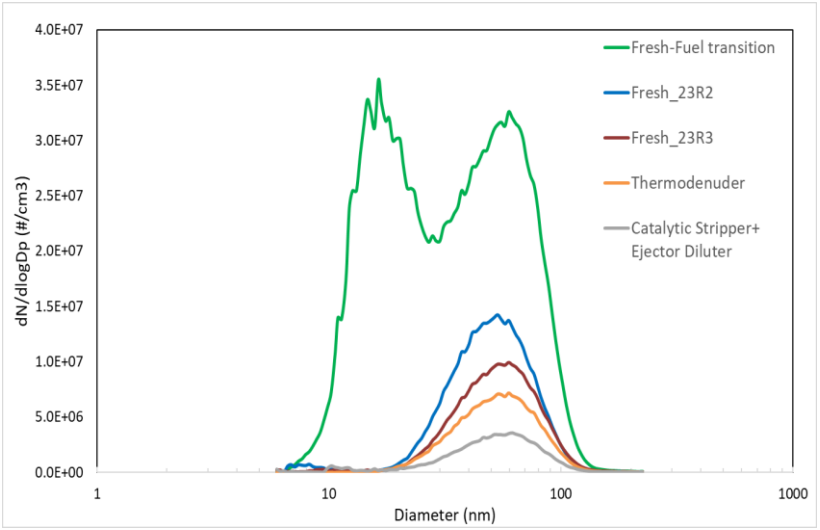
HFO upstream scrubber



HFO downstream scrubber



ULSFO downstream deactivated scrubber



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Conclusions

- **SCR:** Catalyst with urea reduced not only NOx but also CH_4 and other organic species, both volatile and non-volatile. While CH4 is reduced only under urea injection, the non-methane organic species (THC, VOC, PAHs, PM-bound OC) were reduced also when urea is switched off.
- **Methanol fuel**: Reduction of a number of emitted species was observed for the MeOH compared to MGO fuel: NOx by 70%, CH_4 by 40%, CO by 30%, SO_2 by 50%, PM mass and EC by 80% and OC by 70% and PAHs by 40%-60%. Decrease of NMVOCs and NMHCs emissions observed but at the same time an increase of THC emissions, most likely due to emission of HCHO
- **HFO fuel with scrubber**: Emissions of PM downstream the scrubber were significantly higher compared to emissions from ULSFO or MGO fuel observed during SCIPPER and EMERGE campaigns. Large difference in composition of PM emitted from HFO and ULSFO and from MGO. Findings regarding emission of PAHs are not conclusive due to large variation of the measured emissions most likely associated with influence of engine load on emissions. The upstream-scrubber emissions of PAHs are significantly higher than engine-out emissions from MGO fuel on the Ro-Pax ferry.
- **Impact of scrubber aftertreatment**: No reduction of PM or its compounds (soot, OC, sulphate) observed over the scrubber. Significant reduction of PAH observed.

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