

Briefing Note





What is EMERGE?

EMERGE is an innovative 4-year research project funded by the European Commission under the Horizon 2020 programme. The "EMERGE" acronym is short for "Evaluation, control and Mitigation of the EnviRonmental impacts of shippinG Emissions". The project is funded the Call "Ship emission control scenarios, marine environmental impact and mitigation". The project started in February 2020.

The challenge

New global standards were enforced on January 1st 2020 *for shipping emissions* as a consequence of their potentially significant health and environmental effects. The new limit for Fuel Sulphur Content (FSC) will be 0.5 %, a substantial decrease from the previously allowed maximum Fuel Sulphur Content of 3.5 %. In the so-called *Sulphur Emission Control Areas (SECAs)*¹, a stricter regulation of 0.1 % Fuel Sulphur Content has been in place since 1 January 2015. In Europe, these comprise the Baltic and North Seas and the English Channel.

In complying with the new global limit values, *ships are mandated to use fuel oil with Fuel Sulphur Content within the limits*. Alternatively, *vessels may be equipped with abatement systems - SO_x scrubbers - that decrease SO₂ in the exhaust to within the limits*. There are two main categories of scrubbers: closed- or open-loop. In open-loop scrubbers, acidic seawater is continuously discharged into the marine environment and in closed-loop ones, a smaller amount of "bleed-off" water is released. Scrubbing SO_x with large quantities of seawater, with consequent release of wash water to the sea, may lead to substantial deterioration of marine water quality (see *Figure 1*).

Figure 1: Ship smokestack and scrubber wash water emissions at the ship-air-water interface and their potential effects on atmospheric chemistry and marine ecosystems in the surface ocean.



Source: Endres, Sonja & Maes, Frank & Hopkins, Frances & Houghton, Katherine & Mårtensson, Eva & Oeffner, Johannes & Quack, B. & Singh, Pradeep & Turner, David. (2018). A New Perspective at the Ship-Air-Sea-Interface: The Environmental Impacts of Exhaust Gas Scrubber Discharge. Frontiers in Marine Science. 5. 10.3389.

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¹ Sulfur Emission Control Areas (SECAs) are sea areas in which stricter controls have been established to minimize airborne emissions from ships as defined by Annex VI [1] of the 1997 MARPOL Protocol. The emissions specifically include SOx, NOx, ODSs and VOCs and the regulations came into effect in May 2005.





There are limited data on the environmental toxicity of scrubber washwater. The main potentially toxic components in scrubber water are likely to include polycyclic aromatic hydrocarbons (PAHs) and metals and possibly combinations of these. Since metals are not metabolized, bioaccumulation is an indicator for predicting their toxicity. The International Maritime Organization (IMO) has called for studies focused on quantifying the environmental impacts of open-loop scrubbing (*Figure 2*). There is currently very limited quantitative information on the associated environmental effects.

Figure 2: Open-loop scrubber source: https://globaldata.com/. Combustion of fuels in ship engines results in a range of primary and secondary pollutants that have important environmental, health, economic and climatic impacts. Particulate matter (PM), SO_X, NO_X and O₃ exposures from shipping have been associated with an increase in morbidity and premature mortality rates. Gaseous SO_X emissions transform in the atmosphere to sulphate (SO₄) aerosol that poses a health risk to humans and acts as an acidification agent for terrestrial and aquatic environments (*Figure 1*). International shipping is also a contributor to global CO₂ (currently at approximately 2 % of the global CO₂ emissions, although this is likely to be an underestimate).

In addition, abatement measures for nitrogen oxides and PM may have secondary effects, as ammonia release and washwater may further influence the composition of emitted particles and organic matter. Developing a robust scientific overview of the environmental impacts of emission reduction technologies within the shipping sector remains a major scientific and societal challenge. This overview needs to include the impacts associated with secondary waste streams. Comprehensive evaluations, cost-efficient solutions, evidence-justified guidance and policy support are needed for the implementation of ship emissions abatement technologies.

EMERGE's objectives

EMERGE aims to:

- Quantify and evaluate the effects of potential emission reduction solutions for shipping in Europe for several scenarios; and
- Develop effective strategies and measures to reduce the environmental impacts of shipping.





In particular, the project will:

- Collect and synthesize experimental evidence on air emissions and waste streams from ships with potential emission control technologies;
- Develop an integrated modelling framework to assess the combined impacts of shipping emission control options on the aquatic and atmospheric environments;
- Deploy the modelling framework to assess the suitability, cost-effectiveness and impacts of a variety of shipping emission control scenarios to the marine environment; and
- Provide recommendations and guidance for stakeholders and decision-makers on the most suitable, effective and cost-beneficial options to significantly reduce marine pollution.

EMERGE's aims and objectives will be achieved through real-world test cases involving measurements and modelling on actual vessels, along main shipping routes and in sensitive European marine regions. The project will collect and synthesize experimental evidence on waste streams to water and emissions to air originating from ships, for different emission control technologies. The project's measurements will focus on abatement techniques and will include emissions to, and concentrations in water, air and marine biota. EMERGE will especially investigate how the use of available scrubbers will influence the marine environments, human health and climate change.

In the framework of the project:

- *Five geographical case studies will be conducted in different ecologically vulnerable regions*
 - (i) Eastern Mediterranean (including the Port of Piraeus)
 - (ii) Northern Adriatic Sea (including the Port of Venice)
 - (iii) the region surrounding the Lagoon of Aveiro in Portugal
 - (iv) the Solent Strait (including the ports and cities of Southampton and Portsmouth in the UK)
 - (v) the Öresund Strait (between Sweden and Denmark)
- A mobile onboard case study will be also deployed in various European sea regions







EMERGE's value proposition

The researchers working on EMERGE will systematically analyze the complex interactions between technological options, pollutant emissions and dispersion, and the environment. It will follow a unique and ground-breaking approach. The project will evaluate the full chain of processes, including:

- (i) Emissions and discharges from single ships;
- (ii) Dispersion of effluents in water and in the atmosphere;
- (iii) Environmental and other impacts; and
- (iv) The cost-effectiveness of the mitigation options.

The original work that will arise from the EMERGE project is summarized below:

• EMERGE will -for the first time- internationally *apply a wide spectrum of ocean circulation, biogeochemical, oil-pollution and bioaccumulation models in an integrated manner.* This integrated modelling framework will be used to assess the combined impacts of shipping emissions on the aquatic and atmospheric environments, and the effects on marine ecosystems. The assessment will include the benefits and costs of control and mitigation options affecting water quality, air pollution exposure, health impact, climate forcing and bioaccumulation of pollutants (see *Figure 3*).



Figure 3: Schematic representation of the various emissions of ships to water and air, together with their measurement and modelling. EMERGE will focus especially on the various emissions related to the use of scrubbers.

Source: EMERGE Consortium





- The project will make innovative use of earth monitoring data, with respect to shipping pollution in water and air. It will substantially improve the capabilities of the most advanced satellite observations on monitoring ship emissions and use those observations in combination with model predictions and ground-based observations.
- It will use new analytical beyond state-of-the-art techniques for the scrubber water contents. In particular, it will perform novel multivariate analysis of the contents in the scrubber washwater in order to pinpoint the compounds, which alone or in combination with other compound may contribute most to the detected toxicity.
- It will refine the ship emission model STEAM. The model will be extended to also include the effects of weather on ship performance (i.e. impacts of sea ice cover, wind, waves and surface currents). To date, this has not been undertaken in any of the published ship emission models. All the water circulation and quality models will be also interfaced with STEAM. This is a new concept, which has not been used in previous research; it will result in groundbreaking, harmonized results on water and air pollution originated from shipping in Europe. EMERGE will also refine the STEAM inventorying for in-port activities, and interface STEAM data with various oceanic models.
- EMERGE will substantially exceed the state-of-the-art analysis of hazardous substances, using advanced mass spectrometry tools. This will enable more accurate ecotoxicological observations and an improved identification and prioritization of the most relevant pollutants.
- *EMERGE will develop a set of conceivable scenarios to describe the impacts of shipping in the future.* This work will go substantially beyond previous research and exceed the state of the art.
- It will develop a new user-friendly assessment tool to be used by stakeholders and decision makers, to analyze efficiently the cost-efficiency of various abatement strategies and scenarios. Such a tool is not currently available.
- EMERGE will provide recommendations and guidance for stakeholders and decision-makers on costbeneficial options for sustainable use of shipping on the medium and long term.

It is worth noting that the project is highly inter- and cross-disciplinary in character, engaging scientists and researchers from various disciplines and with a unique combination of scientific, technical, management and communication skills. *Given its knowledge, experience and innovative techniques, methods and tools, the EMERGE consortium will be able to model real world emissions of shipping to air and water, pollutant concentrations and the impacts on the environment, public health and climate for the whole of Europe.*







Who we are

18 Organizations







Join the EMERGE Information Network!

EMERGE is open to all stakeholders globally with an interest in marine and maritime technologies, research and innovation as well as environmental protection. By becoming part of our Information Network, you are joining one of the most innovative projects in the marine and maritime field and have the possibility to:

- Shape and contribute to the research work and priorities of the project;
- Be the first to know about critical research results and innovative technologies, tools and methods;
- Take advantage of technology commercialization possibilities;
- Co-design, and develop activities for mutual benefit;
- Develop solutions for your problems, products and services, by capitalizing on the project's research and technology results, tools and methods;
- Find new partners for your activities.





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