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Citation for the original published paper (version of record):
Hassellöv, I., Murray, C., Bailey, S. et al (2025). Editorial: Shipping pressures and impacts on the marine environment. Frontiers in Marine Science, 12. http://dx.doi.org/10.3389/fmars.2025.1615830

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frontiers | Frontiers in Marine Science

TYPE Editorial
PUBLISHED 29 May 2025
DOI 10.3389/fmars.2025.1615830

Check for updates

OPEN ACCESS

EDITED AND REVIEWED BY
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RECEIVED 21 April 2025
ACCEPTED 15 May 2025
PUBLISHED 29 May 2025

CITATION
Hassellöv I-M, Murray CC, Bailey S, Ytreberg E and Lehikoinen A (2025) Editorial: Shipping pressures and impacts on the marine environment. *Front. Mar. Sci.* 12:1615830. doi: 10.3389/fmars.2025.1615830

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Editorial: Shipping pressures and impacts on the marine environment

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KEYWORDS

shipping, AIS automatic identification system, pollution, scrubber (exhaust gas cleaning systems), underwater noise, non-indigenous species, carbon capture and storage (CCS)

Editorial on the Research Topic
Shipping pressures and impacts on the marine environment

Maritime shipping plays a pivotal role in the global economy and 80 percent of the international trade volume is, at some point, transported on a ship (UNCTAD, 2024). Since the mid-1970s until early 2020s the seaborne trade volumes have more than tripled (UNCTAD, 2023), with concurrent increases in shipping pressure on the marine environment, stimulating research within the marine sciences community. Although shipping is often considered an energy efficient mode of transport, it is well known that every ship gives rise to a range of pressures on the marine environment, from biological, to chemical, and energy pollution (e.g., Hannah et al., 2020; Jalkanen et al., 2021). This Research Topic covers investigations of all these pressure types, while also addressing regulatory and policy aspects. In addition, the Research Topic can inform future development, e.g. the opening of new shipping routes in the Arctic, providing support on how to prevent or minimize shipping pressures and impacts in the area.

Ballast water is recognized as a major vector for the spreading of non-indigenous species and the related research efforts continue to be extensive (Bailey, 2015). Yet, Costa-Areglado et al. conclude that the level of available information is highly variable among geographic areas, taxa and habitats; the southern hemisphere being generally underrepresented. The pattern is further exaggerated when considering studies including *in situ* ballast water sampling, and therefore the need for systematic *in situ* measurements across regions was highlighted. These conclusions align with the research conducted by Outinen et al. Their onboard sampling results revealed that while the performance standard for indicator microbes was satisfactory for nearly all ships, almost half of all samples were not compliant with respect to the limit for the ≥50μm-sized organisms. Further, the compliance did not show significant improvement over time, stressing the need for technological and operative advancements to improve the overall reliability of ballast water management and minimize negative impacts on the marine environment.

In addition to ballast water, ships can also transport non-indigenous species in other parts of the ship, including the hull, sea chest, and cargo (Ojaveer et al., 2018). Menéndez-Teleña et al. examined the Global Invasive Species Database to compare the contribution of

hull fouling and dry ship compartments (containers) to successful invasions in marine and terrestrial environments of the Bay of Biscay. Results suggested that fouling transported a higher diversity of invasive species while dry containers were linked to terrestrial invasions (Menéndez-Teleña et al.). To mitigate hull fouling introductions, in-water cleaning (IWC) of the submerged surfaces of ships can remove fouling organisms and reduce the risk of invasion, however (Scianni et al.) show that IWC can also release biocides and microplastics, unintended negative outcomes that must be carefully weighed when choosing mitigation strategies.

Another onboard system that may negatively impact marine ecosystems is exhaust gas cleaning systems, also known as scrubbers (Hassellöv et al., 2020). The majority of published studies have focused on the most common form of scrubbers, so-called open loop, where seawater is pumped onboard, sprayed over the exhausts, and then continuously discharged back to the sea (e.g., Koski et al., 2017; Picone et al., 2023). An increasing number of countries have introduced restrictions against discharge of the acidifying and toxic open-loop scrubber water (NorthStandard, 2025) and in response more ships are expected to use closed-loop scrubbers, where the wash water is recirculated and discharged at a slower rate. However, Jönander et al. showed that short-term exposure to closed-loop scrubber water impaired copepod reproduction, decreased mesozooplankton predation on microzooplankton, and altered the community biodiversity. These results suggest that discharge of closed-loop scrubber water should also be restricted.

When estimating the intensity or volumes of environmental pressures from shipping, AIS-data (Automatic Identification System) combined with emission factors of both gaseous emissions, and liquid discharge such as scrubber effluent, is a common approach, generating spatiotemporal pressure maps (e.g., Jalkanen et al., 2021). Focusing specifically on the AIS data from fishing vessels, Ferrà and Scarcella assess the status and effectiveness of area-based conservation measures with respect to bottom trawling in the Adriatic Sea. In 73 percent of the areas where trawling is prohibited, the analyses showed full compliance, yet trawling activities were recorded in 149 out of 549 managed areas. In addition, Ferrà and Scarcella noted that the statistics may be an underestimate as AIS-equipment is mandatory only for European fishing vessels with a length overall (LOA) exceeding 15 m, and there are many smaller vessels and non-EU vessels operating in the area.

The recognition of shipping as one of the main contributors to underwater noise has led to increased awareness in the design of new builds, to strive for more silent propellers and propulsion (Duarte et al., 2021). Possenti et al., however, highlight additional challenges such as the importance of changing sound propagation properties of seawater following decreased ocean pH due to climate change, which can lead to the appearance of new ducts (sound channels) making specific depths noisier. In addition, accelerating ice melting is expected to open new shipping routes in the Polar regions which will also increase the ship-generated noise in these areas and may require additional regulatory considerations.

The shipping sector will play a crucial role in the diverse transportation and management processes of Carbon Capture and Sequestration (CCS), which has been recognized as an important approach to combat climate change (Argüello and Bokareva). Argüello and Bokareva mapped existing legal instruments applicable to the sequestration of CO_2 in the sub-seabed, and the transboundary transportation by ships, highlighting the need for a comprehensive legal framework covering all stages and sectors of the process. Such a framework will need to include both public and private law as, for example, the prevention of pollution is handled within public law issues, while division of obligations and liabilities between various parties and limitation of liability for maritime claims are handled within private law.

In summary, the article collection of the Research Topic, Shipping Pressures and Impacts on the Marine Environment, contributes to the improved scientific understanding and future needs to reduce adverse impacts from the maritime transport sector. The findings can assist competent authorities at national, regional and global levels in guiding shipping towards improved sustainable performance, aligning with the global UN strategy to support healthy and productive oceans (IOC, 2020).

Author contributions

I-MH: Writing – original draft, Writing – review & editing. CM: Writing – original draft, Writing – review & editing. SB: Writing – original draft, Writing – review & editing. AL: Writing – review & editing, Writing – original draft. EY: Writing – original draft, Writing – review & editing.

Conflict of interest

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