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Maritime Transportation: Let's Slow Down a Bit

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Discussion

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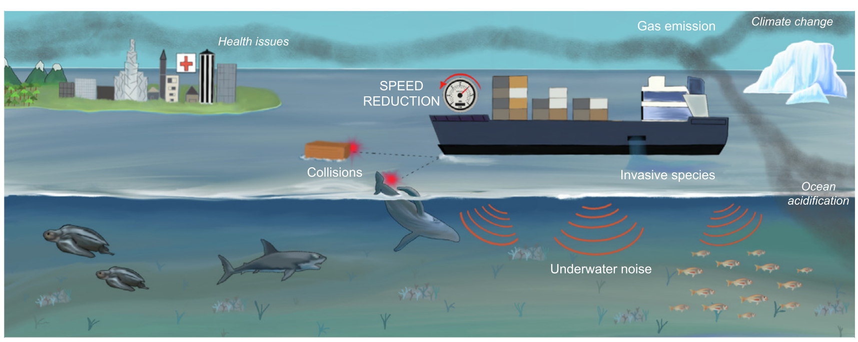
GRAPHICAL ABSTRACT



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ABSTRACT

Maritime transportation is a major contributor to the world economy, but has significant social and environmental impacts. Each impact calls for different technical or operational solutions. Amongst these solutions, we found that speed reduction measures appear to mitigate several issues: (1) collision with wildlife; (2) collision with non-living objects; (3) underwater noise; (4) invasive species; and (5) gas emission. We do not pretend that speed reduction is the best solution for each individual issue mentioned in this paper, but we argue that it could be a key solution to significantly reduce these threats all together. Further interdisciplinary research is required to balance private economic costs of speed reduction measures with environmental and social benefits emerging from all mitigated issues.

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1. Introduction

Maritime transportation is a cornerstone of the world economy. Shipping accounts for more than 90% of global trade, and commercial shipping keeps on increasing (UNCTAD, 2020; Walker et al., 2018). However, shipping creates negative environmental (e.g., collision with wildlife, chemical and noise pollution) and socio-economic (e.g., human mortality due to pollution) externalities. Two kinds of solutions are considered to mitigate adverse impact: technical and operational solutions. Technical solutions rely on new ship designs to reduce the risk of externalities, whereas operational solutions consist of modifying how ships navigate.

Each externality calls for different technical or operational solutions, but speed reduction appears to be solving – or at least mitigating – many of the maritime transportation externalities, namely; (1) collision with wildlife; (2) collision with non-living object; (3) underwater noise; (4) invasive species; and (5) gas emission. This paper proposes a synthesis of the potential impact of speed reduction on the aforementioned externalities and proposes to consider this measure as a way to reduce all together these externalities.

2. Speed reduction vs. shipping social and environmental impacts

2.1. Collisions with wildlife

Collisions are one of the most directly observable impact of shipping on wildlife (Jung and Madon, 2020). Whale-ship collision is the most broadly studied interaction. For instance, whale-ship collisions are believed to kill around 80 whales on the US West Coast each year (Rockwood et al., 2017). This figure represents only a small fraction of the overall impact of whale-ship collisions, which has not yet been estimated by a specific study, but may amount to several thousand deaths worldwide. The survival of some whale populations is threatened by these events (e.g., North Atlantic right whale or humpback whales around the Western Antarctic Peninsula or in waters off California; Pallin et al., 2018; Rockwood et al., 2020). Other species are at risk, such as sea turtles, sharks, dugongs, or pinnipeds, but the level of threat is less well-defined (Hazel et al., 2007; Schoeman et al., 2020). Vessel speed plays a key role in collisions and their related consequences (Ataman et al., 2021; Schoeman et al., 2020; Vanderlaan and Taggart, 2007). Reducing speed leads to a significant decrease in the probability of collision and wildlife-related lethal injury (García-Cegarra and Pacheco, 2019; Schoeman et al., 2020). Leaper (2019) found that a worldwide speed reduction of 10% decreases the ship strike risk by 50% for whales.

2.2. Ship collisions with non-living objects

Ships also collide with non-living objects. Collisions occur with other ships, sea bottom (i.e., grounding), and unidentified floating objects (UFO; e.g., container, log). These events can lead to human injury – and fatalities –, as well as oil spills (Eleftheria et al., 2016). Between 2007 and 2017, 759 collisions occurred, leading to 253, 43 and 27 cases of injuries, deaths and oil spills, respectively, according to the Global Integrated Shipping Information System (i.e., International Maritime Organization (IMO) casualty event database). Oil spill causes many environmental issues. For instance, sediment and water pollution affect the biota on cellular, biochemical and physiological levels (Abdulla and Linden, 2008). While the speed reduction effect on the occurrence of these collisions is case-specific (Zhang et al., 2019a), reduced speed has a significant impact on the severity of these events (IMO, 2008; Zaman et al., 2015). In the U.S., reduced-speed zones exhibited 47.9% less collision between ships than conventional areas (Chang and Park, 2019). Changes in grounding occurrence with reduced speed are not conclusive, but significant decreases regarding the severity of the impact have been noticed (Youssef and Paik, 2018). Similarly, the speed is directly related to the severity of the impact with UFOs (Zaman et al., 2015). From a societal standpoint, reducing speed could lead to reduced crew injuries – and even fatalities (Sèbe et al., 2020; Zhang et al., 2019b).

2.3. Underwater noise

Maritime transportation produces 90% of the marine anthropogenic noise (Panigada et al., 2008). Shipping-related noise mainly originates from machinery, propellers, and cavitation. The ship speed usually increases the radiated noise (Audoly et al., 2017). The noise can affect many marine species, such as amphibians, arthropods, birds, fishes, mammals, molluscs, and reptilians (Kunc and Schmidt, 2019). Ship noise does not result in acute or lethal effects, but can have significant long-term impacts at the population or stock level (Panigada et al., 2008). Masking and disturbances from ship noise impact biologically important activities (e.g., feeding, birth, or mother-young bonding), which in turn may affect longevity, growth, and reproduction (Panigada et al., 2008). Furthermore, long-term exposure to low-intensity sounds may cause hearing loss, which will affect species relying on acoustic to survive (e.g., marine mammal; Panigada et al., 2008). Shipping noise, associated with other anthropogenic noises, may also impact marine flora such as seagrass, by altering plants on a cellular level and causing them to uproot themselves (Solé et al., 2021). The literature shows a direct relationship between speed and noise (McKenna et al., 2013; Zobell et al., 2021). Leaper (2019) concluded that a 10% speed reduction would reduce the total sound energy from shipping by around 40% on the global scale. To be noted, ships concerned with speed reductions should be chosen carefully, as these measures can have opposite effects depending on propeller designs (Leaper, 2019), and as half of ship noises come from 15% of the world fleet (Veirs et al., 2018).

2.4. Invasive species

Shipping activity also contributes to ecosystem degradation through the introduction of invasive species. Ballast waters and hull biofouling are the primary vectors of invasion (Davidson et al., 2018). These ships-related ever-growing introductions of alien species have a higher potential of altering ecosystems than climate change (Sardain et al., 2019) and are a threat to biodiversity (i.e., species homogenisation; Bellefontaine et al., 2010). Alien species can also have human health consequences, such as paralytic shellfish poisoning or cholera infection (O'Brien, 2016). de Castro et al. (2017) defined this issue as out of control. Reducing speed would lengthen voyage duration, which is negatively correlated to larva survival rate and related establishment rate for species introduced by ballast waters (Davidson et al., 2018; van der Meer et al., 2016). However, speed reduction measures need to be well thought, as speed reduction positively affects biofouling species survival rate (Coutts et al., 2010; Davidson et al., 2009).

2.5. Gas emissions

Gas emission from ships is one of the major concerns of the international maritime community. As an illustration, if shipping were a country, it would be the 6th largest producer of greenhouse gas (Eide et al., 2009). Shipping also emits oxide compounds (e.g., SOx and NOx) and a significant amount of particulate matter (PM). SO_2 emissions are around three-fold greater than that from all road traffic and aviation combined (Endres et al., 2018) and contribute to ocean acidification with NOx. This last compound affects the productivity of pelagic phytoplankton in offshore regions (Endres et al., 2018). SOx and NOx also impact terrestrial habitats and biodiversity, through atmospheric deposition (e.g., acidification of grasslands; Wright et al., 2018). PM is responsible for increased human mortality and morbidity, primarily via cardiovascular and respiratory diseases (i.e., several thousand cases per year; Brandt et al., 2013). According to various authors, the large dispersal of PM contributes to more than 50,000 chronic deaths per year due to cardiopulmonary and lung cancers. To oversimplify, greenhouse gases contribute to climate change, oxide compounds to ocean acidification and PM to human health issues. The relationship between the ship speed and fuel consumption – and the related emissions – is almost cubic (i.e., consumption is proportional to speed cubed; Leaper, 2019). Reducing speed is, therefore, one of the most effective solutions to reduce emissions (Aronietis et al., 2014; Psaraftis et al., 2009; Seediek and Transport, 2015). A 10% speed reduction across the global fleet would reduce greenhouse gas by around 13% and improve the probability of meeting greenhouse gas emission targets by 23% (Leaper, 2019). Lack et al. (2011) showed that a 45% speed reduction around the California coast led to ~55% decreased SOx and PM emissions, and Beecken et al. (2015) demonstrated a 12% reduction in NOx with a 10kn speed limit in the Neva Bay (Russia). Similar to invasive species and underwater noise, speed reduction measures to lower exhaust emissions should be well thought. Some authors argue that shipping-related SOx emissions contribute to the global cooling effect (Fuglestvedt et al., 2009); thus, reducing this compound would be an obstacle to reaching the Paris Agreement climate change target.

3. The lack of integrated assessment

The economic impact is usually a limiting factor to the implementation of speed reduction measures. Speed limitation can rise other types of costs (e.g., insurance, stock management in ports; Ben-Hakoun et al., 2016) or security issues (e.g., escaping pirates, control in harsh weather; Lindstad et al., 2011). At the ship level, decisions regarding speed are not always cost-efficient, implying positive utility in increased speed (Lindstad et al., 2011). At the global level, this measure significantly impacts transportation logistics and may have knock-on effects on global trade (Psaraftis, 2019a). When considering the environmental benefits of speed reduction, research is often concentrated on the question of greenhouse gas emission as an extension of fuel consumption optimization problems (e.g., Psaraftis and Kontovas, 2013; Tillig et al., 2020; Wen et al., 2017). This vision fails in considering the entire range of potential benefits from speed reduction as detailed in this paper.

To avoid changing their logistics, the shipping companies attempt to solve the aforementioned issues by investing in technological solutions before considering speed reduction. Shipping companies advocate for Automatic Identification System-based solutions, detection technologies or even propeller guards to reduce collisions, even if the maturity or the effectiveness of such solutions are not proven for wildlife-ship strikes (Huang et al., 2020; Schoeman et al., 2020). Modifying ship design to reduce noise is often proposed (e.g., by changing hull girder spacing, hull thickness or double hull; Audoly et al., 2017). Several devices exist to process ballast water and prevent the introduction of alien species by using chemical, electrochemical, filtration or even UV processes (Tsolaki and Diamadopoulos, 2010). To reduce gas emissions, the shipping industry is working on end-of-pipe solutions (e.g., exhaust gas cleaning systems) or alternative fuels (e.g., Liquefied Natural Gas (LNG) or Hydrogen; Endres et al., 2018; Zis et al., 2016). It should be noted that even if the rewards of a successful technology can be high, the risks are also significant. For instance, LNG has been considered the most promising solution to emissions and significant investments in this fuel occurred in the last decade. Recent research put some shades on this technology due to environmental side-effects (e.g., methane "slips"; IMO, 2020; World Bank, 2021), which might penalize LNG early adopters. Technical solutions usually require high punctual investment cost, but low operational expenditures (Fun-sang Cepeda et al., 2019). Consequently, they would have a lower impact on the global transportation industry than speed reduction. However, here again, there is no integrated vision of these impact.

The existence of potential hidden costs should not overtake the other potential benefits from speed reduction as detailed in this paper. The cost of reducing speed compared to the benefit of one of the issues mentioned is usually high, but might be lowered by integrating the benefits from reducing all these externalities. Further interdisciplinary research is therefore required to balance private economic costs and environmental and social benefits of speed reduction. In this perspective, research can also concentrate on the design of effective institutional arrangements to operationalize measures such as speed reduction (see e.g., Merchant, 2019). For instance, the implementation of differentiated port dues for slowing down ships is an option that could succeed if all countries and ports abide (Mjelde et al., 2019). Some shipping industry stakeholders are favourable to such global actions as reflected by an open letter of more than 100 shipping companies to the IMO asking for the implementation of international regulations on speed reduction (Psaraftis, 2019b). Though, the IMO negotiations on speed limitation schemes are slow, and once again, primarily directed to mitigate shipping emission without integrating the other benefits described in this paper.

4. Conclusions and recommendations

We do not pretend that speed reduction is the best solution for each individual issue mentioned in this paper, but we argue that it could be a key solution to significantly reduce these threats all together. With that in mind, we recommend that stakeholders involved in one of the issues mentioned in this study should support speed reduction discussions brought by other stakeholders. For example, discussions exist at the IMO level to implement speed reductions – or to prompt them through market-based measures – to reach greenhouse gas targets (IMO, 2021; Psaraftis, 2019a). The International Whaling Commission can use its observer status at the IMO (Wright et al., 2016) to steer discussions in the right direction, benefiting whale conservation.

We advocate for further interdisciplinary studies and projects on speed reduction that integrate the entire range of social and environmental implications to provide a comprehensive overview to decision-makers in the shipping industry. Investments in new technologies to mitigate a given social and environmental issue have for a long time been favoured as operational costs of speed reduction were too high. Tough, the integration of all the mitigated impact of speed reduction might lower the overall cost of this measure.

CRediT authorship contribution statement

Authors	Contribution
Maxime Sèbe	Conceptualization; Funding acquisition; Investigation; Project administration; Supervision; Validation; Visualization; Writing - original draft; Writing - review &editing
Pierre Scemama	Conceptualization; Validation; Writing - review &editing
Anne Choquet	Conceptualization; Validation; Writing - review &editing
Jean-Luc Jung	Conceptualization; Validation; Writing - review &editing
Aldo Chircop	Conceptualization; Writing - review &editing
Phénia Marras-Aït Razouk	Conceptualization; Writing - review &editing
Sylvain Michel	Conceptualization; Writing - review &editing
Valérie Stiger-Pouvreau	Conceptualization; Writing - review &editing
Laura Recuero-Virto	Conceptualization; Writing - review &editing

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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