Ships, whales and dolphins: towards a better cohabitation

Reflections on threats from collisions, underwater noise and pollution

An ever growing fleet…

The merchant fleet includes ships carrying cargo or passengers. It encompasses many different types of ships of various size that can be classified into different categories: general cargo ships, tankers (carrying liquids), bulk carriers (carrying bulk cargo such as coal, grain), container ships, ferries, cruise ships, etc.

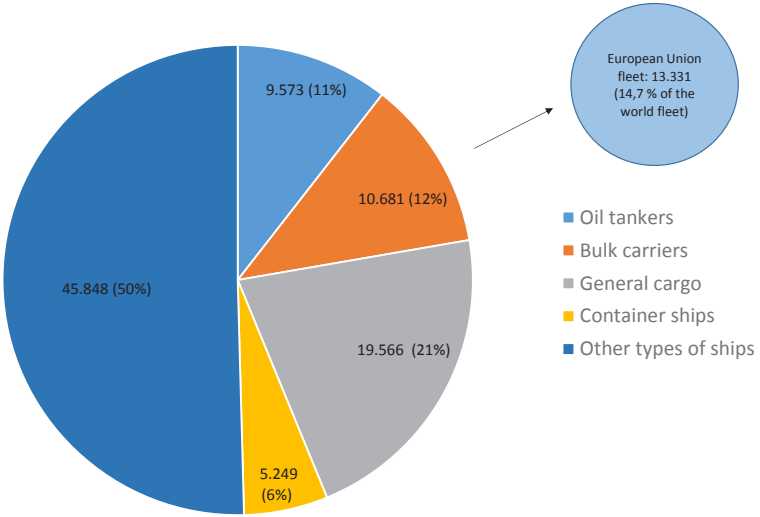

Figure 1 World Fleet: Ship Types

The development of worldwide trade over the last decade has been accompanied by a steady increase of the world fleet: it is now made up of 89.464 vessels[1]. Moreover, ship speed and size tended to increase for most categories of ships because companies aim at economies of scale. The largest commercial vessels are crude tankers, bulk carriers and container ships while cruise ships and ferries have reached unprecedented sizes, too.

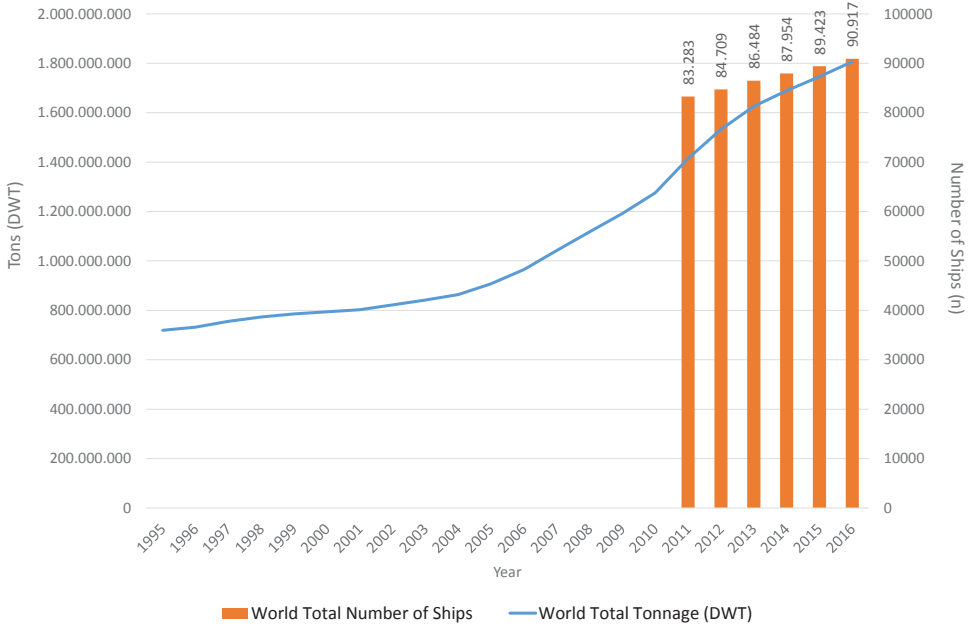

Figure 2 World Merchant Fleet Evolution

1. Statistics from UNCTAD (http://unctadstat.unctad.org/wds/TableViewer/tableView.aspx).

Consequently, there are ever more numerous, faster and larger ships travelling on the seas. European seas are particularly busy areas: there are 400.000 commercial ship movements per year in the North Sea and 220.000 in the Mediterranean Sea[2]. The amount of shipping from the North Sea to the Baltic via the Kiel Canal is also very intense with 47.000 ship movements per year. The English Channel is one of the busiest seaways in the world with 150 passing ships and 300 ferry crossings each day! The busiest single ferry route in Europe in terms of the number of departures is located between Denmark and Sweden (one departure every 15 minute). In some European seas, ferries represent an important part of the shipping industry[3].

2 ASCOBANS Document AC17/Doc.6-06 (2011): Risk Assessment of Potential Conflicts between Shipping and Cetaceans in the ASCOBANS Region (http://www.ascobans.org/sites/default/files/basic_page_documents/AC18_6-04_rev1_ProjectReport_ShipStrikes.pdf); IUCN Document: Maritime traffic effects on biodiversity in the Mediterranean Sea (Volume1), edited by A. Abdulla and O. Linden, 2008, p. 33.

3 ASCOBANS Document AC17/Doc.6-06 (2011): Risk Assessment of Potential Conflicts between Shipping and Cetaceans in the ASCOBANS Region (http://www.ascobans.org/sites/default/files/basic_page_documents/AC18_6-04_rev1_ProjectReport_ShipStrikes.pdf); IUCN Document: Maritime traffic effects on biodiversity in the Mediterranean Sea (Volume1), edited by A. Abdulla and O. Linden, 2008, p. 12.

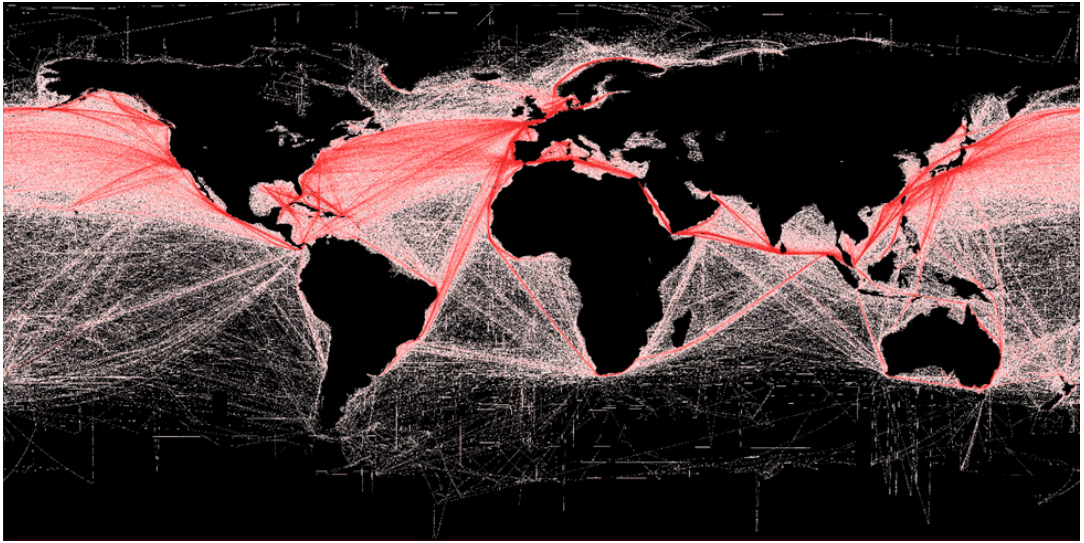

Figure 3 Shipping Routes in the World

(Source refs: Halpern, B.S., et al. 2008. A Global Map of Human Impact on Marine Ecosystems. Science 319(5865):948-952; B.S. Halpern (T. Hengl; D. Groll) / Wikimedia Commons / CC BY-SA 3.0)

… which impacts on whales and dolphins…

Ship strikes

The number of reported collisions between cetaceans and vessels has kept increasing over the last decades. This follows the intensification of the marine traffic and the increasing speed of ships. Ship strikes can be fatal or inflict mutilations, serious wounds or trauma. Many cetaceans get killed while others are mutilated or so seriously injured that they die afterwards. Evidence shows that ship strikes are a substantial cause of mortality for cetaceans. For some whale populations, ship strikes account for up to one third of the known fatalities. The International Whaling Commission launched a global database in 2009 which now holds around 1200 records[4]. However, it is impossible to know the exact number of ship strikes: many collisions are unreported or even unnoticed, and the bodies of dead animals often drift away and sink. Even if the collision is observed, the struck animal's fate is often unknown and an injured whale may later die from its wounds.

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All ship types are potentially dangerous, whatever their size or speed. Ferries, cargo ships, cruise ships, and navy ships have all been involved in strikes with cetaceans. Even whale watching vessels and sailing boats can be dangerous for cetaceans, especially the fastest ones (for example during ocean races).

4 https://iwc.int/ship-strikes

There is evidence that speed and size are determining factors for injury and fatality rate of collisions: from 10 knots (18,5 km/h), the risk of fatality increases dramatically with speed. But even a so-called "slow ship" can still be dangerous from a cetacean's perspective. Most of lethal collisions and serious injuries occurred at a speed of 14 knots (25,9 km/h)[5] or more. Many ships are much faster for example, fast ferries can travel at around 37 knots (68,5 km/h). The faster the ship, the shorter the time to spot a whale in the way and react so as to avoid the animal. Ship size is also an important factor because large ships cannot manoeuver to avoid whales.

Collisions may also be linked with noise. Indeed, the constant background noise produced by the ships traffic may prevent whales from hearing approaching ships: either they are used to the noise and do not react to approaching vessels or there is simply too much noise to detect an approaching ship. Whales may also suffer hearing impairments from high level of underwater noise.

All cetacean (whales and dolphins) species are at risk. However, ship strikes are most commonly reported for large whales. In the North Sea and Bay of Biscay, ships strikes involve many different species such as minke whales and fin whales, but also smaller species such as common dolphins and harbour porpoises[6]. In the Mediterranean Sea, fin whales and sperm whales are the most commonly reported struck[7]. The most well known example of a ship strike conservation problem is the North Atlantic right whale, which is one of the most endangered whale species with a total population estimated to less than 500 individuals (with around 35% of known fatalities caused by ship strikes)[8].

5 F. Ritter, Collisions of Vessels with Cetaceans: how to mitigate an issue with many unknowns.

6 ASCOBANS Document AC17/Doc.6-06 (2011): Risk Assessment of Potential Conflicts between Shipping and Cetaceans in the ASCOBANS Region (http://www.ascobans.org/sites/default/files/basic_page_documents/AC18_6-04_rev1_ProjectReport_ShipStrikes.pdf)

7 IUCN Document: Maritime traffic effects on biodiversity in the Mediterranean Sea (Volume1), edited by A. Abdulla and O. Linden, 2008, p. 12.

8 F. Ritter, Collisions of Vessels with Cetaceans: how to mitigate an issue with many unknowns.

Ocean noise

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Cetaceans rely on hearing to investigate their surroundings just as humans use their eyes, for communication, orientation, feeding, mating and identification of threats. Hearing abilities vary between species but the total hearing range covered by cetaceans ranges from 10 Hz to 150 kHz (while humans can only hear sounds between 20 Hz and 20 kHz)[9]. Over the last decades, human activities have caused a substantial increase in the noise levels in the ocean. Noise pollution is caused by military activities, marine seismic surveying, offshore platforms, construction of offshore wind farms and (commercial and leisure) maritime traffic.

Military activities and seismic surveys produce acute noise that can have direct and sometimes traumatic consequences for cetaceans, causing (temporary or permanent) hearing loss, injuries and, as a possible consequence, strandings.

Other activities produce a continuous background noise on a low-frequency range often used by large whales for communication[10]. Shipping traffic accounts for 90% of underwater

9 Nummela (S.), « Hearing », Encyclopedia of Marine Mammals, dir. W. Perrin, J. Thewissen, et B. Würsig, 2e éd., San Diego, Academic Press, 2009, p. 556 to 558.

10 IUCN Document: Maritime traffic effects on biodiversity in the Mediterranean Sea (Volume1), edited by A. Abdulla and O. Linden, 2008, p. 12.

noise pollution, causing a continuous and ubiquitous background noise[11]. Underwater noise pollution has many consequences for cetaceans, affecting their survival, reproduction or disease resistance. It causes stress and prevents them from communicating with each other and can drive them away from migration routes or feeding areas.

There are still uncertainties about which ship types or sizes are the noisiest. Indeed many variables have to be taken into account: speed, ship size, weather conditions, etc. Small ships (general cargo ships for example) can be as noisy as much larger ships. Moreover, there is good evidence showing that speed increases noise level for most propeller types.

The main sources of noise in a ship are the propellers and the machinery. The noise produced by propellers is caused by cavitation: bubbles created by propellers collapse and burst in water. The level of noise depends therefore more on the design of the hull and propellers than on the ship type. Sometimes, the age of a ship can have an impact because new ships design emphasizes on fuel efficiency, which tends to favour quieter ships. Speed also has an impact on the noise level and reducing a ship's speed would generally help to decrease noise levels.

Ocean pollution

Marine mammals accumulate high levels of pollutants in tissues such as their blubber and their liver because of their extended life span, and their fat store in which lipophilic compounds concentrate. Anthropogenic compounds such as the polychlorinated biphenyls (PCBs), various pesticides and flame retardants have been detected not only in a large number of coastal species such as the harbour porpoise but were also described in oceanic species including the sperm whale[12].

11 IUCN Document: Maritime traffic effects on biodiversity in the Mediterranean Sea (Volume1), edited by A. Abdulla and O. Linden, 2008, p. 12.

12 LAW (R. J.), An overview of time trends in organic contaminant concentrations in marine mammals: Going up or down?, 2014, Marine Pollution Bulletin 82: 7-10.

Many anthropogenic compounds and solid waste are associated to maritime activities including oil, detergents, marine debris, plastics, acidic and alkali substances leaching from battery and vessel cleaning products, trace metals (zinc, copper) in antifouling paints.

Anti-fouling paint as a category of underwater coatings are applied on the hull of a vessel to prevent colonization by aquatic organisms *e.g.* plants, algae or animals (like barnacles) therefore affecting the performance of the vessel. Antifouling paints must be in compliance with emerging regulations as demanded by the IMO (International Maritime Organization[13]), because many of their compounds are toxic to coral reefs, non-target marine algae and a wide variety of aquatic organisms.

Tributyltin (TBT) is a toxic agent used in antifouling paint, banned by the International Convention on the Control of Harmful anti-fouling systems on ships in 2001. It is a well-known endocrine disruptor, especially in invertebrates and can also affect the immune system as demonstrated by *in vitro* studies on marine mammals. Since the ban was put in place, measured concentrations have declined and the percentage of animals in which TBT was detected has fallen sharply. Despite the ban by 73 states (including the EU), TBT is still used in many countries and can be detected in the tissues of marine mammals. In Brazil for instance, the use of TBT as an antifouling agent is forbidden whereas its production and commercialization is still allowed[14].

Copper (Cu) is now one of the principal biocides of many antifouling mixtures and represents an important source of Cu to the coastal environment[15]. In marine mammals, like in humans, Cu toxicity is believed to be less toxic compared to mercury and lead. However, until now, no study has been published yet to assess the potential effects of these antifoul-

13 IMO-MEPC 38 (1996) (v), Terms of reference for a corresponding group on the reduction of harmful effects of the use of antifouling paints for ships, IMO-MEPC Paper MEPC 38/WP.6, 1996

14 DORNELES (P. R.) et al., Evaluation of cetacean exposure to organotin compounds in Brazilian waters through hepatic total tin concentrations, 2008, Environmental Pollution 156: 1268–1276.

15 TURNER (A.) et al., Impacts of boat paint chips on the distribution and availability of copper in an English ria, 2013, Environmental Pollution 151: 176-181.

ing mixtures on marine mammals, which could be released to the marine environment, particularly during the paint application or removal processes.

… in waters under specific jurisdictions…

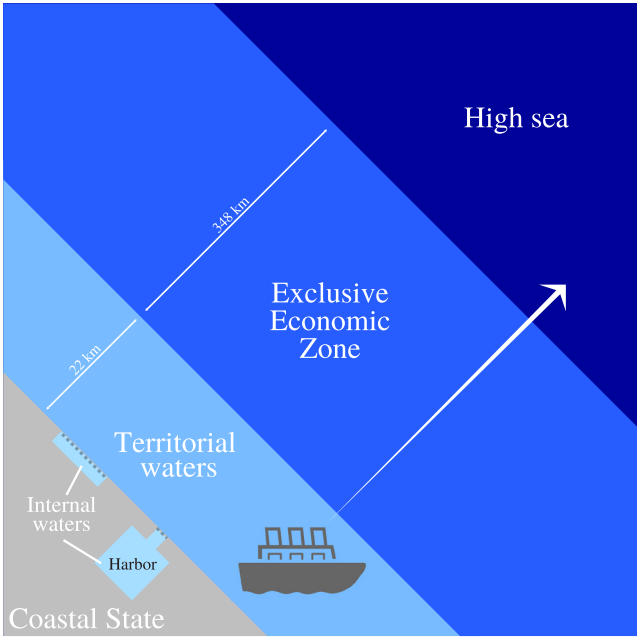

Figure 4 Maritime Zones

High Seas: All ships have freedom of navigation. Only the IMO can adopt rules for the High Sea through international conventions (such as UNCLOS, MARPOL, etc). Besides IMO rules, ships must apply the laws of their flag country.

The Exclusive Economic Zone (EEZ): Foreign ships enjoy freedom of navigation in the EEZ (no interference from other states). Nevertheless, the coastal states have sovereign rights for the conservation and management of living resources. They also have the legislative competence to deal with pollution from ships in the EEZ.

Territorial seas: Any foreign ship has the right of innocent passage in territorial waters (passage that is not prejudicial to peace, good order or security of the coastal state). Coastal states can regulate innocent passage in respect of: the safety of navigation and the regulation of maritime traffic; the conservation of the living resources of the sea; the preservation of the environment of the coastal state and the prevention; reduction and control of pollution (but not in respect of the design or construction of foreign ships).

Internal waters: The coastal state has authority to regulate ships entering its harbours. Consequently, they can close down their ports to any ship. The UNCLOS also foresees that states may establish particular requirements regarding prevention, reduction and control of pollution as port entry conditions.

Ship: A ship sails under the flag of the country in which she is registered. The ship technical properties must respect the international rules as well as its flag state's rules. When sailing, any ship must follow the international rules anywhere as well as the coastal state's law in internal, territorial waters and the EEZs. Once in the high sea, ships must respect their flag state's law in addition to international rules.

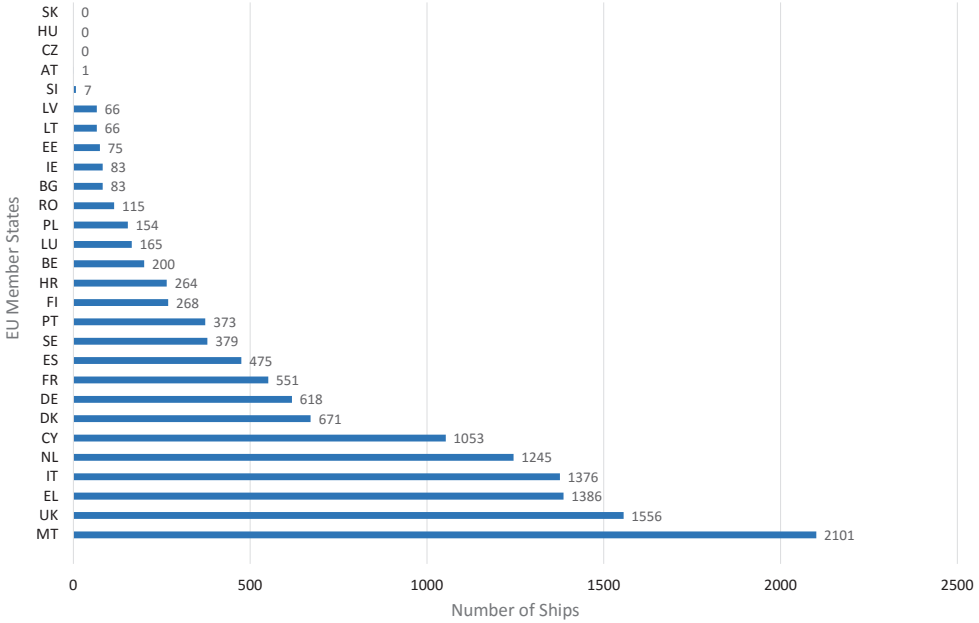

Figure 5 Flags in the European Union Merchant Fleet

… offering possibilities of indicative mitigation measures…

Type of measure	Short-term measures	Mid-term measures	Long-term measures
Ship speed	**Encouraging voluntary speed reduction.** Effects: reduction of noise, ship strikes, fuel consumption and pollution. Actors: states, shipping industry and IMO.	**Mandatory speed limitations in some areas of territorial waters and EEZs.** Effects: reduction of noise, ship strikes, fuel consumption and pollution. Actors: states and shipping industry.	**Mandatory speed limitations in international waters.** Effects: reduction of noise, ship strikes, fuel consumption and pollution. Actors: IMO and shipping industry.
Shipping routes	**Studying and monitoring shipping routes and the overlap with areas dwelled by cetaceans.** Effects: preparing measures for reduction of ship strikes and noise. Actors: states, shipping industry, research institutions and NGOs.	**Realigning the Traffic Separation Schemes (TSS) to move away from high density areas of marine mammals, establishing Areas To Be Avoided (ATBA) in territorial waters and EEZs or designating Particularly Sensitive Sea Areas (PSSAs) with associated routing measures.** Effects: reduction of ship strikes and noise. Actors: states, shipping industry (+IMO approval).	**Realigning the TSS to move away from cetaceans and establishing ATBA or PSSA in international waters.** Effects: reduction of ship strikes and noise. Actors: IMO and shipping industry.

<table>
<tr><th>Type of measure</th><th>Short-term measures</th><th>Mid-term measures</th><th>Long-term measures</th></tr>
<tr><td rowspan="3">Report on whales sightings</td><td>Creating an online interface or an application used by mariners to signal whale sightings in the area

Effect: reduction of ship strikes.
Actors: states, shipping industry and NGOs.</td><td colspan="2">Installing passive acoustic monitoring systems such as real-time broadcasting of whale locations. Making use of mobile phone APPs to report sightings.

Effect: reduction of ship strikes.
Actors: states and shipping industry.</td></tr>
<tr><td colspan="3">Encouraging placing on-board observers on ships to spot whales.

Effect: reduction of ship strikes for small ships that can take avoiding action.
Actors: shipping industry, states.</td></tr>
<tr><td>Encouraging ship strike reporting.

Effect: scientific sound assessment of numbers of ship strikes in preparation of measures.
Actors: shipping industry, NGOs, states and IMO.</td><td>Making ship strike reporting mandatory in territorial waters, EEZs and by the state's own ships.

Effect: preparing measures to reduce ship strikes.
Actors: states and shipping industry.</td><td>Making ship strike reporting mandatory in international waters.

Effect: preparing measures to reduce ship strikes.
Actors: IMO and shipping industry.</td></tr>
<tr><td>Education</td><td colspan="3">Increasing awareness of crews, managers, policy makers but also the general public. Introduction to the issue in navigation schools.

Effect: reduction of ship strikes and noise.
Actors: navigation schools, shipping industry, NGOs, states.</td></tr>
</table>

Type of measure	Short-term measures	Mid-term measures	Long-term measures
Ship design	**Identifying the noisiest ships that would benefit most from application of noise reduction measures.** Effects: preparing measures to reduce noise. Actors: states, shipping industry and IMO.	**Recommending the use of Energy Saving Devices and Wake Flow Devices to improve poorly designed propellers efficiency and saves fuel.** Effects: reduction of noise, fuel consumption and pollution. Actors: shipping industry, states or IMO.	**Including less noisy propellers, hull designs and insulation measures for the hull as a mandatory requirement for the construction & design of new ships.** Effects: reduction of noise, fuel consumption and pollution. Actors: states, shipping industry and IMO.
Antifouling composition	**Studying the effects of new authorized products on the field and possible emerging issues.** Effects: evaluating the possible risks faced by marine mammals. Actors: states, shipping industry, research institutions and NGOs.	**Improving control and enforcement of international agreements about antifouling composition.** Effects: reduction of pollution impacts. Actors: states, shipping industry, research institutions and IMO.	

… illustrated by a few case studies.

In 2009, IMO developed a guidance document for minimizing the risk of ship strikes to cetaceans (MEPC.1/Circ.674). The tables below provide a summary of mitigation measures that have been implemented worldwide since the adoption of that document. This information was presented to IMO in 2016 by the International Whaling Commission.

Ship speed

Measure	Situation to which it might be applied	Implementation process (and observations)	Examples
Permanent speed restriction zones	Long-term patterns of whale distribution are predictable and well understood but routing measures are not practicable.	Can be voluntary or mandatory if implemented in national waters.	East coast of USA (mandatory); Glacier Bay, USA; Hauraki Gulf, New Zealand
Seasonal speed restriction zones	As above but applicable where there are strong seasonal patterns in distribution.	As above.	Panama; California, US; Peninsula Valdez, Argentina
Dynamic Management Areas for speed restrictions	Implemented in response to short- term observations of whale aggregations or known high risk areas. Need reporting systems that can identify such aggregations.	Voluntary measures that need to be communicated to mariners. (Can be difficult to encourage compliance.)	US east coast

Shipping routes

Measure	Situation to which it might be applied	Implementation process (and observations)	Examples
Permanent routing measures through TSS, ATBA or port approach routes	Long-term patterns of whale distribution are sufficiently predictable and well understood to enable a robust analysis of the risk reduction that might be achieved.	Implemented through IMO or national regulation if within territorial sea. Proposals should follow the IMO process including data on the problem, the risk reduction achieved and implications for shipping. (Generally well respected by industry.)	Bay of Fundy, Canada; Boston, USA; California, USA; Panama; Cabo de Gata, Spain
Seasonal routing measures	Similar requirements to permanent routing but applicable where there are strong seasonal patterns in whale distribution	As above	Roseway Basin, Canada; Great South Channel, USA
Recommended (voluntary) routes	Similar requirements to permanent routing through TSS or ABTA but not mandatory	Implemented by IMO or coastal state as a non-mandatory measure	Peninsula Valdez, Argentina; Hauraki Gulf, New Zealand; Glacier Bay, USA; Ports on US east coast
Short-term (days – weeks) and Dynamic routing measures	Implemented in response to short- term observations of whale aggregations or known high risk areas. Need almost real-time reporting systems that can identify such aggregations.	Voluntary measures that need to be communicated to mariners. (Can be difficult to encourage compliance.)	DMAs off US east coast; Gibraltar Strait, Spain

Reporting on whales sightings

Measure	Situation to which it might be applied	Implementation process (and observations)	Examples
Real-time alerting tools to warn vessels of the presence of whales or aggregations that allow vessels to alter course or slow down	A rapid reporting network of whale sightings or acoustic detections alerts all vessels transiting an area to the locations of whales so that they can alter course or slow down.	Individually designed and implemented reporting systems.	REPCET, ACCOBAMS,Mediterranean Sea; Whale Alert App, Boston, USA[16]
Observations from the vessel that allow avoiding action to be taken	Only effective for vessels capable of rapid maneuvers to avoid whale sightings (e.g. vessels of a few thousand GT or less).	Additional dedicated observers, education and outreach to mariners.	Many initiatives

16 http://www.ifaw.org/united-states/news/whale-alert-app

The case of the North Atlantic right whale

The US and Canada adopted different types of measures to protect the critically endangered North Atlantic right whales.

Canada has adopted rerouting measures in its EEZ to reduce ship strikes with North Atlantic Right Whales, which has been approved by the IMO. This is justified by the Part V of UNCLOS which entitles a coastal state to use of its sovereign rights to ensure the protection and the preservation of marine environment even if the threat is not pollution[17]. The USA did the same and also adopted seasonal speed reduction measures in areas used by North Atlantic Right whales during their migrations. Moreover, acoustic buoys were put within the shipping lanes to detect whales and alert vessel crews in real time. The U.S. National Oceanic and Atmospheric Administration estimates that those measures have reduced the collision-related mortality rate of right whales up to 90 %[18].

17 Maritime traffic effects on biodiversity in the Mediterranean Sea (Volume 2), p. 103.

18 CONN (P. B.) and SILBER (G. K.), Vessel speed restrictions reduce risk of collision-related mortality for North Atlantic right whales, 2013, Ecosphere 4(4):43. http://dx.doi.org/10.1890/ES13-00004.1.

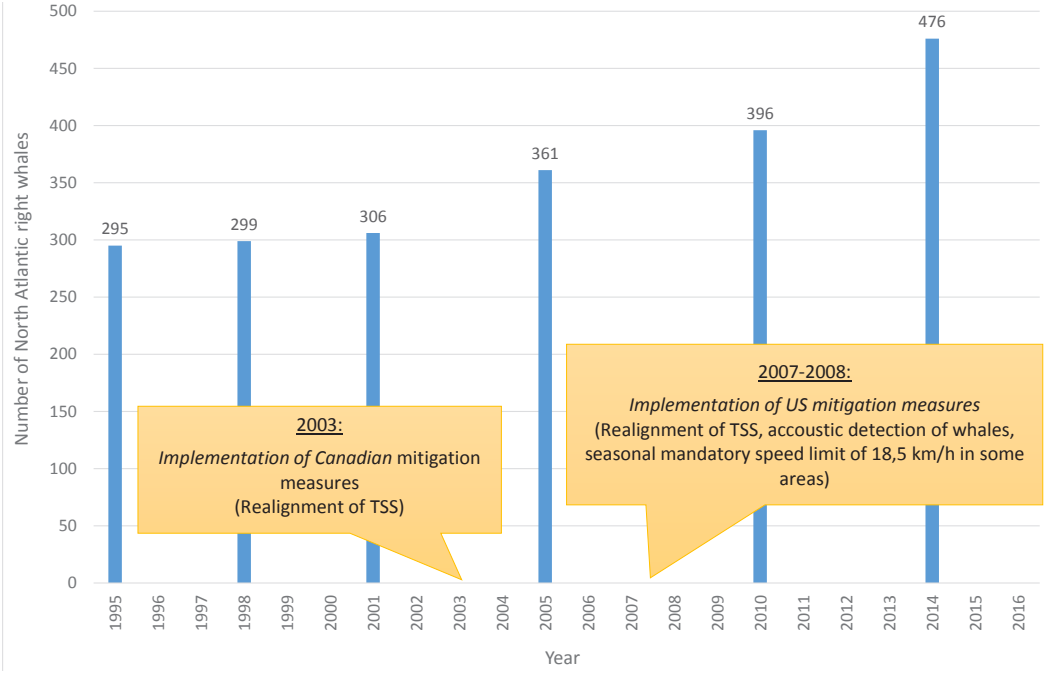

Figure 6 Evolution of the North Atlantic right whale population

Notes

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