Cetaceans and Shipping Interactions – Ship-strikes

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Ship-strikes: An introduction

Shipping is one of the world's largest industries, accounting for 80% of global trade by volume and more than 70% of its value. Groundings, collisions, oil and chemical spills, and the introduction of invasive species are some of the risks that shipping brings to the marine environment. Ship strike and noise pollution currently present the greatest impact to cetaceans (Smith *et al*, 2020). Slower, larger species are typically at greatest risk, especially when at the surface to breath or to forage. Lethal collisions are a recurring and common threat to global populations that are recovering from intense historical commercial whaling (Smith *et al*, 2020). For some populations like the critically endangered North Atlantic right whale (*Eubalaena glacialis*) and an important sub-population of sperm whales (*Physeter macrocephalus*) in the Canary Islands, strikes can have direct implications for population persistence and biodiversity (Gende *et al*., 2019) even where only a small number of strikes occur per year (IWC, 2019).

Most studies are biased towards larger species and knowledge of the impacts on dolphins and porpoises is lacking. There is a common notion that smaller species are not greatly affected but there is increasing evidence that this is not the case. The chances of a smaller cetacean being hit by a boat increases where there is a high concentration of boats in a small and shallow area (Olaya-Ponzone *et al*, 2020). Small and fast watercraft such as jet skis and leisure boats are particularly hazardous as even if an individual detects the approaching boat, they may be unaware of the danger posed by propellers (Waerebeek *et al,* 2020).

Where do ship-strikes occur?

Ship strikes occur globally but there are 'hotspots'. North Atlantic right whales for example, suffer heightened mortality events in the Gulf of St. Lawrence where they have recently expanded their summer foraging range, placing them directly in the path of busy shipping lanes (Halliday *et al*, 2020). On the West coast of the USA, ship strike is one of the primary causes of anthropogenically induced mortality for fin (*Balaenoptera physalus*), humpback (*Megaptera novaeangliae*), and blue (*Balaenoptera musculus*) whales (Redfern *et al*, 2020).

In the Strait of Gibraltar, home to one of the busiest shipping lanes in the world, Herr *et al*, (2020) recorded injury and anomalies on individuals representing all 8 resident species. A total of 502 anomalies were documented over 494 cases of affected cetaceans. Of 245 injuries, 17% were consistent with being anthropogenically induced. This is not surprising considering the Strait is intensely commercially fished, crossed up to 60 times per day by ferries, and is transited by 60,000 vessels annually.

Climate change may also bring about the indirect threat of collisions to bowhead (*Balaena mysticetus*) and beluga (*Delphinapterus leucas*) whales living in the remote Arctic region, with reduced sea ice coverage and increased open water predicted to alter ship traffic, leading to increased cetacean-ship interactions (McWhinnie *et al,* 2018).

Species in managed areas may also experience danger from vessels. Smith *et al*, (2020) investigated strike risk within the Great Barrier Reef Marine Park (GBRMP). The 344,400 km^2 park has employed resilience-based management since 1981, with zoning to protect biodiversity and to regulate activities. Since 2004, 33% of the entire park resides in highly protected zones. The management and permissions system allows ecologically-sustainable and multiple-use of the Reef (BBRMP Authority, 2020). The park is the breeding ground for an east Australian population of humpback whales. The population is one of the largest humpback populations in the world and is increasing by 11% annually.

In recent times the park has seen a substantial increase in both port expansions and associated shipping. Conflict between the resident humpback population and ships occurs primarily in the main inner shipping lanes that serve ports exporting natural resources. Females with a dependent calf were found to be at a higher risk of being struck. Their dependence on the coast later in the breeding season increased their overlap with shipping activities, though due to a lower relative abundance of whales in the area at this time, the chances of being struck may be mitigated somewhat. The chances of a collision are therefore a complex and delicate balance between the temporal habitat usage and behaviours of cetaceans and ships alike.

Healing and survival of injured cetaceans

Healing and survival are dependent on the severity of wounds, the physiology of the species, and the physico-chemical parameters of the habitat used. For example, healing may be faster in warmer, saltier waters whereas colder temperatures decrease blood flow to the skin and therefore slow cell regeneration rate and healing of the epidermis. Despite this, the thicker epidermis that allows the beluga whale to live in colder waters also allows it to heal five times faster than a bottlenose dolphin (*Tursiops truncatus*).

Olaya-Ponzone *et al*, (2020) observed common dolphins (*Delphinus delphis*) populating the water between Gibraltar and Algeciras in the south Iberian Peninsula. Injuries were classified (inspired by Lockyer & Morris, 1990) into five different categories, with those that cut deeper from epidermis through to bone more severe and more likely to be fatal. Individuals with varying severity of wounds took between 3 – 21 weeks to heal from their injuries. Individuals that are severely injured in a human-impacted environment such as a busy Strait may suffer from immunosuppression and increased susceptibility to infection, something that can hinder the healing process.

The difficulties of quantifying ship-strike and risk

Quantifying the number of whales killed by strikes annually can be difficult. A literature review of ship strikes by Halliday *et al*, (2020) found that studies likely underestimated the risk of both lethal and non-lethal ship strikes. Furthermore, unless a strike is explicitly clear e.g. a whale becomes lodged on the bulbous bow of a ship (IWC, 2019), most studies assessing strike and risk rely upon the use of stranding records and/or the remains of the deceased individual. There are many factors that determine whether a strike will be correctly recorded without bias and inaccuracy (Peel *et al*., 2018) these include:

- **Location** - carcass recovery will be dependent upon oceanic processes such as currents and water depth and are more likely to wash up on coastlines with accessible beaches, thus strikes in these areas can be correlated to human population density more easily than remote areas.
- **Species** – species such as the North Atlantic right whale are known to float, are more likely to be recovered, and will therefore have a higher reporting rate. Data collection by non-expert witness accounts can also bias reports due to inaccurate species identification.
- **Vessel type and size** - official vessels such as police, fishery agencies, research, or whale watching vessels are more likely to report a collision. Furthermore, some collisions are undetected entirely, especially in the case of larger vessels.

Even when a carcass is recovered, establishing the cause of death (e.g. blunt force trauma from a strike) by performing a necropsy may prove difficult if the state of decomposition has become too advanced (Halliday *et al,* 2020). Redfern *et al*, (2020) explains how strike risk for larger whales is often assessed using ship traffic data and averaged predictions of species distributions from a single year only. This does not consider the spatial and temporal variability of populations as well as shipping activity itself. The reliance on such data can therefore reduce the effectiveness of management measures designed to reduce strikes.

What methods can we use to reduce ship-strikes and how effective are they?

The measures taken to reduce strikes will be dependent upon the species involved, vessel traffic, the geographic and environmental features of an area, and the economic cost that the chosen measure incurs.

International Whaling Commission

Between 2016 and 2020, the International Whaling Commission has been developing a Strategic Plan that describes the intentions of the commission to permanently reduce the threat of ship strikes from 2020 onwards. At a 2016 meeting the following recommendations were accepted by the IWC:

- Initiate the comprehensive and accurate reporting of ship strike incidents into the Ship Strike Database using standard protocol and publishing a summary of statistics on a routine basis coupled with outreaching efforts
- Review old, and add new records to the database within a reasonable time frame
- Improve reliability of species identification
- Maintain an assessable compendium of resources detailing ship strike issues and produce an associated up to date bibliography on a two-year schedule

Important Marine Mammal Areas (IMMAs)

The IWC is currently investigating the potential development and use of IMMAs which are the subject of a programme run by the International Union for the Conservation of Nature (IUCN, 2020). IMMAs are independent of any socio-economic concerns and are defined as habitats that are important to marine mammal species and have the potential to be managed for conservation. IMMAs may act as ‘red flags’ giving rise to marine protected areas, the introduction of ship or noise directives, marine spatial planning, and other conservation outcomes. A network of IMMAs can be a cost-effective approach to conservation, serving as indicators of marine health by monitoring climate change whilst protecting biodiversity and a variety of species at the same time. In 2019 the IWC reported its progress. During one of its workshops, shipping lanes that overlapped with whale habitat and migration routes were mapped to assess which populations were most at-risk. The workshop then looked at the background and development of IMMAs and overlapped the shipping information with known IMMAs to help pinpoint ship strike ‘hotspots.’ The use of IMMAs is promising but still requires development.

Speed Restrictions

The re-routing of shipping lanes is not always logistically possible. In the case of the GBRMP where the average depth of inshore waters is 35 m, the reef causes physical and spatial limitations, stretching between 60 – 250 Km wide and extending into the surrounding airspace (GBRMP Authority, 2020). Furthermore, in narrow straits such as the Strait of Gibraltar, the modification of shipping lanes can be difficult and requires considerable regulatory effort (Herr *et al*, 2020).

Planning voyages ahead to avoid areas of high whale collision risk and reducing vessel speed may be the best or only option in such physically limited areas (IWC, 2019). The rate of ship strike has been found to increase linearly with vessel speed, with the chances of a lethal strike increasing by 50% when a vessel travels at > 11.8 knots. Increased encounters at speeds above 12 knots suggest that whales are unable to change the course of their path in time when a vessel is approaching at equal to or higher than 12 knots (Halliday *et al,* 2020).

Unfortunately, speed restrictions often have low compliance from the shipping industry as the increased time at sea due to lower speeds may bring economic implications (Herr *et al*, 2020). Due to a lack of data collection there is also currently no known relationship between vessel speed and collision risk for smaller marine species including odontocetes (Schoeman *et al*., 2020).

Alerting Devices

It has been suggested that ships could be equipped with an alerting device to encourage cetaceans to leave the path of oncoming vessels. Nowacek *et al.,* (2004) measured the responses of whales to passing ships and found that North Atlantic right whales exposed to a variety of controlled sounds didn't react at all to the sound of vessels. Whales did however respond to the suggested 'alarm' signal by abandoning deep dives in order to swim rapidly and unseen just below the surface. This behaviour was consistent with antipredator behaviour, allowing the whale to surface for oxygen but remain unseen whilst it moved away from the source of potential danger. It can be concluded from this instance that cetaceans do not yet distinguish between predator danger and vessels, thus this response would be more likely to increase the chances of a strike rather than reduce it (Nowacek *et al*, 2016).

Though not exempt from strikes, smaller cetacean species appear more responsive. Buckstaff (2004) found that the bottlenose dolphin altered its whistle behaviour at various stages of recreational vessel approach. Whistle rate was highest as vessels approached and was lowest after exposure. The increased rate in vocalisations may have been an attempt to minimise disruption to communication by counteracting noise introduced from the boats. Alternatively, on hearing the boats approach, increased whistling may be a prompt for individuals to adopt protective behaviours such as longer dives, the tighter grouping of animals, and a change in their heading and speed in response to approaching boats.

Seasonal Management Areas and Traffic Separation Schemes (TSS)

In 2016 the Smithsonian Tropical Research Institute used satellite tracking data to track the movements of humpback whales in Panama's Las Perlas Archipelago. Along with the Magellan Strait in southwestern Chile, and parts of southern Costa Rica, these areas are important migratory, breeding, and feeding grounds for humpback wales. Working with local authorities, a new science-based policy was brought into law and adopted by the International Maritime Organization. In 2014, the Gulf of Panamas shipping lanes were separated from whale routes and managed by satellite tracking data. A reduction in speed during the critical breeding season and two-mile-wide shipping lanes separated by three nautical miles of open water were predicted to reduce whale collisions by as much as 95% (Smithsonian, 2016).

A recent study however has reported that the Magellan Strait is still a problematic area with nearly two-thirds of the large vessels in the Strait exceeding the recommended 10 knot speed limit. Furthermore, one female out of the 21 whales satellite tagged and with the highest vessel interaction rate was eventually found dead, a potential vessel strike (Guzman *et al,* 2020).

Acoustic Buoys

The US Northeast Passive Acoustic Sensing Network (NEPAN) uses near real-time automated buoys to gather information on the presence of cetaceans in the shipping channel approaching Boston, Massachusetts. A year-round pattern of habitat use by cetaceans can then be used to address conservation concerns (Nowacek *et al*, 2016). However, there are limitations to the use of buoys. The high frequency vocalisations of odontocetes have a lower detection rate and furthermore, the vocalisations of some species are not always consistent, having a temporal pattern. Buoy systems are also expensive, requiring regular maintenance to prevent deterioration (Schoeman *et al*., 2020).

Automatic Identification System (AIS)

Automatic Identification System (AIS) is a traditionally terrestrial-based tracking technology that broadcasts a vessels position and speed therefore improving safety and navigation by making vessels visible to one another. AIS can be used to provide insight into vessel activity in areas used by cetaceans. Greig *et al,* (2020) used AIS broadcasts that were relayed over earth-orbiting satellites (SAIS) as an alternative. SAIS data from 2013 and 2014 was used to calculate vessel speed over ground and vessel density around the coast of Washington, US, an area of high shipping traffic and close in proximity to a designated Biologically Important Area (BIA) for large whale species vulnerable to vessel collisions. SAIS was helpful at documenting the minimum speeds of vessels across large areas that would usually be beyond the reach of the spatially limited terrestrial AIS receivers. There were temporal gaps in SAIS data that led the underestimation of vessel speed, though the authors concluded that the use of additional satellite platforms with AIS receivers coupled with technological improvements could improve data coverage and quality.

The use of Real-time Information

Real time plotting of cetaceans (REPCET) is available as a software system. Sightings entered into a GPS system are sent to a shore-based station and then forwarded to other vessels in the area. This system has been shown to work well for both small and large cetacean species though there are concerns over how the software can be abused to effectively seek out and harass cetaceans (Schoeman., *et al* 2020). When sighting a single whale Gende *et al*., (2019) found that marine pilots in Alaska preferred to change their course rather than slowing their ship. As previously mentioned by Herr *et al,* (2020) increased time at sea due to lower speeds may bring economic implications and therefore can lower compliance or active willingness to avoid cetaceans. However, the sharing of real-time whale sightings data can help facilitate a beneficial change of course for those mariners that are willing.

Propeller Guards

The use of guards (such as cages or ducts) coupled with reduced speeds can help reduce sharp injuries to smaller marine species though they cannot prevent trauma from blunt force hits. The benefits for larger cetacean species are so far untested and unknown (Schoeman., *et al* 2020).

Observations

The simple practice of observing and keeping a record of injuries can be a valuable tool to identify struck individuals and trace their recovery and survivorship from a range of injuries. Observations of affected individuals may also help determine the human or natural source of their injury (Olaya-Ponzone *et al*, 2020) which can in turn bring about the introduction of measures to reduce strikes in known problem areas.

Conclusions

The IWC has acknowledged that there is currently no universal technological solution to prevent ship strikes, particularly on a real-time basis. As with all conservation measures, effectiveness relies upon awareness, cooperation, and the goodwill of the affected stakeholders (Ebdon *et al* 2020) and it is evident that lack of compliance is often an issue. Monetising the protection of whales to aid compliance is one option, though attributing a monetary value to biodiversity is increasingly criticised (Sèbe *et al*, 2019). Voluntary and incentivised speed reductions introduced on the Californian West coast were found to only reach a small percentage of ships that travel in this region and required continued financial support (Redfern *et al*, 2020).

A complete alteration of shipping lanes and their regulation is logistically difficult and often economically undesirable, though they are possible and can be effective as seen from the Smithsonian project in the Panama Canal. In the case of large (and often unresponsive) cetacean species, the avoidance of high-risk areas and/or a reduction in speed to 10 knots can be effective at reducing strike risk and the chances of a fatality should a strike occur.

Absolute risk calculation remains difficult and is hindered by continuing knowledge gaps on the response and avoidance behaviour of whales (Smith *et al,* 2020) as well as low strike-detection rates (Redfern *et al*, 2020). More data is required on species variability, blunt force trauma survivorship, behaviours such as time at surface, and information on ships (e.g. draught and strike zone depth). Greater knowledge can improve existing framework and enable a better assessment of how different scenarios effect strike-risk (Smith *et al,* 2020).

Even where robust information on the presence and location of cetaceans exists, it is not clear what action a mariner should take to avoid a collision (IWC, 2019). As many cetaceans do not understand the dangers of vessels and in the case of large whales are often unresponsive to approaching ships, the responsibility does fall solely on mariners to take evasive action. It is therefore important to develop the skills and knowledge that will allow mariners to do so (Smith *et al*, 2019).

Lastly, though major bodies such as the IWC have submitted various proposals to the International Maritime Organization (IMO) that may help to reduce strikes, it is difficult for the IMO to evaluate the proposed solutions due to the use of a non-standardised format and the non-consideration of the impact on maritime traffic. Whilst having potential, these proposals are redundant information, serving as guidance only and are rarely adopted by the IMO who typically only endorse suggestions when local regulations are pro-active (Sèbe *et al*, 2019). The IMO does however offer a guidance document that sets out the action's a state should take to minimise cetacean strikes. Actions include routing advice and reporting measures, and speed restrictions. Suggested actions are voluntary guidance only, though the IMO encourages member governments to bring the document to the attention of interested parties such as shipping companies for action as appropriate (IMO, 2009).

REFERENCES

Buckstaff, C, K. (2004). Effects of watercraft noise on the acoustic behavior of bottlenose dolphins, Tursiops truncatus, in Sarasota Bay, Florida. *Marine Mammal Science*. 20 (4), 709-25.

Ebdon, P., Riekkola, L., Constantine, R. (2020). Testing the efficacy of ship strike mitigation for whales in the Hauraki Gulf, New Zealand. *Ocean & Coastal Management.* 184.

Gende, S., Vose, L., Baken, J., Gabriele, M, C., Preston, R., Hendrix, N, A. (2019). Active Whale Avoidance by Large Ships: Components and Constraints of a Complementary Approach to Reducing Ship Strike Risk. *Frontiers in Marine Science*.

Greig, C, N., Hines, M, E., Cope, S., XiaoHang, L. (2020). Using Satellite AIS to Analyze Vessel Speeds Off the Coast of Washington State, U.S., as a Risk Analysis for Cetacean-Vessel Collisions. *Frontiers in Marine Science*.

Guzman, M, H., Capella, J, J., Valladares, C., Gibbons, J., Con, R. (2020). Humpback whale movements in a narrow and heavily-used shipping passage, Chile. *Marine Policy*. 118.

Halliday, D, W. (2020). Literature Review of Ship Strike Risk to Whales. Wildlife Conservation Society Canada.

Herr, H., Burkhardt-Holm, P., Heyer, K., Siebert, U., Selling. J. (2020). Injuries, Malformations, and Epidermal Conditions in Cetaceans of the Strait of Gibraltar. *Aquatic Mammals*. 46 (2), 215-35.

International Maritime Organization. (2009). GUIDANCE DOCUMENT FOR MINIMIZING THE RISK OF SHIP STRIKES WITH CETACEANS. Available from:
http://www.imo.org/en/MediaCentre/HotTopics/Documents/674.pdf.

Important Marine Mammal Areas. (2020). IUCN Available from:
https://www.marinemammalhabitat.org/immas/.

IWC (2019). A Joint IWC-IUCN-ACCOBAMS workshop to evaluate how the data and process used to identify Important Marine Mammal Areas (IMMAs) can assist the IWC to identify areas of high risk for ship strike. Available from:
https://iwc.int/private/downloads/MFpRPWVsjK2uFBfZg96z0g/SC_68A_HIM_07_FINAL_WORKSHOP_REPORT.pdf.

McWhinnie, H, L., Halliday, D, W., Insley, J, S., Hilliard, C., Canessa, R, R. (2018). Vessel traffic in the Canadian Arctic: Management solutions for minimizing impacts on whales in a changing northern region. *Ocean & Coastal Management*. 160, 1-17.

Nowacek, P, D., Thorne, H, L., Tyak, L, P. (2004). North Atlantic right whales (*Eubalaena glacialis*) ignore ships but respond to alerting stimuli. *Proceeding of the Royal Society B*. 271 (1536), 227-31.

Nowacek, P, D., Christiansen, F., Bejder, L., Goldbogen, A, J., Friedlaender, S, A. (2016). Studying cetacean behaviour: new technological approaches and conservation applications. *Animal Behaviour*. 120. 235-44.

Olaya-Ponzone, L., Espada, R., Moreno, M, E., Marcial, C, I., García-Gómez, C, J. (2020). Injuries, healing and management of common dolphins (Delphinus delphis) inhuman-impacted waters in the south Iberian Peninsula. *Journal of the Marine Biological Association of the United Kingdom*.

Peel, D., Smith, N. J., Childerhouse, S. (2018). Vessel Strike of Whales in Australia: The Challenges of Analysis of Historical Incident Data. *Frontiers in Marine Science*.

Redfern, J, V., Becker, A, E., Moore, J, T. (2020). Effects of Variability in Ship Traffic and Whale Distributions on the Risk of Ships Striking Whales. *Frontiers in Marine Science*.

Reef Facts. (2020). Great Barrier Reef Park Authority. Available from: http://www.gbrmpa.gov.au/the-reef/reef-facts.

Sèbe, M., Christos, K., Linwood, P, A. (2019). A decision-making framework to reduce the risk of collisions between ships and whales. *Marine Policy.* 109.

Schoeman, P, R., Patterson-Abrolat, C., Plön, S. (2020). A Global Review of Vessel Collisions with Marine Animals. *Frontiers in Marine Science*.

Smith, N, J., Kelly, N., Childerhouse, S., Redfern, V, J., Moore, J, T., Peel, D. (2020). Quantifying Ship Strike Risk to Breeding Whales in a Multiple-Use Marine Park: The Great Barrier Reef. *Frontiers in Marne Science*.

Smithsonian Tropical Research Institute. (2016). Humpback Highway: Creating Traffic Separation Schemes to Protect Whales in the Eastern Pacific.

Waerebeek, K, V., Baker, N, A., Félix, F., Gedamke, J., Iñiguez, M., Sanino, P, G., Secchi, E., Sutaria, D., Helden, V, A., Wang, Y. (2006). Vessel collisions with small cetaceans worldwide and with large whales in the Southern Hemisphere; building a standardized database. WC 58th Annual Meeting, St. Kitts, May-June 2006.