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Scientific Literature Related to Marine Mammals and Climate Change – an Update

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Abstract

Further to a previous report to the IWC Scientific Committee in 2016 and in preparation for the IWC workshop on Climate Change and Cetaceans planned for later in 2021, an update on the relevant scientific literature is provided here. This is still a work in progress and will be further updated and developed.

This preliminary assessment suggests that the focus of studies has broadened in recent years to more regions and species with less of a focus on the Arctic and polar bears. Other significant developments may include research seeking to assess the risk from climate change to marine mammals, including ranking the relative vulnerabilities of different taxa, and papers considering the 'ecosystems services' provided by cetaceans.

Introduction

In 2016 we carried out an extensive review of the literature regarding marine mammals and climate change (Nunny and Simmonds, 2016). We found that between 1997 and 2016, 350 articles or book chapters were published with a marked increase over time (from two papers in 1997 to 41 in 2015). The vast majority of the papers related to Arctic species including polar bears (*Ursus maritimus*), Arctic cetaceans and Arctic pinnipeds.

The current paper offers an update on the papers published since the last review.

Method

Searches were carried out on Google Scholar with the date range 2016 – 2021 and combining the term "climate change" with the following search terms: marine mammal, cetacean, pinniped, sirenia, sea otter, polar bear, whale, dolphin, porpoise, manatee, dugong. For the first three of these searches, the first 10 pages of results were checked. For the others, the first five. Searches on the Web of Science database were also carried out, combining the terms "climate change" and "marine mammal" for the period 2016 to 2021.

The abstracts of each article were looked at to ensure that they did, in fact, address climate change and marine mammals. They were then categorised according to which marine mammals and region/s were covered in the paper.

Papers were categorized according to the taxa mentioned in the paper: "polar bear", "cetaceans", "pinnipeds", "sirenians" or "sea otter". Some papers covered more than one taxon and so were allocated to two or more groups. For those papers which only referred to

marine mammals in general or where the paper was not available in full and the abstract only mentioned marine mammals, these were categorized as “marine mammals (generic)”.

Papers were also categorized according to the geographical region that the paper focused on. Each paper was assigned to one category only. “Arctic” was used here for areas inside the Arctic Circle and also the areas adjacent to the Arctic Circle where Arctic marine mammals are present e.g. Greenland. Other region categories were “Europe and North Africa”, “North America (not Arctic) and Central America”, “Southern Hemisphere” and “Tropics”. The Torres Strait, Queensland, Australia, Shark Bay, Australia and the Arabian Gulf were included in the category “Tropics”. (It is noted that these last two are not technically in the tropics if the tropics are taken to be the area between the Tropics of Cancer and Capricorn, but this seemed the most appropriate category due to geographical proximity to the Tropics.) The category “Worldwide” was used for papers that covered multiple regions or discussed global trends rather than focusing on specific regions.

Once categorized, the data was combined with that from our previous report and a smooth-lined scatter graph was created to show the years that the papers were published (excluding data from 2021 which is clearly incomplete). Pie charts were created with the 2016-2021 data so that they could be compared with the charts in our previous report.

Results

Each Google Scholar search yielded at least 1000 results (up to 17,400 for the search combining “climate change” and “whale”). Web of Science yielded 50 results, some of which coincided with the results from Google Scholar. All these results were examined to ensure they had an appropriate focus, clearly introducing some subjectivity into the review.

Our final dataset included 125 articles published between 2016 and early 2021. In Figure 1 these papers have been combined with those recorded in Nunny and Simmonds (2016) to show how many papers have been published since 1997.

Figure 2 shows the different taxa represented in the papers since 2016 and Figure 3 shows the taxa for the papers 1997-2016.

Figure 4 shows the regions represented in the papers since 2016 and Figure 5 shows the regions for the papers 1997-2016.

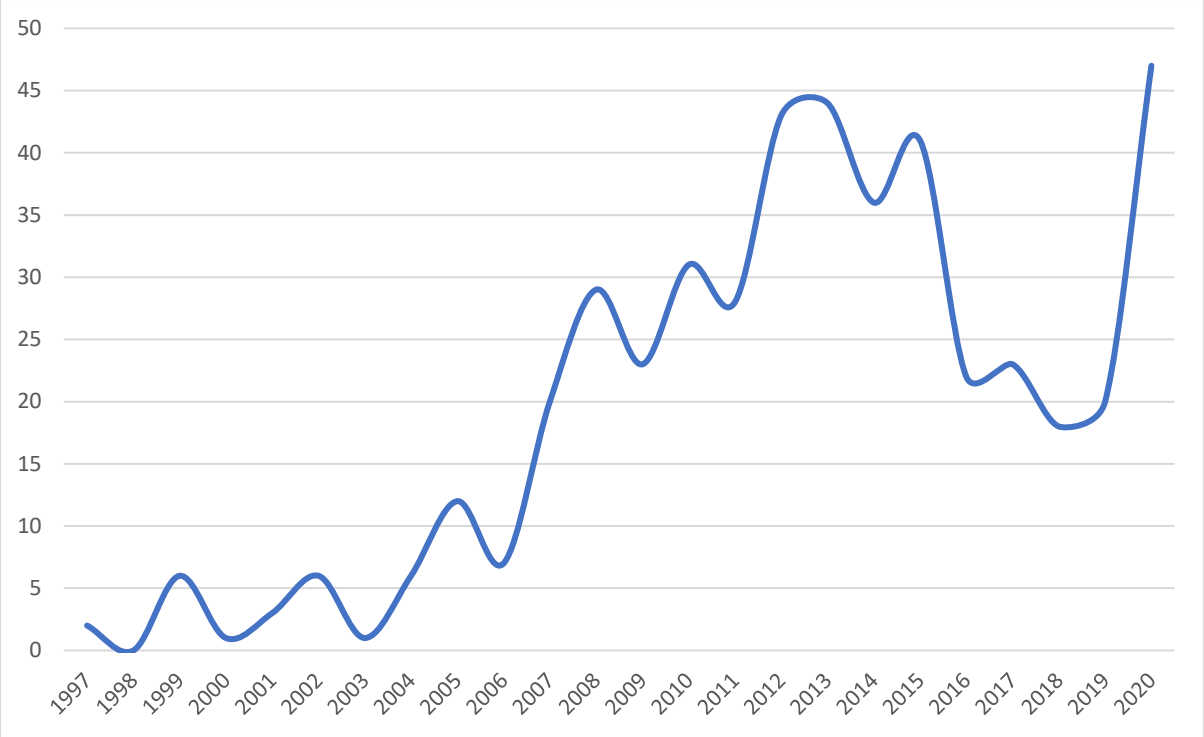

Figure 1: Climate change and marine mammals papers by year of publication 1997 – 2020.

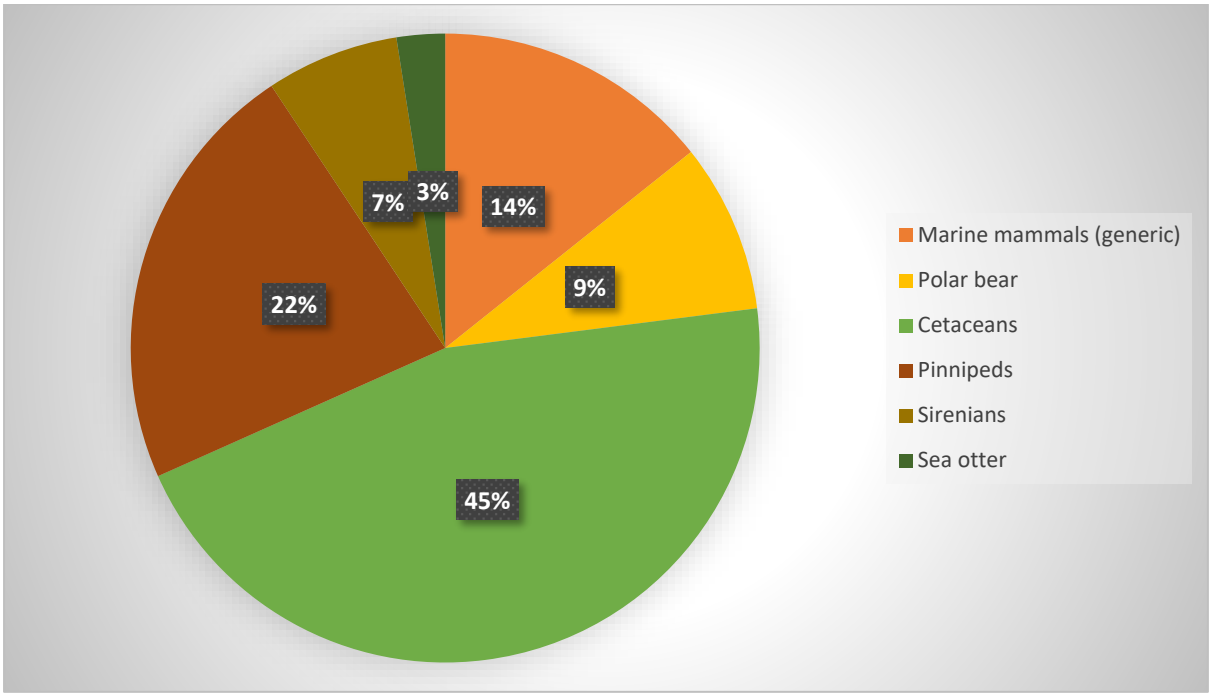

Figure 2: Climate change and marine mammals papers by taxa 2016 – 2021

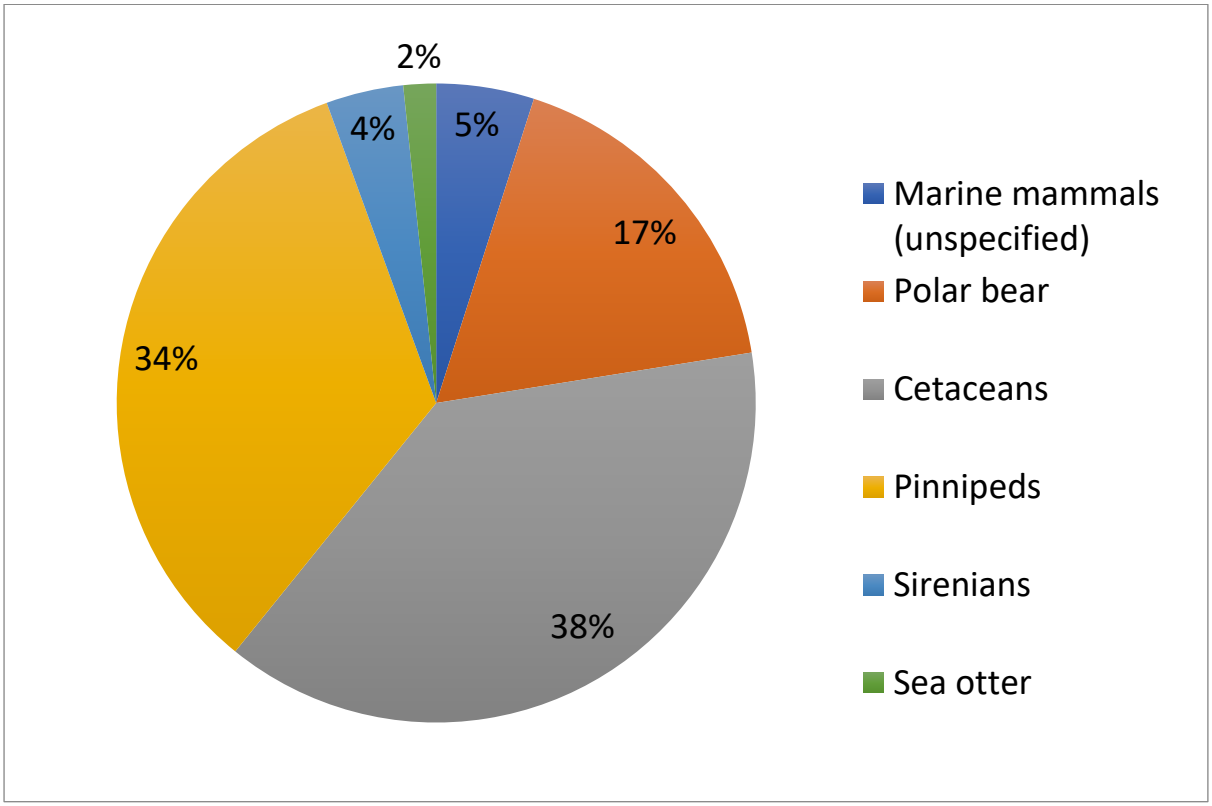

Figure 3: Climate change and marine mammals papers by taxa 1997 – 2016 (From Nunny and Simmonds, 2016)

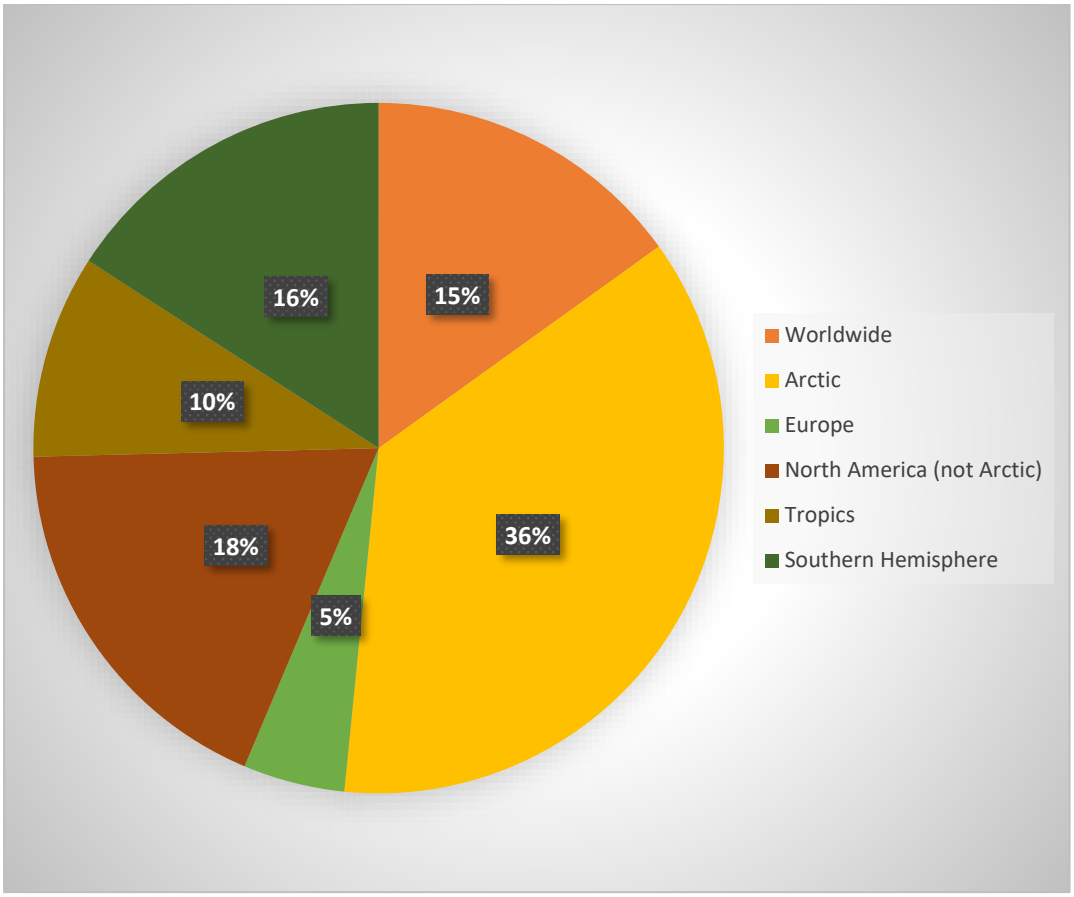

Figure 4: Climate change and marine mammals papers by region 2016 - 2021

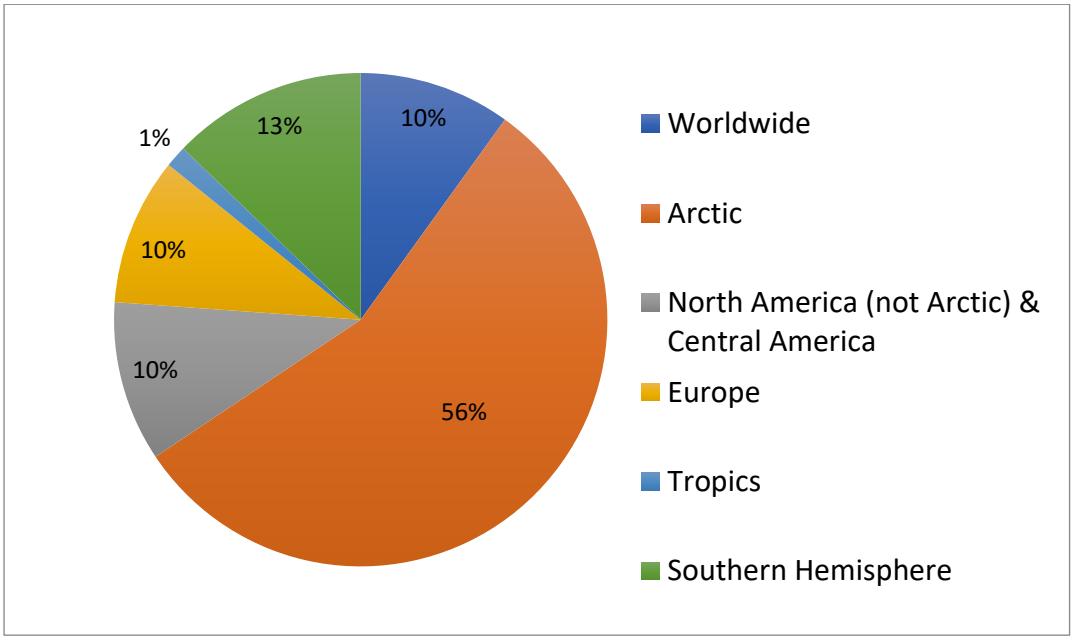

Figure 5: Climate change and marine mammals papers by region 1997-2016 (From Nunny and Simmonds, 2016)

Nunny and Simmonds (2016) found that cetaceans accounted for 38% of articles (see Figure 3). This has increased to 45% (see Figure 2). Articles about pinnipeds have dropped from 34%

to 22%. Whereas 17% of papers from 1997 – 2016 were about polar bears, only 9% of papers in the last 5 years were about polar bears. Sirenians were mentioned in 4% of papers up to 2016 and in recent years they are mentioned in 7%. Sea otters have gone from 2% to 3%. More papers (14%) refer to marine mammals or top predators in general now when compared to 5 years ago when 5% of papers did not specify which marine mammals were covered.

In our last review, the majority of papers (56%) were about the Arctic region (see Figure 5). The Arctic has only accounted for 36% of papers in the last five years (see Figure 4). There has been an increase in papers looking at climate change in the tropics (from 1% between 1997 and 2016 to 10% in the period 2016-2021).

Discussion

In recent years there has been a broadening in the regions of interest when it comes to how climate change is impacting marine mammals. Whereas previously the situation in the Arctic dominated the scientific literature, there has been an increase in interest in the Southern Hemisphere, the Tropics and North/Central America.

In 2019 we reviewed the latest research on climate change and cetaceans and highlighted that climate-related alterations to ocean conditions in many regions were already influencing cetacean habitat use and prey availability (Nunny and Simmonds, 2019). Since then, articles have been published highlighting particularly vulnerable cetacean species and their prey as well as observed and possible outcomes such as increased shipping traffic and the risks that that poses to cetaceans, increased risks of bycatch and mass strandings. Difficulties adapting to climate change because of established migratory routes and culturally learnt behaviours may be issues for some populations.

Albouy et al. (2020) found that the North Pacific Ocean, the Greenland Sea and the Barents Sea are the regions with species that are most vulnerable to global warming. They consider the North Pacific right whale (*Eubalaena japonica*), the gray whale (*Eschrichtius robustus*), the North Atlantic right whales (*Eubalaena glacialis)* and the narwhal (*Monodon monoceros*) as the cetacean species which are particularly vulnerable. Chambault et al. (2020) confirmed the narwhal's vulnerability finding that sea surface temperature (SST) affected the abundance of narwhals with the lowest abundance (<2000 individuals) observed where the mean summer sea temperatures were the highest (6.3^{o}C in Mideast and Southeast Greenland) and the highest abundance (>40,000 individuals) in the cold waters (0.7^{o}C) of the Canadian Arctic Archipelago.

Changes in environmental conditions such as warmer waters and prey availability have been reported as reasons for cetaceans being sighted foraging in new areas (e.g. humpbacks *Megaptera novaeangliae* in St Mary's Bay, Nova Scotia, Canada reported in Askin *et al*., 2017 and belugas in Svalbard, Hamilton *et al.,* 2019). Changes in prey availability due to climate change may result in changes in body condition for cetaceans. Belugas feeding more on capelin (*Mallotus villosus*) than Arctic cod (*Boreogadus saida*) in the Beaufort Sea, for example, had reduced body condition (Choy *et al*., 2020). Changes in foraging habits could put individuals at increased risk of bycatch if they move into fishing areas (Askin *et al.,* 2017).

Reproductive success can be influenced by prey abundance. Calving rates for humpback whales in the Gulf of St. Lawrence, Canada declined when there was a lower abundance of herring, copepods and phytoplankton which affected the female's ability to accumulate sufficient energy reserves (Kershaw *et al.*, 2020)

An increasingly ice-free Arctic is opening up areas to increased shipping and Hauser *et al.* (2018) found that more than half of Arctic marine mammal populations are exposed to open-water vessel transits. Narwhals were considered to be particularly vulnerable and certain areas (i.e. the Bering Strait and eastern Canadian Arctic) are more likely to bring vessels and marine mammals into contact than remoter regions.

A mass stranding of sei whales in southern Chile in 2015 was considered likely to be connected to harmful algal blooms triggered by El Niño (Häussermann *et al.,* 2017). Global warming is causing an increase in the frequency of the strongest El Niño events.

Some cetacean populations may have difficulty adapting to environmental alterations caused by climate change. Southwest Atlantic humpbacks have used a spatially restricted migratory corridor for at least 50 years (Horton *et al*., 2020). Oceanographic variables such as SST, ocean current direction and productivity which were very variable in the period 2003-2018 did not impact their migratory route, timing or velocity.

Cetacean culture may prevent some populations from adapting to climate change (Keith and Bull, 2016).

Alongside other marine top predators, certain species of cetaceans have been recommended as climate sentinels (Hazen *et al*., 2019). This means that the species responds to climate variability and/or change in a "timely, measurable, and interpretable way, and can indicate an otherwise unobserved change in ecosystem structure or function". We also believe that there may be two other trends in the literature worth noting: Firstly, there appears to be a growing body of research seeking to systematically identify the risk to cetaceans from climate change, including ranking relative vulnerabilities between taxa and localities (e.g. Albouy *et al*. 2020) and, secondly, there is a growing interest in the 'ecosystems services' provided by cetaceans and other marine mammals (e.g. Smith *et al*. 2019 and Roman and McCarthy 2010).

The authors welcome comments including suggestions for improving this review of the available published literature.

Acknowledgement
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References

Albouy, C., Delattre, V., Donati, G., *et al.* (2020) Global vulnerability of marine mammals to global warming. *Scientific Reports*. 10: 548. https://doi.org/10.1038/s41598-019-57280-3

Askin, N., Belanger, M. and Wittnich, C. (2017) Humpback Whale Expansion and Climate Change- Evidence of Foraging into New Habitats. *Journal of Marine Animals and Their Ecology.* 9(1): 13- 17.

Chambault, P., Tervo, O.M., Garde, E., *et al.* (2020) The impact of rising sea temperatures on an Arctic top predator, the narwhal. *Sci Rep*. 10: 18678. https://doi.org/10.1038/s41598-020-75658-6

Choy, E.S., Giraldo, C., Rosenberg, B., Roth, J.D., *et al.* (2020) Variation in the diet of beluga whales in response to changes in prey availability: insights on changes in the Beaufort Sea ecosystem. *Mar Ecol Prog Ser.* 647: 195-210. https://doi.org/10.3354/meps13413

Hamilton, C.D., Vacquié-Garcia, J., Kovacs, K.M., *et al*. (2019) Contrasting changes in space use induced by climate change in two Arctic marine mammal species. *Biol. Lett*. 15: 20180834. https://doi.org/10.1098/rsbl.2018.0834

Hauser, D.D.W., Laidre, K.L. and Stern, H.L. (2018) Vulnerability of Arctic marine mammals to vessel traffic in the increasingly ice-free Northwest Passage and Northern Sea Route. *Proceedings of the National Academy of Sciences of the United States of America*. 115(29): 7617-7622. https://doi.org/10.1073/pnas.1803543115

Häussermann, V., Gutstein, C.S., Bedington, M., *et al.* (2017) Largest baleen whale mass mortality during strong El Niño event is likely related to harmful toxic algal bloom. *PeerJ Life & Environment*. 5: e3123. https://doi.org/10.7717/peerj.3123

Hazen, E.L., Abrahms, B., Brodie, S., *et al.* (2019). Marine top predators as climate and ecosystem sentinels. *Frontiers in Ecology and the Environment*. 17(10): 565-574. doi:10.1002/fee.2125

Horton, T.W., Zerbini, A.N., Andriolo A., et al. (2020) Multi-Decadal Humpback Whale Migratory Route Fidelity Despite Oceanographic and Geomagnetic Change. Frontiers in Marine Science. 7: 414. Doi: 10.3389/fmars.2020.00414

Keith, S.A. and Bull, J.W. (2016) Animal culture impacts species' capacity to realise climate-driven range shifts. *Ecography*. 40: 296-304. doi: 10.1111/ecog.02481

Nunny, L. and Simmonds, M.P. (2016) Climate Change and Marine Mammals: An Assessment of the Scientific Literature. SC/66B/E/05.

Nunny, L. and Simmonds, M.P. (2019) Climate Change and Cetaceans – an update. SC/68A/E/07.

Roman, J., & McCarthy, J. J. (2010). The whale pump: marine mammals enhance primary productivity in a coastal basin. *PloS one*, *5*(10), e13255.

Smith, C. R., Roman, J., & Nation, J. B. (2019). A metapopulation model for whale-fall specialists: The largest whales are essential to prevent species extinctions. *Journal of Marine Research*, *77*(2), 283-302.