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The Less Expected Consequences of Climate Change for Cetaceans

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Abstract

There is growing evidence that cetaceans are being affected by climate change. The 2021 IWC on this topic, reviewed some interactions and potential consequences, but there are a range of other interactions between cetaceans and climate change that are now coming into improved focus, such as the effects of increased freshwater ingress into cetacean habitats, persistent areas of atypically warm water and increased storminess. Here we take note of some of the recently published literature on what might, at this point, be described as the 'less expected consequences of climate change for cetaceans' and support the case for a further dedicated IWC workshop to look at such matters.

1. Introduction

The International Whaling Commission has held workshops focused on climate change bringing experts together from all around the world on several occasions (i.e. 1995, 2007, 2010 and 2014). The latest workshop was held virtually last year (2021), in just three three-hour sessions, and looked at a range of topics. It considered mainly baleen whales with, for example, case studies on North Atlantic right whales (*Eubalaena glacialis*) and eastern North Pacific (ENP) grey whales (*Eschrichtius robustus*) (IWC, 2022). However, it was not able to cover its full agenda and recommended that a further (i.e. part two), and preferably in-person, workshop should be held to look more fully at some matters.

Additionally, the 2021 Workshop noted that in the context of "Responses to expected and observed changes in human activities as a result of climate-driven changes (for example, increased shipping in the Arctic, changes in fisheries, storm-related sewage discharges) and potential management actions in anticipation of these changes," further consideration by the Scientific Committee is required.

In this brief review, which is aimed mainly at facilitating further consideration by the Scientific Committee of the potential 'part 2 workshop', we will briefly outline some of the indirect effects of climate change as mediated via physical, biological, and human-behavioural changes, using examples from recent literature. This short paper is not meant to be exhaustive.

2. Physical changes

a. Extra freshwater ingress into key habitat areas

It is well established that prolonged exposure to freshwater or low salinity can have serious health consequences for some marine cetaceans. For example, common bottlenose dolphins (*Tursiops truncatus*) have been recorded with skin lesions, corneal oedema and electrolyte abnormalities following exposure to water with low salinity (Deming et al., 2020). Ninety-six per cent of dolphins exposed to low salinity during Hurricane Harvey, which struck the southeast USA in 2017, were recorded as having at least one skin lesion, with 65% of these dolphins exhibiting lesions of medium or high extent (Fazioli and Mintzer, 2020).

A female bottlenose dolphin who spent at least 32 days in a freshwater lake in Alabama, USA, was rescued from the lake, relocated and released before dying 12 weeks later due to entanglement in fishing gear (Deming et al., 2020). Post-mortem indicated that some of the health issues that had been present following her exposure to freshwater had resolved, such as the skin lesions. However, her corneal oedema had worsened, and this may have been affected by the low salinity conditions, although other causes are also possible. An analysis of tooth dentin revealed that the dolphin had been exposed to low salinity conditions annually prior to death and this may, therefore, be an ongoing issue for dolphins in the region.

In scenarios where there is an acute salinity change, dolphins may experience energetic costs due to a reduction of available prey and increased energy expenditure. This may be due to effects on buoyancy and reduced foraging efficiency (Booth and Thomas, 2021). Although dolphins can tolerate some exposure to low salinity, animals that are in poor health, or which are very young or very old, may die from exposure. Once an animal's skin barrier has been significantly degraded due to prolonged exposure, there is an increased risk of infection, "decompensation of adrenal and renal systems in addition to other chronic illnesses, and subsequent malnutrition."

Bottlenose dolphins in Australia exposed to sudden and marked falls in salinity (>25ppt to <5ppt) developed skin lesions "characterized by hydropic degeneration and epidermal expansion leading to vesicle formation and resulting in gross pallor, erosion and ulceration, often with intra-epidermal pustules and eruption that grossly appears as exudation, and secondary bacterial, fungal and algal infection or overgrowth that manifests as green, brown or orange mats or plaques" (Duignan et al., 2020). Duignan et al. (2020) commented that "depending on the severity of lesions, duration of exposure to adverse conditions, access to halocline refugia, or intercurrent disease (e.g. renal dysfunction), and ambient temperature, the outcome may be complete resolution or death."

Prolonged exposure to low salinity water clearly has an impact on dolphin health and welfare and "understanding the population level impacts of such exposures is very important" (Booth and Thomas, 2021). Increased exposure to low salinity water can be expected as the result of increased rainfall affecting, for example, estuary waters and other areas where fluvial input may have increased. A bibliography is available of studies concerning the health effects (e.g., skin lesions, electrolyte imbalance, microbial infection, and death) of low salinity on cetaceans, with particular focus on bottlenose dolphins (Rowley et al., 2018).

Takeshita et al. (2021) considered the common bottlenose dolphin population (some 2,000 individuals) that inhabits the Barataria Bay Estuarine System in Louisiana, USA. Salinity in the estuary can be highly variable but they found no evidence that dolphins moved coincident with changes in salinity, despite experiencing adverse health effects secondary to low salinity. They concluded that other factors were governing the movements of the Barataria dolphins, including prey availability, occurrence of predators, mating opportunities, calving events, age, sex, and/or social organization. This lack of a behavioural response to low salinity and associated poor health parameters, may become increasingly important as freshwater incursions into coastal habitats increase.

b. Extreme temperature events

A marine heatwave in Western Australia in 2011, where coastal water temperatures rose 2-4°C above average for over two months, led to a catastrophic loss of seagrass meadows and mass mortalities of invertebrates and fish (Wild et al., 2019). The Indo-Pacific bottlenose dolphin (*Tursiops aduncus*) resident in Shark Bay were negatively impacted by the heatwave with both female reproductive rates and dolphin survival declining. Dolphin survival remained low for the seven years following the heatwave. Dolphins which forage using sponges were not as adversely impacted (5.9% decline from pre- to post-heatwave) as dolphins which do not use sponges (12.2%).

Provisioned female dolphins at Monkey Mia, Shark Bay had lower calf mortality than non-provisioned females, before the marine heatwave and in the five years following the heatwave (Mann et al., 2021). Calf mortality was higher in the period 2016-2020 regardless of provisioning status, demonstrating that female reproduction was impacted several years after the marine heatwave. Dolphins that specialised in foraging in seagrass in the Faure Sill region of Shark Bay seagrass were heavily impacted by the marine heatwave which led to a loss of 20% of seagrass in the area, but "they responded by becoming more, not less, specialized. In fact, provisioned dolphins became even more specialized than other seagrass foragers, which likely exacerbated the impact of the MHW" (Mann et al., 2021).

Large scale marine temperature anomalies have been reported in recent years with knock-on effects for marine wildlife and fisheries. For example, in 2013, a persistent area of warm water developed off of Alaska and, by summer 2014, this water mass stretched all the way south to Mexico[1]. This triggered extended HABs and, by the end of 2015, much of the Pacific fishing industry had been shut down and populations of many marine predators were adversely affected. It was also reported that this phenomenon led humpback (*Megaptera novaeangliae*) and other whales to feed closer to shore, with 'record numbers' becoming entangled in lines from crab traps and other fishing gear[2]. In 2019, a second similar huge area of warm water developed again off the Pacific coasts of North America.

Similar marine temperature anomalies have been reported from elsewhere in recent years and notably to the west of New Zealand (Garreaud et al., 2021). Associated far reaching effects were also reported there.

c. Increasing storminess

Fandel et al. (2020) commented that it is increasingly important to determine how intense storms, which are becoming increasingly more frequent, alter oceanography, prey movements, and the behaviour of top predators. In their study they utilized passive acoustic monitoring to characterize the response of bottlenose dolphins to intense storms in offshore Maryland, USA between 2015 and 2017. They showed that during and following four autumnal storms, dolphins were detected less frequently and for shorter periods of time. However, dolphins spent a significantly higher percentage of their encounters feeding after the storm than they did before or during. This change in foraging may have resulted from altered distributions and behaviour of their prey species, which are prone to responding to environmental changes, such as varied sea surface temperatures caused by storms.

[1] https://earthdata.nasa.gov/learn/sensing-our-planet/blob
[2] https://www.fisheries.noaa.gov/feature-story/new-marine-heatwave-emerges-west-coast-resembles-blob

Additionally, it has been reported that hurricanes and storms can lead to dolphins becoming stranded inland with storm surges carrying them into lakes or other waterways (Mullin et al., 2015; Audubon Nature Institute, 2020). This can lead to physical trauma, exposure to poor water quality, a lack of available prey and isolation from conspecifics (Booth and Thomas, 2021).

Hurricanes can also lead to decreased salinity (Fazioli and Mintzer, 2020). For example, in August 2017, Hurricane Harvey led to salinity levels in Galveston Bay, Texas, USA falling from 14ppt to <1 ppt. Hurricane Harvey was described as having "caused long-lasting elevated water level, extraordinarily strong along-channel velocity, sharp decreases in salinity, and huge river plumes" (Du and Park, 2019). It took between 10 days and 3 months for salinity levels to return to pre-hurricane levels, depending on location and this was "explained by different contributions of exchange flow and tidal pumping to salt flux". See Section 2.a. above for the impacts of decreased salinity on dolphins.

d. Other

Orgeret et al. (2022) looked at papers studying the effects of climate change and climate variability on seabirds and marine mammals in terms of their demographics, distribution, condition, phenology, behaviour and diet. They recommended that "a larger diversity of climatic variables should be studied, with particular focus on the under-studied changes in ocean chemical properties, heatwaves, wind regimes, storm events, and human cumulative impacts, that are expected to affect marine ecosystems." Additionally, they estimated that the average time necessary for studies to robustly detect climate change effects was 19 ± 5 years, but that this varied depending on the type of response to climate change and the oceanic region. Climate changes for marine mammals in the Arctic were detected after ~10 years, for example.

3. Biological changes

Harmful algal blooms (HABs) are increasing globally in frequency, persistence, and geographic extent (Duignan et al., 2020; Kelchner et al., 2021; Danil et al., 2021) and there is a growing body of evidence that these can impact cetacean populations. Häussermann et al. (2017), for example, commented that some baleen whale mortality events have been linked to HABs and they suggest that increasing mortality events caused by HABs may become a serious concern in the conservation of endangered whale species.

Häussermann et al. (2017), reported on an unprecedented large mortality of sei whales (*Balaenoptera borealis*) in southern Chile; at least 343 were affected. They link this mass mortality to HABs during a building El Niño. They also suggest that large HABs and marine mammal die-offs along the Northeast Pacific coast may indicate similar processes in both hemispheres.

The areas where HAB species occur is predicted to change due to climate change (Townhill et al., 2018). For example, in the north-west European shelf, environmental conditions suitable for HAB species will generally be found further north, although some species may shift in a southward direction.

Danil et al. (2021) recently published a study to establish baselines for HABs in cetaceans off the California coast using an 18-year dataset. They emphasised the need for further monitoring to better understand the effects of algal toxins across multiple cetacean species and to detect shifting baselines

4. Human behavioural changes

Alter et al. (2010) wrote about the likely consequences for cetacean populations of changes in human behaviours resulting from climate change. Some of the interconnections that they highlighted are summarised here in Figure 1. They also identified the development of marine renewable energy sources as another consequence and this has now been further prioritised by some governments as they strive to become independent of 'foreign' fossil fuels, further to the conflict in Ukraine. In the context of marine renewables, Alter et al. (2010) highlighted acoustic disturbance and the potential for habitat disruption or displacement as likely consequences and there have been a significant number of papers since this publication on this topic. (We will not review them here.)

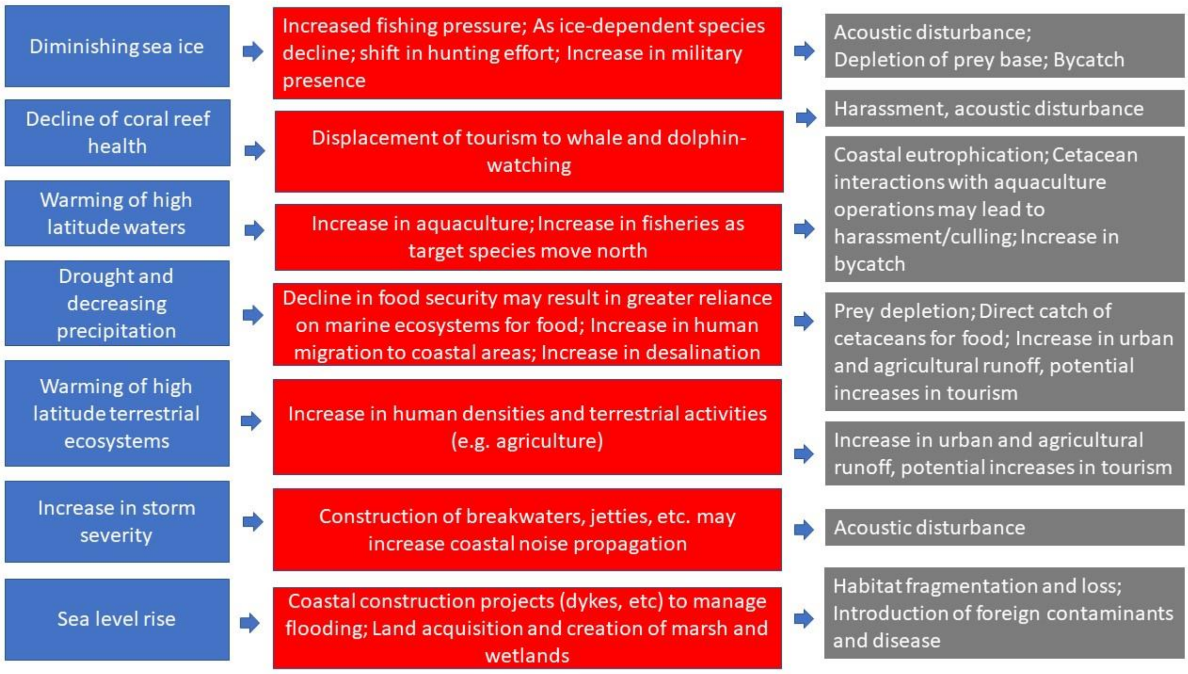

Figure 1: Linking climate change-driven changes (in blue boxes) to changes in human behaviour (in red) that cause potential impacts on cetaceans (in grey) (after Alter et al., 2010).

Climate change-driven changes in human activities were also highlighted at the IWC 2021 workshop, but almost exclusively in the context of the Arctic. Here it was noted that maritime traffic along the Northern Sea route has significantly increased due to loss of sea ice and that traffic is anticipated to become year-round by 2022 (IWC, 2022). Additionally, it was reported that in 2020/2021, several foreign marine debris events, likely associated with expanding northern fishing and commerce vessel traffic, had occurred within the Bering Strait region of Alaska.

5. Conclusions - Responding to the less expected consequences of climate change

As noted above, Orgeret et al. (2022) have emphasised the need to broaden the focus of studies into the full range of oceanic process and they also commented that, to better understand, predict and potentially mitigate the effects of ongoing and future changes, there needs to be a greater focus on dietary and physiological responses, species in the tropics and on life history stages other than breeding adults.

We agree and, as the examples above show, there are a wide range of potential impacts on cetacean populations resulting indirectly from climate change. Some of these impacts are less well described than others and some are only recently starting to be described. In order to more fully understand and better prepare internationally to try to mitigate against adverse changes in this context, it would be helpful to again draw together experts to describe and discuss these matters further and, thence, to provide information to the member nations of the Commission. This could be achieved through a 'part two' climate change workshop where some of the issues outlined here could be further considered alongside mitigation plans.

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