A five-year assessment of the impacts on emperor penguins of low sea-ice extent

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**Working Paper submitted by the United Kingdom, France, Germany and the United States**

***Summary***

The United Kingdom, France, Germany and the United States present the results of a five-year assessment (2018 - 2022) of the impact of low sea-ice extent and early fast ice break up on emperor penguin colonies around Antarctica. Over the five-year period examined, 42% of emperor penguin colonies (i.e., 28 of the 66) likely experienced total or partial breeding failure due to fast ice break up in at least one year.

In light of these findings, the Working Paper co-authors recommend that the Committee encourages:

* Members to report on their implementation of the draft Antarctic Specially Protected Species Action Plan, attached to ATCM XLIV WP34;
* Members to report to the Committee their existing and planned steps to enhance the conservation of the emperor penguin; and
* SCAR and/or interested Members to report recent research results on the status of the emperor penguin population and sea-ice extent around Antarctica to inform the future consideration by the ATCM of the designation of the emperor penguin as a Specially Protected Species under Annex II to the Protocol.

***Background***

Sea ice, and particularly land-fast sea ice, is crucial for emperor penguins as a breeding and moulting platform, as well as a foraging habitat (see Attachment A for definitions of cryosphere terms and supporting documentation). Current models, linked to IPCC climate change predictions and based upon the scientifically-proven relationship of emperor penguins and sea-ice concentration, suggest that the emperor penguin population will decline dramatically by the end of this century. In a scenario where greenhouse gas emissions continue to rise at current levels, predictions suggest that almost all colonies will be quasi-extinct by the end of the century.

At UNFCCC COP27, Sharm el-Sheikh, Egypt (November 2022), WWF, British Antarctic Survey, University of Canterbury/Te Whare Wānanga o Waitaha (New Zealand), Woods Hole Institution, UK Foreign, Commonwealth and Development Office and the International Cryosphere Climate Initiative hosted an event to highlight the risk that emperor penguins face a slippery slope towards extinction and that only ambitious global climate and environmental policy can help to safeguard the future of these icons on ice - their fate rests in our hands.

At CEP XXIII, SCAR introduced WP 37 *Projections of future population decline emphasise the need to designate the emperor penguin as an Antarctic Specially Protected Species*. SCAR described how the primary threats to emperor penguins are loss of breeding habitats and the profound transformation of the foraging habitat associated with significant change in and loss of sea ice as a consequence of climate change.

In its review on the status of the emperor penguin, SCAR found that the emperor penguin was vulnerable to ongoing and projected climate change, which may be exacerbated through additional human pressures to further degrade the species’ conservation status, thereby warranting protection as an Antarctic Specially Protected Species. SCAR recommended that the Committee establish an ICG to review the draft Action Plan prepared by SCAR (provided in Annex A to ATCM XLIII WP37) and provide a draft Action Plan.

The Committee agreed to establish an ICG to prepare a draft Action Plan for the emperor penguin, which was presented subsequently to the Committee in ATCM XLIV WP34, together with SCAR’s assessment of the emperor penguin’s conservation status as ‘Vulnerable’ (see ATCM XLIII WP37).

The Committee did not reach consensus on the recommendation in ATCM XLIV WP34 to propose the listing of the emperor penguin as a Specially Protected Species despite receiving full support from all but one Member. Many Members and Observers expressed intent to use the draft Action Plan provided in WP 34 as guidance to support their actions on the management of this species, including conducting further monitoring of emperor penguin populations, and encouraged other Members to do so.

In this Working Paper, the co-authors present a preliminary five-year assessment of the impact of early fast ice break up, linked to low sea ice concentrations, on emperor penguin colonies around Antarctica.

***New lows in Antarctic sea-ice extent***

Over the last seven years, sea-ice extent and concentration around Antarctica have fallen significantly, and four of the lowest sea-ice extent minima recorded have occurred since 2017 (Figure 1; NSIDC, 2023). In particular, 2022 and 2023 were the first in the satellite record (1979–2023) when the extent of sea ice around Antarctica dropped below 2 million km2. One potential consequence of sea ice loss is early break up of fast ice on which birds breed, thus leading to chick mortality. Here, we assess if these low sea ice years had an adverse effect on emperor penguin breeding success.

Chart, line chart

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Figure 1. Antarctic minimum sea-ice extent over the satellite record of 1979–2023. The black line denotes the annual minimum sea-ice extent based on a five-day running average (NSIDC, 2023).

Sea-ice extent effects on emperor penguin colonies

Researchers used Sentinel2 optical satellite imagery to undertake a five-year assessment of the potential impact of early fast ice break-up on emperor penguin colonies around Antarctic. From 2018 to 2022, they assessed the locations of every emperor penguin colony, and the corresponding fast ice conditions, over the latter part of the breeding season (crèching and fledging). The exact dates of fledging at each colony will vary and are not currently known, so a conservative date for the beginning of fledging of 5 December was used. Using satellite imagery, emperor penguin colonies can be located by the brown staining on the ice, the result of their guano and a unique identifier in this environment. Other seabirds do not breed on sea ice and, therefore, any staining would correspond to an emperor penguin colony. The satellite images also clearly show where the fast ice broke up. Prior to fledging, emperor penguin eggs and chicks are not able to survive seawater immersion. Therefore, it was assumed that total sea ice break-up prior to fledging would result in total or almost total breeding failure (i.e., egg or chick mortality). In the very small number of cases where partial ice break-up occurred before the fledging period commenced and satellite imagery showed the colony successfully moved to firmer ice, breeding success was assumed. Partial fast ice break-up, or total break up during the fledging period, likely reduces fledging success, but it was not possible to ascertain the degree to which this occurred using satellite data.

From the time-series data, there has been a significant increase in the number of sites affected by ice loss over the five-year period (Figure 2).

Figure 2. Emperor penguin colonies affected by partial or total ice loss during the fledging period (yellow), or total ice loss before the fledging period (red) between 2018 and 2022.

In 2022, the reduced extent of sea ice had the following effects on emperor penguin colonies:

* Thirteen colonies experienced total sea-ice loss before the fledging period in early December, likely resulting in total or near-total breeding failure.
* Of the 13 sites that experienced total sea ice loss, eight had not experienced total loss in the previous five years. However, only four of the 13 had not experience partial break up in the fledging period, suggesting that the majority of these sites are located in historically less stable areas.
* A further six colonies experienced ice loss during the fledging period leading to an unknown impact upon breeding success.

In 2021, the reduced extent of sea ice had the following effects on emperor penguin colonies:

* Twelve colonies were affected by fast ice loss.
* Six colonies of the 12 colonies experienced total fast ice loss before the fledging period, and six experienced ice loss during the fledging period.

In the previous three years (2018, 2019 and 2020), some colonies also experienced sea ice losses.

Colonies that regularly experience sea ice loss, termed “blinking” due to their inconsistent presence in given locations, are characteristically small, often just a few hundred birds and could be considered as marginal sites.

Over the five-year period examined, 28 of the 66 colonies (i.e., 42%) were affected to some degree in at least one year. Geographically, several areas were ‘hot spots’ of colony loss in 2022 (Figure 3), including the Bellingshausen Sea, central Amundsen Sea, Wilkes Land and the Budd Coast. All areas had experienced large negative anomalies in sea-ice concentration. Areas such as the Ross Sea and Dronning Maud Land, which did not experience negative sea ice anomalies, remained largely unaffected this year. Variations in sea ice extent there were probably due to regional weather patterns linked to global weather cycles, such as the Amundsen Sea Low and the El Ninõ-Southern Oscillation (Turner et al., 2012). However, two colonies in areas that did not have negative sea ice anomalies were also lost (i.e., at Cape Darlington in the western Weddell Sea and at Davies Bay on the Oates Coast), likely due to recent ice-tongue break-off or calving events.

Map

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Figure 3. Emperor penguin colony locations recorded in 2022. Red: total sea ice loss before fledging (taken as 5Dec); yellow: sea ice loss (partial or total) during fledging (taken as 5 – 31 Dec); green: stable sea ice until the assumed end of fledging on 31 Dec. The colonies are overlayed over the sea ice concentration anomaly map for November 2022. Red colouration indicates areas of positive sea ice concentration anomaly, while blue colouration indicates areas of negative sea ice concentration anomaly (sea ice anomaly data from NSIDC).

Conclusions

The extremely low sea-ice extents recorded around the Antarctic coastline in 2021 and 2022 have likely led to high chick mortality in a large proportion of emperor penguin colonies. Around 29% of all colonies were affected by either total or partial ice loss in 2022, while 18% were affected in 2021.

Over the past seven years, sea ice around Antarctica has decreased significantly. Whether or not this trend will continue is unknown, although climate models predict an accelerating decrease in sea-ice extent. The results of this study highlight the effects of the changing climate on the breeding success of emperor penguins and are an indication of the challenges that the species will face in future decades.

***Recommendations***

In light of these findings, the Working Paper co-authors recommend that the Committee encourages:

* Members to report on their implementation of the draft Antarctic Specially Protected Species Action Plan, attached to ATCM XLIV WP34;
* Members to report to the Committee their existing and planned steps to enhance the conservation of the emperor penguin; and
* SCAR and/or interested Members to report recent research results on the status of the emperor penguin population and sea-ice extent around Antarctica to inform the future consideration by the ATCM of the designation of the emperor penguin as a Specially Protected Species under Annex II to the Protocol.

**Attachment A.**

***Definitions***

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| **Term** | **Definition** | **Source** |
| Sea ice | Any form of ice found at sea which has originated from the freezing of sea water. | https://nsidc.org/learn/cryosphere-glossary/sea-ice |
| Fast ice | Ice that is anchored to the shore or ocean bottom, typically over shallow ocean shelves at continental margins; fast ice is defined by the fact that it does not move with the winds or currents. | https://nsidc.org/learn/cryosphere-glossary/fast-ice |
| Sea ice concentration | The fraction of an area that is covered by sea ice. Ice concentration typically is reported as a percentage (0 to 100 percent ice), a fraction from 0 to 1, or sometimes in tenths (0/10 to 10/10). | https://nsidc.org/learn/cryosphere-glossary/ice-concentration |
| Sea ice extent | The total area covered by some amount of ice, including open water between ice floes; ice extent is typically reported in square kilometers. Extent defines a region as either "ice-covered" or "not ice-covered." A threshold determines this labeling. A typical threshold is 15 percent, meaning that if the data cell has greater than 15 percent ice concentration, the cell is labeled as "ice-covered." | https://nsidc.org/learn/cryosphere-glossary/ice-extent |

***Supporting Documentation***

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