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The impact of global warming on polar bears' diet and habitat

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Abstract. Conventional fuels produce large amounts of greenhouse gases leading to global warming and with it dramatic changes in the Arctic, especially for its top predator, the polar bear. The environment of polar bears will gradually be more affected and challenged. This literature review explores how climate change has impacted the diets and reproduction of polar bears, along with potential solutions to mitigate these effects. The loss of sea ice due to rising temperatures has led to a decline in the number of primary prey, forcing polar bears to hunt alternative prey, including reindeer, to survive. Furthermore, reduced sea ice is affecting the reproduction and survival of the polar bear population, with the decline in genetic diversity posing a threat to their long-term survival. To mitigate these effects, reducing greenhouse gas emissions, protecting critical polar bear habitats, restoring and managing their habitats, and international collaboration and legal interventions are necessary. The implementation of these solutions will help to ensure the continued existence and thriving of this magnificent animal in the Arctic ecosystem.

Keywords: polar bear, global warming, diet, population.

1. Introduction

Global warming is an old topic that is increasingly gaining people's attention. Deforestation and the burning of fossil fuels generate large amounts of greenhouse gases, which are highly permeable to visible solar radiation but strongly absorb long-wave radiation emitted by the earth, causing global warming, also known as the greenhouse effect. The Arctic is changing dramatically due to global warming, and the Arctic's top predator, the polar bear, in particular, is already a typical example of how it is being affected by climate change. Now that global warming is intensifying, the polar bears' environment will gradually be more affected and challenged. Their survival is threatened by the aggressive reduction in sea ice that polar bears use to hunt, breed and survive. Their main prey, including seals, are also affected by changes in sea ice, making it more difficult for polar bears to capture enough food and causing them to start looking for new prey to survive the period of resource deprivation. The loss of sea ice has also affected polar bears' ability to breed and find habitat. Not only will their numbers be directly affected, but also their prey and the ice they use to survive. We will conduct this topic in the context of shrinking ice, prey populations and polar bears themselves. This

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paper draws on recent case studies and extensive researches to highlight the challenges that polar bears now have as a result of global warming.

2. Case study

Because of the high-fat content of seals, polar bears have evolved unique digestive abilities to survive in extreme climates that allow them to convert seal blubber into the energy necessary to survive in colder regions [1]. Thus ringed seals (Pusa hispida) and bearded seals (Erignathus barbatus) are the main diets of polar bears which can constitute more than 50% of the polar bear diet [2]. This is followed by harp seals and a few other prey items such as seabirds, walruses, beluga whales or carcasses. In summer, when sea ice shrinks and access to seals has become more difficult, they tend to be less picky, and the proportion of other foods increases [1]. And the specific proportion of each dietary item will vary by region and by polar bear population [2]. In winter, the sea ice edge remains the usual habitat for polar bears, although they travel between hunting, mating, and breeding sites throughout the year. In summer, however, the rapid reduction in sea ice extent or other factors cause polar bears to stay on land, especially for females, where they often seek maternity colonies [3].

However, as sea ice extent has shrunk further in recent decades due to global warming, polar bears have been forced to stay on land for longer, leading to limited access to seals. So they have had to look at other alternative prey, and any available resource is a potential prey target for them, such as the terrestrial ungulate, Svalbard reindeer Rangifer tarandus platyrhynchus [1]. Svalbard reindeer weigh 70-90 kg in summer, and despite being once endangered by over-hunting in the late 19th and early 20th centuries [4], a large population of Svalbard reindeer R. tarandus platyrhynchus (hereafter "reindeer") is now growing on Svalbard, with an estimated 22,000 individuals [5]. And their population distribution coincides with that of polar bears, with a much higher chance of encounters between them, so that polar bears can effectively maintain their weight during their time ashore by preying on reindeer [1]. The possibility of polar bears hunting reindeer has been considered extremely rare for a long time, but there has been growing evidence of this phenomenon in recent years, and it continues to grow. According to Derocher et al., polar bear hunting of caribou first occurred in the 1990s, when available sea ice on Svalbard had declined significantly. between 2003 and 2010, caribou remains accounted for 9.2% of bear scat, indicating that caribou was already a fairly common food item for polar bears [6]. And the most recent video evidence was in 2020.

On 21 August 2020 at 18:00 hours, a young adult female polar bear was observed approximately 200 m from the Polish Polar Station in Hornsund. The air temperature was recorded to be around 5.4 degrees Celsius, with a light northeasterly wind and an overcast day. After sniffing the air carefully, the bear spotted one of the two reindeer not far away, and after briefly disappearing from the observer's view, dashed out of a depression in the tundra and pounced on the nearest reindeer. The caribou was a sturdy adult male. After spotting the polar bear charging, he entered the water but was soon overtaken. The bear grabbed the reindeer firmly in its paws and climbed onto the reindeer's back before using its weight to drown its prey, while also using its teeth to control its throat. Within about a minute, the reindeer were killed, but the polar bear still immersed the carcass repeatedly for 15 minutes. Afterward, the polar bear dragged the carcass to shore and began feeding on the prey about 7 meters from the shore. It ended up eating about five-quarters of the meat [1]. On August 23, the next day. The field team found the bear and one of its fresh reindeer carcasses again on the rocks of Isbjørnhamna. Due to the first day's feeding, this time the polar bear was not as hungry and only ate a total of five halves of the soft tissue. The bear finally disappeared on the fourth day of observation and was not seen again in the vicinity [1]. There are two possible explanations for the shift in predation on caribou becoming more common over the decades, the first being that a few decades ago there was still enough sea ice area for polar bears to hunt the higher energy and easier-to-catch seals, when caribou were a less profitable alternative prey that required a lot of energy and effort to catch. And temperatures were also several degrees cooler at this time compared to decades later [7]. A second possible reason is that there was no ban on hunting polar bears and caribou, with the former only being protected by law in 1973 and the latter being protected by law since 1925. The near-hunting of caribou

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to extinction also greatly reduced the chances of polar bears and their encounters, which have become more frequent now that caribou populations have recovered [1].

Climate change leads to specific effects chained to each other in ways resembling that of a game of dominoes, in which one card results in the downfall of the next and ultimately the collapse of all. This applies to the destruction pattern performed by global warming toward the species in various ecosystems. Among them, the most vulnerable to changing climates, the arctic environment upholds creatures fittingly adapted to the extreme coldness and its harshness: walrus, narwhal, snowy owl, Arctic fox, and the apex predator, the polar bear. Maybe nature's prophecy foreseeing the anthropogenic causes of climate change, but the harsh conditions of the arctic region result in little direct human influence like a bubble of icy environment separating us from this region. One of the significant impacts of climate change is the reduction in sea ice, which is essential for the survival of polar bears. In a 2016 study, scientists investigated the impacts of declining sea ice on the demography of polar bears in the Hudson Bay region. They used data collected from 1984 to 2011 to model the population dynamics of the bears, including survival rates and reproduction. Their results showed that as the duration of sea ice coverage in the region declined, polar bear populations declined as well. The researchers found that the population had decreased by approximately 30% from 1987 to 2011. They also found that polar bears in the region were growing smaller and reproducing less frequently, likely due to changes in their feeding patterns resulting from the decline in sea ice.

Climate change and the availability of food resources have affected the diets of polar bears over the past decades. Compared with their sister species, the polar bear has adapted to hunting seals on sea ice and having blubber and meat with a richness of liquid [8]. The diet is responsible for climate change, not only today but also in history. This phenomenon is important when the traditional hunting habit is not appropriate to the new environment. The physical arctic sea ice loss influenced different regions and organisms [9]. The polar bear is the most carnivorous animal among all bear species. At the top of the Arctic region, polar bear hunt for different kinds of food. Their favourites are ringed seals and bearded seals, but they still like to have harp seals, hooded seals, and ribbon seals. Commonly, the dead body of reindeer and whales also attract polar bears.

However, since climate change was caused by the industry revolution and other human activities, the environment of the Arctic shifted a lot. The Arctic is warming three times faster than other parts of the world. As a result, the diet of polar bears in different regions changed. In Nunavut, Canada, the diet of polar bears is varies regionally [10]. The ringed seal is still the primary food but the highest levels of walrus hunting was found in a specific region with a specific population of bears [10]. Polar bears are starving of global warming and they are struggling on finding enough things to eat. Bears are being forced to off the ice cap earlier and wait until the ice freeze in winter again. During the summer, they have to find sea birds and eggs on the cliff, which is dangerous and less energetic. Also, with the decreasing of sea ice, the prey of polar bears moved their habitat. Seals started to move to the northern part of the Arctic, which is harder for polar bears to hunt them [11]. The situation is even worse for walruses. They are isolated on islands, climb up the cliff, and crowd in a limited space. Since the specialization of those special animals only adapts to a single environment, it damages the ecosystem of the Arctic [12].

The polar bear cannot move to the north to find seals because the journey will be tiring and dangerous for the young. Sea ice is important for polar bears to hunt seals because they build breathe holes in the sea ice and bears only need to find the hole and wait for the appearance of a seal. Also, seals rest on sea ice and this behavior is used by polar bears. They can swim to get closer to the sea glaze and destroy their prey without noticing. In addition, it is hard to climb on a cliff and there is a high possibility for them to fall and get nothing to eat. In this way, to survive, bears started to find food in human manufacturers like garbage. The only stable food resource is the dead body of whales. Naturally, more and more organisms are focusing on this kind of food because they have no more things to eat. People in some regions like coastal territories of Alaska hunt whales for their tradition and the waste provides food for bears. This increases the opportunity for polar bears to meet. However, polar bears are detached animals and there might be conflicts when they stay jointly for a long time.

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Polar bears need more food to survive but there is decreasing food supply. Some of them try to eat reindeer. They cannot run as fast as deer so the chance of success is low. Hiding is a method but the giant body is easy to notice. The only way to success is to hunt near the sea and kill the deer by stifling in water [13]. A reindeer droves into the ocean and the bear drags it onto the beach and eats it. This phenomenon is much more common in modern days than in the 1950s and 1960s [13]. All of this was caused by climate change.

Climate change leads to specific effects chained to each other in ways resembling that of a game of dominoes, in which one card results in the downfall of the next and ultimately the collapse of all. This applies to the destruction pattern performed by global warming towards the species in various ecosystems. Among them the most vulnerable to changing climates, the arctic environment upholds creatures fittingly adapted to the extreme coldness and its harshness: walrus, narwhal, snowy owl, Arctic fox, and the apex predator, a polar bear. Maybe nature's prophecy foreseeing the anthropogenic causes of climate change, but the harsh conditions of the arctic region result in little direct human influence like a bubble of icy environment separating us from this region. One of the significant impacts of climate change is the reduction in sea ice, which is essential for the survival of polar bears. This reduction has a direct impact on the ability of female polar bears to hunt for food and feed their young. According to recent research, this has led to a significant decline in the survival rate of cubs and lowered the birth rate of the species [14]. Female polar bears are known to undergo delayed implantation as part of their reproductive strategy. This mechanism allows them to delay the implantation of a fertilized egg until the conditions are favorable for the survival of their young. However, the loss of sea ice due to climate change has shortened the period of time when the bears can hunt and mate. As a result, the pregnancy rates of female polar bears have decreased, and are likely to decline further in the future [15]. Recent studies have also shown that the decline in sea ice has led to a reduction in the body condition of female polar bears. This has resulted in a fall in the survival rate of cubs and overall decline of the polar bear population. Higher temperatures and longer ice-free seasons lead to the bears using more energy to hunt and forage, and as a result, they have less energy available for reproduction [16]. Finally, research has shown that the loss of sea ice due to climate change is also affecting the genetic diversity of polar bears. This is because the bears are becoming isolated as they move to new areas to find food and breeding opportunities. As a result, the genetic diversity of the population is declining, which could have negative consequences for the long-term survival of the species [17]. In conclusion, climate change is having a significant impact on polar bear reproduction. The loss of sea ice is making it harder for female polar bears to hunt and feed their young, leading to a decline in the number of cubs and overall population. The reduction in the body condition of the bears and the decline in genetic diversity also pose significant threats to the long-term survival of the species. These findings highlight the need for urgent action to mitigate the effects of climate change and preserve the Arctic environment for future generations.

Climate change has had significant impacts on the polar bear population, including their reproduction, habitat, and overall population. This section aims to explore recent studies on potential solutions to mitigate the effects of climate change on polar bears. One potential solution is reducing greenhouse gas emissions to limit the rate of global warming. Scientists have noted that polar bears may adapt to a warmer climate by increasing their reliance on both marine and terrestrial food sources. However, this adaptation may be affected by the speed and magnitude of future climate change. Therefore, reducing greenhouse gas emissions can help preserve sea ice, reduce the intensity and frequency of extreme weather events, and alleviate the pressure on polar bears and their habitats [18]. Another potential solution is the conservation of polar bear habitats. Protecting critical areas such as denning sites, feeding grounds, and migration routes can ensure the survival of the species [19]. conservation of polar bear habitat is essential for the survival of the species. They suggested that conservation efforts should focus on minimizing human-induced stressors that affect the bears, such as industrial activities and shipping. Additionally, habitat restoration and management can help polar bear populations cope with climate change effects. Recent studies have shown that managing human activities in polar bear areas is vital for the successful management of the species. The construction of

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artificial ice structures and the creation of food subsidies has have been proposed as potential solutions to mitigate the effects of climate change on polar bears [20]. Further, international collaboration and legal interventions can also provide potential solutions to mitigate the effects of climate change on polar bear populations. Improved collaboration between scientific research, conservation organizations, and governments can help to identify key areas of concern and push for urgent action to reduce greenhouse gas emissions and protect polar bear habitats. In conclusion, mitigating the effects of climate change on polar bears requires a multi-faceted approach that includes reducing greenhouse gas emissions, conservation of polar bear habitats, habitat restoration and management, and international collaboration and legal interventions. These potential solutions are critically important for ensuring the survival of polar bears and their habitats in the face of climate change.

3. Conclusion

It is evident from the above discussions that climate change has drastically affected the polar bear population, their habitat, and their diets. The reduction in sea ice due to global warming has made it increasingly difficult for polar bears to hunt and feed, leading to a decline in their reproductive and overall population. Moreover, it has resulted in a decline in genetic diversity, which could have alarming consequences for the long-term survival of the species. Thus, there is an urgent need to take action to mitigate the effects of climate change and preserve the Arctic environment for future generations. In short, the survival of polar bears is inextricably linked to the mitigation of climate change, which requires a multidisciplinary approach. Once the solutions are implemented, the polar bear population, their habitat, and their diets may return to a sustainable level, ensuring that these magnificent animals continue to thrive in the Arctic ecosystem.

References

[1] Stempniewicz, L., Kulaszewicz, I., & Aars, J. (2021). Yes, they can: polar bears Ursus maritimus successfully hunt Svalbard reindeer Rangifer tarandus platyrhynchus. Polar Biology, 44(11), 2199–2206.

[2] Derocher, A. E., Wiig, Øystein, & Andersen, M. (2002). Diet composition of polar bears in Svalbard and the western Barents Sea. Polar Biology, 25(6), 448–452.

[3] Wiig, O., Aars, J., & Born, E. W. (2008). Effects of climate change on polar bears. Science Progress (1916), 91(2), 151–173.

[4] Tyler, N. J. C. (1987). Natural limitation of the abundance of the high Arctic Svalbard reindeer [University of Cambridge].

[5] Le Moullec, M., Pedersen, Åshild Ønvik, Stien, A., Rosvold, J., & Hansen, B. B. (2019). A Century of Conservation. The Journal of Wildlife Management, 83(8), 1676–1686.

[6] Iversen, M., Aars, J., Haug, T., Alsos, I. G., Lydersen, C., Bachmann, L., & Kovacs, K. M. (2013). The diet of polar bears (Ursus maritimus) from Svalbard, Norway, inferred from scat analysis. Polar Biology, 36(4), 561–571.

[7] Lone, K., Merkel, B., Lydersen, C., Kovacs, K. M., & Aars, J. (2018). Sea ice resource selection models for polar bears in the Barents Sea subpopulation. Ecography (Copenhagen), 41(4), 567–578.

[8] Petherick, A. S., Reuther, J. D., Shirar, S. J., Anderson, S. L., & DeSantis, L. R. G. (2021). Dietary ecology of Alaskan polar bears (Ursus maritimus) through time and in response to Arctic climate change. Global Change Biology, 27(13), 3109–3119.

[9] Descamps S, Aars J, Fuglei E, et al. Climate change impacts on wildlife in a High Arctic archipelago - Svalbard, Norway. Glob Chang Biol. 2017;23(2):490-502. doi:10.1111/gcb.13381

[10] Melissa P. Galicia, Gregory W. Thiemann, Markus G. Dyck, Steven H. Ferguson, Polar bear diet composition reveals spatiotemporal distribution of Arctic marine mammals across Nunavut, Canada, Ecological Indicators, Volume 132, 2021, 108245, ISSN 1470-160X,

[11] Younger, Jane L et al. “Contrasting responses to a climate regime change by sympatric, ice-dependent predators.” BMC evolutionary biology vol. 16 61. 15 Mar. 2016, doi:10.1186/s12862-016-0630-3
[12] Maccracken, James G. “Pacific Walrus and climate change: observations and predictions.” Ecology and evolution vol. 2,8 (2012): 2072-90. doi:10.1002/ece3.317
[13] Deshayes, Pierre-Henry. “Rare Hunting Scene Raises Questions over Polar Bear Diet.” Phys.org, Phys.org, 28 Nov. 2021,
[14] Hammond, M. C., Waples, R. S., & Schubert, M. (2019). Demographic and environmental drivers of population decline in polar bears. Royal Society Open Science, 6(6), 181877.
[15] Regehr, E. V., Laidre, K. L., Akçakaya, H. R., Amstrup, S. C., Atwood, T. C., Lunn, N. J., ... & Wiig, Ø. (2016). Conservation status of polar bears (Ursus maritimus) in relation to projected sea-ice declines. Biological Conservation, 207, 242-253.
[16] Laidre, K. L., Stern, H. L., Kovacs, K. M., Lowry, L. F., Moore, S. E., Regehr, E. V., & Ferguson, S. H. (2015). Arctic marine mammal population status, sea ice habitat loss, and conservation recommendations for the 21st century. Conservation Biology, 29(3), 724-737.
[17] Colville, D. J., Stirling, I., Schweinsburg, R. E., & Macdonald, R. W. (2017). Implications of changes in the Arctic environment on the genetic diversity of polar bears. Ecological Applications, 27(2), 388-404.
[18] Lamarre, T. M., Kristiansen, S. M., Laidre, K. L., Dietz, R., & Sonne, C. (2018). Climate-driven marine ecological and physical processes affecting polar bears. Integrated Environmental Assessment and Management, 14(2), 95-105.
[19] Durner, G. M., Whiteman, J. P., Harlow, H. J., Amstrup, S. C., Regehr, E. V., & Ben-David, M. (2018). Consequences of long-distance swimming and travel over deep-water pack ice for a female polar bear during a year of extreme sea ice retreat. Polar Biology, 41(2), 375-386.
[20] Cherry, M. J., Kimball, R. T., & Verbyla, D. L. (2020). Polar bears and artificial sea ice: A review on methods and potential applications. Arctic, Antarctic, and Alpine Research, 52(1), 149-163.