TECHNICAL BRIEF

coop4cbd.eu @coop4cbd.eu CO-OP4CBD

IMPLICATIONS OF POLAR ECOSYSTEM CHANGE FOR ACHIEVING TARGETS 3,4 AND 8

Introduction

Polar regions play a critical role in the Earth system. They regulate global climate through oceanic and atmospheric circulation, support highly productive marine ecosystems, and provide essential feeding and breeding grounds for many migratory species, including whales, seabirds and commercially important krill and fish (e.g. Atlantic cod, capelin, pollock).

They also host unique habitats associated with seasonal and multi-year sea ice, supporting species highly adapted to these conditions. **The functioning of these ecosystems, therefore, has implications that extend far beyond polar regions, affecting global climate, ocean systems, and biodiversity, with consequences for economies, food security, and societal stability.**

At the same time, polar regions are among the environments most rapidly affected by climate change, with profound transformations in physical and biological conditions (IPCC, 2019).

In this context, this brief examines how these transformations in polar regions may affect progress toward Targets 3, 4 and 8 of the Global Biodiversity Framework.

Funded by the European Union

This document has been produced by the author(s) in their individual expert capacity, in the context of the CO-OP4CBD project and under the supervision of the French Foundation for Research on Biodiversity (FRB), in collaboration with the Prince Albert II of Monaco Foundation and its Polar Initiative, as well as the EU Horizon-funded Polar Ocean Mitigation Potential project; grant ID: 101136875. Views and opinions expressed are solely those of the author(s) and do not necessarily reflect those of the CO-OP4CBD project, its partner organizations, the European Union, or the European Commission. Neither CO-OP4CBD, the EU nor the EC can be held responsible for them.

BOX 1 Targets 3, 4 and 8 of the Global Biodiversity Framework

Target 3 – Area-based conservation

Ensure that at least 30% of terrestrial, inland water, and marine areas are effectively conserved and managed through ecologically representative, well-connected and equitably governed systems of protected areas and other effective area-based conservation measures.

Target 4 – Species conservation

Halt human-induced extinctions and ensure the recovery and conservation of species, maintaining genetic diversity and adaptive potential.

Target 8 – Climate change and biodiversity

Minimise the impacts of climate change and ocean acidification on biodiversity and enhance ecosystem resilience through mitigation and adaptation actions.

Key Messages

- **Polar ecosystems are undergoing rapid and systemic transformations** driven by sea ice decline and climate change, affecting their structure, functioning and ecological dynamics.
- **These transformations are reshaping species distributions, food webs and ecologically important areas**, creating mismatches between ecological processes and existing management frameworks.
- **These dynamics create specific challenges for achieving Targets 3, 4 and 8,** particularly in marine environments where conservation, species management, and resource use and exploitation are closely interconnected.
- **Knowledge gaps remain significant, particularly regarding sea ice-associated ecosystems, a gap was explicitly recognised in CBD COP16 Decision 16/17** on marine and coastal biodiversity, limiting the capacity to anticipate ecosystem transformations and monitor expected changes.
- **Decision-making in polar regions increasingly takes place under conditions of limited long-term data and rapidly changing ecological conditions, highlighting the need for adaptive conservation, fisheries management and spatial management approaches that can respond to rapidly evolving ecological conditions.**

Polar ecosystems are undergoing rapid and systemic transformations driven by climate change and the decline of sea ice. These changes affect not only species and habitats, but also the ecological interactions responsible for ecosystem functioning, including primary production, food chains, and species distributions.

Sea ice plays a central role in structuring polar ecosystems. It provides habitat for organisms ranging in size from bacteria to seals, supports early-season primary production through ice-associated algae, and regulates exchanges, such as heat, light, and CO_2, between the ocean and atmosphere. These processes underpin food webs, with many species synchronising their life cycles with the seasonal formation and melting of sea ice (Figure 1).

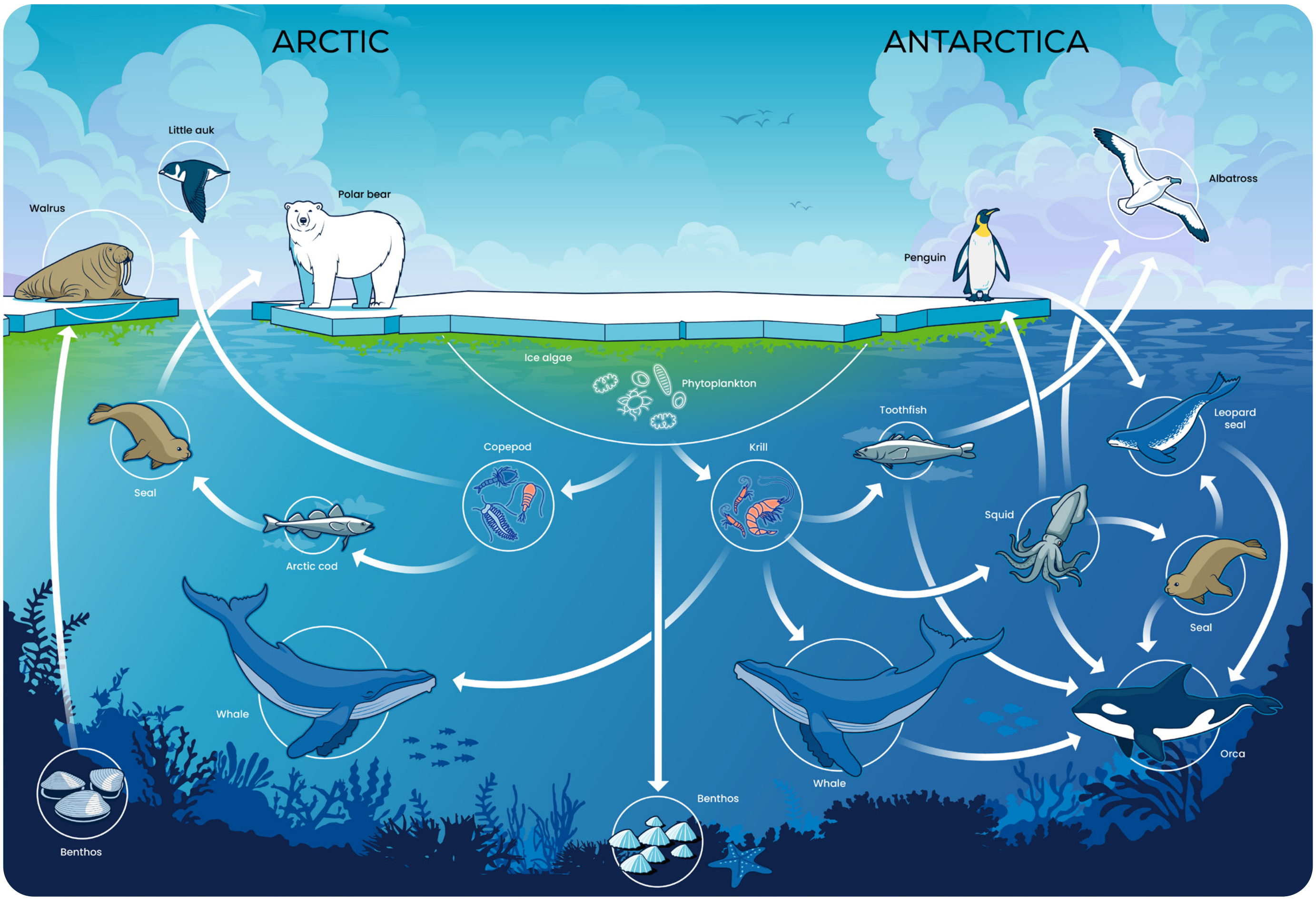

Figure 1. Arctic and Antarctic food webs. Arctic and Antarctic food webs differ in species composition and trophic structure, but both depend strongly on sea ice dynamics, primary productivity, and tightly interconnected marine ecosystems.

The rapid decline of sea ice is disrupting these mechanisms. Changes in its extent, thickness and seasonal duration affect the timing, location and magnitude of primary production. As a result, food availability may no longer align with key life stages of species, particularly larvae and juveniles. These trophic mismatches can affect survival and reproduction, with cascading effects across food webs.

Ocean warming further amplifies these changes by driving shifts in species distributions (Figure 2). Temperate species are expanding into polar regions, while cold-adapted species are declining or shifting poleward. This process, often referred to as "borealization" in the Arctic, is reshaping ecological interactions and food web structure. While species richness may increase locally, this often reflects a reorganisation of ecosystem functioning rather than an improvement in ecological integrity.

The case of Arctic cod (*Boreogadus saida*) illustrates these dynamics. This fatty, nutritious key species plays a central role in Arctic food webs and is sensitive to changes in temperature and sea ice conditions given its eggs are hidden underneath sea ice. Its decline and redistribution affect predator–prey relationships and reduce resource availability for higher trophic levels, including marine mammals and seabirds.

In the Antarctic, krill (*Euphausia superba*), which links primary producers to higher predators, is similarly dependent on sea ice during early life stages. Changes in sea ice conditions affect its distribution and abundance, with cascading impacts across ecosystems.

At the same time, reduced sea ice is increasing the accessibility of polar regions, enabling the expansion of activities such as shipping traffic, including fisheries and tourism. These growing human pressures interact with climate-driven ecological changes, creating cumulative impacts that may further increase ecosystem vulnerability.

Taken together, these stressors are likely to amplify ecosystem vulnerability and reduce resilience, reflecting a reorganisation of polar ecosystem structure and functioning. These transformations directly influence the conditions under which Targets 3, 4 and 8 can be implemented, particularly regarding spatial conservation, species management and ecosystem resilience.

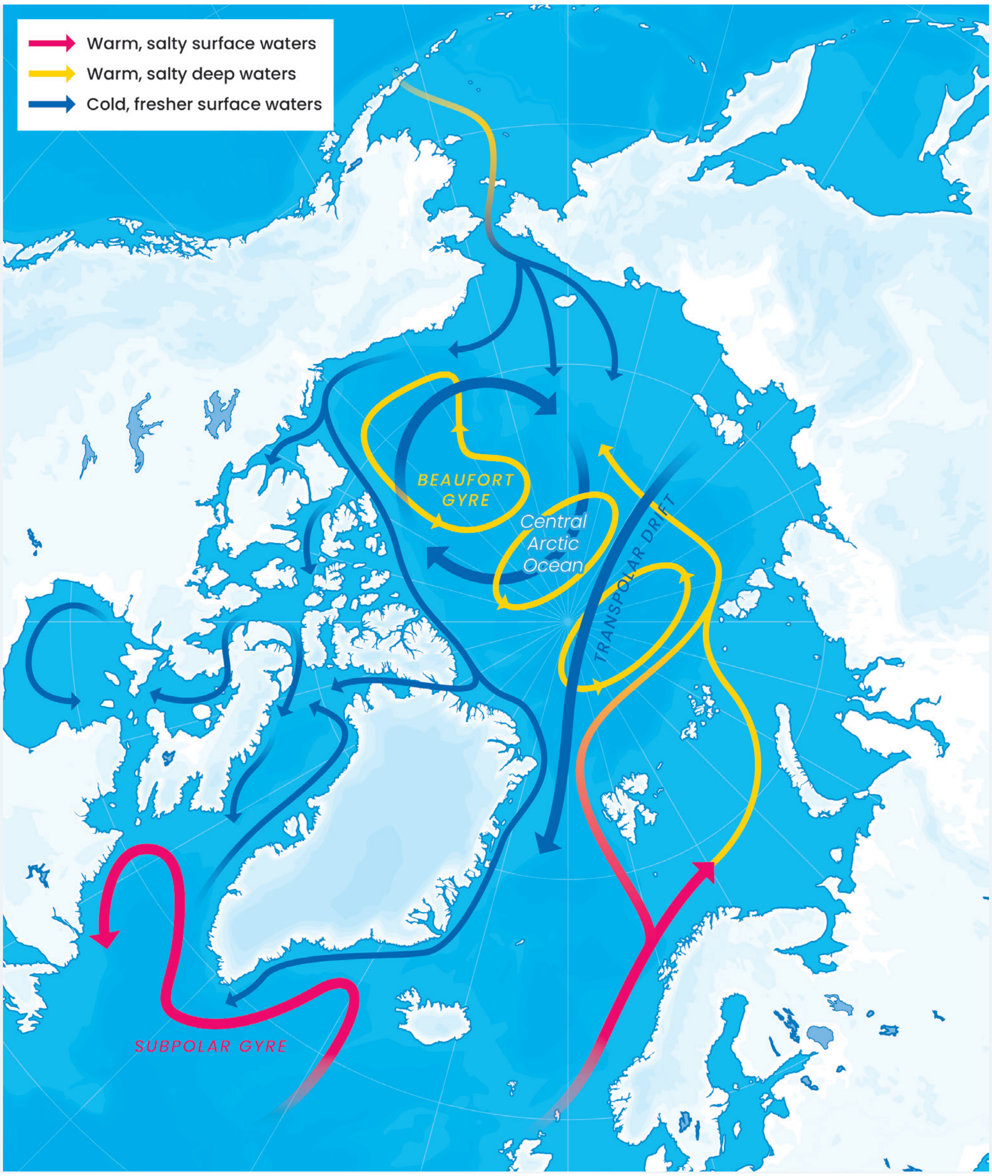

Figure 2. Main Arctic Ocean Currents (Adapted from Husson et al., 2024). While these currents are natural features of Arctic oceanic circulation systems, climate warming and sea-ice loss can increase the inflow of warmer waters and facilitate the northward expansion of boreal species, thereby contributing to Atlantification and borealization of Arctic ecosystems.

Implications for the implementation of Targets 3, 4 and 8

Target 3 – Area-based conservation in dynamic ecosystems

Target 3 aims to ensure that at least 30% of terrestrial, inland water and marine areas are effectively conserved through ecologically representative, well-connected and equitably governed systems.

In polar regions, area-based conservation plays a key role in limiting human pressures and maintaining ecosystem functioning. However, rapid environmental change is altering the spatial distribution of key ecological features. Areas of high ecological importance – such as feeding or breeding grounds – are closely linked to sea ice and may shift in space over time.

These dynamics challenge key objectives of Target 3, particularly ecological representativeness and connectivity. They raise practical questions regarding how protected areas can maintain their ecological function when environmental conditions and species distributions are shifting.

As a result, Parties may need to consider how protected areas are identified, designed and periodically reassessed in contexts where ecological conditions evolve over time.

These dynamics challenge conservation approaches based on fixed spatial boundaries and raise broader questions about how ecological representativeness and connectivity can be maintained in rapidly changing marine systems.

BOX 2 Challenges in implementing area-based conservation in the Antarctic

The proposed Weddell Sea Marine Protected Area (MPA) (Figure 3), covering around 2.2 million km², is one of the largest conservation initiatives currently under negotiation within the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR).

Despite strong scientific evidence supporting the ecological importance of this region, progress has been limited. This reflects several challenges that are relevant beyond this specific case:

- **Diverging priorities between conservation objectives and future resource use opportunities, particularly regarding krill fisheries.**
- **Uncertainty in dynamic ecosystems**: Climate-driven changes in species distributions raise questions about the long-term effectiveness of fixed spatial protection measures.
- **Consensus-based decision-making**: Within CCAMLR, decisions require consensus, which can slow down or prevent agreement even when scientific support is strong.

Taken together, these challenges illustrate the difficulty of reconciling conservation objectives, economic interests and scientific uncertainty in rapidly changing ecosystems.

Figure 3. Antarctica MPAs (Adapted from Antarctic and Southern Ocean Coalition). MPAs designated and under negotiation in the Southern Ocean illustrate ongoing efforts to strengthen area-based conservation in Antarctic waters. The Weddell Sea MPA proposal highlights both the ecological importance of large-scale protection and the governance challenges of implementing conservation measures in dynamic and internationally managed ecosystems.

Target 4 — Species conservation under changing conditions

Target 4 focuses on halting human-induced extinctions and supporting the recovery and conservation of species.

In polar regions, many species are closely linked to sea ice conditions and are therefore particularly sensitive to environmental change. For example, early sea ice melt in Antarctica has been associated with breeding failure in some penguin colonies, illustrating direct impacts on their reproduction. Changes in sea ice conditions also affect species such as ringed seals in the Arctic, which depend on stable ice for breeding, and seabirds whose feeding success is linked to availability of ice-related prey.

In the Arctic, the decline and northward shift of the Arctic cod (*Boreogadus saida*), a key prey species for seals, whales and seabirds, can disrupt trophic interactions across Arctic food webs.

Commercially important species such as Antarctic toothfish may also face increasing pressure from the combined effects of environmental change and exploitation.

These examples highlight how climate-driven changes in habitats and species interactions may negatively influence population dynamics and ecosystem functioning of ecologically and commercially important polar species, and point to the importance of maintaining the adaptive capacity of species under changing environmental conditions.

These trends complicate species monitoring and conservation planning by making population trends harder to assess and increasing uncertainty around long-term recovery trajectories.

Target 8 — Climate change and ecosystem resilience

Target 8 addresses the need to minimise the impacts of climate change on biodiversity and to enhance ecosystem resilience. Ecosystem resilience - the ability of an ecosystem to recover following disturbance - is supported by several factors, including genetic diversity of individual species, multi-species diversity, and intact food-web structures.

Polar regions illustrate the scale and pace at which climate change can transform ecosystems. Environmental conditions are evolving rapidly, and ecosystems are undergoing directional changes rather than fluctuations around stable baselines (IPCC, 2019). Multiple-stressors are accumulating due to increased human use of polar oceans, reducing ecosystem resilience and increasing vulnerability, thereby lowering ecological thresholds.

As sea ice declines, polar regions are becoming more accessible to shipping traffic, including fisheries and tourism. These expanding activities can increase fuel spill risks, underwater noise, black carbon emissions and release of chemical pollutants, including microplastics, and thereby add pressure on already stressed ecosystems. Managing these cumulative pressures requires stronger coordination across sectoral governance frameworks.

These changes affect not only individual species but also ecosystem processes, including primary production, trophic interactions and biogeochemical cycles.

Understanding how ecosystems respond to these changes is essential for assessing resilience. This includes distinguishing between short-term variability and long-term trends, and identifying thresholds beyond which ecosystem functioning may be altered.

These cumulative pressures highlight the importance of stronger coordination across climate, biodiversity and sectoral governance frameworks.

Cross-cutting policy implications

Strengthen long-term ecological monitoring, particularly for sea ice-dependent ecosystems where major knowledge gaps remain.

Ensure conservation planning better accounts for shifting species distributions and changing ecological boundaries.

Improve coordination across biodiversity, climate, fisheries and maritime governance frameworks.

Apply precautionary approaches where ecological thresholds remain uncertain.

Accelerate global greenhouse gas emissions reductions, without which progress toward Targets 3, 4 and 8 will remain constrained.

Reduce cumulative pressures from expanding human activities in polar regions

Conclusion

Polar ecosystem changes highlight a structural mismatch between dynamic ecological systems and governance frameworks that are often based on assumptions of stability. Combined with persistent knowledge gaps, this situation results in decision-making under conditions of uncertainty.

This mismatch does not call into question the relevance of Targets 3, 4 and 8, but underscores the importance of the conditions under which they are implemented in rapidly changing systems. In polar regions, conservation and management must operate in the contexts of shifting ecological baselines, evolving species distributions, and increasing cumulative pressures.

These conditions have direct implications for implementation. They reinforce the need for approaches that are adaptive, coordinated across governance levels, and capable of integrating evolving scientific knowledge into decision-making. They also highlight the importance of anticipatory and precautionary approaches in situations where uncertainty is large.

While adaptive governance can help reduce additional pressures on polar ecosystems, progress toward these targets will remain fundamentally constrained without rapid global reductions in greenhouse gas emissions.

Polar regions therefore provide a particularly demanding context for the implementation of the Global Biodiversity Framework, while also illustrating more broadly the challenges of applying biodiversity targets in dynamic and uncertain systems.

Authors

Editorial lead: Julie de Bouville

Editorial coordination: Camille Guibal

Lead Authors: Bodil A. Bluhm, Hans Poertner, Catherine Iorns, Clara Manno, Nathalie Morata, Paul E. Renaud

Reviewers: Ute Jacob, Salomé Mormentyn

References

https://www.asoc.org/campaign/weddell-sea-mpa/

https://www.frontiersin.org/journals/environmental-science/articles/10.3389/fenvs.2024.1481420/full

Disclaimer: This document has been produced by the author(s) in their individual expert capacity, in the context of the CO-OP4CBD project, in collaboration with the Prince Albert II of Monaco Foundation and its Polar Initiative, as well as the EU Horizon-funded Polar Ocean Mitigation Potential project; grant ID 101136875. Views and opinions expressed are solely those of the author(s) and do not necessarily reflect those of the CO-OP4CBD project, its partner organizations, the European Union, or the European Commission. Neither CO-OP4CBD, the EU nor the EC can be held responsible for them.c