Antarctic Blue Carbon

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**Summary**

**Resolution 8 (2021) *Antarctica in a Changing Climate* recommended that Parties consider, research and communicate the implications of climate change for Antarctica (including at UNFCCC COP26), and seek to avoid or mitigate further stresses to Antarctic terrestrial and marine biodiversity and ecosystems. Blue carbon is significant in the Southern Ocean’s coastal fjords and continental shelf where new carbon sinks are emerging and increasing. A new British Antarctic Survey / WWF project aims to map georeferenced blue carbon stocks around the Southern Ocean, initially focussing on West Antarctica.**

**Introduction**

‘Blue carbon’ refers to the **carbon stored in coastal and marine ecosystems.** Through photosynthesis, marine ecosystems very efficiently convert CO2 from the atmosphere and dissolved in water into the tissues of marine organisms. This is an ecosystem service (benefit from nature) with considerable climate mitigation potential. **Protecting blue carbon habitats and sinks may be considered an important strategy in mitigating climate change globally.**

Antarctica does not possess mangrove, seagrass or salt marshes which are typically considered as blue carbon habitat. However, its coastline does include many fjords which are ideal blue carbon habitat, and the continental shelf carbon sinks occupy a vast area of 4.4 million km2. Besides considerable size, polar continental shelves show many key features for effective carbon sinks including near intact ecosystems with less direct human impacts and so far seem to increase in power with climate change intensity (i.e. work as mitigating ‘negative feedbacks’ on climate change).

New blue carbon sinks are emerging and increasing with changes to the marine environment around Antarctica, for example through 1) ice shelf collapses generating new phytoplankton blooms and benthic assemblages; 2) seasonal sea ice losses leading to a doubling of growth by underlying benthos over the last 25 years; and 3) glacier retreat exposing super-productive fjord systems. Hotspots have been found in terms of habitats (e.g. fjords and moraines) but also at larger regional scale such as the South Orkney Islands shelf.

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**Blue carbon and the climate and nature crises**

Intensifying human activities and resource requirement have led to a rapid, recent and massive increase in greenhouse gases in the atmosphere. This has directly led to warming, ocean acidification, ice losses, sea level rise, weather and precipitation change, and many significant knock-on effects all grouped together as ‘climate change’. In parallel, the same activities have led to widespread and historically unprecedented nature losses. These crises are linked because each increases the other; nature is very efficient at CO2 greenhouse gas sequestration and thus climate regulation. Tackling one without considering the other can be less effective and even counterproductive; meaningful protection and restoration of carbon- and species-rich systems is a key part of the solution [1,2]. COP26 and other initiatives have driven a steep rise in societal interest in valuing and protecting marine nature in order to halt its decline, help to mitigate climate change and benefit the quality of human life.

**What is polar blue carbon?**

Ecosystems along polar coasts are quite different from those at lower latitudes. In the polar regions there are no mangrove, seagrasses or salt marsh but there are extensive carbon-rich ecosystems fuelled by macro- and micro-algae. Per unit area or time polar blue carbon is thought to be less productive or efficient as a carbon pathway (and thus climate mitigation) as low latitude coastal wetlands because of seasonal darkness and very low temperatures. However, although still little researched to date, there is strong evidence that polar blue carbon could be important as a ‘nature-based solution’ to aid climate mitigation. Not least because one of the most carbon-rich habitats proven to be strong in sequestration of carbon are fjords, which occur mainly at high latitudes.

The fate of much of the rich, endemic biodiversity living in polar fjords is burial in the anoxic muds on the fjord floor [3,4], but there are much more extensive polar carbon sinks throughout the deep and sometimes wide continental shelves. Key features for strong carbon sink and climate mitigation performance in nature are that ecosystems are 1) intact or near intact; 2) extensive and long term; and 3) involve conservation that is not too focussed on single goals. Unlike those at lower latitudes polar continental shelf carbon sinks meet all these, with a massive 4.4 million km2. They have a number of advantages over carbon sinks elsewhere. Being far from urban centres they have fewer other anthropogenic stressors, few other complicating factors such as non-indigenous species, and mainly require protection, rather than time, effort and finance costly restoration or creation. Perhaps most importantly, polar areas work as the largest negative (mitigating) feedbacks on climate change – that is they drawdown, store and sequester more carbon with intensity of climate change [3-6].

**How and why is polar blue carbon changing?**

Physio-chemical change and biological responses to these around the Polar Regions are complex in both space and time [7]. Arctic seas can generate considerable blue carbon but clear climate-driven change in this remains to be detected [8]. Blue carbon estimation and quantification in the Southern Ocean has involved investigating the magnitude and density of organismal carbon storage on the seabed [3,9], or organic carbon in sediment cores, or both [4]. Increases in blue carbon have been found associated with three main climate-forced processes:

* Ice shelves collapse to generate new phytoplankton blooms and benthic assemblages [10]. The combination of opening up new bay scale ecosystems and enrichment in the wake of the giant icebergs created can amount to a million tonnes for a single giant iceberg [6].
* Seasonal sea ice losses change the timing, duration and cell size of phytoplankton blooms [7], leading to a doubling of growth by underlying benthos over the last 25 years [9]. This can be complicated by carbon losses in some areas caused by a) increased iceberg scour in the shallows [11]; b) increased seasonal sea ice in some areas [12]; and c) losses of ice associated zooplankton biomass [13].
* glacier retreat along fjords exposes potential new productive habitat for phytoplankton at the surface, macro-algae in the shallows and rich biodiversity on the seabed [3,4]. This is the most important of the three processes per unit area, but occupies by far the least area.

**Where are the hotspots of polar blue carbon?**

Blue carbon magnitude has been little mapped in either Polar Region to date, though there is a considerable literature on georeferenced biomass and carbon content of sediment cores. A new British Antarctic Survey / WWF project will map existing information from July 2022 onwards. Despite being relatively young, fjords are likely to be hotspots [4]. Beyond the habitat scale the South Orkney Islands shelf (44,000 km2) appears to be a regional hotspot, overlapping with a CCAMLR Marine Protected Area. The size, distribution and export of macro algal forests will be a key area to look at in forthcoming blue carbon hotspot mapping. One of the key challenges of such mapping will be issues of spatial scale and interpolation and scaling up in a very data-poor region of complex change.

**Is polar blue carbon vulnerable?**

Polar biota is slow growing, sensitive to change and highly vulnerable, and faces a complex diversity of stressors as well as climate change so disruption to growing carbon sinks could be significant. Polar continental shelves offer a rare opportunity for reducing nature loss and aiding efficient climate mitigation by protection of growing blue carbon sinks (rather than expensive and less effective, restoration and creation of habitat).

To date, no areas have been protected under the Antarctic Treaty System specifically for their blue carbon value. However, as new embayments, fjords and other areas open up with marine ice losses, productivity is likely to considerably increase [4,6,7,9,10] and such areas may be subject to human activities, such as fishing, tourism or new infrastructure.

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