Healthy coastal ecosystems are crucial to mitigate climate change

The coastal zones are among the most effective areas on Earth at sequestering carbon from the atmosphere. Treated right, these ecosystems are important cornerstones in climate change mitigation, but if degraded, they instead release large amounts of greenhouse gases, re-enforcing global warming. Urgent action is needed to preserve and restore the Baltic Sea coasts and use these systems to work in favor of the climate – not against it.

Coastal zones, where land and sea meet, are biodiversity and productivity hot spots. In submerged coastal landscapes, a mosaic of seafloor vegetation provides habitat for numerous marine organisms, but these ecosystems also play a significant role in the oceanic carbon cycle (*1*). In fact, coastal ecosystems sequester carbon – often referred to as 'blue carbon' – from the atmosphere and oceans at significantly higher rates, per unit area, than terrestrial forests (*2*, *3*). To date, it is estimated that coastal blue carbon systems sequester 4 to 10 tons of carbon dioxide per hectare each year (*4*), thereby accounting for almost half of the total carbon sequestered in ocean sediments, despite that they cover less than two percent of the ocean floor (*5*).

With these outstanding properties, vegetated coastal ecosystems play a critical role in capturing carbon that would otherwise remain as atmospheric carbon dioxide and exacerbate climate change (*6*). Although often overlooked, it is now time to acknowledge this important ecosystem service and consider it a key argument for both the preservation and restoration of Baltic Sea coasts.

Long-term storage of carbon in coastal sediments

Mangrove forests, salt marshes and seagrass meadows are typical examples of blue carbon ecosystems. Such ecosystems are found along the coastlines of every continent, except Antarctica, and they are extremely efficient in capturing carbon dioxide from the atmosphere through photosynthesis. They also trap organic matter from the water column, and their complex underground stem and root systems help binding and storing large amounts of carbon in the sediment below (*4*). Meadows of eelgrass (Zostera marina) – a seagrass with a large capacity to store carbon – are distributed along the coasts of Scandinavia and the Baltic Sea (7, 8). In addition, other shallow submerged coastal ecosystems with mixed vegetation and salt marshes in the Baltic Sea are considered hot spots of carbon cycling (*9*). In undisturbed areas, plants can absorb large amounts of carbon, which may be transported into the sediments, where it can remain for a long time.

Coastal macroalgae also absorb large amounts of carbon. In the Baltic Sea, the bladder wrack (*Fucus vesiculosus)* is widespread. It has a high biomass and productivity, and often dominates shallow benthic communities with a positive effect on coastal biodiversity (*10*). Although lacking roots and, hence, the ability to directly transfer carbon into local sediments, these algae can be exported across the open ocean, and their carbon can be sequestered in long-term reservoirs like coastal sediments and the deep sea (*11*).

Unlike terrestrial soils, the sediments of marine ecosystems are largely anaerobic (without oxygen). This means that the carbon incorporated into the sediments decomposes very slowly and that it takes a long time until it is eventually released back to the water as carbon dioxide. If more sediment is continuously accumulated, the organic matter can be sequestered over geological timescales. The carbon found in coastal sediments is often thousands of years old.

Degraded coasts emit greenhouse gases

Coastal ecosystems worldwide bring an enormous value in ecosystem services. However, they face increasing pressures due to climate change and other anthropogenic environmental stressors, such as eutrophication, chemical pollution, and physical exploitation. The rates of loss of coastal blue carbon ecosystems are estimated to be twice that of forests: 0.03 – 1 percent of the total area is lost annually.

When these ecosystems are degraded, disappear, or converted to other uses, their carbon sink capacity is lost. But the degradation of coastal blue carbon habitats does not only slow the uptake of carbon from the atmosphere. When degraded or destroyed, these ecosystems start emitting the carbon they have stored for centuries into the atmosphere and oceans. Consequently, they become sources of climate-relevant greenhouse gases, both in the form of carbon dioxide and methane – the latter is a potent greenhouse gas with a sustained flux global warming potential 45 times that of carbon dioxide *(12)*. Currently there is, however, a major knowledge gap in our understanding of the variability of such emissions over various spatial and temporal scales, particularly in Baltic Sea coastal environments.

The Baltic Sea coast – already a carbon source?

There is growing evidence that warming in high-latitude regions releases stored methane from hot spots such as the Arctic tundra, further exacerbating climate change. Less recognized is the fact that the same may apply to shallow coastal zones in the Baltic Sea, too.

To date, emissions of methane partially offsets coastal blue carbon burial around the world, and the emissions are likely to increase due to continued urbanization, eutrophication, and global warming (*13*). Likewise, measurements in the Baltic Sea during the heatwave in 2018 showed record-high levels of released methane from the coastal zone (*14*).

As extreme weather events are predicted to become more frequent in a changing climate, and eutrophic conditions are characteristic for coastal Baltic Sea habitats, it is of uttermost importance to protect Baltic Sea coastal habitats from further degradation that may turn these systems into greenhouse gas hot-spots. At the same time, we need to better understand the factors that drive methane emissions in both healthy and disturbed coastal ecosystems. Continued research in the Baltic Sea could improve our understanding of blue carbon ecosystems globally because the sea is considered a ”time machine” for the world’s coastal zones *(15)*. The Baltic Sea is responding to climate change (or exhibiting the effects of climate change) more rapidly than other regions, while also suffering from other human stressors.

Right measures can restore the ecosystems

Unlike the expected release of methane from the Arctic tundra, the release of greenhouse gases from coastal ecosystems is not an irreversible process. Although warming enhances the release of methane from coastal sediments temporarily, it can be prevented by moderating other pressures.

Taking measures to reduce eutrophication and stop physical disturbance in shallow waters can help re-establish carbon sequestering systems such as seagrasses. Also, methods to actively restore degraded coastal habitats, such as eelgrass and bladderwrack, are already in use and ready for broader adoption.

Need for implementing blue carbon to policies

Conserving and restoring coastal habitats has been recognized as an essential component of climate change mitigation (*16*). In a recent report from the World Resources Institute, the global mitigation potential of healthy coastal marine ecosystems has been estimated to 1.4 billion tons of carbon dioxide equivalents annually. This can be compared to the total annual reductions of greenhouse gas emissions needed by 2050 to fulfill the Paris agreement of 56 billion tons of carbon dioxide equivalents (*17*).

As assets for carbon sequestration, the coasts also have a monetary value. For example, carbon sequestration by blue carbon ecosystems in the coastal waters of the United Kingdom has been estimated to be 60 billion British pounds for the year 2019, which is about ten times as much as the estimated value of fish captures in the same waters (*18*). Such national assessments are needed to develop policies aimed at preserving vegetated coastal ecosystems to help mitigate climate change. For the Nordic countries, however, there are large uncertainties regarding the carbon stocks and sequestration rates of coastal ecosystems, and limited data are available on the loss and fate of carbon after disturbance. As this knowledge deficit currently hinders the adoption of these systems into policies, carbon trading, and national inventories (*19*), it is important to rapidly start filling these knowledge gaps, especially considering the fast rate of decline reported for many blue carbon ecosystems.

Thus, maintaining the health of coastal ecosystems is not only beneficial for livelihoods, food security, recreational opportunities and biodiversity, but it is also an effective strategy for climate mitigation. To have a chance to reach the goals of the Paris agreement, we cannot afford to lose more of the high carbon sequestering coastal ecosystems or let important habitats degrade into greenhouse gas sources. Instead, we have to make all effort to break the cycle, restore damaged habitats and return the Baltic Sea coasts to the long-term carbon sinks they have the potential to be.

Recommendations:

Promote healthy coastal ecosystems by:

- Reducing pollution, such as hazardous chemicals and nutrients, especially in shallow areas and bays.
- Prohibiting bottom disturbing activities, such as bottom trawl fishing and dredging in coastal regions.
- Stopping the ongoing exploitation of the coast by limiting new buildings and piers.

Actively restore degraded but important carbon-sequestering coastal habitats, such as those of eelgrass and bladderwrack.

Include managment of marine coastal ecosstems in climate policies.

Support research on blue carbon ecosystem in the Baltic Sea.

Coastal blue carbon

Blue carbon is a concept describing carbon captured from the atmosphere and water and stored in coastal and marine ecosystems. It highlights that coastal ecosystems, in addition to terrestrial forests (coined as 'green carbon'), contribute significantly to carbon sequestration.

The carbon uptake in coasts and oceans can both result in a short-term storage in plants and algae (i.e., in their biomass), but more importantly, to a long-term sequestration within the seafloor. Through continuous sedimentation, organic material may be buried for millennia.

Conservation and restoration of coastal ecosystems, specifically salt marshes, seagrass meadows, mangrove forests, and macroalgae habitats are, therefore, excellent examples of nature-based solutions for climate mitigation.

Co-benefits of coastal protection and restoration

Biodiversity: Healthy coastlines host biodiverse ecosystems.

Water quality: Wetlands and coastal vegetation can filter water, take up nutrients, enhance the water quality, and produce oxygen.

Ocean acidification: Coastal vegetation can locally alleviate low pH conditions, thereby representing a possible tool to mitigate the consequences of ocean acidification.

Food security: Coastal ecosystems are breeding grounds for commercially important fish species.

Recreation and tourism: Coasts provide attractive settings for outdoor activities.

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