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Blue Carbon Ecosystems in Nationally Determined Contributions and national greenhouse gas reporting

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1 Key take aways

- Blue carbon ecosystems (BCE) are not yet widely included in National Determined Contributions (NDCs) and National Inventory Reports (NIRs), but the number of countries taking BCE into account in their NDCs is increasing.
- Most countries including BCE in their NDC submissions are developing countries. They usually emphasise the role of Blue Carbon Ecosystems both for adaptation and mitigation.
- The current reporting on BCE in NIRs is insufficient for a reliable assessment of the greenhouse gas (GHG) emissions and removals arising from such ecosystems. Only seven countries include one or more BCE in their reporting. Mangroves are most frequently included in the NIRs, followed by tidal marshes.
- Australia and the USA are the most advanced countries when it comes to reporting on BCE. They report on mangroves and tidal marshes and include CO_2 and non-CO_2 emissions from the degradation and destruction of BCE as well as CO_2 removals from restoration/regeneration activities.
- Among the EU Member States, only France and Malta report on coastal wetlands. However, they only report on tidal marshes.
- More knowledge transfer on reporting and monitoring GHG fluxes in BCE is needed based on more scientific field work to generate the needed data to enable more countries to include BCE in their reporting and reduce uncertainty in current reporting.

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2 Introduction

Reducing emissions in all economic sectors and consumption of resources needs to be achieved rapidly to achieve the climate mitigation targets set by the Paris Agreement. Additionally, to keep global warming to well below under 2°C, efforts to capture CO_2 from the atmosphere and store carbon over the long term are necessary. Natural carbon sinks can contribute to achieving this target. Tidal or salt marshes, seagrass meadows and mangroves are coastal ecosystems that have gained increasing public interest because of their importance as natural carbon sinks. Hence, they are often referred to as "blue carbon ecosystems" (BCE) (IUCN 2021; IPCC 2019b). The term "blue carbon" is not uniformly defined but in this report, we refer to "blue carbon" as the carbon captured by marine organisms and stored in living and dead biomass as well as in organic compounds in the sediment/soil. BCE accumulate a lot of carbon in the soil because the anaerobic conditions of mainly waterlogged habitats slow decomposition of organic carbon and reduce emissions compared to non-waterlogged ecosystems. In vegetated coastal ecosystems like mangroves the accumulation of carbon in aboveground biomass can also be significant. If BCE are destroyed, huge amounts of carbon in form of CO_2 emissions are released. Hence, the protection, restoration and sustainable management of BCE is important not only for climate change mitigation, but also for biodiversity and coastal protection against floods. Therefore, BCE are also important for climate change adaptation.

As a consequence, in recent years an increasing number of countries are recognising the links between measures to protect and restore BCE and their climate mitigation and adaptation goals.

Besides requiring all countries to submit Nationally Determined Contributions (NDCs), the Paris Agreement establishes the Enhanced Transparency Framework (ETF) for reporting on action and support. Under the ETF, developed and developing countries have the same reporting obligations. Starting from December 2024 they must present Biennial Transparency Reports, which contain information on their GHG inventories and on the implementation of NDCs. The ETF strengthens reporting obligations for developing countries, which did not have the obligation to report their GHG inventories every two years before the Paris Agreement. Annex I Parties[1] to the United Nations Framework Convention on Climate Change have been submitting GHG inventories and the accompanying National Inventory Reports (NIRs) annually since the early 2000s. Thus, their transparency systems are well established, and more recent information is available for this group of countries. Developed countries will continue to provide annual GHG inventories. The Intergovernmental Panel on Climate Change (IPCC) provides methods to include GHG fluxes of coastal wetlands in national reporting (IPCC 2006; IPCC 2014; IPCC 2019a).

The aim of this report is to investigate to what extent countries consider measures such as the protection and restoration of BCE in their NDCs and NIRs to achieve mitigation or adaptation goals. For this, we summarize the latest report by Lecerf et al. (2023) on the inclusion of BCE in NDCs. Regarding the NIRs, we focus on assessing how developed countries are reporting BCE - assuming that they have the most experience in this area and that their applied methodologies can serve as a basis for discussion on future improvements in reporting of emissions and removals from BCE.

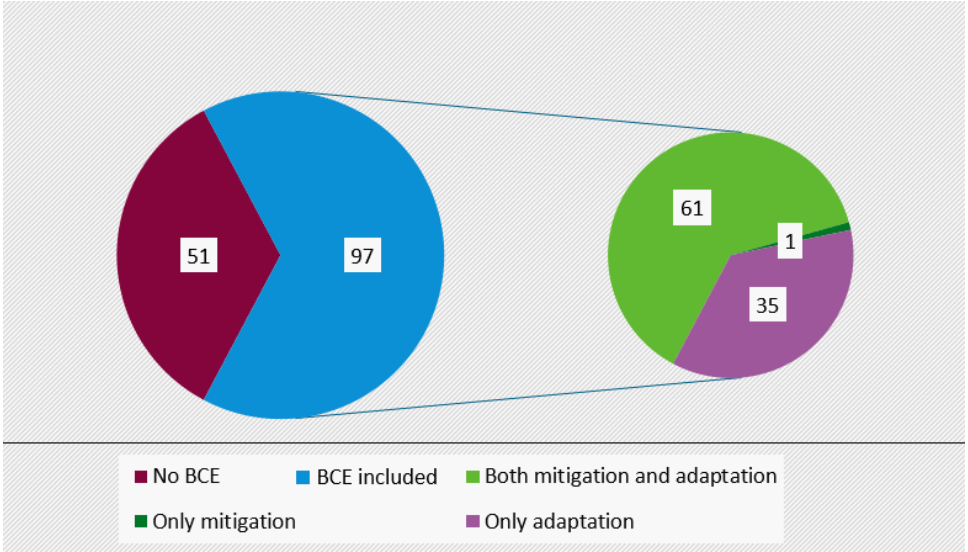
[1] 43 Parties (42 countries and the European Union).

3 Blue Carbon in Nationally Determined Contributions

Blue carbon and BCE are gaining increasing interest, as shown by several studies and guidelines published on if and how BCE can be considered in NDCs (Beeston et al. 2023; Dencer-Brown et al. 2022; Hamilton et al. 2023; Herr and Landis 2016; Lecerf et al. 2023; Ocean Conservancy 2023). By the end of September 2023, 168 NDCs representing 195 Parties to the Paris Agreement have been submitted to the UNFCCC.[2] Lecerf et al. (2023) analysed 148 new or updated NDCs regarding their consideration of marine nature-based solutions (NbS) or BCE (cut-off date 1st of October 2023). Highlighting some of the findings of Lecerf et al. (2023) and the Ocean Conservancy (2023), this section considers if BCE contribute to national mitigation and/or adaptation goals, which BCE are included and whether biodiversity, financial instruments or monitoring measures are mentioned in the NDCs. In the analysis of Lecerf et al. (2023), BCE include mangroves, seagrass and/or tidal (salt) marshes which is in line with the definition presented in section 1. Their analysis considers the 27 submissions of EU countries as one (Party). We crosschecked the selected findings from Lecerf et al. (2023) with the NDCs in question and analyzed the NDCs further for the country examples at the end of this section.

Out of 148 NDCs analysed in Lecerf et al. (2023), 97 include terms such as 'blue carbon' and BCE. About two thirds of these 97 NDCs include BCE for only mitigation or both mitigation and adaptation purposes (mentioning either protection, conservation or restoration measures). One third of NDCs refers to BCE exclusively as part of adaptation measures. Figure 1 shows how BCE are considered in the NDCs:

Figure 1: Overview of 97 (out of 148) new/updated NDCs which considered BCE



Source: Own compilation based on data from Lecerf et al. (2023)
Note: 97 out 148 NDCs consider BCE (left pie chart) for varying purposes (right pie chart).

The majority of countries which consider BCE for mitigation purposes in their NDC are developing country Parties. Only three developed country Parties consider BCE for mitigation purposes: Iceland, United Kingdom (UK) and United States of America (USA).

The NDCs from 18 landlocked countries do not include references to BCE for obvious reasons. 33 NDCs, including the EU, that don't consider BCE are from Parties which have a coastline. Among these 33 parties is also New Zealand – although New Zealand reports on BCE in its NIR

[2] Difference in submissions versus Parties because EU-27 countries all submitted the same EU NDC. NDCR registry https://unfccc.int/NDCREG.

(section 4). The relatively large number of these coastal countries not including BCE indicates that there is an untapped potential of BCE in NDCs.

Only 14 NDCs included a reference to the IPCC 2013 Wetlands Supplement[3] in relation to their BCE measures, including Australia, Canada, and the UK.

Compared to the first round of NDCs, the share of countries considering BCE has increased in the NDC updates (48% compared to now 63% - exempting 6 countries which have submitted only one NDC and no update). Particularly, using BCE for adaptation efforts has increased. This is in line with an increased recognition of multiple pressures or threats to or from the ocean mentioned in the NDCs. Likewise, additional quantitative targets for coastal and marine NbS were added into some updated NDCs.

About half of the 97 NDCs mention and recognize that implementing BCE measures with a focus on mitigation has co-benefits for adaptation and vice-versa. For example, it is often mentioned that mangroves sequester carbon while also providing flood protection and reducing soil erosion. The protection or restoration of BCE can potentially have many additional sustainable development impacts. A total of 44 NDCs recognize socioeconomic benefits of their BCE measures for local communities.

Out of 97 NDCs analysed in Lecerf et al. (2023) and considering BCE, 54 NDCs mention specific tracking/monitoring or transparency measures and/or specific quantitative targets and indicators in relation to their BCE measures. These can include commitments to general monitoring of ocean ecosystems or management of marine protected areas. Some pledges are also quite specific. For example, Equatorial Guinea aims to restore 1.300 ha and conserve 24.700 ha of mangroves by 2050, leading to the absorption of 344.500 tCO_2eq annually by 2050. Ideally, Equatorial Guinea will report the methodology used for this calculation in its upcoming biennial transparency report.

32 NDCs state that they plan to increase financial resources dedicated for BCE measures. The Seychelles, for instance, plan to identify financing mechanisms to support its NDC implementation, such as blue carbon credits and bonds, and other innovative conservation financing mechanisms.

NDC examples are chosen to represent different regions of the world, developed and developing parties, different levels of detailed description and are based on examples highlighted for including the restoration/conservation of BCE in Lecerf et al. (2023, p. 22). If given, information on national mitigation and/or adaptation goals, which BCE are included and whether biodiversity, financial instruments or monitoring measures are provided.

China refers to BCE for both mitigation and adaptation efforts and directly mentions BCE in its NDC. China states that "*Based on systematic investigation to the distribution of national marine carbon sink (blue carbon) ecosystems, China will protect and restore the existing blue carbon ecosystems by means of various blue carbon pilot projects and marine ecological protection and restoration projects, giving full play to the role of blue carbon in mitigating climate change*" (The Ministry of Ecology and Environment the Peoples Republic of China 2021, p. 45). Mangroves, seagrass beds and salt marshes will be considered. While the NDC does not further specify how the BCE measures will be financed or monitored, a 2022 submission on progress in the implementation of the NDC states that "*technical specifications for surveying and assessing the carbon sink capacities of mangroves, coastal salt marshes and seagrass beds*" have been issued and a carbon storage survey conducted in 16 pilot areas (The Ministry of Ecology and Environment the Peoples Republic of China 2022, p. 19). Chinas National Communication from

[3] The IPCC 2013 Wetlands Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories provides guidelines on how to estimate emissions of CO_2, CH_4 and N_2O for activities in tidal marshes and seagrass meadows.

2018 mentions that periodical monitoring and protection of mangrove forest has occurred in Macao (The Ministry of Ecology and Environment the Peoples Republic of China 2018, p. 272).

Costa Rica also plans to use BCE for both mitigation and adaptation efforts and directly mentions BCE in the NDC. The country also explicitly recognizes co-benefits of BCE. Costa Rica has concrete targets and measures: conserving and protecting 100% of its coastal wetlands that are included in the National Registry of Wetlands, expanding the area of registered estuarine wetlands by at least 10% by 2030, restoring 80% of mangrove forests located in the Gulf of Nicoya by 2030, and stopping/reverting loss of wetlands by 2030 (Gobierno del Bicentenario de Costa Rica et al. 2020, pp. 44, 45, 79). The country aims to implement effective monitoring including sustainable management of mangrove areas by dependent communities (Gobierno del Bicentenario de Costa Rica et al. 2020, p. 44). BCE measures shall amongst others be funded through innovative finance mechanism, including payments for ecosystem services, and by exploring public-private investments (Gobierno del Bicentenario de Costa Rica et al. 2020, p. 46). In its latest national communication from 2021, Costa Rica highlights a specific mangrove conservation program, the "Regional Strategy for the Management and Conservation of Mangroves in the Gulf of Nicoya-Costa Rica (2019-2030)", with an expected mitigation potential of 23,528 t CO_2eq (Gobierno del Bicentenario de Costa Rica et al. 2021, p. 194). But no further details about the project or the calculation of the mitigation potential are provided.

The **Republic of Sudan** refers to BCE in its NDC and counts blue carbon towards its mitigation targets. As a mitigation measure in the forestry sector, Sudan mentions restoration and conservation of mangrove forests in Red Sea State (Higher Council for the Environment and Natural Ressources of the Republic of Sudan 2021, p. 10) as well as for coral reefs and seagrasses (Higher Council for the Environment and Natural Ressources of the Republic of Sudan 2021, p. 24). The NDC also identifies the coastal zone as a 'vulnerable sector' where building resilience for local communities relying on coastal ecosystems is an adaptation priority. Increased carbon sequestration is thereby mentioned as a mitigation co-benefit of this adaptation priority (ibid). Also, the Republic of Sudan wants to provide alternative livelihoods for communities depending on mangrove resources (ibid). Costs for the measures, amongst others, are indicated with 150 Mio. USD (ibid).

One of the most detailed elaborations on blue carbon can be found in the NDC of the **Seychelles.** The resilience of BCE is one of the adaptation priorities listed in the NDC (Republic of Seychelles 2021, p. 27). The NDC elaborates on the importance of BCE for the Seychelles, on their vulnerability and how BCE will be incorporated into climate targets in the future. The NDC highlights the role BCEs play for adaptation as well as mitigation (Republic of Seychelles 2021, p. 17): "[..] *forests, soils and coastal wetlands are important carbon stocks, and all measures directed at protecting and enhancing these ecosystems – meant to reduce erosion, improve or protect against flooding and salination – also maintain and improve the country's carbon sink capabilities.*" The Seychelles is currently mapping the full extent of seagrass and mangrove ecosystems within its exclusive economic zone (EEZ), and wants to measure their carbon stock values (Republic of Seychelles 2021, p. 32). These assessments will inform the inclusion of BCE in the country's GHG inventory by 2025. The Seychelles aim to protect at least 50% of its seagrass and mangrove ecosystems by 2025, and 100% of seagrass and mangrove ecosystems by 2030 (ibid). These conservation targets are subject to external support and identification of financing mechanisms to support the measures, such as multilateral and bilateral funds, insurance products, debt-for-nature swaps, private investment, blue carbon credits and bonds, and other innovative conservation financing mechanisms (Republic of Seychelles 2021, p. 33). A long-term monitoring program for both ecosystems will be established by 2025 (Republic of Seychelles 2021, p. 17). The Seychelles also commits to the implementation of its adopted

Marine Spatial Plan and the effective management of the 30% marine protected areas within the Seychelles' EEZ (Republic of Seychelles 2021, p. 32).

While the examples above show that some developing countries provide at least some information and develop ambitious targets for concrete BCE measures and how these are to be financed, developed countries which include BCE in their NIR (section 4) provide little reference to BCE in their NDCs. For example, **Australia** simply notes its use of the IPCC 2013 Wetlands Supplement in estimating greenhouse gas emissions and removals and does not further detail any planned policies and measures related to BCE. The NDC submission of the **United States of America** states that nature-based coastal resilience projects will be supported. This will include "*pre-disaster planning as well as efforts to increase sequestration in waterways and oceans by pursuing 'blue carbon'*" (United States of America 2021, p. 6). Insofar as countries have economy-wide absolute emission reduction targets, emissions and removals from BCE are potentially also within the scope of their NDC as long as these countries report on BCE in their GHG inventories (section 4). An example of an economy-wide absolute emission reduction target would be the EU target of -55% by 2030 compared to 1990 levels, covering all GHG addressed by the UNFCCC and all sectors. All developed countries had this type of target under the Kyoto Protocol and continue to have it under the Paris Agreement (see Article 4.4.).

4 Reporting of Blue Carbon in National Inventory Reports

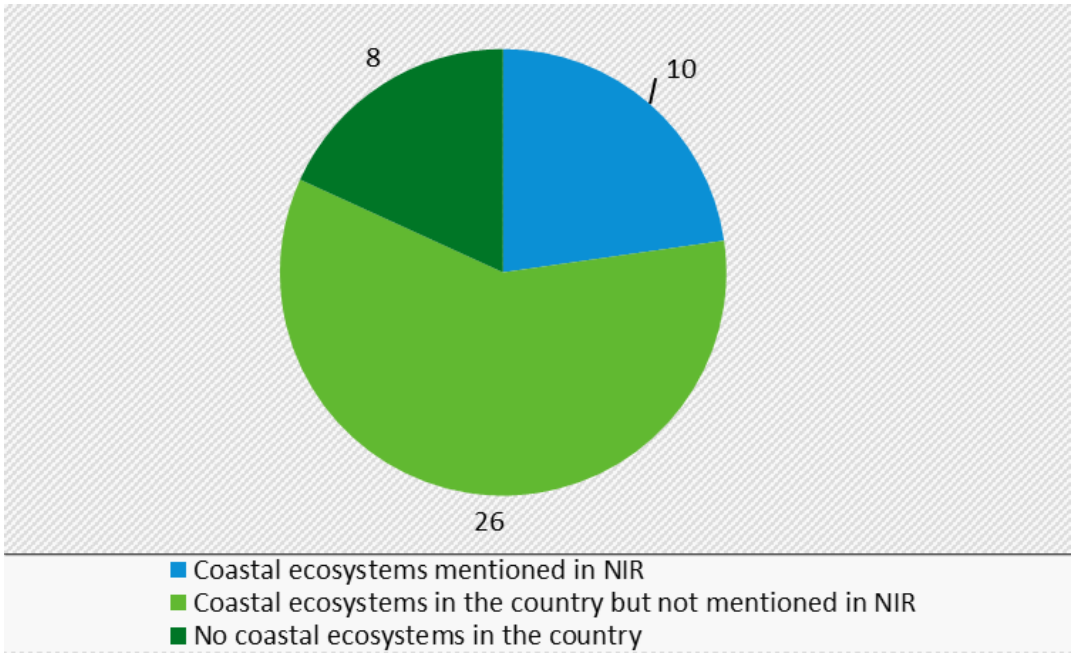
Emissions and removals resulting from anthropogenic activities in mangroves, tidal marshes, and seagrass meadows are reported under the sector of land use, land use change and forestry (LULUCF). Further details on IPCC reporting methodologies are summarized in Reise et al. (2024; chapter 5). GHG reporting under the ETF is the basis for assessing whether a Party has achieved its NDC. Developed country NDCs are referred to as economy-wide quantified targets, they encompass all economic sectors and all GHG gases not covered by the Montreal Protocol. According to the ETF, Parties must self-determine the indicator they will use for tracking progress and achievement of their NDC. In case of the NDC targets of developed countries, this indicator relates to the level of GHG emissions as reported in their NIR in the target year. For example, if the target is a reduction of all GHG emissions by 55% by 2030 compared to the emission level in 1990, then a Party will compare its reported emission for the year 2030 to the reported emission for the year 1990 and assess, whether the intended reduction was achieved.

All 44 NIRs submitted by developed countries by the end of October 2023 were searched for keywords that indicate potential inclusion of BCE in their reporting. The term BCE is not used in the IPCC guidelines, instead the term "coastal wetland" is used as well as the three main coastal ecosystems: mangrove forests, tidal marshes, and seagrass meadows[4]. NIRs that mentioned the terms coastal wetland and/or at least one of the three coastal ecosystems were further analysed. Although, 36 Parties have coastal ecosystems, only ten NIRs (Australia, France, Japan, Malta, New Zealand, United Kingdom, United States of America, Iceland, Monaco, Cyprus) mentioned either coastal wetland (n=4), mangroves (n=6), tidal marshes (n=5) and/or seagrasses (n=1). These ten NIRs were further checked for the inclusion of coastal wetlands in the reporting under the chapters dedicated to the LULUCF sector. The NIR of Monaco includes a reference to mangroves, which are not native to the Mediterranean country. But it only mentioned mangroves as an example of projects that the country supports financially to promote NbS. No further details are given, nor are any other coastal ecosystems mentioned (Direction de l'Environnement Monaco 2023). Hence, the NIR of Monaco is not further considered for the analysis. The methods for determining emissions and removals in coastal ecosystems in the

[4] The following keywords were used for the full-text search: mangrove, salt marsh / saltmarsh, seagrass, tidal, coast, and coastal wetland. For countries which did not submit their NIR in English, the keywords are translated in Spanish and French. The Russian NIR was translated into English and the keyword search was applied in the translated version.

remaining nine NIRs were analysed in more detail. The methods of the individual countries were analysed with regard to the reported categories in the LULUCF sector, the calculated type of emissions (CO_2 and non-CO_2) and removals (CO_2), their emission factors and applied Tier levels of the corresponding methods according to the IPCC (2006; 2014; 2019a).

Figure 2: Number of developed countries reporting on coastal ecosystems in their National Inventory Reports



Source: Own compilation

Out of nine countries, six countries (Australia, France, Japan, United Kingdom, USA, New Zealand) have included mangroves in their definition of the land use category “forests” or "wetlands". Compared to tidal marshes and seagrass meadows, mangroves are therefore most frequently included in the NIRs analysed. Although in all nine countries seagrass meadows are potentially present in their coastal areas (McKenzie et al. 2020), only Australia currently reports emissions caused by the destruction of seagrass meadows (Table 1). The USA plans to include seagrass meadows in their upcoming NIR 2024 (EPA 2023). One reason for the limited integration of seagrass meadows into reporting could be the difficult conditions to access and monitor this coastal ecosystem. Compared to mangroves and tidal marshes they lie below the sea surface all year round. Hence, research and monitoring require diving, different methods compared to terrestrial land monitoring and potentially high costs. Emissions resulting from aquaculture in coastal areas are so far only reported by Australia and the USA but are not further discussed here. Overall, both the USA and Australia are currently leading the way in reporting emissions from coastal ecosystems. Both countries address land-use change and carbon pools of coastal ecosystems affected by it. The methods and emission factors used by both countries are often based on national research and therefore provide more accurate data compared to the default values published by the IPCC. But still, both countries as well as the IPCC guideline

methods do not differentiate between allochthonous[5] (non-resident) and autochthonous[6] (resident) carbon fluxes as incoming carbon sources (Reise et al. 2024). This differentiation is important to be able to draw conclusions on the total carbon sequestration rate into the sediment and consequently the net ecosystem production (Gallagher et al. 2022). However, EPA (2023) states that research is already being carried out in this area to improve GHG flux reporting.

Table 1: Overview of countries including coastal wetlands in their NIRs

Country	Includes only an overall reference to coastal ecosystems in NIR	Includes mangroves in NIR	Includes seagrass meadows in NIR	Includes tidal marshes in NIR
Australia		x	x	
Cyprus	x (tidal marshes)			
France		x		x
Japan		x		
Malta				x
New Zealand		x		
United Kingdom		x		
USA		x	Announced for 2024	x
Iceland	X (tidal marshes)			

Sources: Own compilation based on (Australian Government 2023; UK Government 2023; MfE 2023; Malta Resources Authority 2023; Environment Agency of Iceland 2023; EPA 2023; Greenhouse Gas Inventory Office of Japan and Ministry of the Environment 2023; Direction de l'Environnement Monaco 2023; CITEPA 2023)

Table 1 summarises the state of GHG reporting of **mangroves** in six countries. But the USA and New Zealand categorise mangroves together with other vegetated (coastal) wetlands like tidal marshes (EPA 2023; MfE 2023). In the USA mangroves at a certain height are reported under Vegetated Coastal Wetlands together with tidally influenced palustrine emergent marshes (EPA 2023). Hence, it is not possible to extract emissions and removals specifically for mangroves from the NIRs. GHG reporting on vegetated coastal wetlands in the USA is summarized in Table 3. In Australia, the United Kingdom (UK) and France, mangroves fall under the forest definition of the country and are mainly reported under the LULUCF category "Forest land". France and the UK have mangroves in their tropical oversea territories, like Guyana and Cayman Islands. The level of detail in describing reporting methods and data is very different in the NIRs. For example, in the French NIR (CITEPA 2023) there are no methodological details described on the emission factors used to estimate emissions and removals from the carbon pools in mangroves. Likewise, methods applied in the NIR are inconsistent. For example, estimates of emissions and

[5] Carbon that was originally sequestered in a location other than where it is ultimately stored. In coastal ecosystems, for instance, allochthonous carbon may have been sequestered by terrestrial plants in their biomass and then transported to coastal areas by rivers (Reise et al. 2024).

[6] Carbon that is locally sequestered by plants in coastal ecosystems and subsequently stored in both living and dead biomass. A significant proportion of this biomass goes into the sediment, contributing to long-term carbon storage (Reise et al. 2024).

removals in “wetlands remaining wetlands” in the NIR of New Zealand are based on methods from chapter 7 (Wetlands) of the IPCC (2006). This method doesn’t consider woody vegetation and consequently coastal woody vegetation is not considered. In contrast, when changes from the other land reporting categories to wetlands are addressed, New Zealand applies a Tier 2 method and country specific emission factors for living and dead biomass (Table 2). Also, losses of vegetated wetland occur (in 2021: 9,500 ha, MfE 2023) mainly due to conversion to grasslands. But this is not further mentioned under the chapter concerning emissions and removals from grasslands in the NIR (MfE 2023). Inconsistency in the applied methods continues, as a Tier 1 method from the IPCC (2006) is applied to address the conversion from the other land reporting categories to grassland but it is not clear whether the biomass carbon stock from vegetated wetlands is considered or not. Other countries (USA, Australia, UK) also include emission and removals from land-use changes. For example, the destruction of mangroves for infrastructure expansion in Australia and the UK overseas territories as well as the restoration of mangroves in Australia. Usually, all relevant mangrove carbon pools (living biomass, dead wood or dead organic matter, litter, soil) and their carbon stock changes are considered (Table 2). Japan and the UK apply default values and the Tier 1 methodology provided by the 2013 Wetland Supplement (IPCC 2014) and 2006 IPCC guidelines (IPCC 2006) but don’t report any non-CO_2 emissions. Australia applies a Tier 3 modelling approach to account for all of its carbon stock changes in the LULUCF sector, including a specifically developed wetland module (Full Carbon Accounting Model (FullCAM)) (Australian Government 2023). The data used for the model is country specific. Also, the USA applies country specific emission factor for carbon stock changes in soils and living biomass but relies on default values for dead organic matter (DOM) and CH_4-emissions from soils. The methods applied for vegetated coastal wetlands to calculate emissions and removals are based upon stock change methods for soils, and on gain loss method for biomass and DOM. The methods correspond to Tier 2 or 1 (EPA 2023).

Table 2: Overview of GHG reporting of mangroves in NIRs

	Australia	France	Japan	United Kingdom	United States of America	New Zealand
Inventory Categories reported	a) Forest land remaining forest land; b) Forest land converted to settlements; c) Wetlands converted to forest land	Forest land; Wetlands	Wetlands remaining wetlands	a) Forest land b) Wetland remaining wetland c) Land converted to settlements	See Table 3 on tidal marshes[7]	a) Wetlands remaining wetlands b) Land converted to wetlands
Carbon Stock change	For a), b), c): living biomass; dead wood; litter; organic soils	living biomass, dead wood, litter, soil	living biomass, DOM, litter, soil	For a): living biomass, DOM, organic soils For b), c): unclear		For a): soil For b): living biomass, dead biomass, soil
CO_2 Emission factors	For a), b), c): CS, determined with a carbon accounting model	Unclear	D (IPCC 2014)	a) D (tropical dry mangrove, IPCC 2014); b) D (tropical shrubland, IPCC 2006); c) D (tropical dry mangrove forest and tropical mangrove shrubland converted to settlement, IPCC 2014)		a) EF don't consider woody biomass. b) CS
Non-CO_2 Emission factors	For a), b), c): CS	Unclear	NE	Unclear		NE
Method applied	For a), b), c): CS (Full Carbon Accounting Model (FullCAM))	IPCC 2006?	IPCC (2014)	IPCC (2006, 2014)?		a) The method doesn't consider woody biomass. b) IPCC (2006)
Tier level	For a), b), c): T3	Unclear	T1	T1		b) T2
Planned improve-ments	Updating spatial data; calibration of FullCAM model with field data	Study on forestry data and forest mapping in overseas territories	No	No		No

[7] The United States compile mangroves and tidal marshes under the same category, called coastal wetlands. The reporting aspects listed in this table are thus the same as the ones provided in the table on tidal marshes.

	Australia	France	Japan	United Kingdom	United States of America	New Zealand
Comments	FullCAM is further explained in the Annex to the NIR but it is still very complex to follow the modelled approach in detail.	Mangroves occur in French overseas territories of Guyana, Guadeloupe, Martinique and Réunion, Wallis et Futuna; Explicit methods for carbon stock changes in mangroves are not described	Area of mangrove forest is not part of the total land area of Japan by definition, it is not included in the area for the category.	Tropical dry mangroves occur in the overseas territories and crown dependencies of the Cayman Islands and Bermuda.		Mangroves are only briefly mentioned as part of the wetland definition

Sources: Own compilation based on data collected from NIRs of EPA (2023), UK Government (2023), MfE (2023), CITEPA (2023), Australian Government (2023), Greenhouse Gas Inventory Office of Japan and Ministry of the Environment (2023) Abbreviations used: CS (country specific), D (default), DOM (dead organic matter), EF (emission factor), NE (not existing), T (Tier).

Compared to mangroves, **tidal marshes** are less frequently reported on in GHG inventories (Table 3). As mentioned above, the USA categorizes tidal marshes and mangroves together in one category as "Vegetated Coastal Wetlands" (EPA 2023, p. 6-103ff.) and therefore initial methods remain similar according to EPA (2023). The USA has a very comprehensive reporting on tidal marsh habitats, which is expressed by the many inventory categories that are reported, as well as by country specific emission factors for soils in coastal wetlands. However, as with mangroves, specific conclusions about GHG emissions and removals of tidal marshes can't be assessed from the NIR. Cyprus and Iceland mention tidal marshes in their category definition of wetlands but don't consider tidal marshes in their reporting of GHG fluxes in wetlands (Department of Environment, Ministry of Agriculture, Rural Development and Environment 2023; Environment Agency of Iceland 2023). In its methodology, the French NIR equates the mineral soil carbon stock of tidal marshes with that of grasslands and calculates all carbon fluxes with the aid of a model (CITEPA 2023). Hence, carbon stocks data used is country specific but not specifically measured for tidal marshes. The second EU country reporting on tidal marshes is Malta. In its NIR, default emission factors and Tier 1 methods are applied to address GHG emissions and removals for example originating from the restoration of a tidal marsh in Għadira (Malta Resources Authority 2023).

Table 3: Overview of GHG reporting of tidal marshes (and mangroves in the USA) in NIRs

	France	Malta	United States of America
Inventory categories reported	Wetlands	a) Other wetlands remaining other wetlands b) Land converted to wetlands	a) Coastal wetland remaining coastal wetland b) Vegetated coastal wetland converted to unvegetated coastal wetland c) Unvegetated coastal wetland converted to vegetated coastal wetland d) Land converted to coastal wetland
Carbon stock changes	mineral soils	For a), b): Living biomass, soils	For a): living biomass, soils For b), c), d): living biomass, DOM, soils
CO_2 Emission factors	CS (grassland mineral soil)	For a), b): D (IPCC 2006; 2014)	a) CS b), c): CS (biomass, soil); D (DOM for subtropical estuarine forested wetlands) d) D, CS (biomass); D (DOM); CS (soil)
Non-CO_2 Emissi on factors	NE	a) NE b) D (tidal freshwater and brackish water and mangrove, IPCC 2014)	For a), b), c), d): D (CH_4)
Method-ology applied	Modelled (grid stock variation model)	For a), b): IPCC 2006 for living biomass; IPCC 2014 for soil b) IPCC 2014 for CH_4	a) CS (biomass); IPPC 2014 (soil, CH_4) b) CS (biomass); IPPC 2014 (DOM, soil, CH_4) c) CS (biomass, DOM); IPPC 2014 (soil, CH_4) d) Unclear (biomass, DOM); IPCC 2014 (soil, CH_4)
Tier level	T2	For a), b): T1	a) T2, T3 (biomass); T1 (soil, Ch4) b) T2, T3 (biomass); T1 (soil, DOM, Ch4) c) T2, T3 (biomass); T2 (soil); T1 (DOM, Ch4) d) T1 (biomass, DOM, CH4); T2 (soil)
Planned improveme nts	Better quantification of the surface areas and carbon flows	NE	Examples: Including seagrass soil and biomass C stocks in the reporting. Updating default soil carbon data, including higher resolution imagery for monitoring, Research on quantifying the distribution, area, and emissions resulting from impounded waters; developing a model to represent changes in soil carbon

	France	Malta	United States of America
Comment	Tidal marshes are assimilated to a stock of permanent grassland. According to a review, it is not yet clear if the model provides more accurate estimates than the IPCC methodology	Two RAMSAR sites, L-Għadira and is-Simar are considered wetlands in Malta. Għadira reserve was restored during the past 40 years and developed into a tidal marsh ecosystem.	Coastal wetlands (i.e. mangroves and tidal marshes) from conterminous USA are considered but not from Alaska and Hawaii or any other United States Territories. Seagrasses are not included due to insufficient data.

Sources: Own compilation based on data collected from NIRs of EPA (2023), Department of Environment, Ministry of Agriculture, Rural Development and Environment (2023), Environment Agency of Iceland (2023), CITEPA (2023), Malta Resources Authority (2023).

Abbreviations used: CS (country specific), D (default), M (modelled), DOM (dead organic matter), EF (emission factor), T (Tier).

Seagrass meadows are only considered in the Australian NIR with emissions arising from the excavation of the sea soil for e.g. port construction (Australian Government 2023). As a consequence, seagrass meadows can be destroyed. The resulting emissions are modelled by the seagrass excavation model (Table 4). Country-specific values, gathered from scientific literature, were incorporated into the model (Tier 2). It is assumed that all excavated plant and soil based organic carbon is mineralised in the year of removal (Australian Government 2023). To date, no other emissions from activities like the restoration of seagrass meadows are reported.

Table 4: Overview of GHG reporting of seagrass meadows in NIRs

	Australia
Categories reported	Wetlands remaining wetlands
Carbon stock changes	Living biomass; soil
CO_2 Emission factors	CS
Non-CO_2 Emission factors	NE
Methodology applied	Seagrass excavation model
Tier level	T2
Planned improvements	Updating data new and on-going capital dredging activity from 2018–19 onwards.
Comment	CO_2 emissions originating from the removal of seagrass meadows are reported.

Sources: Own compilation based on data collected from the Australian NIR (Australian Government 2023). Abbreviations used: CS (country specific), NE (not existing), T (Tier).

5 Conclusions

Currently about 60 % (including individual EU member states) of coastal countries include references to BCE in their NDCs. Only, very few countries are reporting on BCE in their GHG inventories. This analysis focused on assessing BCE reporting by developed countries, considering there is more BCE data available in their GHG reporting. We found that countries including BCE in their NIR do not necessarily specify BCE related measures in their NDC or even mention them. Most countries including BCE in their NDCs submission are developing countries. They usually emphasise the role of BCE both for adaptation and mitigation.

A very limited number of developed countries is currently including BCE in their GHG inventories. Australia and the USA are the most advanced countries when it comes to reporting on coastal wetlands as they report on mangroves and tidal marshes. They include CO_2 and non-CO_2 emissions as well as CO_2 removals from restoration/regeneration activities and the destruction of BCE. Australia also accounts for emissions arising from the destruction of seagrass meadows. The USA is planning to implement seagrass meadows in its NIR in 2024. According to Bertram et al. (2021), Australia and the USA are among the countries with the highest annual sequestration potential from blue carbon ecosystems, together with Mexico, Indonesia and Saudi Arabia.

There is considerable room for improvement in reporting on coastal wetlands in the EU, especially considering that seagrass meadows and tidal marshes are important ecosystems along the EU coast. Among the EU Member States, only France and Malta report on coastal wetlands, however they only report on tidal marshes. Cyprus includes tidal marshes in its definition of coastal wetlands but does not provide further information.

The current reporting on BCE in NIRs is insufficient for a reliable assessment of the GHG emissions and removals arising from BCE. Only 7 countries include one or more BCE in their reporting. Mangroves are most frequently included in the NIRs, followed by tidal marshes. If BCE are to be accounted towards reaching NDC targets, all countries that aim to do so need to increase their efforts to reliably quantify emissions and removals from their BCE ecosystems. Collaboration and knowledge transfer between countries would be a necessary first step to achieve these improvements. For example, through research collaborations to generate data on GHG fluxes and joint monitoring efforts.

More countries have included BCE in their updated NDCs, indicating an increased awareness of the role BCE play for climate change mitigation and adaptation. Yet, descriptions of concrete measures and how these will be financed remain limited. In the future concrete measures should go hand in hand with improved reporting of BCE, to allow for a reliable assessment of their contribution to climate change mitigation and support their protection.

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