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CLIMATE CHANGE IN THE MEDITERRANEAN SNAPSHOT:

Blue carbon and Marine Protected Areas

This factsheet presents current knowledge on blue carbon ecosystems, to show what is happening, what is likely to happen, and how these ecosystems can be affected in Mediterranean MPAs. It is part of a series of climate change factsheets specifically developed to keep Mediterranean MPA managers informed.

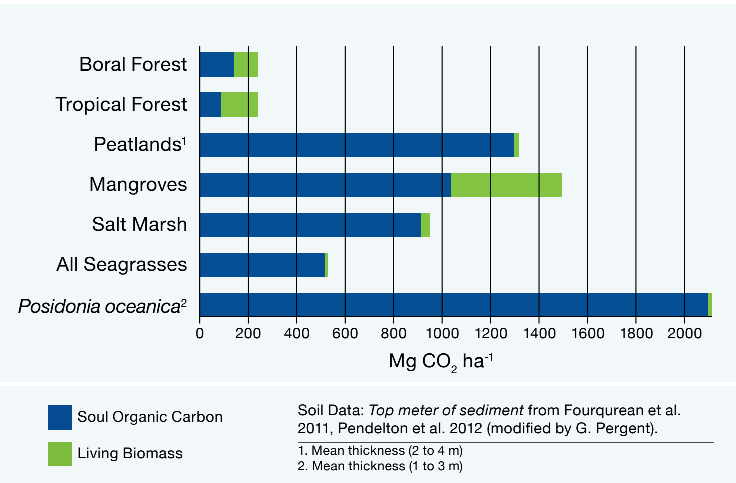
WHAT ARE COASTAL BLUE CARBON ECOSYSTEMS?

The oceans absorb about one-third of anthropogenic Carbon Dioxide (CO_2) emisions annually through biological, physical, and chemical processes. Biological processes refers to the uptake of CO_2 by marine plankton from the surface waters through photosynthesis and the uptake by vegetated coastal habitats and calciferous organisms which is then buried in the sediments for the long term. This carbon, as well as the organic carbon that is exported from the coastal zone to offshore areas and buried in the ocean sediments, are natural carbon stores [ref.01].

Coastal Blue Carbon– that is, the absorbed and stored carbon by coastal ecosystems such as wetlands including marshes, mangroves and seagrasses, represents a large pool of this natural carbon that is sequestered and stored over millennia in these environments. In the Mediterranean, **Coastal Blue carbon Ecosystems** made by wetland plants (salt marsh) and marine plants (seagrass) as *Posidonia oceanica* meadows have been demonstrated to be highly efficient Carbon sinks.

In addition to the significant contribution of these blue carbon ecosystems to organic carbon production and sequestration, saltmarshes and seagrass meadows also contribute to carbonate accumulation [ref.02].

Fig. 1. Estimation of total organic carbon stock in different ecosystems (above as living biomass and below in the soild). Here, the seagrass *Posidonia oceanica* is a unique seagrass in terms of the quantity of organic carbon that can be stored in its sediments and mat.



WHAT ARE THE RISKS ASSOCIATED TO CLIMATE CHANGE IMPACTS ON BLUE CARBON SINKS?

The main climate drivers threatening blue carbon ecosystems and their related services are seawater warming, sea-level rise, and increased hydrodynamic energy, or through higher prevalence and severity of extreme weather events. Acidification and hypoxia (low or depleted oxygen in water bodies) could also affect the stability of blue carbon ecosystems, or some ecosystem services.

The **degradation of these coastal habitats due to climate change and other pressures, could lead to the release of the massive carbon stocks** that these ecosystems have stored over millennia.

The **increase of seawater warming,** as well as **the increase in the frequency and severity of heat waves,** can affect blue carbon habitats and their associated sinks in different ways:

- The increase of the seawater temperature could reach the thermal limit of the seagrass *Posidonia oceanica* in some localities and affect the vitality of the meadows [Ref 03].
- A warmer sediment might increase their microbial metabolism, which could accelerate organic matter mineralization in blue carbon habitat sediments, thereby increasing CO_2 efflux (soil respiration) and reducing the carbon sink capacity of these habitats.
- Sea warming is expected to deepen the seasonal seawater thermocline, which could affect deep seagrass meadows, as well as increase the opportunity for the settlement of warm affinity species of algae and seagrasses, like the non-native seagrass *Halophila stipulacea*.
- Warming can also affect the carbon sink capacity in saltmarshes, and also have positive or negative effects on a local scale, due to changes in species composition, phenology, productivity, and latitudinal range of distribution [Ref 04].

The **impact of seawater acidification** on blue carbon habitats stability is generally believed to be relatively low [Ref 05]:

- Some seagrass species might benefit from the changes in carbonate chemistry associated with ocean acidification as their photosynthesis is CO_2-limited [Ref 06], and their organic carbon burial (or sequestration) could increase. Although there is uncertainty about this, as carbon burial and other important ecosystem services could be affected by acidification.
- Calcified marine organisms that live on seagrass meadows could be negatively impacted by a lowered seawater pH, although to what extent remains unclear [Ref 07].
- Acidification may increase dissolution of sediment carbonate deposits, and in the short term could enhance seawater alkalinity and atmospheric CO_2 dissolution in seawater [Ref 02].

Saltmarshes are **highly sensitive to sea-level rise,** particularly where coastal constructions and steep slopes limit landward migration and/or insufficient sediment is delivered to support their accretion. Reduced supply of coastal sediment is a frequent driver of decline for these ecosystems worldwide.

Seagrass ecosystems are more resilient to sea level rise, as they can adapt as long as they have sufficient sediment inputs by increasing the vertical and horizontal growth of the plants. Nevertheless, such resilience could be vulnerable to the cumulative impacts of pressures and climate driven changes.

HOW CAN MPAs CONTRIBUTE TO ADAPT AND MITIGATE THOSE RISKS?

Mediterranean Marine Protected Areas, especially the coastal ones, commonly host one or more blue carbon ecosystems as saltmarshes and seagrass meadows. The capacity of these habitats to remove carbon dioxide (CO_2) from the atmosphere and to store it in the sediment over thousands of years, is recognised MPAs as significant **net carbon sinks** for mitigating climate change.

MPAs can help to fight climate change by offering an increased CO_2 storage capacity **by creating, maintaining or restoring *Posidonia oceanica* meadows and saltmarshes.**

Table 1. Average capacity of sequestration and carbon sink of blue carbon ecosystems in the Mediterranean. Carbon stock in 1m of sediment
Source: Mateo et al 1997; Nelleman et al 2009; Mateo et al 2006; Mateo & Serrano 2012; Pendleton et al 2012; LIFE Blue Natura 2018.

	SEQUESTRATION (tCO_2/ha per year)	STOCKS (tCO_2/ha)
Saltmarshes	5.5	550
Seagrass meadows	3.7	2,500

Evidence shows that when stored sediment carbon from seagrass and saltmarshes are destabilized by being eroded or degraded, they can release carbon dioxide (CO_2) and methane (CH_4) to the marine environment or in the case of saltmarshes to the atmosphere [Ref 08].

Conservation and restoration of blue carbon sink habitats in new MPAs can contribute to local and global mitigation and adaptation to climate change [Ref 09]. Such measures could include habitat protection to avoid further emissions, habitat restoration and re-vegetation, and marine or land-based interventions, such as improving hydrological management and reducing nutrient pollution, that increase CO_2 uptake and reduce emissions of other greenhouse gases such as CH_4 and N_2O.

Blue carbon ecosystems provide other important environmental services, like coastal protection against sea-level rise and increased frequency and severity of storm event, as well as biodiversity support and fisheries provision, amongst others. These environmental services increase the overall coastal resilience against climate-change.

Here we provide some case examples of estimated blue carbon stocks and sequestration in different MPAs under different situations and management activities.

Case 1
NATURAL PARK OF CÁDIZ BAY, SPAIN

The Natural Park of Cádiz Bay extends along 10,522 hectares along the coast of Andalusia. It harbours extensive tidal salt-marshes and small seagrass meadows *(Cymodocea nodosa and Zostera noltei)*, especially in the Santibañez Lagoon. In the 740 km^2 of the natural park, the total organic Carbon stock in the top meter sediment has been estimated in 2616 Kt CO_2.[1]

The average stock in the natural saltmarshes is of 269 ± 64 tCO_2 ha^{-1}, and the average carbon sequestration over last century has been estimated to be 0.9 ± 0.7 t CO_2 ha^{-1} $year^{-1}$ although nutrient inputs from man-made activities could at the same time release other greenhouse gases as N_2O and CH_4.

In the active artisanal saltpans, the average carbon stock has been estimated to be 47% of that in the natural saltmarsh. Abandoned saltpans reconnected to the tidal regime since 1985, partially recovered their organic carbon stock. Today, their carbon stock in the top 1m is 68% of that found in a natural saltmarsh in 2016. This suggests that the average carbon sequestration has recovered, and at an average rate of 3 ± 2 t CO_2 ha^{-1} yr^{-1} is now triple that of the average carbon flux in the natural saltmarsh [Ref 08].

Marshes, Natural Park of the Bay of Cádiz, Spain

1.- 1 kt = 1000 ton of CO_2 equivalent

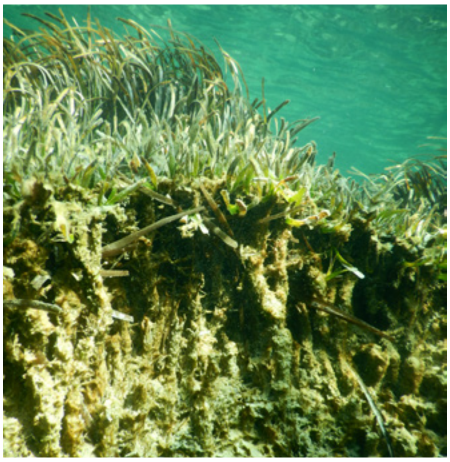
Case 2

MPA PELAGIE ISLANDS, ITALY

The main blue carbon ecosystem at the Pelagie Islands MPA in Southern Italy is *Posidonia oceanica* meadows that surround the two main islands of the archipelago, Lampedusa and Linosa Islands.

Based on latest carbon sequestration rates found in literature, the estimated carbon sequestration rate is 693 ± 58 t CO_2 annually. The total carton storage by *Posidonia oceanica* meadows of the 460 ha of meadows growing on sandy bottoms and the 137 ha of meadows growing on rocks, is of 986 ± 346 Kt CO_2 in its living plants and top 1 meter of sediment. An equivalent of more than 2 million of barrels of oil.

These stocks could be significantly larger if we take into account the whole thickness of *Posidonia oceanica* meadow mats which at some Mediterranean sites may reach.

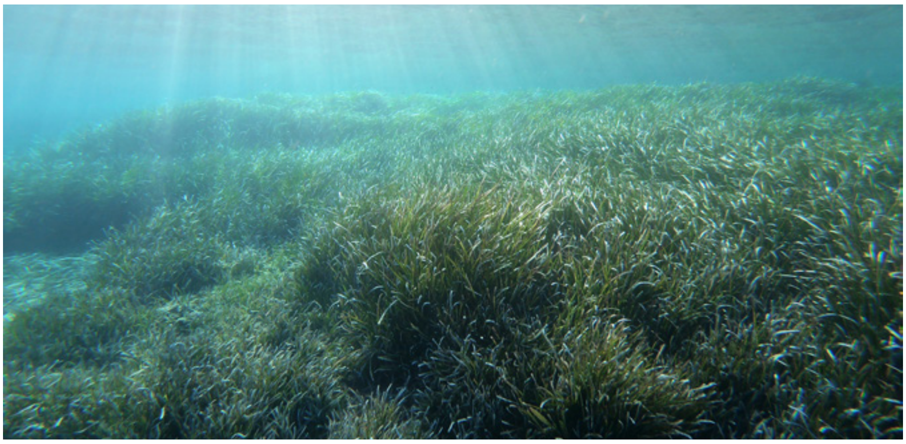


Case 3

NATURA 2000 SITE OF BARRIER REEF OF ROQUETAS DE MAR, SPAIN

At the coast of Roquetas de Mar (Andalucia, Spain), *Posidonia oceanica* form a barrier reef with a thick mat of 3 m that has been calculated to store as much as 2685 ± 275 tCO_2 ha^{-1} since year 541 BC [Ref 10]. This millennial store lost part of its seagrass cover over the last years due to diverse pressures, such as outflows of partially treated sewage in the area, trawling and dredging activities.

At 12-15 meters depth, the same meadow has suffered intensive degradation in the 90s from erosion processes that occurred mostly due the trawling and dredging, in places reducing the mat by more than 1 m and removed the seagrass plants. Recent estimates consider that carbon lost from the stock that had accumulated in the last 4,382 years in the whole area was 799 ± 70 tCO_2 ha^{-1} (trawled areas) and 402 ± 25 tCO_2 ha^{-1} (surrounding) [Ref 10]. This is equivalent to 340 m^3 of petrol burnt. To reverse this trend and ensure the conservation of the carbon sink, restoration and revegetation activities have been recommended.



For more information on blue carbon:
https://www.thebluecarboninitiative.org/

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GLOSSARY OF TERMS:

CARBON SINK
A reservoir of carbon. A system which has the capacity to absorb and stores more carbon from the atmosphere than it releases as carbon dioxide.

CARBON STOCK
The absolute quantity of carbon held within a pool (e.g. wetland) at a specified time. The units of measurement are mass (e.g. tCO_2/ha)

CARBON SEQUESTRATION
The process of increasing the carbon content of a carbon pool.

CARBON SEQUESTRATION RATE (or flux) is the transfer of carbon from one carbon pool (e.g. atmosphere) to another (e.g. wetland) in units of measurement of mass per unit area and time (e.g., t C ha^{-1} yr^{-1})

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