Future MARES

Policy Brief 5

BLUE FORESTS IN A FUTURE CLIMATE

2024

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HIGHLIGHTS

European blue forests - including saltmarshes, seagrass meadows and canopy-forming macroalgae - form fringes along the coastlines from the intertidal to the subtidal as deep as water clarity and other habitat conditions allow. **They support biodiversity, constitute a coastal nutrient filter and contribute to carbon uptake and storage** in the marine environment while also **protecting coastlines** against flooding and erosion and **buffering extreme temperatures and acidification**.

Blue forests have experienced **major declines** in distribution and associated provision of ecosystem services due to pressures such as eutrophication, physical damage caused by activities like coastal construction and trawling, as well as impaired top-down control from overfishing.

FutureMARES projected that **climate change**, including warming and heatwaves, will be **an increasingly challenging pressure interacting with other human activities** to alter the distribution and health of these habitat-forming species in Europe in the decades to come.

Our findings strongly suggest consideration of climate change effects on the distribution and health of blue forests to ensure that conservation and restoration efforts for these species remain sustainable. Beyond taking into account projections of climate change impacts, there is a need to reduce other pressures, such as eutrophication and physical damage. Hence, combined actions are crucial to avoid further losses and promote recovery of habitats and associated benefits, thereby offering nature-based contributions to address multiple challenges.

This policy brief presents **FutureMARES'** results linked to blue forests and the grounds of our recommendations.

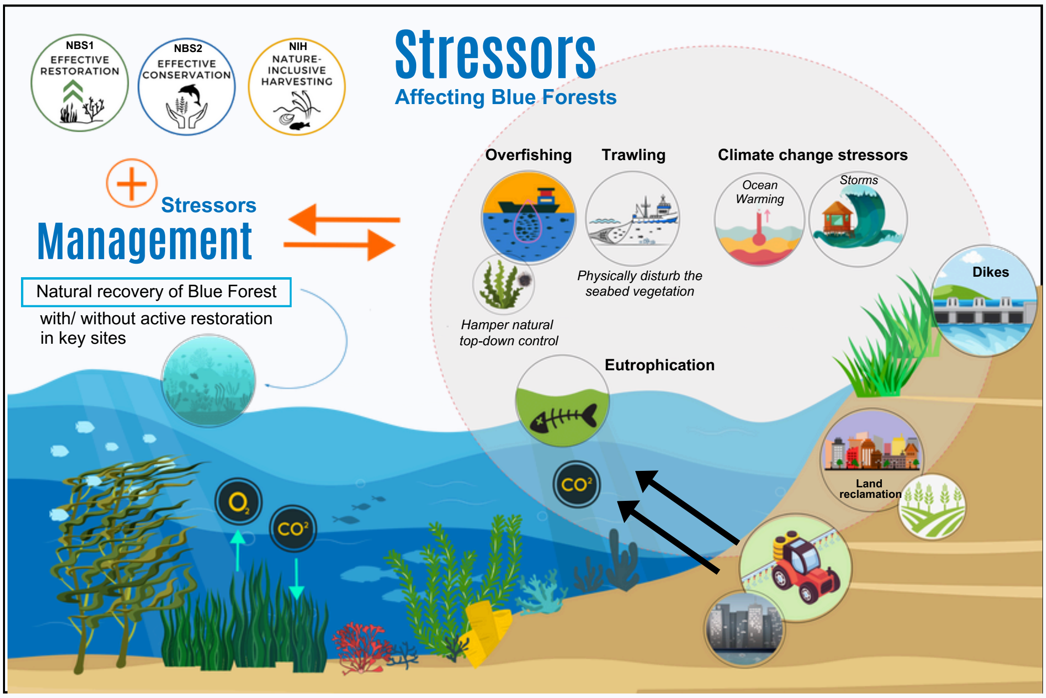

Figure 1. Principal pressures affecting Blue Forest and how nature-based contributions can help to avoid further losses.

KEY STATEMENTS

Blue forests support biodiversity, nutrient filtering, carbon burial and coastal protection while also ameliorating local temperature and pH conditions. Recovering lost forests can, therefore, be considered Nature-based Solutions (NBS) or, rather, nature-based contributions to buffer the combined biodiversity, climate and pollution crises. **FutureMARES** has explored protection and restoration as well as Nature-inclusive Harvesting (NIH) to recover blue forests and other key habitats and associated benefits. Given the extent of ongoing and projected climate change in combination with other multiple pressures acting on marine habitats, **FutureMARES** has identified the following climate-ready sustainable management actions:

- Ensure holistic management that considers **the multiple ecosystem benefits** of blue forests and addresses **the multiple pressures**, including climate change (rather than targeting a single benefit or a single pressure). By reducing pressures such as eutrophication and physical damage (e.g., trawling), blue forests can potentially colonize deeper, cooler waters, that may increase their climate resilience and benefits.
- **Generate better projections for the future distribution of key European blue forest species**. This could be possible by integrating new ecological knowledge to identify climate refugia and "bright spots" where healthy blue forests can be expected in the future. This will also provide more accurate advice to **design climate-smart conservation and restoration actions**, taking into account that European waters will experience climate-driven changes at different rates and magnitudes. Hence, networks of Marine Protected Areas (MPAs) should support protection of climate refugia and bright spots and consider large-scale connectivity of the habitats.
- **Implement active restoration to accelerate recovery of lost habitat features - such as removal of dikes and drains to restore natural hydrology of wetlands- and key species, where pressures are controlled and natural recovery of blue forests is slow.** Lost climate-tolerant habitat-forming species and genotypes may be re-introduced by seeds/transplants at sites where mother populations and connectivity nodes have been lost and where it is likely that future conditions will allow the target species to spread.

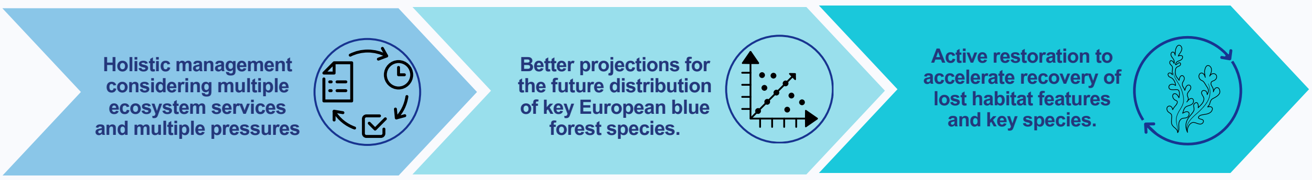

Figure 2. FutureMARES has identified climate-ready sustainable management actions, considering the ongoing and projected climate change in combination with other multiple pressures acting on marine habitats.

CONTEXT & BACKGROUND

Blue forests have experienced major losses as a consequence of multiple human pressures including eutrophication, over-fishing, habitat destruction due to, for instance, coastal construction and land reclamation, as well as direct and indirect effects of climate change (Duarte et al. 2020).

Substantial recovery of these and other marine habitats could be achieved by 2050, if major pressures - including climate change - are mitigated (Duarte et al. 2020). The Kunming Montreal global biodiversity framework calls for the effective protection and management of 30% of the world's terrestrial, inland water, and coastal and marine areas by the year 2030. The European biodiversity strategy including the Nature Restoration Law aims to recover at least 20% of the EU's land and sea areas by 2030, and ultimately, all ecosystems in need of restoration by 2050.

To help improve the extent and functionality of blue forests ecosystems in relation to global and European targets, **FutureMARES** has explored sustainable management of blue forests via 19 Storylines (SLs) covering saltmarshes, seagrass meadows, kelp forests and other seaweed beds in European Seas.

The studies have involved analyses of pressure-response relationships based on long-term datasets, experiments in the field and laboratory, as well as well as species distribution modelling under future climate scenarios and modeling of habitat connectivity, among others. Stakeholders have also informed socio-ecological analyses on climate risks.

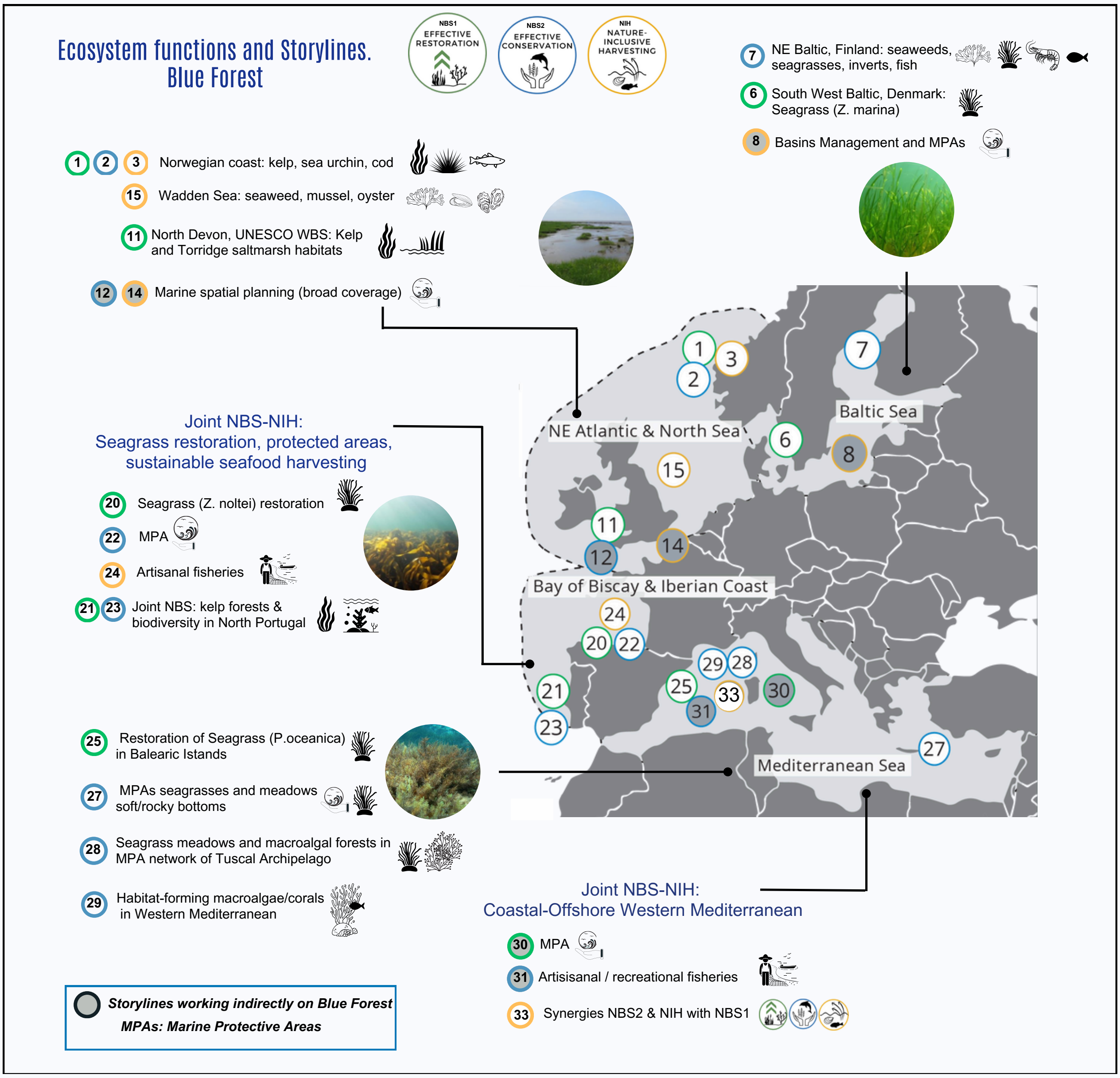

Figure 3. FutureMARES explored sustainable management of blue forests via Storylines (SLs) covering saltmarshes, seagrass meadows, kelp forests and other seaweed beds in European Seas.

KEY RESULTS

FutureMARES explored how protection, NIH and restoration jointly support blue forests, and how **"climate smart" strategies can help prioritise what, where and how to manage**. As protection and NIH must always precede restoration, key findings are presented in this order.

Overall, the project underscored that sustainable management of blue forests supports multi-functionality including biodiversity and climate change mitigation and adaptation (Garmendia et al. 2023, Ravaglioli et al 2024, Shin et al. 2022).

1) Assure better protection of blue forests and create climate-resilient and well-connected MPAs.

FutureMARES highlighted the need to take action against the multiple pressures on blue forests, including climate change, eutrophication, physical disturbance, fisheries, to facilitate recovery of these key habitats (Krause-Jensen et al. 2020 & 2022).

FutureMARES also showed that protecting climate refugia and bright spots enhance the climate-resilience of MPAs (Queirós et al. 2021).

FutureMARES has projected the future distribution of the seagrasses *Posidonia oceanica* and *Zostera marina* as well as key kelp species in Europe (Deliverable Report 4.1 Wilson et al. 2023), an important step before selecting target areas for climate-smart seagrass protection.

Moreover, the research underlined that modelling of the connectivity of blue forests, such as seagrass meadows, can also guide management plans to facilitate recovery (Deliverable Report 4.1 Wilson et al. 2023, Pastor et al. 2022, 2023).

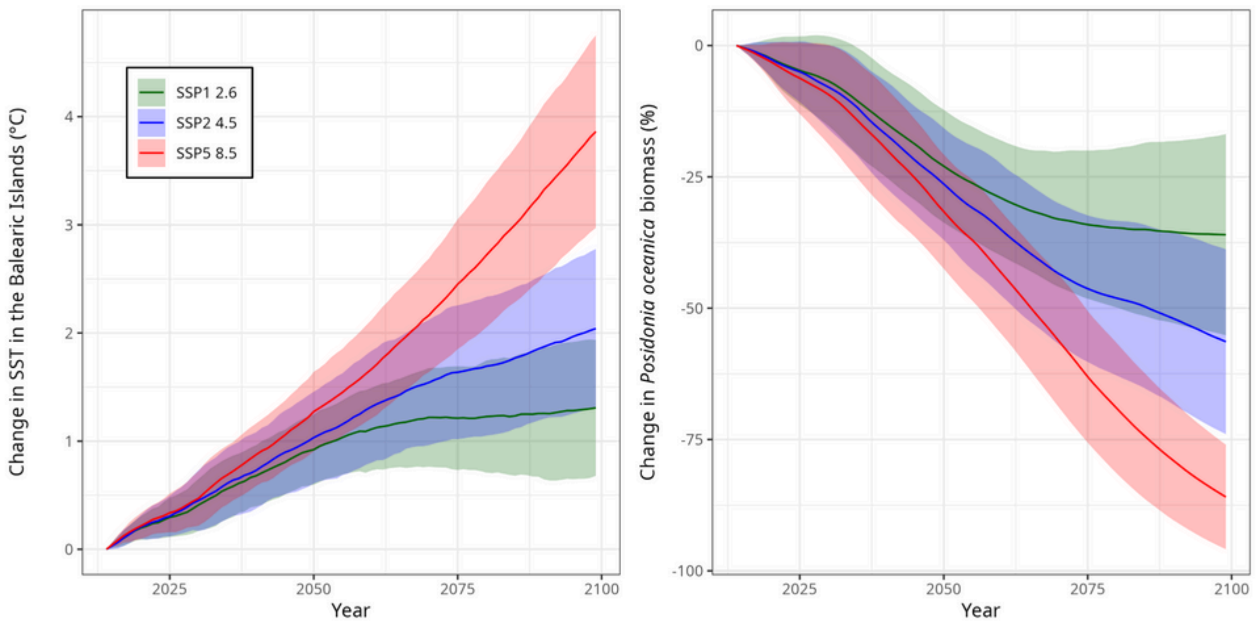

Figure 4. Projected changes since 1995-2014 in average sea surface temperature (left) and above-ground *Posidonia oceanica* biomass in the Balearic Islands under three climate change scenarios. Future impacts of climate change on seagrass in the Balearics were projected using a mechanistic seagrass model and an ensemble of 16 bias-corrected global climate models. In each plot, the solid line represents the average change across the ensemble of 16 climate models, and the shaded area represents +/- one standard deviation of the multi-model spread. The analysis does not consider the potential for *P. oceanica* to adapt to climate warming. (Deliverable Report 4.1 Wilson et al. 2023).

2) Nature-inclusive Harvesting supports healthy blue forest.

FutureMARES acknowledges that healthy blue forests depend on fishery regulation to ensure well-functioning top-down control and to avoid disturbance of the seafloor (Krause-Jensen et al. 2021, Christie et al. 2019).

Sustainable kelp farming was also identifiedas having potentials to support multiple UN sustainability goals (Duarte et al. 2022) while sinking seaweed in the deep ocean for carbon neutrality is considered ahead of science and beyond ethical boundaries (Ricart et al. 2022).

3) Active restoration may accelerate the recovery process when blue forests have been lost, pressures are controlled, and natural recolonization is slow.

If recovery is lacking or is slow despite reduction of pressures through protection and NIH practices, active restoration may be implemented to help accelerate recovery. **FutureMARES** offers examples of active **restoration of the physical habitat** such as the removal of sea urchins in selected Norwegian kelp habitats to ease kelp restoration (SL 1). Another action was the **re-introduction of target seagrass species via seeding** in the Basque Country (SL 20) and the development of associated guidelines (Garmendia et al. 2023). The project also supported seagrass transplantation in Danish coastal waters, with variable success (SL 6), and applied green gravel for kelp restoration along the Norwegian coast (SL 1).

Overall, recommendations are to target restoration of **foundation species/genotypes** tolerant to climate change in areas where mother populations and key **connectivity** nodes are lacking (Pastor et al 2022, 2023) and where future climate supports growth (Deliverable Report 4.1), including **climate refugia** and **"bright spots"** (Queirós et al. 2022).

Policy Recommendations

When designing new conservation and restoration actions for European blue forests, **FutureMARES** recommends **immediate inclusion of evidence from new projections of the impacts of climate on the distribution of key species.** This includes maps of where these species have the best chances **of holding healthy populations despite climate pressure, as well as areas supporting phenotypes more resistant to climate change.** Curbing human actions that disturb or destroy these habitats is essential to ensure they will be sustainably managed in the coming decades, to avoid further losses, and to promote recovery and associated benefits. Management must take a **holistic approach** considering the diversity of ecosystem functions and services (rather than solely focusing on e.g., blue carbon), **combining protection, NIH and active restoration**, with future monitoring to document effects and adjust actions if needed.
Recommendations include:

- **Protecting** blue forests from the multiple pressures by ensuring proper water- and seafloor quality and limiting physical damage while also reducing concentrations of greenhouse gases in the atmosphere.
- **Prioritising protection and restoration of areas where European blue forest species can thrive and are likely to withstand future environmental conditions.** Projected impacts of climate change on these species are severe and widespread. Protecting areas where climate impacts will be lower provides the best opportunity for them in the decades to come (Deliverable Report 4.1 Wilson et al. 2023).
- **Establishing networks of MPAs** designed to maximize the protection of habitats and ecosystems and natural corridors between them, considering future scenarios and underpinning climate refugia.

Long-term classification of the Balearic Islands ecosystem regarding climate change sensitivity of seagrass *Posidonia oceanica* and associated fish communities between 2026-2069, under different Scenarios.

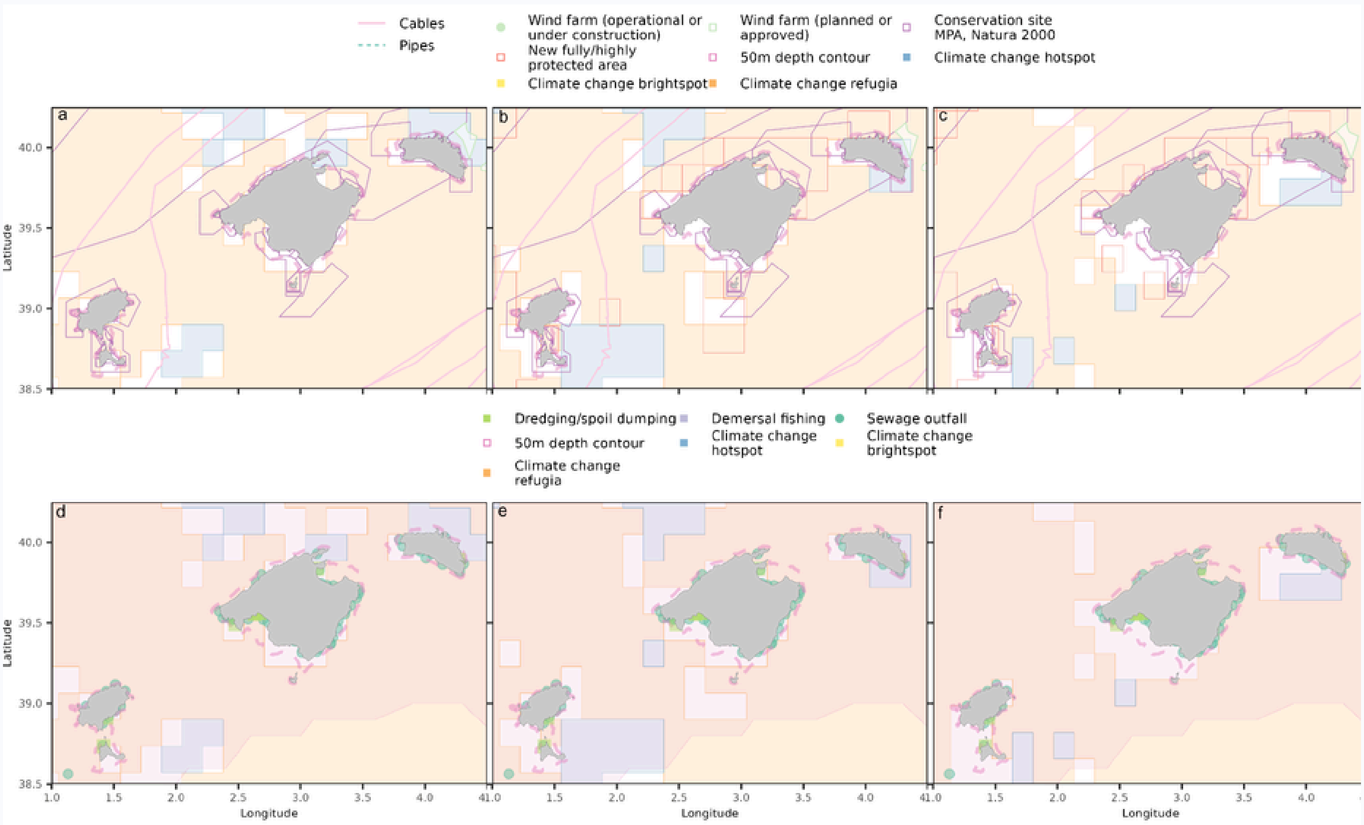

Figure 5. Scenarios RCP 8.5: Status Quo (a and d), National Enterprise (b and e), World Markets (c and f). Whilst several areas (blue) highlight that conservation and restoration programmes are sensitive to climate change (e.g., SE Menorca and Formentera), identified climate change refugia in coastal areas (orange, within 50 m depth contour) also indicate that there is opportunity for climate-resilient conservation of these iconic habitats, even under higher emissions (RCP 8.5). GIS data representing the current distribution of maritime activity sectors overlaid (keys in figures), including those that may provide some degree of protection from extractive uses (top) or those that represent additional sources of impacts (bottom). Newly designated Fisheries Protection Areas and Highly Protected Areas (simulated interventions in model scenarios, red) are also plotted in panels b and c. (Deliverable Report 6.3 Queirós et al 2024; Deliverable Report 4.1 Wilson et al. 2023). Further validation of such modelling work with observational data (ongoing) is needed to best inform policy advice.

- **Implementing Nature-inclusive Harvesting** together with other protective measures to ensure well-functioning food webs and top-down control mechanisms.

- **Active restoration** to speed up recovery where blue forests have been lost and pressures are controlled, when natural recovery is slow. Active restoration is typically resource-demanding, and effects should be carefully prioritised to include restoration of lost habitat features supported by seeds/transplants of lost, climate-tolerant foundation species at sites where connectivity nodes are lost and where future conditions are likely to allow the target species to grow.

- **Communicating** the ecological and societal importance of blue forests (for biodiversity, coastal protection, nutrient and carbon uptake and retention), the major losses they have suffered, and the need for sustainable management in terms of protection, NIH and restoration. Communication should target policymakers, managers and local communities to support top-down and bottom-up collaboration on sustainable management.

Figure 6. Healthy Blue Forest in European Seas. Above saltmarshes in the North Sea. Below examples of seagrass meadow and canopy-forming macroalgae. They support biodiversity, constitute a coastal nutrient filter and contribute to carbon uptake and storage in the marine environment while also protecting coastlines against flooding and erosion and buffering extreme temperatures and acidification.

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