COASTAL ZONE MANAGEMENT

# SEAGRASS BED RESTORATION

CZM4

NATURE-DEMO

ADDRESSED HAZARDS

PROTECTED CRITICAL INFRASTRUCTURE

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**Seagrass stabilises sediments and slows down waves, contributing to coastal protection.**
Image Credit: [Benjamin L. Jones, Unsplash], [2021]. Free to use.

## Primary functions and key services

(Van Katwijk et al., 2016; Paling et al., 2009)

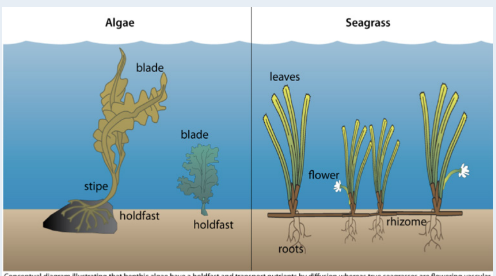
- **Flood risk reduction:** seagrass meadows dissipate wave energy and reduce current speeds, protecting coastal infrastructure such as buildings and roads from flooding.
- **Coastal erosion control:** the root systems of seagrass stabilise sediments, preventing shoreline erosion and protecting critical infrastructure from wave and tidal action.
- **Wave height reduction:** seagrass beds reduce wave heights by up to 90% in shallow areas, minimising damage to coastal structures during storms (Jacob et al., 2023).
- **Storm surge mitigation:** seagrass meadows act as a buffer during storm surges, decreasing the impact on levees, dikes, and other engineered coastal defences.
- **Supplementing coastal defences:** seagrass restoration enhances the effectiveness of man-made coastal protection, reducing the need for frequent maintenances

**Infrastructure protected:** seagrass beds protect **coastal infrastructure** such as **embankments, seawalls, roads, ports**, and **nearshore settlements** by reducing hydrodynamic energy and stabilising sediments. Their root and rhizome systems bind the seabed, reducing erosion and re-suspension of sediments, while the aboveground biomass attenuates wave energy and current velocity. These functions reduce flood risk, **lower maintenance needs for grey infrastructure**, and help preserve navigable waterways and aquaculture areas.

## Main components

(Gómez-Pina et al., 2002; Sharma et al., 2016)

- **Vegetation:** Seagrasses are flowering plants with grass-like leaves that create friction and lower wave velocity.
- **Root system:** The root system of seagrass meadows.




Conceptual diagram illustrating that benthic algae have a holdfast and transport nutrients by diffusion whereas true seagrasses are flowering vascular plants with an internal transport system and roots that penetrate the sediment to transport nutrients.
Diagram courtesy of the Integration and Application Network (ian.umces.edu), University of Maryland Center for Environmental Science. Source: Kruczynski, W.L., and P.J. Fletcher (eds.). 2012. Tropical Connections: South Florida's marine environment. IAN Press, University of Maryland Center for Environmental Science, Cambridge, Maryland. 492 pp.

**A schematic of seagrass on the right, and algae on the left.**
Image Credit: [Kris Beckert, Integration and Application Network (ian.umces.edu/media-library)], [2012], Used with permission.

## What is it?

**Seagrass beds (meadows)** are submerged flowering plant ecosystems found in shallow, sunlit coastal waters around the world. Anchored in sediment by their root and rhizome networks, these underwater meadows form dense mats that stabilise the seabed and provide critical habitat for marine life. Beyond their ecological value, seagrass beds offer important **nature-based coastal protection** (Forrester et al., 2024). Their flexible blades create drag and friction within the water column, which slows current velocities and dissipates wave energy. In shallow waters, this can reduce wave impact (Luhar et al., 2017; Jacob et al., 2023), making them highly effective in reducing shoreline erosion and protecting adjacent infrastructure. When used alongside engineered coastal defences, seagrass restoration strengthens shoreline resilience, offering additional benefits such as **carbon sequestration, water quality improvement**, and **biodiversity enhancement** (Paling et al., 2009).

## Challenges this NbS addresses

- **Floods –** prevention/ reduction;
- **Coastal Erosion –** prevention/reduction;
- **Storm surge –** prevention/ reduction;
- **Heatwaves -** reduction
- **Drought –** prevention (coastal wetlands);
- **Climate change –** mitigation.

## Ecosystem services

(Reynolds et al., 2016; Nordlund et al., 2018; Oreska et al., 2020; Orth et al., 2020; Ward et al., 2023)

- **Soil retention:** seagrass beds capture $CO_2$ and result in long-term carbon storage in plant biomass (Ward et al., 2023; Oreska et al., 2020; Nordlund et al., 2018).
- **Biodiversity Support:** seagrass beds are critical habitats for marine species, supporting ecosystem services related to biodiversity and habitat provision (Orth et al., 2020).
- **Water Filtration:** seagrasses trap sediments and filter nutrients, improving water quality (Reynolds et al., 2016).
- **Nutrient Cycling:** through decomposition, seagrass meadows contribute to the cycling of essential nutrients like nitrogen and phosphorus, supporting marine resource management.
- **Fisheries Enhancement:** seagrass habitats provide nurseries for fish, supporting sustainable food production.

## Environmental impacts

**(EU taxonomy)**

- ☑ **Climate change mitigation**
- ☑ **Climate change adaptation**
- ☑ **Sustainable use and protection of water and marine resources**
- ☑ **Transition to a circular economy**
- ☑ **Pollution prevention and control**
- ☑ **Protection and restoration of biodiversity and ecosystems.**

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## Examples of installation

**1. Seagrass Restoration in Virginia's Coastal Bays (USA) - 'Virginia Seagrass Restoration Project'**

- **Location:** Eastern Shore, Virginia, USA
- **Implemented by:** Virginia Institute of Marine Science (VIMS) and The Nature Conservancy (TNC)
- **Description and results:** This is one of the world's largest and longest-running seagrass restoration efforts, spanning over two decades and resulting in the successful establishment of 3,612 hectares of new Zostera marina (eelgrass) meadows in Virginia's coastal bays. Since 1999, over 70 million eelgrass seeds have been actively planted on a 200-hectare pilot area off the southern end of Virginia's Eastern Shore, with the effort steadily expanding (Orth et al., 2020; Samurović, 2020). The project addresses losses caused by a 1930s disease outbreak and hurricane, with scientists and 40–60 volunteers annually collecting and sowing seeds in suitable areas. The restored meadows have significantly improved water quality, carbon sequestration, biodiversity, and shoreline resilience (Orth et al., 2020). Today, the project serves as a global model for large-scale marine habitat restoration, supported by continuous research and innovation.

**2. Seagrass Restoration in the United Kingdom - 'LIFE Recreation ReMEDIES'**

- **Location:** South Coast of England (e.g., Plymouth Sound and Solent Marine Protected Areas)
- **Implemented by:** Natural England, in partnership with Ocean Conservation Trust, Marine Conservation Society, and others
- **Description and results:** Launched in 2020, LIFE ReMEDIES is England's largest seagrass restoration project, funded by the EU LIFE Programme (£2.5 million). It focuses on restoring degraded meadows of Zostera marina (eelgrass), a vital marine plant that provides nursery habitat, improves water quality, and stabilises sediments. To date, **eight hectares** of seagrass have been restored across five Special Areas of Conservation using biodegradable hessian mats to anchor collected seeds and promote root growth.

In parallel, the project works to prevent future damage through sustainable boating initiatives, including the installation of eco-moorings and public awareness efforts. Local volunteers support seed processing and outreach, making the project both ecologically and socially impactful. The project is ongoing and contributes to the UK's broader goal of restoring **15% of seagrass habitats by 2030**, including work supported by WWF-UK and other national partners (Ocean Conservation Trust (n.d).

## Cost-benefit profile

Seagrass restoration is one of the most **expensive and technically demanding** forms of marine habitat restoration. According to a global synthesis of 235 studies from restoration or rehabilitation projects of coral reefs, seagrass, mangroves, salt-marshes, and oyster reefs worldwide by Bayraktarov et al. (2016), the **median reported cost for restoring one hectare of marine coastal habitat**—including seagrass—was approximately **US$80,000 (2010)**, while the **average cost was as high as US$1.6 million per hectare**. For Seagrass restoration specifically, median costs per hectare of 64 studies were 106,782 (US$ 2010), and average cost: 399,532 US$ per hectare restored. However, actual total costs may be **two to four times higher** due to under-reporting and unaccounted expenses. Among all habitat types assessed, **seagrass and coral reefs ranked as the most expensive** to restore. Factors such as site complexity, low survival rates (median **38% for seagrass**), and labour-intensive methods contribute to the high costs. Nonetheless, **community-based and volunteer-supported projects** were found to be more cost-effective. Despite the financial challenges, seagrass restoration yields long-term ecological benefits, including carbon sequestration, water quality improvement, and shoreline protection—making it a high-value nature-based solution when successfully implemented.

## Site suitability, scale and coverage

Seagrass restoration and protection are most suitable in **shallow, sheltered coastal zones** with appropriate salinity, light availability, and low-to-moderate wave energy. This includes **bays, estuaries, lagoons, and coastal flats** in temperate and tropical regions. Projects can range from small-scale planting efforts to large-scale ecosystem restorations (van Katwijk et al., 2016; Matheson et al., 2017). Site selection must consider sediment type, water quality, and nearby anthropogenic pressures such as dredging, anchoring, or pollution.

**Eelgrass (Zostera marina) at Cape Cod National Seashore.** Image Credit: [Eastern Ecological Science Center], [2016], Public domain.

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