Scorecard methodology (tool) for coastal system restoration effects on ESS and BDV

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REST-COAST, Large Scale RESToration of COASTal Ecosystems through Rivers to Sea Connectivity

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Preface

REST-COAST aims to promote the development of healthy and climate-resilient European coastal regions achieved through innovative large-scale systemic restoration, enhance the delivery of ecosystem services and improve coastal biodiversity. The project strives to demonstrate that upscaled coastal restoration can provide a low carbon footprint solution to climate adaptation and disaster risk reduction for threatened coastal systems, combined with gains in their biodiversity.

Work package 4, Adaptation management for restoration and upscaling, integrates and coordinates coastal adaptation-through-restoration management by developing coastal systemic adaptation pathways. Within the REST-COAST project, Work Package 4 focuses on adaptation management for restoration and upscaling. It aims to provide a comprehensive view of restoration measures as nature-based solutions (NbS), exploring climate adaptation strategies across pilot sites. The first step is to develop a scorecard methodology for coastal system behaviour considering indicators and homogeneous metrics for restoration effects on ESS and BDV gains under climate change. This report (deliverable 4.1) is the result of this task and establishes a common language for ESS delivery within REST-COAST, utilizing semi-quantitative ecosystem service and biodiversity indicators based on homogeneous metrics applied to EUNIS biotope mapping.

Summary

The REST-COAST project aims to demonstrate the advantages of coastal restoration by focusing on how it contributes to Ecosystem Services (ESS) and biodiversity gains (BDV). It highlights the importance of understanding and quantifying ESS to inform decision-making processes, preventing their underappreciation and potential loss. The project identifies five key ecosystem services: Food Provisioning, Climate Change Regulation, Water Quality Purification, Reduction of Coastal Flooding Risk, and Reduction of Coastal Erosion Risk. Each service is defined, along with metrics to quantify their impact, providing a framework for evaluating restoration efforts.

REST-COAST seeks to scale up coastal restoration measures across Europe to enhance ecosystem services and biodiversity in vulnerable coastal ecosystems. This requires a systematic approach, including adopting a uniform spatial unit for describing habitats. The European Nature Information System (EUNIS) for standardized data collection and habitat classification will be utilized. Biotope mapping within EUNIS incorporates biodiversity elements such as species occurrences and integrates with relevant international conventions and Red Lists. The project's approach involves defining biotope maps, assigning scores to ecosystem services and biodiversity indicators, and assessing spatial changes in habitats due to climate change and restoration efforts.

This deliverable presents the generation of EUNIS habitat maps for Europe as a whole and for each of the pilot areas in REST-COAST. Subsequently, it presents the assignment of semi-quantitative scores for the contribution of each EUNIS (sub)habitat to the five key ecosystem services applying the rank scale 0 (none), 1 (very low contribution), 2 (low contribution), 3 (medium contribution), 4 (high contribution) to 5 (very high contribution). It also describes the assignment of the IUCN Red List of Habitats to each of the depicted EUNIS (sub)habitats in the pilot areas. And finally, to assess coastal system behaviour and restoration effects on ecosystem services and biodiversity gains under climate change, a homogenised score card methodology is presented to overcome the problem of comparing minor changes (some percents) with major changes (tens of percents) in the total scores for ESS or BDV in each pilot area.

1. Introduction

Aiming to demonstrate the benefits of coastal restoration, the REST-COAST project focuses on how coastal restoration measures contribute to delivering Ecosystem Services (ESS) and biodiversity gains (BDV). ESS refers to the valuable contributions that ecosystems make to human well-being (Haines-Young & Potschin, 2018). Notably, in 2018, marine ecosystems within the European Union generated an impressive annual turnover of €750 billion (Maes et al., 2020). Understanding the differences in ESS across various ecosystems is crucial when designing or restoring coastal areas. Such insights support holistic decision-making processes, ensuring that restoration efforts align with sustainable outcomes. Failure to comprehend and quantify these ESS can lead to their underappreciation in decision-making, potentially resulting in their loss (Granek et al., 2010).

In the REST-COAST project, five ecosystem services have been selected that represent urgent coastal problems; Food (Fish) provisioning; Climate change regulation; Water quality purification; Reduction of coastal flooding risk and Reduction of coastal erosion risk. A short definition for each ESS is given as follows:
FP: Food (Fish) Provisioning. *Contribution of habitats as spawning / nursery area*. Coastal restoration can result in stronger fish populations by restoring spawning and nursery habitats. A coupling can be made between restored biotopes and their spawning- or nursery function (for instance the role of shallow coastal waters, lagoons or seagrass meadows). A quantitative metric is numbers/ha of juvenile fish for different biotopes.
CCR: Climate Change Regulation. *Contribution of habitats to carbon sequestration*. Coastal restoration can capture carbon from the atmosphere and store it underground in coastal wetlands. Carbon sequestration is expressed in kg equivalent CO_2/ha/year. This metric is a commonly used quantification of the amount of stored carbon and can be coupled to different types of restored biotopes, specifically the saltmarsh subtypes as well as seagrass meadows.
WP: Water Quality Purification. *Contribution of habitats to nitrogen and phosphorus removal rate*. Coastal restoration can purify surface waters by enlarging their capacity to remove nitrogen and phosphorus from the water column. This can be achieved by increasing residence time and/or by restoring coastal vegetation. This will increase burial (P and N) or denitrification (N). A common metric is removal rate in g P/N per m^2 per year. This can be coupled to restored biotopes (i.e. lagoons, marshes, seagrass), in combination with other parameters (river flow, …).
RCE: Reduction of coastal erosion risk. *Contribution of habitats to erosion resistance*. Coastal restoration can increase the resistance against the erosive forces of currents and waves by restoring habitats that disseminate wave energy and/or provide more firm, erosion-resistant soils. For example salt marshes offer a firm natural resistance against erosion and seagrasses can disseminate waves before they enter the coastline. Metrics are the shoreline migration rate for various habitats and the wave dissemination capacity for various habitats.
RFR: Reduction of coastal flooding risk. *Contribution of habitats to protection against flooding*. Coastal restoration can restore habitats that form a natural barrier against high flood levels during storms, such as coastal dunes. A metric is the elevation of natural habitats relative to sea level.

REST-COAST aims to showcase how coastal restoration measures can be effectively scaled up to large restoration plans across Europe. By doing so, it seeks to enhance **ecosystem services** and **biodiversity** for vulnerable coastal ecosystems. Achieving this goal requires a systematic approach. To compare and analyse ecosystems consistently across Europe, it is crucial to adopt a **uniform and harmonized spatial unit** for describing **biotopes**. Additionally, the chosen methodology must align with the delivery of ecosystem services (ESS) and biodiversity at both local and larger scales.

The methodology is based on the **EUNIS**—the **European Nature Information System**. Managed collaboratively by the European Topic Centre on Biological Diversity, the European Environment Agency, and the European Environmental Information Observation Network, EUNIS provides a comprehensive pan-European habitat classification system. This system facilitates the standardized description and data collection across the continent, covering a wide range of habitats—from natural to artificial, terrestrial to freshwater, and marine. In the EUNIS framework, a **habitat type** is defined as the interplay of **plant and animal communities** alongside abiotic factors, all operating within a specific scale. This descriptive framework forms a hierarchical system, ensuring a consistent language for discussing habitats.

Biotope mapping within the EUNIS information system delves into the biotic environment, capturing elements of biodiversity such as **species occurrences**. Notably, this system also integrates the **European Red List of habitats**, along with information on species, habitat types, and designated sites mentioned in relevant international conventions and the **IUCN Red Lists**. By linking these data sources, EUNIS becomes a valuable resource for identifying sites and species with **high biodiversity**—a critical step toward achieving REST-COAST's ambitious restoration and conservation goals.

The approach in REST-COAST is:

1. To define biotope maps using the EUNIS classification system for each pilot area.
2. To give homogeneous rank scores to ecosystem services (ESS) and biodiversity value indicators (BDV) applicable to each EUNIS habitat.
3. To assess spatial changes in the type or size of EUNIS habitats, resulting from climate change and/or restoration responses, for changes in the overall score of ESS and BDV applying a transfer function to show homogeneous scores for restoration measures.

2. Biotope mapping in REST-COAST applying EUNIS

2.1 The EUNIS information system

The **hierarchical classification system** for habitats, such as the one used in the **European Nature Information System (EUNIS)**, organizes habitats into a structured framework. The system consists of multiple levels, each representing a different level of detail. At the top level, broad habitat categories are defined (e.g., lakes, wetlands, marine ecosystems). Descending the hierarchy, more specific subcategories emerge, providing finer distinctions. Each level is characterized by specific criteria, which may include factors like **species composition**, **abiotic conditions**, and **geographic location**. These criteria help define and differentiate one habitat type from another. Habitats are nested within each other, forming a tree-like structure. This hierarchical structure ensures consistency in describing marine habitats across different regions. Each level adds specificity, allowing researchers and conservationists to precisely identify and study these ecosystems.

In the context of REST-COAST, this hierarchical classification system plays a crucial role in harmonizing habitat descriptions, supporting cross-disciplinary research, and promoting effective conservation efforts in marine and coastal environments. The EUNIS information system allows us to aggregate local, small-scale habitat descriptions into larger landscape-scale units. These aggregated units align with archetypical **deltaic**, **estuary**, and **lacustrine coastal landscapes** across Europe—areas where scaled-up restoration efforts are crucial. These landscapes exhibit distinct features described in EUNIS. In the marine environment, we find littoral biotopes (MA-series) and infralittoral biotopes (MB-series). On the terrestrial side, sandy shores and coastal dunes fall under the N1-series, occasionally accompanied by shingle (N2-series) or cliff coasts (N3-series). Further inland, lacustrine biotopes (C1-series in EUNIS 2012-classification) emerge. In estuaries, where marine waters gradually blend with freshwater rivers, we encounter the C2-series. Both marine and estuarine environments may also host a lacustrine littoral zone (C3-series in EUNIS 2012-classification). It's essential to recognize that species compositions within marine and coastal biotopes vary significantly across different regional seas. Consequently, the EUNIS classification extends to specific environments: Atlantic, Arctic, Baltic, Black Sea, and Mediterranean, emphasizing the need for tailored restoration strategies in each unique coastal context.

2.2 European scale EUNIS maps

2.2.1 EUNIS seabed habitats

One of the major advantages of applying the EUNIS maps is that there are maps of the seabeds for all European seas. EMODnet made available a broad-scale seabed habitat map for Europe, known as EUSeaMap (Figure 1). The latest product is the EUSeaMap 2023 Broad-Scale Predictive Habitat Map for Europe, which was released in October 2023 (Vasquez et al. 2023).

The extent of the mapped area includes the Mediterranean Sea, Black Sea, Baltic Sea, and areas of the North Eastern Atlantic extending from the Canary Islands in the south to the Barents Sea in the north. The map was produced using a "top-down" modelling approach using classified habitat descriptors to determine a final output habitat. Habitat descriptors differ per region but include: Biological zone, Energy class, Oxygen regime, Salinity regime, Seabed substrate and Riverine input. Habitat descriptors (excepting Substrate) are calculated using underlying physical data and thresholds derived from statistical analyses or expert judgement on known conditions. The model is produced using R and Arc Model Builder (10.1). The model was created using raster input layers with a cell size of 0.00104dd (roughly 100 metres). The model includes the sublittoral zone only; due to the high variability of the littoral zone, a lack of detailed substrate data and the resolution of the model, it is difficult to predict littoral habitats at this scale. EUSeaMap is classified into

EUNIS 2019 level 3 (or more detailed levels where appropriate), EUNIS 2019 level 2 , EUNIS 2007-2011, the MSFD benthic broad habitat types, the HELCOM HUB classification in the Baltic, and the recently revised habitat classification in the Mediterranean. In the Black Sea, EUSeaMap is not classified into EUNIS 2007-2011 (due to inapplicability), but is classified according to a classification that was developed by EMODnet Seabed.

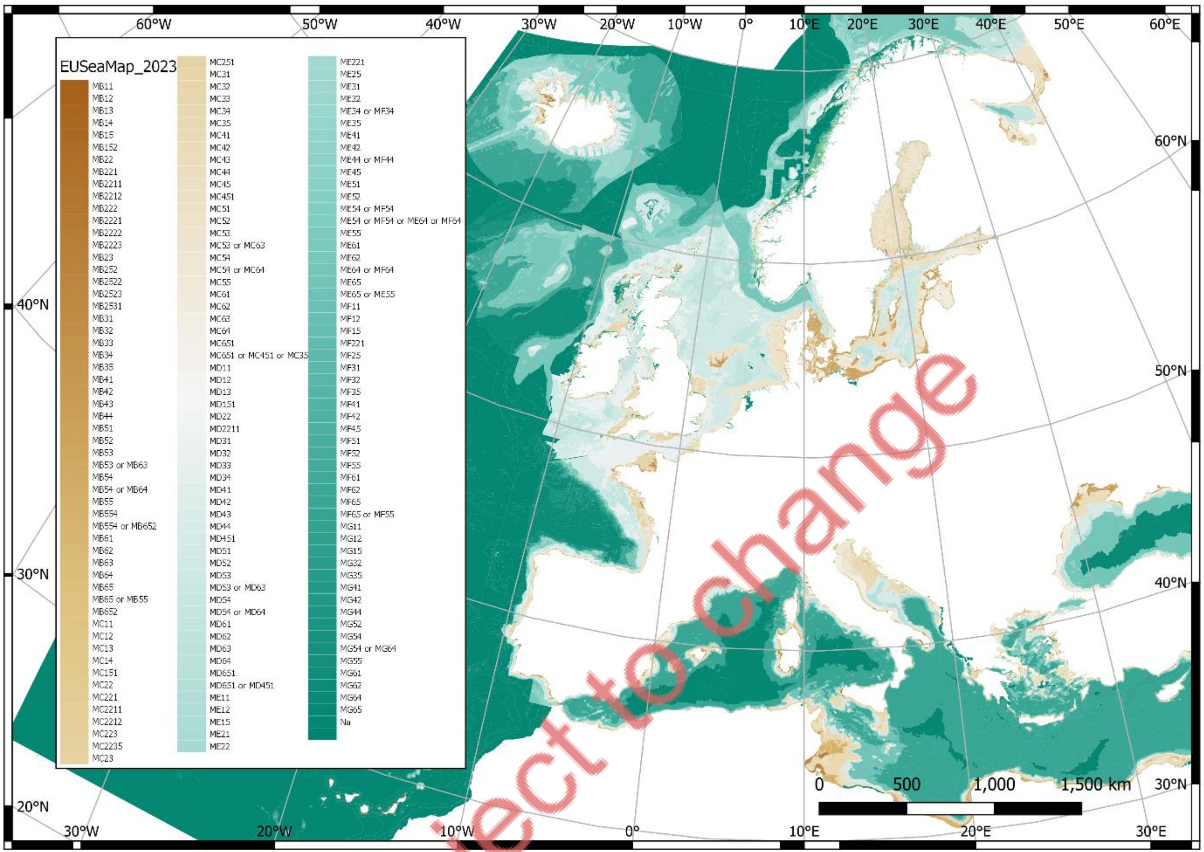


Figure 1. EUNIS classified EUSeaMap 2023 Broad-Scale Predictive Habitat Map for Europe.

2.2.2 EUNIS marine and terrestrial habitats: European Environment Agency map

A EUNIS map is available for all of Europe from the European Environment Agency, https://www.eea.europa.eu/data-and-maps/data/ecosystem-types-of-europe-1 (Figure 2). This is a raster map showing the EUNIS2012 typology on Level 2. The raster format has serious drawbacks and there are major biotopes lacking in coastal and marine zones.

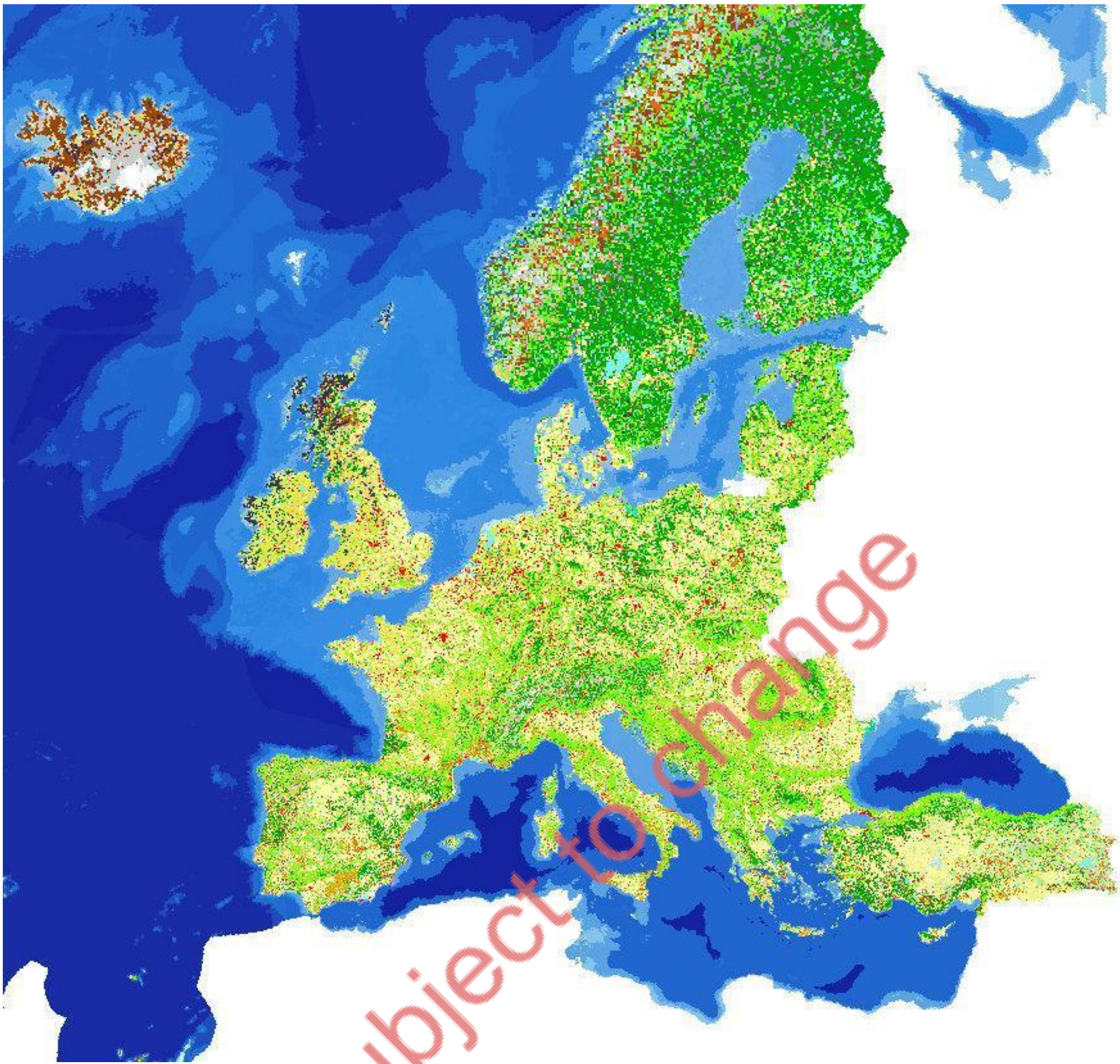


Figure 2. EUNIS map of Europe, raster map in EUNIS2012 Level 2.

2.2.3 EUNIS terrestrial habitats derived from Corine Land Cover 2018

The CORINE Land Cover 2018 dataset provides a comprehensive inventory of land cover and land use across European territories. It is derived from Sentinel-1 and Sentinel-2 satellite imagery. It encompasses 44 thematic classes representing various land cover types. The map is available in vector format with a Minimum Mapping Unit (MMU) of 25 hectares (ha) for areal phenomena (e.g., forests, wetlands) and 100 meters for linear phenomena (e.g., rivers, roads). The most recent map refers to the 2018 reference year.

The CORINE Land Cover 2018 map for Europe (version U2018_CLC2018_V2020_20u1) has GIS polygons available for coastal and terrestrial features (https://land.copernicus.eu/pan-european/corine-land-cover). The CORINE typology used in the European map can be converted to the EUNIS typology by use of the crosswalk between EUNIS habitats Classification and Corine Land Cover from the European Topic Centre on Biological Diversity, http://biodiversity.eionet.europa.eu. Applying the crosswalk table first a conversion to EUNIS2012 was made and, where possible, the EUNIS2012 habitats were converted to the EUNIS2022 typology for marine habitats and the EUNIS2021 typology for terrestrial habitats, which are listed on https://eunis.eea.europa.eu/habitats-code-browser-revised.jsp (Figure 3). At the time of completion, four groups were pending review for their conversion from the EUNIS2012 typology: Inland waters (C-2012), Wetlands (D-2012), Constructed, industrial and other artificial habitats (J-2012) and Complexes (X-2012). In this study the label 'EUNIS2122' is used for the mix of the marine and terrestrial typologies and the EUNIS2012 biotope types are coded with 2012, Table 1.

Table 1. Code conversions from the European CLC map to EUNIS.

CLC2018	EUNIS2012C	EUNIS2122C	EUNIS2122D
111	J1	J1-2012	Buildings of cities, towns and villages
112	J1.2	J1.2-2012	Residential buildings of villages and urban peripheries
121	J2	J2-2012	Low density buildings
122	J4	J4-2012	Transport networks and other constructed hard-surfaced areas
123	J4.5	J4.5-2012	Hard-surfaced areas of ports
124	J4.4	J4.4-2012	Airport runways and aprons
131	J3	J3-2012	Extractive industrial sites
132	J6	J6-2012	Waste deposits
133	J1.6	J1.6-2012	Urban and suburban construction and demolition sites
141	X11	X11-2012	Large parks
142	J1.7	J1.7-2012	High density temporary residential units
211	I1	V1	Arable land and market gardens
212	I1.1	V11	Intensive unmixed crops
213	I1.4	V14	Inundated or inundatable croplands, including rice fields
221	FB.4	V54	Vineyards
222	FB.3	V53	Shrub plantations for ornamental purposes or for fruit, other than vineyards
223	G2.4	T24	Olive - carob woodland
231	E2	R2	Mesic grasslands
241	I1	V1	Arable land and market gardens
242	I2	V2	Cultivated areas of gardens and parks
243	I1.3	V13	Arable land with unmixed crops grown by low-intensity agricultural methods
244	E7	R7	Sparsely wooded grasslands
311	G1	T1	Broadleaved deciduous woodland
312	G3	T3	Coniferous woodland
313	G4	G4-2012	Mixed deciduous and coniferous woodland
321	E1	R1	Dry grasslands
322	F4	S4	Temperate shrub heathland
323	F5	S5	Maquis, arborescent matorral and thermo-Mediterranean brushes
324	E5	R5	Woodland fringes and clearings and tall forb stands
331	B1	N1	Coastal dunes and sandy shores
332	A1	MA1	Littoral rock and other hard substrata
333	H5	U5	Miscellaneous inland habitats with very sparse or no vegetation
334	H5.5	H5.5-2012	Burnt areas with very sparse or no vegetation

CLC2018	EUNIS2012C	EUNIS2122C	EUNIS2122D
335	H4	U4	Snow or ice-dominated habitats
411	C3	C3-2012	Littoral zone of inland surface waterbodies
412	D1	D1-2012	Raised and blanket bogs
421	A2.5	MA2	Coastal saltmarshes and saline reedbeds
422	J5.1	J5.1-2012	Highly artificial saline and brackish standing waters
423	A2	MA5	Littoral sand
511	C2	C2-2012	Surface running waters
512	C1	C1-2012	Surface standing waters
521	X02	X02-2012	Saline coastal lagoons
522	X01	X01-2012	Estuaries
523	A5	MB5	Infralittoral sand
999	999	999	NODATA

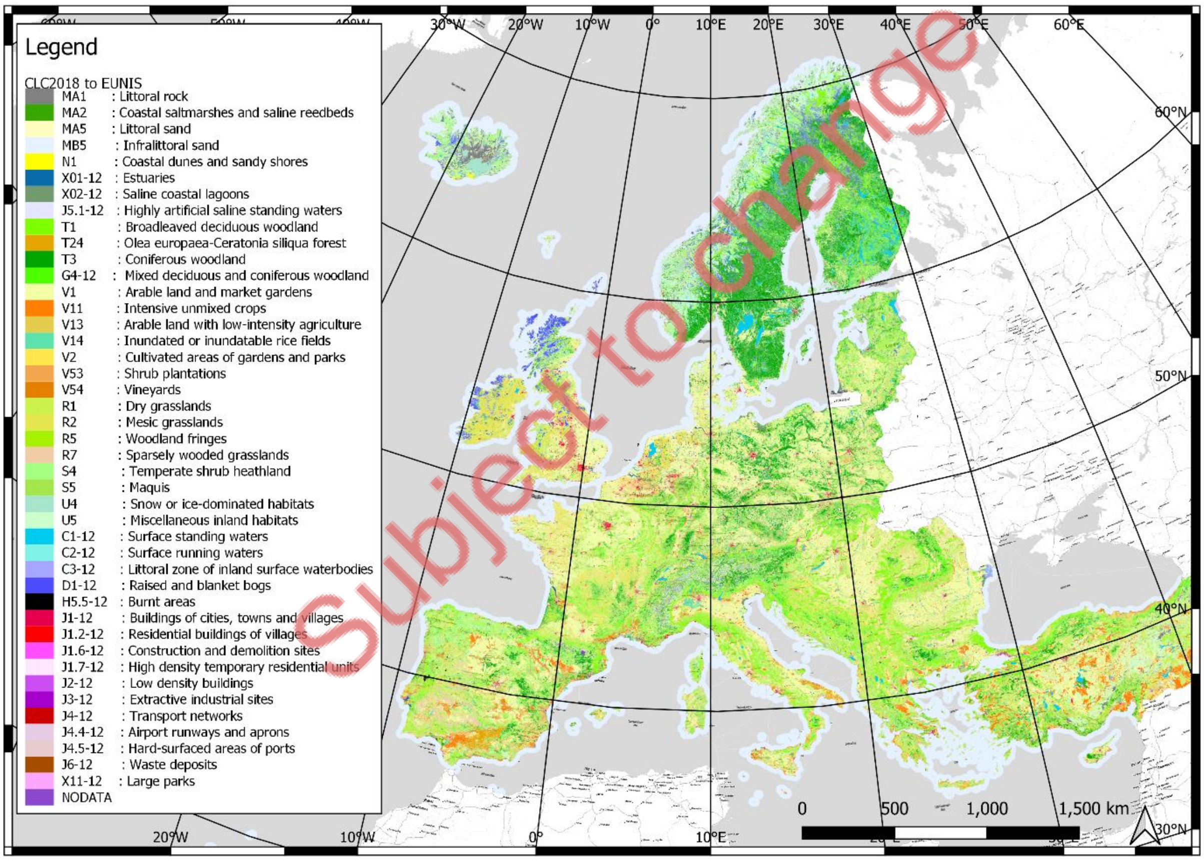


Figure 3. EUNIS classification map of Europe derived from CLC2018. Background map Stamen Toner Lite.

2.2.4 EUNIS terrestrial habitats derived from the Copernicus Coastal Zone map of Europe

The Copernicus Coastal Zones product provides detailed information about land cover and land use for European coastal territories up to a landward distance of 10 kilometres. The product covers all European coastal areas, spanning approximately 730,000 square kilometres. It includes a wide range of thematic classes, totalling 71 categories. The dataset undergoes updates every six years. It is currently available for the 2012 and 2018 reference years. The dataset is available as vector data, allowing for precise mapping and analysis and has a Minimum Mapping Unit (MMU) of 0.5 hectares and a Minimum Mapping Width

(MMW) of 10 meters. The production of coastal zone layers is coordinated by the European Environment Agency (EEA) as part of the Copernicus Land Monitoring Service (CLMS) Local Component. The buffer zone of coastline is derived from EU-Hydro v1.1 data.

This map will have great use for mapping restoration measures and ecosystem services on a European scale (Figure 4). However, the data are not validated yet and therefore can only be applied with careful checks for the correctness on a local scale.

Table 2. Code conversions from the European CLC Coastal Zone map level 3 to EUNIS broad scale.

CLC2018C	CLC2018D	EUNIS2122C	EUNIS2122D
111	Urban fabric	'J1-2012'	Buildings of cities, towns and villages
112	Industrial, commercial, public and military units	'J2-2012'	Low density buildings
121	Road networks and associated land	'J4.2-2012'	Road networks
122	Railways and associated land	'J4.3-2012'	Rail networks
123	Port areas and associated land	'J4.5-2012'	Hard-surfaced areas of ports
124	Airports and associated land	'J4.4-2012'	Airport runways and aprons
131	Mine, dump and construction sites	'J6-2012'	Waste deposits
132	Land without current use	'J2.6-2012'	Disused rural constructions
140	Green urban, sports and leisure facilities	'E2.6-2012'	Heavily fertilised grassland, including sports fields and grass lawns
211	Arable irrigated and non-irrigated land	'V11'	Intensive unmixed crops
212	Greenhouses	'J2.43-2012'	Greenhouses
221	Vineyards, fruit trees and berry plantations	'V5'	Shrub plantations
222	Olive groves	'T24'	Olea europaea-Ceratonia siliqua forest
231	Annual crops associated with permanent crops	'V15'	Bare tilled, fallow or recently abandoned arable land
232	Complex cultivation patterns	'V12'	Mixed crops of market gardens and horticulture
233	Land principally occupied by agriculture with significant areas of natural vegetation	'V13'	Arable land with unmixed crops grown by low-intensity agricultural methods
234	Agroforestry	'V6'	Tree dominated man-made habitats
311	Natural & semi-natural broadleaved forest	'T1'	Deciduous broadleaved forest
312	Highly artificial broadleaved plantations	'T29'	Broadleaved evergreen plantation of non site-native trees
321	Natural & semi-natural coniferous forest	'T3'	Coniferous forest
322	Highly artificial coniferous plantations	'T3N'	Coniferous plantation of site-native trees
331	Natural & semi-natural mixed forest	'G4-2012'	Mixed deciduous and coniferous woodland
332	Highly artificial mixed plantations	'G4.F-2012'	Mixed forestry plantations

CLC2018C	CLC2018D	EUNIS2122C	EUNIS2122D
340	Transitional woodland and scrub	'T41'	Early-stage natural and semi-natural forest and regrowth
350	Lines of trees and scrub	'T42'	Coppice and early stage plantations
360	Damaged forest	'T43'	Recently felled areas
410	Managed grassland	'V3'	Artificial grasslands and herb dominated habitats
421	Semi-natural grassland	'R2'	Mesic grasslands
422	Alpine and sub-alpine natural grassland	'R4'	Alpine and subalpine grasslands
510	Heathland and moorland	'S4'	Temperate shrub heathland
520	Alpine scrub land	'S2'	Arctic, alpine and subalpine scrub
530	Sclerophyllous scrubs	'S5'	Maquis, arborescent matorral and thermo-Mediterranean scrub
611	Sparse vegetation on sands	'U2'	Screes
612	Sparse vegetation on rocks	'U2'	Screes
621	Beaches and dunes	'N1'	Coastal dunes and sandy shores
622	River banks	'C3.6-2012'	Unvegetated or sparsely vegetated shores with soft or mobile sediments
631	Bare rocks, outcrops, cliffs	'U3'	Inland cliffs, rock pavements and outcrops
632	Burnt areas (except burnt forest)	'U5'	Miscellaneous inland habitats usually with very sparse or no vegetation
633	Glaciers and perpetual snow	'U4'	Snow or ice-dominated habitats
711	Inland marshes	'D2-2012'	Valley mires, poor fens and transition mires
712	Peat bogs	'D1-2012'	Raised and blanket bogs
721	Salt marshes	'MA2'	Littoral biogenic habitat
722	Salines	'J5.1-2012'	Highly artificial saline and brackish standing waters
723	Intertidal flats	'MA5'	Littoral sand
811	Natural & semi-natural water courses	'C2-2012'	Surface running waters
812	Highly modified water courses and canals	'J5-2012'	Highly artificial man-made waters and associated structures
813	Seasonally connected water courses (oxbows)	'C2.5-2012'	Temporary running waters
821	Natural lakes	'C1-2012'	Surface standing waters
822	Reservoirs	'J5.3-2012'	Highly artificial non-saline standing waters
823	Aquaculture ponds	'J5.32-2012'	Intensively managed fish ponds
824	Standing water bodies of extractive industrial sites	'J5.34-2012'	Standing waterbodies of extractive industrial sites with extreme chemistry
831	Lagoons	'X02-2012'	Saline coastal lagoons
832	Estuaries	'X01-2012'	Estuaries
833	Marine inlets and fjords	'MB1'	Infralittoral rock

CLC2018C	CLC2018D	EUNIS2122C	EUNIS2122D
841	Open sea	'MC5'	Circalittoral sand
842	Coastal waters	'MB5'	Infralittoral sand

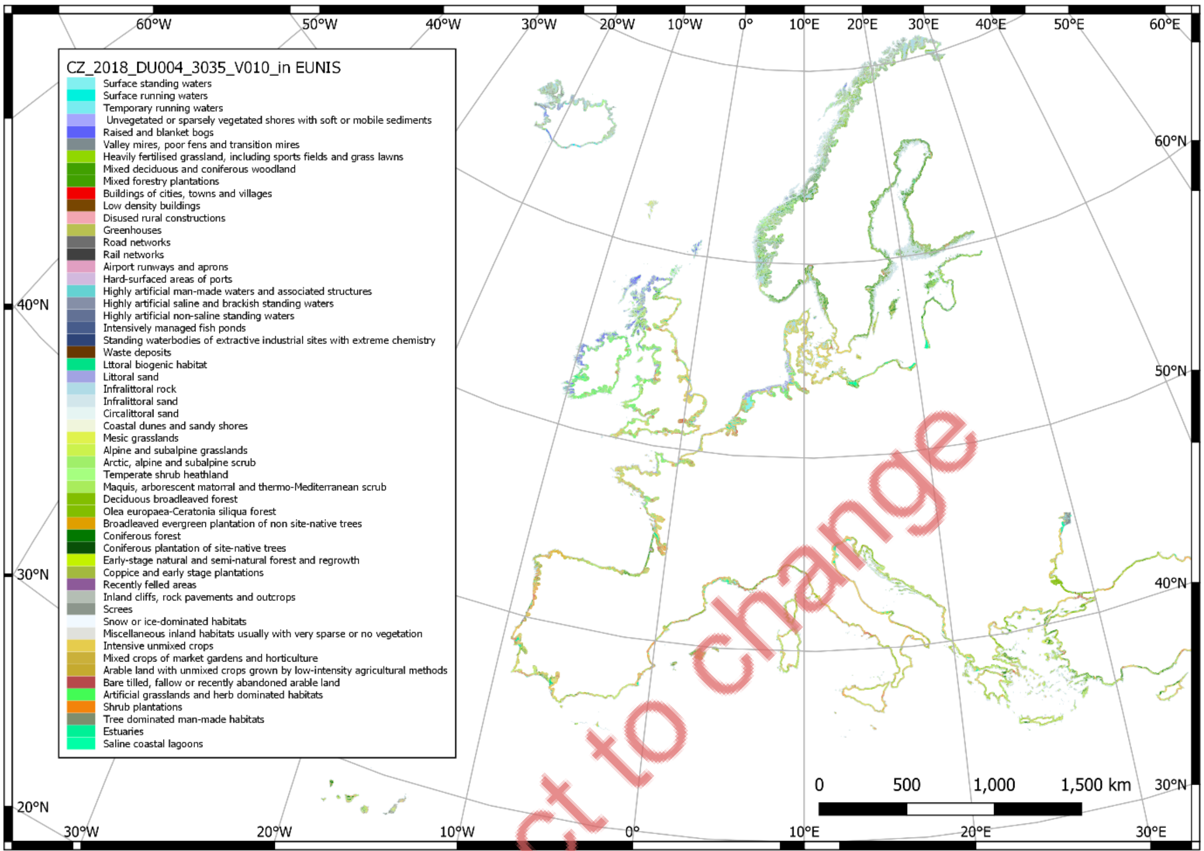


Figure 4. EUNIS classification map for the coastal zone of Europe derived from CLC CZ_2018.

2.3 EUNIS maps of pilot sites

Each pilot site in REST-COAST is requested to produce a EUNIS habitat map in the latest EUNIS classifications, i.e. marine version 2022 and terrestrial version 2021. It is noted that during production the Inland waters, Wetlands, Constructed, industrial and other artificial habitats and Complexes were pending review.

2.3.1 Wadden Sea Ems-Dollard (Netherlands / Germany)

The Wadden Sea encompasses vast expanses of bare sand and mud flats, covering about 4,700 square kilometers, which emerge twice daily during low tide. The consistent supply of sediment from the sea has effectively counteracted the gradual rise in sea levels over the past 8,000 years, thereby preserving a coastal landscape characterized by a seaward sandy barrier, extensive tidal flats, and periodically inundated marshes. Although dominated by oceanic waters, the region experiences influence from river flows as well. Its dynamic sandy shoals and dune islands afford partial protection against the formidable forces of waves and winds prevalent in the open sea.
Annually, the Wadden Sea serves as a sanctuary for an unparalleled influx of 10-12 million birds, which utilize the area for foraging and rest along their East Atlantic flyway. Abundant food resources, primarily in the form

of tidal flat fauna, exhibit concentrations 10-20 times greater than those found in adjacent deeper waters. During high tide, the flats function as a thriving nursery for shrimp and fish.
Functioning as a colossal biological filter between terrestrial and marine environments, the Wadden Sea owes its purification capacity to several key components: extensive beds of molluscan suspension feeders, which filter the local tidal volume approximately twice a month; sediment rendered permeable through the activity of bioturbating lugworms; and marsh vegetation, which acts as a filter during episodic storm surges when waters carry suspended fine particles.
Remarkably, the Wadden Sea supports a diverse array of approximately 10,000 species of plants, fungi, and animals. Following an era of rampant exploitation, conservation efforts have facilitated remarkable recoveries in populations of breeding birds and seals. Large-scale land reclamation activities have ceased, and today, the Wadden Sea garners acclaim for its tranquil beauty.
Nevertheless, the specter of global warming, coupled with an accelerating rise in sea levels, poses a potential threat to the stability of the sandy barrier and the expanse of tidal flats that define this unique ecosystem (Reise et al. 2010).

<u>EUNIS map of the Dutch Wadden Sea</u>
A spatially detailed biotope map is available for the Dutch Wadden Sea (including the Dutch/German Ems-Dollard estuary) in which biotopes were defined following the Dutch typology for the 'Coastal waters Ecotope System ZES.1' (Bouma et al., 2005). An 'ecotope' is defined as: "a geographical unit homogeneous within limits for the most important hydromorphological and physical-chemical environmental factors that are relevant for biota" (Verdonschot et al., 1992). An ecotope, therefore, strongly resembles a biotope, which defines a community's physical environment. For application in the REST-COAST project, the Dutch ecotope typology was converted to the EUNIS typology. In the report by Bouma et al. (2005) a conversion table was presented for EUNIS biotopes. However, these represented a very early EUNIS version that did not even comply to Davies et al. (2004). New tables were therefore made for conversion from ZES.1 ecotopes to the EUNIS-2012 biotopes as well as the EUNIS-2022 marine biotopes.

The Dutch ZES.1 typology consists of hierarchical classification with the following coding:
- A letter z, v or b for saline (z), variable salinity (v), brackish (b) or freshwater (f);
- A number 1 or 2 for hard substrate (1) or soft substrate (2);
- A dot;
- A number 1, 2 or 3 for sublittoral (1), littoral (2) or supralittoral (3);
- A number 1 or 2 for high-energy environment (1) or low-energy environment (2);
- A number 1, 2 or 3 for low-littoral (1), mid-littoral (2) or high-littoral (3) in combination with littoral types, OR a number 2 or 3 for deep-sublittoral (2) or shallow-sublittoral (3) in combination with sublittoral types.
- A letter z, f or s for coarse sand (z), fine sand (f) or mud (s) in combination with soft substrate, OR a letter h or z for hard clay or peat (h) or soft clay or peat (z) in combination with hard substrate.
- The letter x is used in the code for a wildcard.

Table 3. Variables, classes and class boundaries to describe the ecotopes of the Dutch 'Coastal Waters ecotope System ZES.1'. Code denotes the coding used to construct an ecotope.

Variables	Classes	Class boundaries	Code
Mean salinity	Fresh	yearly mean < 0.5 ppt	f
	Brackish	0.5 ppt ≤ yearly mean < 18 ppt	b
	Marine	yearly mean ≥ 18 ppt	z
Salinity	Stable	st. dev./mean ≤ 0.25	

Variables	Classes	Class boundaries	Code
variability	Variable	st. dev./mean > 0.25	v
Substratum1	Sediment	soft sediment	1
	Hard	dikes, dams, quays, etc.	2
Depth1	Sublittoral	mean exposure < 4%	1
	Littoral	4% ≤ mean exp. < 85%	2
	Supralittoral	mean exposure ≥ 85%	3
Hydrodynamics	High-energy	v-max > 80cm/s OR U-bot > 25cm/s	1
	Low-energy	v-max < 80cm/s AND U-bot < 25cm/s	2
Depth2	Deep sublittoral	depth < -5 m MLWS	2
	Shallow sublittoral	-5 m MLWS ≤ depth < 4% mean exp.	3
	Low littoral	4% ≤ mean exposure < 25%	1
	Middle littoral	25% ≤ mean exposure < 75%	2
	High littoral	75% ≤ mean exposure < 85%	3
Substratum2	Undetermined	no data	
	Mud	silt content ≥ 25%	s
	Fine sand	D50 < 250 µm	f
	Coarse sand	250 µm < D50 < 2000 µm	z
	Hard	hard clay or peat	h
	Soft	soft clay or peat	z

Firstly, the ZES.1 ecotopes were converted into the most appropriate EUNIS-2012 biotope. Secondly, the EUNIS-2012 biotopes were converted into EUNIS-2019 biotopes based on the Excel table 'EUNIS marine habitat classification 2022 including crosswalks' from the European Environment Agency.

The following conversions were applied:
All deep sublittoral parts having either a low- or high-energy environment were converted into 'A5.25: Circalittoral fine sand' => 'MC52: Atlantic circalittoral sand'. The application of circalittoral fine sand for the majority of the deep tidal inlets and deep estuarine channels in the Wadden Sea is in accordance with the EUSeaMap 2021, the EMODnet broad-scale seabed habitat map for Europe. In the EUSeaMap 2021 the sublittoral parts of the German and Danish Wadden Sea (but not the Dutch Wadden Sea) are mapped. Besides fine sand, the sublittoral channels in EUSeaMap 2021 also contain sandy mud, coarse sediment or mixed sediments at some locations. Information on the sublittoral sediment type is not present in the Dutch ecotope map and it was assumed that all sediment consists of fine sand. Furthermore, the EUSeaMap 2021 contains parts with 'deep circalittoral' biotopes, but because these biotopes were described for offshore parts in European seas (Davies et al. 2004), these were not considered for the Dutch Wadden Sea.

All shallow sublittoral parts (above 5 m below MLWS) having a high-energy environment were converted into 'A5.23: Infralittoral fine sand' => 'MB52: Atlantic infralittoral sand'. This is in accordance with the majority of the tidal gullies in the EUSeaMap 2021 for the Wadden Sea. There is an exception for some locations with 'infralittoral sandy mud' or 'infralittoral coarse sediment' in the German or Danish Wadden Sea. For shallow sublittoral parts having a low-energy environment a subdivision was made based on salinity in order to better describe the faunal composition in these biotopes. This subdivision could only be made for EUNIS-2012. Shallow sublittoral channels with low-energy in brackish salinity were converted into 'A5.21: Sublittoral sand in low or reduced salinity'. Shallow sublittoral channels with low-energy and variable salinity were converted into 'A5.22: Sublittoral sand in variable salinity (estuaries)'. Shallow sublittoral channels with low-energy and marine salinity were converted into ‘A5.23: Infralittoral fine sand’. In the EUNIS-2022 typology these three types all convert to ‘MB52: Atlantic infralittoral sand’. The subdivision for salinity was not made for the deep sublittoral biotopes neither for the high-energy shallow sublittoral because Van Donk & Baptist (2021) concluded that depth and hydrodynamics have a dominant effect on the macrofauna species composition over salinity in the Dutch Wadden Sea.

All littoral high-energy fine sands were converted into ‘A2.22: Barren or amphipod-dominated mobile sand shores’ => ‘MA523: Barren or amphipod-dominated Atlantic littoral mobile sand’ representing the non-cohesive mobile sands with a relatively high degree of wave exposure. All littoral low-energy fine sands were converted into ‘A2.24: Polychaete/bivalve-dominated muddy sand shores’ => ‘MA525: Polychaete/bivalve-dominated Atlantic littoral muddy sand’. An alternative choice would be ‘A2.23 Polychaete/amphipod-dominated fine sand shores’. However, the presence of muddy sand with an anoxic layer below 5 cm of the sediment surface is typical for the sheltered tidal environments in the Dutch Wadden Sea. In the ZES.1 ecotope typology a detailed subdivision is made for the inundation period of tidal flats resulting in low-, mid- and high-littoral biotopes, but this subdivision is lacking in the EUNIS typology. Furthermore, the ZES.1 ecotope typology distinguishes a subdivison for salinity that is applied to littoral sandy biotopes, but this is also lacking in the EUNIS typology.

For the littoral low-energy muds a subdivision could be made based on salinity. The marine saline intertidal mudflats were converted into ‘A2.33: Marine mud shores’ => ‘MA621: Faunal communities of full salinity Atlantic littoral mud’. The mudflats with brackish or variable salinity were converted into ‘A2.32: Polychaete/oligochaete-dominated upper estuarine mud shores’ => ‘MA622: Faunal communities of variable salinity Atlantic littoral mud’, which is typical for the Dollard for instance.

Supralittoral high-energy sediments are beaches and therefore converted into ‘B1.2: Sand beaches above the driftline’ => ‘N11: Atlantic, Baltic and Arctic sand beach’. Supralittoral low-energy sediments are not represented well in the EUNIS typology. In the Dutch Wadden Sea these biotopes are mainly found in front of the pioneer zone of salt marshes. It was therefore chosen to describe these as littoral low-energy muds, as above, with similar subdivision in salinity.

The pioneer saltmarsh ecotope was converted into ‘A2.55: Pioneer saltmarshes’ => ‘MA225: Atlantic pioneer saltmarshes’. The saltmarsh ecotope in the Dutch ecotope map can be represented by several EUNIS-2012 biotopes i.e. ’A2.52 Upper saltmarshes’, ‘A2.53: Mid-upper saltmarshes and saline and brackish reed, rush and sedge beds’ or ‘A2.54: Low-mid saltmarshes’. Considering the average age and vegetation composition of Dutch saltmarshes, the A2.53 type is chosen to be the most appropriate which equals to ‘MA223: Atlantic upper-mid saltmarshes and saline and brackish reed, rush and sedge beds’.
The littoral hard substratum is all artificial and was converted into ‘dike’. There is however a special subtype for the littoral consolidated peat layer ‘A1.127: Ceramium sp. and piddocks on eulittoral fossilised peat’ => ‘MA1237: Ceramium sp. and piddocks on eulittoral fossilised peat’.

The resulting biotope maps for the Dutch Wadden Sea in the EUNIS-2012 and EUNIS-2022 typologies are presented respectively in Figure 5 and Figure 6.

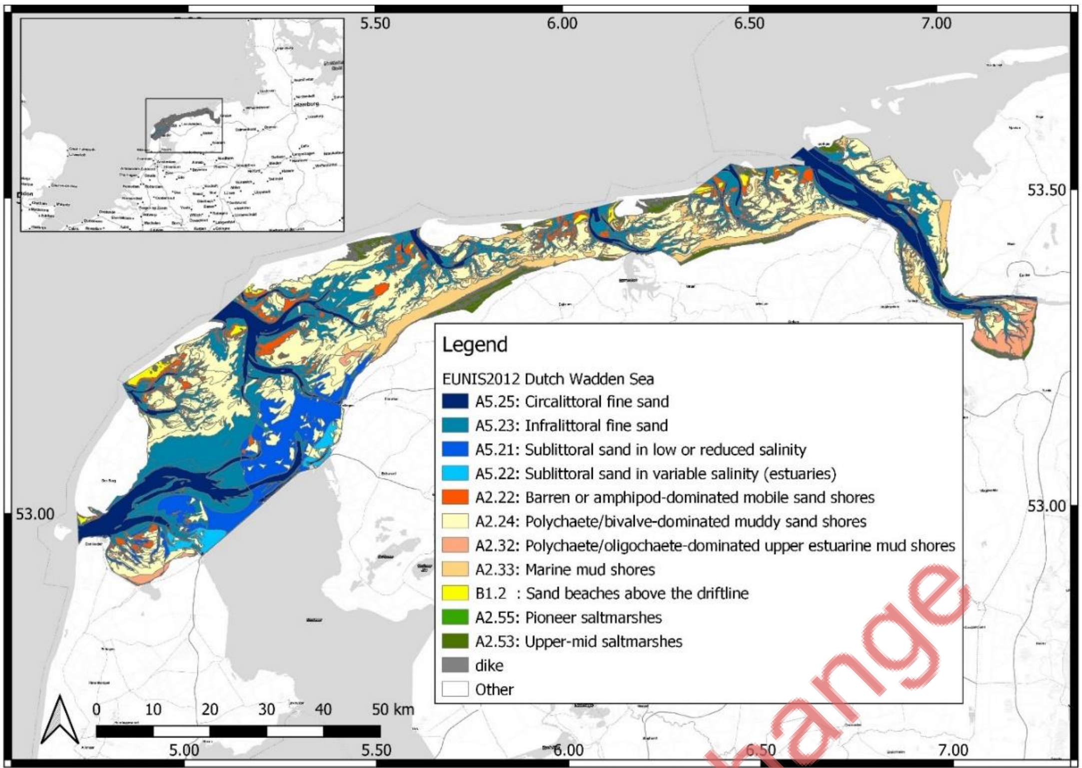


Figure 5. EUNIS-2012 biotope map of the Dutch Wadden Sea.

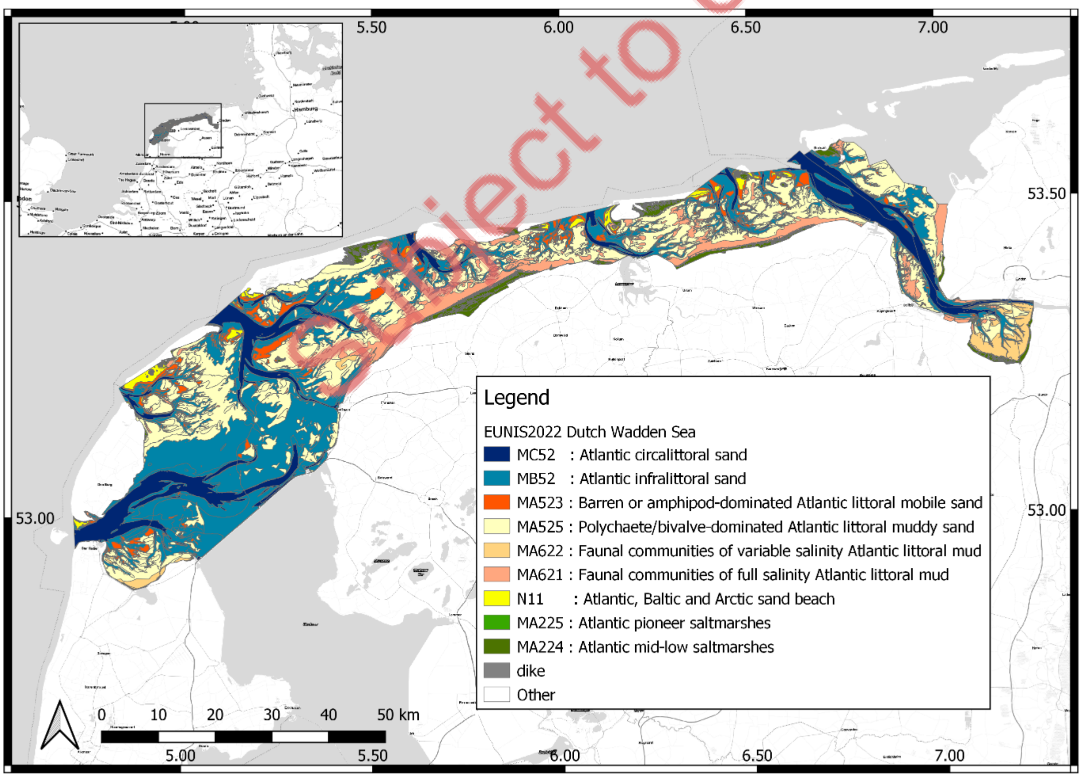


Figure 6. EUNIS-2022 biotope map of the Dutch Wadden Sea.

<u>EUNIS map of the international Wadden Sea</u>

A biotope map is available for the trilateral Wadden Sea, Figure 7 (Baptist et al., 2019; 2022). Biotopes were defined following the Dutch typology for the 'Coastal waters Ecotope System ZES.1' (Bouma et al., 2005).

For application in the REST-COAST project, the ecotope typology in the trilateral Wadden Sea map was converted to the EUNIS typology. The variables, classes, class boundaries and codes to construct ecotopes are shown in *Table 4*.

Table 4. Variables, classes and class boundaries to describe the ecotopes of Coastal Waters ecotope System ZES.1. Code denotes the coding used to construct an ecotope in the trilateral map.

Variables	Classes	Class boundaries	Code
Mean salinity 'SaltClass'	Fresh	yearly mean < 0.5 ppt	0
	Brackish	0.5 ppt ≤ yearly mean < 18 ppt	1
	Marine	yearly mean ≥ 18 ppt	2
Salinity variability 'SaltVarib'	Stable	st. dev./mean ≤ 0.25	0
	Variable	st. dev./mean > 0.25	1
Substratum 'HardSubCod'	Sediment	soft sediment	0
	Hard	dikes, dams, quays, etc.	1
Depth 'LitoralCod'	Deep sublittoral	depth < -5 m MLWS	0
	Shallow sublittoral	-5 m MLWS ≤ depth < 4% mean exp.	1
	Low littoral	4% ≤ mean exposure < 25%	2
	Middle littoral	25% ≤ mean exposure < 75%	3
	High littoral	75% ≤ mean exposure < 85%	4
	Supralittoral	mean exposure ≥ 85%	5
	Salt marsh	vegetated	6
Hydrodynamics 'DynamicCod'	Low dynamic	max. current velocity < 0.8 m/s	0
	High dynamic	max. current velocity ≥ 0.8 m/s	1
Sediment composition 'SedCode'	Undetermined	no data	0
	Silt	Silt content ≥ 25%	1
	Fine sand	D50 < 250 µm	2
	Coarse sand	250 µm < D50 < 2000 µm	3
Salt marsh 'SaltMarshC'	No vegetation	TMAP coastal vegetation S.0	0
	Pioneer zone	TMAP coastal vegetation S.1	1
	Low salt marsh	TMAP coastal vegetation S.2	2
	Brackish marsh	TMAP coastal vegetation S.5	3
	High salt marsh	TMAP coastal vegetation S.3	4
	Other marsh	TMAP coastal vegetation other S	5
	Dune slack	TMAP coastal vegetation D.1	6
	Fresh grassland	TMAP coastal vegetation S.6	7

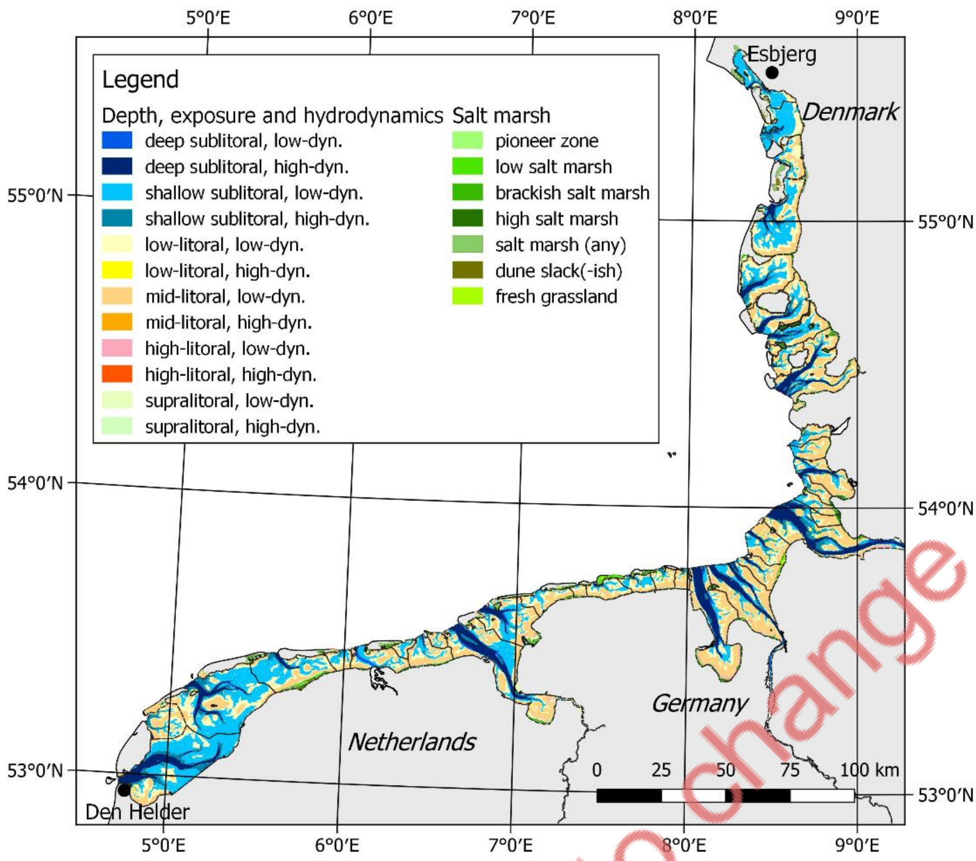


Figure 7. Biotope map of the trilateral Wadden Sea. Source: Baptist et al. (2022).

The level 3 marine benthic EUNIS2022 biotopes for the Atlantic region are composed of a combination of depth and substrate. For the Wadden Sea environment the littoral habitats (MA), infralittoral habitats (MB) and circalittoral habitats (MC) are relevant. Each habitat has six different substrates: 1. Rock, 2. Biogenic habitat, 3. Coarse sediment, 4. Mixed sediment, 5. Sandy sediment and 6. Muddy sediment.

The trilateral ecotope map contains data about water depth and inundation period, from which the littoral habitats were defined by all Low littoral, Middle littoral, High littoral and Supralittoral ecotopes, the infralittoral habitats by the Shallow sublittoral ecotopes and the circalittoral habitats by the Deep sublittoral ecotopes. The map contains a classification of the substrate on basis of which the Coarse sediment, Sandy sediment and Muddy sediment can be distinguished based on Coarse sand, Fine sand and Silt ecotopes respectively. However, substrate data is only available for the littoral parts so it is assumed here that all infralittoral and circalittoral biotopes are sandy. For some small littoral parts the sediment data is lacking and also here it is then assumed the sediment is sandy. The salt marshes of the Wadden Sea, which are included in the trilateral map, belong to the littoral biogenic habitats, which are subdivided in Level 4 in Atlantic upper saltmarshes (High salt marsh ecotope), Atlantic upper-mid saltmarshes and saline and brackish reed, rush and sedge beds (Brackish marsh ecotope), Atlantic mid-low saltmarshes (Low salt marsh ecotope) and Atlantic pioneer saltmarshes (Pioneer zone ecotope). Some parts of salt marshes are dune slacks (EUNIS2021 terrestrial biotope N1H) and other parts are managed for cattle and classified as meadows (EUNIS2021 terrestrial biotope R22). Also at level 4, some of the littoral and infralittoral EUNIS biotopes contain information on salinity, distinguishing between full salinity and reduced and variable salinity. This information is also available in the trilateral ecotope map. In EUNIS the Level 3 Atlantic littoral sandy biotopes are subdivided in Level 4 on basis of sediment mobility and a further subdivision in fine sands and muddy sands. This information is not available in the trilateral ecotope map.

Based on the Variables and Codes in *Table 4* the following 15 EUNIS biotopes could be defined based on the trilateral ecotope map, defined for EUNIS marine habitat types 2022 and EUNIS terrestrial habitat types 2021, together abbreviated to EUNIS2122, *Table 5*.

Table 5. Code conversions from the trilateral ecotope map to EUNIS2021 & EUNIS2022.

LitoralCod	SedCode	SaltClass	SaltMarshC	EUNIS2122C	EUSIS2122D
0				MC521	Faunal communities of Atlantic circalittoral sand
1		2		MB523	Faunal communities of full salinity Atlantic infralittoral sand
1		1 or 0		MB524	Faunal communities on variable salinity Atlantic infralittoral sand
2, 3, 4 or 5	0 or 2			MA52	Atlantic littoral sand
2, 3, 4 or 5	1	2		MA621	Faunal communities of full salinity Atlantic littoral mud
2, 3, 4 or 5	1	1 or 0		MA622	Faunal communities of variable salinity Atlantic littoral mud
2, 3, 4 or 5	3	2		MA321	Faunal communities on full salinity Atlantic littoral coarse sediment
2, 3, 4 or 5	3	1 or 0		MA322	Faunal communities on variable salinity Atlantic littoral coarse sediment
6			1	MA225	Atlantic pioneer saltmarshes
6			2	MA224	Atlantic mid-low saltmarshes
6			3	MA223	Atlantic upper-mid saltmarshes and saline and brackish reed, rush and sedge beds
6			4	MA222	Atlantic upper saltmarshes
6			5	MA22	Atlantic littoral biogenic habitat (i.e. saltmarshes undefined)
6			6	N1H	Atlantic and Baltic moist and wet dune slack
6			7	R22	Low and medium altitude hay meadow

The resulting EUNIS map for the trilateral Wadden Sea is shown in Figure 8.

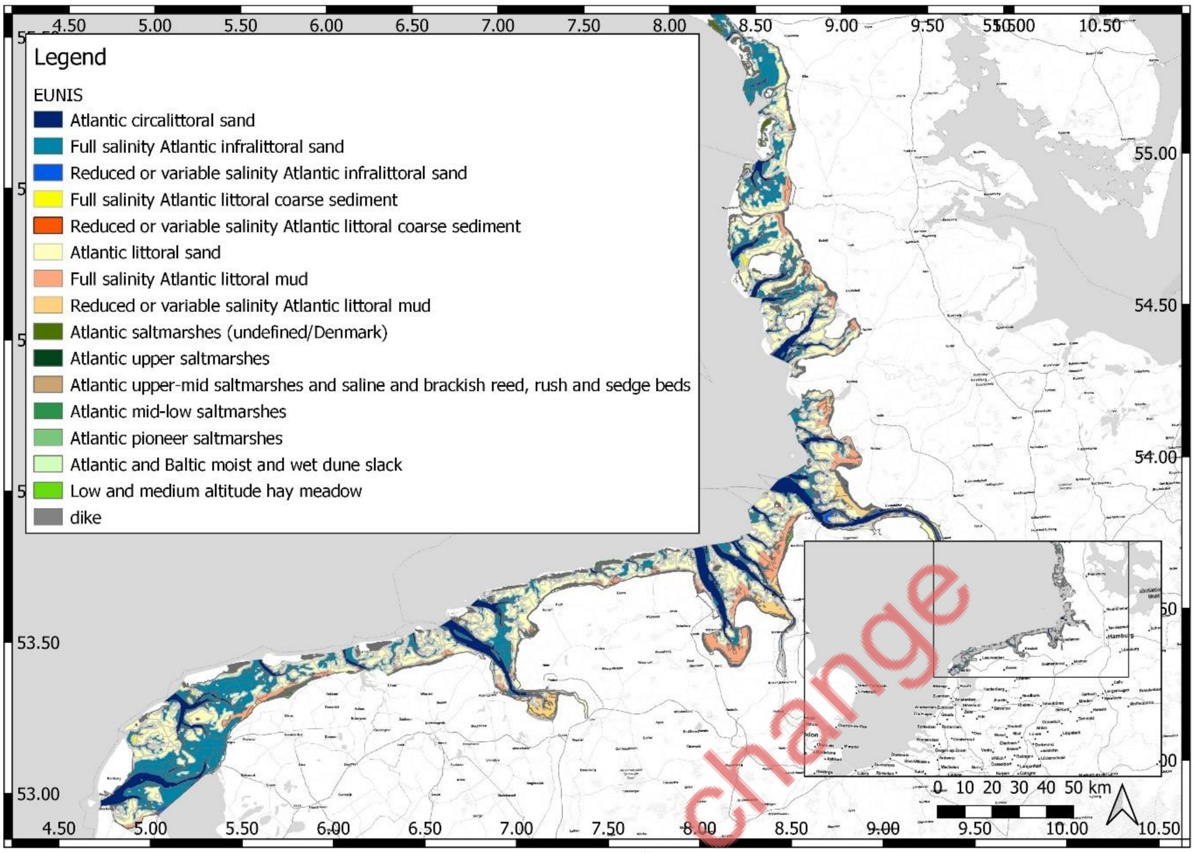


Figure 8. EUNIS map of the trilateral Wadden Sea.

EUNIS map of the Ems-Dollard area

In October 2023 an updated ecotope map of the Dutch-German Ems-Dollard was delivered (Paree et al. 2023). This map is based on the bathymetric survey of 2020 and a revised rule set (ZES.2) for the definition of ecotopes, based on the advice of Van Donk & Baptist (2021). The vegetation composition of the salt marshes in the Dutch part of the Ems-Dollard was most recently mapped in 2018 and 2019. The German part was last mapped in 2015 and 2016. These vegetation data were applied to map the salt marshes in the updated ecotope map. However, the number of salt marsh types in the ecotope map is limited to two (pioneer marsh or salt marsh). To better link to the EUNIS habitats it is advisable to use the TMAP classification scheme for salt marshes, which distinguishes more classes. Finally, because the ecotope map only maps the estuarine parts outsides the dikes and there are also inland restoration measures planned, it is advisable to include inland parts as well. This can be done based on the 10 km wide coastal zone map derived from Corine Land Cover (https://land.copernicus.eu/en/products/coastal-zones).

A recent map of the Ems-Dollard EUNIS habitats was compiled from:

1. The updated ecotope map from Rijkswaterstaat for the Ems-Dollard tidal system
2. The latest salt marsh maps from the TMAP classification
3. The inland mapping based on Corine Coastal Zones Land Cover/Land Use 2018 (CZ_2018_DU004_3035_V010).

Ad. 1 Dutch ecotopes ZES.2 to EUNIS

The ecotope conversion as described for the Dutch Wadden Sea map was used, resulting in EUNIS habitats for an updated bathymetry and updated hydrodynamic modelling in the subarea of the Wadden Sea.

Ad. 2 TMAP salt marsh codes to EUNIS

The salt marsh maps in the TMAP typology (Petersen et al. 2017) were converted to EUNIS according to Table 6.

Table 6. Conversion from TMAP codes to EUNIS habitats for the salt marshes in the Ems-Dollard area.

TMAP_Code	EUNIS2122
'G.1.0'	'R22'
'X.0'	'N1'
'X.1'	'N11'
'X.3'	'N131'
'X.7.1'	'N1A'
'H.0'	'MA22'
'S.0'	'MA22'
'S.0.1'	'MA22'
'S.0.2'	'MA22'
'S.0.3'	'MA22'
'S.1.1'	'MA225'
'S.1.2'	'MA225'
'S.2.0'	'MA224'
'S.2.1'	'MA224'
'S.2.2'	'MA224'
'S.2.3'	'MA224'
'S.3.0'	'MA222'
'S.3.2'	'MA222'
'S.3.3'	'MA222'
'S.3.5'	'MA222'
'S.3.7'	'MA222'
'S.3.9'	'MA222'
'S.3.10'	'MA222'
'S.3.11'	'MA222'
'S.3.13'	'MA222'
'S.3.14'	'MA222'
'S.5.1'	'MA223'
'S.5.2'	'MA223'
'S.5.3'	'MA223'
'S.6.1'	'R22'
'S.8.0'	'X02-2012'
'S.9'	'MA22'

Ad. 3 Corine Coastal Zones Land Cover

The Corine Coastal Zones Land Cover map was converted (to the best possible extent) to EUNIS habitats according to Table 2.

The resulting map is shown in Figure 9.

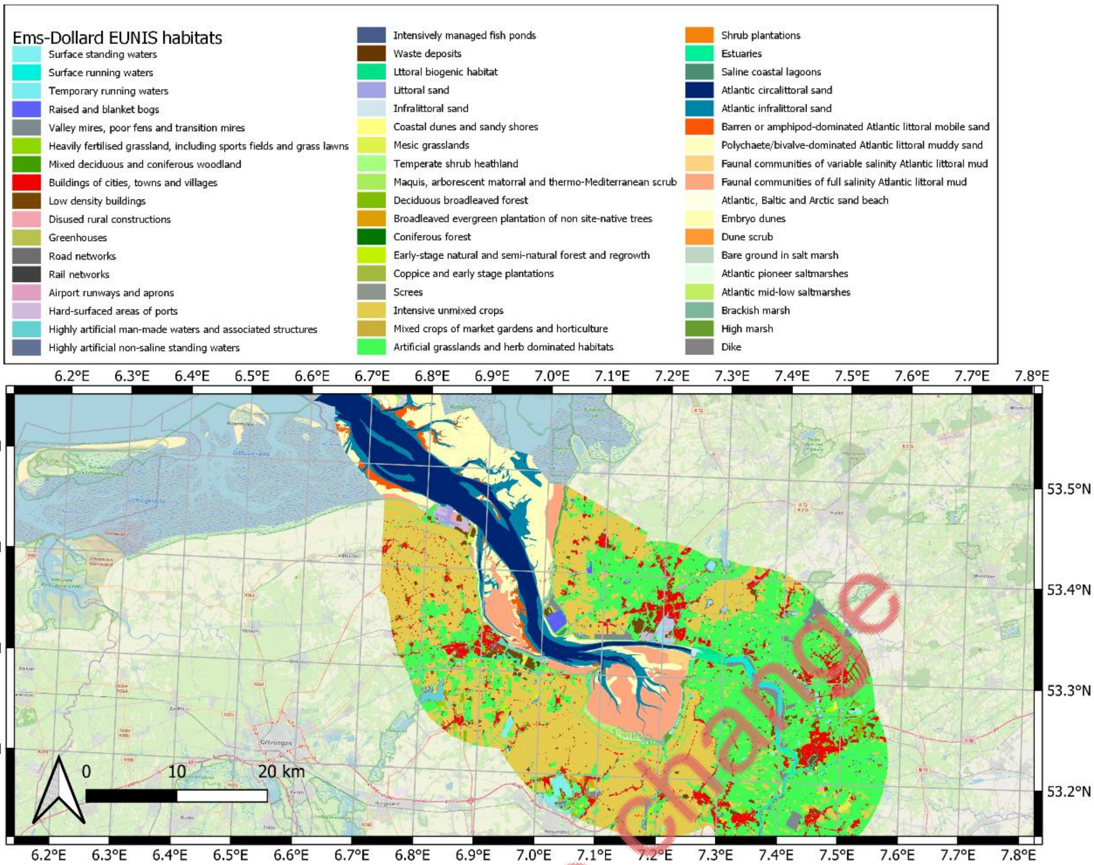


Figure 9. EUNIS habitat map of the Ems-Dollard area.

2.3.2 Venice Lagoon (Italy)

The Venice Lagoon is an aquatic transitional ecosystem consisting of a large coastal lagoon, whose surface of 550 km^2 is the largest among the brackish coastal lagoons in the Mediterranean. The Venice Lagoon receives freshwater from rivers, influencing especially the northern part of the basin, while in the southern part, river input is regulated and mainly determined by the outflow of small channels with lower flow. Tidal exchange with the Adriatic Sea is ensured through the three inlets – Lido, Malamocco, and Chioggia- and ports entrances of the Venice Lagoon. Currently, these inlets house a system based on a series of submerged movable gates, known as MOSE, which purpose is to control the entry of exceptionally high tides. The submerged movable gates are typically lying on the seafloor within the inlet, but in case of emergency, they are raised to maintain the water level inside the lagoon below +110 cm above mean sea level. This is done to protect Venice and the inhabited islands from flooding, which could become more frequent due to the effects of climate change.

The hydro-morphology of the Venice Lagoon has been severely affected due to centuries of erosion caused by increasing water level and tide motion triggered by boat and ship traffic, landscape elements and anthropogenic interventions. The habitats typical to the Venice lagoon started to be highly affected and threatened, among such habitats the most important are saltmarshes, mudflats, and seagrasses meadows as they are interlaced with the distribution and the dynamics of channels and canals and, on the other side, shallow water areas located between them.

In 2023, the Venice team in the REST-COAST project has been working on a new and locally adjusted EUNIS map with a fine spatial resolution, presented in Figure 10.

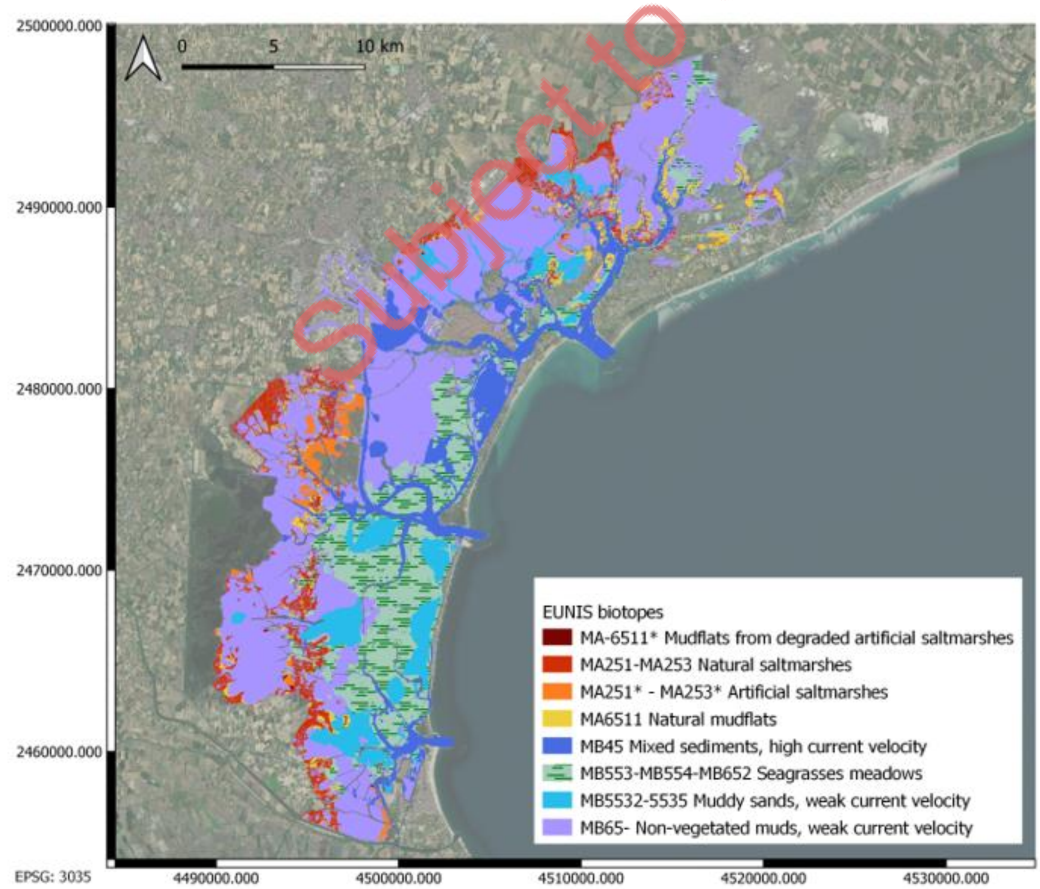


Figure 10. EUNIS habitats in Venice Lagoon.

The Venice Lagoon, like any highly dynamic transitional environment, possesses multiple habitats with boundaries that are challenging to discern except through the introduction of discretionary criteria, that may be based on geomorphological features, or on the characteristics of the ecological community that have established there. This categorization process, unfortunately, is not always harmonizable with the EUNIS classification framework, which aims to classify habitats based on precise distinctive features that determine the difference between one ecotope and another, allowing each ecotope to be well-mapped. This approach is indeed better applicable to marine zones or estuarine areas with well-defined gradients in at least one or two physical factors (e.g., salinity and current velocity). In lagoon areas, however, gradients are not always as well-defined, and daily variability can lead to completely different combinations of the environmental factors depending on the tidal phase, time of day, or even the season. Therefore, it is quite common for lagoon ecotopes, especially if primarily determined by biological elements, to partially overlap, making it challenging to both map and classify lagoon areas under a single EUNIS ecotope code. Moreover, in the Venice Lagoon, where ecological restoration work and the reconstruction of salt marshes and other landscape elements have been implemented for decades now, it is essential to consider the difference between natural habitats, with their natural geomorphological origin and history, and habitats that have been restored, reconstructed or entirely generated by human interventions to resemble the natural version of the habitat and trigger the development of a natural ecological community. For these reasons, in the case of the pilot site in the Venice Lagoon, the mapping of EUNIS habitats followed sequential steps.

The first step was to gather the baseline data from the official geographical repositories Geoportale Regione Veneto (https://idt2.regione.veneto.it/idt/downloader/download) and Repertorio Nazionale Dati Territoriali (https://geodati.gov.it/geoportale, last accessed on February 2024), along with the geotopographical layer depicting the extent of natural saltmarshes in the Venice lagoon available on the Venice lagoon local geospatial repository (https://cigno.atlantedellalaguna.it/, 2014; last accessed on January 2020).
An initial check on saltmarshes boundaries as reported in the official dataset resulted in the detection of several inaccuracies and the presence of obsolete data. Therefore, a new mapping was based on satellite imageries retrieved by Sentinel 2-A and 2-B multiband onboard optical sensors. Suitable imageries have been selected for mapping saltmarshes and mudflat boundaries among 14 images collected by the satellite fleet between October 2022 and March 2023. Suitability criteria included cloud cover less than 9.9% of the image and satellite overpass outside extraordinary low tides periods. Based on these images, a photointerpretation process allowed for the update of all the layers to the most recent view of the lagoon, i.e. via the editing of the natural saltmarshes layer, the addition of newly restored artificial saltmarshes, and the replacement of some areas formerly classified as "artificial saltmarshes" with polygons falling under the group of mudflats. Subsequently, the availability of a recently collected LiDAR geo-dataset (Scientific activity performed in the Research Programme Venezia2021, coordinated by CORILA, with the contribution of the Provveditorato for the Public Works of Veneto, Trentino Alto Adige and Friuli Venezia Giulia) enabled a final editing of the map at the highest possible resolution, namely up to 1 meter with full accuracy for the areas above 0 m above mean sea level. The aim of preparing an accurate update of saltmarshes extension was to have a common basemap for both the ecologists' team and the modelers team, enabling them to share an identical baseline in terms of the current lagoon conditions.
The hydrodynamics data characterizing the areas covered by water were simulated using the System of HydrodYnamic Finite Element Modules (SHYFEM, Umgiesser et al., 2004), which is a 3D baroclinic finite-element circulation model. This model solves the Navier–Stokes equations by incorporating hydrostatic and Boussinesq approximations. For this investigation, we employed the SHYFEM-MPI version developed by Centro Euro-Mediterraneo sui Cambiamenti Climatici (CMCC) (Micaletto et al., 2022) to simulate the recent past conditions of the Venice lagoon.
Finally, the assignment of the EUNIS code was carried out by referring to the habitat hierarchical view tool. The identification of the ecotope encompassed a multicriteria algorithm aimed at guiding along the hierarchical tool toward the most suitable EUNIS code. The applied criteria are illustrated in Fig. 12. According to the implemented workflow, 10 habitats have been identified. Some biogenic habitats have been attributed

to two or three EUNIS level-4 codes, due to the contemporary presence of overlapping habitats that correspond to both (three) EUNIS habitat descriptions.

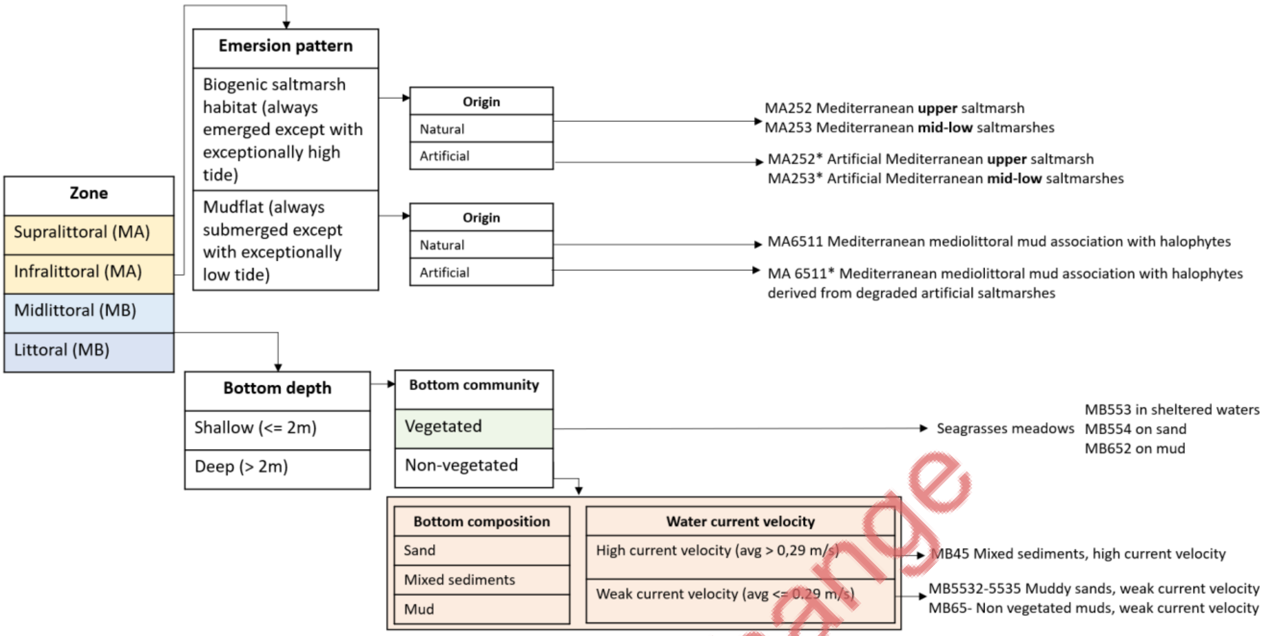


Figure 11. Workflow for the assignment of the EUNIS code in the Venice Lagoon.

2.3.3 Ebro Delta (Spain)

An Ebro delta (NE Spain) spatially detailed EUNIS habitats map (Figure 12) was crafted by cross-analysing a CORINE habitats map at a scale of 1:50.000, and a CORINE to EUNIS habitat classification system conversion table. The habitat types not encompassed by the CORINE system, such as benthic and circalittoral marine habitats, as well as running surface waters, were sourced from three distinct references: the Seabed Habitats maps developed by the European Marine Observation and Data Network (EMODnet) (https://emodnet.ec.europa.eu/geoviewer/), the seagrass meadows maps developed by the Catalan government (https://agricultura.gencat.cat/ca/detalls/Article/Herbassars-o-praderies-de-fanerogames-marines-00002#contingut-de-la-base), and the Ebro delta maps developed by the Ebro River water authority (https://iber.chebro.es/sitebro/sitebro.aspx).

The CORINE land cover specific to the Ebro delta was extracted from a broader CORINE map developed by the Catalan government covering all of Catalonia. The Catalonia CORINE habitats map, initially generated in 2001 and last updated in 2018, served as a foundational resource: (https://sig.gencat.cat/metadades/geonetworkMetadataDetailUuid.html?uuid=TMP0000A_16571). Notably, the map's creation adhered to certain standards set by the Catalan Government, including a minimal drawing area of 22,500 m^2 and the use of polygons with no more than three legend items.

The CORINE habitats classification was transformed into the EUNIS 2012 habitats classification system using a conversion table developed by the Government of Catalonia: https://mediambient.gencat.cat/ca/05_ambits_dactuacio/patrimoni_natural/sistemes_dinformacio/habitats/habitats_terrestres/habitats-de-catalunya/correspondencies_entre_habitats/. In instances where a Corine habitat type comprised an amalgamation of 2 or more types, we selected the most representative type for the conversion process. Furthermore, we proceeded to convert the EUNIS-2012 habitats into either EUNIS-2021 (terrestrial) or -2022 (marine) habitats (Table 7). This conversion was carried out using the EUNIS marine habitat classification 2022 crosswalks table provided by the European Environment Agency. It's noteworthy that for certain EUNIS-2012 categories, namely C, D, and J, the conversion is pending. In such cases, we've maintained the 2012 category until the conversion process is completed.

Table 7. Conversion table from Corine to EUNIS-2012 and EUNIS-2122 habitats.

CORINE code	EUNIS2012 code	EUNIS2122 code	EUNIS2122 description
14a	A2.2	MA55	Mediterranean littoral sand
15a	A2.552	MA2533	Mediterranean coastal halo-nitrophilous pioneer communities
16a	B1.2	N12	Mediterranean and Black Sea sand beach
16b	B1.312	N141	Western Tethyan embryonic dunes
18c	A1	MA15	Mediterranean littoral rock
21a	X02	X02	Saline coastal lagoons
34g	E1.2A	R1A5	*Brachypodium phoenicoides* swards
44.8	F9.31	F9.31-2012	*Nerium oleander*, *Vitex agnus-castus* and *Tamarix* galleries
44h	G1.311	T1421	Iberian poplar galleries
53.13	C3.23	C3.23-2012	*Typha* beds
53a	D5.11	D5.11-2012	*Phragmites australis* beds normally without free-standing water
53c	C3.28	C3.28-2012	Riparian *Cladium mariscus* beds
53d	C3.32	C3.32-2012	*Arundo donax* beds

CORINE code	EUNIS2012 code	EUNIS2122 code	EUNIS2122 description
82	I1.1	T3M	Coniferous plantation of non site-native trees
82d	I1.4	V14	Inundated or inundatable croplands, including rice fields
83b	G1.D4	V614	Fruit orchards
83c	G2.92	V622	Citrus orchards
86a	E5.1	V37	Annual anthropogenic herbaceous vegetation
86b	E5.1	V37	Annual anthropogenic herbaceous vegetation
87a	I1.53	V153	Fallow un-inundated fields with annual and perennial weed communities
87b	E5.1	V37	Annual anthropogenic herbaceous vegetation
89a	J5.12	J5.12-2012	Saltworks
		MB35	Mediterranean infralittoral coarse sediment
		MB252	Biocenosis of Posidonia oceanica
		MB55	Mediterranean infralittoral sand
		MB65	Mediterranean infralittoral mud
		MC35	Mediterranean circalittoral coarse sediment
		MC451	Biocenosis of Mediterranean muddy detritic bottoms
		MC651	Biocenosis of Mediterranean circalittoral coastal terrigenous muds
		MB5521	Mediterranean Cymodocea beds
		C2-2012	Running surface waters

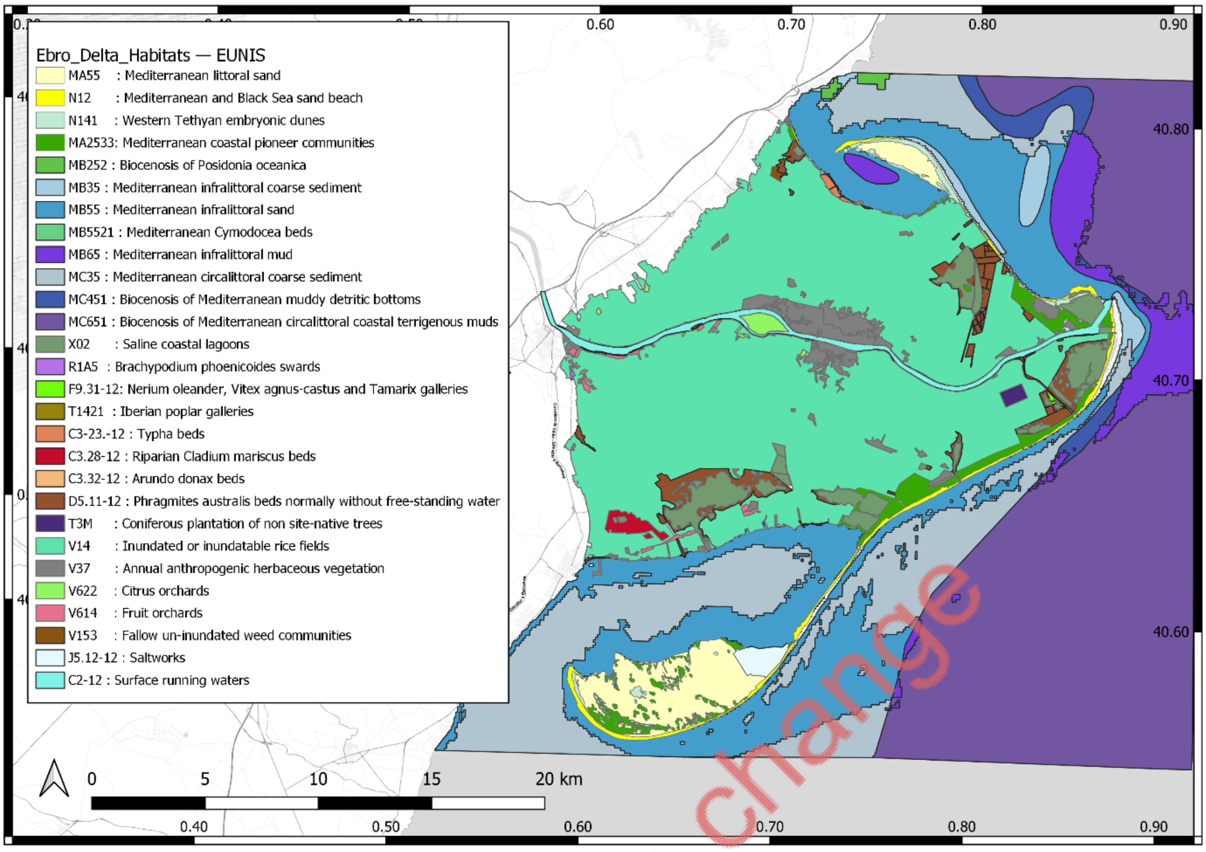


Figure 12. EUNIS habitat map of the Ebro delta.

2.3.4 Arcachon Bay (France)

The Arcachon EUNIS maps comes from historical data. It was published in August 2012 in the EUNIS-2012 coding. The seabed habitat map was performed by CREOCEN, EPOC and GEO Transfer within the framework of CARTHAM ("cartographie des habitats marin") project coordination by the French Biodiversity Agency (Now called French Biodiversity Office, OFB).

All the information concerning data used to create the EUNIS maps are available here :
https://gis.ices.dk/geonetwork/static/fre/catalog.search#/metadata/16b9c5d2-5348-4948-8ee8-2c038d206853

The following sources have been used to assemble the Arcachon EUNIS map:

BLANCHET, H. (2004). Structure et Fonctionnement des peuplements benthiques du Bassin d'Arcachon, Thèse Université Bordeaux 1, Talence, 226 p.

DALLOYAU S., TRUT G., PLUS M., AUBY I., EMERY E., juin 2009. Caractéisation de la qualité biologique des Masses d'Eau : Cartographie des herbiers de Zostera noltii et Zostera marina du Bassin d'Arcachon, Laboratoire Environnement Ressources d'Arcachon, IFREMER, Agence de l'Eau Adour - Garonne, 52p.

LAFON V., 2012. Inventaire biologiques et analyse écologique de l'existant, Natura 2000 en mer, Lot 3 - Arcachon. Cartographie de la limite inférieure du schorre, des champs d'huitres et des lacs de tonnes par télédetection. GEO-Transfert, AAMP, 51 p.

Lafon V., Froidefond J.M., 2010. Surveillance des passes du bassin d'arcachon en 2010 par imagerie SPOT-5. Rapport final, SIBA - ADERA - CNRS - Université Bordeaux-1, 53 p.

Conservatoire du littoral, 2000. Plan de gestion du Site de Saint-Brice, Tome 1. BIOTOPE, 109 p.

Conservatoire du littoral, 2003. Plan de gestion de Certes et de Graveyron - document 2. GEREA / AVEC.

Conservatoire du littoral, 2005. Etat des lieux du plan de gestion de l'île de Malprat - Tome 1. BIOTOPE, 162 p.

Conservatoire du littoral, 2008. Réalisation du plan de gestion de la Réserve Naturelle des prés salés d'Arès et de Lège et du site des "Abberts" 2009-2014, Tome 1 : diagnostic. BIOTOPE, 96p.

The EUNIS map for the pilot site Arcachon Bay (France) is shown in Figure 13.

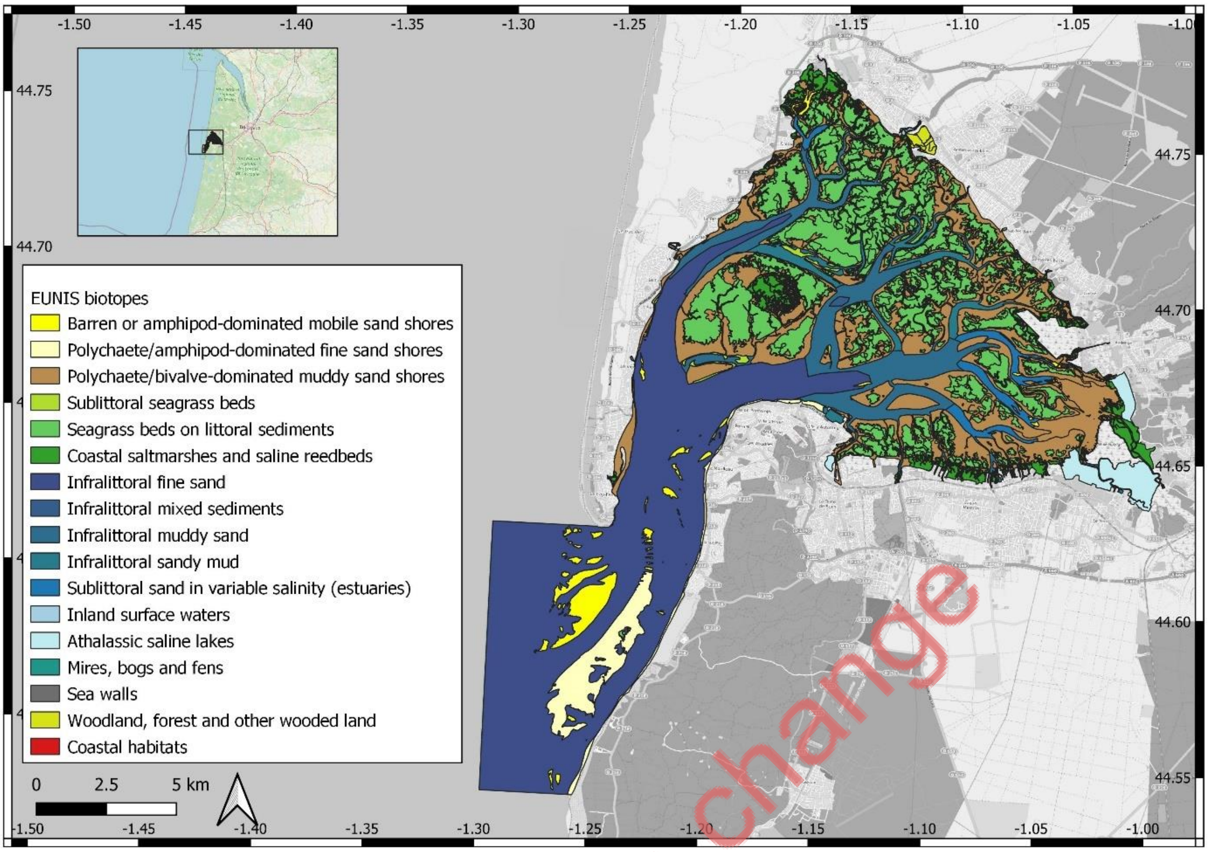


Figure 13. EUNIS biotope map of Arcachon Bay.

2.3.5 Vistula Lagoon (Poland)

For Vistula Lagoon there was no dedicated EUNIS map available. Based on the CORINE Land Cover 2018 map for Europe (version U2018_CLC2018_V2020_20u1) and the conversion table to EUNIS habitats made for REST-COAST (Table 1), a EUNIS classification map was made. The resulting map shows the situation in 2018, prior to the construction of the artificial bird breeding island in the lagoon (Figure 14).

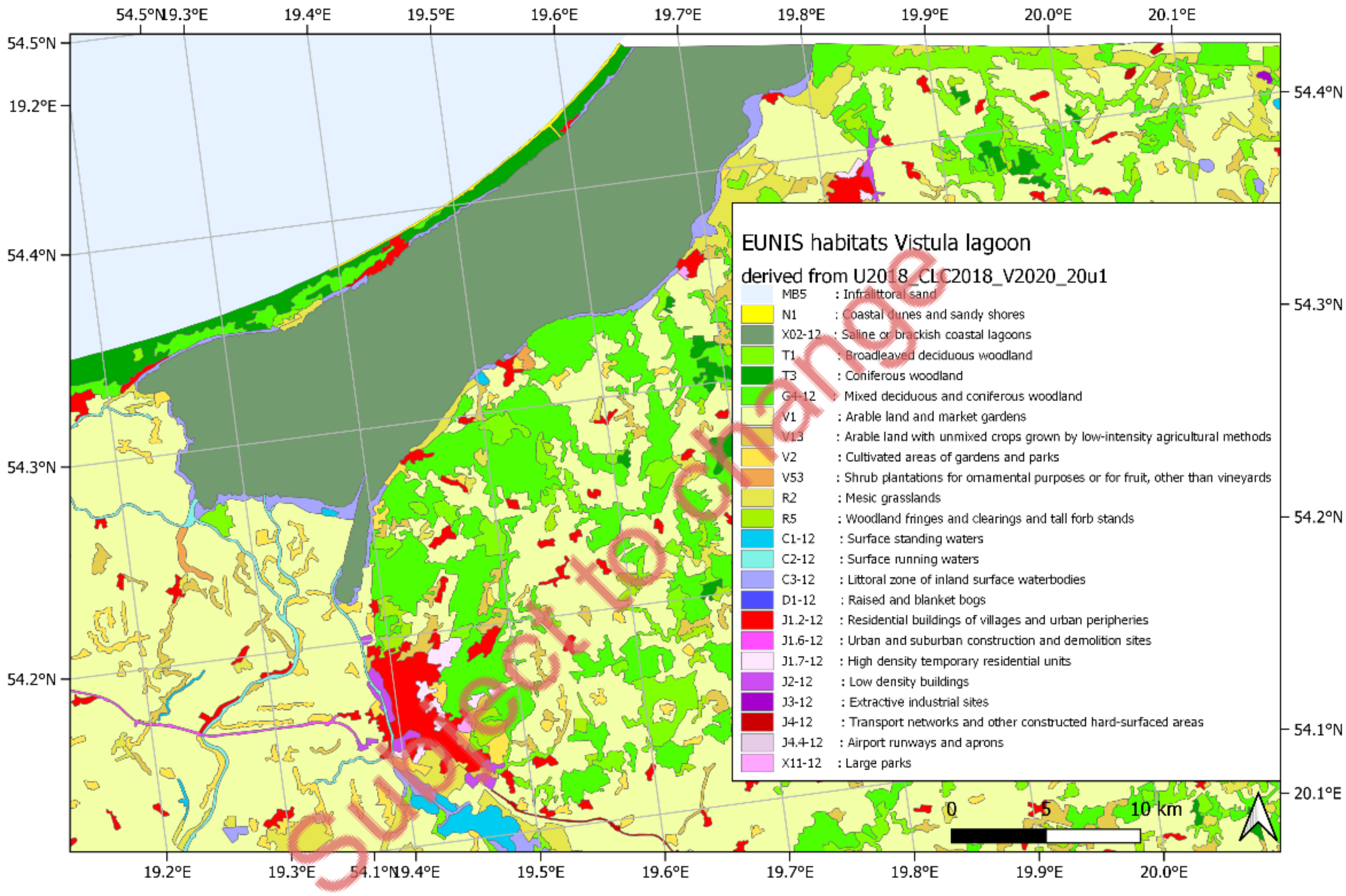


Figure 14. EUNIS habitats in Vistula Lagoon.

2.3.6 Sicily Lagoon (Italy)

A spatially detailed EUNIS map of the Sicily lagoon system was produced (Figure 15) through the cross-analysis of two maps datasets, the Corine Biotopes map of Sicily (scale 1:10,000), which is freely provided by the local regional administration, and the Corine Coastal Zones Land Cover/Land Use 2018 (CZ_2018_DU004_3035_V010, https://land.copernicus.eu/pan-european/corine-land-cover). The Corine Biotopes classification was converted to the EUNIS 2012 by using the Italian Interpretation Manual of the 92/43/EEC Directive habitats (http://vnr.unipg.it/habitat/index.jsp), which includes all the natural habitat types. To convert semi-natural and artificial habitats found within the area of the Sicily lagoon system, a crosswalk table between EUNIS 2012 habitats Classification and Corine Land Cover from the European Topic Centre on Biological Diversity (http://biodiversity.eionet.europa.eu) was applied. Conversion to the updated EUNIS 2021 terrestrial habitat Classification was achieved by applying the crosswalks listed at https://eunis.eea.europa.eu/habitats-code-browser-revised.jsp. In some cases (i.e class J1 – Buildings of towns, cities and villages), such EUNIS 2012 codes and nomenclatures cannot be converted to EUNIS 2021 due to the lack of a conversion system to be applied. Once the EUNIS map was released, it was validated by field surveys and satellite imagery analysis.

Table 8. Conversion table of Sicily lagoon Corine biotope codes to EUNIS-2012 and EUNIS-2122. CB = Corine Biotopes. When the EUNIS-2012 class cannot be converted into the EUNIS-2021 class (depicted in the table as N/A), the EUNIS-2012 code and classification was adopted.

CB	EUNIS2012	EUNIS2122	EUNIS2122D or EUNIS2012D
15.1	A2.5	MA25	Mediterranean littoral biogenic habitat
15.12	A2.5513	MA2252	*Salicornia* spp. pioneer saltmarshes (artificial island)
15.5	A2.5261	MA2515	Mediterranean *Sarcocornia perennis* mats
16.12	B1.1	N12	Mediterranean and Black Sea sand beach
16.21	B1.3	N14	Mediterranean, Macaronesian and Black Sea shifting coastal dune
16.21	B1.3	N14(d)	Mediterranean, Macaronesian and Black Sea shifting coastal dune (degraded)
21	X02	N/A	Saline coastal lagoons
32.2	F5.5	S54	Thermo-mediterranean arid scrub
34.6	E1.4	R1E	Mediterranean tall perennial dry grassland
53.1	D5.1	N/A	Reedbeds normally without free-standing water
18	B3	N3	Rock cliffs, ledges and shores with angiosperms
82.3	I1.3	V13	Arable land with unmixed crops grown by low-intensity agricultural methods
86.1	J1	N/A	Buildings of cities, towns and villages
N/A	J1.2	N/A	Residential buildings of villages and urban peripheries
N/A	J4	N/A	Transport networks and other constructed hard-surfaced areas
N/A	J2.43	N/A	Greenhouses

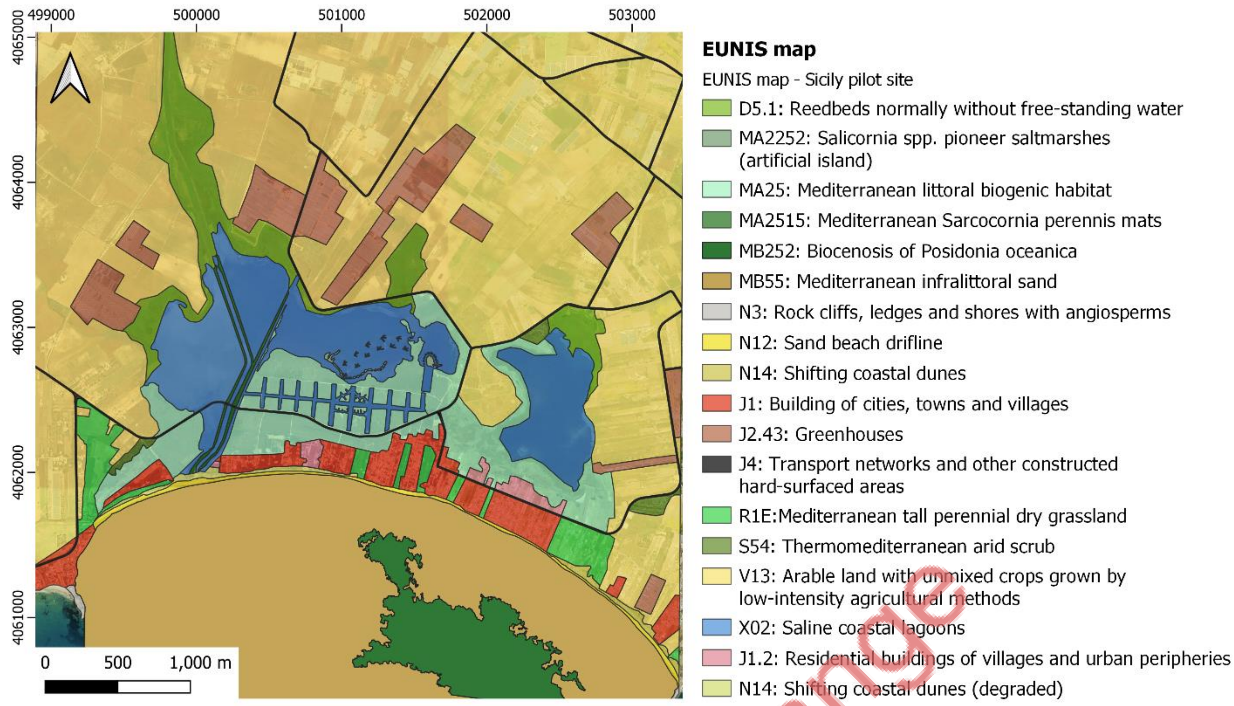


Figure 15. EUNIS habitats in Sicily Lagoon.

2.3.7 Foros Bay (Bulgaria)

For the preparation of the biotope map for the Foros Bay pilot site, which encompasses marine and terrestrial areas, different official sources of information were used, as well as recent studies and observations performed at the site.

For the ***sublittoral zone*** habitat maps for the Black Sea are available from the EMODnet project: https://emodnet.ec.europa.eu/geoviewer/. The 2021 habitat version was used for the map preparation (Vasquez et al., 2021)

For ***littoral and land habitats*** the following sources of information were used:

- Layers from habitat mapping of coastal dunes and beaches (Prodanov et al., 2023)
- Layers from coastline mapping
- Layer from habitat mapping for the purposes of NATURA 2000 network, available from the Bulgarian Ministry of Environment and Waters: https://natura2000.egov.bg/EsriBg.Natura.Public.Web.App
- Information (area, description and species composition, where available) from habitat mapping for the purposes of NATURA 2000 network: https://natura2000.egov.bg/EsriBg.Natura.Public.Web.App
- Information for vegetation type and distribution from field visits and available literature (Management Plan of the Protected Area “Poda” (2002 – 2010)” (MP of PA “Poda” (2002 - 2010”))
- Other layers of information, available from the Black Sea Basin Directorate (marine region units, acc. MSFD, water bodies, settlements, the Bulgarian Black Sea watershed area etc.)

The ***sublittoral zone*** EUNIS habitats designation at the level 3 was available from Vasquez et al., 2021: https://archimer.ifremer.fr/doc/00723/83528/88577.pdf, https://emodnet.ec.europa.eu/geoviewer/.

Only the seagrass and other submerged aquatic vegetation habitat was designated at level 4 as: *MB546 Seagrass and rhizomatous algal meadows in Black Sea freshwater influenced infralittoral muddy sands.* Motives for this designation are presented in *Table 9*.

Table 9. Designation criteria for sublittoral seagrass and other aquatic plants meadow according to EUNIS level 4 classification

EUNIS 2022 habitat description*:	**Habitat features**	**Description**	**Source**
Sheltered shallow **(0.5-2 m)** coastal waters **such as embayments,** inlets, **bights, harbours and estuaries, more or** less influenced **by** freshwater **(salinity 0.5-10 psu), where sedimentary stability leads to muddy sands. Mixed** or **monospecific** meadows **are formed by** *Nanozostera noltei*, ***Ruppia maritima***, ***R. cirrhosa***, ***Chara spp.***, *Stuckenia pectinata* **(syn. *Potamogeton pectinatus*)**, *Najas minor* and *Ranunculus baudotii*. Algae commonly found include	Wave exposure	sheltered	Valchev et al., 2023
	Freshwater inflow	Significant Salinity during summer (dry season) varying between 12 and 14	Proximity to a freshwater reservoir inflow point - 2.7 km
	Depth boundaries of the meadow	From 0.2 to 3.0 – 3.5 m	Monitoring data (sampling campaigns 2015, 2016, 2017, 2018, 2021 and 2022)

species of ***Cladophora*** and ***Ulva*** which are tolerant of very low salinities.	Sediment type	*Fine sand*	Sampling campaign 2015, 2016
	Species present (summer season)	*Zostera noltei,* *Zannichelia palustris* *Stuckenia pectinata* *Cladophora sericea* *C. albida* *C. coelothrix* *C. vagabunda* *Ulva rigida* *U. intestinalis* *Ulvella lens* *Ceramium virgatum*	Monitoring data (sampling campaigns 2015, 2016, 2017, 2018, 2021 and 2022)

* Note: Those characteristics that correspond to the local situation are marked with **bold**.

The Black Sea is a microtidal basin and the littoral zone is a narrow strip along the coastline. The ***littoral*** zone was most recently mapped in 2011 and designated according to the Annex I of the Habitat directive (Gyosheva, 2011). A conversion was done from Annex I type to EUNIS 2022, following the conversion tables available from EEA https://www.eea.europa.eu/data-and-maps/data/eunis-habitat-classification-1/eunis-marine-habitat-classification-review-2022. The designation is presented in *Table 10*.

Table 10. Conversion from Habitat Directive Annex I type to EUNIS 2021 type of habitat

Annex I code and name	Corresponding EUNIS 2022 habitat code and name
1140 Mudflats and sandflats not covered by seawater at low tide;	MA54 Black sea littoral sand

For ***land*** habitats, EUNIS designation was done according to the conversion table, available from EEA where applicable.

Plant species description within the beach area was most recently done prior to 2002 (MP of PA "Poda" (2002-2010)), designation of *coastal dunes* according to Annex I of the Habitat Directive was done most recently in 2011 (Gyosheva, 2011), while mapping of *beaches* and *dunes* was done from 2018 to 2022 (Prodanov et al., 2023). See *Table 11*.

Table 11. Conversion from Habitat Directive Annex I type to EUNIS 2021 type of habitat

Annex I code and name	Corresponding EUNIS 2022 habitat code and name
2110 Embryonic shifting dunes	N14 Mediterranean, Macaronesian and Black Sea shifting coastal dune
No Annex I type	N12 Mediterranean and Black Sea sand beach

The wetland (swamp) area along the coast – the protected area "Poda" is an important bird and habitat diversity location and therefore flood risk is an important factor that should be considered from biodiversity protection point of view. The appearance, structure and functions of the protected area are significantly impacted by development of the swamp itself and adjacent areas due to human interventions and presently the wetland is an actively managed, heavily modified body.

Designation of the habitats according to the Annex I of the Habitat Directive and vegetation composition of the areas were most recently mapped in 2011 (Gyosheva, 2011), when the area of the protected area “Mandra – Poda” was designated as “Coastal lagoons” with habitat code 1150. According to Gyosheva, 2011 this coastal lagoons habitat is defined as “… a complex made up by wetlands of semi natural origin, separated from one another by old dikes and roads. The area shows signs of eutrophication, such as microalgae blooms and hygrophytes overbrowning and shallowing on the periphery”. On the other hand, according to the Management Plan of the Protected Area “Poda” (2002-2010) “The area is a complex system of swamp type (a eutrophic swamp), a diverse mosaic of marine, littoral, freshwater, brackish and hypersaline ecosystems. The territory is inseparable part of the estuary and is in direct connection with the sea. The fluctuations of the salinity depend on the processes of the both water bodies. The biggest part of the area is occupied by *Phragmites australis*. The landscape elements define the area as a typical Black Sea swamp, emerged at the place of a former lagoon, consisting of hypersaline, saline, brackish water, freshwater water basins and the overall appearance is dominated by the reed vegetation” (MP of PA “Poda”(2002-2010)).

In the reference table for conversion from Annex I to EUNIS 2021 classification for the Black Sea there is only one option for the habitats designated as 1150 “Coastal lagoons” to be translated into MB544 “Black sea infralittoral sands and muddy sands with annual algae”. Obviously the description of the site which lays beyond the coastline and is never submerged by coastal waters during regular hydro-meteorological conditions, as well as bordered from the sea by coastal littoral, sand beach and dunes, does not correspond to the description of the latter EUNIS habitat. Therefore, based on available information and existing guidelines we have identified the area as both belonging to Q51 “Tall-helophyte bed” and MA241 “Black Sea littoral saltmarsh”. According to the definitions in Davies et al., 2004 such wetlands areas with saline water and tall salt tolerant vegetation can be a part of either marine (former EUNIS A code, present EUNIS M code) or inland water bodies (former EUNIS C code). The present definition of marine benthic habitats coincides with the one given in Davies et al., 2004 as concerns “enclosed coastal saline or brackish waters, without a permanent surface connection to the sea but either with intermittent surface or sub-surface connections (as in lagoons)”. Previous studies on the salinity regime of different basins of the wetland during different seasons (spring and summer) has shown significant changes of the salinity of each water body – e.g. from brackish water to saltwater or to hypersaline water (MP of PA “Poda”(2002-2010)). As the wetland is “a part of the largest liman along the Bulgarian Black sea coast – the Burgas – Mandra one” and “inseparable part of the estuarine lake “Uzungeren” and is directly connected to sea and its water and salinity regime is formed as a result of the processes taking part in these water bodies and “Mandra” reservoir” (MP of PA “Poda”(2002-2010)), presently we cannot designate it as either marine or inland type, therefore we propose both types as relevant for this area. Further studies (beyond REST-COAST project) are necessary to better understand the hydrology and hydrochemistry of the wetland to see how to distinguish between both habitat types i.e. the inland one and marine benthic one (*Table 12*).

Table 12. Designation criteria for protected area “Poda” according to EUNIS classification

EUNIS 2022 habitat description*:	Habitat features*	Description	Source
Q51Tall-helophyte bed: This habitat of **tall helophytes** characteristically occupies a zone from **shallow to moderately deep mesotrophic to eutrophic fresh or slightly brackish water along the banks** of rivers and **lakes**, in artificial water bodies and at **nutrient-rich terrestrial sites on**	Proximity to freshwater water body (river, lake) According to Davies et al., 2004 Inland and non-coastal habitats are identified under this type	Yes (reservoir Mandra)	Map analysis and field visits

EUNIS 2022 habitat description*:	Habitat features*	Description	Source
waterlogged ground. … The occurrence of different dominant species depends on water depth, duration of flooding, substratum, trophic level, disturbance by waves or current, herbivory and human influence. Because of the competitive ability and clonal growth of tall helophytes, the **stands are usually species-poor** and often dominated **by one or a few co-dominants**. **No Annex I type** ***Phragmites australis***; *Lythrum salicaria; Glyceria maxima; Galium palustre aggr.; Phalaroides arundinacea;* ***Typha latifolia***; *Iris pseudacorus; Lycopus europaeus; Lysimachia vulgaris;*	Trophic status	Meso-, eutrophic	Gyosheva, 2011
	Salinity	*Variable from hyper saline to freshwater*	MP of PA "Poda"(2002-2010) Gyosheva, 2011
	Species present	*The species composition is typical for the natural habitat Ruppia cirrhosa, Phragmites australis, Spirogyra sp., Typha latifolia, Alisma plantago-aquatica, Potamogeton natans, Typha angustifolia*	Gyosheva, 2011
MA241 Black Sea littoral saltmarsh: Black Sea salt marshes on sandy and muddy substrates along sheltered shores, characterized by small tidal ranges and relatively low salinity. Tall rushes dominate at most sites, but locally shrub and herb communities may occur that are typical of inland continental salt pans. Due to desiccation, the substrate of such communities in the upper zone can be **hypersaline**.	This habitat is designated as marine type according to the definitions given in Davies et al., 2004 and EUNIS 2022 marine benthic habitat: "… enclosed coastal saline or brackish waters, **without a permanent surface connection to the sea** but either with intermittent surface or **sub-surface connections (as in lagoons)**."	*The place is formed at the place of a former lagoon*	MP of PA "Poda"(2002-2010)

* Note: Those characteristics that correspond to the local situation are marked with bold.

Within the wetland area there are spots occupied by *Salicornia* and other annuals. The most recent description and mapping of the habitat and its designation according to the Annex I of the Habitat Directive was done in 2011 (Gyosheva, 2011). A conversion was done from Annex I type to EUNIS 2021 classification, following conversion tables available from the EEA https://www.eea.europa.eu/data-and-maps/data/eunis-habitat-classification-1/eunis-terrestrial-habitat-classification-review-2021 (*Table 13*):

Table 13. Conversion from Habitat Directive Annex I type to EUNIS 2021 type of habitat

Annex I code and name	**Corresponding EUNIS 2022 habitat code and name**
1310 *Salicornia* and other annuals colonizing mud and sand	R6352 Western Pontic glasswort-seablite-saltwort swards

The lake Mandra (Uzungeren) is a part of a former larger lowland, hypereutrophic, estuarine lake (liman), western part of which was dammed to form the presently freshwater Mandra reservoir. The Mandra (Uzungeren) lake has a direct connection and exchanges water volumes with the Foros Bay through a canal (Rozhdestvenski, 1961, MP of PA "Poda"(2002-2010)). The habitat designation of the lake and description according to the Annex I was made most recently in 2011 (Gyosheva, 2011). The lake was designated as 1130 "Estuary".

According to Davies et al., 2004 and EIONET classification (https://cdr.eionet.europa.eu/help/natura2000/Documents/NATHABS_HABCODE_090416.pdf) estuaries are treated as complex habitats (codes X01) and "Littoral and sublittoral habitat types typical of estuaries are included in A2 and A5 " (*sensu* EUNIS classification 2012) i.e. marine types of habitats – M code, according to the EUNIS 2022 revision. Actually, the lake is not a part of the Black Sea, but it has been formed as a submerged river(s) mouth (Aleksandrova, 1963). As in the latest revisions of the EUNIS classification complex, the habitat X01 is not specifically considered, i.e. classification is actually not available, and due to the guidance to be regarded as part of marine types we have identified the estuarine lake to the closest possible marine type habitat: MB546 Seagrass and rhizomatous algal meadows in Black Sea freshwater influenced infralittoral muddy sands (*Table 14*).

Table 14. Designation criteria for "Mandra" lake (Uzungeren) according to EUNIS classification

EUNIS 2022 habitat description*:	**Habitat features**	**Description**	**Source**
Sheltered shallow (0.5-2 m) coastal waters such as embayments**,** inlets, bights, harbours and estuaries, **more or** less **influenced by freshwater (salinity 0.5-10 psu), where sedimentary stability leads to muddy sands.** Mixed or monospecific meadows are formed by ***Nanozostera noltei,*** *Ruppia maritima*, *R. cirrhosa*, *Chara spp.*, ***Stuckenia pectinata*** (syn. *Potamogeton pectinatus*), *Najas minor* and *Ranunculus baudotii*. Algae commonly	Wave exposure	Extremely sheltered	Map analysis
	Freshwater inflow	Significant Salinity during summer (dry season) varying between 10 -12	Proximity to a freshwater reservoir inflow point - 2 km
	Depth boundaries of the meadow	From 0.1 to 0.4 m	Observation in 2022

found include species of ***Cladophora*** and ***Ulva*** which are tolerant of very low salinities.	Species present (summer season)	*Potamogeton natans, Ceratophyllum demersum, Potamogeton perfoliatus, Zanichellia palustris, Zostera noltei, Cladophora sp., Ulva intestinalis, Phragmites australis, Typha spp., Zostera marina*	Gyosheva, 2011
		Stuckenia pectinata	Own observation

* Note: Those characteristics that correspond to the local situation are marked with bold.

The "Mandra" reservoir was mapped and designated according to Annex I of the Habitat Directive as 3150 "Natural eutrophic lakes with Magnopotamion or Hydrocharition-type vegetation" most recently in 2011. There is no currently revised EUNIS classification for standing water bodies; therefore, the most recent classification (EUNIS 2012) is shown on the map. It would not be subjected to changes during sea level rise but is given for information only.

All the habitats considered at the Foros Bay pilot are summarized in *Table 15*.

Table 15. Summary table of the habitats present at the Foros Bay pilot

No	Water or land object	EUNIS 2021/2022 Code	EUNIS 2021/2022Description	Annex I code
1	Foros Bay	MB14	Black Sea infralittoral rock	1170 1160
2	Foros Bay	MB34	Black Sea infralittoral coarse sediment	1110 1160
3	Foros Bay	MB44	Black Sea infralittoral mixed sediment	1110 1160
4	Foros Bay	MB54	Black Sea infralittoral sand	1110 1160
5	Foros Bay Mandra lake (Uzungeren)	MB546	Seagrass and rhizomatous algal meadows in Black Sea freshwater influenced infralittoral muddy sands	1110 1160 1130
6	Foros Bay	MB64	Black Sea infralittoral mud	1130 1160
7	Foros Bay	MA54	Black sea littoral sand	1140
8	Foros Bay	MA14	Black sea littoral rock	1130
9	Foros Bay	N12	Mediterranen and Black Sea sand beach	No Annex I type
10	PA "Poda"	N14	Mediterranean, Macaronesian and Black Sea shifting coastal dunes	1210
11	PA "Poda"	Q51	Tall-helophyte bed	No Annex I type

No	Water or land object	EUNIS 2021/2022 Code	EUNIS 2021/2022Description	Annex I code
12	PA "Poda"	MA241	Black Sea littoral saltmarsh	1150
13	PA "Poda"	R 6352	Western Pontic glasswort-seablite-saltwort swards	1310
14	Mandra reservoir	none	none	3150

The map produced is shown on fig. 15.

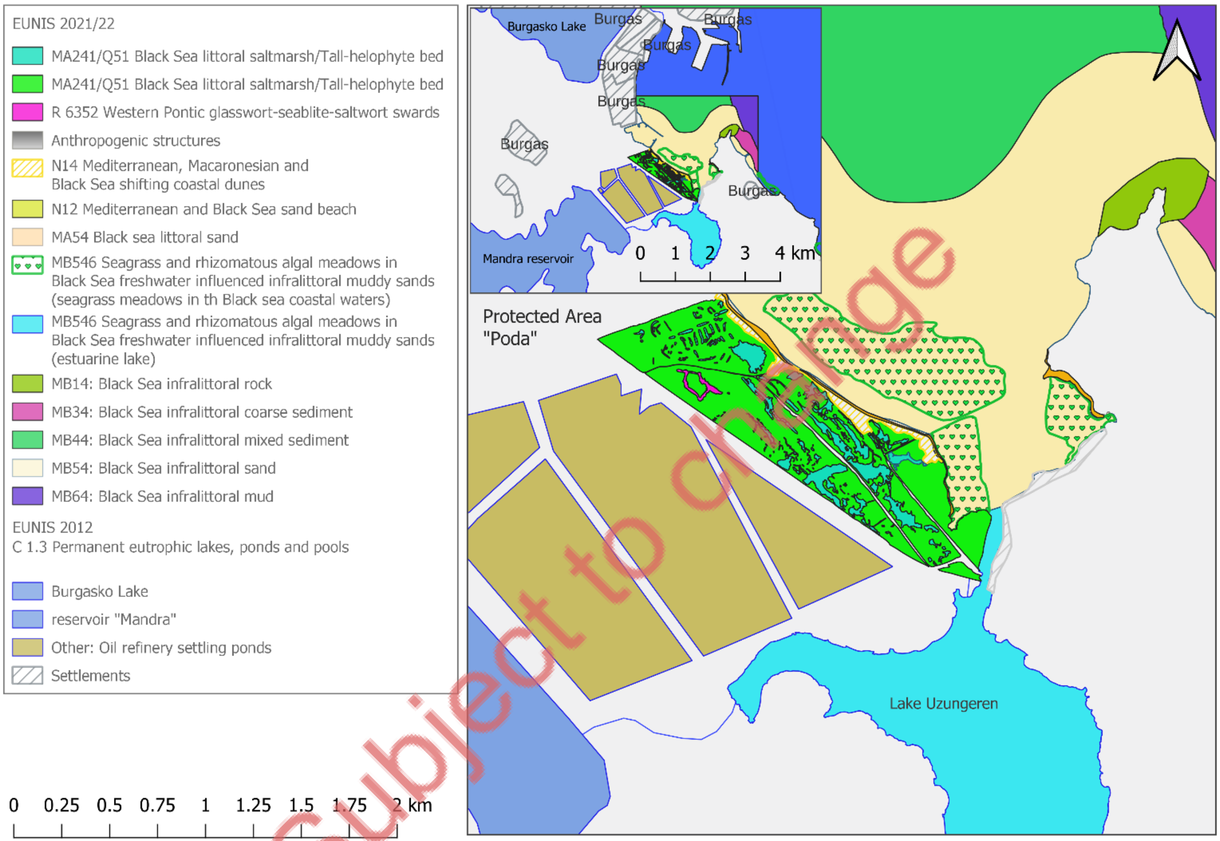


Figure 16. EUNIS habitats in Foros Bay.

2.3.8 Rhône Delta (France)

The inventory and mapping of habitats of community interest were first conducted regarding a larger scale, as Natura 2000 sites for the regional natural park of "Camargue" (Rhône delta). This study took part of the development of objectives in management plans. On a finer scale, several field informed habitat mapping works were carried out between 2010 and 2018. These efforts were supplemented by revisions and updates in 2020 and 2021 as part of the development of the management plan for site “Etang et marais des salins de Camargue”, corresponding to the REST-COAST site.

A conversion table between the interpretation Manual of European Union Habitats (EUR15 codes, Table 16) and other non-community habitats from Corine Biotope classification (CBC codes, Table 17) was used to establish the habitat classification map according to the EUNIS 2012 typology. Then the conversion between EUNIS 2012 to EUNIS 2022 was conducted based on conversion table from European Environment Agency. Habitats of EUNIS 2012 with no corresponding habitat in classification 2022 are denoted in grey in Table 16 and Table 17. They correspond to aquatic habitats (C and X in EUNIS 2012) and anthropic settlements.

An expert evaluation of habitats of the site completes the classification, to define the status of conservation of each habitat (Conservation status).

Table 16. Conversion from Corine Biotope Classification to EUNIS 2012 and 2022.

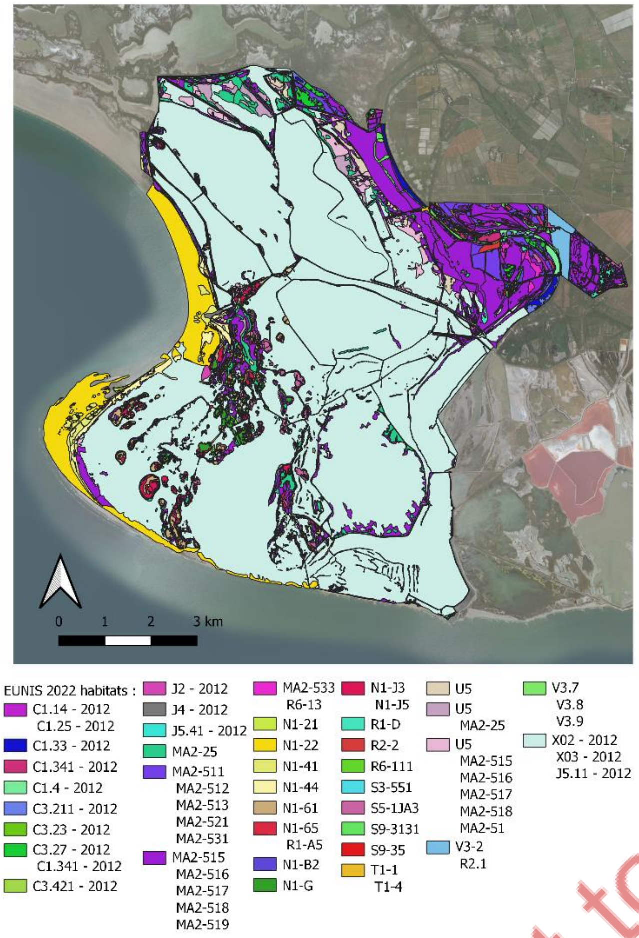
CBC	EUNIS2012	EUNIS2022	EUNIS Description	Conservation Status
89.21	J5.41	J5.41 - 2012	Non-saline water channels with completely man-made substrate	Not evaluated
51.1	C1.4	C1.4 - 2012	Permanent dystrophic lakes, ponds and pools	Very poor
22.432	C1.341	C1.341 - 2012	Shallow-water floating communities	Medium
53.17 x 22.432	C3.27 x C1.341	C3.27 -2012; C1.341 - 2012	Halophile Scirpus, Bolboschoenus and Schoenoplectus beds x Shallow-water floating communities	Medium
53.111	C3.211	C3.211 - 2012	Flooded Phragmites beds	Poor
53.13	C3.23	C3.23 - 2012	Typha beds	Poor
87	E5.1	V3.7; V3.8; V3.9	Annual anthropogenic herbaceous vegetation/ Dry perennial anthropogenic herbaceous vegetation/ Mesic perennial anthropogenic herbaceous vegetation	Not evaluated
38.2	E2.2	R2-2	Low and medium altitude hay meadow	Good
34.8 x 87	E1.6 x E2.1	V3-2; R2.1	Mediterranean subnitrophilous annual grasslands x Mesic permanent pasture of lowlands and mountains	Medium to Good
32.21A3	F5.51A3	S5-1JA3	Western Phillyrea thickets	Good
31.891	F3.221	S3-551	Franco-Iberian sub-Mediterranean deciduous thickets	Good
44.8131	F9.3131	S9-3131	West Mediterranean tamarisk thickets	Not evaluated
N.D	F9.35	S9-35	Riparian stands of invasive shrubs	Not evaluated
86	J2	J2 - 2012	Low density buildings	Not evaluated
86	J4	J4 - 2012	Transport networks and other constructed hard-surfaced areas	Not evaluated
87	E5.1	V3.7; V3.8; V3.9	Annual anthropogenic herbaceous vegetation/ Dry perennial anthropogenic herbaceous vegetation/ Mesic perennial anthropogenic herbaceous vegetation	Not evaluated
NA	NA	U5	Miscellaneous inland habitats usually with very spa vegetation	Not evaluated
NA	NA	U5; MA2-25	Atlantic pioneer saltmarshes	

Table 17. Conversion from habitats of community interest to EUNIS 2012 and 2022.

EUR15	EUNIS2012	EUNIS2022	EUNIS Description	Conservation Status
1110	A5.2	MB5-5	Mediterranean infralittoral sand	Good
1140	B1.21	N1-22	Unvegetated Mediterranean and Black Sea sand beaches above the driftline	Poor to Good
1150-2	X02; X03; J5.11	X02 - 2012 ; X03 - 2012; J5.11 - 2012	Saline coastal lagoons.; Brackish coastal lagoons; Saline and brackish industrial lagoons and canals	Poor to Good
1210-3	B1.13	N1-21	Tethyan sand beach driftline communities	Not evaluated
1310-3	A2.551	MA2-25	Atlantic pioneer saltmarshes	Good
1310-4	A2.552; E6.13	MA2-533; R6-13	Mediterranean coastal halo-nitrophilous pioneer communities/ Mediterranean inland halo-nitrophilous pioneer communities	Good
1410	A2.522; A2.523; A2.524; A2.532; A2.543	MA2-511; MA2-512; MA2-513; MA2-521; MA2-531	Mediterranean Juncus maritimus and Juncus acutus saltmarshes; Mediterranean Juncus, Carex, Hordeum and Trifolium short saltmeadows; Mediterranean Elymus or Artemisia stands; Mediterranean halo-psammophile meadows; Mediterranean coastal-saltmarsh grass swards	Medium to Good
1420	A2.5261 ; A2.5262 ; A2.5263 ; A2.5264 ; A2.5265	MA2-515; MA2-516; MA2-517; MA2-518; MA2-519	Mediterranean Sarcocornia perennis mats; Mediterranean Sarcocornia fruticosa thickets; Mediterranean Arthrocnemum macrostachyum thickets; Mediterranean Suaeda vera thickets; Mediterranean Halimione portulacoides-Arthrocnemum scrubs	Good to Very good
1510	E6.111	R6-111	Ibero-Tyrrhenian sea-lavender steppes	Very good
2110	B1.312	N1-41	Western Tethyan embryonic dunes	Poor to Good
2120	B1.322	N1-44	Western Tethyan white dunes	Poor to Good
2190	B1.83; B1.85	N1-J3; N1-J5	Mediterranean and Black Sea dune-slack fens; Mediterranean and Black Sea dune-slack reedbeds, sedgebeds and canebeds	Medium to Good
2210	B1.43	N1-61	Mediterraneo-Atlantic fixed grey dunes	Poor to Good
2240	B1.49; E1.2A	N1-65; R1-A5	Dune Mediterranean xeric grassland; Brachypodium phoenicoides swards	Good
2250	B1.63	N1-B2	Dune Juniperus thickets	Medium
2270	B1.74	N1-G	Mediterranean coniferous coastal dune forest	Poor to Good
3140	C1.14; C1.25	C1.14 - 2012; C1.25 - 2012	Charophyte submerged carpets in oligotrophic waterbodies; Charophyte submerged carpets in mesotrophic waterbodies	Medium to Good
3150-1	C1.33	C1.33 - 2012	Rooted submerged vegetation of eutrophic waterbodies	Good
3170	C3.421	C3.421 - 2012	Short Mediterranean amphibious communities	Good to Very good
6220	E1.313	R1-D	Mediterranean closely grazed dry grassland	Medium to Good
92A0	G1.33	T1-1; T1-4	Temperate Salix and Populus riparian forest/ Mediterranean and Macaronesian riparian forest	Poor

In total, 41 natural and semi-natural elementary habitats (EUNIS typology) have been identified within the Natura 2000 sites. Among these, 22 are "habitats of community interest" listed in Annex 1 of the European Directive "Habitats, Fauna, Flora". Due to the complexity of habitat and the precise field informed work, part of REST-COAST site is described as mosaic habitat with dominant habitat first and secondary habitats.

For Rhône Delta a EUNIS map was produced, Figure 17.



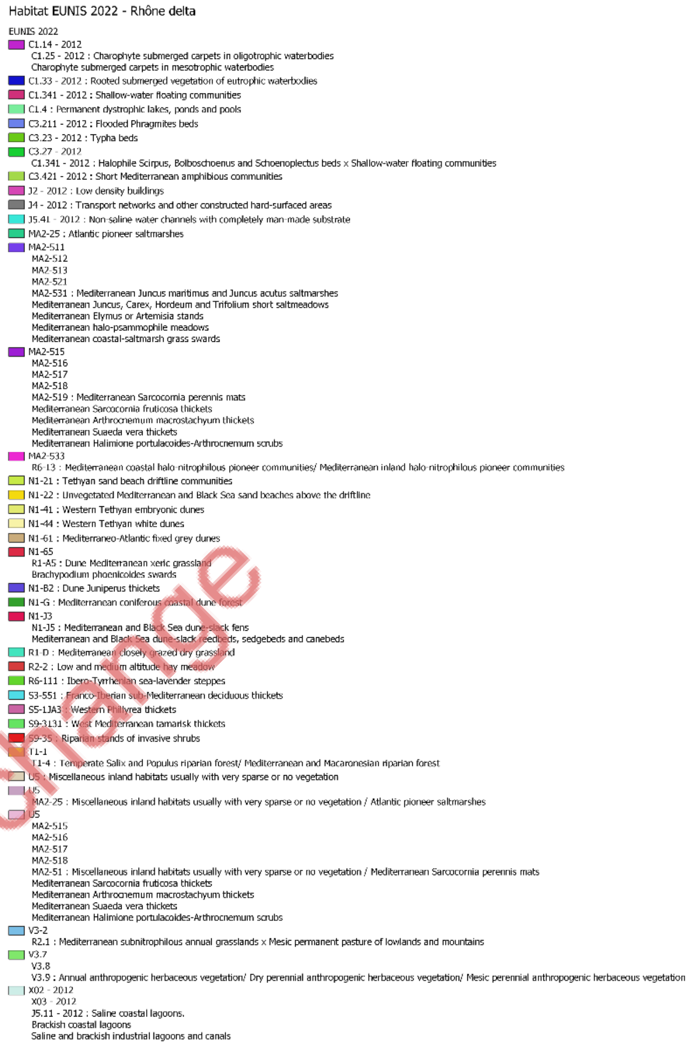


Figure 17. EUNIS habitats (2022) in Rhône Delta.

2.3.9 Nahal Dalia (Israel)

The Nahal Dalia pilot is in Hof HaCarmel region, In the Northern Coastal plain of Israel. A survey that was conducted in 2022 by the Open Landscape Institute has defined a biotope map for the region.

The mapping was conducted in a non-agricultural open area and found that there are 30 different habitats classified into 6 general categories of habitats, as seen in Table 18. The mapping analysis demonstrates the percentage share of each general category in the space: about tenth of the are Sandy beach with no vegetation, In the vegetated areas, about a third is sandy, a quarter is lithified sandstone, a quarter consists of variety of wetlands and about tenth of the area is alluvial gravelly soils.

Table 18. Classification of 30 habitats in 6 general categories in HaCarmel region, Israel by Perlberg et al. (2022).

Sandy beach with no vegetation	Beach 9%
Pebble Beach with no vegetation	
rocky Beach with no vegetation	
Shells Beach	
Drifting Sand Dunes	Sands 32%
Semi-stabilized Sand Dunes	
Stabilized Sand Dunes	
Semi-stabilized Sand on Lithified Sandstone	
Stabilized Sand on Coastal Plain	
Stabilized Sand on Lithified Sandstone	
Stabilized Sand on Lithified Sandstone (Mound)	
Sand on Coastal Lithified Sandstone	
Coastal Lithified Sandstone	Lithified Sandstone 25%
Mediterranean Lithified Sandstone	
Alluvium in Coastal Plain	
Alluvium on Lithified Sandstone	
Alluvium on Lithified Sandstone (Mound)	
Alluvium on Coastal Lithified Sandstone	
Alluvium on Coastal Cliff (Mound)	
Wet Meadow	Wetlands 23%
Wet Hollow	
Marshland	
Springs	
Surface Runoff	
Riverbank	
Winterbourne	
Winterbourne Estuary	
Estuary\Salt marsh	
Salt marsh	
Ruins	Other 0.3%

To adapt the information from the regional survey to the pilot area, a comprehensive historical review was conducted by Moran Development and Consulting, that included an examination of previous data and the integration of historical aerial photographs with the current situation. These contributed to understanding the original infrastructure of the area. Additional 11 follow-up local surveys of the existing situation were conducted in the fields of hydrogeology, hydrology, hydro-geochemistry, bathymetry, algae, aquatic macroinvertebrates, vegetation, fish, birds, softshell turtles, and mammals.

After collecting the data, integration was carried out between the spatial units defined by OLI and the findings of the local surveys, accurately classifying the habitats according to the local scale of the pilot area. The habitats integrated classification in the pilot area as defined by Moran (literal translation to English): 1-Nahal Dalia Surface Runoff, 2-Northern and central marshland, 3- Southern marshland, 4- Fishponds, 5-Coastal stable dune, 6-Sandy beach with no vegetation, 7-Coastal thickets, 8- Lithified sandstone, 9-Estuaries, 10-Coastal marshland, 11-Water canals.

For application in the REST-COAST project, the integrated pilot habitats classification was converted to the EUNIS-2012 biotopes as well as the EUNIS-2022 marine biotopes. For Nahal Dalia this resulted in the EUNIS map shown in Figure 18.

Figure 18. EUNIS habitats in Nahal Dalia.

3. Methodology for scoring ecosystem services and biodiversity indicators

3.1 Literature on existing scoring methodologies for ESS in combination with EUNIS

In order to compare ecosystem services in view of upscaled coastal restoration measures, a harmonised and comparable system of indicators is desired. Such indicators have mostly been developed semi-quantitatively using rank scores (e.g. Potts et al., 2014; Galparsoro et al., 2014; Tempera et al., 2016).

For example, Galparsoro et al. (2014) used EUNIS maps of the north-east Atlantic marine benthic habitats in combination with expert judgement to categorize and map ecosystem services in three classes high, low and negligible. In total, twelve ecosystem services were considered in their investigation: (i) Food provision; (ii) Raw materials (biological) (incl. biochemical, medicinal, and ornamental); (iii)Air quality and climate regulation; (iv) Disturbance and natural hazard prevention; (v) Photosynthesis, chemosynthesis, and primary production; (vi) Nutrient cycling; (vii) Reproduction and nursery; (viii) Maintenance of biodiversity; (ix) Water quality regulation and bioremediation of waste; (x) Cognitive value; (xi) Leisure, recreation and cultural inspiration; and (xii) Feel good or warm glow. Galparsoro et al. (2014) applied these to 62 EUNIS habitat types.

A direct application to the ESS selected in REST-COAST is not possible. The best matches are:

1. a combination of (i) Food provision and (viii) Reproduction and nursery for the REST-COAST ESS Food (Fish) Provisioning,
2. (iv) Disturbance and natural hazard prevention for the REST-COAST ESSs Reduction of coastal flooding risk and Reduction of coastal erosion risk.
3. a combination of (vi) Nutrient cycling and (ix) Water quality regulation and bioremediation of waste for the REST-COAST ESS Water quality purification.

Table 19. Ecosystem services assessment in three classes High, Low and Neglible for EUNIS Atlantic marine benthic habitats by Galparsoro et al. (2014).

Table 2 | Ecosystem services assessment for each habitat and seabed feature type (H, high; L, low; and N, Negligible).

Habitat name	EUNIS code	Food	Raw material	Air quality	Disturbance	Photosynthesis	Nutrient	Reproduction	Biodiversity	Wate	Cognitive	Leisure	Feelgood
Infralittoral rock and other hard substrata	A3*	H	H	H	H	H	L	H	H	H	H	H	H
Atlantic and Mediterranean high energy infralittoral rock	A3.1*	H	H	H	H	H	L	H	H	H	H	H	H
High energy infralittoral seabed		H	H	H	H	H	L	H	H	H	H	H	H
High energy infralittoral mixed hard sediments		H	H	H	H	H	L	H	H	H	H	H	H
Atlantic and Mediterranean moderate energy infralittoral rock	A3.2*	H	H	H	L	H	H	H	H	H	H	H	L
Moderate energy infralittoral seabed		H	H	H	L	H	H	H	H	H	H	H	L
Moderate energy infralittoral mixed hard sediments		H	H	H	L	H	H	H	H	H	H	H	L
Atlantic and Mediterranean low energy infralittoral rock	A3.3*	H	H	H	L	H	H	H	H	H	H	H	L
Low energy infralittoral seabed		H	H	H	N	H	H	H	H	H	H	H	L
Low energy infralittoral mixed hard sediments		H	H	H	N	H	H	H	H	H	H	H	L
Silted kelp on low energy infralittoral rock with full salinity	A3.31	H	H	H	N	H	H	H	H	H	H	H	L
Circalittoral rock and other hard substrata	A4*	H	H	L	H	N	H	H	H	H	H	L	L
Atlantic and Mediterranean high energy circalittoral rock	A4.1*	H	H	L	H	N	H	H	H	H	H	L	L
High energy circalittoral seabed		H	H	L	H	N	H	H	H	H	H	L	L
High energy circalittoral mixed hard sediments		H	H	L	H	N	H	H	H	H	H	L	L
Very tide-swept faunal communities on circalittoral rock or mixed faunal turf communities on circalittoral rock	A4.11 or A4.13*	H	H	N	H	N	H	H	H	H	L	L	L
Sponge communities on deep circalittoral rock	A4.12	H	H	N	H	N	H	H	H	H	H	L	L
Atlantic and Mediterranean moderate energy circalittoral rock	A4.2*	L	L	L	N	N	H	H	H	H	H	L	L
Moderate energy circalittoral seabed		L	N	L	N	N	H	H	H	H	H	L	L
Moderate energy circalittoral mixed hard sediments		L	N	L	N	N	H	H	H	H	H	L	L
Faunal communities on deep moderate energy circalittoral rock	A4.27	L	L	L	N	L	H	H	H	H	H	L	L
Atlantic and Mediterranean low energy circalittoral rock	A4.3*	H	L	H	N	L	H	H	H	H	H	H	L
Low energy circalittoral seabed		H	L	L	N	N	H	H	H	H	H	H	L
Low energy circalittoral mixed hard sediments		H	L	L	N	N	H	H	H	H	H	H	L
Brachiopod and ascidian communities on circalittoral rock	A4.31	L	L	L	L	L	L	L	H	L	H	H	L
Faunal communities on deep low energy circalittoral rock	A4.33	H	L	H	N	L	H	H	H	H	H	H	H
Infralittoral coarse sediment	A5.13*	H	H	N	N	N	L	H	N	N	N	L	L
Circalittoral coarse sediment	A5.14*	H	H	N	N	N	L	L	L	N	N	N	N
Deep circalittoral coarse sediment	A5.15*	H	L	N	N	N	L	N	L	N	N	N	N
Deep circalittoral seabed		H	L	N	N	N	L	N	L	N	N	N	N
Infralittoral fine sand or infralittoral muddy sand	A5.23* or A5.24*	H	L	N	N	N	L	H	L	N	N	L	L
Infralittoral fine sand	A5.23*	H	L	N	N	N	L	H	L	N	N	L	L
Infralittoral muddy sand	A5.24*	H	L	N	N	N	L	H	L	N	N	L	L
Circalittoral fine sand or circalittoral muddy sand	A5.25* or A5.26*	H	L	N	N	N	L	H	L	N	N	N	N
Circalittoral fine sand	A5.25*	H	L	N	N	N	L	H	L	N	N	N	N
Circalittoral muddy sand	A5.26*	H	L	N	N	N	L	L	L	L	N	N	N
Deep circalittoral sand	A5.27	H	L	N	L	N	L	L	L	L	N	N	N

(Continued)

Galparsoro et al. Mapping services from benthic habitats

Table 2 | Continued

Habitat name	EUNIS code	Food	Raw material	Air quality	Disturbance	Photosynthesis	Nutrient	Reproduction	Biodiversity	Wate	Cognitive	Leisure	Feelgood
Infralittoral sandy mud or infralittoral fine mud	A5.33* or A5.34*	H	N	N	N	N	L	L	L	L	N	N	N
Infralittoral sandy mud	A5.33*	H	N	N	N	N	L	L	L	L	N	N	N
Infralittoral fine mud	A5.34*	L	N	N	N	N	L	N	L	L	N	N	N
Circalittoral sandy mud or circalittoral fine mud	A5.35* or A5.36*	H	N	N	N	N	L	L	L	L	N	N	N
Circalittoral sandy mud	A5.35*	H	N	N	N	N	L	L	L	L	N	N	N
Circalittoral fine mud	A5.36*	H	N	N	N	N	L	L	L	L	N	N	N
Deep circalittoral mud	A5.37*	H	N	N	N	N	L	L	L	L	N	N	N
Infralittoral mixed sediments	A5.43*	H	L	N	N	N	L	L	H	L	N	N	N
Circalittoral mixed sediments	A5.44*	H	L	N	N	N	L	L	H	L	N	N	N
Deep circalittoral mixed sediments	A5.45*	H	L	N	N	N	L	L	H	L	N	N	N
Deep circalittoral mixed hard sediments		H	N	N	N	N	N	H	H	N	N	N	N
Upper slope seabed		H	N	N	N	N	N	L	H	N	N	N	N
Upper slope mixed hard sediments		H	N	N	N	N	N	L	H	N	N	N	N
Deep-sea rock and artificial hard substrata	A6.1*	L	N	N	N	N	N	N	H	N	N	N	N
Deep-sea bedrock	A6.11	N	N	N	N	N	N	N	H	N	N	N	N
Deep-sea mixed substrata	A6.2	L	N	N	N	N	N	N	H	N	N	N	N
Deep-sea sand or deep-sea muddy sand	A6.3* or A6.4	L	N	N	N	N	N	N	H	N	N	N	N
Deep sea coarse sediment		L	N	N	N	N	N	N	H	N	N	N	N
Deep-sea sand	A6.3*	L	N	N	N	N	N	N	H	N	N	N	N
Deep-sea muddy sand	A6.4	L	N	N	N	N	N	N	H	N	N	N	N
Deep-sea mud	A6.5	L	N	N	N	N	N	N	H	N	N	N	N
Abyssal seabed		N	N	N	N	N	N	N	L	N	H	N	N
Upper bathyal seabed		N	N	N	N	N	N	N	L	N	L	N	N
Mid bathyal seabed		N	N	N	N	N	N	N	L	N	L	N	N
Lower bathyal seabed		N	N	N	N	N	N	N	L	N	L	N	N

*EUNIS habitat code is given for those habitats included in the classification; * indicates that the assessment was based upon Salomidi et al. (2012).*

A study by Potts et al. (2014) have identified ecosystem services from UK protected habitats and species and subjected them to internal and external peer review through an expert-based process. They described the protected habitats using a EUNIS classification. Results are presented in matrices in which ecosystem services are scored for Broad Scale Habitats (EUNIS Level 3) and Habitats (EUNIS Level 4). Their relevant matrix is presented as Fig 3 in Potts et al. (2014). A shading of each cell within the matrix represents an indication of the relative importance of each EUNIS habitat in providing the respective ecosystem service (darker being more important, lighter less important). For the purpose of REST-COAST ecosystem service mapping, we have translated the shading in Potts et al. (2014) into numbered classifications where 3=Moderate contribution, 2=Low contribution, 1=No or negligible contribution, 0=Not known contribution, Blank=Not assessed (Table 20).

Potts et al. (2014) distinguished Intermediate ecosystem services and Goods/benefits *from* Intermediate services. The Intermediate services provide the foundation for Goods/benefits. As Potts et al. (2014) describe it: "A good/benefit generally requires the input of complementary (human and physical) capital in order to realise benefits, for example, the final ecosystem service of fish/shellfish provides the good/benefit of food and complementary capital (e.g. labour, fishing vessels and energy) transforms this into a product for human consumption and health". Potts et al. (2014) have listed the following services:
Supporting services: Primary production, Larval / Gamete supply, Nutrient cycling, Water cycling, Formation of species habitat, Formation of physical barriers, Formation of seascape.
Regulating services: Biological control, Natural hazard regulation, Regulation of water & sediment quality, Carbon sequestration.

from Provisioning services: Food, Fish feed, Fertiliser, Ornaments (incl. aquaria), Medicine & blue biotechnology.
from Regulating services: Healthy climate, Prevention of coastal erosion, Sea defence, Clean water and sediments, Immobilisation of pollutants.
from Cultural services: Tourism / Nature watching, Spiritual / Cultural wellbeing, Aesthetic benefits, Education.
In linking the services described by Potts et al. (2014) to the selected ESS in REST-COAST, we consider the Intermediate services to be most closely linked to natural features and therefore preferential. For application in REST-COAST, a selection can be made of the following five ecosystem services as scored by Potts et al (2014):
FP: Food provisioning;
CCR: Carbon sequestration;
WP: Regulation of water & sediment quality;
RFR: Natural hazard regulation;
RCE: Prevention of coastal erosion.

A study by Tempera et al. (2016) have mapped the distribution of seabed-associated ecosystem services capacity by using (i) a geospatial dataset representing the broadscale distribution of permanently-submerged seabed habitats with (ii) information on each habitat capacity to provide ecosystem services. The latter was found in six publications among which Galparsoro et al. (2014) and Potts et al. (2014). They made lookup tables that relate 33 classes of Common International Classification of Ecosystem Services (CICES) to 67 EUNIS and 24 non-EUNIS seabed habitats. They categorized the ecosystem services in a binary way: present or absent. They also listed the completeness of the evidence on the provision of each ecosystem service from literature. Out of the 36 ecosystem services, 15 were graded as well or very-well assessed, 6 were assessed fairly and 17 were poorly or very poorly assessed.

Table 20. Ecosystem scores in four classes 3=Moderate contribution, 2=Low contribution, 1=No or negligible contribution, 0=Not known contribution per EUNIS biotope modified from Potts et al. (2014). Yellow-marked are relevant ESS for REST-COAST.

Feature Type	EUNIS code Note: Eunis codes were identified using the JNCC EUNIS translation matrix Some habitats do not have a direct relationship to the EUNIS code and this column should only be used as a guide.	Feature	Primary production	Larval / Gamete supply	Nutrient cycling	Water cycling	Formation of species habitat	Formation of physical barriers	Formation of seascape	Biological control	Natural hazard regulation	Regulation of water & sediment quality	Carbon sequestration	Food	Fish feed	Fertiliser	Ornaments (incl. aquaria)	Medicine & blue biotechnology	Healthy climate	Prevention of coastal erosion	Sea defence	Clean water and sediments	Immobilisation of pollutants	Tourism / Nature watching	Spiritual / Cultural wellbeing	Aesthetic benefits	Education
			Intermediate services											Goods/Benefits													
			Supporting services							Regulating services				from Provisioning services					from Regulating services					from Cultural services			
Broad Scale Habitat																											
E,W	A11	High energy intertidal rock	3	3	1		3	3	1		3		1	2					1	3	3			1	1	1	1
E,W	A12	Moderate energy intertidal rock	2	2	1		3	3			3		1	2					1	2	2			1	1	1	1
E,W	A13	Low energy intertidal rock	1	1	1		3	3			3		1	2					1	1	1			1	1	1	1
E,W	A2.1	Intertidal coarse sediment	1	2	1		2	2	2		2			1						2	2			3	1	3	1
E,W	A2.2	Intertidal sand and muddy sand	1	2	2		3	2	3		2		1	2					1	2	2			3	1	3	1
E,EU	A2.4	Intertidal mixed sediments	1	2	2		3	2	2		2		1	2					1	2	2			3	1	3	1
E,W	A2.3	Intertidal mud	1	3	2		2		2		1	1	2	2					2	1	1	2	2	1	1	2	1
E	A2.5	Coastal saltmarshes and saline reedbeds	3	3	3		3	2	2		2	3	3	3		1			3	2	2	3	3	3	1	3	1
E,EU,W	A2.6	Intertidal sediments dominated by aquatic angiosperms	3		3		3	2	1		2	3	3	2		2			3	2	2	3	3	2	1		1
E,EU,W	A2.7	Intertidal biogenic reefs	3	2	2		3		1		2	2	2	2					2	2	2	2	2	1	1		1
E,W	A3.1	High energy infralittoral rock	2	2			3	3			2			3						2	2			2	1		1
E,W	A3.2	Moderate energy infralittoral rock	2	2			3	3			2			3						2	2			2	1		1
E,W	A3.3	Low energy infralittoral rock	2	2			3	3			2									2	2			2	1		1
E,W	A4.1	High energy circalittoral rock	1	2			2	1			1			3						1	1			2	1		1
E,W	A4.2	Moderate energy circalittoral rock	1	2			2	1			1			3						1	1			2	1		1
E,W	A4.3	Low energy circalittoral rock	1	2			2	1			1			3						1	1			2	1		1
E,W	A5.1	Subtidal coarse sediment	1	2	2		2				1	0		2	3					1	1	2	1		1		1
S	A5.1, A5.2	Offshore subtidal sands and gravels	1	2	2		3	1		1	1	1		2	3	0	1	2	1	1	1	1	1	1	1		1
E,W	A5.2	Subtidal sand	1	1	2		2				1	0		2	3					1	1	2	1		1		1
E,W	A5.3	Subtidal mud	1	2	2		2				1	0		2	3					1	1	2	2		1		1
E,EU,W	A5.4	Subtidal mixed sediments	1	2	2		2				1	0		2	3					1	1	2	2		1		1
W	A5.4, A5.3	Subtidal mixed muddy sediments	1	2	2		2				1	0		2	3					1	1	2	2		1		1
E,EU,W	A5.5	Subtidal macrophyte-dominated sediment	3	2	3		3				2	3	2	3		2			2	2	2	2	2	2	1		1
E,EU,W	A5.6	Subtidal biogenic reefs	3	2	2		3				2	2	2	3			1		2	2	2	3	1	1	1		1
S	A7.4, A7.7	Salinity fronts	3	2	2		3	2		1	1	0	1	2		0	0	2	1	0	0	1	2	2	1		1
S	Various	Low or variable salinity habitats	2	2	3		3	1	3	1	3	2	1	2		0	1	1	1	2	2	2	2	3	2	3	3
EU	X02	Saline lagoons		1	2		2		2					1										2	1		
Habitats																											
E	A132	Estuarine rocky habitats	2	2			2		2		2			2						2	2			2	1	3	1
E,W	A12142, A3.2112	Intertidal under boulder communities	1	2			2				1			1						1	1			1	1	2	1
E	A1127. A1223. A4.231	Peat and clay exposures		1			2																	1	1		1
S	A1325	Sea loch egg wrack beds	3	2	3		2	2	1	3	2	3	3	3		3	0	3	3	2	2	3	1	3	3		0
E	A1441, B3.114, B3.115	Littoral chalk communities	1	1			2																	1	1		1
EU	A144	Submerged or partially submerged sea caves					3		1															2	1		1
E,S,W	A2.2, A2.7, A5.6	Blue Mussel beds	1	2	2		2	1	2	3	1	2	2	2		0	1	2	2	2	2	2	2	2	2		1
E,W	A2.71	Honeycomb worm *Sabellaria alveolata* reef		2	1		3	1		2	2	1	1	1					1	1	1	1	1	1	1		1
S	A3.126, A3.213	Tide-swept algal communities (Laminaria hyperborea, Halidrys siliquosa)	3	2	3		2	2	2	3	2	3	3	3		3		3	3	2	2	3	1	3	3	1	0
S	A3.126, A3.213, A1.15	Tide-swept algal communities	3	2	3		2	2	2	3	2	3	3	3		3		3	3	2	2	3	1	3	3	1	0
E,W	A4.12, A4.12	Fragile sponge&anthozoan communities on subtidal rocky habitats		2			2			1				1									1	2	1		1
W	A4.131A4.2122	Subtidal rock with Ross 'coral' Pentapora foliacea		2			2			1				1									1	2	1		1
S	A4.133, A4.211	Northern sea fan and sponge communities					2		2														1			1	
E	A4.22	Ross worm *Sabellaria spinulosa* reefs		2	1		3	1		2	2	1	1	1					1	1	1	1	1	1	1		1
E	A4.23	Subtidal chalk		1			3																	1	1	1	1
E	A5.12, A5.13	Subtidal sands and gravels	1	2	2		2					2		2	3							2		1	1		1
S	A5.133	Shallow tide-swept coarse sands with burrowing bivalves (Morella sp.)			0		0					2		2								0			0		0
E,S	A5.361	Sea-pen and burrowing megafauna communities	1	2	2		2	0	1	2	1	1	1	1		0	0	1	1	1	1	2	2	1	1	1	1
S	A5.371	Inshore deep mud with burrowing heart urchins	1	2	2		2				1	1		2						1	1	2	2		1		1
W	A5.371	Mud habitats in deep water	1	2	2		2				1	1		2	3					1	1	2	2		1		1
E,W	A5.43, A2.41, A2.42	Sheltered muddy gravels		1	1		2					2	1	1					1			2	2	1	1		1
E,S	A5.434	Flame/ File shell beds	1	2	1		2		2	1	1		1	2					1	1	1		1	1	1	2	1
E,S,W	A5.435	Native Oyster *Ostrea edulis* beds		2	2		3		1	2	2	3	1	3					1	2	2	3	2	1	1	1	1
All	A5.51	Maerl beds	2	2	2		3	1	1	2				2		1	1							1	1	2	1
S	A5.5112	Maerl or coarse shell gravel with burrowing sea cucumbers	2	2	2		3	1	1	2				2		1	1							1	1		1
S	A5.52	Kelp and seaweed communities on sublittoral sediment	3	2	3		2	2	2	3	2	3	2	3		3	0	3	3	2	2	3	2	3	3	3	0
All	A5.53, A5.545, A2.61	Seagrass beds	3	1	3		3	1	2	2	2	2	2	3		2	0	2	2	2	2	2	2	2	2	3	1
E,S,W	A5.62	Horse mussel (Modiolus modiolus) beds	2	2	3		3	0	1	3	2	3	2	2		0	0	2	2	2	2	3	2	1	1	1	1
E	A5.63	Cold-water coral reefs		2	1		2	1					2	1					1					1	1	3	1
EU	A5.71	Submarine structures made by leaking gases			3		3							1				2							1		1
E,S	A6.61	Coral Gardens	1	2	2		2	1	1	1	0	2	1	1		0	1	2	1	0	0	0		1	1	2	1
S	A6.75	Carbonate mound communities	0	2	2		2	0		0	0	2	0	0		0	0	2	0	0	0	0		0	0		0
E,W	Various	Tide-swept channels		2			3																	1	1		1
W	Various	Sediment habitats with long lived bivalves			3		0	0		1		2		2								1	2	0	2		1
E	N/A	Areas of high planktonic primary productivity	3	1	3		0	0		3	1		2	3	3				2	0	0	0	1	1	0		0

3.2 Scoring ESS per EUNIS habitat type in REST-COAST

In REST-COAST we selected five relevant and urgent ecosystem services. For each of them we want to derive semi-quantitative scores for the contribution of each EUNIS habitat in six categories conform Burkhard et al. (2014), i.e.: **0** (none), **1** (very low contribution), **2** (low contribution), **3** (medium contribution), **4** (high contribution), **5** (very high contribution). To achieve this we applied the matrix model (Jacobs et al. 2015): ecosystem service supply is modelled using expert estimations per EUNIS habitat type, such as in the examples shown in the previous paragraph.

For Atlantic & Baltic coastal biotopes, Mediterranean & Black Sea coastal biotopes, Atlantic marine biotopes and Mediterranean marine biotopes expert estimates were assembled using questionnaires that were distributed among the respondent pool of REST-COAST partners. Each respondent was first asked to indicate how experienced the respondent considers him/herself on the topic scoring of ecosystem services, ranging from very little to very high. Next, for each of the five REST-COAST ecosystem services respondents were asked to rank the contribution of EUNIS habitats to each ESS. The EUNIS habitats consisted of broad scale habitats in Level 3 (and some Level 4) for Mediterranean coastal habitats (N-series), Atlantic coastal habitats (N-series), Mediterranean marine benthic habitats (M-series) and Atlantic marine benthic habitats (M-series). Detailed descriptions of EUNIS habitats were provided by showing tables with clickable URLs to their habitat descriptions on the EUNIS website https://eunis.eea.europa.eu/habitats-code-browser-revised.jsp. A special form of a two-round Delphi method was applied: for each combination of EUNIS habitat and ESS, a rank score based on an expert assessment of previous literature was already given. For each combination respondents were asked to indicate how much evidence there is on each ecosystem service for each habitat, in classes Hardly explored, little studied, well studied. Finally, respondents could provide free comments for each ranking matrix.

3.2.1 Results of questionnaires for ESS scores per EUNIS habitat type

Based on the results from the questionnaires for each ESS, boxplots were made to express the range in rank scores for the expert estimates. The boxplots show the median score (thick black lines), percentiles, as well as outliers (circles). In case no percentiles are shown there was a large agreement amongst experts. The experts' judgements on the amount of evidence given for each ESS varied a lot. This might be caused by the amount of background knowledge one has.

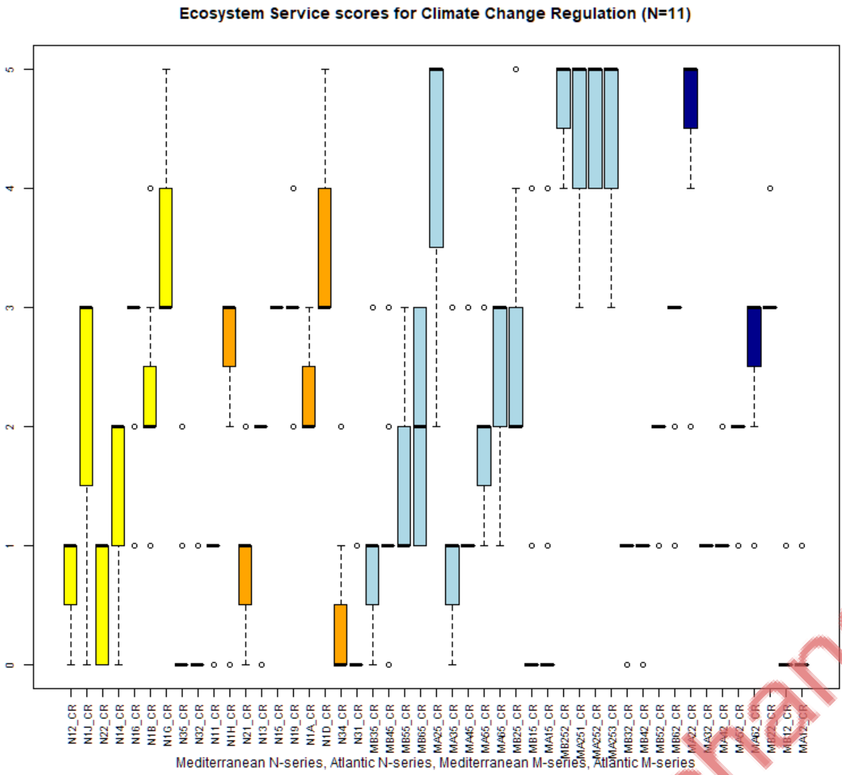


Figure 19. Boxplots for expert estimates of rank scores for ESS contributions to Climate Change Regulation per EUNIS biotope.

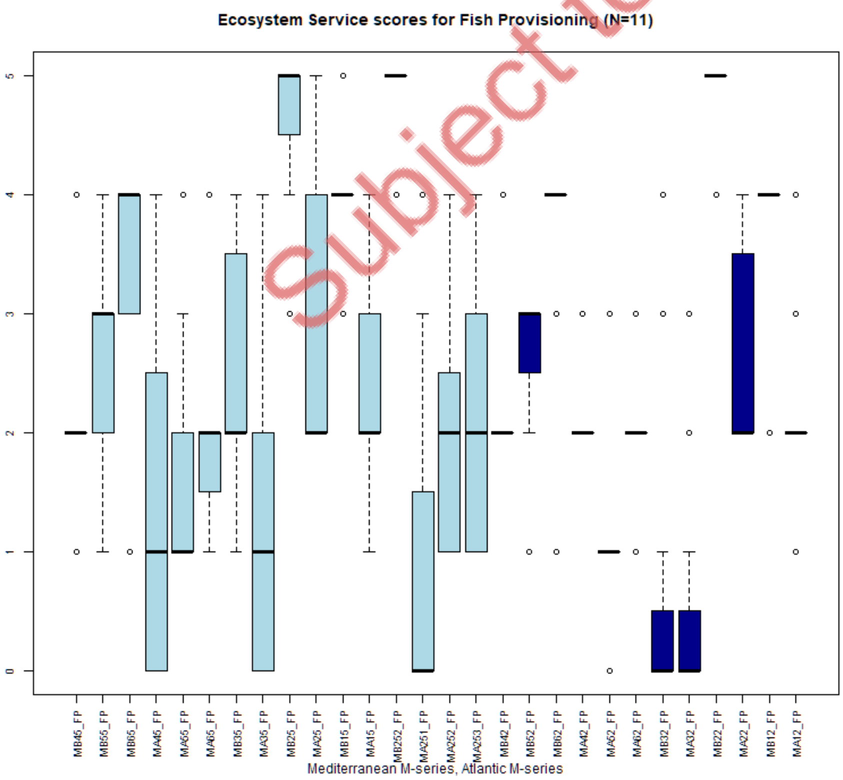


Figure 20. Boxplots for expert estimates of rank scores for ESS contributions to Fish Provisioning per EUNIS biotope.

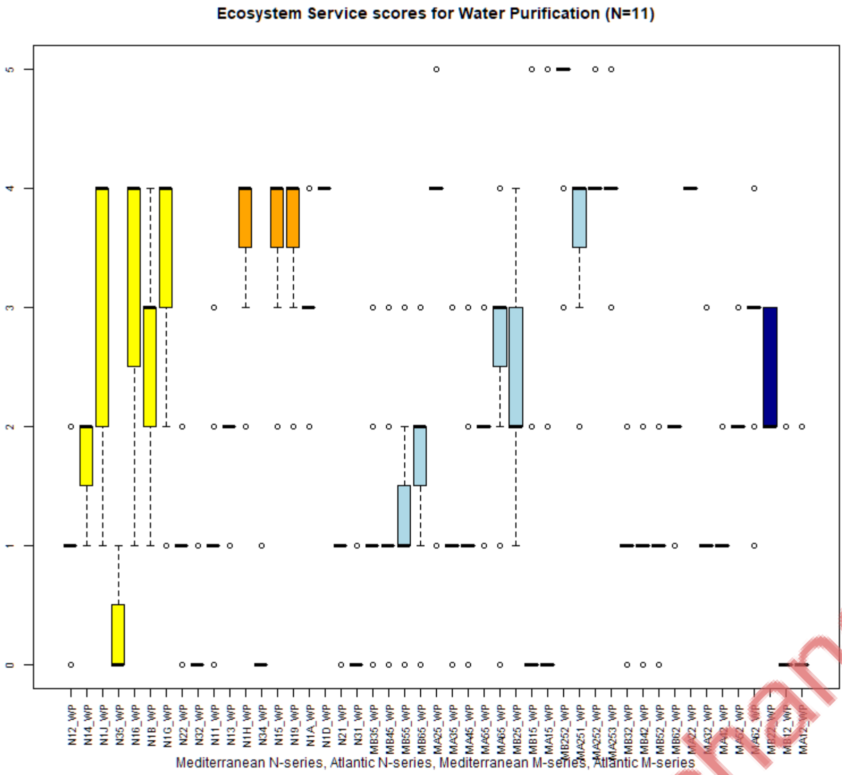


Figure 21. Boxplots for expert estimates of rank scores for ESS contributions to Water Quality Purification per EUNIS biotope.

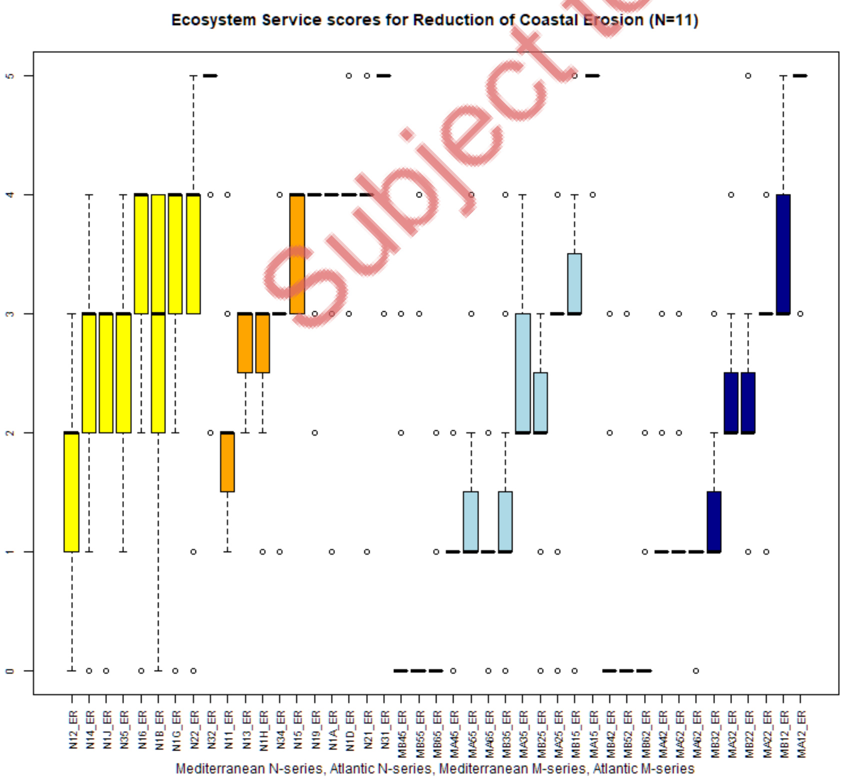


Figure 22. Boxplots for expert estimates of rank scores for ESS contributions to Reduction of Coastal Erosion Risk per EUNIS biotope.

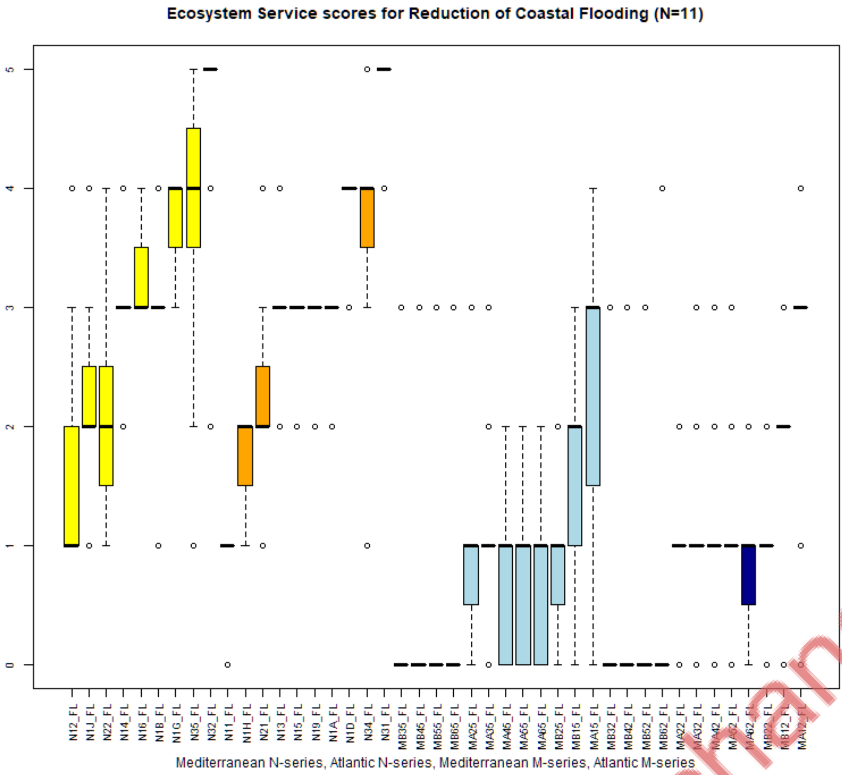


Figure 23. Boxplots for expert estimates of rank scores for ESS contributions to Reduction of Coastal Flooding Risk per EUNIS biotope.

For each ESS a mean score rounded to the nearest integer was calculated, Table 21. These values will be applied in the scorecard methodology for coastal system behaviour for restoration effects on ESS gains under climate change.

Table 21. Semi-quantitative rank scores for the five selected REST-COAST ecosystem services applied to Mediterranean & Black Sea and Atlantic & Baltic EUNIS habitats. Scores are rounded to the nearest integer, ranging from 0 (none) to 5 (very high contribution). Cell colours on a red-to-green scale are based on nonrounded scores. Blank means not assessed.

Code	EUNIS Name	WP	CCR	FP	RCE	RFR
N12	Mediterranean and Black Sea sand beach	1	1		2	2
N14	Mediterranean and Black Sea shifting coastal dune	2	1		2	3
N1J	Mediterranean and Black Sea moist and wet dune slack	3	2		2	2
N35	Mediterranean and Black Sea soft sea cliff	0	0		3	4
N16	Mediterranean coastal dune grassland (grey dune)	3	3		3	3
N1B	Mediterranean and Black Sea coastal dune scrub	2	2		3	3
N1G	Mediterranean coniferous coastal dune forest	3	3		3	4
N22	Mediterranean and Black Sea coastal shingle beach	1	1		3	2
N32	Mediterranean and Black Sea rocky sea cliff and shore	0	0		5	5
N11	Atlantic, Baltic and Arctic sand beach	1	1		2	1
N13	Atlantic and Baltic shifting coastal dune	2	2		3	3
N1H	Atlantic and Baltic moist and wet dune slack	4	3		3	2
N34	Atlantic and Baltic soft sea cliff	0	0		3	4

N15	Atlantic and Baltic coastal dune grassland (grey dune)	4	3		4	3
N19	Atlantic coastal Calluna and Ulex heath	4	3		4	3
N1A	Atlantic and Baltic coastal dune scrub	3	2		4	3
N1D	Atlantic and Baltic broad-leaved coastal dune forest	4	3		4	4
N21	Atlantic, Baltic and Arctic coastal shingle beach	1	1		4	2
N31	Atlantic and Baltic rocky sea cliff and shore	0	0		5	5
MB35	Mediterranean infralittoral coarse sediment	1	1	2	1	0
MB45	Mediterranean infralittoral mixed sediment	1	1	2	0	0
MB55	Mediterranean infralittoral sand	1	2	3	1	0
MB65	Mediterranean infralittoral mud	2	2	3	0	0
MA25	Mediterranean littoral biogenic habitat	4	4	3	3	1
MA35	Mediterranean littoral coarse sediment	1	1	1	2	1
MA45	Mediterranean littoral mixed sediment	1	1	1	1	1
MA55	Mediterranean littoral sand	2	2	2	2	1
MA65	Mediterranean littoral mud	3	2	2	1	1
MB25	Mediterranean infralittoral biogenic habitat	2	3	5	2	1
MB15	Mediterranean infralittoral rock	1	0	4	3	2
MA15	Mediterranean littoral rock	1	0	2	5	2
MB252	Biocenosis of *Posidonia oceanica*	5	5	5	2	1
MA251	Mediterranean upper saltmarshes	4	5	1	3	1
MA252	Mediterranean upper-mid saltmarshes	4	5	2	3	1
MA253	Mediterranean mid-low saltmarshes	4	5	2	3	1
MB32	Atlantic infralittoral coarse sediment	1	1	1	1	0
MB42	Atlantic infralittoral mixed sediment	1	1	2	0	0
MB52	Atlantic infralittoral sand	1	2	3	1	0
MB62	Atlantic infralittoral mud	2	3	4	0	0
MA22	Atlantic littoral biogenic habitat	4	5	3	3	1
MA32	Atlantic littoral coarse sediment	1	1	1	2	1
MA42	Atlantic littoral mixed sediment	1	1	2	1	1
MA52	Atlantic littoral sand	2	2	1	1	1
MA62	Atlantic littoral mud	3	3	2	1	1
MB22	Atlantic infralittoral biogenic habitat	2	3	5	2	1
MB12	Atlantic infralittoral rock	0	0	4	3	2
MA12	Atlantic littoral rock	0	0	2	5	3

Comments made by experts

Some experts commented on their lack of experience for specific habitats or regions. For instance experts working in the Atlantic region have little experience in the Mediterranean habitats and vice versa. But, as an expert noted "I do not have experience on Atlantic coasts. I would rank them similar to the Mediterranean equivalent habitats."

An expert commented on a large number of missing (subscale) habitats specific for their pilot site. The intention of the survey was to generate a generic framework for broadscale habitats, which serves as a base for more detailed assessments of scores on the pilot scale, for which detailed EUNIS maps are required.

On RCE of coastal types:
“Beaches and dunes do not reduce the risk of erosion by themselves, but wider beaches with more dunes prevent negative impacts of erosion (narrowing beaches).”
“At least for the Black Sea, very steep geomorphology makes these expert score at least 1 point less with increased risk of erosion (acc. to my very little knowledge and experience).”
“I ranked the resistance to erosion of the different habitats, not the reduction of erosion risk.”
“I feel exposed sand and soft clay with little vegetation should not be relied upon for preventing erosion, rather these can delay erosion from becoming critical to infrastructure and only constitute a solution if part of a suppletion scheme (e.g. the sand engine).”
In conclusion, for a more elaborate assessment of the contribution of natural habitats to the reduction of coastal erosion risk the width of each habitat perpendicular to the coast must be interpreted as well.

On RFR of coastal types:
“For sandy coasts the combination of a wide beach with dune fields is the most effective against coastal flooding (interpreted as inland flooding). Here we have assessed separately baches and dunes but in real terms both come together, so this makes more difficult the scoring. For flooding risk reduction the presence of marshes in the backshore are relevant (but not for risk reduction of erosion).”
“The reduction of the flooding risk depends on the width of the beach or the volume/heigh of the dunes, so I ranked them as if they have "mean" value of those variables. If the beach is narrower then I would rank it with a lower value, and so on.”
“N35. Mediterranean and Black Sea soft sea cliff is confusing. According to the description this soil is unstable, meaning it cannot be relied upon for flood protection.”
“N21. On steep beaches shingles can actually be really effective in dispersing wave energy similar to off-shore breakwaters!”
In conclusion, for a more elaborate assessment of the contribution of natural habitats to the reduction of coastal flooding risk also the combined presence of habitats, their width, as well as the order in which they occur is relevant.

On WP of coastal types:
“Water purification stands for freshwater (rain water, storm water) purification.”
“Considered according to estimated exposure to sea and potential burial capability (less impact) vs water residence time (more impact).”
“To me, ranking also depends a lot on what we include under the name "water purification". If we mean water purification from pollutants, these habitats could play a less effective role than the role they play for nutrient removal.”
“I have very limited experience with water purification. However, my logic is: 0= no effect, 1 = biotope slightly and occasionally promotes residence time (e.g. roughness from seasonal vegetation), 2 = biotope slightly promotes residence time, 3 = biotope improves residence time, 4= biotope considerably improves residence time, 5= biotope contains a mechanism actively removing pollutants from the system (e.g. filter feeders).”
In conclusion, for a more elaborate assessment of the contribution of natural habitats to reduction of nutrients the residence time should be assessed as well.

On CCR of coastal types:
“Very little expertise on quantifying carbon storage capacity of habitats. When filling in, one though struck my mind: shall we consider seasonal increased emissions from especially beaches (touristic)?”
“I have very little expertise on this topic. As far as my logic goes: no vegetation =0, little vegetation =1, sparse vegetation = 2, full vegetation cover = 3,4 , active entrainment of CO_2 by biotope besides storage in plant matter (e.g. capturing sediment or filtering) = 5.”
In conclusion: the presence of vegetation as denoted by sublevels in EUNIS is important in assessing the contribution to climate change regulation.

On RCE of marine types:
"The reduction of coastal erosion risk will depend on the coarseness of sediment and the depth where the habitat is present (here local conditions are more relevant than for beaches). We have not enough information to quantify the risk reduction in those infralittoral habitats."
"I consider reduction only for very shallow submerged habitats. I interpret "littoral" as shallow and "infralittoral" as deeper if am correct."
In conclusion, for a more elaborate assessment of the contribution of natural habitats to the reduction of coastal erosion risk the sediment properties as well as the depth profile of the coast are relevant as well.

On RFR of marine types:
"The submerged habitats are flooded and do not prevent flooding of the emerged ones." *Yes, but in some cases, submerged habitats can dampen waves and mitigate wave runup which prevents wave overtopping of coastal defences.*

On WP of marine types:
"Some of the bottom types water purification function highly depends on whether or not these are vegetated or not. That is why a "compromise" was taken and they were scored in the middle. Water purification stands for seawater purification."
In conclusion: the presence of vegetation as denoted by sublevels in EUNIS is important in assessing the contribution to water purification.

On CCR of marine types:
"Some of the bottom types CCR regulation function highly depends on whether or not these are vegetated or not. That is why a "compromise" was taken and they were scored in the middle."
In conclusion: the presence of vegetation as denoted by sublevels in EUNIS is important in assessing the contribution to climate change regulation.

On FP of marine types:
"According to my experience, brackish reed and sedge beds are still being overlooked about their capacity to act as nursery and shelter for fish."
In conclusion: some wetland habitats might be important for marine fish.

3.2.2 ESS scores for Wadden Sea Ems-Dollard biotopes

A relatively large number of EUNIS biotopes have been defined for the Ems-Dollard area, resulting from the amalgamation of maps from Rijkswaterstaat, TMAP and Corine Coastal Zones. Rank scores for the EUNIS habitats occurring in the Ems-Dollard region were based on the results of the questionnaire and were supplemented by expert judgement for the terrestrial types. The latter scored 0 for many of these ecosystem services (Table 22).

Table 22. Semi-quantitative rank scores for the five selected REST-COAST ecosystem services applied to Ems-Dollard EUNIS biotopes.

Code	EUNIS Name	WP	CCR	FP	RCE	RFR
N1	Coastal dunes and sandy shores	1	1	0	2	1
N11	Atlantic, Baltic and Arctic sand beach	1	1	0	2	1
N131	Embryo dunes	2	2	0	3	3
N1A	Atlantic and Baltic coastal dune scrub	3	2	0	4	3

Code	EUNIS Name	WP	CCR	FP	RCE	RFR
MA22	Atlantic littoral biogenic habitat	2	2	3	2	1
MA222	High marsh	4	5	1	3	1
MA223	Brackish marsh	4	5	1	3	1
MA224	Atlantic mid-low saltmarshes	4	4	2	3	1
MA225	Atlantic pioneer saltmarshes	3	3	2	2	1
MA52	Atlantic littoral sand	2	2	1	1	1
MA523	Barren or amphipod-dominated Atlantic littoral sand	2	2	1	1	1
MA525	Polychaete/bivalve-dominated Atlantic littoral muddy sand	2	2	1	1	1
MA621	Faunal communities of full salinity Atlantic littoral mud	3	3	2	1	1
MA622	Faunal communities of variable salinity Atlantic littoral mud	3	3	2	1	1
MB12	Atlantic infralittoral rock	0	0	4	3	2
MB52	Atlantic infralittoral sand	1	2	3	1	0
MC52	Atlantic circalittoral sand	1	2	3	1	0
X02-2012	Saline coastal lagoons	4	3	3	2	1
X01-2012	Estuaries	3	2	2	1	1
J1-2012	Buildings of cities, towns and villages	0	0	0	0	0
J2	Low density buildings	0	0	0	0	0
J4.2-2012	Road networks	0	0	0	0	0
J4.3-2012	Rail networks	0	0	0	0	0
J4.5-2012	Hard-surfaced areas of ports	0	0	0	0	0
J4.4-2012	Airport runways and aprons	0	0	0	0	0
J2.6-2012	Disused rural constructions	0	0	0	0	0
E2.6-2012	Heavily fertilised grassland, sports fields and grass lawns	0	1	0	0	0
V11	Intensive unmixed crops	0	1	0	0	0
J2.43-2012	Greenhouses	0	0	0	0	0
V5	Shrub plantations	0	1	0	0	0
V12	Mixed crops of market gardens and horticulture	0	1	0	0	0
T1	Deciduous broadleaved forest	1	1	0	0	0
T29	Broadleaved evergreen plantation of non site-native trees	0	1	0	0	0
T3	Coniferous forest	1	1	0	0	0
T41	Early-stage natural and semi-natural forest and regrowth	1	2	0	0	0
T42	Coppice and early stage plantations	0	1	0	0	0
R2	Mesic grasslands	1	2	0	0	0
S4	Temperate shrub heathland	1	1	0	0	0
S5	Maquis, arborescent matorral and Mediterranean scrub	0	1	0	0	0
U2	Screes	0	0	0	0	0
D2-2012	Valley mires, poor fens and transition mires	2	1	0	0	0
D1-2012	Raised and blanket bogs	3	1	0	0	0
C2-2012	Surface running waters	1	1	2	0	0
C2.5-2012	Temporary running waters	0	0	0	0	0
C1-2012	Surface standing waters	2	2	2	0	0
X02-2012	Saline coastal lagoons	4	3	3	2	1
X01-2012	Estuaries	3	2	2	1	1
	Dikes	0	0	0	5	5

3.2.3 ESS scores for Venice Lagoon biotopes

An advantage of the semi-quantitative scores for ESS per EUNIS biotope is the versatility and flexibility of this approach. A multidisciplinary team of 11 experts of the Venice Lagoon case study critically reviewed how the EUNIS biotope system can be applied to their study area. The experts' team was composed of people with different expertise and background, ranging from environmental scientists, ecologists, applied environmental biologists, environmental planners and engineers, to people representing local institutions and decision makers. All of them were invited to join a meeting focused on the assignment of the scores representing the potential of each biotope to provide ESS. After the presentation of the EUNIS biotopes map and the features characterizing each habitat, the ESS scorecard was compiled individually through a questionnaire. Subsequently, the team engaged in a discussion following the Delphi approach to reach a consensus on the final score that can be assigned with the highest possible confidence. The results of this participative process are shown in Table 23.

The results showed how natural mudflats and seagrass meadows have been assigned high scores for all five ecosystem services considered, while the perceived lowest scores are assigned to areas characterized by shallow waters and slow current velocity. It is interesting to note that, according to the perceptions of the consensus of the experts involved, a lower values in the potential capacity to timely supply 3 out of 5 ecosystem services has been assigned to the artificial versions of the ecotopes, both for mudflats and saltmarshes.

Table 23. Semi-quantitative rank scores for the five selected REST-COAST ecosystem services applied to Venice Lagoon EUNIS biotopes.

Code	Venice Lagoon description	WP	CCR	FP	RCE	RFR
MA251-253	Natural saltmarshes	4	4	4	4	4
MA251-253*	Artificial saltmarshes	3	3	3	4	4
MA6511	Natural intertidal mudflats ("velme")	3	3	4	3	3
MA6511*	Intertidal mudflats from degraded artificial saltmarshes	2	3	3	2	2
MB553-MB554-MB652	Seagrasses meadows	4	4	5	4	3
MB45-	Mixed sediments with high current velocity	1	1	3	1	0
MB65-	Infralittoral non-vegetated muds with weak current velocity	2	2	3	2	1
MB5532-5535	Infralittoral muddy sands with weak current velocity	2	1	3	2	2

3.2.4 ESS scores for Ebro delta biotopes

The process of assessing the potential delivery of ecosystem services (ESS) in the Ebro delta, particularly focused on EUNIS habitats targeted for restoration efforts, involved the application of semi-quantitative scores. These scores were utilized to gauge the capacity of these habitats to provide essential ecosystem services, as outlined in Table 24.

To establish these scores, inputs from expert judgments were gathered from both the Eurecat and UPC teams, alongside stakeholders associated with the Ebro delta CORE-PLAT. Specifically, the focus was on evaluating three of the five targeted ESS: food provisioning, prevention of erosion, and inundation. It's worth noting that significant insights pertinent to this subject were garnered during the CORE-PLAT meeting convened in June 2023. This meeting primarily focused on deliberating the financial aspects of restoration, involving active participation from REST-COAST partners engaged in work package 3. This underscores the notion that valuable information can often be gleaned from activities not specifically tailored for ESS scoring purposes. The insights garnered from these stakeholders were synthesized to form the basis of the assessment.

For the remaining ESS, namely water purification and climate regulation, the semi-quantitative scoring was informed by the expert opinions of the Eurecat team. Additionally, relevant literature pertaining to these ESS and their association with the targeted habitats in the Ebro delta, published within the last five years, was referenced. Examples include works by Fennessy et al. (2019), Matamoros et al. (2020), Morant et al. (2020), and Berenguer-Manzanedo et al. (2021), among others, to ensure a comprehensive understanding of the ecosystem's potential in delivering these services.

Table 24. Semi-quantitative rank scores for the five selected REST-COAST ecosystem services applied to the Ebro delta EUNIS habitats affected by the restoration actions. WP - water purification, CCR – climate change regulation, FP-food provisioning, PE - prevention of erosion, PF - prevention of flooding.

EUNIS Code	EUNIS Description	WP	CCR	FP	PE	PF
MA2533	Mediterranean coastal halo-nitrophilous pioneer communities	1	4	1	0	4
N12	Mediterranean and Black Sea sand beach	0	0	0	0	4
N141	Western Tethyan embryonic dunes	0	2	0	0	4
X02	Saline coastal lagoons	5	4	5	0	4
C3.23-2012	Typha beds	5	4	2	0	3
D5.11-2012	Phragmites australis beds normally without free-standing water	5	4	2	0	3
C2-2012	Running surface waters	1	3	5	0	0

3.2.5 ESS scores for Arcachon Bay biotopes

The scores for Arcachon Bay were obtained from expert opinion:

CODE	EUNIS Description	Type	RCE	FP	CRR	RFR	WP
A2.22	Barren or amphipod-dominated mobile sand shores	Marine	0	0	0	1	0
A2.23	Polychaete/amphipod-dominated fine sand shores	Terrestrial	1	0	0	1	2
A2.24	Polychaete/bivalve-dominated muddy sand shores	Marine	3	1	3	2	5
A2.5	Coastal saltmarshes and saline reedbeds	Marine	4	4	5	2	4
A2.61	Seagrass beds on littoral sediments	Marine	3	4	5	2	3
A5.22	Sublittoral sand in variable salinity (estuaries)	Marine	1	1	0	1	0
A5.23	Infralittoral fine sand	Marine	0	1	0	0	0
A5.24	Infralittoral muddy sand	Marine	0	1	2	0	1
A5.33	Infralittoral sandy mud	Marine	0	2	3	0	1
A5.43	Infralittoral mixed sediments	Marine	0	2	3	0	1

A5.53	Sublittoral seagrass beds	Marine	3	4	5	2	3
B	Coastal habitats	Terrestrial	3	4	3	1	1
C	Inland surface waters	Marine	2	3	3	1	0
C1.51	Athalassic saline lakes	Terrestrial	1	3	3	1	0
D	Mires, bogs and fens	Terrestrial	1	4	0	1	1
G	Woodland, forest and other wooded land	Terrestrial	1	3	2	1	1
J2.53	Sea walls	Terrestrial	5	2	0	4	0

3.2.6 ESS scores for Vistula Lagoon biotopes

The scores for the Vistula Lagoon are defined only for the aquatic habitat 'Saline/Brackish coastal lagoon'. After construction of the bird island, the island will become a 'Mesic grassland' first, and natural succession in combination with limited management measures are expected to yield a Sparsely wooded grassland (Figure 24), Table 25, developing within the brackish coastal lagoon.

Table 25. Semi-quantitative rank scores for the five selected REST-COAST ecosystem services applied to Vistula Lagoon EUNIS biotopes.

Code	EUNIS Name	WP	CCR	FP	RCE	RFR
X02-12	Saline/Brackish coastal lagoon	1	0	3	0	0
R7	Sparsely wooded grasslands	2	0	4	0	0

The following arguments are used to score for Mesic grasslands:
Climate change regulation – score 0 – or even negative as we will not exploit carbon sequestration potential by maintaining grassland and preventing natural vegetation succession, moreover emission of ca. 700 kg C/ha/year can be expected from areas just filled with wet sediment.
Water purification – score 2 – some residual purification (denitrification) occurs when water returns to the lagoon after the placement of dredged material on the island; this however is a small by-product of the scheme (artificial island) without real impact on curbing permanent eutrophication of Vistula Lagoon due to past agricultural malpractices.
Food provisioning – score 4 – we can expect spontaneous development of reed fields and spawning grounds for fish around the rim of the island – another by-product of the scheme.
Reduction of coastal/lowland flooding risk – score 0 – the risk of floods exists only in the western sector of the Lagoon and is subject to a vast refurbishment project with time horizon of 2030- this is absolutely outside REST-COAST.
Reduction of coastal erosion – score 0 – the lagoon is very shallow and there is no risk of erosion in its Polish part.

Figure 24. Proposed EUNIS classification of artificial island (180 ha).

3.2.7 ESS scores for Sicily Lagoon biotopes

For the Sicily lagoon pilot site, terrestrial EUNIS biotopes were assessed by a team of experts with different expertise and backgrounds. Each member of the team individually compiled a questionnaire assigning a score ranging from 0 to 5 for each EUNIS biotope about their contribution to each specific Ecosystem Service, i.e. *Water Quality Purification (WP), Reduction of Coastal Erosion Risk (RCE), Reduction of Coastal Flooding Risk (RFR).* For each ESS a mean score rounded to the nearest integer was calculated (Table 26). Moreover, two habitat subtypes were added, in order to include those habitats that are degraded due to anthropogenic reasons (coastal squeeze, pressure due to intensive agricultural systems etc.), namely: *Mediterranean, Macaronesian and Black Sea shifting coastal dune (degraded)* and *Saline coastal lagoons (degraded).*

Table 26. Semi-quantitative rank scores for three of the five selected REST-COAST ecosystem services applied to Sicily Lagoons EUNIS biotopes.

Code	EUNIS Name	WP	RCE	RFR
D5.1-2012	Reedbeds normally without free-standing water	5	5	4
MA2252	*Salicornia* spp. pioneer saltmarshes	5	3	3
MA25	Mediterranean littoral biogenic habitat	3	4	3
MA2515	Mediterranean *Sarcocornia perennis* mats	4	4	4
N3	Rock cliffs, ledges and shores, with angiosperms	2	4	4
N12	Mediterranean and Black Sea sand beach	1	4	4

N14	Mediterranean, Macaronesian and Black Sea shifting coastal dune	2	5	4
N14(d)	Mediterranean, Macaronesian and Black Sea shifting coastal dune (degraded)	1	4	3
J1-2012	Buildings of cities, towns and villages	0	0	0
J1.2-2012	Residential buildings of villages and urban peripheries	0	0	0
J2.43-2012	Greenhouses	0	0	0
J4-2012	Transport networks and other constructed hard-surfaced areas	0	0	0
R1A5	*Brachypodium phoenicoides* swards	3	4	3
R1E	Mediterranean tall perennial dry grassland	3	4	3
S54	Thermo-Mediterranean scrub	3	4	4
V13	Arable land with unmixed crops grown by low-intensity agricultural methods	0	1	1
V61	Broadleaved fruit and nut tree orchards	1	2	2
X02	Saline coastal lagoon	5	4	5
X02	Saline coastal lagoon (degraded)	4	3	4

3.2.8 ESS scores for Foros Bay biotopes

For Black Sea marine biotope, present at the Foros Bay pilot, the assessment is done based on the Foros Bay teams expert judgement. For the coastal types (N) the scores are taken from the REST-COAST survey and for the terrestrial ones the scores are derived from Burkhard et al., 2014 and expert opinion, Table 27.

Table 27. Semi-quantitative rank scores for the five selected REST-COAST ecosystem services applied to Black Sea marine EUNIS biotopes.

Code	EUNIS Name	WP	CCR	FP	RCE	RFR
MA14	Black sea littoral rock	0	0	1	4	2
MA241	Black Sea littoral saltmarsh	4	4	2	3	0
MA54	Black sea littoral sand	1	2	2	1	1
MB14	Black Sea infralittoral rock	3	3	3	3	2
MB34	Black Sea infralittoral coarse sediment	1	1	2	1	0
MB44	Black Sea infralittoral mixed sediment	1	1	2	1	0
MB54	Black Sea infralittoral sand	2	2	3	1	0
MB546	Seagrass and rhizomatous algal meadows	3	5	4	2	1
MB64	Black Sea infralittoral mud	2	2	4	0	0
N12	Black Sea sand beach	0	0	0	1	4
N14	Black Sea shifting coastal dunes	0	2	0	2	4
Q51	Tall-helophyte bed	3	2	2	0	2
R6352	Western Pontic glasswort-seablite-saltwort swards	3	3	2	0	0

3.2.9 ESS scores for Rhône delta biotopes

For the Rhône Delta site, various habitats have been defined using EUNIS codes, adapted from the Interpretation Manual of European Union Habitats (EUR15 codes, Table 9), and other non-community habitats from the Corine Biotope Classification (CBC codes, Table 10).

To establish the Ecosystem Service Score, we combined scores provided by the questionnaire from the REST-COAST advisory board (paragraph 3.2.1) with expert analysis. The scores from the questionnaire were applied to Marine Benthic habitats (M-class from EUNIS 2022) and Coastal habitats (N-class from EUNIS 2022). Other types of habitats were scored based on expert judgment from fish biologists, hydrologists, and ecologists, considering our specific site conditions.

For the reduction of coastal erosion (RCE) and flooding risk (RFR), the morphology and sediment availability of habitats were the main parameters evaluated to achieve a high score (4). The climate change regulation score is the most uncertain and requires further investigation, particularly concerning future carbon sequestration and emission results provided by REST-COAST measurements on the site. Terrestrial habitats are indicated in black for fish provisioning (Table 28, Table 29). Good scores are provided by permanent water and low salinity habitats. Habitats with non-permanent water, lacking water to support fish provisioning conducted to lower the score. For water purification, non-permanent water and abiotic environment have a low score.

As a general result, habitats from the Manual of European Union Habitats received higher scores due to their good ecosystem functionality (Table 28). Conversely, other non-community habitats received lower scores due to poor ecosystem functionality and anthropogenic influences (Table 29).

Table 28. Semi-quantitative rank scores for the five selected REST-COAST ecosystem services applied to Rhône delta EUNIS biotopes, from European Union Habitats.

EUR15	EUNIS2012	EUNIS2022	EUNIS Description	Conservation Status	WP	CCR	FP	RCE	RFR
1110	A5.2	MB5-5	Mediterranean infralittoral sand	Good	1	2	3	1	1
1140	B1.21	N1-22	Unvegetated Mediterranean and Black Sea sand beaches above the driftline	Poor to Good	1	1		2	2
1150-2	X02; X03; J5.11	X02 - 2012 ; X03 - 2012; J5.11 - 2012	Saline coastal lagoons.; Brackish coastal lagoons; Saline and brackish industrial lagoons and canals	Poor to Good	5	5	5	3	3
1210-3	B1.13	N1-21	Tethyan sand beach driftline communities	Not evaluated	1	1		2	2
1310-3	A2.551	MA2-25	Atlantic pioneer saltmarshes	Good	4	4	1	3	1
1310-4	A2.552; E6.13	MA2-533; R6-13	Mediterranean coastal halo-nitrophilous pioneer communities/ Mediterranean inland halo-nitrophilous pioneer communities	Good	4	4		3	2
1410	A2.522; A2.523; A2.524; A2.532; A2.543	MA2-511; MA2-512; MA2-513; MA2-521; MA2-531	Mediterranean Juncus maritimus and Juncus acutus saltmarshes; Mediterranean Juncus, Carex, Hordeum and Trifolium short saltmeadows; Mediterranean Elymus or Artemisia stands; Mediterranean halo-psammophile meadows; Mediterranean coastal-saltmarsh grass swards	Medium to Good	4	4		3	2
1420	A2.5261 ; A2.5262 ; A2.5263 ; A2.5264 ; A2.5265	MA2-515; MA2-516; MA2-517; MA2-518; MA2-519	Mediterranean Sarcocornia perennis mats; Mediterranean Sarcocornia fruticosa thickets; Mediterranean Arthrocnemum macrostachyum thickets; Mediterranean Suaeda vera thickets; Mediterranean Halimione portulacoides-Arthrocnemum scrubs	Good to Very good	4	4	1	4	3
1510	E6.111	R6-111	Ibero-Tyrrhenian sea-lavender steppes	Very good	1	1		1	1
2110	B1.312	N1-41	Western Tethyan embryonic dunes	Poor to Good	2	2		3	4
2120	B1.322	N1-44	Western Tethyan white dunes	Poor to Good	2	2		3	4
2190	B1.83; B1.85	N1-J3; N1-J5	Mediterranean and Black Sea dune-slack fens; Mediterranean and Black Sea dune-slack reedbeds, sedgebeds and canebeds	Medium to Good	3	2		3	4
2210	B1.43	N1-61	Mediterraneo-Atlantic fixed grey dunes	Poor to Good	4	3		4	4
2240	B1.49; E1.2A	N1-65; R1-A5	Dune Mediterranean xeric grassland; Brachypodium phoenicoides swards	Good	4	3		4	4
2250	B1.63	N1-B2	Dune Juniperus thickets	Medium	4	3		4	4
2270	B1.74	N1-G	Mediterranean coniferous coastal dune forest	Poor to Good	4	3		4	4
3140	C1.14; C1.25	C1.14 - 2012; C1.25 - 2012	Charophyte submerged carpets in oligotrophic waterbodies; Charophyte submerged carpets in mesotrophic waterbodies	Medium to Good	4	4	4	1	1
3150-1	C1.33	C1.33 - 2012	Rooted submerged vegetation of eutrophic waterbodies	Good	3	4	4	1	1
3170	C3.421	C3.421 - 2012	Short Mediterranean amphibious communities	Good to Very good	3	2	2	1	0
6220	E1.313	R1-D	Mediterranean closely grazed dry grassland	Medium to Good	1	2		2	1
92A0	G1.33	T1-1; T1-4	Temperate Salix and Populus riparian forest/ Mediterranean and Macaronesian riparian forest	Poor	4	4	2	2	4

Table 29. Semi-quantitative rank scores for the five selected REST-COAST ecosystem services applied to Rhône delta EUNIS biotopes, from other non-community habitats.

CBC	EUNIS2012	EUNIS2022	EUNIS Description	Conservation Status	WP	CCR	FP	RCE	RFR
89.21	J5.41	J5.41 - 2012	Non-saline water channels with completely man-made substrate	Not evaluated	3	3	3	1	1
51.1	C1.4	C1.4 - 2012	Permanent dystrophic lakes, ponds and pools	Very poor	0	1	2	1	1
22.432	C1.341	C1.341 - 2012	Shallow-water floating communities	Medium	4	3	4	1	1
53.17 x 22.432	C3.27 x C1.341	C3.27 -2012, C1.341 - 2012	Halophile Scirpus, Bolboschoenus and Schoenoplectus beds x Shallow-water floating communities	Medium	5	3	4	1	1
53.111	C3.211	C3.211 - 2012	Flooded Phragmites beds	Poor	5	4	3	2	2
53.13	C3.23	C3.23 - 2012	Typha beds	Poor	3	3	3	1	2
87	E5.1	V3.7; V3.8; V3.9	Annual anthropogenic herbaceous vegetation/ Dry perennial anthropogenic herbaceous vegetation/ Mesic perennial anthropogenic herbaceous vegetation	Not evaluated	1	1		1	0
38.2	E2.2	R2-2	Low and medium altitude hay meadow	Good	1	2		1	0
34.8 x 87	E1.6 x E2.1	V3-2; R2.1	Mediterranean subnitrophilous annual grasslands x Mesic permanent pasture of lowlands and mountains	Medium to Good	1	2		1	0
32.21A3	F5.51A3	S5-1JA3	Western Phillyrea thickets	Good	1	1		1	0
31.891	F3.221	S3-551	Franco-Iberian sub-Mediterranean deciduous thickets	Good	1	1		0	0
44.8131	F9.3131	S9-3131	West Mediterranean tamarisk thickets	Not evaluated	1	1		2	2
N.D	F9.35	S9-35	Riparian stands of invasive shrubs	Not evaluated	1	1		2	1
86	J2	J2 - 2012	Low density buildings	Not evaluated	0	0		0	0
86	J4	J4 - 2012	Transport networks and other constructed hard-surfaced areas	Not evaluated	0	0		0	0
87	E5.1	V3.7; V3.8; V3.9	Annual anthropogenic herbaceous vegetation/ Dry perennial anthropogenic herbaceous vegetation/ Mesic perennial anthropogenic herbaceous vegetation	Not evaluated	1	1		1	1
N.D	N.D	U5	Miscellaneous inland habitats usually with very sparse or no vegetation	Not evaluated	0	0		0	0
N.D	N.D	U5; MA2-25	Atlantic pioneer saltmarshes		1	1		1	1

3.2.10 ESS scores for Nahal Dalia delta biotopes

For Nahal Dalia, the ESS scores per localized description of the EUNIS biotopes are based on experts' opinions and discussions among the project team. Since RCE is not a research area of the pilot, no scores were given (Table 30).

Table 30. Semi-quantitative rank scores for the five selected REST-COAST ecosystem services and BDV applied to Nahal Dalia EUNIS biotopes.

Code	Nahal Dalia Description	WP	CCR	FP	RCE	RFR
N1J	Moist and wet dune slacks	0	0	0	X	0
C3.2	water fringing reedbeds and tall helophytes	3	2	2	X	2
C3.2111	Flooded Phragmites beds - poor conditions	4	2	2	X	2
J5.32	abandoned fishponds	4	4	0	X	0
J5.32	Intensively managed fishponds	0	0	5	X	0
N162	Coastal stable dune grassland (grey dunes)	0	0	0	X	0
N124	Sandy beach ridges with no or low vegetation	0	0	0	X	0
N1B1	Coastal dune thickets	0	2	0	X	2
S7242	*Sarcopoterium bathas*	0	2	0	X	0
C2.3	Permanent non-tidal, smooth-flowing watercourses	1	2	0	X	3
X01-2012	Estuaries	4	3	1	X	3

3.3 Methodology for scoring biodiversity in REST-COAST

For scoring biodiversity in REST-COAST we make use of the European Red List of Habitats. The EUNIS site of the EEA gives a hierarchical view in https://eunis.eea.europa.eu/habitats-code-browser-redlist.jsp. Crosswalks between EUNIS habitats and the Red List Habitats are also provided by the European Environment Agency (EEA, 2022). It allows for the integration of Red List Habitat data into EUNIS habitat maps, so that changes in habitats can be translated into a gain or loss of endangered biotopes as an indicator for changes in biodiversity.

Many Red List Habitats are distinguished. In the marine realm there are 86 Red List habitats in the Atlantic seas, 61 in the Baltic Sea, 63 in the Black Sea and 47 in the Mediterranean Sea. Another 30 are defined for coastal habitats along European seas. The descriptions for these habitats give ample information on biodiversity in terms of characteristic species. Each of these habitats is classified into their status for concern, which consists of 8 categories: Collapsed (CO), Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT), Least Concern (LC), Data Deficient (DD), and Not Evaluated (NE). The first six categories (CO, CR, EN, VU, NT and LC) are ordered in decreasing risk of collapse. The categories Data Deficient and Not Evaluated do not indicate a level of risk. The countries included for the Red List status are the EU Member States (28 countries in total) plus Iceland, Liechtenstein, Norway and Switzerland – further on referred to as the EU28+ countries.

Because there is no one-to-one conversion of EUNIS habitats to Red List habitats, scores for the Red list status were generated based on the closest matching EUNIS habitat. In the following paragraphs the EUNIS habitat code (EUNIS_C) and its corresponding Red List code (RL_C) are shown. When the EUNIS habitat applied in each map for the pilot area deviates from the chosen EUNIS code this is shown in the first column of the table (EUNIS on map). The relationship (Rel) between the EUNIS habitat code (EUNIS_C) and the Red List code (RL_C) is denoted using the following symbology:

=   The revised EUNIS habitat is equal to the Red List habitat
≈   The revised EUNIS habitat is more or less equal to the Red List habitat, this is translated as equal (=)
The revised EUNIS habitat overlaps with the Red List habitat
>   The revised EUNIS habitat is wider than the Red List habitat
<   The revised EUNIS habitat is narrower than the Red List habitat
MOV   the type is moved to a different main group in the Red List compared to EUNIS and an assigned qualifier shows the relation to the new habitat(s)
blank   The revised EUNIS habitat is not assessed in the Red List project

3.3.1 Wadden Sea Ems-Dollard

For the Wadden Sea Ems-Dollard pilot area a Red List status was assigned to the marine types.

Table 31. Red List Habitat status for assigned EUNIS habitats in pilot area Wadden Sea Ems-Dollard.

EUNIS on map	EUNIS_C	Rel	RL_C	Red List name	EU28+
N1	N11	=	B1.1a	Atlantic, Baltic and Arctic sand beach	VU
	N11	=	B1.1a	Atlantic, Baltic and Arctic sand beach	VU
N13	N13	=	B1.3a	Atlantic and Baltic shifting coastal dune	NT
	N1A	=	B1.6a	Atlantic and Baltic coastal dune scrub	LC

EUNIS on map	EUNIS_C	Rel	RL_C	Red List name	EU28+
	MA22	<	RLA2.5c	Atlantic coastal salt marsh	VU
	MA222	<	A2.5c	Atlantic coastal salt marsh	VU
	MA223	<	A2.5c	Atlantic coastal salt marsh	VU
	MA224	<	A2.5c	Atlantic coastal salt marsh	VU
	MA225	<	A2.5c	Atlantic coastal salt marsh	VU
MA52	MA524	≈	A2.23	Polychaete/amphipod-dominated Atlantic littoral fine sand	DD
	MA523	≈	A2.22	Barren or amphipod-dominated Atlantic littoral mobile sand	DD
	MA525	≈	A2.24	Polychaete/bivalve-dominated Atlantic littoral muddy sand	DD
	MA621	≈	A2.33	Marine Atlantic littoral mud with associated communities	EN
	MA622	≈	A2.32	Polychaete/ oligochaete-dominated upper estuarine Atlantic littoral mud	EN
	MB12	>	A3.2x	Macaronesian seaweed communities on moderate energy infralittoral rock	DD
MB52	MB524	>	A5.22	Estuarine Atlantic sublittoral sand	DD
MC52	MC521	>	A5.25	Atlantic upper circalittoral fine sand	EN

3.3.2 Venice Lagoon

The Red List status was assigned to each EUNIS habitat in Venice Lagoon, however, there are some concerns regarding the assignment of the Red List type A2.5d saltmarshes. This code encompasses not only Mediterranean but also Black Sea lagoon and estuarine salt marshes. The current classification tends to push the result towards a "nearly threatened" status. While this may be applicable to the Black Sea, where saltmarshes remain relatively well conserved, it doesn't accurately reflect the situation in the Mediterranean areas. Therefore, on a Mediterranean scale, the conservation status is changed to ‘endangered’.

A similar concern is raised by the assignment of the status "Least concern" to seagrasses beds. While this may be realistic on a European scale, it does not reflect the current situation in the Mediterranean Sea, potentially leading to the misconception that these habitats are of low priority; on the contrary, they are extremely important from an ecological functionality perspective and face significant anthropogenic pressures in Mediterranean coastal lagoons. Therefore, the conservation status is changed to ‘endangered’.

Table 32. Red List Habitat status for assigned EUNIS habitats in pilot area Venice Lagoon.

EUNIS on map	EUNIS_C	Rel	RL_C	Red List name	EU28+
	MA251	<	A2.5d	Mediterranean and Black Sea coastal salt marsh	***EN***
	MA252	<	A2.5d	Mediterranean and Black Sea coastal salt marsh	***EN***
	MA253	<	A2.5d	Mediterranean and Black Sea coastal salt marsh	***EN***

MB6511	MA651	>	A2.31	Communities of Mediterranean mediolittoral mud estuarine	EN
	MB553	≈	A5.28	Faunal communities of sheltered Mediterranean infralittoral muddy sands	DD
	MB45	>	A5.5x	Communities of Mediterranean infralittoral coastal detritic bottoms	NT
MB65	MB652	≈	A5.32	Communities of Mediterranean sublittoral estuarine sediments	VU
MB5532-5535	MB553	≈	A5.28	Faunal communities of sheltered Mediterranean infralittoral muddy sands	DD
MB5532-5535	MB553	>	A5.53	Seagrass beds (other than Posidonia) on Mediterranean infralittoral sand	***EN***
MB5532-5535	MB553	>	A5.52b	Algal dominated communities in the Mediterranean infralittoral sediment	EN

3.3.3 Ebro Delta

The Red List status was assigned to each EUNIS habitat in the Ebro Delta. For the compound habitat type X02 ´Saline coastal lagoons´ a Red List status is not available and it was decided to assign it 'endangered'.

Table 33. Red List Habitat status for assigned EUNIS habitats in pilot area Ebro Delta.

EUNIS on map	EUNIS_C	Rel	RL_C	Red List name	EU28+
MA2533	MA253	<	A2.5d	Mediterranean and Black Sea coastal salt marsh	NT
	N12	=	B1.1b	Mediterranean and Black Sea sand beach	NT
N141	N14	=	B1.3b	Mediterranean, Macaronesian and Black Sea shifting coastal dune	VU
C3.23	C3.2	#	C5.1a	Water-fringing reedbeds and tall helophytes other than canes	LC
D5.11	D5.1	# MOV	C5.1a	Reedbeds normally without free-standing water	LC
C2	C2.3	=	C2.3	Permanent non-tidal, smooth-flowing watercourses	LC
	X02			Saline coastal lagoons	***EN***

3.3.4 Arcachon Bay

The Red List status was assigned to each EUNIS habitat in Arcachon Bay, with the exception of D ´Mires, bogs and fens´ and the non-natural type J2.53-2012 ´Sea walls´.

Table 34. Red List Habitat status for assigned EUNIS habitats in pilot area Arcachon Bay.

EUNIS on map	EUNIS_C	Rel	RL_C	Red List name	EU28+
	MA523	≈	A2.22	Barren or amphipod-dominated Atlantic littoral mobile sand	DD
	MA524	≈	A2.23	Polychaete/amphipod-dominated Atlantic littoral fine sand	DD
	MA525	≈	A2.24	Polychaete/bivalve-dominated Atlantic littoral muddy sand	DD
	MA22	<	RLA2.5c	Atlantic coastal salt marsh	VU
	MA522	<	A2.61	Seagrass beds on Atlantic littoral sediments	NT
	MB524	>	A5.22	Estuarine Atlantic sublittoral sand	DD
	MB523	>	A5.23	Marine Atlantic infralittoral fine sand	DD
	MB523	>	A5.24	Marine Atlantic infralittoral muddy sand	NT
MB62	MB624	>	A5.33	Marine Atlantic infralittoral sandy mud	NT
	MB423	≈	A5.43	Marine Atlantic infralittoral mixed sediments	DD
	MB522	>	A5.53	Seagrass beds on Atlantic infralittoral sand (non-Macaronesian)	CR
	N11	=	B1.1a	Atlantic, Baltic and Arctic sand beach	VU
	C1.3	#	C1.2b	Mesotrophic to eutrophic waterbody with vascular plants	NT
C1.51	C1.5	=	C1.5	Permanent inland saline and brackish waterbody	NT
	T35	=	G3.4a	Temperate and continental Pinus sylvestris woodland	NT

3.3.5 Vistula Lagoon

The Red List status was assigned to the R2 habitat in Vistula Lagoon.

Table 35. Red List Habitat status for assigned EUNIS habitats in pilot area Vistula Lagoon.

EUNIS on map	EUNIS_C	Rel	RL_C	Red List name	EU28+
R2	R21	≈	E2.1a	Mesic permanent pasture of lowlands and mountains	VU

3.3.6 Sicily Lagoon

The Red List status was assigned to each EUNIS habitat in Sicily Lagoon for which a Red List status is available. In the EUNIS map for Sicily Lagoon, habitat V13 'Arable land with unmixed crops grown by low-intensity agricultural methods' is included. On European scale this habitat is listed as EN, however, this particular habitat is not EN in the Sicily Lagoon pilot site. It is true that agricultural practices in the region progressively switched from particulate, family-scale cultivation to greenhouse high-intensity practices from the 1960s to now, but judged from for the land cover use at a broader scale (for the whole South-East of Sicily region) the status is changed to LC.

The compound habitat type X02 'Saline coastal lagoons' is not listed on the Habitats Red List. In the Sicily Lagoon pilot site, these lagoons are heavily degraded due to reshaping (to saltpans and fish culture ponds), reduction of surface, excess of nutrients (which favoured reedbeds invasive species) and improper waste disposal. There are several examples in the region of these environments being "squeezed" by urban areas and/or infrastructures, reducing their natural accommodation space with a range of consequences (hydraulic risk, bird biodiversity etc.). Therefore, we assigned EN.

Table 36. Red List Habitat status for assigned EUNIS habitats in pilot area Sicily Lagoon.

EUNIS on map	EUNIS_C	Rel	RL_C	Red List name	EU28+
	D5.1	# MOV	C5.1a	Tall-helophyte bed	LC
MA2252	MA225	<	A2.5c	Atlantic coastal salt marsh	VU
MA25	MA251	<	A2.5d	Mediterranean and Black Sea coastal salt marsh	NT
MA2515	MA251	<	A2.5d	Mediterranean and Black Sea coastal salt marsh	NT
N3	N32	=	B3.1b	Mediterranean and Black Sea rocky sea cliff and shore	LC
	N12	=	B1.1b	Mediterranean and Black Sea sand beach	NT
	N14	=	B1.3b	Mediterranean and Black Sea shifting coastal dune	VU
R1A5	R1A	=	E1.2a	Semi-dry perennial calcareous grassland (meadow steppe)	VU
	R1E	=	E1.3b	Mediterranean tall perennial dry grassland	LC
	S54	=	F5.5	Thermomediterranean scrub	VU
	V13	=	I1.3	Arable land with unmixed crops grown by low-intensity agricultural methods	***LC***
	X02			Saline coastal lagoons	***EN***

3.3.7 Foros Bay

The Red List status was assigned to each EUNIS habitat in Foros Bay, with the exception of MA44 'Black Sea littoral mixed sediment' and R6352 'Western Pontic glasswort-seablite-saltwort swards' for which no Red List status is available.

Table 37. Red List Habitat status for assigned EUNIS habitats in pilot area Foros Bay.

EUNIS on map	EUNIS_C	Rel	RL_C	Red List name	EU28+
MA14	MA141	≈	A1.15	Pontic Supralittoral Rock	DD
	MA241	<	A2.5d	Mediterranean and Black Sea coastal salt marsh	NT
MA34	MA341	≈	A2.132	Pontic mediolittoral cobbles and gravels	DD
MA44	MA441	≈	A2.42	Communities of Marmara littoral mixed sediment	-
MA54	MA541	≈	A2.2x	Pontic mediolittoral sands	DD
MA64	MA641	≈	A2.32	Polychaete/oligochaete-dominated upper estuarine Pontic littoral mud	DD
MB14	MB141	≈	A3.3w	Invertebrate-dominated Pontic lower infralittoral rock	DD
MB24	MB241	≈	A5.61	Polychaete worm reefs in the Pontic infralittoral zone	DD
MB24	MB242	≈	A5.62	Mussel beds in the Pontic infralittoral zone	DD
MB24	MB243	≈	A5.64	Oyster reefs on Pontic lower infralittoral rock	DD
MB34	MB341	≈	A5.a	Fauna-dominated Pontic infralittoral cobbles and gravels	DD
	MB44	≈	A5.13	Pontic infralittoral mixed substrata	DD
MB54	MB541	≈	A5.22	Estuarine Pontic infralittoral sand	DD
	MB546	≈	A5.53	Seagrass and rhizomatous algal meadows in Pontic freshwater-influenced sheltered infralittoral muddy sands and sandy muds	NT
MB64	MB641	≈	A5.34	Pontic infralittoral fine mud	DD
	N12	=	B1.1b	Mediterranean and Black Sea sand beach	NT
	N14	=	B1.3b	Mediterranean, Macaronesian and Black Sea shifting coastal dune	VU
	Q51	#	C5.1a	Tall-helophyte bed	LC

3.3.8 Rhône Delta

The Red List status was assigned to each EUNIS habitat in Rhône Delta for which a status is available.

Table 38. Red List Habitat status for assigned EUNIS habitats in pilot area Rhône Delta.

EUNIS on map	EUNIS_C	Rel	RL_C	Red List name	EU28+
MB55	MB551	<	A5.23	Faunal communities in Mediterranean infralittoral fine sand	DD
N122	**N12**	**=**	**B1.1b**	Mediterranean and Black Sea sand beach	NT
N121	N12	=	B1.1b	Mediterranean and Black Sea sand beach	NT
	MA225	<	A2.5c	Atlantic coastal salt marsh	VU
MA2533; R613	R61	≈	E6.1	Mediterranean inland salt steppe	VU
MA2511; MA2512; MA2513; MA2521; MA2531	MA252	<	A2.5d	Mediterranean and Black Sea coastal salt marsh	NT
MA2515; MA2516; MA2517; MA2518; MA2519	MA251	<	A2.5d	Mediterranean and Black Sea coastal salt marsh	NT
R6111	R61	≈	E6.1	Mediterranean inland salt steppe	VU
N141	N14	=	B1.3b	Mediterranean and Black Sea shifting coastal dune	VU
N144	N14	=	B1.3b	Mediterranean and Black Sea shifting coastal dune	VU
N1J3; N1J5	N1J	=	B1.8b	Mediterranean and Black Sea moist and wet dune slack	LC
N161	N16	=	B1.4b	Mediterranean and Macaronesian coastal dune grassland (grey dune)	EN
N165; R1A5	N16	=	B1.4b	Mediterranean and Macaronesian coastal dune grassland (grey dune)	EN
N1B2	N1B	=	B1.6b	Mediterranean and Black Sea coastal dune scrub	VU
	N1G	=	B1.7d	Mediterranean coniferous coastal dune woodland	LC
C1.14; C1.25	C1.1	#	C1.2a	Permanent oligotrophic to mesotrophic waterbody with Characeae	VU
C1.33	C1.3	#	C1.2b	Mesotrophic to eutrophic waterbody with vascular plants	NT
C3.421	C3.4	#	C5.1b	Small-helophyte bed	NT
	R1D	=	E1.3a	Mediterranean closely grazed dry grassland	LC
T11; T14	T14	=	G1.3	Mediterranean and Macaronesian riparian woodland	VU
	C1.4	=	C1.4	Permanent dystrophic waterbody	NT

EUNIS on map	EUNIS_C	Rel	RL_C	Red List name	EU28+
C1.341	C1.3	#	C1.1b	Permanent oligotrophic to mesotrophic waterbody with soft-water species	LC
C3.27; C1.341	C3.2	#	C5.1a	Tall-helophyte bed	LC
C3.211	C3.2	#	C5.1a	Tall-helophyte bed	LC
C3.23	C3.2	#	C5.1a	Tall-helophyte bed	LC
	R22	=	E2.2	Low and medium altitude hay meadow	VU
V32; R21	R21	≈	E2.1a	Mesic permanent pasture of lowlands and mountains	VU
S51JA3	S51	=	F5.1	Mediterranean maquis and arborescent matorral	LC
S3551	S35	=	F3.1e	Temperate and submediterranean thorn scrub	LC
S93131	S93	=	F9.3	Mediterranean riparian scrub	LC
S935	S93	=	F9.3	Mediterranean riparian scrub	LC
U5; MA225	MA225	<	A2.5c	Atlantic coastal salt marsh	VU

3.3.9 Nahal Dalia

The Red List status was assigned to each EUNIS habitat in Nahal Dalia for which a status is available.

Table 39. Red List Habitat status for assigned EUNIS habitats in pilot area Nahal Dalia.

EUNIS on map	EUNIS_C	Rel	RL_C	Red List name	EU28+
	N1J	=	B1.8b	Mediterranean and Black Sea moist and wet dune slack	LC
	C3.2	#	C5.1a	Tall-helophyte bed	LC
C3.2111	C3.2	#	C5.1a	Tall-helophyte bed	LC
N162	N16	=	B1.4b	Mediterranean and Macaronesian coastal dune grassland (grey dune)	EN
N124	N12	=	B1.1b	Mediterranean and Black Sea sand beach	NT
N1B1	N1B	=	B1.6b	Mediterranean and Black Sea coastal dune scrub	VU
S7242	S72	=	F7.3	Eastern Mediterranean spiny heath (Phrygana)	LC
	C2.3	=	C2.3	Permanent non-tidal, smooth-flowing watercourse	LC

4. Visualization of indicator scores for ESS and BDV in REST-COAST

4.1 Introduction and aims

For each REST-COAST case study a EUNIS (sub)habitat map was made and homogeneous rank scores for five ecosystem services and biodiversity indicators were developed and assigned to each EUNIS (sub)habitat. The next step is to assess spatial changes in the type or size of EUNIS habitats, either resulting from climate change and/or restoration responses, for their effect on ESS and BDV. The overall aim is to assess the extent to which climate change leads to a deterioration of ecosystem services and biodiversity value and which restoration measures can help mitigating the effects of climate change.

First, for each pilot area a total score for ESS and BDV is calculated for the present situation, i.e. the present distribution of EUNIS (sub)habitats in the area. Next, a change in EUNIS sub(habitats) is predicted (either by numerical modelling or semi-quantitatively), which leads to a relative change in the score for ESS and BDV. These changes are predicted for climate change as well as for short-, medium- or long-term restoration measures. By comparing the size (from very large to very small and no change) and direction (decrease, increase or no change) of the relative changes in the scores for ESS and BDV, a final assessment for restoration effects on ecosystem services and biodiversity gains under climate change can be made. For this final step a transfer function has been developed.

4.2 General methodology for ESS scores

An overall score for each of five ecosystem services (WP, CCR, FP, RCE & RFR) is calculated by summing the product of each EUNIS habitat's area with the rank score of the ESS for that EUNIS habitat:

$$ESS_{tot} = \sum_{i=1}^{n} Area_i \times ESS_i$$

where ESS_{tot} is the total score for a (one of five) ESS in a pilot area, *n* is the number of EUNIS (sub)habitats, $Area_i$ is the surface area (m^2) of EUNIS habitat *i* and ESS_i is the rank score (0 to 5) of the ecosystem service for EUNIS habitat *i*.

Any change in surface area of EUNIS (sub)habitats for a future situation, either due to climate change scenarios or restoration activities, leads to a change in the overall score ESS_{tot}. The change is calculated as a relative change:

$$ESS_{rel,2} = \frac{ESS_{tot,2} - ESS_{tot,1}}{ESS_{tot,1}}$$

where $ESS_{rel,2}$ is the relative change in the ESS-score at time 2 with respect to time 1, $ESS_{tot,1}$ is the total ESS score at the (initial) time 1 and $ESS_{tot,2}$ is the total ESS score at the (next) time 2.

The relative change in the total score for the ESS is a value between -1 and +1 and expresses the magnitude of improvement (+) or deterioration (-) in the delivery of a specific ecosystem service.

4.3 General methodology for BDV scores

For scoring the changes in the biodiversity value a similar methodology is applied as for scoring ESS. An overall score for each BDV-status (Red List habitat status CO > CR > EN > VU > NT > LC > DD > NE) is calculated by summing the areas for EUNIS habitats that have a particular BDV-status:

$$BDV_{tot} = \sum_{i=1}^{n} Area_i$$

where BDV_{tot} is the total area for a certain BDV-status in a pilot area, n is the number of EUNIS (sub)habitats having that BDV-status, $Area_i$ is the surface area (m^2) of EUNIS habitat i having that status.

Any change in surface area of EUNIS (sub)habitats for a future situation, either due to climate change scenarios or restoration activities, leads to a relative change in the overall areas for the BDV-status. The change is calculated as a relative change:

$$BDV_{rel,2} = \frac{BDV_{tot,2} - BDV_{tot,1}}{BDV_{tot,1}}$$

where $BDV_{rel,2}$ is the relative change in the BDV-area at time 2 with respect to time 1, $BDV_{tot,1}$ is the total BDV-area at the (initial) time 1 and $BDV_{tot,2}$ is the total BDV-area at the (next) time 2.

The relative change in the total area is a value between -1 and +1 and expresses the magnitude of increase (+) or decrease (-) in the surface area of habitat having that BDV-status. A shift towards more area of BDV-status CR, EN or VU is an improvement, as it indicates the expansion of habitats that have become rare in Europe. On the contrary, an increase in the area of NT or LC is a deterioration of the biodiversity value, as it suggests the expansion of habitats that are more common.

4.4 Scale issues in scoring relative changes

The maps for broad-scale habitats in the EUNIS classification fit well to the scale of archetypical coastal landscapes of river-delta systems and estuaries for which upscaling of coastal restoration plans is desired. The use of these maps also fits well to the output of numerical models for hydrodynamics and morphodynamics. These models usually have computational cells of several hundreds of meters to kilometres. With these models the most important physical conditions for EUNIS habitats can be modelled, such as (changes in) water depth and coastal profiles, sediment characteristics and salinity. These models can thus be applied to predict changes in the extent and distribution of EUNIS habitats under scenarios of climate change.

However, the scale that is typical for coastal restoration measures is usually a lot smaller than the landscape scale. These measures range over only several to tens of hectares (Arcachon, Nahal Dalia), or some hundreds of hectares (Ebro delta, Sicily, Vistula Lagoon). Large-scale restoration schemes the size of thousands of hectares also exist (Rhône Delta, Venice Lagoon and Wadden Sea) but these take place in large pilot areas. The consequence of this is that the effect of coastal restoration measures is often hardly noticeable in terms of relative change in ESS-scores or BDV-status at the pilot scale. The relative change can be in the order of a few percent. On the other hand, in some pilot studies restoration measures are carried out resulting in changes of tens of percents. The challenge was to find a homogeneous method to express these changes and for that a transfer function is applied.

4.5 Methodology of applying a transfer function

To overcome the problem of comparing minor changes (some percents) with major changes (tens of percents) in the total scores for ESS or BDV, a transfer function is implemented. The transfer function has the form of a sigmoid curve that outputs between -5 to +5 in the domain of -1 to +1:

$$\sigma(x) = \frac{10}{1 + e^{-kx}} - 5$$

where σ is the sigma-score between -5 and 5, x is the relative change in ESS-score $ESS_{rel,2}$ or BDV-status $BDV_{rel,2}$ between -1 and +1 and k (>0) is a shape parameter for which k=10.

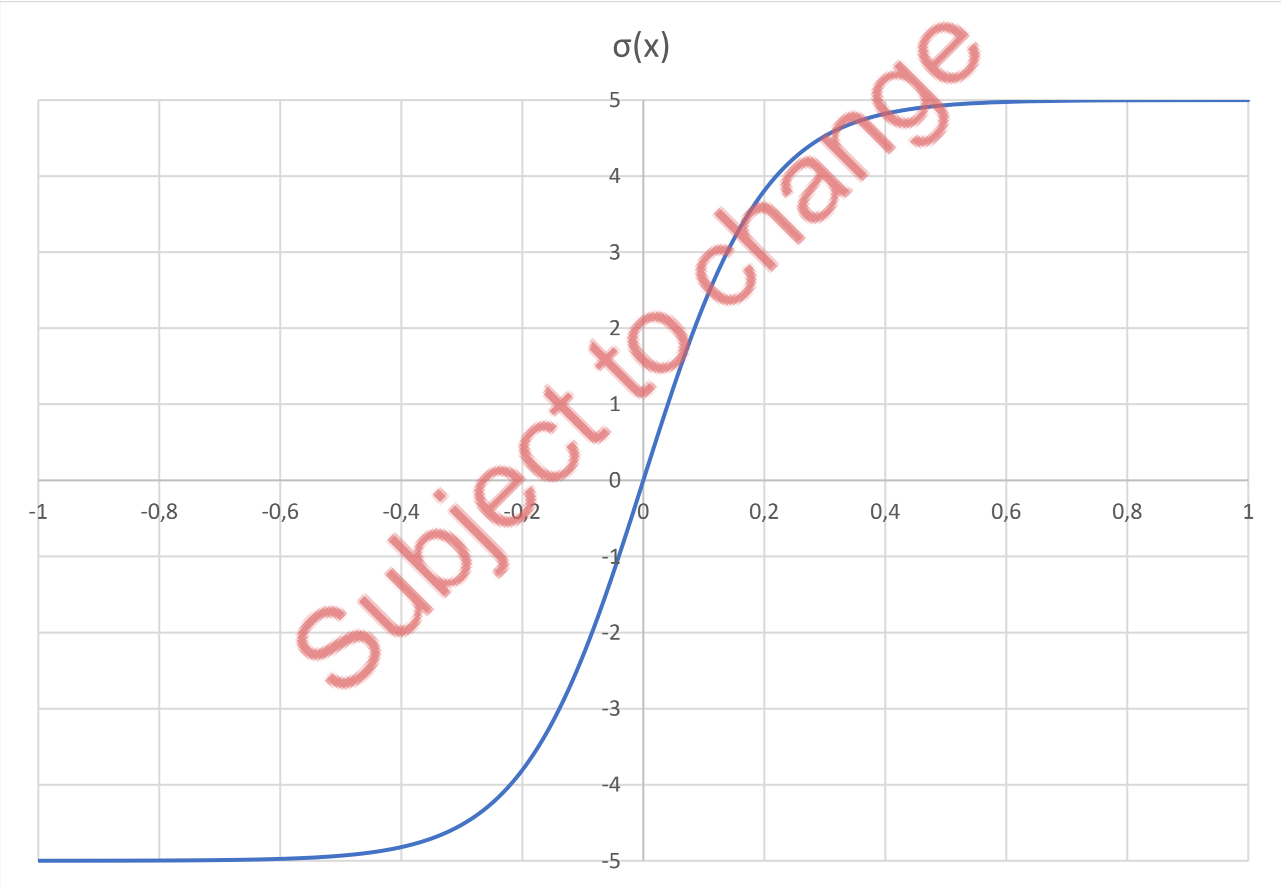


Figure 25. Shape of the sigmoid transfer function for relative changes.

The shape of the sigmoid curve approaches a steep linear profile in the domain -0.1 to 0.1, meaning that the function shows high sensitivity to small changes in the order of percents (-10% up to +10%), which are translated to sigma-scores between -2.3 to +2.3. For large changes in the order of 10-40% the shape gently curves to sigma-scores of 2.3 to 4.8 (or -4.8 to -2.3). Any big change larger than 40% results in sigma-scores approaching 5 (or -5). The resulting sigma-score is transformed into eleven classes of change (for an increase or decrease) following Table 40. This way the relative change in an ESS-score or BDV-status is expressed in a homogeneous metric for ESS gains or losses or BDV gains or losses.

Table 40. Transformation of sigma-scores to rounded classes, their meaning in terms of magnitude of change and the relative change in percentage.

σ-score	-5 to -4	-4 to -3	-3 to -2	-2 to -1	-1 to 0	0	0 to 1	1 to 2	2 to 3	3 to 4	4 to 5
rounded	-5	-4	-3	-2	-1	0	1	2	3	4	5
meaning	very large decrease	large decrease	medium decrease	small decrease	very small decrease	No change	very small increase	small increase	medium increase	large increase	very high increase
%change	100 to -22	-22 to -13.9	-13.9 to -8.5	-8.5 to -4.1	-4.1 to 0	0	0 to 4.1	4.1 to 8.5	8.5 to 13.9	13.9 to 22	22 to 100

Examples

Suppose we have a pilot area with scores for each of the five ESS at time 2 compared to time 1, resulting in relative changes in the order of percents, than Table 41 may be the result. In this example all scores for all ecosystem services have improved. Similarly for changes in scores of each of the Red list status for BDV in Table 42. In this case there was a severe decrease in habitats with status Vulnerable and increases in habitats with status EN, NT and DD.

Table 41. Example table of scoring changes in ecosystem services.

ESS-score	Score at time 2	Score at time 1	Rel. change	Sigma-score
Score_RCE	8.85514E+11	8.01514E+11	0.105	3
Score_FP	1.33316E+12	1.29616E+12	0.029	1
Score_CCR	1.68805E+12	1.56505E+12	0.079	2
Score_RFR	4.30378E+11	4.08378E+11	0.054	2
Score_WP	1.36838E+12	1.26538E+12	0.081	2

Table 42. Example table of scoring changes in biodiversity values.

Red List Status	Area at time 2 (ha)	Area at time 1 (ha)	Rel. change	Sigma-score
CR	0	0	0.000	0
EN	19832075	18132075	0.094	3
VU	8271648	12471648	-0.337	-5
NT	24615578	22915578	0.074	2
LC	0	0	0.000	0
DD	9538224	8738224	0.092	3

5. Conclusion

We report a scorecard methodology for coastal system behaviour considering indicators and homogeneous metrics for restoration effects on ESS and BDV gains under climate change. The methodology is based on the EUNIS standardized description of natural habitats in Europe. For each REST-COAST case study a EUNIS (sub)habitat map was made. Next, homogeneous rank scores for five ecosystem services and biodiversity indicators were developed and assigned to each EUNIS (sub)habitat. Spatial changes in the type or size of EUNIS habitats resulting from climate change and/or restoration responses then lead to changes in the overall score of ecosystem services and biodiversity value in a pilot area. To visualize the effect of restoration measures in pilot areas with different spatial scales a novel scoring system with a transfer function is developed to show homogeneous scores.

This scoring system forms the basis of the Quick Scan Tool (QST), which is in development in Work Package 4 (T4.4) of REST-COAST. The QST is a digital tool designed to support the development of (regional / local) coastal restoration strategies to improve ecosystem services and biodiversity. It will provide visualization of results to facilitate decision-making and will be elaborately reported in a later stage.

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