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WP 5	Deliverable No. 5.4

MARBEFES Project

Title: **(A) Report on the synthesis reviews, including gap analysis results** **Delivery date:** M18 (February 2024)
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Submission date 29 February 2024

MARBEFES project has received funding from the European Union's Horizon Europe research and innovation programme under Grant Agreement no 101060937

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Disclaimer

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Abbreviation list

EU	European Union
MS	Member States
BBT	Broad Belt Transect
MPAs	Marine Protected Areas
DAPSI(W)R(M)	Drivers-Activities-Pressures-State-Impacts(Welfare)-Responses(Measures)
BowTA	Bow-tie analysis
RCP	Representative Concentration Pathway

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Summary

The main aim of the MARBEFES project is to determine the links between biodiversity and ecological structure with the functioning of coastal and marine ecosystems and the resulting ecosystem services and societal goods and benefits.

In order to contribute to evidence-based knowledge for policy purposes, MARBEFES has developed a six-step methodology that will allow the Consortium to identify and analyse the major concerns in relation to biodiversity change in 12 representative cases from European seas, These are the Broad Belt Transects (BBTs), which are replicated 3 times in each of the regional seas (Artic, Baltic, Northeast Atlantic and Mediterranean). The entire process is carried out through comparison between the causality patterns deriving from stakeholders' views from each BBT and one-to-one interviews with researchers of each BBT (step 1). In step 2, the bow-tie analysis (BoTA), will allow the identification of the main drivers and consequences of those changes in biodiversity in each BBT. It will also capture prevention measures for its drivers, and mitigation measures for its impacts. These drivers will be compared against an overall framework of causes of biodiversity decline developed in previous EU projects (step 3). Through the application of high-level scenarios (step 4) and its quantification (step 5), bow-ties under different scenarios will be obtained for each BBT (step 6).

This report "(A) Synthesis reviews, including gap analysis results" describes the above methodology as well as the criteria for the selection of high-level scenarios to be applied (Sustainability, Regional rivalry and Fossil-fuelled development from the 6th IPCC Assessment Report).

As an example of the preliminary results obtained (steps 2-3), this report shows the results from the Curonian lagoon / Lithuanian Coast Broad Belt Transect. It also points out the next steps which results will be included in "(B) Synthesis reviews, including gap analysis results" (due June 2026, M44 of the project).

This knowledge will help to prioritise lines of potential policy/ management interventions that would be modelled for each BBT, according to the data available.

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1. Introduction

EU Member States need to understand how biodiversity and ecosystem functioning must be maintained to ensure the delivery of ecosystem services, goods and benefits, which, in turn, must be sustainably used by society. The European Commission has funded MARBEFES, a 4-year project that, through 23 highly experienced partners, aims to determine the links between the above elements. MARBEFES will guide Member States in the understanding of the causes and consequences of the maintenance, loss and gain of biodiversity and ecological and economic value and their repercussions for the management and governance of the European seas.

The core of the project is the development and validation of a set of ecological, economic and socio-cultural valuation tools, using existing and new information and data in 12 Broad Belt Transect (BBT) case studies from Europe. These case studies cover the breadth of European marine biodiversity, from the Arctic to sub-tropical areas, across dominant habitats and iconic species, and from shallow to deep areas and encompass a range of socio-economic contexts (see Figure 1; Table 1).

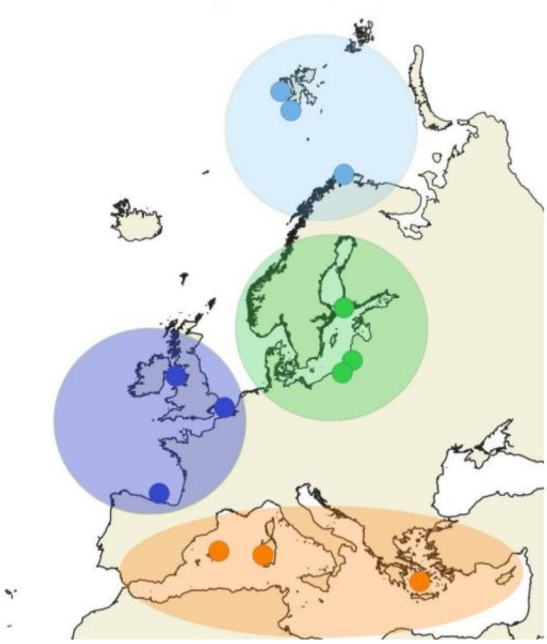

Figure 1. The MARBEFES Broad Belt Transects (BBTs) in the Artic, Baltic, NE Atlantic and Mediterranean (from MARBEFES Grant Agreement).

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Table 1. Overview of case study sites within the BBTs and their main characteristics.

Region	BBT	Biodiversity	Max depth	Openness	Salinity	Dominant activities
Arctic	Porsanger fjord-Barents Sea	Moderate	300 m	Fjord	Oceanic	Fishing, tourism, shipping, oil, gas
Arctic	South Spitsbergen	Moderate	300 m	Shallow fjord	Oceanic	Moderate tourism, research, moderate fishing
Arctic	North Spitsbergen	Moderate	500m	Deep fjord	Oceanic	Moderate tourism, research, moderate fishing
Baltic	Finnish Archipelago	Low	100m	Inner-outer archipelago	Brackish	Tourism, fishing, shipping
Baltic	Curonian lagoon-Lithuanian coast	Low	40m	Lagoon-open sea	Brackish	Tourism, fishery, shipping
Baltic	Gulf of Gdansk	Low	100m	Open bay	Brackish	Tourism, fishery, shipping
Atlantic	Belgium-Dogger bank	Moderate	40m	Open sea	Coastal sea	Shipping, windfarms, urban
Atlantic	Liverpool-Dublin Bay	Moderate	150m	Channel	Coastal sea	Fishing, windfarms, urban, recreation
Atlantic	Southern Gulf of Biscay	Moderate	30 m	Open coast	Oceanic	Fishery, shipping, industry, urban, recreation.
Med	Balearic	High	200m	Open bay-channel	Coastal sea	Tourism, fishery, shipping
Med	Sardinia	High	150m	Lagoon-open sea	Coastal sea	Tourism, aquaculture, shipping
Med	Gulf of Heraklion	High	200m	Open bay-open sea	Coastal sea	Tourism, fishery, urban

Through stakeholder co-creation of evidence for policy development and implementation, MARBEFES demonstrates the tools to value different natural capital resources and inform planning activities ranging from financial allocations to management, demonstrated with both monetary and non-monetary benefits.

This report *"(A) Synthesis reviews, including gap analysis results*" is considered as a mid-term report framed in Work package 5 "*Integration and Scenarios*" that includes the methodology developed by the consortium to understand the detailed network of pathways of the causes of the main event(s) of "*biodiversity change*" for each BBT, and their consequences. In addition, to explore how high-level different scenarios could impact on those causes and consequences in order to point out management strategies for each BBT. These results will be used to identify the most important and useful aspects to present evidence-based knowledge for policy purposes.

This report presents an analysis of the preliminary results obtained to date. It points out the challenges and the way forward. The final version of this report "(B) *Synthesis reviews, including gap analysis results*" is to be delivered in June 2026 (M44 of the project). The final report will include the comprehensive results of applying at least 3 high-level scenarios to the causes and consequences of biodiversity decline in each of the BBTs.

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2. Methodology

2.1 Overview

This chapter describes the six-step methodology (Figure 2) followed, as designed by the consortium of MARBEFES. It summarizes the conclusions from several WP5 meetings and it integrates the output from the extensive discussions between partners during MARBEFES General Assembly (*29-31 August 2023, Klaipedas, Lithuania*).

This methodology forms in principle the Roadmap of WP5: Integration and Scenarios. It is based on the use of the ISO accredited and industry-compliant tool called bow-tie analysis (BowTA) to provide guidance for the BBTs to derive and test storylines[1] under different scenarios (See: *Elliott, M. 2023. Task 5.1 Guidance for Bow-tie Storyline Creation and Analysis at BBTs*). Bow-ties address a risk or problem and indicate the causes of that problem, ways to prevent those causes and eliminate or mitigate the resulting consequences that occur because of the problem.

As the proposed structure for the Bow-tie diagram analysis in MARBEFES (Figure 3), the central knot of the Bow-tie diagram represents the central event, and more concretely, a particular risk (e.g., change in biodiversity). The left side of this central event lists pathways of potential causes, whereas the right side of the central event lists consequences resulting from the event. Prevention measures to control, reduce or prevent the causes to occur are positioned along the pathways of risks on the left side of the central event (solutions to prevent the central event), whilst on the right side of the central event mitigation, compensation and/or complete recovery measures are depicted. Prevention measures are aimed at stopping the causes of the risk, stopping the hazard becoming a risk or reducing the likelihood that the hazard will occur or create consequent risks. Escalation factors, which undermine the effectiveness of a given prevention measure or a proposed mitigation measure, can also be added at both sides of the central theme along with additional barriers. Hence, BowTA scheme can accommodate uncertainty in risk management. The performance of management control in managing or reducing these uncertainties relies on a suite of barriers that eliminate, avoid or control the likelihood of a given risk to occur or to mitigate or recover from the consequences of a given risk. Barriers implemented closest to the sources of the risk (e.g., at the site of an activity) provide the greatest assurance in reducing uncertainty in achieving environmental management objectives. At the same time, determining the prevention or response to risk allows the opportunities to be defined for the sector in question to address impacts and enhance growth successfully.

[1] Storylines are defined in MARBEFES as “line of stories when applying different scenarios”.

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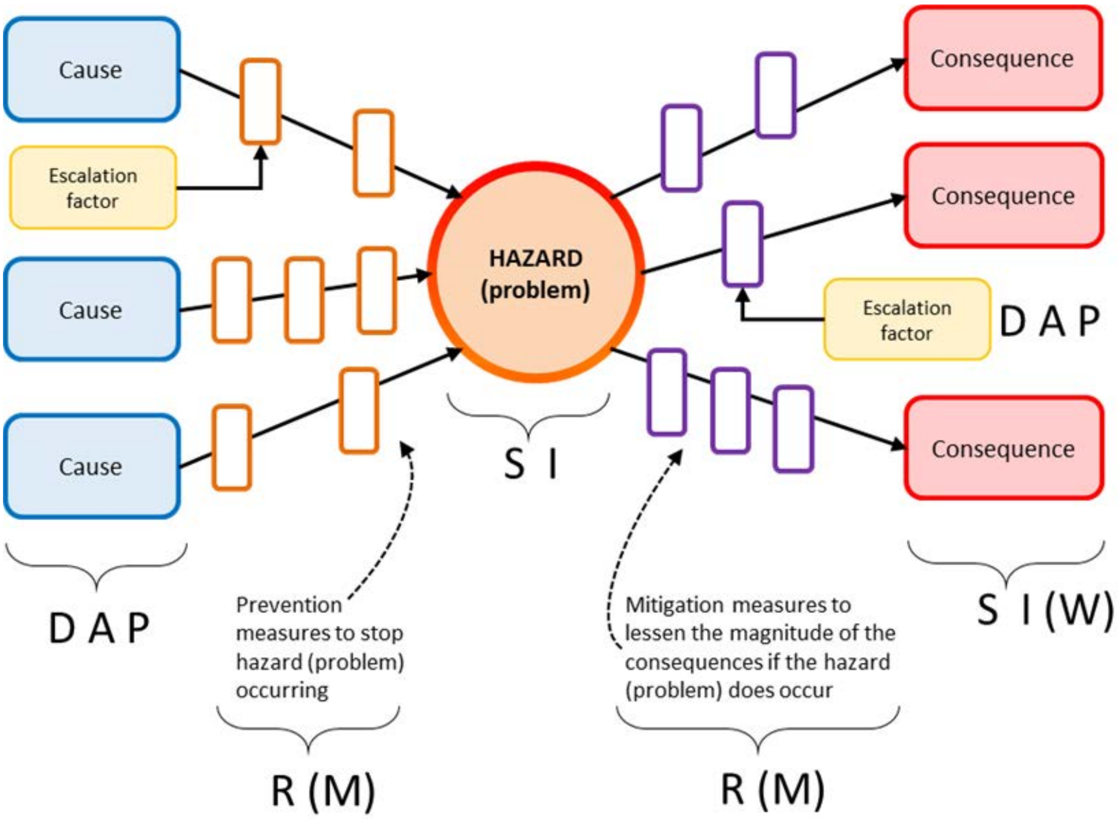

Figure 3. A simplified generic Bow-tie analysis (BowTA) structure overlain by the DAPSI(W)R(M)[2] framework. (Elliott, M., 2023)

The timeline of the six-step methodology has been designed so as to produce and present key results at the next General Assembly (October 2024, Dublin, Ireland).

[2] Drivers-Activities-Pressures-State-Impacts(Welfare)-Responses(Measures).

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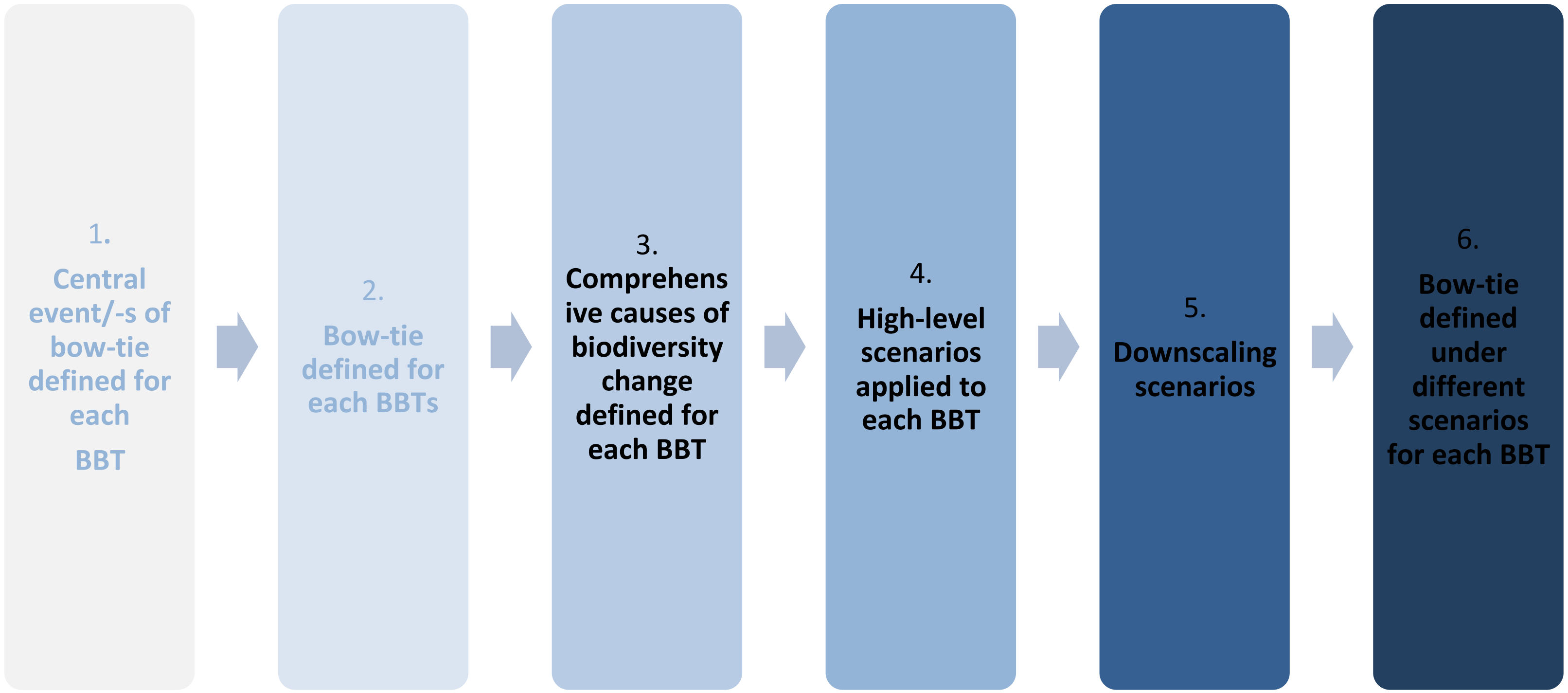

Figure 2. Six-step methodology on Synthesis and Integration

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2.2 Step 1. The major concern on biodiversity change in each BBT

Objective: To identify the central event in the BBTs, the major concern on biodiversity change in each BBT.

Methodology: Patterns of scientific views of the BBTs (primarily, Mind Maps produced by the partner BC3 as a result of one-to-one interviews with researchers of each BBTs) will be compared with those from Stakeholders views (WP1 results gathered by partner Hufoss after conducting physical workshops for consultation with stakeholders of each BBT), in order to suggest central event(s) of major concern for biodiversity change, at each BBT. The identification process could result in selecting more than one central event in case there might be several major concerns. BoTwA(s) can be applied individually or nested in series or stacked in parallel with other concerns.

It is worth mentioning that during the one-to-one interviews with scientists from the BBTs, the identification of data/models to back-up the BowTA are also to be prioritised. MARBEFES project will prioritise stakeholder´s views/issues in the centre of BowTA, but will also bring all scientific and research data and knowledge on these issues so as to better suggest what management actions could be applied to overcome some of these issues.

Results: **Central event of one or more bow-ties defined for each BBTs.**

Partners: Hufoss, UCD, IECS, BC3 Research, University of Klaipedas, responsible of each BBT(AKVAPLAN-NIVA, IOPAN, AAU, KU, VLIZ, CEFAS, UCD, UC, FIHAC, IMEDEA, CSIC, CNR-IAS, Oristano, HCMR) and LW ERIC.

Deadline: November 2023 (internally submitted).

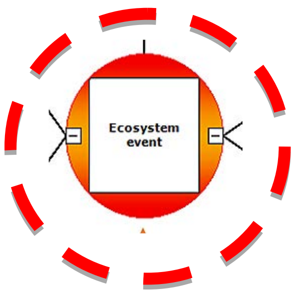

Figure 4. Central event characterisation schema in a bow-tie analysis (Source: Elliot, M. et al., 2019).

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2.3 Step 2. Causes and consequences (generic)

Objective: To determine (in general terms) causes and consequences of the central event(s) of biodiversity change in each BBT.

Methodology: Once the central event(s) of the bow-tie has been identified for each BBT, the potential causes (a) of the bow-tie will also be defined, as well as the consequences (b), through the results of the interviews with overarching stakeholders as well as through the internal data and knowledge of each BBT experts.

Results: Causes / Consequences definition for **bow-ties defined for all BBTs.**

Partners: Hufoss, IECS, responsible of each BBT (AKVAPLAN-NIVA, IOPAN, AAU, KU, VLIZ, CEFAS, UCD, UC, FIHAC, IMEDEA, CSIC, CNR-IAS, Oristano, HCMR) and LW ERIC.

Deadline: February 2024 (partially submitted internally).

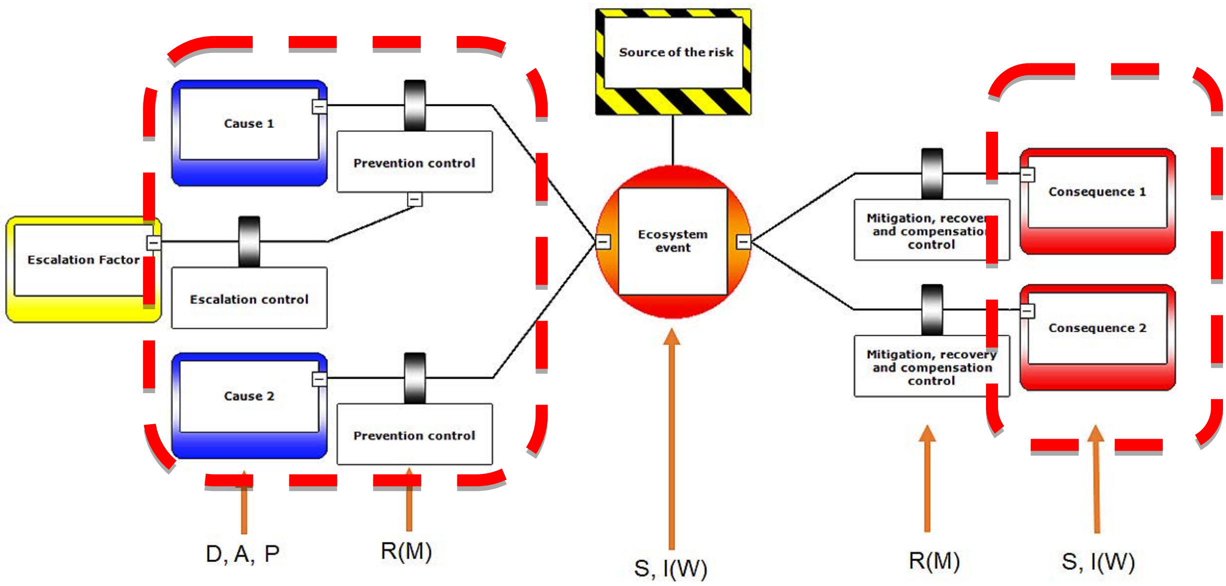

Figure 5. Causes (a) and consequences (b)characterisation schema in bow-tie analysis (Source: Elliot, M. et al, 2019).

2.4 Step 3. Causes and consequences (detailed)

Objective: To establish in detail the causes and consequences of the main event(s) of biodiversity change, for each BBT.

Methodology: Potential causes (a) of the main event of biodiversity change for each BBTs (Step 2.a) will be compared against the overall framework of causes of biodiversity decline

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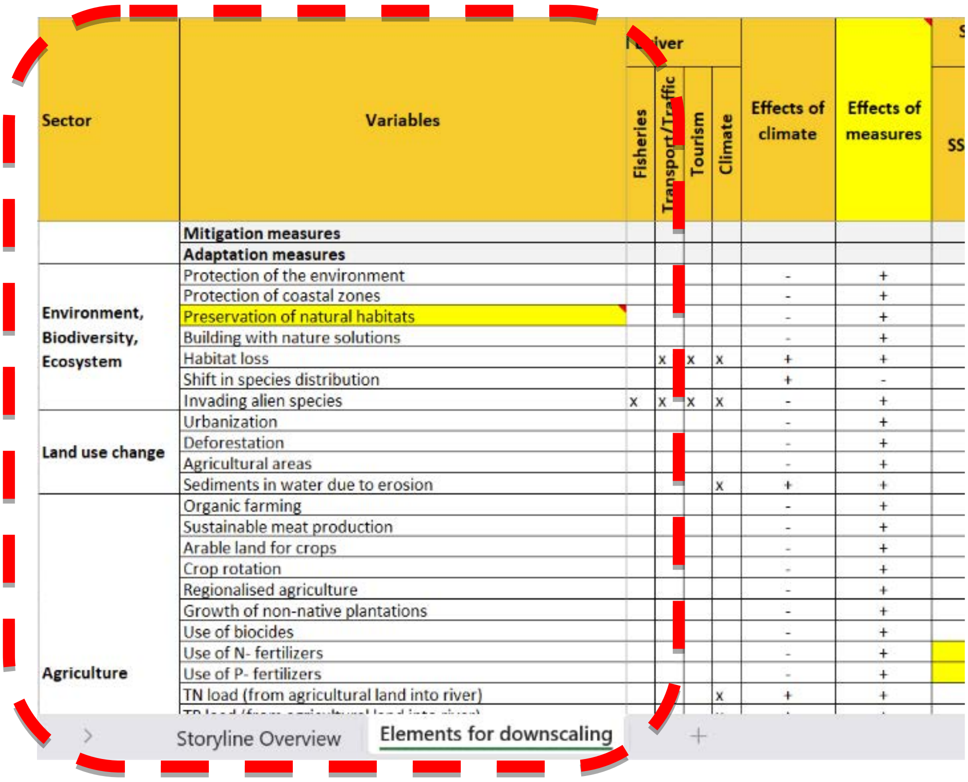
developed in the frame of the Land2Sea project (Mack et al., 2019). Consequences will also be expanded in more detail.

<u>Results</u>: **Comprehensive identification of causes of biodiversity change for each BBT.**

<u>Partners:</u> UCD, IECS, responsible of each BBT (AKVAPLAN-NIVA, IOPAN, AAU, KU, VLIZ, CEFAS, UCD, UC, FIHAC, IMEDEA, CSIC, CNR-IAS, Oristano, HCMR) and LW ERIC.

Deadline: March/April 2024.



Sector	Variables	…iver				Effects of climate	Effects of measures	SS
		Fisheries	Transport/Traffic	Tourism	Climate			
	Mitigation measures							
	Adaptation measures							
Environment, Biodiversity, Ecosystem	Protection of the environment					-	+	
	Protection of coastal zones					-	+	
	Preservation of natural habitats					-	+	
	Building with nature solutions					-	+	
	Habitat loss		x	x	x	+	+	
	Shift in species distribution					+	-	
	Invading alien species	x	x	x	x	-	+	
Land use change	Urbanization					-	+	
	Deforestation					-	+	
	Agricultural areas					-	+	
	Sediments in water due to erosion				x	+	+	
Agriculture	Organic farming					-	+	
	Sustainable meat production					-	+	
	Arable land for crops					-	+	
	Crop rotation					-	+	
	Regionalised agriculture					-	+	
	Growth of non-native plantations					-	+	
	Use of biocides					-	+	
	Use of N- fertilizers					-	+	
	Use of P- fertilizers					-	+	
	TN load (from agricultural land into river)				x	+	+	

Figure 6. Examples of variables that may vary among high level scenarios and influence biodiversity and ecosystem services (Source: Land2Sea project - Mack et al., 2019).

2.5 Step 4. Applying high-level scenarios to each BBT

<u>Objective</u>: Apply high-level scenarios to each BBT.

<u>Methodology</u>: Apply three different high-level scenarios to the comprehensive causes defined by each BBT, following the same methodology of the Land2Sea project, with overarching stakeholders, practitioners and scientists of each BBT.
Material will be produced to guide the discussions in each BBT.

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Results: **High-level scenarios applied to all BBTs.**

Partners: Hufoss, BC3 Research, University of Klaipeda, responsible of each BBT((IECS, AKVAPLAN-NIVA, IOPAN, AAU, KU, VLIZ, CEFAS, UCD, UC, FIHAC, IMEDEA, CSIC, CNR-IAS, Oristano, HCMR) and LW ERIC.

Deadline: May 2024.

See section 3 on the selection of High-level scenarios used from this methodological step.

2.6 Step 5. Quantifying the application of high-level scenarios to each BBT

Objective: Apply downscaling process to all BBTs. Quantify the results of applying high-level scenarios to each BBT.

Methodology: With the information gathered in Step 4, implement the downscaling process followed by the Land2Sea for each BBT.

Results: **Downscaling for all causes**.

Partners: UCD, LW ERIC and IECS.

Deadline: June 2024.

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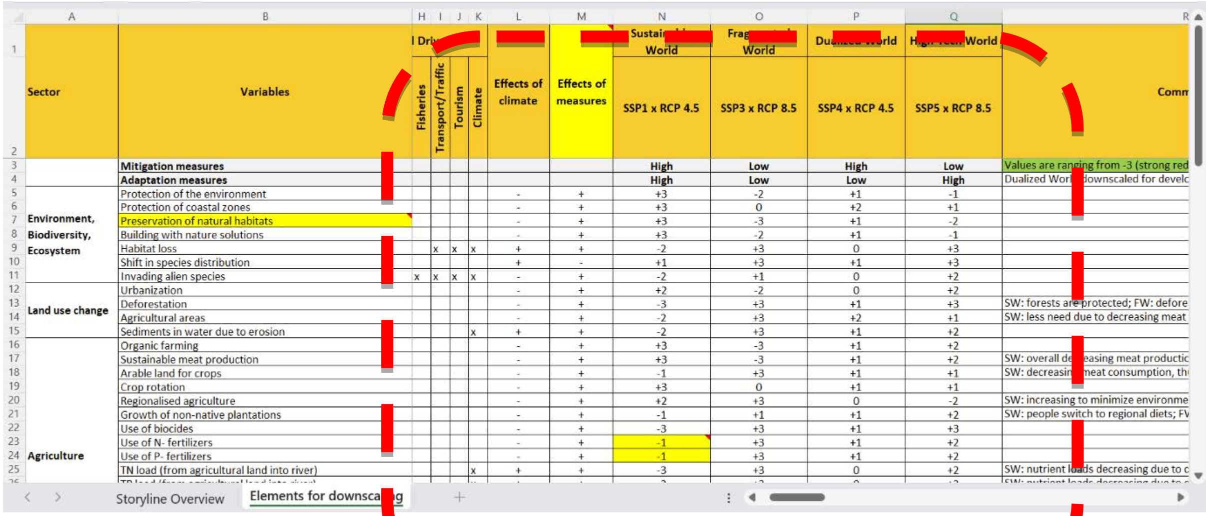


	A	B	H	I	J	K	L	M	N	O	P	Q	R
1			l Dri						Sustainable World	Fragmented World	Dualized World	High-Tech World	
2	Sector	Variables	Fisheries	Transport/Traffic	Tourism	Climate	Effects of climate	Effects of measures	SSP1 x RCP 4.5	SSP3 x RCP 8.5	SSP4 x RCP 4.5	SSP5 x RCP 8.5	Comm
3		**Mitigation measures**							**High**	**Low**	**High**	**Low**	Values are ranging from -3 (strong red
4		**Adaptation measures**							**High**	**Low**	**Low**	**High**	Dualized World downscaled for develo
5	**Environment, Biodiversity, Ecosystem**	Protection of the environment					-	+	+3	-2	+1	-1	
6		Protection of coastal zones					-	+	+3	0	+2	+1	
7		Preservation of natural habitats					-	+	+3	-3	+1	-2	
8		Building with nature solutions					-	+	+3	-2	+1	-1	
9		Habitat loss		x	x	x	+	+	-2	+3	0	+3	
10		Shift in species distribution					+	-	+1	+3	+1	+3	
11		Invading alien species	x	x	x	x	-	+	-2	+1	0	+2	
12	**Land use change**	Urbanization					-	+	+2	-2	0	+2	
13		Deforestation					-	+	-3	+3	+1	+3	SW: forests are protected; FW: defore
14		Agricultural areas					-	+	-2	+3	+2	+1	SW: less need due to decreasing meat
15		Sediments in water due to erosion				x	+	+	-2	+3	+1	+2	
16	**Agriculture**	Organic farming					-	+	+3	-3	+1	+2	
17		Sustainable meat production					-	+	+3	-3	+1	+2	SW: overall decreasing meat productio
18		Arable land for crops					-	+	-1	+3	+1	+1	SW: decreasing meat consumption, th
19		Crop rotation					-	+	+3	0	+1	+1	
20		Regionalised agriculture					-	+	+2	+3	0	-2	SW: increasing to minimize environme
21		Growth of non-native plantations					-	+	-1	+1	+1	+2	SW: people switch to regional diets; FV
22		Use of biocides					-	+	-3	+3	+1	+3	
23		Use of N- fertilizers					-	+	-1	+3	+1	+2	
24		Use of P- fertilizers					-	+	-1	+3	+1	+2	
25		TN load (from agricultural land into river)				x	+	+	-3	+3	0	+2	SW: nutrient loads decreasing due to c

Storyline Overview | Elements for downscaling

Figure 7. Application of scenarios in Land2Sea project (source: Mack et al., 2019).

2.7 Step 6. Production of bow-ties under different scenarios for each BBT

Objective: To apply high-level scenarios to all BBTs.
Methodology: Production of bow-tie under different scenarios, based on the quantification of step 5.
Results: **Bow-tie/-s under different scenarios for each BBT.**
Partners: IECS, LW ERIC and UCD.
Deadline: September 2024.

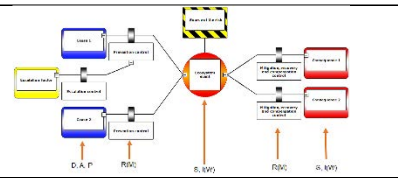
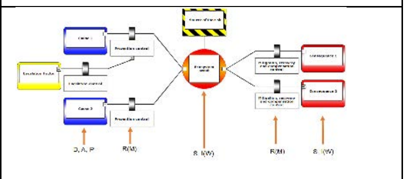
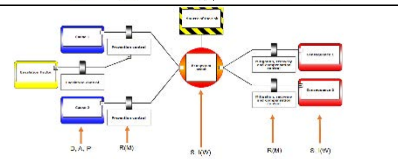
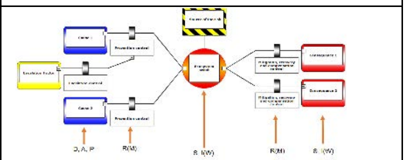
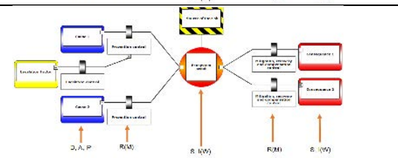
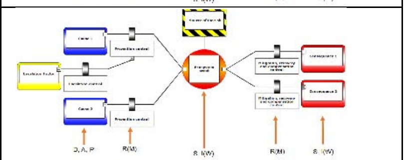
	BBT x	BBT n
Scenario 1		
Scenario 2		
Scenario 3		

Figure 8. Bow-tie for all BBTs under different scenarios.

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3. High-level scenarios

As a necessary exercise to apply the above-mentioned methodology, high-level scenarios had to be chosen. For that, an extensive literature review was performed (*Goudeseune, 2020; Meier, 2014; Sala et al, 2000 Groeneveld et al, 2018, Rounsevell et al, 2021; O'Neil, 2017; Pinnegar, 2021)*.

The criteria for selecting high-level scenarios were:

a) A sufficient number of high-level scenarios to explore alternative futures but avoid over-complicating the exercise.
b) To build on previous EU projects and make the use of the "know-how" produced to date. This approximation would also allow the possibility to compare the results with other projects.
c) To facilitate the alignment with the sister project of MARBEFES, Marine SABRES[3], in order to facilitate synergies of results and decrease stakeholder fatigue.

By applying the criteria mentioned above, three scenarios were found to be the most representative, and which include two opposite extreme scenarios and 1 intermediate. Subsequently, several previous EU projects which have made use of these scenarios were identified. It is worth highlighting two of them: CERES and Land2Sea projects, which both have run similar exercises and therefore had experience to share with MARBEFES. Figure 9 shows the three high-level scenarios both projects shared.

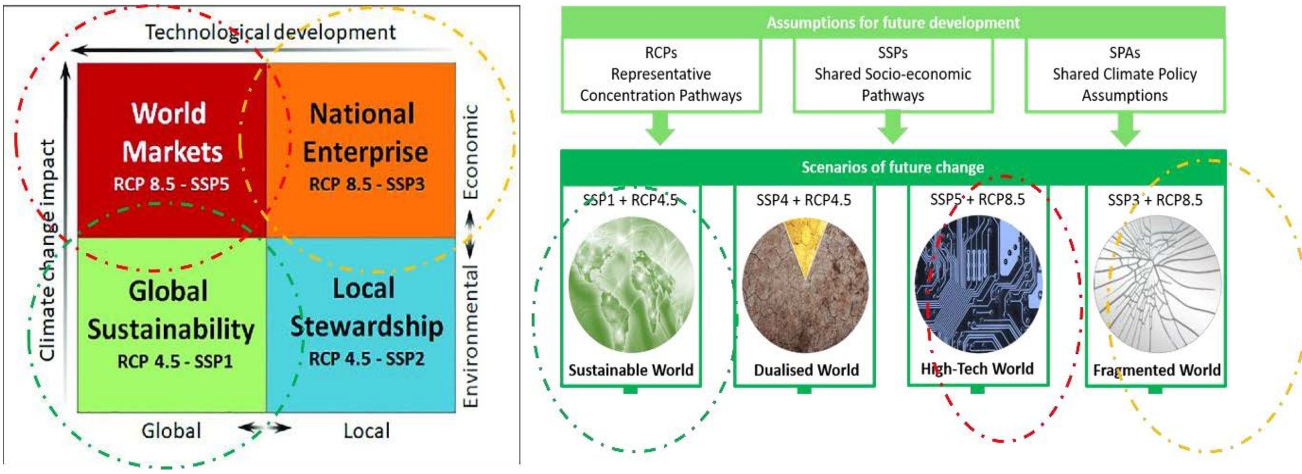

Figure 9. Comparison between high-level scenarios from CERES project and Land2Sea project (Source: Elliott et al, 2019; and Mack et al, 2019)

3 Marine SABRES, Marine Systems Approaches for Biodiversity Resilience and Ecosystem Sustainability, is a project funded by the European Union's Horizon Europe research and innovation programme under grant agreement no. 101058956.

MARBEFES project has received funding from the European Union's
Horizon Europe research and innovation programme under
Grant Agreement no 101060937

As for the application of the third criterion, Bremner et al (2024) selected 4 high-level scenarios (see Table 2) from the IPCC 6th Assessment Report (2023) for MARINE SABRES project (Figure 10).

Table SPM.1 | Changes in global surface temperature, which are assessed based on multiple lines of evidence, for selected 20-year time periods and the five illustrative emissions scenarios considered. Temperature differences relative to the average global surface temperature of the period 1850–1900 are reported in °C. This includes the revised assessment of observed historical warming for the AR5 reference period 1986–2005, which in AR6 is higher by 0.08 [–0.01 to +0.12] °C than in AR5 (see footnote 10). Changes relative to the recent reference period 1995–2014 may be calculated approximately by subtracting 0.85°C, the best estimate of the observed warming from 1850–1900 to 1995–2014.
{Cross-Chapter Box 2.3, 4.3, 4.4, Cross-Section Box TS.1}

	Near term, 2021–2040		Mid-term, 2041–2060		Long term, 2081–2100	
Scenario	Best estimate (°C)	*Very likely* range (°C)	Best estimate (°C)	*Very likely* range (°C)	Best estimate (°C)	*Very likely* range (°C)
SSP1-1.9	1.5	1.2 to 1.7	1.6	1.2 to 2.0	1.4	1.0 to 1.8
SSP1-2.6	1.5	1.2 to 1.8	1.7	1.3 to 2.2	1.8	1.3 to 2.4
SSP2-4.5	1.5	1.2 to 1.8	2.0	1.6 to 2.5	2.7	2.1 to 3.5
SSP3-7.0	1.5	1.2 to 1.8	2.1	1.7 to 2.6	3.6	2.8 to 4.6
SSP5-8.5	1.6	1.3 to 1.9	2.4	1.9 to 3.0	4.4	3.3 to 5.7

Figure 10. IPCC 6th Assessment Report (IPCC, 2023).

Table 2. High-level scenarios used by Marine SABRES Project (Bremner et al, 2024).

Global future scenario (SSP-RCP)	
Sustainability (SSP1-RCP2.6)	Global shift gradually but pervasively toward a more sustainable path, respect for perceived environmental boundaries. Warming <=2°C.
Middle-of-the-road (SSP2-RCP4.5)	Social, economic and technological trends do not shift markedly from historical patterns. Warming <=3°C.
Regional rivalry (SSP3-RCP7.0)	Nationalism, concerns about competitiveness and security result in increasing focus on domestic or, at most, regional issues. Warming <=4°C.
Fossil-fuelled development (SSP5-RCP8.5)	Increasing faith in competitive markets, innovation and participatory societies to produce rapid progress. Warming > 4°C

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As a result, the following SSP high-level scenarios from the IPCC 6th Assessment Report have been selected for MARBEFES: SSP1, SSP3 and SSP5. Table 3 presents an overview.

Table 3. MARBEFES 3 high-level scenarios.

Shared Socioeconomic Pathways	Name
SSP1	Sustainability
SSP3	Regional rivalry
SSP5	Fossil-fuelled development

Representative Concentration Pathway[4] (RCP) scenarios will be chosen at a later stage for modelling purposes.

4. Preliminary Results

To date, the main concerns in relation to biodiversity change in each BBT have been identified (step 1, in line with the implementation of the methodology) based on stakeholders concerns and scientists' knowledge. Most of the BBTs have also undergone the BowTA and developed their bow-ties for one or several concerns (central event(s)), and also identified in broad terms their causes and the consequences (step 2).

Commonalities have already been identified amongst BBTs (Table 4). For example, tourism has been identified as either the main or one of the main drivers of biodiversity change in at least 4/12 BBTs. Other drivers identified through the process are: within the Baltic: eutrophication and climate change, various sources of pollution; within the Northeast Atlantic: large scale fisheries, renewables, recreational activities, and various sources of pollution.

Table 4. Suggested central events to BBTs.

Region	BBT#	BBT	nº bow-tie themes	Main drivers	Main concerns biodiversity loss (central theme)
Artic	1	Porsanger fjord to the Barents Sea	3	Large scale fisheries	Habitat/ species affected
				Recreational activities	
				Energy cables	

[4] Representative Concentration Pathway (RCP) is a greenhouse gas concentration (not emissions) trajectory adopted by the IPCC.

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	2	South Spitsbergen	1	Large scale tourism	Habitat/ species affected
	3	North Spitsbergen			
Baltic	4	Archipelago Sea	2	Small scale tourism	Habitat/ species affected
				Various sources of pollution (Waste water/ Sanitation; Agriculture; Aquaculture)	
	5	Curonian lagoon and Lithuanian coast	3	Large scale tourism	Habitat/ communities affected
				Agriculture	
				Harbours	
	6	Gulf of Gdansk	2	Large scale tourism	Habitat/ communities affected
				Various sources of pollution (Waste water/ Sanitation; Harbours)	
Atlantic	7	North Sea (Belgian coast – Dogger bank)	3	Large scale tourism	Habitat/ species affected
				Large scale fisheries	
				Marine renewables	
	8	Irish Sea (Liverpool Bay and/or Dublin Bay to Irish Sea)	3	Recreational activities	Habitat/ species affected
				Marine renewables	
				Various sources of pollution (waste water; agriculture; urbanisation; harbours)	
	9	Southern Gulf of Biscay	2	Large scale tourism	Habitat/ species affected
				Infrastructure development	
Mediterranean	10	Menorca Channel (Balearic Islands)	1	Large scale tourism	Habitat/ species affected
	11	Oristano, Sardinia	2	Large scale tourism	Habitat/ species affected
				Local fisheries	
	12	Crete / Heraklion	1	Large scale tourism	Habitat/ species affected

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At the same time, preliminary BowTA shows different levels of development between BBTs. The most advanced analysed Regional Sea is the Northeast Atlantic, where the Balearic, southern Gulf of Biscay, Liverpool-Dublin Bay and Curonian lagoon-Lithuanian coast as the BBTs who have advanced the most in BowTA development.

Similarly, BBTs have produced different levels of detail at their BowTAs. As such, there is a need to standardise the elements of the BBTs to match the relevant large-scale scenarios that will be included at later stages of the process, but also so as to allow bow-ties to be compared. In this deliverable the results from the Coronian lagoon/ Lithuanian coast BBT are presented as an example.

The Curonian lagoon / Lithuanian coast is one of the BBTs included from the Baltic Sea. It is a lagoon-open sea, with dominant activities: tourism, fishing, shipping. Stakeholders at Curonian BBT are very worried mostly about large scale tourism, large scale fisheries, recreational activities, protected areas, biodiversity and harbours (in that order of importance). Stakeholders consider the impacts that large scale tourism has on habitats and environments coming from bathing, swimming, local fisheries (including ice fishing) and creating entry and capacity issues. Impacts of recreational activities are mostly recognized (or simply caused) from recreational shipping. Protected areas are also recognized to be affected by pollution mostly coming from agriculture and affecting deltas (eutrophication, anoxia) but also affecting dunes (balance between trees and dunes is also mentioned). Harbours are mentioned to impact local biodiversity by their physical presence, that is taking out areas of natural biodiversity but also by practices implemented to maintain their function, such as dredging.

With this context, the main concern in this BBT is the impact on habitats and species of three main drivers: large scale tourism, various sources of pollution and harbours. These drivers were suggested to the BBT who has produced 3 BowTAs to reflect these concerns. Below the initially suggested BowTA to the Curonian lagoon BBT is presented, where one can see the driver for harbours, as a general cause of change to the central event and the potential impacts (Figure 11).

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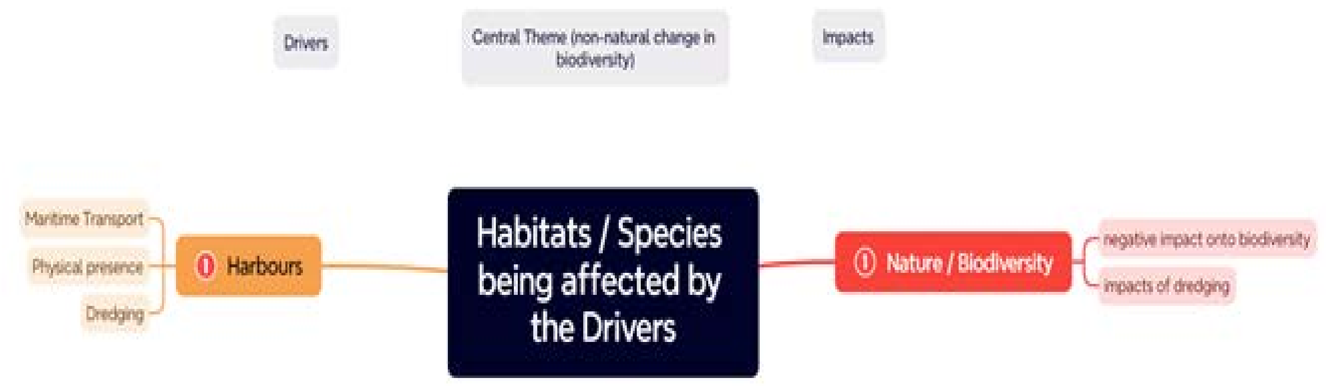

Figure 11. Suggested BowTA for the Curonian lagoon BBT with Shipping, harbour infrastructure development and maintenance as the main driver of biodiversity change in the Curonian Lagoon.

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By developing this first suggested BowTA structure further, the Curonian lagoon BBT further developed its BowTA and included many other aspects at both sides of the central event (Figure 12).

The left-hand side specifies the drivers of biodiversity changes in the Curonian lagoon and prevention measures to decrease the magnitude of those drivers. Policy measures on spatial planning, environmental monitoring, measures to reduce emissions and disturbances during project implementation and ballast water regulations are also considered to potentially contribute to reducing one of the main drivers of biodiversity change in the Curonian lagoon. Figure 12 also shows the consequences that biodiversity change could bring to the Curonian lagoon. These are classified by economic, social or nature impact. Associated mitigation measures are also indicating potential policy and management measures to reduce those impacts: monitoring environmental impacts, developing a green port concept and the introduction of green infrastructure and new technologies for ballast water treatment.

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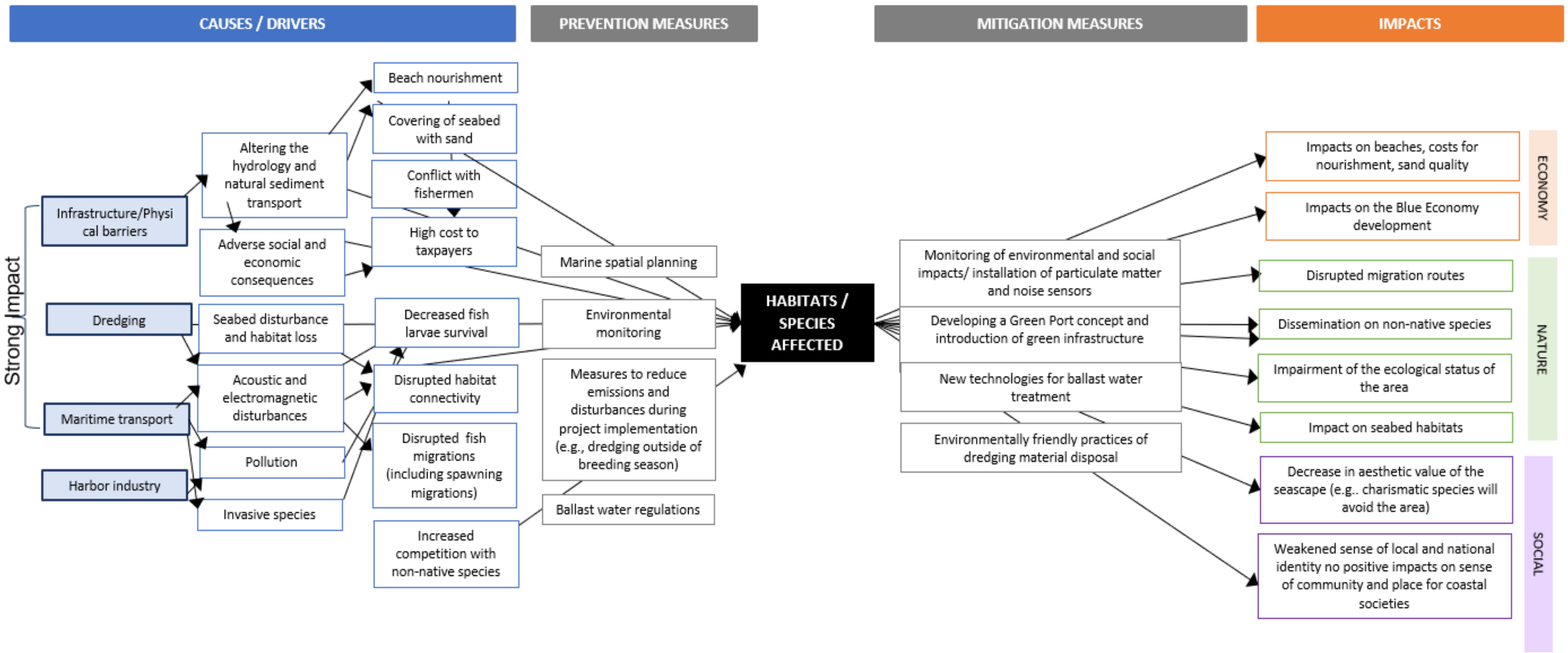

Figure 12. BowTA from Cuoronian lagoon with harbour as the main driver of biodiversity change.

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5. Next Steps

This deliverable shows how steps 1-2 of the Synthesis and Integration methodology have been applied through WP5 of MARBEFES. The following months will allow for BBTs to perform and deliver the remaining outputs of steps 3-6.
Results of the BowTAs will also need to be standardised[5] as these results will be used to prioritise causes-consequences storylines which will then be explored under various scenarios.

6. References

Bremner, J. et al (2024). Scenarios to reach biodiversity, sustainability and climate targets: developing pathways to transformation. Marine SABRES, European Union's Horizon European research and innovation programme under grant agreement no. 101058956. UKRI Project Number 10050525.

Elliott, M. (2023). Task 5.1 Guidance for Bow-tie Storyline Creation and Analysis at BBTs. MARBEFES Project.

Elliott, M. et al. (2020). *Industry and policy driven conceptual frameworks of climate change impacts on aquaculture and fisheries.* Deliverable 5.1, CERES Project, Report.

Elliot, M. et al. (2019). *Deliverable 5.1. Industry-and policy-driven conceptual frameworks of climate change impacts on aquaculture and fisheries.* https://ceresproject.eu/ceres-results-and-solutions/

Goudeseune, L. et al. (2020). *Handbook on the use of Biodiversity Scenarios in support of decision-making.* https://www.biodiversa.org/1823/download

Groeneveld, R.A. et al. (2018). Defining scenarios of future vectors of change in marine life and associated economic sectors. *Estuarine, Coastal and Shelf Science*, 201 164-171.

IPCC (2023). *Synthesis Report of the IPCC Sixth Assessment Report.* https://www.ipcc.ch/report/sixth-assessment-report-cycle/

Mack, L. et al. (2019). *Deliverable 2.1. Land2 Sea project. Storylines and scenarios for the case study catchments.* https://landsea-project.eu/

[5] Focused workshop on BBTs BoTA in March 2024.

MARBEFES project has received funding from the European Union's Horizon Europe research and innovation programme under Grant Agreement no 101060937

Meier, M. et al (2014). *Ensemble Modeling of the Baltic Sea Ecosystem to Provide Scenarios for Management.* https://link.springer.com/article/10.1007/s13280-013-0475-6

O'Neil, B.C. (2017). The roads ahead: Narratives for shared socioeconomic pathways describing world futures in the 21st century. Global Environmental Change 42, 169-180.

Pinnegar, J.K.(2021). Future Socio-Political Scenarios for Aquatic Resources in Europe: A Common Framework Based on Shared-Socioeconomic-Pathways (SSPs). *Frontiers in Marine Science* 7, 568219.

Sala, 0.E., et al. (2000). Global Biodiversity Scenarios for the Year 2100. Science 287, 1170.

Rounsevell, M.D.A., et al. (2021). Identifying uncertainties in scenarios and models of socio-ecological systems in support of decision-making. One Earth 4, 967-985.

MARBEFES project has received funding from the European Union's Horizon Europe research and innovation programme under Grant Agreement no 101060937