WP 5	MIlestone No. 40

MARBEFES Project

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Project General Coordinator: Jan Marcin Węsławski
Project Scientific Manager: Julie Bremner
Project Manager: Joanna Przedrzymirska-Ziółkowska

Task Leader(s)
Cristina Huertas-Olivares (LifeWatch ERIC)
Christos Arvanitidis (LifeWatch ERIC)

Author(s)
Cristina Huertas-Olivates (LifeWatch ERIC)
Christos Arvanitidis (LifeWatch ERIC)
Julie Bremner (CEFAS)
Mike Elliott (IECS)
Marta Pascual (BC3)
Tasman Crowe (UCD)

Disclaimer

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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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 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).

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).

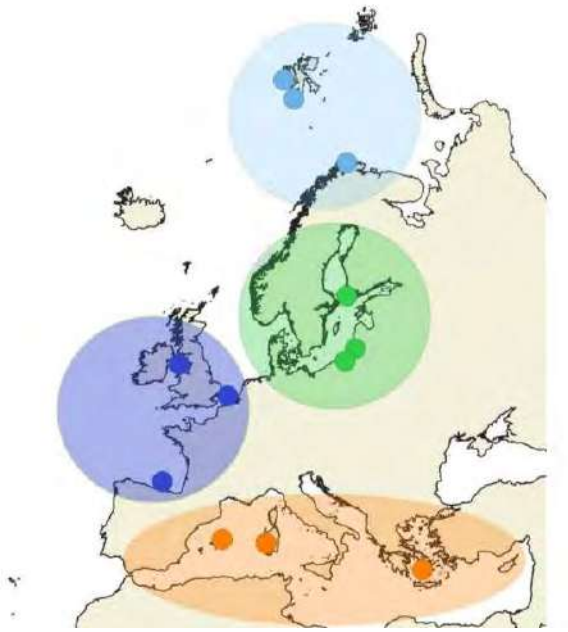

Figure 1. The MARBEFES Broad Belt Transects (BBTs) in the Artic, Baltic, NE Atlantic and Mediterranean (from MARBEFES Grant Agreement).

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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 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.

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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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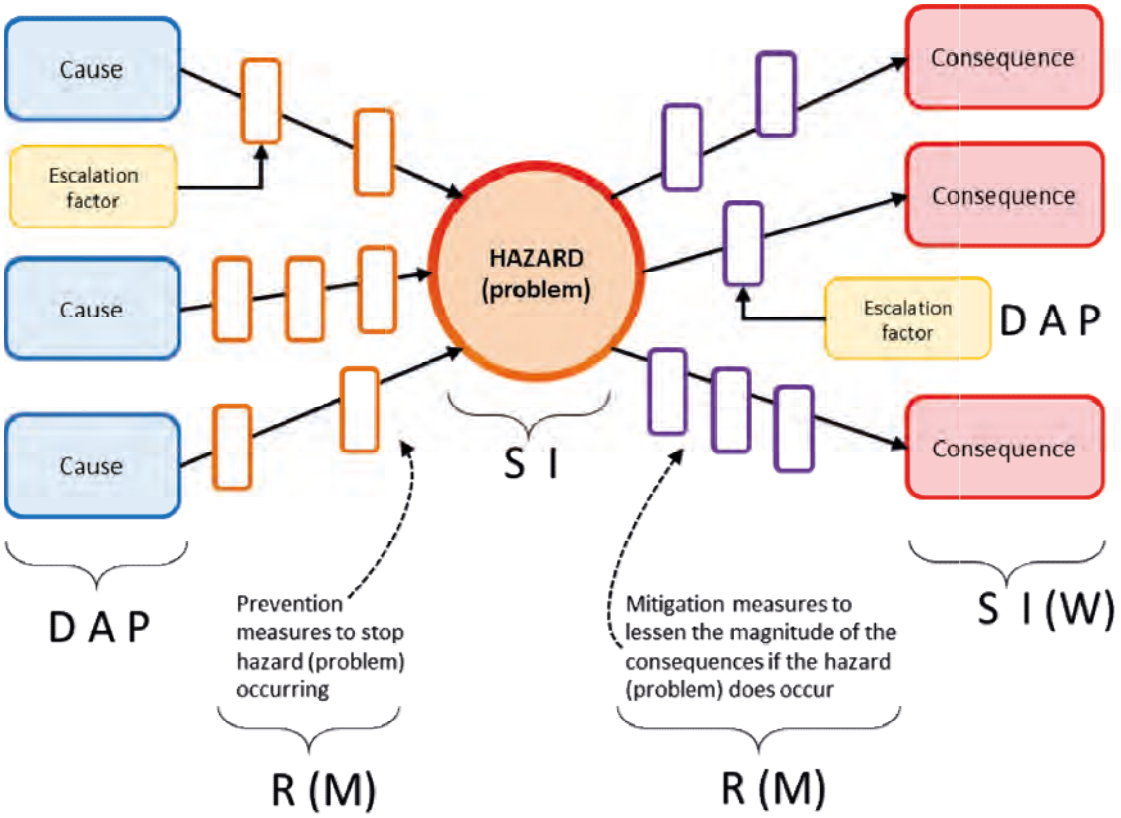

Figure 3. A simplified generic Bow-tie analysis (BowTA) structure overlain by the DAPSI(W)R(M)[2] framework. (Elliott, M., 2023)

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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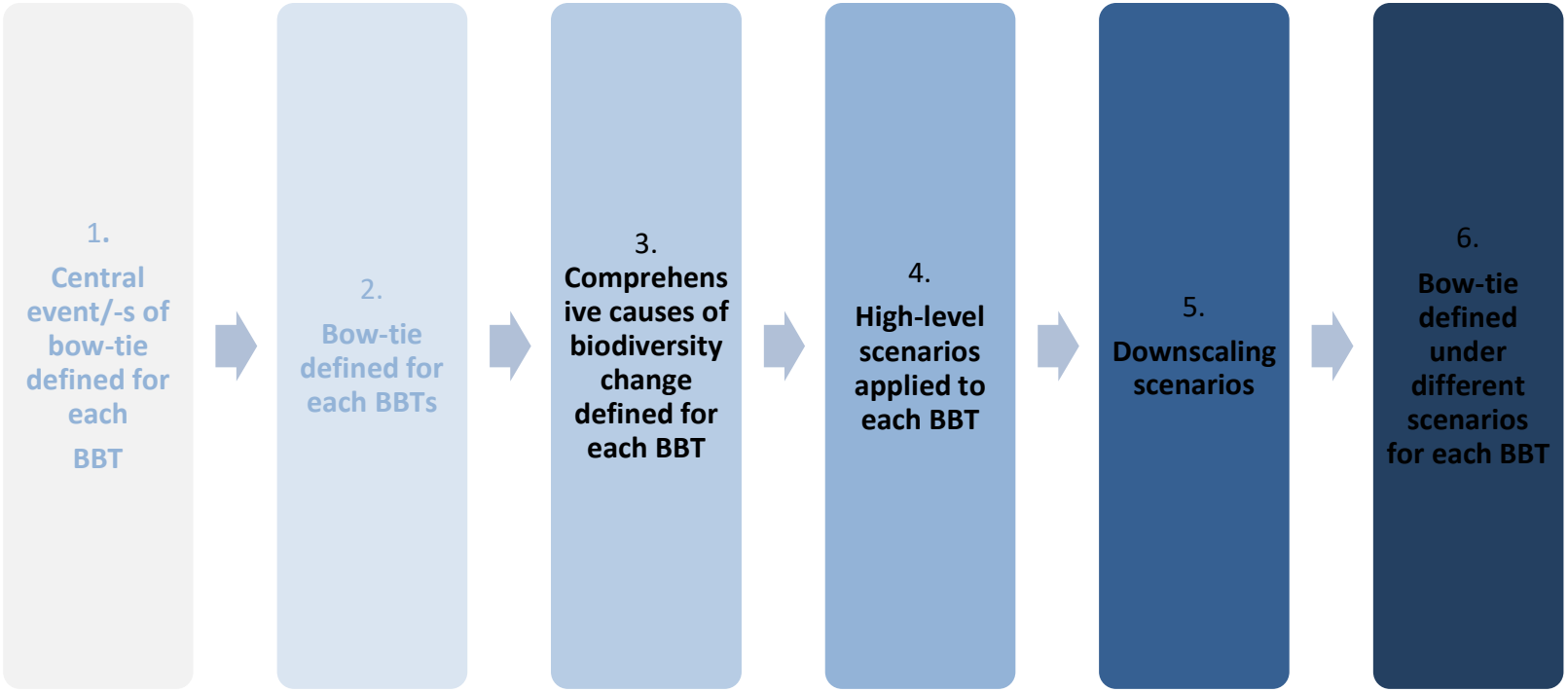

Figure 2. Six-step methodology on Synthesis and Integration

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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).

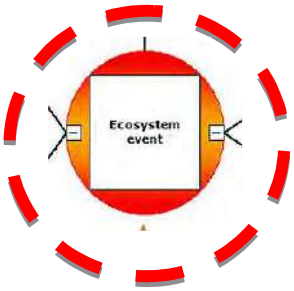

Figure 4. Central event characterisation schema in a bow-tie analysis (Source: Elliot, M. et al., 2019).

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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).

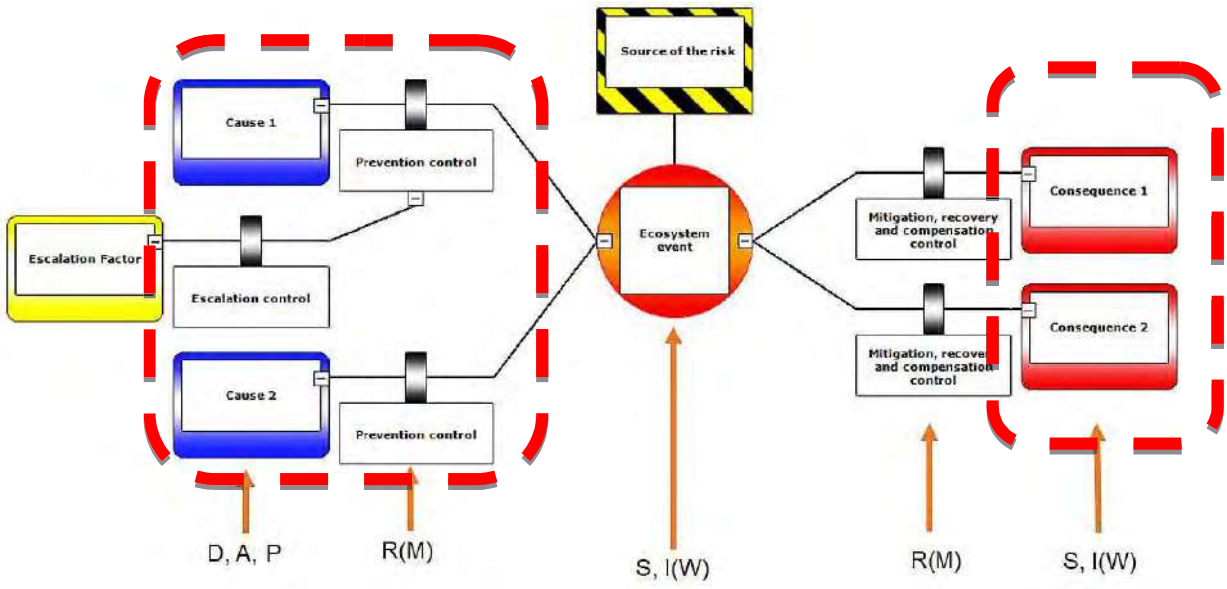

Figure 5. Causes (a) and consequences (b)characterisation schema in bow-tie analysis (Source: Elliot, M. et al, 2019).

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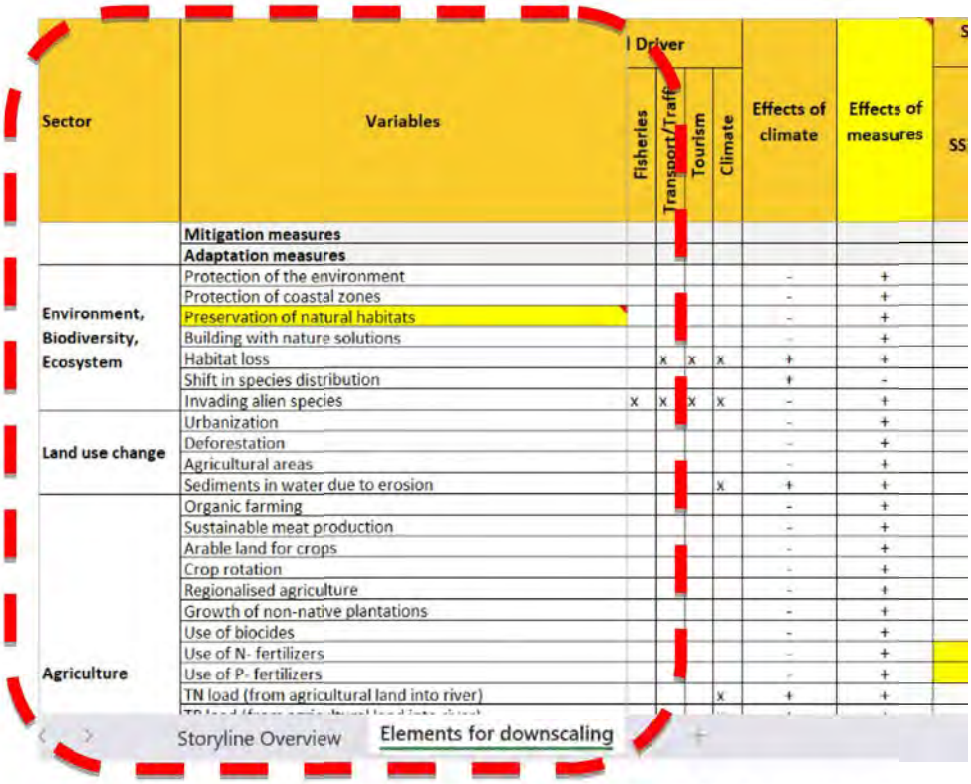
developed in the frame of the Land2Sea project (Mack et al., 2019). Consequences will also be expanded in more detail.

Results: **Comprehensive identification of causes of biodiversity change for each BBT.**

Partners: 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	Driver: Fisheries	Driver: Transport/Traffic	Driver: Tourism	Driver: Climate	Effects of climate	Effects of measures	SS
	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	+	+	

Storyline Overview | Elements for downscaling

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

Objective: Apply high-level scenarios to each BBT.

Methodology: 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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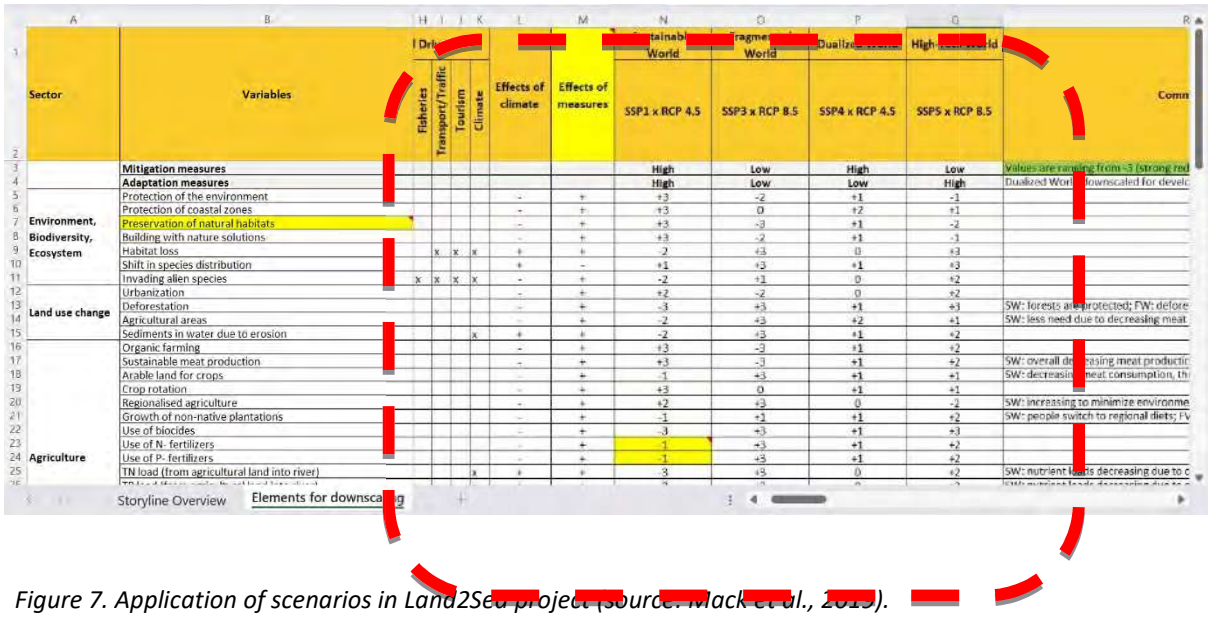


Sector	Variables	Fisheries	Transport/Traffic	Tourism	Climate	Effects of climate	Effects of measures	SSP1 x RCP 4.5	SSP3 x RCP 8.5	SSP4 x RCP 4.5	SSP5 x RCP 8.5	Comm
	Mitigation measures							High	Low	High	Low	Values are ranging from -3 (strong red
	Adaptation measures							High	Low	Low	High	Dualized Worl downscaled for develc
Environment, Biodiversity, Ecosystem	Protection of the environment					-	+	+3	-2	+1	-1	
	Protection of coastal zones					-	+	+3	0	+2	+1	
	Preservation of natural habitats					-	+	+3	-3	+1	-2	
	Building with nature solutions					-	+	+3	-2	+1	-1	
	Habitat loss		x	x	x	+	+	-2	+3	0	+3	
	Shift in species distribution					+	-	+1	+3	+1	+3	
	Invading alien species	x	x	x	x	-	+	-2	+1	0	+2	
Land use change	Urbanization					-	+	+2	-2	0	+2	
	Deforestation					-	+	-3	+3	+1	+3	SW: forests are protected; FW: defore
	Agricultural areas					-	+	-2	+3	+2	+1	SW: less need due to decreasing meat
	Sediments in water due to erosion				x	+	+	-2	+3	+1	+2	
Agriculture	Organic farming					-	+	+3	-3	+1	+2	
	Sustainable meat production					-	+	+3	-3	+1	+2	SW: overall de asing meat productic
	Arable land for crops					-	+	-1	+3	+1	+1	SW: decreasin meat consumption, th
	Crop rotation					-	+	+3	0	+1	+1	
	Regionalised agriculture					-	+	+2	+3	0	-2	SW: increasing to minimize environme
	Growth of non-native plantations					-	+	-1	+1	+1	+2	SW: people switch to regional diets; FV
	Use of biocides					-	+	-3	+3	+1	+3	
	Use of N- fertilizers					-	+	-1	+3	+1	+2	
	Use of P- fertilizers					-	+	-1	+3	+1	+2	
	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.

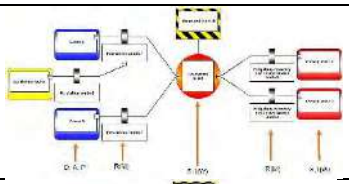
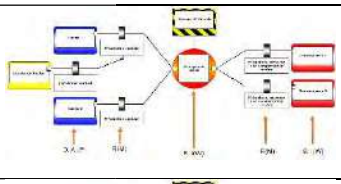
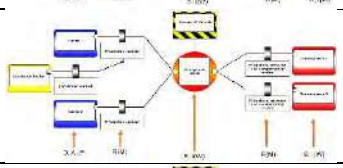
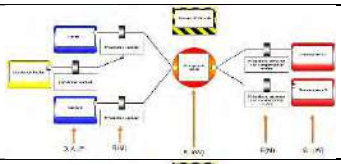
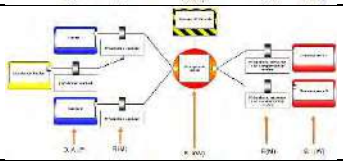
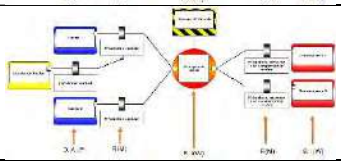
	BBT x	BBT n
Scenario 1		
Scenario 2		
Scenario 3		

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.

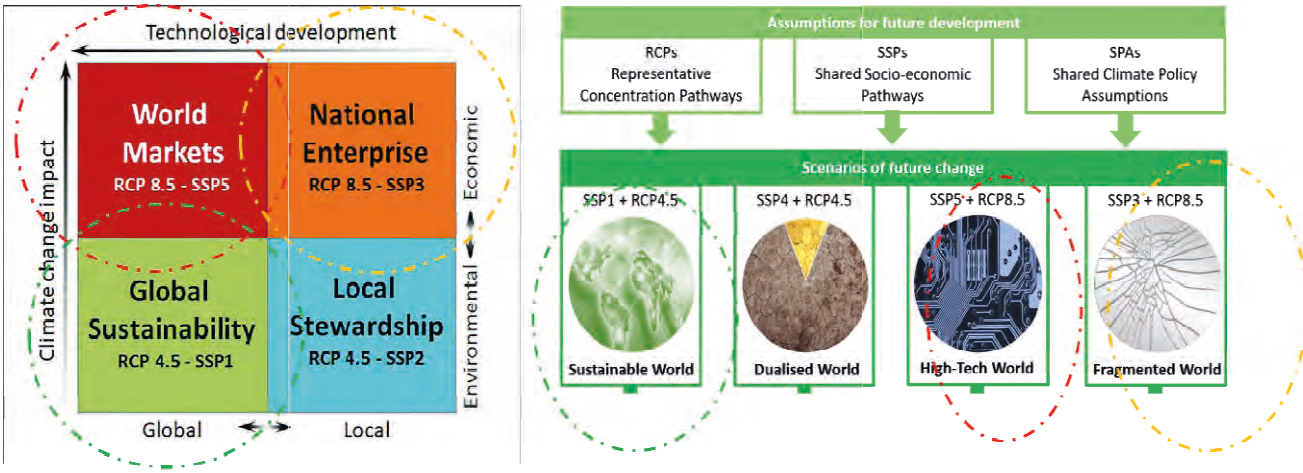

Figure 9. Comparison between high-level scenarios from CERES project and Land2Sea project (Source: Elliott et al, 2019; and Mack et al, 2019)

[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.

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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.

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

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