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Project Deliverable Report 1.2
Report on regionalized PESTLE Scenarios as adapted for Storylines

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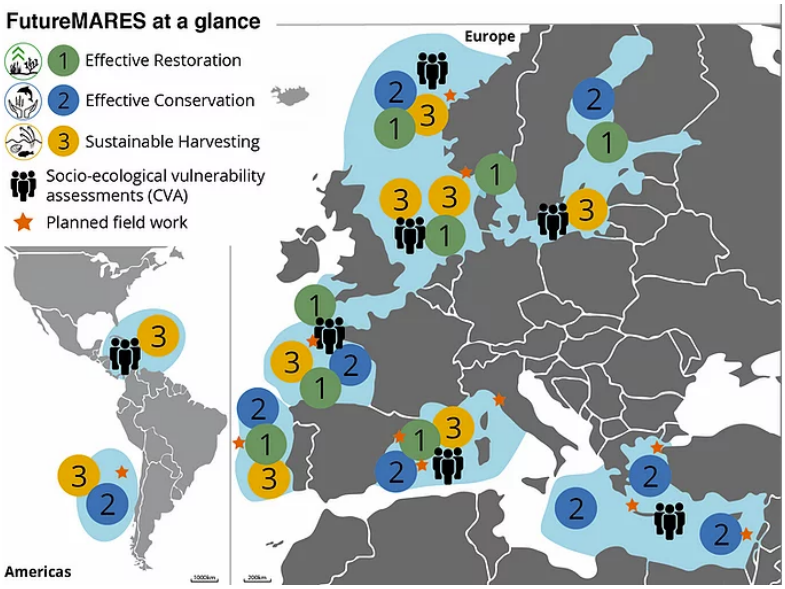
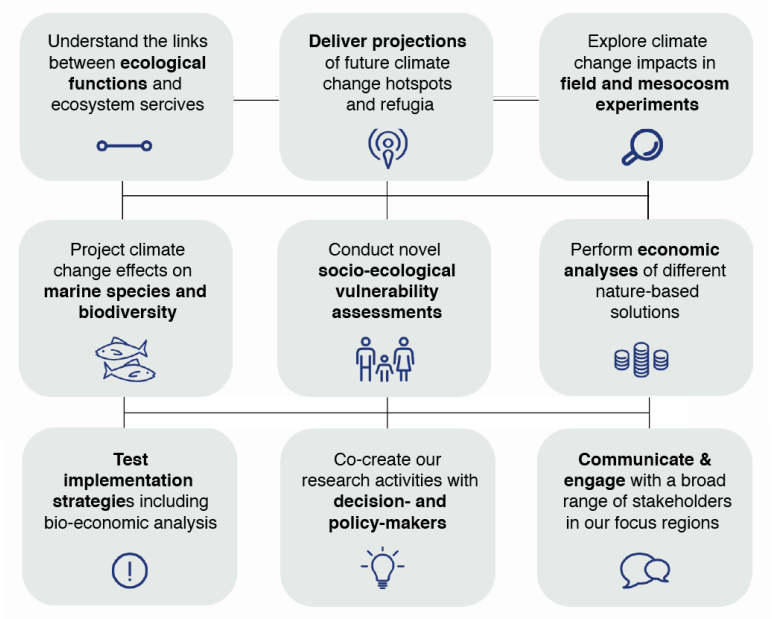
FutureMARES Project

FutureMARES - Climate Change and Future Marine Ecosystem Services and Biodiversity is an EU-funded research project examining the relations between climate change, marine biodiversity and ecosystem services. Our activities are designed around two Nature-based Solutions (NBS) and Nature-inclusive Harvesting (NIH):



We are conducting our research and cooperating with marine organisations and the public in Case Study Regions across Europe and Central and South America. Our goal is to provide science-based policy advice on how best to use NBS and NIH to protect future biodiversity and ecosystem services in a future climate.

FutureMARES provides socially and economically viable actions and strategies in support of nature-based solutions for climate change adaptation and mitigation. We develop these solutions to safeguard future biodiversity and ecosystem functions to maximise natural capital and its delivery of services from marine and transitional ecosystems. To achieve this, the objectives of *FutureMARES* defined following goals:



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Involved partners

In total, 17 partners contributed to stakeholder engagement to regionalize scenarios for this deliverable: NIVA, AU , AUTH , AZTI, Ciimar, CSIC, Deltares, Cefas, DCC, HCMR, INRAE, IOLR, NIVA, SU, SYKE , UNIPI, WUR.

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02	21.04.23	V2.0 – Incorporated comments by partners
03	03.05.23	V3.0 – Final feedback incorporated by Myron Peck

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Table of content

List of symbols, abbreviations and a glossary

CBD	Convention on Biological Diversity
CC	Climate change
CFP	EU Common Fisheries Policy
DoA	Description of Action, a part of the project Grant Agreement describing the project work plan
EC	European Commission
EC GA	European Commission Grant Agreement – a contract between the European Commission and FutureMARES consortium
ELY	Regional coastal Environment Centres (Finland)
ES	Ecosystem Services
FRAs	Fishing Restriction Areas
GA	Grant Agreement
GES	Good Environmental Status
HBD	EU Habitats and Birds Directive
MEY	Maximum Economic Yield (for fisheries management)
MSFD	The EU Marine Strategy Framework Directive
MSP	Marine Spatial Planning
NBS	Nature-based Solutions
NIH	Nature-inclusive Harvesting
OA	Ocean Acidification
PESTLE	Political, Economic, Societal, Technological, Legal, Environmental
RCP	Representative Concentration Pathway
SEA	Strategic Environmental Assessment
SL	Storylines
SSP	Shared Socioeconomic Pathway
Tn.x	Task – a sub-component of a work package where “n” is a number of the work package and “x” is a number of the task within this work package
WP	Work Package

Executive Summary

FutureMARES examines the potential effectiveness of three case studies (Nature-based Solution (NBS) 1 – habitat restoration, NBS 2 – conservation, and Nature-inclusive Harvesting (NIH). This work is applied within 40 regional Storylines and is based on scenarios of NBS and NIH implementation. This report summarizes the activities taken in FutureMARES to regionalize narratives on NBS1, NBS2 and NIH developed toward the start of the project for three "global" or generic scenarios: Global Sustainability (GS), National Enterprise (NE) and World Markets (WM). The regionalization of GS, NE and WM was needed to conduct analyses and create products and advice on potential solutions that are most useful to local and regional stakeholders.

Questionnaires were distributed to stakeholders to gain Storyline-specific context on Political (P), Legal (L) and Societal / cultural (S) elements of the 'PESTLE' framework described in the three generic scenarios. This regional information was also gained from in-person workshops. Questionnaires and/or workshops provided information for 33 of the 36 Storylines that represent specific regions or locations. This information will be used to enrich the narratives presented in Storyline Documents that are being prepared as part of synthesis of FutureMARES activities. Note, four FutureMARES Storylines had broad spatial coverage and no regionalization of scenarios was needed.

This report also discusses the new information that was gathered and added to the scenario narratives so that specific social-ecological analyses could be conducted. In this case, these details were similar across regions so that the results of ecosystem modelling could be compared. This modelling was conducted within 4 broad-scale Storylines (Western Mediterranean Sea, Bay of Biscay, North Sea and Baltic Sea). Ecosystem models can now be run with consistent scenarios of future changes in NBS1 (the surface area coverage as well as the location of Marine Protected Areas), NBS2 (restoration targets for habitat-forming species), and NIH (fishing effort).

The report also describes the scenario- and region-specific information collected for 31 ecological risk assessments conducted in 16 Storylines. In that case, expert opinion was used to rank the effectiveness of implementation of NBS or NIH in the three scenarios. This allows FutureMARES to rank the risks of the negative impacts of climate change with and without implementation of these future solutions.

1. Introduction

The primary objective of this deliverable is to report on the final activities in Task 1.4 aiming to regionalize scenarios to be used in analyses and simulations in downstream Workpackages (WPs) in *FutureMARES*. Broad narratives for three scenarios were developed in D1.1. In this step, additional information, including that collected by engaging stakeholders, was needed to add regional detail required for performing analyses testing NBS and/or NIH implementation within specific Storylines.

1.1. Defining the Challenge

The future is uncertain and projections are needed of the potential benefits and trade-offs of different strategies and actions such as NBS and NIH to address the ongoing climate and biodiversity crises. Global-level scenarios have been developed by the IPCC which need to be regionalized for use in fit-for-purpose analyses incorporating differences in local / regional contexts. Stakeholder engagement is needed to create regional narratives of scenarios to be compared in targeted analyses to inform decision making on where and to what extent Nature-based Solutions (NBS) and Nature-inclusive Harvesting (NIH) should be implemented.

1.2. Approach

Scenarios are imagined 'futures', that are not necessarily "visions" or "plans". Scenarios can help guide strategy and are created in sets of plausible and coherent alternatives. Scenarios can help define the scope for adaptation by characterizing the responses of various stakeholder groups (policymakers, conservationists, business owners, the general public) under each future world. The IPCC has developed two types of complimentary scenarios. Representative Concentration Pathways (RCPs) describe future trajectories in the concentration of CO_2 and other greenhouse gasses. Shared Socio-economic Pathways (SSPs) describe future changes in society (population growth, gross domestic product, levels of international cooperation, etc.) that influence how easy it is for countries to implement actions for climate adaptation or climate mitigation and, by extension, biodiversity conservation and restoration. The SSPs (social-economic, geo-political) and RCPs (amounts of global warming) were designed to be used together and, although not specifically matched, some RCP-SSP combinations are much more or much less likely.

Narratives on NBS and NIH were developed for three IPCC scenarios: SSP1-2.6 (Global Sustainability), SSP3-8.5 (World Markets) and SSP5-8.5 (National Enterprise). These narratives were regionalized using input from stakeholders associated with specific Storylines and, to a lesser extent, information exchanged among project partners in specific *FutureMARES* Tasks.

1.3. Contribution to the project

The regionalized scenarios reported here will guide analyses and simulations in downstream WPs and Tasks. Specifically, downscaled physical and biogeochemical modelling (WP2) used RCPs 2.6, 4.5 and 8.5. Those RCPs helped guide specific treatment levels used in laboratory and mesocosm experiments (WP3) that produced new data to inform spatially-explicit physical and biological models (WP4). Model simulations of broader ecological impacts (Task 4.4) will test scenario-based contrasts in the extent and type of NBS / NIH implementation. These contrasting scenarios will be incorporated into Risk Assessments (WP5) of ecological elements, ecosystem services, and human communities in various Storylines to inform economic analyses (WP6.2) based on projected changes in ecosystem service. Ecosystem services were defined in Task 1.3. The scenarios, therefore, bind together various aspects of the *FutureMARES* project, allowing internal consistency in project outputs as well as cross-region comparisons. The use of the IPCC (RCP-SSP) scenario framework also allows this and other projects to compare their findings with those of other projects examining the potential for climate change adaptation and mitigation to more impactful messages and create strategies on the actions needed regional and globally to halt the loss of biodiversity in aquatic (marine and freshwater) and/or terrestrial habitats.

1.4. Dissemination and Exploitation

This deliverable report will be made publicly accessible to scientist and managers within and beyond *FutureMARES*. Furthermore, the regionalized scenarios will a visible component of each of the Storylines described in on-line documents. Numerous peer-reviewed publications (from various WPs) will be generated that use the scenarios described within this report. Furthermore, at least one peer-reviewed manuscript will be developed for submission to a high-profile journal that describes efforts taken here to regionalize the three FutureMARES scenarios (combined with similar efforts in other EU-funded projects such as SOMBEE (BiodivERsA-Belmont Forum) and ACTNOW (Horizon). These regionalizes scenarios will eb share with the broader European biodiversity community as part of a final 2023 workshop of BioDivScen, a cluster of projects funded under the EU Biodiversa program creating and

examining biodiversity scenarios in terrestrial and urban case studies. The *FutureMARES* synthesis report (particularly Task 8.2) will include a section on self-reflection that describes the challenges, successes and lessoned learned during stakeholder engagement including the effectiveness of steps taken to regionalize the *FutureMARES* scenarios.

2. Introduction and brief review of concepts

2.1. Background and aim of the deliverable

Broad narratives were developed for three *FutureMARES* scenarios in D1.1 and the present deliverable describes efforts to regionalize these scenarios for use in specific Storylines and/or regions.

2.2. Using Scenarios in Climate and Biodiversity Projections

In recognition of the importance of using scenarios to explore potential future uncertainty and dynamics of complex, social-ecological systems, the BiodivERsA-Belmont Forum joint action (BiodivScen) funded multi-disciplinary projects creating and using biodiversity scenarios. A suite or 21 projects were funded in 2018 by BioDivScen. Each of these projects was tasked with creating scenarios to promote dialog on potential services and disservices associated with future trajectories of change in biodiversity in Europe and elsewhere. The projects funded under the BioDivScen focused on a variety of habitats and solutions including scenarios of protected area management for collision risk of birds with wind energy installations and tradeoffs between protection (birds saved) and renewable expansion or for migratory bird conservation in wetlands (ENVISION, GLOBAM and Future BirdsScenarios projects); terrestrial agriculture including pollinator conservation (OBServ, SALBES), multiple use of lakes and catchments (LimnoScenES project), threats of climate change to high-altitude systems (BioDiv-Support project) and urban environments, and alien invasive species (InvasibES and AlienScenarios projects). Scenarios have also been developed for specific marine habitats including the future delivery of ecosystem services from shallow reef systems in Nordic Seas and North Atlantic (Reef-Futures project) and impacts of reductions in sea ice on Actic coastal biodiversity (ACCESS project).

These results of these BioDivScen projects are currently being compiled to produce a series of policy briefs on five topics related to scenarios of: i) values of biodiversity and transformative change, ii) terrestrial ecological planning, iii) ecosystem services or disservices, iv) nature-based or ecosystem based solutions, and v) innovative approaches for biodiversity monitoring including early warning systems. The list of projects can be viewed using the following link: Results of the joint Belmont Forum-BiodivERsA Call for proposals on biodiversity scenarios – Biodiversa +.

Accompanying these ongoing projects and programs, a handbook was developed by Goudeseune et al. (2020) to help users (scientists) co-develop biodiversity scenarios with potential end users (policy-makers, businesses, practitioners). Information contained in that handbook relied heavily on several publications stemming from work conducted under the auspices of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) including the Methodological Assessment on Scenarios and Models (IPBES 2016) produced by the IPBES Task Force on Scenarios and Models (Pichs-Madruga et al. 2016).

European seas offer large contrasts in physical and anthropogenic effects that make it challenging to use a consistent set of scenario narratives across all regions. Moreover, across European regional seas, there are differences in the history of developing regional scenarios of physical and anthropogenic forcing. A case and point is the Baltic Sea where the scientific community and other stakeholders have worked together (under the auspices of HELCOM) to develop scenarios. Unlike some other European regional seas, the Baltic Sea is an area where eutrophication has been a dominant driver of historical environmental change (promoting hypoxia in coastal areas and anoxia in bottom waters of deep basins. Therefore, eutrophication

is featured in HELCOM scenarios. Recent work by Zandersen et al. (2019) defined regional narratives for SSPs based on a bottom-up, stakeholder approach to add sectoral details needed to study plausible future trends of eutrophication, fisheries, and marine traffic. As part of the BALTICAPP project, 33 scientists, funding managers, and policy-makers participated in a 2-day workshop to examine drivers / state / change relationships. A smaller group of stakeholders participated in follow-up meetings to refine the regional narratives. and the regionalization of global SSBs. Zandersen et al. (2019) placed special emphasis on the future types and extents of agricultural across that watershed due to the inputs of nutrients and impacts on eutrophication.

In a second, European example, scenarios were also developed in the Plan4Blue Interreg project (2016-2019) to examine the future development of blue economies in the Gulf of Finland and Archipelago Sea. In that case, four scenarios were used: “Unlimited growth”, “Virtual Reality”, “Sustainability above all” and “Sustainability dilemma” to test Maritime Spatial Planning objectives in light of balancing economic, social and environmental goals (Pöntynen and Erkkilä-Välimäki 2018).

Finally, a third, recent example of the development of scenarios stems from the North Sea region (Olsen et al. 2023). Olsen et al. (2023) used Fuzzy Cognitive Mapping (FCM) to facilitate open stakeholder discussions on future management strategies in the framework of Integrated Ecosystem Assessment and as a precursor to developing and testing Shared Socio-economic Pathways. Qualitative FCMs were built for three sub-regions of the North Sea and used to define scenarios to be compared in quantitative ecosystem model runs performed for two of those sub-regions using Ecopath with Ecosim (EwE). In that case, projections used scenarios for changes in fishing pressure (the only common driver among the models) and RCPs 4.5 and 8.5.

2.3. FutureMARES Climate & Biodiversity Scenarios

The scenarios developed in FutureMARES (D1.1) were inspired by the IPCC Special Report on Emissions Scenarios framework (Nakićenović et al. 2000) and, as previously described, combined the system of Shared Socioeconomic Pathways (SSPs) (O’Neill et al. 2014) with Representative Concentration Pathways (RCPs). The SSPs are scenarios that provide narratives for projected social and economic global changes up to 2100. The different SSPs (e.g. SSP1, SSP3, and SSP5) deal with different challenges for mitigation and adaptation to climate change based on different assumptions on social and political futures. The RCP2.6, RCP4.5, and RCP8.5 represent low, moderate and relatively high greenhouse gas emission scenarios that increase radiative forcing on Earth by the end of the century to 2.6, 4.5 and 8.5 W m^{-2} , respectively (Moss et al. 2010). Although debate exists on how best to map RCPs onto SSPs, logical differences exist. For example, the continued, heavy reliance on fossil fuels defined in the SSP5 scenario seems highly unlikely to be paired with a low emissions RCP2.6 scenario and, indeed, models have struggled to reconcile that SSP-RCP combination (Rogelj et al. 2018). On the other hand, only SSP5 is expected to lead to increased greenhouse gas concentrations that reach levels defined in the RCP8.5 (Rogelj et al. 2018). At the present time, SSPs 1, 3 and 5 are most often associated with RCPs 2.6, 4.5 (or 8.5) and 8.5, respectively, and these combinations were used in NBS/NIH scenario narratives developed for FutureMARES as outlined in D1.1 (see Appendix 1).

The narratives for the RCP-SSP scenarios used in *FutureMARES* were not built de novo but were based on the socio-political scenarios developed under the Horizon 2020 project CERES (Peck et al. 2020, Pinnegar et al. 2021). The four scenarios, published by Pinnegar et al. (2021), included the three generic scenarios used in *FutureMARES*: World Markets (WM, RCP

8.5 and SSP 5), National Enterprise (NE, RCP 8.5 and SSP 3), and Global Sustainability (GS, RCP 2.6 and SSP 1) which differ in their focus on consumerism (WM, potentially NE) versus environmental (GS) goals, their local (e.g. NE) versus global (GS, WM) outlook, technological development as well as on the severity of global warming. A fourth scenario adapted for fisheries and aquaculture in CERES (Local Enterprise, RCP 6.0, SSP 2), was not used in *FutureMARES* to simplify the number of comparisons to be made. This deliverable adds regional context to these scenarios so that they can be used in specific analyses within specific Storylines and/or regions.

The ability to use those broad scenario narratives in quantitative economic or social-ecological projection modelling requires that future changes in a more holistic set of factors be defined. The 'PESTEL' approach (Aguilar 1967, Johnson and Scholes 2002) describes how political, economic, social, technological, environmental and legal factors may cause risks and/or threats to specific plans / objectives. PESTEL stems from PEST as originally conceived by Aguilar (1967). PEST, PESTEL and various, similar approaches have been most often used to define the macro-environment of businesses. Although most commonly applied to business, the PESTEL framework was used in the EU CERES project to define a set of realistic alternative futures allowing economic projections of the impact of climate change through 2050 on two EU Blue Growth sectors: aquaculture (Kreiss et al. 2020) and fisheries (Hamon et al. 2021). For example, the EU CERES project defined future changes in fuel and fish prices (Hamon et al. 2021) based on the macroeconomic general equilibrium model MAGNET (Woltjer and Kuiper 2014). For fisheries, Hamon et al. (2021) also created contrasting levels of fishing effort relative to Maximum Sustainable Yield (MSY). For social-ecological projections of climate impacts on aquaculture, the scenarios also included future changes in the prices of electricity and fish feed ingredients as well as differences in the use of subsidies (Kreiss et al. 2020), inputs needed for economic calculations using the "typical farm" approach (Chibanda et al. 2020). Those scenarios were used in projections of social-ecological impacts of climate change on specific communities of the European fisheries or aquaculture sectors. In one example, Rambo et al. (2022) integrated these scenarios within quantitative Bayesian Belief Network (BBN) modelling to examine different climate-societal futures on the economic profit of specific, local (small-scale) fisheries on dolphinfish (*Coryphaena hippurus*) (also known as mahi mahi) operating in the NW Mediterranean Sea.

Although these broad scenarios and their specific PESTEL elements were designed to examine climate impacts on European fisheries and aquaculture, their architecture was well suited for exploring potential impacts of differences in the type and level of implementation of NBS and/or NIH. PESTEL analyses have also been used to explore risks and threats to other aspects of sustainability including the increased use of biofuels in the EU (Achinas et al. 2019) and the use of nature-based solutions (artificial floating islands) for improvement of water quality for communities in developing countries (Fonseca et al. 2022).

Based on previous work in the Baltic Sea previously mentioned, FutureMARES applied the scenarios Zandersen et al. (2019) when projecting physical and biogeochemical changes for the Baltic Sea. This represented the first, practical "regionalization" of scenarios with additional regionalization outlined in this deliverable report. In all cases (including the Baltic Sea region), all Storylines included common elements including the same three RCPs (the Environment element of PESTEL).

3. Methods

The IPBES (2016) categorized four types of scenarios: 1) Exploratory scenarios for raising awareness and setting agendas, 2) Target-seeking scenarios to design actions to meet specific targets or goals, 3) Intervention scenarios to forecast effects of alternative actions, and 4) Retrospective scenarios to evaluate how intended targets (e.g. increased fish stocks or biodiversity) of previous actions (e.g. MPA designation) compare with alternative actions or interventions (IPBES 2016). The three FutureMARES scenarios can be categorized as both type 1 (exploratory) in terms of different levels of climate drivers (e.g. warming) or conservation / harvesting strategies and type 2 (target-seeking) to describe pathways of implementation of the European Green Deal biodiversity strategy that mandates protection of 30% of marine areas with 10% strict protection by 2030. FutureMARES relied on both of these methods not only to build NBS and NIH implementation scenario narratives (in D1.1) but also to regionalize these scenarios (this report) for specific Storylines or groups of Storylines.

To regionalize the PESTEL scenarios in FutureMARES, various regional partners were provided with tools needed to engage stakeholders after D1.1 (scenario glossy card) was produced:

1) A 90-minute workshop was developed that introduced the three scenarios to stakeholders including PowerPoint slides for background and the option to use Mentimeter software to collect (either in-person or remote/on-line) feedback. This method allowed partners to use either the “expert-based” and “participatory method” approaches. Mentimeter results slides are shown in Section 4.
2) An online questionnaire was created and provided to partners that focused specifically on three of the PESTEL elements: Political, Societal and Legal. The questionnaire was an “expert-based” approach targeting knowledgeable stakeholders in specific Storylines and/or regions. The questionnaire is provided in Annex X2.

These tools and resources were explained to *FutureMARES* partners in sessions at the 1st Integration Meeting (online, March 2021), the 1st Annual Meeting (on-line September 2021) and the 2nd Integration Meeting (online, April 2022). Furthermore, representatives from each partner institution were contacted with the questionnaire after the 2nd Integration Meeting (July 2022) and after a follow-up presentation on stakeholder engagement made at the 2nd Annual Meeting (online and in-person, Porto, Spain, October 2022). The work was performed in close collaboration with Task 8.2 (Stakeholder Engagement – Vera Köpsel, UHAM). The use of on-line materials was based on the recognition of challenges caused by the Covid-19 pandemic and recommended best practice for continuing stakeholder engagement in large EU projects during periods when national restrictions prohibited in-person meetings (Köpsel et al. 2021). Regionalization of elements of the PESTEL scenarios was also gained by “expert-based” engagement as part of ecological risk assessments performed in specific Storylines (Task 5.1). That effort included specific training of partners on detailed spreadsheets.

Furthermore, cross-regional elements of the three, broad narratives that needed to be defined to perform scenario-based projections of ecosystem-level impacts of differences in the implementation of NBS / NIH and to make cross-regional comparisons of model runs being performed for the NW Mediterranean, Bay of Biscay, North Sea and Baltic Sea (Task 4.4). A series of internal project meetings was used to reach consensus on specific details of regional scenarios required for making projections using spatially-explicit end-to-end models (Ecopath with Ecosim).

4. Results

4.1. Regionalization of Scenarios by Storyline

This section provides a summary of the activities undertaken by partners to provide regional details for the scenario narratives developed in FutureMARES. Activities included distributing questionnaires to stakeholders on the Political (P), Legal (L) and Societal / cultural (S) elements of the PESTEL framework and conducting regional workshops where narratives were discussed. Either or both of these activities occurred in 33 of the 40 Storylines (Table 3.1). Five Storylines (12-13, 36 and 37) represent broad, cross-region activities where regionalization via stakeholder engagement was not planned.

Table 3.1. Summary information for regionalization of scenarios for Storylines in FutureMARES. Q = Questionnaire, no = number of questionnaires returned, Wkshp = stakeholder workshop.

Reg	Title	#	Storyline / Regions	NBS / NIH	Lead	Q (no.) or Wkshp
NE Atlantic & North Sea	***Joint:** Nature-based Solutions along the Norwegian Coast: Inter-relationships among kelp and sea urchins*	1	Norwegian Coast, inter-relationships among kelp, sea urchins and cod	NBS1	NIVA	2
		2		NBS2		
		3		NIH		
	NIH in NE Atlantic & North Sea:	4	Salmon (Hardangerfjord)	NIH	NIVA	NA
	NBS1 in North Sea	10	Restoration of oysters reefs	NBS1	WUR	1
	***Joint:** Marine spatial planning (broad coverage)*	12	Marine spatial planning (broad coverage)	NBS2	Cefas	*
		14		NIH		
	Dutch Coastal Waters	15	Seaweed, mussels, oyster	NIH	Deltares	Wkshp
	North Sea shelf (soft) seabed	13	infauna and epifauna (carbon cycling / burial)	NBS2	Cefas	*
	North Devon UNESCO World Biosphere Reserve (Torridge)	11	Kelp and saltmarsh	NBS1	DCC	1
Baltic Sea	*Conservation of coastal seaweeds, seagrasses, invertebrates and fish in the north-east Baltic Sea*	7	NE coast (seaweeds, seagrasses, inverts., fish)	NBS2	SYKE	3
	Restoration of eelgrass (Zostera marina) in the south-west Baltic Sea	6	Eelgrass (Zostera)	NBS1	AU	1 + Wkshp
	Sustainable mussel culture in the Limfjorden, SW Baltic Sea	9	blue mussel culture	NIH	AU	Wkshp
	Basin-scale management & MPAs at the Baltic Sea	8	Basins. Management & MPAs	NIH	SU	1
Rivers	***Joint:** Marine-estuarine opportunists in the NE Atlantic Ocean*	16	Fish (marine opportunists) Atlantic and Scandinavian	NBS2	INRAE	1 (w/18)
		17		NIH	INRAE	1 (w/19)
		18	Fish (diadromous) Atlantic Transitional & upstream	NBS2	INRAE	1 (W/16)

	Joint: *Diadromous species in the North-East Atlantic Ocean, including transitional and upstream waters*	19		NIH	INRAE	1 (&17)
Iberian & Bay of Biscay	***Joint:*** *Nature-based Solutions in the Basque coast of Bay of Biscay: seagrass restoration, protected areas, and sustainable seafood harvesting*	20	Seagrass (*Zostera noltei*) restoration	NBS1	AZTI	1 (SL 20, 22, 24)
		22	MPA in the SW	NBS2		
		24	Artisanal & commercial fisheries	NIH		
	Joint: *Kelp forests & biodiversity in northern Portugal*	21	Kelp forests & biodiversity in northern Portugal	NBS1	Ciimar	2
		23		NBS2	Ciimar	2
The Mediterranean Sea	*Restoration of seagrass (*Posidonia oceanica*) in the Balearic Islands (NW Mediterranean)*	25	NW (Balearic Islands) seagrass (*P. oceanica*)	NBS1	CSIC	2
	Aegean Sea MPA network	26	pelagic & demersal communities	NBS2	AUTH	1
	Karpathos & Saria MPAs: seagrasses and meadows, soft/rocky bottom	27	Karpathos & Saria MPAs: seagrasses and meadows, soft/rocky bottom	NBS2	HCMR	4
	Seagrass meadows & macroalgal forests in the Tuscan Archipelago MPA network	28	West: MPA network (*P. oceanica* communities)	NBS2	UNIPI	Wkshp
	Habitat-forming macroalgae / corals in the western Mediterranean Sea	29	West: habitat-forming macroalgae / corals	NBS2	CSIC	1
	Joint: *Nature-based Solutions and the Management of Coastal to Offshore ecosystems and their services in the Western Mediterranean*	30	MPA networks (including HFS)	NBS2	CSIC	1 (NBS2) 1 (NIH)
		31	artisanal, recreational commercial fisheries	NIH		
		33	Synergies of NBS2 & NIH with restoration	NBS1		
	Basin-wide Mediterranean Sea turtle conservation	32	sea turtle conservation	NBS2	AUTH	Wkshp
	SE Mediterranean Sea Climate change & bioinvasion impacts on reef & canopy-forming macroalgae & shelf fisheries	34	SE reef & canopy-forming macroalgae and AIS	NBS2	IOLR	2
		35	SE shelf fisheries catch	NIH	IOLR	1
CELAC	*Sustainable Seafood Harvesting in the Belize EEZ*	38	Fisheries species (e.g. conch, lobster)	NIH	CZMAI	NA
	Joint: *Ecosystem approach for the Chilean island systems*	39	Island MPA network	NBS2	CEAZA	NA
		40	Spiny lobster fishery	NIH		
Broad	*Biogeography and biodiversity change on coastal communities at continental scales*	36	Rocky intertidal biodiversity	NBS2	BIOPOLIS	*
	Offshore European Seas: plankton (Blue Carbon)	37	biodiversity and resilience	NBS2	CMCC	*

* Not regional Storylines, no regionalization of scenarios planned or implemented within *FutureMARES*. NA = not reported.

1.1.1. Political (government institutions)

Between 1 and 8 institutions were identified for each Storyline by questionnaire respondents. These government institutions included national, regional and local agencies (Table 3.1.1). The national and/or regional policies related to NBS and NIH were identified including differences in implementation of these solutions by scenario (Table 3.1.2). The cultural importance of the habitats (NBS1 & 2) and/or marine harvests (NIH) to local communities are listed in Table 3.1.3. The legal (L) instruments related to implementation of NBS or NIH (or related to the habitats / resources) were identified by respondents (Table 3.1.4) including respondents impression of the potential changes in the implementation of these solutions in each of the three different scenarios (Table 3.1.5).

The answers from respondents will be distilled into brief statements that are integrated within the section describing the FutureMARES scenarios in the Storyline documents. These statements not only help identify target audiences (e.g. policymakers) and implementation mechanisms (legal instruments) but make those documents more germane to those and other local / regional stakeholders.

Table 3.1.1. Summary information for the Political (government institutions) related to each Storyline (SL). The number of respondents and institutions provided by each respondent is provided in the second column (e.g. 3 – 13). The total number of unique institutions for that Storyline is provided in the third column (Total No.). In Storylines with multiple respondents, institutions identified multiple times are denoted with asterisks (*).

SL	No.	Total No.	Government Institutions
1-3	3	3	Regional: 1) Fishery directorate (Norway), Nationally: 2) Directorate of Fisheries) – responsible for harvesting of sea urchins and cod and transplanting/planting kelp. However, 3) Norwegian Environment Agency is responsible for allowing large-scale removal of sea urchins using quicklime. The municipalities determine the coastal zone spatial planning.
6	8	8	Danish Ministry of the Environment (https://en.mim.dk/) includes the 1) Department, the Environmental Protection Agency and 2) Danish Nature Agency including 3) Danish Coastal Authority. 4) The Danish Regions are charged with the generation of regional development plans, 5) municipalities grant permits and inspect local enterprises, carry out the majority of specific public sector duties and are the point of contact for the general public and companies wishing to access information on the environment. 6) The Danish Ministry of Climate, Energy and Utilities responsible for blue carbon legislation such as climate mitigation benefits. Two newly established centers: 7) think tank on the Danish ocean ("Tænketanken Hav"/"Ocean Institute"; https://www.taenketankenhav.dk/) is charged with supporting a sustainable use of the sea, and 8) center for marine restoration ("Center for marin naturgenopretning") aims to support knowledge-based implementation of marine restoration in Danish coastal waters.
7	3 - 13	7	1) Ministry of the Environment** (Regulation, permitting and establishment of conservation areas), 2) coastal ELY centres (Regional Centres for Economic development, Transport and the Environment**), AVI, cities and municipalities (under direction / legislature from ministries)* (Municipal environmental centres – Management of state-owned protected areas), 3) Ministries of agriculture and forestry, 4) Ministry of the interior, 5) Ministry of finances, 6) Ministry of traffic and communication, 7) Metsähallitus Park & Wildlife Finland*
8	5	5	1) EU Commission, 2) DG Mare, 3) BALTFISH, 4) HELCOM (regional), 5) ICES for science advice
10	2	2	1) Ministry of Agriculture, 2) Ministry of Waterworks

11	3	3	1) Joint Nature Conservation Committee, 2) Natural England, 3) Department for Environment, Food and Rural Affairs. This happens in consultation / engagement / leadership from UNESCO North Devon Biosphere.
16 & 18	5	5	1) French Biodiversity Agency (OFB) (marine, transitional) 2) French Ministry of Ecology (marine, transitional and upstream), local level 3) Water Agencies (marine, transitional, upstream) 4) MPA boards (marine), 5) Territorial councils (upstream)
17 & 19	6	6	1) EU fishery Ministry Council (e.g. quotas), 2) NASCO (salmons), 3) French Biodiversity Agency (OFB) (transitional to upstream)*, 4) Fishery national committee (CNPMEM and CONAPPED) (marine, transitional and upstream respectively), 5) French Ministry of Ecology*, 6) French Ministry of Agriculture (marine, transitional and upstream).
21 & 23	2 - 12	8	1) Instituto da Conservação da Natureza e Florestas (ICNF)*, 2) Direção geral de recursos marinho (DGRM)s*, 3) City Halls and 4) Local captainships*/Municipalities, 5) Council of Ministers, 6) Concelho de Ação Climática (Climatic Action Council)* – since December 2021, 7) Parque litoral Norte de Esposende, 8) Ministério da Economia e do Mar
20, 22, 24			1) IHOBE (https://www.ihobe.eus/about-ihobe) under the Basque Government's Ministry of Economic Development, Sustainability and the Environment. The Basque Government can establish MPAs that are coastal continuity of land protected areas. Main policy contact for MPAs is at national level, 2) Fundación Biodiversidad (https://www.fundacion-biodiversidad.es/en/about-us) under Spanish Government.
25	2	3	1) Conselleria de Medi Ambient and Territori of the Govern of the Illes Balears (regional Balearic Islands Government, Legislation approved by this body should be according to national (Spain level) and E16uropean legislation, 2) Ministry of Environment (National)->regulations, not enforcement, 3) Regional Balearic Islands Government
26	5	5	1) North Aegean MPA management bodies, 2) South Aegean MPA management bodies, 3) Ministry of Environment and Energy 4) Ministry of Agriculture – Directorate General of Fisheries, 5) Ministry of Tourism Natural Environment & Climate Change Agency
27	4 (6)	4	1)) Ministry of the Environment and Energy**, 2) Management Agency of the Dodecanese Protected Areas (MADPA)* under the Natural Environment & Climate Change Agency (NECCA / (Ο.ΦΥ.ΠΕ.Κ.Α)** (https://necca.gov.gr/en/home/), 3) National Centre for the Environment and Sustainable Development (ΕΚΠΑΑ) with 24 management units for protected areas (ΜΔΠΠ) established According to Law 3044/2002, 11 more were added since 2018, 4) Management Unit of the Southeastern Aegean Protected Area**, 5) South Aegean Region and Karpathian Mayor
28	1	4	1) ISPRA, 2) MITE, 3) MIPAF AFT, 4) PNAT (Arpat minstero dell ambiente Regione Capitaneria Area Marina Protetta in Generale)
29	1	1	Generalitat de Catalunya (regional government)
30	2	2	1) National sectional governmental agencies, mostly the Ministries of the Environment or similar, 2) Sub-national governmental agencies, mostly Ministries of Environment and Fisheries
31	2	2	1) Ministries of the Agriculture and Fisheries or similar, 2) sub-national Ministries of Agriculture and Fisheries, 3) GFCM framework (Med-wide)
34 & 35	3 – 6	4	1) Israeli Ministry of Environmental Protection*, 2) Israeli Ministry of Interior, 3) Israeli Ministry of Energy, 3) The Israel Nature and Parks Authority (INPA), 4) Fisheries Department under the Ministry of Agriculture and rural development*

Table 3.1.2. National policies related to NBS and NIH and likely future changes identified by respondents for Global Sustainability (GS), National Enterprise (NE) and World Markets (WM) scenarios. For Storylines 1, 2, 7, 21, 23, 25, 27 and 34, answers from multiple respondents are provided.

SL	Nation's policies	GS	NE	WM
1-3	There is growing interest in using kelps as NBS to store carbon, but so far there is no initiative to build a sustainable sea urchin harvesting industry to allow recovery of kelp in the extent sea urchin barrens in northern Norway. There is a large potential to convince politicians on the ecosystem benefits of the restored kelp forests.	positive change favouring sea urchin harvesting to recover kelp forest	A positive change favouring sea urchin harvesting that allow recovery of kelp forests, but motivated by high prices of the sea urchins	Less favourable sea urchin harvesting allowing less recovery of kelp forests, motivation is still the high prices of the sea urchins for global market
1-2 (2)	There is in general little focus on NBS/restoration for kelp forest in Norway at a political level. All restoration efforts have been made for scientific purpose, not as a measure to recover kelp on a larger scale. The value of protecting / restoring kelp has received most attention as a measure for carbon sequestration while the potential for increasing biological diversity has had low focus.	It will recieve increased focus	Kelp restoration will decrease.	May increase. Probably dependent on the market value for sea urchins and/or kelp
6	There is no national policy for eelgrass restoration as a NBS. Benefits of eelgrass restoration are acknowledged in terms of nutrient retention and some large-scale restoration initiatives have been funded mainly with this focus. It is increasingly acknowledged that eelgrass meadows support carbon sequestration and biodiversity but there is no specific blue carbon policy. National policy on eelgrass mainly targets regulations to reduce stressors on eelgrass and other marine ecosystems (see above).	More awareness of supporting the restoration and protection of eelgrass meadows (against a variety of stressors) as a nature-based solution with multiple benefits (biodiversity, nutrient retention, carbon sequestration, coastal protection). More holistic environmental-biodiversity-climate policy. Targeted restoration at the national scale. Due to increased societal education, there is more focus on environmental issues incl. eelgrass restoration/protectio n.	Less attention to the benefits of protecting and restoring coastal ecosystems incl. eelgrass meadows.	Less attention to the benefits of protecting and restoring coastal ecosystems incl. eelgrass meadows.
7	The aim is to increase marine environment protection (30 by 30 policy); realistically there are competing aims that slow down	Current national policy is implemented (effective and efficient). Use of	International goals still agreed but are not a priority. Job creation would	No protection goals. Innovations would help

	this progress. Finland implements EU directives (MSFD, Water Framework Directive, Habitats and Birds Directive), as well as EU Biodiversity strategy*, intending to increase coverage of MPAs and to restore degraded habitats. Also adheres to CBD goals, once approved. There is one major national programme, HELMI, which aims, inter alia, to restore aquatic bird habitats, wetlands and coastal areas, and a large (20 M€, 8 years) LIFE IP project BIODIVERSEA to support Finnish PAF and contribute to increasing biodiversity. Data and information to support decision-making is produced by the VELMU Programme (Finnish Inventory Programme for Underwater Marine Divers)	marine space based on conservation targets, and other uses would be conditional on that.	have higher priority than natural conservation. Some areas and species that are part of the national story / image would be protected. No coordination among Baltic countries	commercially exploit species. Use of marine space driven by transport and industry. CC has caused the loss of loss of large parts of the protectable ecosystem.
7 (2 & 3)	The aim is to implement the two Pledges of the EU Biodiversity Strategy 2030 by (i) increasing the area of MPAs to 30 % and (ii) by improving the state of European habitats by 2030 (30 % of deteriorated habitats improved) and 2050 (70 % of European habitats improved).	Best possibilities to reach the goals, especially Pledge 2, because Scenario implies more effort in conservation and sustainable use of marine areas. As eutrophication and climate change are the main threats of the Baltic Sea, the anticipated investments in preventing nutrient loading and pollution, and in climate change mitigation and adaptation, will also	Very poor possibilities to reach goals, because least concern of environmental issues, including marine conservation and prevention of nutrient loading from land (i.e. from national agriculture, important for food security). Also small investment in mitigation of climate change and environmentally friendly solutions.	Poor possibilities to reach goals, because global markets and emphasis on economic growth may drive the system towards unsustainability. Low possibilities for limiting climate change, since slow transition to sustainable energy. Some hope is given by global and regional cooperation, by which some relevant measures of conservation and climate change mitigation and adaptation, including transition to sustainable energy.
8	Mainly application of the EU environmental policy CFP and MSFD	Full implementation of EU Directives; strong	Breakdown of EU policy framework and HELCOM; national subsidy	Change in environmental regulation towards relative

		environmental regulation; and diet changes towards more plant-based, local food. Dense, rapid urbanisation	schemes support food and energy security; reduced environmental performance; slow urbanization; and decreasing population in the region	targets; rapid technical development with some environmental improvements; increased demand and export of animal products; and expansive, rapid urbanisation
10	Closing areas of the North Sea to enhance biodiversity	continue at same pace or increased pace	Reduced pace of closing / protecting areas	Reduced pace of closing / protecting areas
11	Restoration and conservation goals are enshrined in the UK government's 25 Year Environment Plan and in the Environment Act 2021. Specific actions, come from Natural England (as a govt agency in England), from local managers (e.g. North Devon UNESCO Biosphere) but also from grassroots drivers (such as in the Help our Kelp initiative in Sussex), typically supported by NGOs. Funding comes from a variety of sources (governmental, previously EU via LIFE fund, and philanthropic). Interaction between such interventions and other sectors are also supported and or limited by marine planning mechanisms.	Supported and expanded.	Some support but with focus on co-location solutions.	Not prioritized.
16 & 18	New biodiversity action plan of 30% of protected areas – try to achieve the target National (French) Protected Areas Strategy National Plan in favour of Migratory Diadromous Species National action plan for sturgeon – actions to assess the amount of suitable habitats for *A. sturio* within the current/future MPA network	In line with current policy but apply increased spatial protection (i.e. > 30% of MPAs, more areas with strong restrictions, e.g. generalized ban of fisheries, no offshore installations)	Decreased level of protection (i.e. prioritizing local human communities happiness and incomes, neglecting mitigation)	Decreased level of protection (i.e. priority on economic activities to develop high-tech solutions to certain environmental issues)
17 & 19	1) EU CFP and species management plan, 2) Eel management plan (Eel directive)	All the species are at 0.8 MSY and ban of most impacting fishing gears	MSY for all the species with artisanal and industrial fisheries	Industrial fisheries MSY for all species with a high demand for aquaculture
20, 22, 24	the Basque Country 2030 is the instrument that establishes the priorities and commitments regarding Basque region natural heritage. This initiative also has a	The policy considers that there are several potential scenarios with different	The current plan considers also actions that would be also beneficial for worst case	

	global perspective and is in line with the Strategic Plan for Biological Diversity 2011-2020, an offshoot of the United Nations Convention on Biological Diversity, the European Union Biodiversity Strategy to 2020 and the Spanish Government's Strategic Plan for the Natural Heritage and Biodiversity 2011-2017. This strategy is also in keeping with the United Nations Sustainable Development Goals of the Agenda 2030 for Sustainable Development, approved in 2015. One of these goals is to "promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss"	degrees of climate change impacts. The policy considers areas of common impact in all scenarios that are prioritized in the plans implementation. This scenario is the most likely given that climate change is having (and expected to have) a lower impact in Basque coast than in other regions.	scenarios of high emission and high sea level rise. Local mitigation is one of the focus of current plans with Greenhouse Gas Inventory and reduction. Historically and in absolute terms, emissions in the Basque Country were 20.8 million tonnes of CO2 eq. in 1990, 25.3 million tonnes of CO2 eq. in 2005 with the following recent achievements: A 35% reduction in emissions compared to 2005. A 21% reduction in emissions compared to 1990. A 12% reduction in emissions in 2020 compared to the year before, 2019.	
21 & 23	Climate law decree nº98/2021, from the December 31st, 2021) target the ecological balance while fighting CC pursuing the following objectives: - Promote a rapid and socially balanced transition to a sustainable economy and a greenhouse gas neutral society; - Ensuring the protection of the most vulnerable communities to CC – Strengthen national resilience and capacity to adapt to CC – Develop and strengthen existing carbon sinks and other carbon sequestration services – Protect and promote the regeneration of biodiversity, ecosystems and services	Consistent with Current Portuguese policies – strongly committed to achieving climate neutrality by 2050. International collaborations to achieve common environmental and climate goals are envisaged and supported.	Portugal focuses on achieving energy and food security goals at the expense of green development. Massive exploitation of natural resources leading to deep environmental degradation. Finding solutions to environmental problems (such as implementing MPAs) no longer national priority.	Policies focus on enhancing international cooperation and technological improvement to better manage ecological and society issues. The push for economic and social development is coupled with energy-consuming lifestyles which will demand an extensive exploitation of local resources.
21 & 23 (2)	1) Diário da Répulica nº 165, 29 August 2019: National MPAs established and will integrate all into single network with commission for management and	Policies aligned on GS. There are common European efforts and goals for environment		Maximize exploitation of natural resources in the large marine territory.

	monitoring, involving all government agencies. 2) Lei do Clima, in Diário da Républica nº253, 31 December 2021: Portugal will support scientific and technological development to evaluate CO2 sequestration by marine ecosystems and define goals such that these ecosystems can contribute to the goals of carbon neutrality by 2050. Maritime area is considered huge opportunity for renewable energy production and Marine management will attempt to best realize this coastal production capacity	protection and cooperation between countries. More specifically, there is an agreement between Portugal and Spain for a stable Iberian energy market.		Small oil deposits would be exploited. The setting up of renewable energy production at sea would be made with disregard for environmental impacts. MPAs would not be expanded or defined until resources were depleted enough to prohibit their economically viable exploitation.
25	At the national level (Spain) the Ministry of the Environment has initiated the process of drafting a National Restoration Strategy which will include the marine environment and the seagrass ecosystems. This national policy document will be in line with the recent draft proposal of the European about restoring Nature (COM(2022) 304 final, 2022/0195 (COD) published in Brussels, 22.6.2022) that it is still under discussion. It is not clear at present what will be the content of both documents. At the local level the Government of the Balearic Islands might prepare and approve *a P. oceanica* restoration plan that will have to be consistent with the content of the national and 21uropean legislation.	More supportive of P. oceanica restoration	Less supportive of P. oceanica restoration	Less supportive of P. oceanica restoration
25 (2)	Firm 30/30 ecosystem agenda. Restoration of *P. oceanica* is going to be fostered along with protection. Enforcement of measures to stop damage to meadows are in place including boat patrolling, apps with suitable anchoring places, fines to boats anchoring over meadows and to contaminating practices. Educational initiatives. -Compensating damage to *P. oceanica* by industry is a must for companies (e.g. harbour building,	-Keep fostering actions to meet sustainability goals -Enforcing ecosystem-based advice to restore/conserve -Stronger law enforcement, and higher fines to violators	-Probably stop fostering actions with no demonstrated ecosystem as yet (ecosystem) -Probably following on the bare ecosystem EU obligations. -Delaying any environmental transposition of EU directive into national legislation,	-Restoration 21cos have an economic component, probably linked to companies exploiting the visit to restored 21cosy -Trading with ecosystem services values

	underwater cable installations etc.)		or not observing it tightly	
26	No systematic conservation planning (uncoordinated) and poorly enforced. Human-induced pressures include coastal development and habitat destruction, overfishing, pollution, eutrophication, climate change and invasive species. There are continuous conflicts between marine protection targets and existing human activities, mainly fishing and aquaculture industry, tourism and coastal activities. Most MPAs have not been selected based on a specific set of selection criteria, and with little quantitative ecological information to guide the respective decisions. Most MPAs remain without an administrative body or management plan. Important ecological aspects (protected species and vulnerable habitats) are poorly represented, in current MPA network. Climate change conservation objectives are ignored and the climate change not considered in planning MPA network limiting effectiveness of conservation efforts in near future.	Well designed (in terms of conservation goals and management), climate adaptive MPA network. More focus on reaching conservation goals, imposing more strict restrictions on fishing and coastal development	Priority given to economic development, by encouraging coastal activities and massive tourism	Similar to the National Enterprise scenario
27	The current national policy is officially to protect the MPA but in reality not much is being done.	Positive change (enforcement, protection)	More neglect of MPA regulations.	More neglect of MPA regulations.
27 (2)	Greece has gradually developed a strong institutional framework for environmental protection and nature conservation, adopting several international conventions (since 1974) and all relevant EU Directives (since 1983) while enriching it with numerous national protection provisions (since 1950). The current legislative framework covers a wide range of environmental issues, spanning from the conservation of genetic resources to climate change, with an emphasis on the establishment and legal protection of the country's protected areas. The Karpathos and Saria MPA is included in the list of Natura2000	Better application of existing policies. Additional protected areas maybe established. The existing protected area in Karpathos & Saria maybe managed more efficiently, e.g. under gradual use-zones (red zones = no activities allowed)	Lack of globalization in the application of protection measures and regulations will eliminate the MPA conservation efficiency. 3rd scenario – This scenario will be more efficient than the 2nd one, since technological development will be boosted and some environmental problems will be	

	sites (GR4210003) and hosts a rich biodiversity and many endemic species (flora and fauna, including birds).		efficiently addressed	
27 (3)	9.21% of the Karpathos & Saria MPA network is protected only through national laws, 58.22% of the MPA network consists solely of Natura 2000 sites and 32.57%consist of and overlaps between the two. Regulations exist for fish stock management, regarding legal restrictions on fishing methods, years of fishing, types of vessels, sizes of fish etc. Greece is establishing the appropriate national plans for marine strategies to follow the strict schedule of MSFD implementation plan, reaching the "good environmental status"	Better budget concentrated in Natura 2000 network protected areas. Sensibilisation and environmental/bio diversity education in schools. More regulations about overexploitation of marine resources.	Less budget on environmental education. Less regulations of overexploitation of marine resources.	Less budget on environmental education. Less regulations of overexploitation of marine resources.
27 (4)	years. The general tendency for the NBS lies somewhere between scenarios II (High challenges to mitigation and adaptation) and III (High challenges to mitigation, low challenges to adaptation). Another important drawback is the recent centralization of environmental management and conservation through the establishment of a central management agency in the capital (Athens) and the elimination of responsibilities of management bodies of individual protected areas	Things will become better (optimistic scenario – too good to be true)	There are some opportunities (rather short-term), but knowing how things work in Greece, everything will become worse (this is going to happen anyway)	There are some opportunities (rather short-term), but knowing how things work in Greece, everything will become worse (this is going to happen anyway).
27 (5)	In September 2021, Greece was one of the 8 Mediterranean governments to sign the action plan "The Mediterranean: a model sea by 2030" at the opening of the IUCN Congress. As part of this initiative, Greece is committed to increase the spatial coverage of marine protected areas to 30% (from 22% today), establish strong protection measures (including ban to fishing) to 10% of the national waters, and reduction of marine litter by 50%, among other measures aiming to the preservation of marine and coastal biodiversity.	GS scenario of would be the most favourable and supportive to the current agenda and would aid its implementation with minimal societal conflict and delay.	As evidenced in the recent political and economical crises, instability and focus on short-term relief would hamper implementation of an environmental-friendly agenda, both at the local (e.g. protection measures) and the broader scale (e.g. transition to green energy)	Same entry as NE
29	3 Natura 2000 sites with different levels of protection: two also designated as Natural Parks, reinforced protection no-take no-	The areas will be better managed, with effective management	Ineffective management of areas by government, with	Probably well managed areas but worst-case CC (SSP5-8.5) causes

	use zones (e.g., in Illes Medes and Cap de Creus), no-take zones (e.g. Illes Medes) to partial protection areas (specific fishing regulations and recreational use) up to similar regulation as in non-protected zones.	plans, the areas with no-take zones will be enlarged and the three MPAs would be somehow connected.	few regulations, similar to unprotected areas. Increasing pressures such as CC, OA, fishing, recreational activities, etc.	intense ecological impacts. Management should be directed towards preserving climate refugia for these species.
30	The current national policy is limited to few MPAs that have been established due to ad hoc value/aims. Overall, there has not been a proactive planning for Marine Conservation. Most existing MPAs are partially protected, with low protection efficiency, and of small size.	Areas in EU waters may increase to reach 30% in 2030, with 10% fully protected and 20% highly protected. Areas outside EU waters may follow if financial cooperation enhanced.	Areas in EU waters may not increase to reach global conservation targets and MPA may remain similar. Areas outside EU waters may not improve either.	Areas in EU waters may increase to reach 10%-30% in 2030, mostly poorly or moderately protected. Areas outside EU waters may follow if financial cooperation is enhanced.
31	The current national policy is limited to the application of the CFP in EU waters, and sub-national legislation in national interior waters, with little success due to low compliance. National legislation and regional agreements are applied in non-EU waters	Areas in EU waters may reach MSY targets (CFP) and MSFD complementary targets in 10 years. Areas outside EU waters may follow if financial cooperation is enhanced	Areas in EU waters may not reach MSY targets (CFP) and MSFD complementary targets with further degradation with as CC intensifies in region. Substantial improvements unlikely in areas outside EU waters.	WM same as NE.
34	1) MSP maritime Policy for Israel's Mediterranean Waters, 2) Israel SEA – guidelines for offshore petroleum & natural gas exploration, 3) Israel planning & declaring MPAs (coastal and marine), 4) Israel Species protection (threatened, ecologically important	Improve	Stay as is or change in negative way	Change in negative way (in terms of environment)
34 (2)	Israel committed to international treaties to protect 10% of its territorial waters by 2020. INPA strives to achieve 20% protection of Israeli Mediterranean territorial waters. General plan to achieve that is with a coastal MPA network covering most shelf habitats. So far, less than 1% is protected with seven, mostly very small, declared MPAs. Most of them protect shallow reef habitats. In the past few years there is a large push to increase the number and size of MPAs to approach 20%. Three more MPAs are approved (two	The pending MPAs will be approved and also enforced and monitored and will also adapt to the changing climate	More MPAs will not be approved, existing MPAs might not be monitored or even enforced	Some new MPAs will be approved and declared, but not those that are perceived to conflict with the oil and gas industry, or open sea aquaculture. Sophisticated technology will be used for monitoring and enforcing.

	larger) and four more are suggested (most large). MPA research has also dramatically increase in the past half-decade.			
35	1) Fishing regulations -Breeding season moratorium, 2) New restrictions and regulations on Trawl fishing, 3) New regulations on recreational fishing (quotas, ban on spearfishing for SCUBA divers). 4) Nature reserves in areas where benthic features serve as habitat for territorial predatory fish (such as Groupers).	Improve	Stay as is or change in negative way	Change in a negative way (in terms of the environment)

1.1.2. Cultural

Table 3.1.3. The cultural importance of habitats / species associated with habitat restoration (NBS1), marine conservation (NBS2) and nature-inclusive (sustainable) harvesting (NIH).

SL	NOW	In the Future
1-3	tourism – tourist based fishery – recreational fishery – Robust local communities	tourism – tourist based and recreational fishery might be positively affected under global sustainability. Robust local communities would probably be negatively impacted by the WM scenario
1-2 (2)	Conservation may lead to conflict with fishery and tourist industry. Destructive restoration measures to decrease sea urchin populations (e.g. treatment with quicklime) may lead to conflicts with conservationists. The costs for kelp restoration is high and conflicts may arise if society does not see the value in investing for restoration of kelp.	GS may improve opportunities for traditional activities such as recreational fishing, diving, tourist opportunities, while NE and WM would focus more on the creation of jobs and business opportunities.
5	Both commercial and leisure fishing suffer because the poor health of coastal and marine habitats has changed fish communities towards lower value fish. The leisure value and attractiveness of the coastal areas may also decrease due to eutrophication and cyanobacteria booms in summer. This effect has to date been limited, however, since few local people stop visiting their summer cottages or stop boating and yachting entirely despite the obvious environmental problems. This may change, however, if the state of the environment collapses, with murky water, persistent cyanobacteria blooms and degraded habitats. Climate change (CC) is projected to worsen the environmental problems of the Baltic Sea, but CC may, controversially, also increase the tourism of the northern Europe by more 25southern inhabitants, due to the extreme heat waves	The impacts of scenarios are in this respect, from best to worst: 1) Global sustainability; 2) World markets; 3) National enterprise. Especially in the worst scenario, in long-term, the possibilities for spending leisure time at sea may worsen. This includes summer cottaging and boating/yachting. Also both leisure and professional fishing may decrease. The slowly emerging nature tourism will decrease with the declining attractiveness of the natural environment. Mitigation of eutrophication and restoring the state of habitats, as well as prevention of biodiversity loss by increasing conservation of sea areas will be indispensable for which way the future will go: (a) further decrease of the state of the marine environment, and consequent decrease of ecosystem services for humans, including fisheries and leisure value, or (b) sustained ecosystem services and leisure value for local inhabitants and increasing tourism

	nowadays occurring in southern Europe. This attractiveness however largely depends on the state of the environment. The murky and cyanobacteria laden of the Baltic Sea may appear "polluted" by people accustomed to the relatively clear waters of the Mediterranean and the Atlantic coasts.	attractiveness for the more southern inhabitants of Europe and the World.
6	Eelgrass meadows support biodiversity, with benefits for e.g. coastal fishery and protect the local coastlines (in addition to other benefits), which direct support the local community. Other activities such as anchoring in eelgrass meadows, trawling for e.g. mussels in shallow waters, dumping of sand (e.g. from digging of harbor canals), coastal constructions, etc. damage eelgrass meadows and will need regulation in order not to conflict with eelgrass health.	GS: population will obtain a closer connection with the coastal ecosystems and acknowledge that healthy ecosystems support both direct activities such as fisheries, and also help protect the coastline and retain both carbon and nutrients. NE: risk that people ignore the benefits of healthy ecosystems and that e.g. local fishery will no longer be possible. WM: peoples connection to marine habitats is likely to be intermediate between GS & NE.
8	Implementation of NBS1 (restoration) and NBS2 (MPAs) will conflict with fishing activities, especially spatially.	Storyline 8 examines scenario impact only on small-scale boat fisheries. Other aspects are detailed in Zandersen at al. (2019) for SSPs.
10	Oyster restoration is aiming for offshore areas that are now used for fisheries. There may be a conflict with that.	Oyster restoration is aiming for offshore areas that are now used for fisheries. There may be a conflict with that.
11	Coastal tourism; coastal fisheries depend on these habitats for nursery but restrictions on activities can lead to conflict; water sports (can also lead to conflict e.g. though restrictions on mooring deployment). In general, the level of conflict is low.	In general, people in the region feel a strong sense of belonging to the coast. So long as livelihoods are not strongly impacted, I think it is unlikely people would oppose to NBS1 and 2 type of activities. The growth of economic activities under the NE and WM scenarios leading to environmental degradation will likely be strongly opposed by local communities.
16 & 18	tourism – recreational fisheries – other outdoor activities (sport…) – heritage, also traditional commercial fisheries	GS: less tourism because increased environmental protection, NE: touristic areas may decrease due to CC impacts but several strong initiatives to promote tourism in local spots. WM: tourism decreases due to CC impacts and no investment due to low return to global economy. Similar trends for the three other cultural activities
17 & 19	Acknowledge the important cultural values of commercial fisheries.	GS>NE>WM 1) small-scale fisheries diminish, 2) industrial fisheries intensifies causing 3) a decrease of traditional know-how, 4) an increase of new gears/technologies more selective and respectful of the resources when moving from scenario 1 to 3. WM decrease/disappearance of small ports and other infrastructures
20, 22, 24	Estuaries restoration have mainly conflicts with recreational uses. MPAs can help to resolve conflicts between endangered mammal and seabird species that can be interacting with some fishing gears.	Fisheries capacity has been reduced and likely to continue to be reduced due to a lack of generational replacement and lower fish prices. Recreational use of estuaries is likely to keep increasing but together with higher protection of endangered and key species.
21 & 23	Healthy, clean and biodiverse marine ecosystems (i.e. macroalgae and seagrass forests) can be a target for recreational and touristic activities, attracting divers and	GS: policies improve the management of natural resources, reducing exploitation and, at the same time, improving marine biodiversity and water quality through habitat restoration and

	other water sports enthusiast. Protection of coasts and communities can improve water quality and the development of rich ecosystems, which represent a strong point for tourist and recreational activities.	coastal protection. Improves tourism and recreational opportunities (increased ES). NE: Solving local issues takes priority at expense of environmental research, restoration, education and technological development. Lack of strong environmental policies causes habitat degradation. GM: economic and social growth prioritized over ecosystem health (protection and restoration policies) causing overexploitation of the natural resources.
21& 23 (2)	Portugal is culturally very connected to the sea with coast renown destination for marine sports (surfing, kite-surfing, etc.), scuba diving (around islands) and vacation tourism. These activities gain from improved environmental quality and protection, be it because people want to swim at beaches with good water quality or because scuba divers are drawn by rich biodiversity. Economically, the Portuguese society depends a lot on marine resources with large communities of fisherman who might not approve of having MPAs that exclude fishing. Renewable energy production also viewed negatively by fishermen either because they believe the structures will scare off the fish or because of spatial limits to fishing area. The management of our resources will, invariably put limits on the exploitation of certain fish species, which will drive up prices in a country with among the world's highest fish consumption. This will lead to negative view even though people may understand the good intention of policies.	GS: Better management of our resources curbing overexploitation, improving biodiversity, water quality and energy efficiency. Countries pushed to find long- term solutions in lieu of short-term rewards, short-term disadvantages largely compensated in long-term. Traditional activities will increase. NE: influence of wealthy corporations increased with focus on GDP as opposed to long-term sustainability. Wealth production a priority and not ocean health with long-term negatively impacts on ecosystems and coastal water quality with impacts on traditional activities. WM: short-term economic benefit prioritized over nature protection and ecosystems health. Restoration either halted or greatly reduced. Exploitation of natural resources would have a positive impact on GDP but negative impacts on (or cessation of) traditional activities such as collapse of sardine fisheries.
25	Enjoyment of the sea through amateur fishing, recreational navigation, bathing, swimming and other aquatic sports depend on the health of *P. oceanica* meadows. The implementation of restoration, forcefully at small scale given the restoration resources available, might not lead to conflict with these activities. The increase of MPAs could potentially generate conflicts mostly with recreational navigation and limitation / regulation of anchoring in specific areas.	GS: Responsible enjoyment of sea would improve with benefits to all traditional activities. NE and WM: the marine environment will be affected negatively and traditional activities might be also affected negatively although this might not be perceived by all.
25 (2)	-Boating/yachting -Recreational fishing -Diving, snorkelling -Tourism in general Conflicts are expected with boating and recreational fishing in protected / restored areas. However, avenues to reconcile disputes exist	Probably artisanal fisheries will suffer, as it is an economically residual activity. It could, however, be improved in the global sustainability/world markets scenario if a proper link between conservation and fisheries is established. Diving activities, of some economic importance, will be enhanced in the most favourable scenarios. Beach maintenance will also be enhanced if Posidonia meadows are properly managed, which implies strong conservation efforts.

		Restoration is unlikely to serve as a quantitatively solid solution in the Balearic Islands because seagrass meadows are well conserved in general. However, it has the potential to 1) aid in restoration of degraded areas at both small, localized as well as broader Mediterranean scales.
26	Aegean Sea is an important part of Greek 28society with unique cultural heritage linked to historical and religious values, to education and scientific interests but also to recreational experiences, such as outdoor activities and sports as well as different forms of ecotourism. The region has millions of tourists per year (causing environmental problems) Overfishing is also common in the Aegean Sea. In these cases, the 28other national regulations and conservation measures, might be perceived as a conflict to the existing economic interest	GS: cultural activities, ecotourism, education and sustainable, traditional fishing would be favoured. NE & WM: those activities would probably be neglected over mass touristic activities and commercial fishing.
27	Implementation of NBS2 will only be beneficial for the MPA and the overall health of the marine habitat. The main issue would be that local communities might object to the implementation of the scenario, but I believe that in the end they will also assist in its implementation.	Fishing will certainly be impacted, as no-fishing zones probably will be designed. Also, touristic activities will be impacted, as people may be banned from visiting certain areas of the MPA.
27 (2)	Local activities that would be benefited from a GES, as well as form the application of NBS2, include leisure fishing, scuba diving and tourism. In addition, the Karpathos and Saria MPA area has a significant archaeological value due to the 7^{th}-10^{th} century AC settlements that are present, while the Ephorate of Underwater Antiquities performs field research as there are remains which are yet to be studied. No conflicts relevant to societal issues are expected.	Fishing activities from local fishermen may be impacted (restricted) if a more strict scenario for explicit no-use zones will be applied in the MPA area. The idea of closing access to specific areas (i.e. Tristomo Bay) will not be well accepted by some of the locals.
27 (3)	Tourism is the major activity dependent on coastal and marine habitats in Karpathos & Saria MPA. NBS1 could indeed lead to conflicts with hotel owners who would like to extend their properties, as building authorizations will gradually decrease. Water sports and other polluting touristic activities could also be problematic if NBS2 implementation gets strict. An issue could also be fisheries. Telling to people to stop industrial fishing and aquaculture could lead to a feeling of injustice within fishermen.	Emphasis should be put on the strong connection between smaller (island) communities and their natural environment and other species. Agricultural traditions are conscious, there are less industrialized practices in these fields, compared to big cities with greater populations. The centralization of the economy in bigger cities has led to the major urbanization of territories, the artificialization of soils and oceans, the industrialization of execution, etc; therefore leading to an almost total disconnection of humans from other species and a loss of the sense of interdependencies within the ecosystem. GS: If damage to biodiversity remains despite RCP2.6, the only alternative solution is increasing education and public awareness. People would have better understanding of their interactions

		with other species and professions would increase concern about conservation of marine life. They could pay more attention to what they buy or the activities that they exert, for example due to tourism development. Traditional activities such as sustainable fishing would be strengthened, despite massive fishing industrial practices. NE: Increased competitiveness, combined to RCP8.5 scenario would lead to a low funding for biodiversity preservation, increasingly threatened due to climate change and overexploitation of marine resources. WM: Productivity being the aim, overexploitation would decrease biodiversity. However education could hopefully bring staff to protection units.
27 (4)	Local traditional communities have strong links with the sea, including cultural feasts, agricultural and fishing activities. My feeling is that local communities would benefit from NBS 1 & 2 and there would not be any significant conflicts	The coastal fisheries sector would benefit from the establishment of MPAs. Local economy would also benefit from the increase of tourist activities. However, it is important that the tourism sector grows in a sustainable and eco-friendly way, respecting local culture and minimizing effects on the natural environment.
27 (5)	Artisanal fisheries is a major activity in the Karpathos/Saria MPA, which is directly dependent on the health of coastal and marine habitats, while at the same time has a strong and direct impact to this exact health if performed without regulation and sound management. In the same manner, tourism is strongly based on a pristine environment and enjoyment of the coastal area of high environmental quality and pristine nature – but must comply with regulations to respect carrying capacity and sustainable practices. The implementation of conservation- and restoration-oriented NBSs is thus essential, but stakeholders should be involved and informed in the best way possible and in all stages of policy-making to achieve and ensure consensus and societal acceptance.	GS: better management of resources and emphasis on human well-being will improve the main activities (fisheries, tourism) in the MPA in the long-term, by enhancing environmental quality, availability of resources, and environmental consciousness. NE: negative impacts on these activities, through emphasis on short-term profit and relief which is expected to lead to depletion of resources and general environmental degradation. WM: although generally favourable to environmental sustainability through economic and political stability, maintaining environmental health and resource management will be challenging due to increased demand and will require effective management and public education to impose the necessary mitigation measures to ensure long-term benefits and wise management.
29	Nautical activities, fisheries, tourist sector. The implementation of NBS2 including no-use no take zones will lead to conflicts with these activities.	GS: Even though more strictly regulated, the activities outside MPAs could benefit from better ecological status of habitats. NE: long-term, unsustainable use of resources will harm a number of activities. WM: The urge for economic development will lead to conflicts with certain stakeholders but, at the same time, other sectors could benefit from this like Eco-tourism or sustainable traditional fisheries.
30	There are several cultural activities that may conflict with marine conservation, including fishing (recreational, artisanal or industrial), recreation and tourism, diving, etc.	GS: most activities may improve, with the exception of highly impacting industrial fishing such as bottom trawling which could be banned or highly reduced. WM: some activities may improve, mostly related to recreational fishing, tourism and diving. NE: it is likely that all activities will worsen.

31	There are several cultural activities that may conflict with sustainable fishing, including recreational, artisan and/or industrial fishing as well as tourism and its impacts (pollution of waters, use of the coastal line and beaches, use of the maritime domain, increase of noise, ...)	GS: fishing activities may reach sustainability, and highly impacting industrial fishing such as bottom trawling may be banned. Other activities related to tourism may reduce their impact and converge towards lower footprints, WM: some activities may reach sustainability, mostly related to recreational and artisanal fishing, but negative activities may persist, especially related to tourism. NE: all activities will worsen and impacts will increase.
34	Sport fishing (especially in the vicinity of coastal rocky reefs and abrasion platforms). We believe that a ban on sport fishing in MPAs will be a conflict with sport fishing activities	In case Rocky Reefs will be included in a nature reserve and sport fishing will be banned, it is obvious that sport fishing will no longer exist (it will affect the fishermen but be an improvement for nature)
34 (2)	Professional (very small sector), artisanal and sport (a growing and large sector) fishing depend on healthy reef habitats but placing MPA is already creating huge tension and conflict with these stakeholders/users because of distrust and misconceptions, and maybe relatively poor communication with these sectors. Snorkelling and diving also depend on the health of these ecosystems but here there is less conflict and perhaps a support by these stakeholders.	GS: fishermen will have to adapt and for a while they might suffer but eventually, hopefully, they will see the benefits of a healthy network of MPAs that will also export fish outside their boundaries. Other sea-users will certainly benefit. NE: fishermen will be happy at first but when the sea eventually empties due to increased overfishing they will suffer, but probably will blame this on other “stressors”. All other sea-users will suffer too. WM: Fishermen of all sectors will be satisfied that no more pieces of the ocean are being “taken” from them. Other sea-users will not see the full benefits of extensive ocean protection.
35	Sport fishing and commercial fishing. NBS2 implementation can create conflict with the above-mentioned activities (in case all recreational fishing activities will be prohibited in the nature reserve/MPA)	GS: sport fishing could be banned / will no longer exist – negative impact on fishermen but improvement for nature). Tough, in the long run, fish populations may be restored inside MPAs and spill over may occur. WM: trawl fishing will be free and without any restrictions, benthic and mid-water fish species and invertebrates (along with non-target species) will suffer great losses, bottom integrity will be damaged and fish populations and invertebrate populations will decline. Long-term negative impact on traditional activities (like fishing)

1.1.3. Legal

Table 3.1.4. Current legal instruments (or comments on legal instruments) associated with the implementation or other aspects of NBS1, NBS2 and NIH.

SL	Answer
1-3	improved laws /regulations that make habitat restoration more simple would promote the NBS benefits of kelp restoration
1-2(2)	The negative impact on kelp forest from eutrophication and overgrazing could have been less if the legislation relating to nutrient emissions (from land and aquaculture) were stricter and if the management of fishery resources was ecosystem-based
5 & 7	Conservation actions due to national Nature Conservation Act and EU requirements to establish a Natura 2000 network.
6	Global policies are The Convention on Biological Diversity (CBD), the Ramsar convention for wetlands, the UNESCO Biosphere Reserves and Natural World Heritage sites, and the United Nations' Sustainable Development Goals. At the regional scale, these are the EU Water Framework Directive, The marine Strategy Framework Directive, The Habitats Directive, and The Birds Directive, The Nitrate Directive. The Baltic Sea Action plan and the OSPAR convention also play positive roles.
8	Simulations for the Central Baltic Sea are performed using an end to end ecosystem model from primary producers to top predators (Gray Seal). Harvested species are cod, sprat, herring and flounder. Fishing fleets: according to DCR passive gears, trawls and pelagic trawls.
10	Natura2000 regulation and Good Environmental Status (MSFD)
11	The Natural Capital Assessment undertaken by the Biosphere (not a legal document) which provided advice on the desire from stakeholders to grow carbon sequestration locally. We have a natural capital strategy in the area that is used as material consideration in the development of any activity for the area and therefore indirectly supports conservation and enhancement of the natural capital.
16 & 18	EU green deal – Transposition into national laws of EU regulations and directives Local level: MPA action plan written by the MPA boards
17 & 19	EU CFP and species management plan, Eel management plan (Eel directive), Transposition into national laws of EU regulations / directives listed above
21 & 23	1) Climate law decree nº98/2021, from the December 31st, 2021) target the ecological balance while fighting the climate change effects, 2) EU Water Framework Directive establishes the minimum requirements to achieve and maintain a 'Good' status for all water bodies, as well as an adequate management of pressures, which allows reducing or eliminating the resulting impacts. 3) EU Habitats Directive focuses on the protection of vulnerable ecosystems, creating specific lists of priority habitats which include the afore mentioned marine forests.
21& 23 (2)	Some MPAs are having positive impacts in local ecosystems and fishing quotas have protected some populations from collapse. National laws and regulations are still faulty, with not enough effort in decreasing the capture of non-target species and some fishing quotas are too relaxed or too many permits have been issued (e.g. sea urchin collection). Water quality and coastal ecosystems need better protection such as better management of freshwater and from activities such as dredging. Our rivers are getting increasingly polluted by industry and though regulations exists, there isn't enough oversight in place. In a country with a large river network, coastal water can be greatly impacted. The networks of residual water treatment facilities also needs stronger directives to improve their efficiency.
20, 22, 24	Please, see legislation section in: https://www.ihobe.eus/biodiversity
25	*P. oceanica* meadows are protected by national and regional legislation. This approved legislation may be used by environmental managers to support/approve *P. oceanica* restoration initiatives. However, the lack of approved legislation specific about *P. oceanica* restoration makes that restoration initiatives are not coordinated or proposed to be done in locations where restoration success or associated benefits are low.
25 (2)	-It is forbidden to 1) anchor over *P. oceanica* (positive), 2) to collect it (positive). The highest proportion of MPAS in Spain is in the Balearic Islands (positive). It is compulsory to compensate

	(environmentally) damages to Posidonia conducted by companies (e.g. through underwater electric cables, etc.). It is forbidden to trawl in waters < 50m depth.
26	National laws for MPAs and species protection, fishing regulations and FRAs. EU Habitats Directive for the Natura 2000 network, Barcelona Convention for the protection of the marine environment, EU Biodiversity Strategy by 2020 and the Convention on Biodiversity for the protection of the habitats.
27	In our country (Greece), legal instruments have not had a strong influence on the MPA. For example, the Presidential Degree that would turn the MPA into a National Marine Park has been prepared for years but was never signed. I think important species will require the highest level of protection in the future.
27 (2)	- Biodiversity Law (2011) for designation of "Habitats and Species Protection Areas", distinguished in Special Areas of Conservation (SAC) and/or Special Protection Areas (SPAs). – Law No. 3937/2011 (Official Journal 60/A/2011) for the protection and conservation of the Natura 2000 network. – EU Water Framework Directive – Marine Strategy Framework Directive 2008/56/EC and national Greek legislation law No. 3983/2011 – Habitats Directive (92/43/EEC)
27 (3)	- Law No. 3937/2011 (Official Journal 60/A/2011) Conservation of biodiversity and other provisions. – 2000/60/EU Water Framework Directive. – Law No. 3983/2011 (Official Journal 144/A/2011) National strategy for the protection and management of the marine environment – Harmonization with MSFD Directive 2008/56/EC of the European Parliament and of the Council of June 17, 2008 and other provisions. – Regulation (EC) No. 1967/2006 for the sustainable management of fisheries resources in the Mediterranean. – Law No. 4519/2018 (Official Journal 25/A/2018) Protected Area Management Bodies and other provisions. – Law No.4685/2020 (Official Journal 92/A/2020) Modernization of environmental legislation, incorporation into Greek legislation of Directives 2018/844 and 2019/692 of the European Parliament and the Council and other provisions.
27 (4)	Numerous national laws and regulations which change all the time according to the agendas of individual governments, ministers and their consultants
27 (5)	Greece has integrated the EU Habitats Directive in its legislation and is part of the Natura 2000 Network with a total of 446 designated areas. For marine habitats, in particular, Natura 2000 sites occupy 20% of the national waters. However, so far the management scheme has proved generally ineffective to promote environmental protection and sustainability, mainly through an insufficient regulatory scheme, fragmentation of management, and lack of coordination, environmental control and legal enforcement.
29	1) EU Habitats and Birds Directives 2) National Biodiversity Law: La Ley 42/2007 de 13 de diciembre, del Patrimonio Natural y de la Biodiversidad.
30	Fisheries and environmental legislation is having a negative impact on marine conservation due to the lack of compliance and effective implementation. Other legislation is also having negative impacts in coastal and offshore areas due to the lack of compliance and the fact that legislation is sectoral and does not consider the cumulative impacts of multiple activities.
31	Bottom trawling requires more strict enforcement in MPAs. Currently other legislation (or the lack of compliance) is also having negative impacts in coastal and offshore areas due to pollution and the cumulative impacts of several human activities.
34	1) National parks, Nature reserves, National sites and monuments Law, 2) Planning and Building Law, 3) Fishing regulations, 4) Environmental regulations such as "protected species law"
34 (2)	Fishing regulation are set by the Fisheries Department (they were greatly updated in 2016), approved by the Finance Committee in the Parliament (last updated approved in 2017) and today enforced by INPA (before by the Fisheries Department). All fishing activities in Israel, apart from pole and line fishing from the shoreline, require a license. MPAs are suggested by INPA, declared by law and enforced by the INPA. There are strict government regulations against marine pollution from terrestrial sources (the pollution law) and restrictions on coastal development.
35	Shelf fisheries catch established by Fisheries Department, enforced by the INPA

Table 3.1.5. Ratings of the change for each of the three scenarios (GS = Global Sustainability, NE = National Enterprise, WM = World Markets) from 1 (much less) to 5 (much more) in aspects relevant to the implementation of marine habitat restoration (NBS1), marine conservation such as MPAs (NBS2) and/or nature-inclusive (sustainable) harvesting (NIH). In this table, Storylines (SL) are organized by NBS/ NIH category.

SL	NBS / NIH	Aspect	GS	NE	WM
1-3	NBS1	Implementation of kelp restoration (urchin harvesting)	4	1	2
1-2(2)	NBS1	Implementation of kelp restoration (urchin harvesting)	3	1	2
11	NBS1	Restoration of salt marsh and kelp habitats	4	2	1
21/23	NBS1	Kelp forests and overall health of ecosystem	4	1	2
29	NBS1	Habitat-forming macroalgae & corals in W. Mediterranean	5	1	3
25	NBS1	Restoration of *Posidonia oceanica* habitat / beds	4	2	3
25(2)	NBS1	Restoration of *Posidonia oceanica* habitat / beds	4	2	3
17/19	NBS2	Total marine- estuarine opportunistic & diadromous fishes	2	2	3
16/18	NBS2	Marine- estuarine opportunistic & diadromous fishes	5	2	1
30	NBS2	Environmental conservation (MPA implementation)	5	2	4
34	NBS2	Protection of coastal (rocky shores) and offshore waters	5	2	1
26	NBS2	Protection of 68 ecological (benthic and pelagic) features	4	2	2
27	NBS2	Species protection using MPA	4	1	1
27 (2)	NBS2	Coastal fish, marine mammals, benthos conservation MPA	4	2	5
27 (3)	NBS2	Conservation of habitats / species in MPA	4	3	1
27 (4)	NBS2	Conservation of coastal habitats using MPA	5	1	2
27 (5)	NBS2	Conservation of seagrass, sandbanks, rocky reefs, marine caves	5	1	2
5 & 7	NBS2	Protection of seagrass and seaweed habitat	5	3	4
6	NBS1&2	Protection & restoration of eelgrass habitat	5	1	2
10	NBS1&2	Protection and restoration of oyster habitat	4	2	2
8	NIH	Sustainable fisheries exploitation in central Baltic	3	4	5
31	NIH	Sustainable fishing	5	2	4
35	NIH	Fisheries active in SE Med	1	4	3
35(2)	NIH	Shelf fisheries catch	4	2	1
20,22,24	NBS+NIH	Restoration of seagrass, conservation areas & NIH	4	4	4

4.2. Regional Information from Workshops

4.2.1. Storylines 6 and 9 (Danish Coastal Waters)

A stakeholder workshop was convened for the Danish coastal waters from the SW Baltic Sea to the southern North Sea (Limfjorden) region. This stakeholders were asked questions regarding activities in Storylines 6 (eelgrass Zostera marina restoration) and 9 (suspended mussel culture). Answers were collected using the online software package Mentimeter (see Figs 4.1.1 and 4.1.2 for results).

Figure 4.1.1. Stakeholders answers to questions posed on Storyline 6 (eelgrass restoration). Panel A) Five benefits were provided and stakeholders indicated whether disagreed (right) or agreed (left). Not all Stakeholders agreed that pH buffering was a benefit whereas most agreed that eelgrass protect against coastal erosion). Panel B) Five potential concerns were listed and ranked in importance (e.g. high cost of implementation was the top concern. Panel C) Stakeholders listed 12 potential barriers to implementation, two of which were related to harmful activities of other sectors such as trawling and pollution (eutrophication).

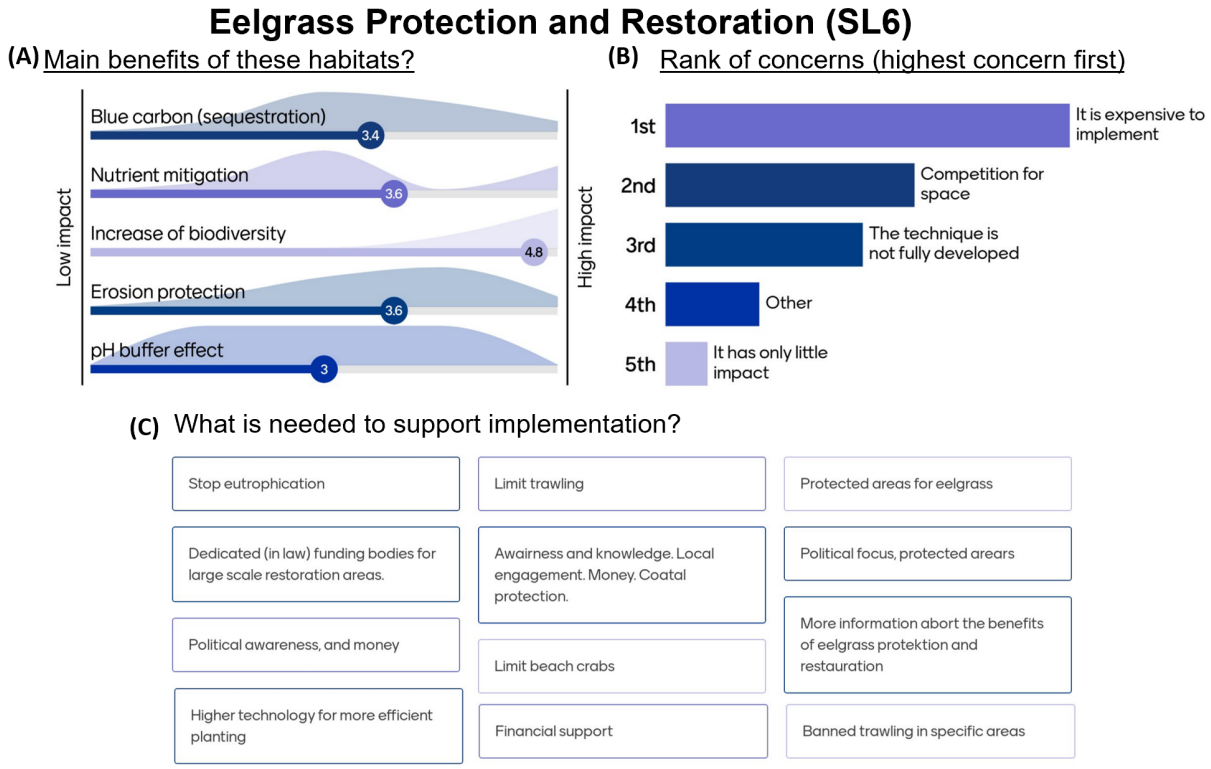

Figure 4.1.2 Stakeholders answers to questions posed on Storyline 9 (mussel culture). Panel A) Five benefits were provided and stakeholders indicated whether they disagreed (right) or agreed (left). Most stakeholders agreed that the main benefit was providing protein with a low carbon footprint, at the same time, they disagreed most on whether it was a healthy food. Panels B & C) Six potential concerns were listed and ranked in importance for either commercial culture or culture for mitigation. Competition for space and local pollution in sediments were the top concerns. Panel D) Stakeholders listed 12 potential barriers to implementation, two of which were related to increasing public knowledge to gain social acceptance.

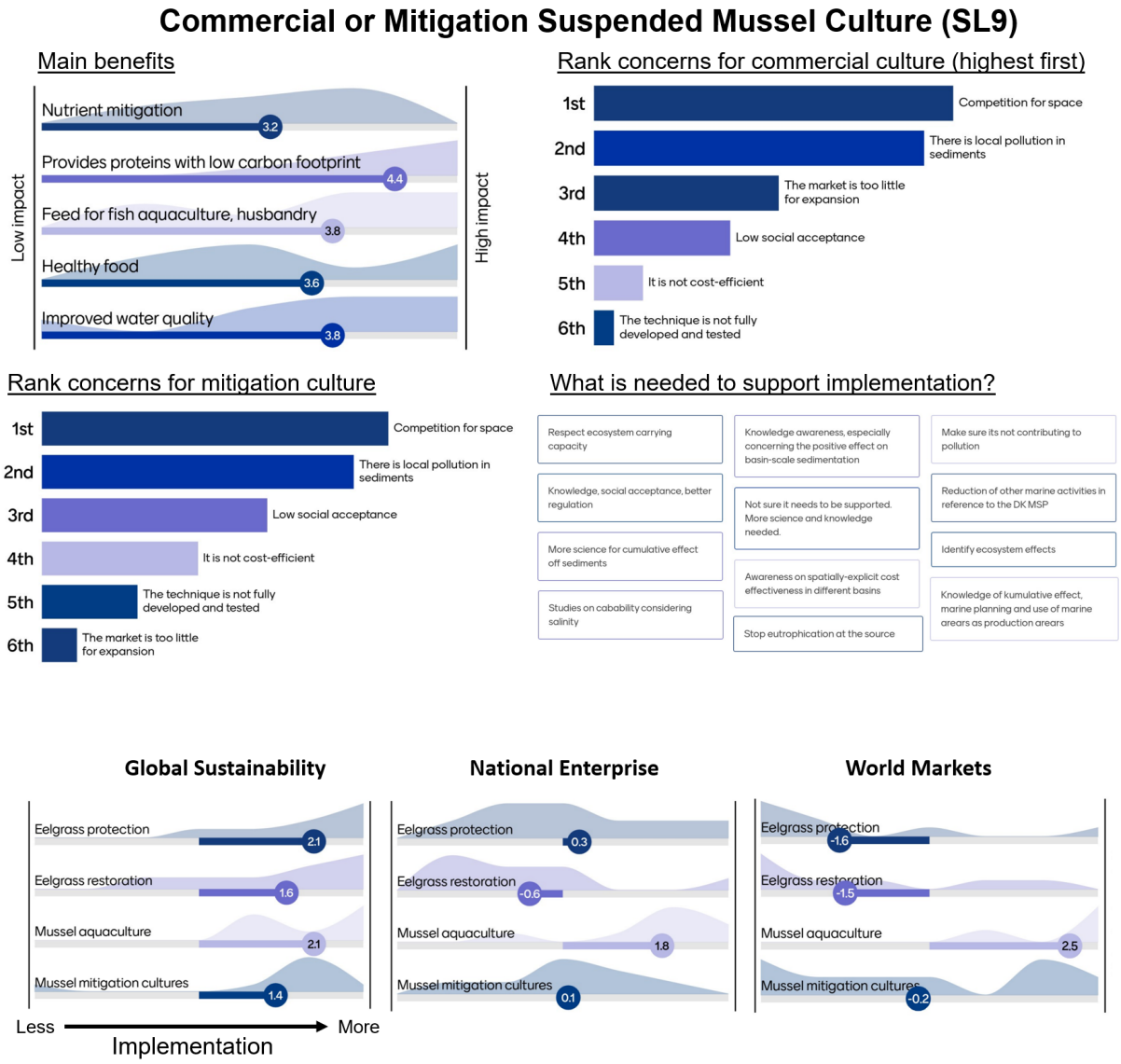

Fig 4.1.3 Changes in the implementation of eelgrass protection and restoration, and mussel aquaculture and mitigation culturing among the three, FutureMARES scenarios. A value of 0, indicates no change. In the opinion of stakeholders, mussel aquaculture would increase in each of the three scenarios. The strongest increases in implementation were in Global Sustainability (for all four activities) and the strongest decrease (and agreement among stakeholders) was for a decrease in eelgrass protection and mitigation in the World Markets scenario.

4.2.2. Storylines 10 and 15 (seaweed, mussels and oysters in North Sea)

For Storylines 15 (NE Atlantic & North Sea – seaweed, mussels, oysters) and Storyline 10 (restoration of oyster reefs in North Sea), a stakeholder event was conducted on Wednesday 8th September 2021 with the Dutch Community of Practice (CoP) North Sea stakeholders. Scenarios were one of multiple topics related to Sustainable Blue Economy topics. Luca van Duren (Deltares) presented FutureMARES and a discussion followed on which aspects to consider when determining which model scenarios to run to determine the carrying capacity of the North Sea for different aquaculture scenarios. Participants included shellfish and seaweed farmers, NGOs, fisheries producers' organizations, government representatives and other research groups. The following is a brief summary of the questions, comments and suggestions made during the discussions with stakeholders.

For shellfish farmers, the dialog indicated that two things were important. First, the production of shellfish and second, delivering a sustainable product. This includes shellfish production in balance with the carrying capacity of the North Sea. Together with NGO's, the shellfish sector will perform future pilot studies where shellfish production (hanging culture) can be combined with nature restoration (reef building due to shellfish falling to the seabed), thus, the it is critical to provide information on the nexus between NBS1 and NIH.

For the future, the Dutch shellfish sector is looking at doubling the present shellfish production with a rough estimation of 40 – 100 km^2. The scenarios discussed for FutureMARES involve much larger areas (~3000 km^2). In addition, when looking at shellfish plots on the North Sea within wind farms, 1 km^2 plots are considered with room between multiple plots so as not to have negative effects caused by local depletion of nutrients. Stakeholders suggested to consider smaller areas within the scenarios, finding a balance between a large enough area to see effects but also keeping in mind an economically viable situation. The suggestion is made to have a follow-up meeting with the shellfish sector to determine the practical boundaries of shellfish production on the North Sea as input for and to fine-tune the scenarios.

At present, the scenarios will include the locations and sizes of areas of Dutch windfarms planned until 2030. One of the stakeholders suggested to use these scenarios to determine the potential locations for Dutch wind farms planned up to 2050 based on the carrying capacity for aquaculture (seaweed or shellfish). The location of the additional wind farms, however, will also have to be practical e.g. as mussels will have to landed for processing within a day.

Stakeholder Questions and Answers by FutureMARES:

• To what extent will multi-use of floating solar panels be included in the scenarios?

Solar panels will not be included in the model, however the effect of windfarm themselves will be a part of the scenarios.

Fishers have experienced an increase in seaweed production in the North Sea to such an extent that it is impacting the spatial areas available for their fishing activities.

• What is the probability that fish farming is technically and economically feasible on the North Sea?

The Dutch climate is not ideal for fish farming due to its temperate zone. However, offshore waters of the North Sea provide a more moderate breeding zone, making it technically possible.

• To what extent are acceptable negative effects of aquaculture on a larger scale on the North Sea considered?

What is considered acceptable will be a policy matter. The work in FutureMARES serves to get a first sense of the order of magnitude of NBS1 and NIH activities. After that information is available, the discussion on what is acceptable can follow. In addition to this answer by FutureMARES, a participant observed that, at the present time, scientific knowledge can contribute to an informed discussion on the possibilities and limits of aquaculture on the North Sea before politics come into play.

• Do the scenarios look at the Dutch EEZ only or the entire North Sea?

At present, the scenarios involve only the Dutch EEZ, but in fact the whole North Sea can be modelled. For example, wind farms in Belgium could be added. The suggestion is made to not only look at the Dutch (aquaculture) activities but to also involve Belgium and German activities within the scenarios.

Cultivating seaweed in areas with high nutrient concentration is challenging due to fouling problems, making it impossible to cultivate year-round. It would be more efficient if seaweed can be left year-round, which is in areas with low concentration of nutrients but with a high water flow rate. Would it be possible to incorporate this in the scenarios?

It is possible, yes. Areas with low nutrient concentrations and a high water flow rate are limited in the North Sea. Borsele (a specific, windfarm) may be one of them. However, the further away from land you will find low nutrient concentrations but also a lower water flow rate. Finding these areas could be done relatively easy using hydrodynamic and nutrient charts.

• Is the natural occurrence of seaweed and shellfish on wind farm monopiles considered in the models?

No, there is no scenario considering only the natural occurrence of seaweed or shellfish on monopiles. Such scenarios are considered in other projects (Dutch Wind at Sea – WOZEP - program). FutureMARES does look at a reference scenario without aquaculture in wind farms.

The suggestion was made to incorporate the 100km^2 Friese Front area in the North Sea in the scenarios. Stakeholders also indicated that it was unclear how realistic it was to combine / integrate seaweed and shellfish aquaculture within a windfarm.

• Do the models differentiate between aquaculture on the seabed and aquaculture at the water surface?

Yes, seaweed aquaculture is at the water surface, cultivation of mussel will be at > 8m depth.

Based on the discussions with stakeholder, two scenario will be used for seaweed culture including 15km^2 nearshore (possible status for 2030) and a maximum carrying capacity approach.

4.2.3. Storylines 28 Tuscan Archipelago MPA network

A stakeholder workshop was held for Storyline 28 (Seagrass meadows and macroalgal forests in the Tuscan Archipelago MPA network). That workshop was based on the stakeholder questions outlined in Deliverable 1.1. Elements of the PESTEL framework were covered with 6 stakeholders providing free-written answers to 2, 5, and 4 questions, on Political, Social, and Legal aspects, respectively. All stakeholders agreed that climate change poses a serious threat to the habitats and infrastructure as well as the cultural and economic assets of the Archipelago. Based on the answers, the following general picture emerged on how these PESTEL elements would change within each of the three scenarios.

Policy – identification of key actors and their interaction. Five regional and national bodies were identified (see section 3.3).

Social – user groups: Trade-offs and potential conflicts between fishers (recreational and commercial) and diving clubs were considered to change among the scenarios. Establishment of a SIC (site of community importance) at Secche di Vada could exacerbate conflicts among grouped. GS – the opinion was that all will be winners but some stakeholders warned of problems in the long-term for fisheries and the eventual need for subsidies. NE – All groups will be losers. WM, some winners and losers, with the latter being weakest social / interest groups due to actions of large companies / investors. Among the three scenarios, in the viewpoint of some stakeholders, recreational fishers were considered to be the least impacted.

Legal - Habitat protection: GS – improve monitoring activities to better implement enforcement and targeted rules / restrictions including those related to the Blue Economy and greater funding available to support science (including that by citizens). Establish mooring fields, and strict protection (strong limits on activities) in some of the region. WM – new rules defined to make safeguarding the environment compatible with rapid economic development but, in general a weakening of control (protection and enforcement) in both WM and NE (although some stakeholders believed NE represents a continuation of the present situation). More ad hoc regulations (national) would be made in NE – with little regard to transboundary issues. Some stakeholders believe key species would be lost in WM.

The information obtained from these stakeholders is already integrated in the five tables listed in section 3.1.

4.3. Regional Scenario Information from Risk Assessments

4.3.1. Background

The use of Climate Vulnerability Assessments (now termed Climate Risk Assessments, CRAs) has evolved as their application has grown and spread to encompass multiple scales, sectors, and purposes (Fussel and Klein, 2006; Cardona et al., 2012). Methods and approaches have shifted from assessing the physical, ecological and socio-economic impacts of CC at long temporal and large spatial scales to more thorough considerations of the adaptive capacity of social systems needed at shorter time and smaller (local/regional) spatial scales (Fussel and Klein, 2006; Cardona et al., 2012). CRAs allow policymakers to better understand the priorities for actions for climate adaption planning by identifying the most at-risk species and habitats in a future climate a critical step to effectively prepare and adapt society (Lindegren and Brander, 2018). The workplan of FutureMARES included a series of CRAs performed on specific Storylines in Task 5.1. These CRAs rank the risks to specific species and habitats with and without the implementation of NBS or Nature-inclusive (sustainable) Harvesting (NIH). The specific details can be found in Deliverable Report 5.1.

The calculation of risk includes assessing three main components: Exposure, Hazard, and Vulnerability. The latter is separated into Sensitivity and Adaptive Capacity. The Adaptive Capacity of the species or group to each hazard was considered to be the potential of the NBS or NIH to counteract the harm caused by the hazard. The approach used in FutureMARES is similar to that used by Cinner et al. (2013) who calculated ecological vulnerability related to specific social groups and approaches that use expert opinions to assess ecological and social risk/vulnerability to climate-driven changes in living marine resources ((e.g. Hare et al., 2016; Colburn et al., 2016). In FutureMARES, the term Hazard was applied to various natural or human-induced factors that potentially degrade habitats particularly those factors that cause harm to habitat-forming species. A variety of Hazards were included in FutureMARES CRAs (12 climate and 8 human Hazards) such as eutrophication, climate-driven warming, heatwaves, ocean acidification and physical disturbance to benthic habitats by fisheries trawling and anchoring. These CRAs were performed at the local to regional level and required stakeholders to gauge differences in the various components among the three FutureMARES scenarios at two time slices (2040-2050 and 2080-2090). The CRAs, therefore, provide a strong example of regionalization of the FutureMARES scenarios.

4.3.2. Input from Regional Experts on CRAs (3 examples)

Stakeholders with expertise on the specific habitat or species in each Storyline were consulted during the ecological risk assessment. These stakeholders ranked the various components of the CRA including Adaptive Capacity for each of the three FutureMARES scenarios. This analysis was performed on 16 Storylines and included 31 ecological CRAs (see Deliverable Report 5.1). For the present report, examples are provided for three Storylines examining the implementation of NBS1 (restoration, Storyline 6) and NBS2 (conservation, Storylines 5 and 28). The measure of the agreement (A) among stakeholders was calculated as: A = the Standard Deviation of the voting across Experts divided by the number of experts. This method has been used to measure agreement in IPCC assessment reports. The experts ranked the importance and severity of hazards among the three scenarios (shown in Tables 4.2.1 and 4.2.2). These were pooled for a final calculation of mean values (Table 4.2.3). The assessments of the AC were done for each specific hazard (shown in Tables 4.2.4 and 4.2.5). These were pooled for a final calculation of mean values (Table 4.2.6.).

Among the three scenarios, stakeholders agreed that hazards were much reduced in GS compared to NS and WM scenarios. The NE was considered to be the most “severe” scenario in terms of hazards. On average, stakeholder considered NBS more effective – more

successfully implemented and with greater positive impacts (Adaptive Capacity was higher) in GS compared to NE and WM scenarios but there was considerable variability with scores depending on the hazard assessed. For example, AC was high for Eutrophication in GS in both time slices for all groups except fish while AC was low for Warming in 2040 and only slightly higher in 2080. Across all groups, scenarios and time slices, AC to Heatwaves was relatively low.

The agreement among stakeholders decreased in 2080 relative to 2040 within each of the three scenarios used here as examples of scenario implementation. For ranking the hazards, the agreement among experts in the three Storylines shown here was lowest for Storyline 7. Among the three scenarios, the agreement of stakeholders on adaptive capacity was highest in GS, somewhat lower in WM and lowest in NE. See FutureMARES Deliverable 5.1 for details. Although it appears that the agreement among stakeholders was relatively low for the hazard rankings compared to the agreement among stakeholders in Adaptive Capacity (compare Table 4.2.3 and Table 4.2.6), this is merely due to methodological differences – the options provided stakeholders for expressing their perspectives (see Deliverable 5.1).

Table 4.2.1 Summary of agreement (A) among stakeholders ranking Hazard among the three FutureMARES scenarios (GS – Global Sustainability, NE – National Enterprise, WM – World Markets) for the 2040 to 2060 time horizon. Exp = Experts. Hazards (HAZ) examined include: Eutrophication (E), Trawling (T), Habitat Degradation (HD), and Anchoring (AN).

Hazard scale (0 to 1, low to high)

<0.16, 0.16 to < 0.33, 0.33 to < 0.5, 0.5 to < 0.66, 0.66 to < 0.83, >0.83

Agreement Scale (1 poor, 5 good)

1, 2, 3, 4, 5

NBS	SL	Species / Group	HAZ 2040	Exp. (No)	Hazard score				Agreement		
					GS	NE	WM		GS	NE	WM
1	6	Seagrass: *Z. marina*	E	3	0.10	0.45	0.37		1	1	1
			T	3	0.32	0.54	0.48		1	1	1
2	7	Macroalgae: *Fucus spp.*	E	2	0.22	0.52	0.38		2	1	2
			HD	2	0.22	0.52	0.48		2	1	1
2	28	Algae: *Cystoseira sp*	E	5	0.16	0.37	0.32		1	1	1
			AN	5	0.05	0.36	0.31		2	1	1
2	28	Algae: Corallinaceae	E	5	0.19	0.40	0.38		1	1	1
			AN	5	0.06	0.20	0.20		2	1	1
2	28	Fish: *Epinephelus*	E	5	0.39	0.55	0.58		1	1	1
			AN	5	0.07	0.35	0.33		2	1	1
2	28	Echinoderm: *P. lividus*	E	5	0.32	0.47	0.42		1	1	1
			AN	5	0.09	0.39	0.28		2	3	2
2	28	Seagrass: *P. oceanica*	E	5	0.18	0.42	0.34		1	1	1
			AN	5	0.17	0.39	0.33		1	1	1

Table 4.2.2 Summary of agreement (A) among stakeholders ranking Hazard among the three FutureMARES scenarios (GS – Global Sustainability, NE – National Enterprise, WM – World Markets) for the 2080 to 2100 time horizon. Exp = Experts. Hazards (HAZ) examined include: Eutrophication (E), Trawling (T), Habitat Degradation (HD), and Anchoring (AN).

Hazard scale (0 to 1, low to high) <0.16, 0.16 to < 0.33, 0.33 to < 0.5, 0.5 to < 0.66, 0.66 to < 0.83, >0.83

Agreement Scale (1 poor, 5 good) 1, 2, 3, 4, 5

NBS	SL	Species / Group	HAZ 2040	Exp. (No)	Hazard score			Agreement		
					GS	NE	WM	GS	NE	WM
1	6	Seagrass: *Zostera marina*	E	3	0.08	0.45	0.37	2	2	2
			T	3	0.28	0.52	0.48	2	2	2
2	7	Macroalgae: *Fucus spp.*	E	2	0.12	0.62	0.38	2	2	2
			HD	2	0.18	0.62	0.58	2	2	2
2	28	Algae: *Cystoseira sp*	E	5	0.16	0.48	0.39	1	1	1
			AN	5	0.03	0.36	0.30	3	2	2
2	28	Algae: Corallinaceae (family)	E	5	0.12	0.48	0.38	2	2	2
			AN	5	0.06	0.21	0.20	2	2	2
2	28	Fish: *Epinephelus*	E	5	0.32	0.57	0.59	1	1	1
			AN	5	0.07	0.35	0.32	2	1	1
2	28	Echinoderm: *Paracentrotus lividus*	E	5	0.21	0.53	0.43	2	1	1
			AN	5	0.09	0.36	0.31	2	2	2
2	28	Seagrass: *Posidonia oceanica*	E	5	0.14	0.45	0.34	1	1	1
			AN	5	0.12	0.38	0.32	1	1	1

Table 4.2.3 Summary of stakeholder estimates of hazard scores and their agreement for each of the three FutureMARES scenarios at the two time horizons (2040 and 2080). The mean and variation (st. dev = standard deviation) was calculated by pooling across habitats / species and hazards. The mean agreement is also provided. (GS – Global Sustainability, NE – National Enterprise, WM – World Markets).

Scenario	Time Horizon	Hazard score			Stakeholder Agreement
		Score (mean)	Variation (st dev)	CV	Score (mean)
GS	2040	0.18	0.10	58%	1.42
	2080	0.14	0.08	59%	1.78
NE	2040	0.42	0.09	22%	1.14
	2080	0.45	0.11	25%	1.57
WM	2040	0.37	0.09	26%	1.14
	2080	0.38	0.10	28%	1.57

Table 4.2.4 Summary of agreement (A) among stakeholders ranking Adaptive Capacity (AC) among the three FutureMARES scenarios (GS – Global Sustainability, NE – National Enterprise, WM – World Markets) for the 2040 to 2060 time horizon. Exp = Experts. Hazards (HAZ) examined include: Eutrophication (E), Heatwaves (H), Warming (W), Trawling (T), Habitat Degradation (HD), Salinity Decrease (SD), Anchoring (AN) and Ocean Acidification (OA).

Adaptive Capacity Scale (0 to 5, low to high)

<1, 1 to < 2, 2 to < 3, 3 to < 4, 4 to < 5

Agreement Scale (1 poor, 5 good)

1, 2, 3, 4, 5

NBS	SL	Species / Group	HAZ 2040	Exp. (No)	Adaptive Capacity			Agreement		
					GS	NE	WM	GS	NE	WM
1	6	Seagrass: *Zostera marina*	E	3	3.3	2.3	2.3	4	1	1
			H	3	2.3	2.3	1.7	4	2	4
			W	3	2.7	1.7	1.7	4	2	2
			T	3	3.3	2.3	2.3	4	1	1
2	7	Macroalgae: *Fucus spp.*	E	2	3.0	1.0	1.5	5	5	2
			HD	2	2.5	1.0	1.5	2	5	2
			H	2	1.0	0.5	0.5	1	2	2
			SD	2	1.0	0.5	0.5	1	2	2
			W	2	1.0	2.0	0.5	1	1	2
2	28	Algae: *Cystoseira sp*	W	5	2.2	0.6	1.4	4	4	3
			E	5	3.8	0.6	2.0	5	4	3
			AN	5	4.4	1.6	3.6	4	2	2
2	28	Algae: Corallinaceae (family)	W	5	1.8	0.7	1.3	4	5	4
			H	5	1.8	0.7	1.3	4	5	4
			OA	5	2.2	0.7	1.5	4	5	4
			E	5	4.2	1.5	2	4	5	4
			AN	5	4.5	2.7	3.7	4	3	3
2	28	Fish: *Epinephelus*	W	4	1.2	0.2	0.2	5	5	5
			H	4	1.8	1.0	0.8	4	4	5
			OA	4	0.8	0.0	0.2	5	5	5
			E	4	1.0	0.2	0.6	4	5	4
			AN	4	4.0	1.6	2.2	1	4	3
2	28	Echinoderm: *Paracentrotus lividus*	W	4	1.8	1.4	1.4	4	2	3
			H	4	1.8	0.6	1.0	5	4	4
			OA	4	1.6	1.2	1.2	3	3	3
			E	4	3.2	1.4	1.6	4	4	4
			AN	4	4.0	3.0	3.4	4	4	3
2	28	Seagrass: *Posedonia oceanica*	W	4	2.6	1.0	1.6	2	4	3
			H	4	2.0	0.6	1.0	3	4	4
			OA	4	2.2	1.0	1.4	3	4	3
			E	4	3.2	1.4	2.0	4	4	4
			AN	4	3.8	2.4	2.6	5	4	4

Table 4.2.5 Summary of agreement (A) among stakeholders ranking Adaptive Capacity (AC) among the three FutureMARES scenarios (GS – Global Sustainability, NE – National Enterprise, WM – World Markets) for the 2080 to 2100 time horizon. Exp = Experts. Hazards (HAZ) examined include: Eutrophication (E), Heatwaves (H), Warming (W), Trawling (T), Habitat Degradation (HD), Salinity Decrease (SD), Anchoring (AN) and Ocean Acidification (OA).

Adaptive Capacity Scale (0 to 5, low to high)

<1, 1 to < 2, 2 to < 3, 3 to < 4, 4 to < 5

Agreement Scale (1 poor, 5 good)

1, 2, 3, 4, 5

NBS	SL	Species / Group	HAZ 2080	Exp. (No)	Adaptive Capacity			Agreement		
					GS	NE	WM	GS	NE	WM
1	6	Seagrass: *Zostera marina*	E	3	3.7	2.3	2.3	4	1	1
			H	3	3.0	2.0	1.7	2	1	4
			W	3	3.0	2.0	2.0	2	1	1
			T	3	3.3	2.3	2.3	4	1	1
2	7	Macroalgae: *Fucus spp.*	E	2	3.0	1.0	1.5	5	5	2
			HD	2	3.0	1.0	2.0	5	5	5
			H	2	1.5	0.5	0.5	1	2	2
			SD	2	1.5	0.5	0.5	1	2	2
			W	2	1.5	0.5	0.5	1	2	2
2	28	Algae: *Cystoseira sp*	W	5	2.6	0.6	1.4	2	4	2
			E	5	3.8	1.2	2.2	5	4	3
			AN	5	4.8	1.6	3.8	5	2	3
2	28	Algae: Corallinaceae (family)	W	5	2.7	0.5	1.3	3	5	3
			H	5	2.5	0.5	1.1	3	5	3
			OA	5	3.0	0.5	2.0	3	5	3
			E	5	4.5	1.7	2.7	5	4	4
			AN	5	4.8	2.8	4.0	5	3	4
2	28	Fish: *Epinephelus*	W	4	1.2	0.2	0.2	5	5	5
			H	4	1.8	1.0	0.8	4	4	5
			OA	4	0.8	0.0	0.2	5	5	5
			E	4	1.0	0.2	0.4	4	5	4
			AN	4	4.0	1.6	2.2	1	4	3
2	28	Echinoderm: *Paracentrotus lividus*	W	4	2.4	1.2	1.4	4	3	3
			H	4	1.8	0.6	1.0	3	4	4
			OA	4	3.0	1.2	1.4	3	3	3
			E	4	3.8	1.8	2.4	3	4	3
			AN	4	4.4	2.8	3.2	4	3	3
2	28	Seagrass: *Posedonia oceanica*	W	4	3.0	1.2	2.0	3	3	2
			H	4	2.0	0.6	1.6	3	4	2
			OA	4	2.8	1.2	1.8	2	3	2
			E	4	3.6	1.6	2.4	3	3	3
			AN	4	4.2	2.6	3.0	5	4	4

Table 4.2.6 Summary of stakeholder estimates of adaptive capacity and their agreement for each of the three FutureMARES scenarios at the two time horizons (2040 and 2080). The mean and variation (st. dev = standard deviation) was calculated by pooling across habitats / species and hazards. The mean agreement is also provided. (GS – Global Sustainability, NE – National Enterprise, WM – World Markets).

Scenario	Time Horizon	Adaptive Capacity			Stakeholder Agreement
		Score (mean)	Variation (st dev)	CV	Score (mean)
GS	2040	2.50	1.11	44%	3.59
	2080	2.87	1.12	39%	3.38
NE	2040	1.24	0.78	63%	3.56
	2080	1.23	0.80	65%	3.40
WM	2040	1.58	0.89	57%	3.19
	2080	1.74	0.98	56%	3.00

4.4. Scenarios tested in NBS-NIH Ecosystem Simulations

4.4.1. Background

The research activities in FutureMARES include projecting the ecosystem-level impacts of different scenarios of climate change and implementation of NBS and NIH. Various spatially-explicit models have been created to explore changes in the distribution and productivity of marine plants and animals (Peck et al. 2018) and FutureMARES chose to use Ecopath with Ecosim (EwE), as this model was available across three different regions. EwE is the oldest and most widely used food web model globally with more than 443 unique models listed in an "EcoBase repository" (EcoPath with EcoSim repository). Continuous development has occurred across several decades allowing the model to explore complex scenarios of ecosystem change including how bottom-up and top-down forcing influences key species such as top-predators (Guénette et al. 2006) or interacting effects of climate, eutrophication and fishing and fisheries harvests and biodiversity (Bauer et al. 2019). Importantly, EwE has recently been integrated into stakeholder engagement approaches (e.g. serious gaming) to examine different scenarios of Marine Spatial Planning in European regional seas (Steenbeek et al. 2021). In that case, changes in energy infrastructure, shipping, and the marine environment over several decades were simulated with the outputs of different scenarios visualized using indicators and heat maps.

EwE models are available to FutureMARES in the NW Mediterranean, Bay of Biscay, North Sea and Baltic Sea to examine scenarios of implementation of NBS1, NBS2 and NIH. In this case, it was important to take a regionally relevant but, at the same time, a consistent approach with the scenarios to be tested to faciliate comparisons across European regional seas.

4.4.2. Scenarios to be tested

Global Sustainability (GS, SSP1, RCP2.6)

NBS 1 & NBS 2 – EU nations have made a joint effort to meet the 2030 targets of protection. Thus, in European waters, there is a network of efficient and well-managed marine protected areas of different levels of protection providing social and ecological benefits, with 10% as fully protected areas and 20% as highly protected areas. Further, there is a strong emphasis to progress towards habitat restoration within MPAs (considering the new EU restoration legislation and MSFD targets). For non-European countries, there has also been an increase in protection, with commitments to advance in fully protected and highly protected areas.

NIH – There is a full and effective implementation of the European Common Fisheries Policy (CFP, e.g. multiannual plan for demersal stocks, FMSY targets and discard ban) and MSFD and MSP Directives to achieve GES.

National Enterprise (NE, RCP 8.5, SSP 3)

NBS1 & NBS2 – With the increase of nationalism, there are poor linkages and very limited joint efforts among European countries towards a common environment objective. MPAs are used to protect species of national importance/value and protection does not take into account transnational connectivity. European countries have a limited progression towards the 30% target protection, instead, currently existing MPAs surface is kept, and only slightly increased by 5% as highly protected areas and 5% as low protected areas will take place based on mixed criteria to protect essential fixed habitats and vulnerable marine sites. For non-European countries, the level of protection is even smaller with 5% as fully protected areas and 5% as highly protected areas.

NIH – There is a lack of agreement between countries leading to an inconsistent and smaller-scale implementation of policies. Besides, there is strong political tension among countries regarding shared marine resources. Given that context, there is a partial failure in the implementation of the CFP (e.g. FMSY targets in some species, discard ban and increase of selectivity).

World Markets (WM, RCP 8.5, SSP5)

NBS1 & NBS 2 – Political agendas in European countries are increasingly driven by global economic interest with a clear tendency to position Europe as a key world Green economic actor (in line with the Green New Deal), which leads at short term to a quite inertia in protection actions with a higher preference for those that may lead to monetary clear and quick outcomes. The conservation priorities are shifting towards conserving marine ecosystems that produce market valuable resources or services. MPAs are designed and planned to support economic growth, protecting essential fish habitats for highly commercial species (e.g. hake and red shrimp) instead of prioritising vulnerable marina habitats/species.

NIH – There is a growing interest to manage fisheries considering Maximum Economic Yield (MEY) instead of maximum sustainable yield. Therefore, there is an optimisation toward commercial species of high value in Europe. “Common level field” economic tensions allow limited differences between EU and non-EU countries in terms of fisheries but, at the same time, they limit the ambition at the EU level.

Table 3.4.1 Rationale behind differences in the NBS and NIH implementation among the three FutureMARES scenarios to be used in T4.4 developed from D1.1 with regional considerations.

General Scenario	RCP	SSP	NBS1-Restoration	NBS2-Protection	NIH-Fisheries Sustainability
GS	2.6	1	Reaching EU & international legal regulations and targets for restoration of HFS (oysters, blue mussels, seagrass, corals)	Reaching EU & international targets for protection (MSFD, HD, Biodiversity strategy, Green Deal, ...) with priority for connectivity and climate-ready	Fully implement EU fisheries directives (CFP, MSFD), RSC conventions, and EBFM principles
NE	8.5	3	Priority to restore high value species according to food security, job security or coastal protection within EU EEZ (according to national targets)	Small MPAs with national interests and no connectivity	Fisheries sector (high or overfishing) with the help of subsidies operating in national EEZ to ensure food security, maximum landed volumes
WM	8.5	5	Priority to restore high economic value (oysters, blue mussels, commercial species) with limited scale interventions	Small MPAs with economic value and no connectivity	Largest scale fisheries increase while SSF decrease, with the aim to achieve a maximum landed value
Status quo, low CC	2.6	co	Baseline (average of last final years of calibration period and continue to future)	Baseline (average of last final years of calibration period and continue to future)	Baseline (average of last final years of calibration period and continue to future)
Status quo, high CC	8.5	cp	Baseline (average of last final years of calibration period and continue to future)	Baseline (average of last final years of calibration period and continue to future)	Baseline (average of last final years of calibration period and continue to future)

Table 3.4.2 Details of scenarios of NBS and NIH implementation to be tested using spatially-explicit ecosystem modelling in FutureMARES Task 4.4 including areas and locations of Marine Protected Areas (MPAs) and sustainable fishing effort in Nature-inclusive Harvesting (NIH).

Name	NBS S	NBS 2	NBS 1	NIH
	MPA surface	MPA location	Restoration Target	Fishing Effort
GS	EU countries and UK: 20% HP and 10% FP; non-EU countries: same targets as EU-countries and UK	Based on priorities of National Plans and already existing areas, turning all MPAs to FPA or HPA	≥ 30 %, 60% AND 90% of degraded area within MPAs in NBS2 of each group of habitat types by 2030, 2040, and 2050, respectively, considering EU restoration law (coastal areas) and MSFD (habitats), including VMS. Focus on Natura 2000 network	Reduction of fishing effort from 2022 to 2030 to achieve sustainable exploitation for 90% stocks. Ban high impact fleets (following standard definitions). No increased effort in any case.
NE	5% HPA and 5% FPA	Based on priorities of National Plans and already existing areas, favouring small MPAs within EEZ (no transboundary MPAs)	National targets will prevail for the restoration within MPAs	Continue individual country strategies with an overall increase of fishing effort due to technology improvements, annual tech creep of 2%(**) or specific values per fleet (if available in Palomares & Pauly 2019). Small-scale fisheries increase by 3% annually to support national economies. Only fishing within own EEZ.
WM	5% HP and 5% FP	Keep MPAs at current, and add new ones based on EFHs of high market value species (shrimp and hake) presence	No restoration of HFS because the effort will be in EFH	Increase effort of fleets with high value or volume (industrial) by 1% annually in addition to the tech creep, and close the small scale fishing by 2030.

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6. Appendix 1

Future MARES

Implementation Scenarios for Marine Nature-based Solutions (NBS)

This document introduces scenarios and seeks specific input from stakeholders on their perceptions of regional aspects most important to be contrasted in FutureMARES activities. Project activities include projections of spatial ecological impacts, social-ecological risk assessment, and bioeconomic analyses. This work is performed using different scenarios of NBS implementation.

Grant Agreement No 869300

1 Nature-based Solutions (NBS)

Actions inspired by nature to provide environmental, social and economic resilience to change.

The European Commission defines Nature-based Solutions (NBS) as 'solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions.' NBS must benefit biodiversity and support the delivery of a range of ecosystem services.[1] Nature-based Solutions have also been defined by the IUCN as 'actions to protect, sustainably manage, and restore natural or modified ecosystems that address societal challenges effectively, and adaptively, simultaneously providing human well-being and biodiversity benefits.'[2]

Three closely-related activities in marine and coastal areas are Habitat Restoration, Marine Conservation, and Seafood Harvesting (aquaculture and fisheries).

FutureMARES has developed contrasting future narratives on the implementation of these NBS. This brochure explains how we use scenarios and is a guide for stakeholders to provide their regional perspectives. Seeing how these scenarios might work in different regions helps to plan our research.

Marine NBS and the ecosystem services they provide (listed below)	Habitat Restoration	Marine Conservation	Seafood Harvesting
Reduce coastal erosion and flooding (stabilise shorelines, reduce storm surge)	✓		
Increase water quality (combat eutrophication)	✓		✓
Mitigate climate change (sequester carbon, reduce emissions)	✓	✓	
Increase productivity of food from the sea (fish nurseries, growth of shellfish / kelp)	✓	✓	✓
Maintain / increase biodiversity (make natural areas more resilient against change)	✓	✓	✓
Support tourism and cultural heritage (increase aesthetic and economic value)	✓	✓	✓

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Habitat Restoration

Marine habitats include seagrasses, salt marshes, mangroves, kelp forests, coral and shellfish reefs, which form natural coastal protection and help to adapt to increased storminess, rising sea levels and floods resulting from climate change. Expanding vegetated habitats also mitigates climate change by developing carbon sinks, like afforestation. These habitats also support biodiversity by forming key nursery areas, and providing natural refuges and feeding grounds. They also improve seawater quality and clarity, and sustain tourism and cultural activities.

Marine Conservation

Effective conservation considers effects of climate change on habitat suitability for flora & fauna. Strategies explicitly consider the range of impacts of climate change and other hazards on habitat suitability for flora and fauna. Strategies explored include preserving the integrity of food webs and sustaining population connectivity across networks of climate refugia where biogeophysical conditions are stable or changing slowly over multiple spatial and temporal scales (i.e. from site-specific marine protected areas to conservation strategies for certain large marine species such as turtles or dolphins).

Seafood Harvesting

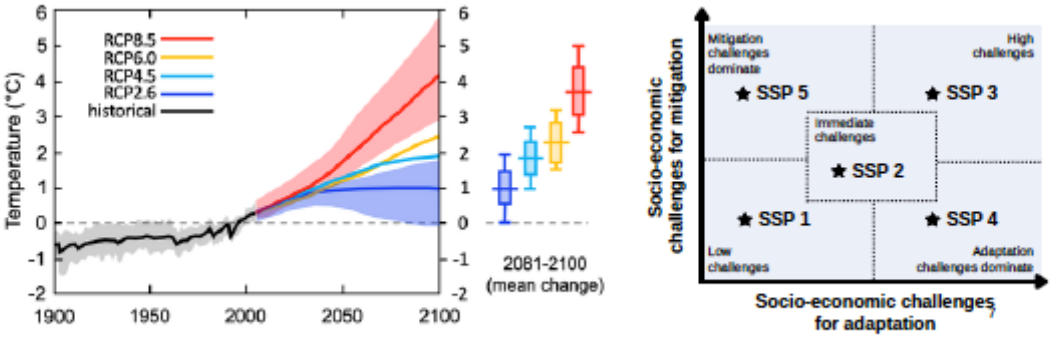
Sustainably harvesting seafood from fisheries and aquaculture should be flexible, adaptive and managed according to each ecosystem. Addressing the impacts of climate change requires ecosystem-based management and a multi-species approach that can adapt to shifts in productivity, distribution and species interactions and also limit the disturbance of the seafloor. Harvesting strategies must consider potential trade-offs among multiple users, economic sectors and ecosystem services such as cultural heritage for effective Blue Growth. It has a strong connection to restoration and conservation efforts.

2 What are Scenarios?

Scenarios are imagined 'futures', that are not necessarily 'visions' or 'plans.'

Scenarios can help guide strategy and are created in sets of plausible and coherent alternatives. Scenarios can help define the scope for adaptation by characterising the responses of various stakeholder groups (policymakers, conservationists, business owners, and the general public) under each future scenario.

The Intergovernmental Panel on Climate Change (IPCC) has developed two types of complimentary scenarios. The first describes how the concentration of CO^2 and other greenhouse gasses may rise or fall in the future, so-called Representative Concentration Pathways (RCPs). The second are Shared Socio-economic Pathways (SSPs), which describe how future changes in society (population growth, gross domestic product, international cooperation, etc.) can influence how easy it is for countries to enact climate adaptation or climate mitigation policies. The SSPs (social-economic, geo-political) and RCPs (amounts of global warming) were designed to be used together and, although not specifically matched, some RCP-SSP combinations are more likely to happen than others. The figures on the left illustrate the RCPs with their mean temperature changes until the year 2100 (top) as well as the SSPs with different socio-economic challenges for climate change mitigation and adaptation (bottom).



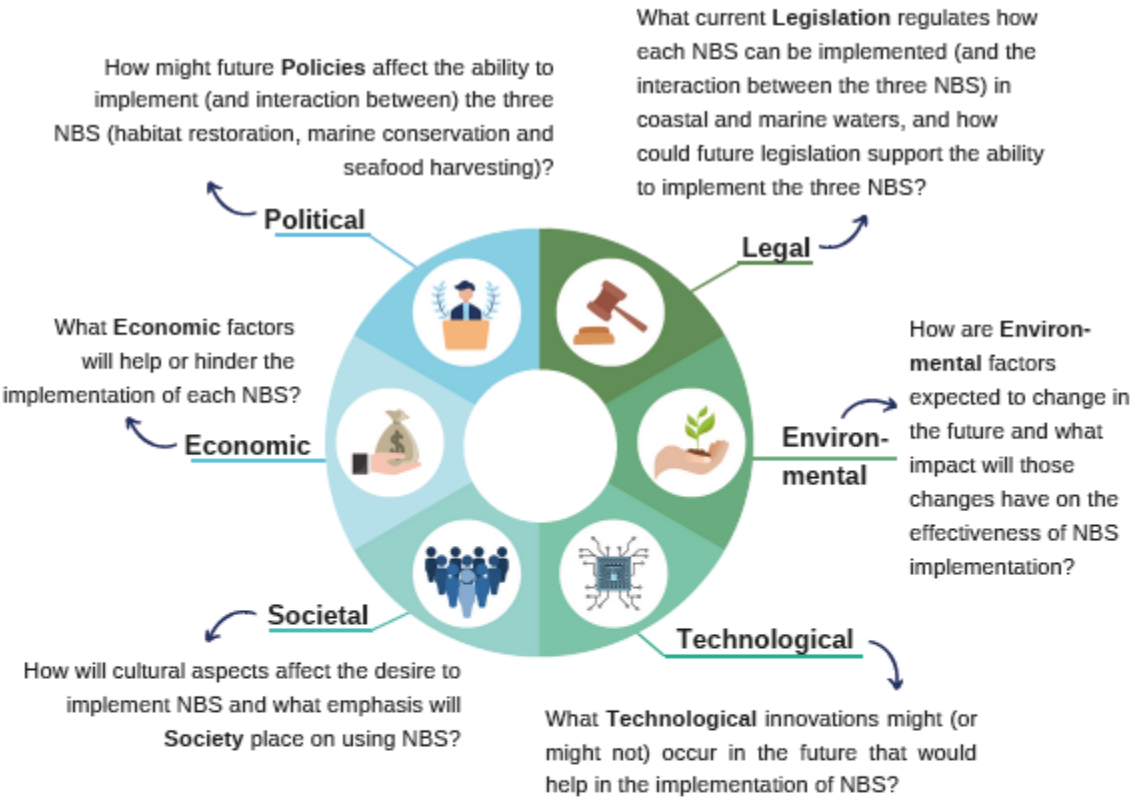
Global temperature change, based on Knutti & Sedláček (2013). **RCPs** show global temperature change and uncertainty. Global temperature change is illustrated relative to 1986–2005 for the SRES scenarios run by CMIP3 and the RCP scenarios run by CMIP5, with the number of models in brackets. For more information and a detailed explanation, see .

>>> Scenarios are also guiding the work of the Intergovernmental Science-Policy Platform for Biodiversity and Ecosystem Services (IPBES) to recommend actions (such as NBS) to halt the alarming loss of biodiversity occurring around the globe. These scenarios specifically address the future of nature and nature's contributions to people.[8] <<<

3 The PESTLE Approach to developing scenarios

PESTLE is a mnemonic which in its expanded form denotes P for Political, E for Economic, S for Social, T for Technological, L for Legal, and E for Environmental.

PESTLE is a way to look at all the potential factors that may influence planned actions. Although PESTLE analysis stems from the business community, it was used to explore future scenarios for EU aquaculture and fisheries in the CERES project.[3,9] To help guide stakeholders in providing more detailed, region-specific information for each PESTLE element, the following illustrates general questions to ask when building contrasting scenarios for NBS impementation.






4 The FutureMARES Scenarios

How society tackles climate adaptation and mitigation in three plausible scenarios.

FutureMARES will develop policy-relevant scenarios with stakeholders across the world. These scenarios are based on commonly used IPCC frameworks including SSPs and RCPs.

Global Sustainability (RCP2.6, SSP1)

Low challenges to mitigation and adaptation

The world shifts gradually but pervasively to a more sustainable path, emphasising inclusive development that respects perceived environmental boundaries. Management of the global commons slowly improves, investments in educational and health accelerate lower birth and death rates, and the emphasis on economic growth shifts to an emphasis on human well-being. Societies increasingly commit to achieving development goals and this reduces inequality across and within countries. Consumption is oriented toward lower material growth, resource and energy intensity.

National Enterprise (RCP8.5, SSP3)

High challenges to mitigation and adaptation

A resurgent nationalism, concerns about competitiveness and security, and regional conflicts push countries to focus on domestic or regional issues. Policies shift over time to be oriented more on national and regional security. Countries focus on achieving energy and food security goals within their own regions at the expense of broader-based development. Investments in education and technological development decline. Economic development is slow, consumption is material-intensive, and inequalities persist or worsen over time. Population growth is low in industrialised countries and high in developing ones. A low international priority for addressing environmental concerns leads to strong environmental degradation in some regions.

World Markets (RCP8.5, SSP5)

High challenges to mitigation, low challenges to adaptation

The world increasinly believes in competitive markets, innovation and participatory societies to produce rapid technological progress and train and educate people for sustainable development. Global markets become more integrated and strong investments in health, education, and institutions are made to enhance human and social capital. The push for economic and social development is coupled with exploiting abundant fossil fuel resources and adopting resource and energy intensive lifestyles around the world. All these factors lead to rapid growth of the global economy, while global population peaks and declines in the 21st century. Local environmental problems like air pollution are successfully managed. There is faith in the ability to effectively manage social and ecological systems, including by geo-engineering if necessary.

More details: futuremares.eu/futurescenarios



5 Habitat Restoration: PESTLE Table

Element	 **Global Sustainability** (RCP2.6, SSP1)	 **National Enterprise** (RCP8.5, SSP3)
 P	A collaborative, international atmosphere exists and governments (e.g. UN, EU) provide strong, consistent leadership to support restoration. Habitat restoration is supported through consistent policies at regional, national and international levels.	Lack of agreement between nations leads to inconsistent and smaller-scale (within EEZ) application of policies for the three NBS. Restoration strategies differ among countries. Restoration is relatively low on national policy agendas as opposed to meeting energy demands.
 E	Less severe, climate-driven changes and shifts in suitability of habitats Large-scale habitat restoration and recovery increases ecosystem services (e.g. carbon capture). Recovery is fostered by reductions in pollution (plastics, eutrophication) and other habitat stressors.	Stronger climate-driven changes in the suitability of habitats to support local species increase shifts and add uncertainty to regional NBS implementation. Large areas set aside for food production may pose carrying capacity issues; Biodiversity declines due to little restoration of habitat-forming species.
 S	High awareness of the importance of well-functioning marine habitats & ecosystems supported by education programs. Protecting natural capital is a priority. Increased demand for restored habitats for recreation and leisure and to meet ethical concerns.	Restoration is not a priority particularly of habitats (e.g. saltmarshes) that take up valuable farmland. Restoration targeted to iconic species / habitats and those protecting assets (resilience of coastline).
 T	Increased investment in technology leads to breakthroughs in low-cost, efficient environmental monitoring (e.g. satellite, drones). Biodegradable techniques for effective restoration and long-term monitoring of habitats. Biotechnology (e.g. assisted evolution) increases resiliency of restored species.	Concentration on locally-developed technologies and knowledge to restore habitats or species (little learning from elsewhere). Using technology to restore native habitats that have cultural meaning.
 L	International commitments to agreed goals (e.g. Paris Climate Agreement) are fully embedded within legal frameworks in each country (including CBD, IPCC, IPBES). Regulations include severe penalties to ensure programmes are respected / effective. Habitat restoration is compulsory; Restored habitats play role in carbon capture for Nationally Determined Contributions (NDCs).	International commitments to UN policies are poorly implemented and depend on national interests.
 E	Citizens and industries prepared to pay for restoration (either directly for access or via taxes). Sustainable, green business practices are norm. High revenue from ecotourism.	Local/regional investment in restoration and conservation shifted to sectors that create jobs/ have higher economic relevance. Restoration targeted to high-value harvestable species (shellfish).



Political, Environmental, Societal, Technological, Legal, and Economic Dimensions of the future.

World Markets
(RCP8.5, SSP5)

The EU falls apart as a political force, and there is no unified strategy for national environmental policies, with environmental goals less valued than economic growth.

Restoration largely abandoned or conducted for production (profit) or if cheapest way to protect coastal assets.

Warming leads to changes in suitability of waters to support historical, natural habitat; Increased habitat degradation from short-term profit-driven activities.

International trade leads to decline in biodiversity in developing counties; well-established populations of invasive species can compromise restoration efforts.

Full support for restoring marine ecosystems that produce market valuable resources (e.g. cheap protection of coastal assets) or services; Network of harvesting artificial created habitats - blue farms; Poor ocean and climate literacy.

Promotion of bio-engineering in restoration (i.e. assisted evolution, active restoration, etc.) in habitats considered profitable; low ethical constraints on technological development; Potential use of artificial habitats instead of traditional species.

International commitments and agreements on environment/ocean heath objectives are abandoned; National legislation for MPA programmes is weak in favour of investment in sectors that create jobs.

Conflicts arise in marine spatial planning due to economic v.s conservation objectives; Increased international trade conventions, including CITES, with little legal focus on habitat restoration if deemed non-profitable.

High cost effectiveness of restoration actions (e.g. for blue carbon); Biodiversity banking possible to support restoration; Private sector may increase investment in restoration; Focus on short-term wealth generation – degradation in long term.


Seagrass


Kelp & other macroalgae


Oysters & mussels

What is the next step?

FutureMARES needs to add more detail to these three scenarios for habitat restoration in your region. This stakeholder input helps define the work to be performed.

→ See page 12 for example questions.



6 Marine Conservation: PESTLE Table

Element	 **Global Sustainability** (RCP2.6, SSP1)	 **National Enterprise** (RCP8.5, SSP3)
 P	A collaborative, international atmosphere exists and governments (e.g. UN, EU) provide strong, consistent leadership to support conservation. MPAs planned as a precautionary approach (not only based on cost-effectiveness), their size meets current 2030 targets (e.g. EU >30%, >10% integral reserves). Trans-national Marine Spatial Planning creates climate-ready conservation.	Lack of agreement between nations leads to inconsistent and smaller-scale (within EEZ) implementation of policies for the three NBS. MPAs used to protect species of national importance / value and compete for space with energy and food provision. Conservation policy is not high on the political agenda. Lack of coordinated policies for (trans-boundary) species.
 E	Less severe, climate-driven changes and shifts in suitability of habitats Large-scale (in some cases trans-national) conservation efforts allow rehabilitation of sensitive ecosystems and associated species.	More severe, climate-driven changes in the suitability of habitats to support local species increasing shifts and adding uncertainty to site-specific / regional NBS implementation. Smaller, regional conservation efforts with limited scope for planning MPAs based on large-scale connectivity patterns and other conservation actions.
 S	Increased awareness of the importance of well-functioning marine habitats and ecosystems supported by education programs. Protecting Natural Capital is a priority. Improved MPA effectiveness by local community support. High value and legitimacy of local and indigenous knowledge. Education supports local ownership and engagement with conservation initiatives.	MPA effectiveness improved by local community suppor.; High value and legitimacy of local and indigenous knowledge. Education supports local ownership and engagement with conservation initiatives. A mosaic of societal attitudes on conservation. Some countries highly concerned - others - main focus on production.
 T	Increased investment in technology leads to breakthroughs in low-cost, efficient environmental monitoring (e.g. satellite, drones). Advanced tools support connectivity planning.	Little or no technological advancement. Intensive monitoring of nationally important assets.
 L	International commitments to agreed goals (e.g. Paris Climate Agreement) are fully embedded within legal frameworks in each country (including CBD, IPCC, IPBES). Regulations include severe penalties to ensure programmes are respected / effective.	International commitments to UN policies are poorly implemented and depend on national interests. Arguments and legal disputes between countries about transboundary issues and who is to blame for decline in vulnerable species. Weak conservation legislation.
 E	Environmental conservation seen as economically beneficial with emphasis on valuation of Natural Capital and Ecosystem Services but not for profit (MPAs freely accessible perhaps via government funding).	Less financial support for monitoring and enforcement of conservation; Potential subsidies to protect valuable assets. Investment diverted to sectors that create jobs/ have higher economic relevance.



Political, Environmental, Societal, Technological, Legal, and Economic Dimensions of the future.

World Markets
(RCP8.5, SSP5)

The EU falls apart as a political force, and there is no harmonised strategy for national environmental policies, with environmental goals less important than economic growth.

Political agendas are driven by global economic interests, omitting conservation and environmental needs.

Warming continues and loss / shifts of some keystone species may decrease ecosystem functioning.

International trade leads to decline in biodiversity in developing counties; in some areas, well-established populations of invasive species compromise restoration efforts.

Full support for the conservation of marine ecosystems that produce market valuable resources or services; Poor ocean and climate literacy; Loss of traditional knowledge and cultural values associated with conservation effectiveness in MPAs.

Technological advances increase efficiency of monitoring and enforcement and better of MPAs deemed to support economic growth; Assisted evolution to support MPAs; Investment in MPAs with artificial habitats.

International commitments and agreements on environment/ocean heath aims are abandoned; National legislation for MPA programmes is weak in favour of investment in sectors that create jobs

Conflicts arise in marine spatial planning due to economic versus conservation objectives; Increased international trade conventions, including CITES, with little legal focus on pure conservation.

Entrance fees to MPAs to support profitable ecotourism and/or exploitation of marketable ecosystem services such as harvesting, blue carbon, etc.; Biodiversity banking in MPAS.


Macroalgae & seagrass


Habitat-forming corals


Sea turtles

What is the next step?

FutureMARES needs to add more detail to these three scenarios for marine conservation in your region. This stakeholder input helps define the work to be performed.

→ See page 12 for example questions.



7 Seafood Harvesting: PESTLE Table

Element	 **Global Sustainability** (RCP2.6, SSP1)	 **National Enterprise** (RCP8.5, SSP3)
 P	A collaborative, international atmosphere exists and governments (e.g. UN, EU) provide strong, consistent leadership to support sustainable harvesting. International treaties ensure sustainable fisheries management, including strong, cohesive trans-boundary regulations; High ecosystem considerations such as balanced harvesting, protecting large female fish.	Lack of agreement between nations leads to inconsistent and smaller-scale (within EEZ) implementation of policies for the three NBS Strong political tension among nations regarding shared resources, particularly highlight migratory species or those experiencing range shifts.
 E	Less severe, climate-driven changes and shifts in suitability of habitats for harvested species Long-term increases in fish stock sizes lead to recovery of top predators (marine mammals); Ecolabels focus on reducing environmental impact (e.g. 'dolphin safe', low carbon emissions).	More severe, climate-driven changes in the suitability of habitats to support local species increasing shifts and adding uncertainty to site-specific / regional NBS implementation.
 S	Increased awareness of the importance of well-functioning marine habitats and ecosystems supported by education programs. Protecting Natural Capital is a priority. Increased desire for culture and consumption at the base of the food web (seaweeds and bivalves). Only sustainable fishing practices are permitted.	Large support of traditional fisheries to sustain cultural heritage and employment at the national level.
 T	Environmentally-friendly fishing gear (low bycatch); large-scale culture of lower trophic level species (seaweeds, bivalves).	Pace of fishing and aquaculture innovation slows in some countries without international exchange and harvesting sector continues to operate as now; Depending on national priorities, some countries may have a large investment in technology for food security; High investment in innovation to monitor infringements into EEZ (investments in drone and remote sensing technology)
 L	International commitments to agreed goals (e.g. Paris Climate Agreement) are fully embedded within legal frameworks in each country (including CBD, IPCC, IPBES). Regulations include severe penalties to ensure programmes are respected / effective. Fisheries shifts towards balanced harvesting and/or ecosystem-based management; High enforcement of regulations.	International commitments to UN policies are poorly implemented and depend on national interests; focus on protectionism (import / trade laws)
 E	Stock rebuilding may reduce fishing & profits. Subsidies provided to support alternative employment. Wild fish price low, cultured fish price increases.	Depending on national priorities, subsidies may support traditional fisheries; fish price increases due to international trade barriers

Future MARES



Political, Environmental, Societal, Technological, Legal, and Economic Dimensions of the Future.

World Markets (RCP8.5, SSP5)

The EU falls apart as a political force, and there is no harmonised strategy for national environmental policies, with environmental goals less important than economic growth.

Management based on maximum economic yield and not maximum sustainable yield.

Warming continues and some stocks collapse or shifted also due bio-invasions – new assemblages offer opportunities to be exploited.

Migration and marginalisation of artisanal / traditional fishers and farmers continues to degrade coastal communities dependent on those activities; loss of traditional knowledge, local identities and cultural values linked to fisheries due to economic rights; Increased reliance on aquaculture for protein security.

Investment in high-tech aquaculture, fish feed rations decrease, increased efficiency / profitable (fish meal replacement) with little investment in offshore (deep water) solutions.

Promoting management harvested species to maximum economic yield; GATT style trade agreements may take precedence over conservation and environmental legislation; Open trade for seafood and seafood processing.

Profit driven efficiency of harvesting but not based on minimising pollution; private access rights to fisheries, and tradable permits.

Huge multinational companies allow fish to be obtained from cheapest sources worldwide (both for fishing and mariculture) benefiting a few countries; Market-based incentives dominate with no subsidies.

Artisanal fishing

Aquaculture

Industrial fishing

What is the next step?

FutureMARES needs to add more detail to these three scenarios for seafood harvesting in your region. This stakeholder input helps define the work to be performed.

→ See page 12 for example questions.

8 Questions for Stakeholders

Political	NOW	At the local / regional level, which governmental agency(ies) or body(ies) establish environmental regulations and manage activities related to habitat restoration, marine conservation and/or seafood harvesting? If there are multiple agencies / bodies, can you provide examples of how these have interacted to impact (either help or hinder) the implementation of marine habitat restoration, conservation and/or sea food harvesting?
	IN THE FUTURE	The extent of implementation of NBS and, more generally, national goals for climate adaptation and mitigation, will differ among the three scenarios. Given these differences, what goals might be set by specific governmental agencies / bodies with respect to climate-ready environmental policies and how might these goals impact marine habitat restoration, marine conservation and/or sea food harvesting?
Environmental	NOW	At the local / regional level, in your view what are the most relevant environmental threats faced by marine species and/or habitats important for marine habitat restoration, marine conservation and/or sea food harvesting? What changes have you observed in marine habitats and/or species in the last decades and what do you think has(have) been the main cause(s) of those changes?
	IN THE FUTURE	Climate change will continue to interact with other human-made stressors (e.g. habitat destruction, pollution, invasive species) to impact marine habitats and species but the magnitude of these and other threats differs among the three scenarios. How might these environmental threats change in each of the scenarios?
		What important environmental losses or gains might occur in these three scenarios that will impact marine habitat restoration, marine conservation and/or sea food harvesting?
Societal	NOW	In your community or region, how do coastal and marine habitats play a role in your cultural values and identity? What cultural activities in your community depend on the health of coastal and marine habitats? Do you see conflicts among different activities if one attempt to implement each of the three NBS in your region?
	IN THE FUTURE	Depending on the scenario, the type and strength of connection that people have to marine habitats and species may markedly differ. Given the differences in NBS implementation in the three scenarios, in your view, what specific, traditional activities may be impacted (improved or worsened)?
		If you perceive that conflicts or tradeoffs exist now in terms of marine habitat restoration, marine conservation and/or sea food harvesting, how might these change in each of the three future scenarios?





Techno-logial	*NOW*	In your region, what has / have been the most important technological advance-ment(s) that has influenced the implementation of habitat conservation, restoration or sea food harvesting?
	IN THE FUTURE	What technological advancement might (or might not) take place in the scenarios that will influence the implementation and effectiveness of NBS? The ability to measure and monitor changes in marine habitats and species will impact the effectiveness of each of the three NBS. Given the differences among the scenarios, how might environmental monitoring change in the future?
Legal		In your region, what legal instruments exist that have had a strong (either positive or negative) influence on marine habitat restoration, marine conservation or sea food harvesting?
	NOW	Are you aware of transboundary (across regional or national jurisdictions) agreements or conflicts that are important for marine habitat restoration, marine conservation or sea food harvesting?
	IN THE FUTURE	Cooperation between nations, such as trans-boundary agreements, differs considerably among the scenarios. How might this difference impact the effectiveness of habitat restoration, marine conservation and/or sea food harvesting?
		Among the three scenarios, the level of protection and conservation of habitats and species may markedly differ. In your opinion, what level of protection will sensitive / important habitats or species be afforded in each scenario (relative to the present-day situation)?
Economic	*NOW*	Marine and coastal habitats and species provide both direct and indirect economic benefits to various sectors. In your opinion, what are the primary economic incentives or activities in your region driving changes in marine habitat restoration, marine conservation and/or sea food harvesting?
	IN THE FUTURE	What economic changes might be expected in each of the three scenarios that will impact on the implementation of marine habitat restoration, conservation and/or sea food harvesting?



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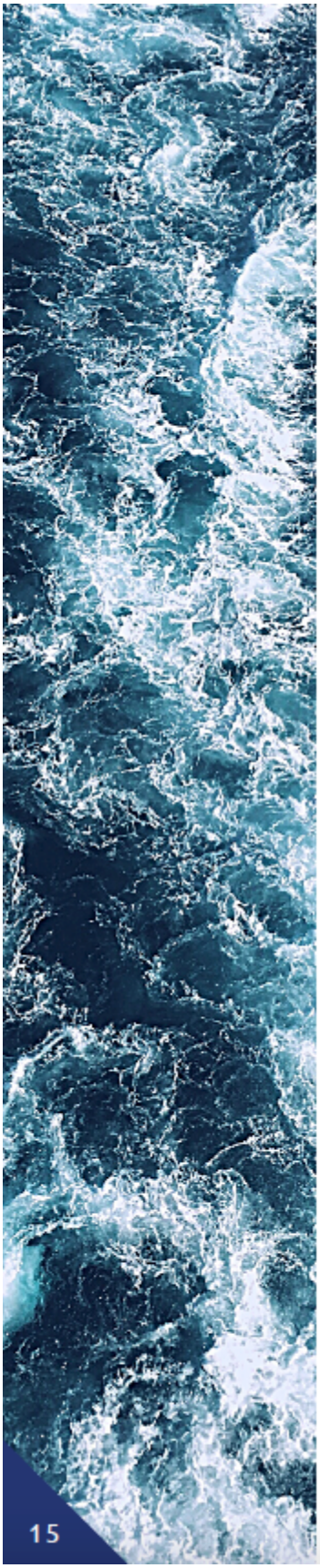
Notes



What is FutureMARES?

FutureMARES is an EU-funded research project examining the relations between climate change, marine biodiversity and ecosystem services. Our activities are designed around three Nature-based Solutions (NBS):

- Effective Restoration (NBS1)
- Effective Conservation (NBS2)
- Sustainable Harvesting of Marine Resources (NBS3)

We are conducting our research and cooperating with 32 marine organisations and the public in five broad regions across the globe (North Sea, Baltic Sea, Mediterranean Sea, North-East Atlantic, South Pacific). Our goal is to provide science-based policy advice on how best to use NBS to protect future biodiversity and ecosystem services in a future climate.

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Further details about the work of FutureMARES can be found at futuremares.eu.

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Appendix 2

SURVEY

Regionalising the FutureMARES Scenarios

The aim of this questionnaire is to help regionalise the three FutureMARES scenarios using the perspectives of stakeholders including scientists. The outcome will be a report comparing perceptions and information on three PESTLE elements (political, social and legal) in the three scenarios across regions and NBS. By answering these questions, you provide valuable inputfor this comparison. Therefore, we would be grateful if you answered the following six questions. If possible, please also share the survey with other key stakeholders affiliated withyour Storyline / region - these contributions will allow us to define and test meaningful scenariosto provide science-based advice for the ongoing implementation of NBS in your region.

FutureMARES SCENARIOS

Low challenges to mitigation and adaptation (RCP2.6, SSP1)

More sustainable path, emphasizing inclusive development and respecting environmental boundaries. Better management of global commons; investment in education and health; emphasis on human wellbeing over economic growth. Reduction of inequalities.

High challenges to mitigation and adaptation (RCP8.5, SSP3)

Resurgent nationalism, competitiveness and security, regional conflicts push countries to focus on domestic issues. Policies oriented on national and regional security. Focus on energy and food security within countries. Lower investment in education and health. Low priority foraddressing environmental concerns. Material-intensive production/consumption.

High challenges to mitigation, low challenges to adaptation (RCP8.5, SSP5)

Increasingly competitive markets, innovation, rapid technological progress. Society trained for sustainable development. Global markets more integrated; strong investments in health, education, human capital. Push for economic development and exploitation of fossil fuels. Resource-intense lifestyles, global economic growth. Faith in technological solutions.

For more information on the scenarios and NBS, see the FutureMARES Scenario Glossy: https://www.futuremares.eu/_files/ugd/f7f964_3654bc1b4ef146858716df191e3c3796.pdf

What NBS or ecosystem benefit will you refer to in this questionnaire? *Please choose one.*

☐ Habitat Restoration ☐ Marine Conservation ☐ Seafood Harvesting

To help us understand your responses,please **indicate the specific ecosystem / Storyline** you will refer to in this questionnaire by typing the title in the text field below the category.

Future MARES

1. POLITICAL

1.1. **Now:** At the local / regional level, which governmental agency(ies) or body(ies) establish environmental regulations and manage activities related to the NBS / ecosystembenefit you are referring to? *(Please type in text field)*

1.2. a) **In the future:** Can you explain your nation's policy for the NBS / ecosystem benefityou are referring to? What is the current national policy for the category you are describing? *(Please type in text field)*

1.2. b) How might this policy change under the three scenarios?

Global Sustainability	National Enterprise	World Markets

2. SOCIETAL

2.1. **Now:** What cultural activities in your community/Storyline depend on the health of coastaland marine habitats and do you think the implementation of NBS1 (restoration) and NBS2 (conservation such as MPAs) will lead to conflicts with these activities?
(Please type in text field)

2.2. **In the future:** Depending on the scenario, the type / strength of people's connection tomarine habitats and species may markedly differ. Given the differences in NBSimplementation in the three scenarios, in your view, what specific, traditional activitiesmay be impacted, improved or worsened? *(Please type in text field)*

3. LEGAL

3.1. **Now:** In your region, what legal instruments (e.g. national laws / regulations) exist thathave had a strong (either positive or negative) influence the NBS / ecosystem benefityou are referring to? *(Please type in text field)*

3.2. **In the future:** Among the three scenarios, the level of protection and conservation ofhabitats and species may greatly differ. In your opinion, what level of protection will sensitive / important habitats or species be afforded in each scenario (relative to thepresent-day situation)? *(Please type in text field)*

Which habitat / species / harvesting activity do you describe?

Global Sustainability: In the future, how might protection / conservation / harvesting change?

☐ much less ☐ less ☐ unchanged ☐ more ☐ much more

National Enterprise: In the future, how might protection / conservation / harvesting change?

☐ much less ☐ less ☐ unchanged ☐ more ☐ much more

World Markets: In the future, how might protection / conservation / harvesting change?

☐ much less ☐ less ☐ unchanged ☐ more ☐ much more

After completing the questionnaire, please email the PDF to:

>>> futuremares@gmail.com <<<

Thank you for taking the time! In case of questions, email to:

myron.peck@nioz.nl